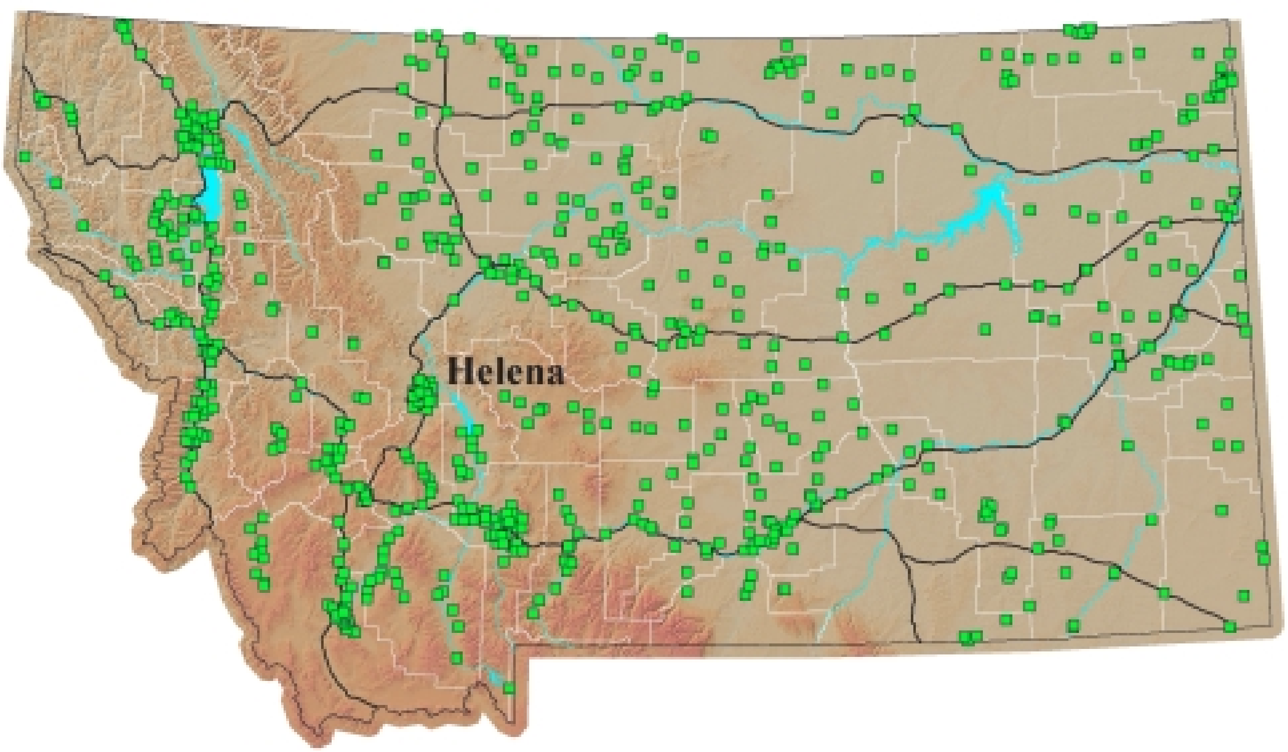
Montana Ground-Water Assessment
Statewide Monitoring Well Network



Montana Ground-Water Assessment
Water-level Monitoring and Drought: October-December 2002

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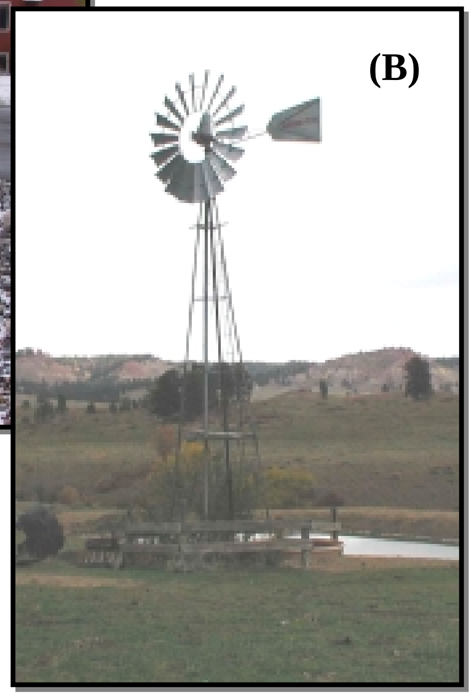
The statewide monitoring network currently contains about 850 wells. Most of the wells are measured quarterly by staff at the Montana Bureau of Mines and Geology (MBMG) but some wells in the Paradise, Helena, Gallatin, and Missoula valleys are measured by cooperators at local water-quality districts and the universities. In addition to the quarterly measurements, there are about 90 water-level recorders that provide daily water levels, 10 of which are operated by the U.S. Geological Survey under a cooperative agreement. Other cooperators include the Coal Hydrology program at MBMG which measures wells in Rosebud and Big Horn counties, the Ground-Water Characterization Program at MBMG which measures wells in its active study areas, the Confederated Salish and Kootenai Tribes, and the Sheridan County Conservation District's water reservation monitoring program in northeast Montana. Water-level data from all of these efforts are available through the GWIC web site at **http//:mbmggwic.mtech.edu.**

The statewide network is designed to collect water-level and water-quality data that may be used for a wide variety of purposes. Considering the current desire for information regarding the response of water wells to climatic conditions, this document focuses on how water levels in wells are responding to drought.



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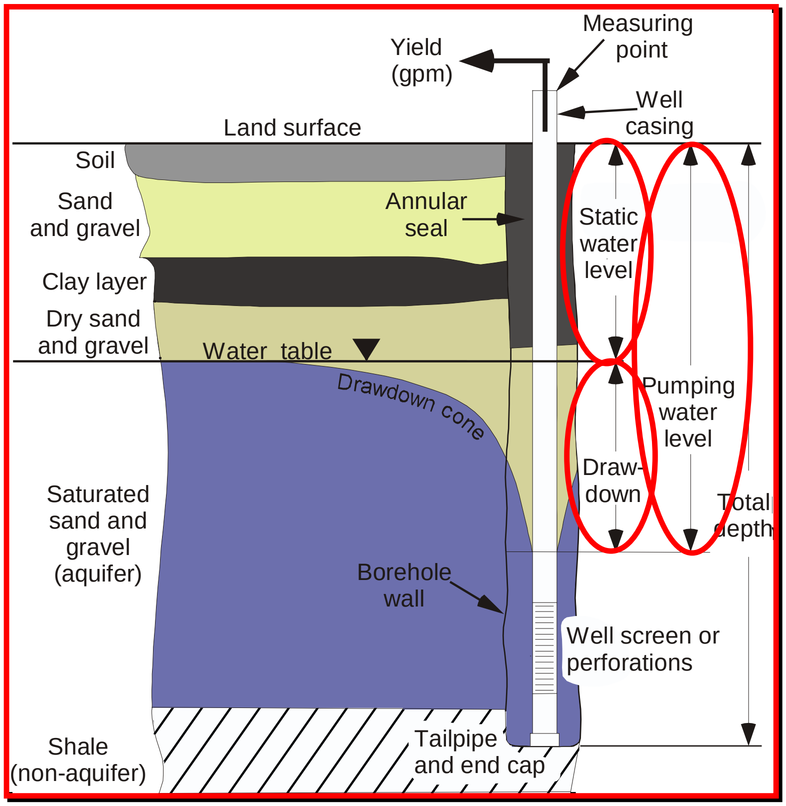
(A) The Crystal Springs statewide network well in Yellowstone County provides water-level records valuable for assessing the impact of subdivision and climate on near-surface alluvial aquifers.

(B) The Liscom statewide network well in Powder River County is one of about 90 network wells completed in the Fort Union Formation. Water-level measurements from Fort Union Formation wells provide data helpful in evaluating the aquifer's response to drought and development.

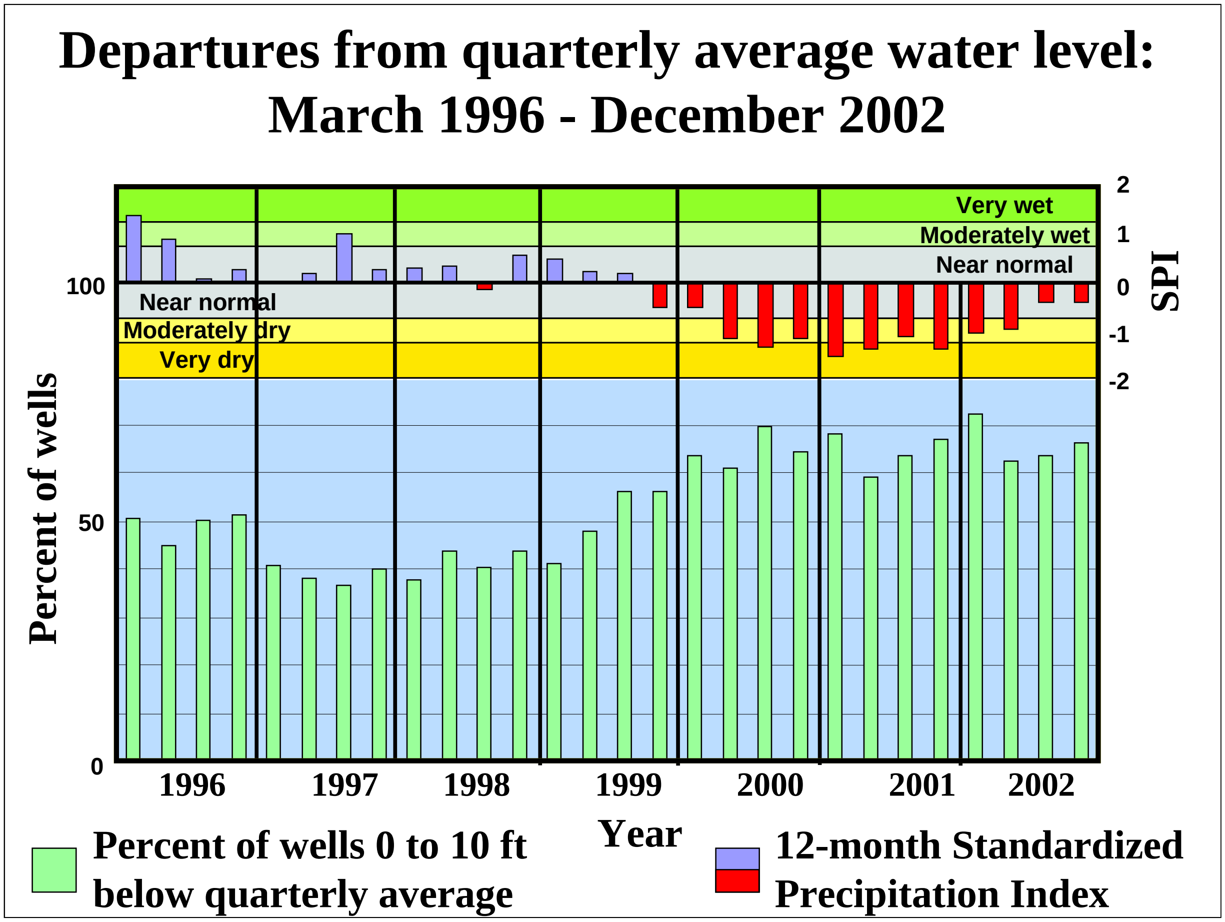


Well construction and terminology

Typical water well construction and Terminology

The **static water level** is the distance *from the land surface to the water in a well* when the well is not being pumped. A **pumping water level** is a measurement made while a well is being pumped and at a known time after pumping began. **Drawdown** is the difference between the pumping water level and the static water level at the time the pumping water level is measured. Distances to water (both static and pumping) are reported as positive numbers. Therefore a water level of 10 ft below land surface is "*higher*" than a water level of 20 ft below land surface. Increasing distances to water in wells indicates that water levels are "*declining*"; decreasing distances indicate that water levels are "*rising*".

The amount of **drawdown** required to produce water from a well depends on the yield, the amount of time that the well has been pumped, and the characteristics of the aquifer. Generally, if **static water levels** in the well decline, **pumping water levels** must also, so that the well can produce the amount of water desired. Because a pump in the well is at a constant depth, declining static water levels may cause pumping water levels to fall below the level of submergence required for the pump, and production from the well will be disrupted. The amount of water-level decline that can be tolerated depends on each well. For example, a shallow well that requires only inches of drawdown may continue producing while nearby deep wells that require feet of drawdown fail. Other deep wells in the same aquifer may appear unharmed because they require less drawdown to operate. However, the shallow well is relatively sensitive to the position of the shallow water table. If the drought continues and is severe, enough water-level decline will occur so that the shallow well "dries" up even though it may have still been operating with only a few inches of water in its bottom.

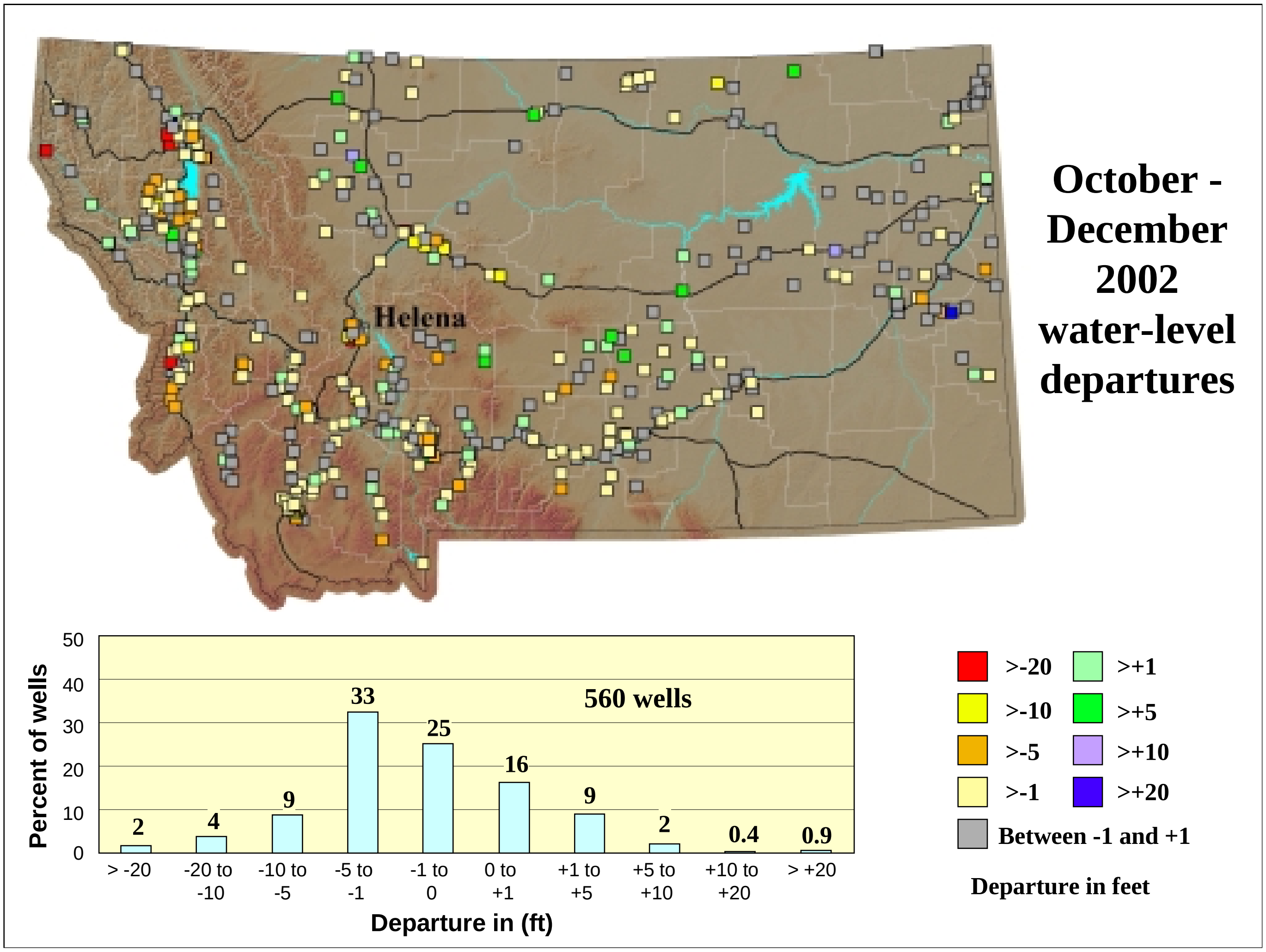


Departures from quarterly average water level: March 1996-December 2002

The graph shows the percentage of wells in the statewide network that were between 0 and 10 feet below their long-term quarterly averages for each calendar quarter between January 1, 1996 and December 31, 2002. Quarterly postings of the 12-month statewide Standardized Precipitation Index (SPI) for the same time period are in the upper part of the chart. Between the quarter ending March 1996, and the quarter ending September 1999, the SPI was mostly near, but on the wet side of normal. During this period the percentage of wells that were below their quarterly averages dropped to less than 40%, before beginning to rise during the quarter ending June 1999. The 12-month SPI became negative in the quarter ending December 1999, became moderately dry in the quarter ending June 2000, and continued to be moderately dry to very dry through the second quarter of 2002. The statewide SPI was in the “near-normal” (but still negative) range during the last half of 2002.

Since June 2002 the percentage of wells between 0 and 10 ft below their long-term averages has gradually increased similar to increases observed in 2001. The percentages of wells between 0 and 10 feet below their quarterly averages in the last quarters of 2001 and 2002 are almost identical.

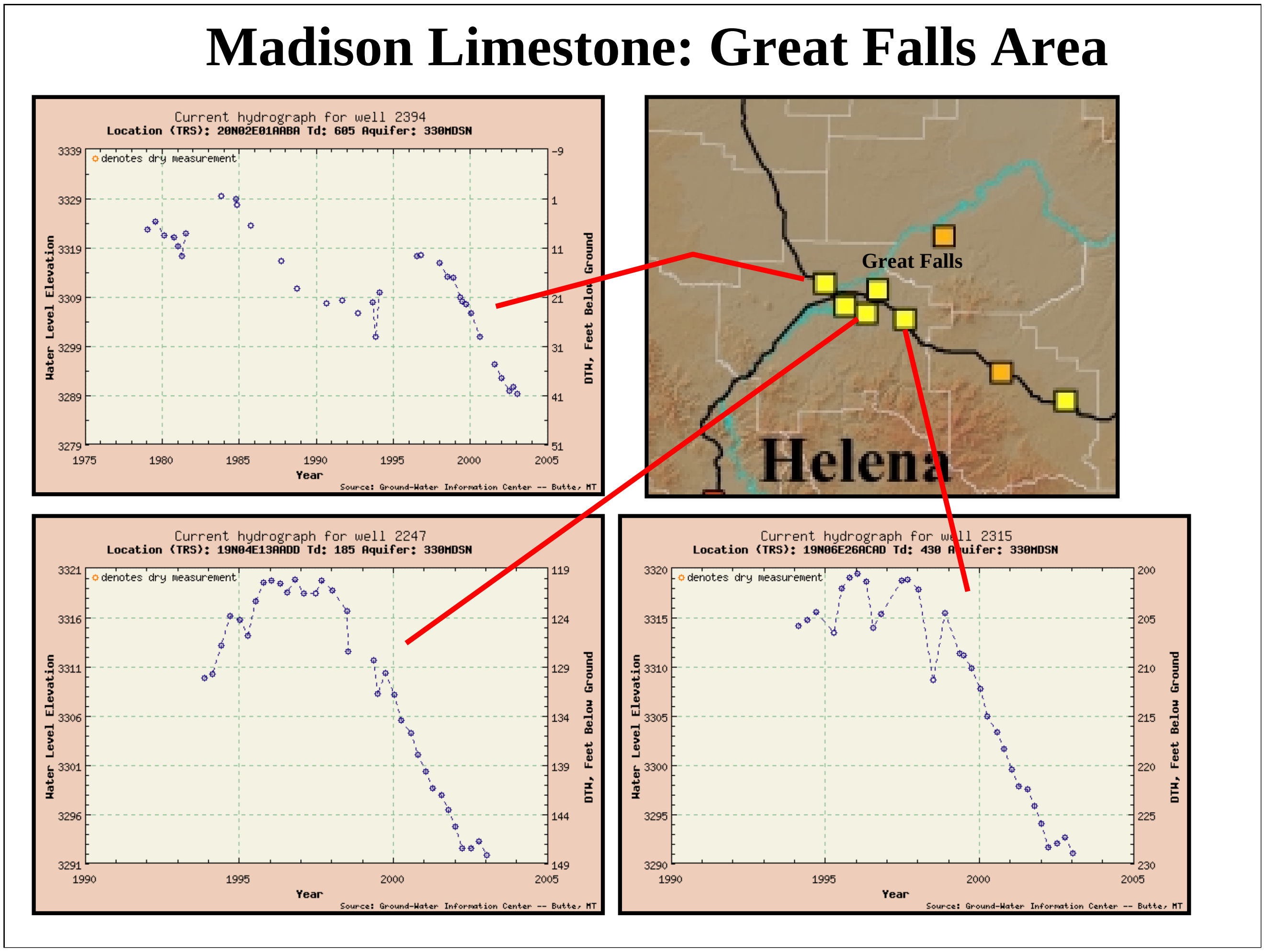
The illustration shows that although more wells are below their quarterly averages in response to the current dry climatic conditions than previously, there was a substantial percentage of wells (about 40%) that were between 0 and 10 feet below their quarterly averages even when climatic conditions were relatively wet. Other factors influence water levels in wells and examination of water-level records (hydrographs) in conjunction with climatic, pumping, and other data is essential to determine what may be happening in specific areas.



October - December 2002 seasonal water-level departures

Although the monitoring network currently contains about 850 wells, only 560 have October-December 2002 seasonal records of **more than 5 years, more than 5 measurements representing the October-December period, and that were measured between October 1, and December 31, 2002**. Each point on the map shows the difference in feet (**departure**) between the well's most recent measurement and the average of all its measurements for the October-December period. Yellow, orange, and red points show wells in which the most recent measurement is below average. Green and blue points indicate wells where water levels are above average. Gray points show where water levels are less than 1 foot above or below average.

The histogram shows the percentage of wells that are in each departure category. About 40% of the wells have water levels within +/-1 ft of their long-term quarterly averages, although 25% of the wells are below and 16% are above their averages. Wells with water levels between 1 and 5 ft below their seasonal averages populate the largest category at 33%. About 15% of the wells were more than 5 ft below average during the October-December 2002 period, while only about 3% of wells were more than 5 ft above their averages.



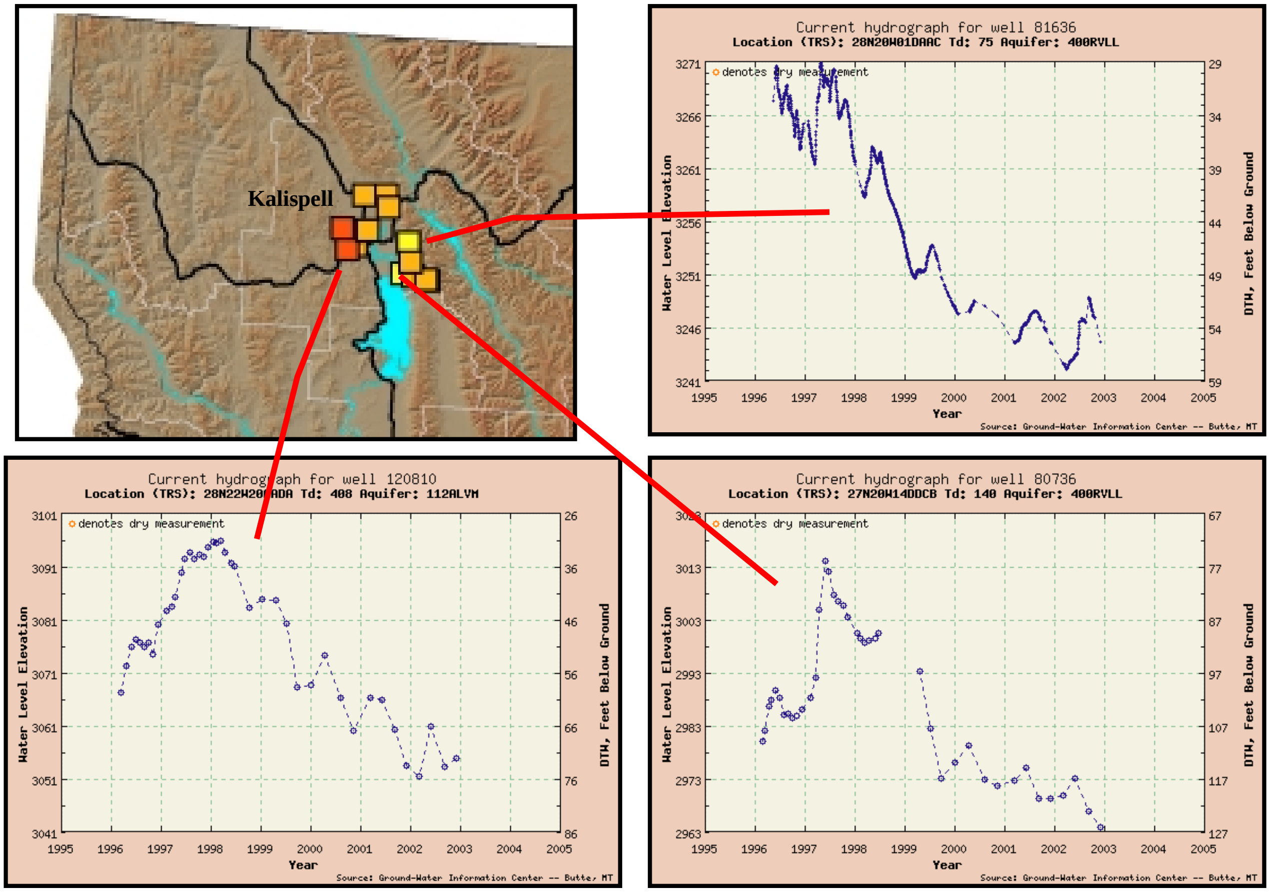
Madison Limestone: Great Falls Area

Four monitoring wells (only three shown here) completed in the Madison Limestone near Great Falls have surprisingly similar water-level records. Well 2394 has the longest period of record and comparison of that record beginning in about 1994 to the records for wells 2247 and 2315 shows the similarity. The Madison Limestone aquifer provides water to many wells in the Great Falls area and is the source for Giant Springs.

All of the wells have steadily declined since 1997 and reached near record low levels in early 2002, but July and September 2002 measurements showed some minimal recovery. Even though the amount of recovery does not approach the magnitude of the recent declines, that recovery has occurred at all is significant considering current climatic conditions. The hydrographs show that recharge in 2002 disrupted the rate of water-level decline and that without the recharge, current record-low water levels would have likely occurred about 9 months ago.

The Madison Limestone is at the land surface in extensive areas of the Little Belt Mountains (near the word Helena on the map above). The general water-level declines likely represent lack of recharge from snow pack and run off in streams along the northern flank of the mountains.

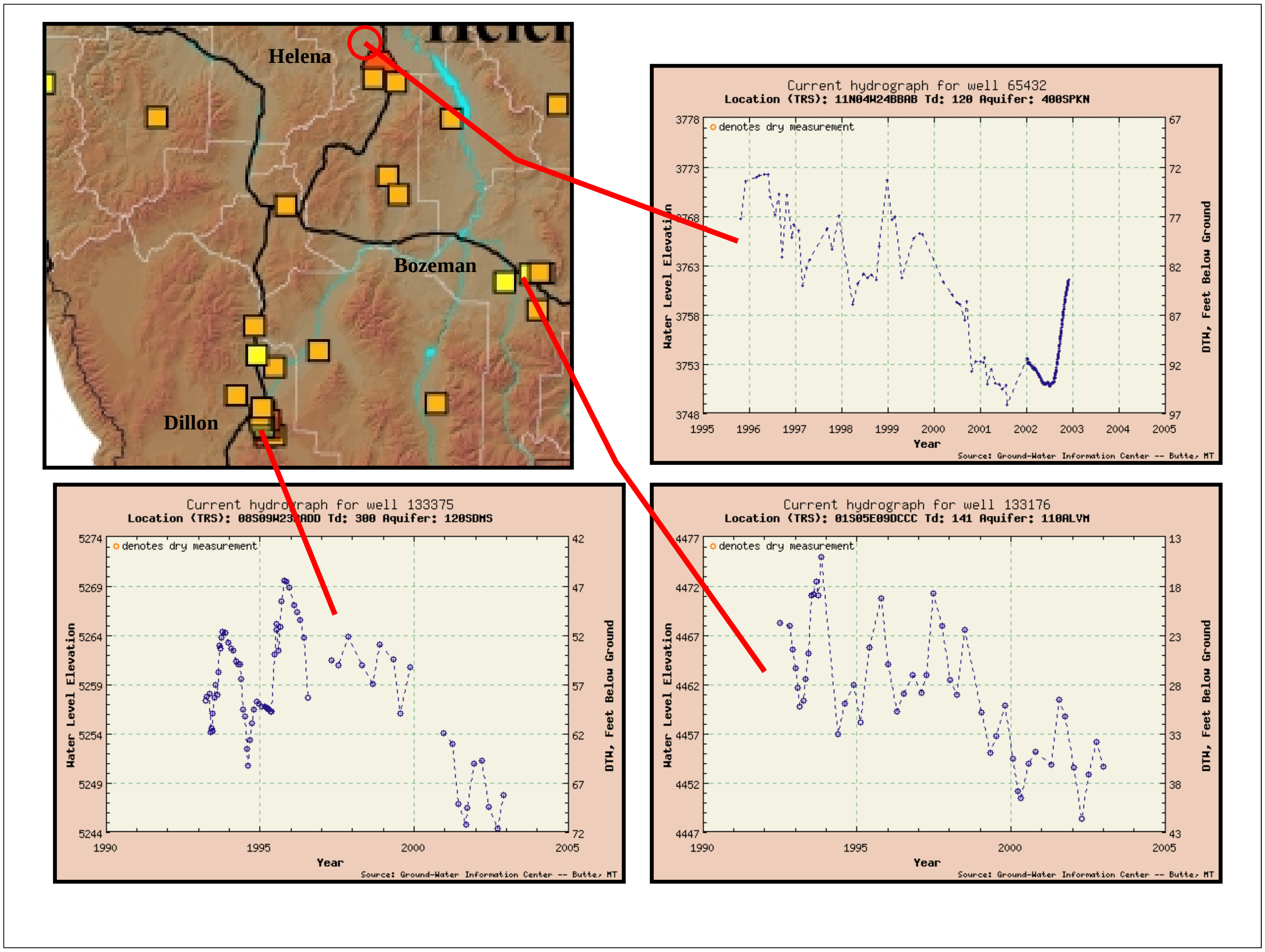
Kalispell valley: fractured bedrock



Kalispell valley: fractured bedrock

The three wells represented by the hydrographs on this page all obtain water from fractured bedrock aquifers around the perimeter of the Kalispell valley. Water levels peaked in 1997 or 1998 and have steadily fallen since. Well 81636 (upper right) is an unused 75 ft deep well located adjacent to a small stream that drains the western face of the Swan Range. Short term upward water-level movements in this well probably show recharge from snowmelt, rainfall, and stream flow in the spring and summer. The downward trend shows the impact of the recent dry years. The rate of decline decreased beginning in about 2000 and water levels have been between 50 and 60 ft below land surface for the past 2 years.

Records for wells 120810 and 80736 show that water levels were rising in 1996 toward peaks in 1997. The current water level in well 120810 has, since late 2001, fluctuated between 66 and 76 ft below land surface. Water levels in well 80736 are about 20 ft feet lower than they were in 1996 and reached a new record low in December 2002.



Water-level change: Helena, Bozeman, and Dillon

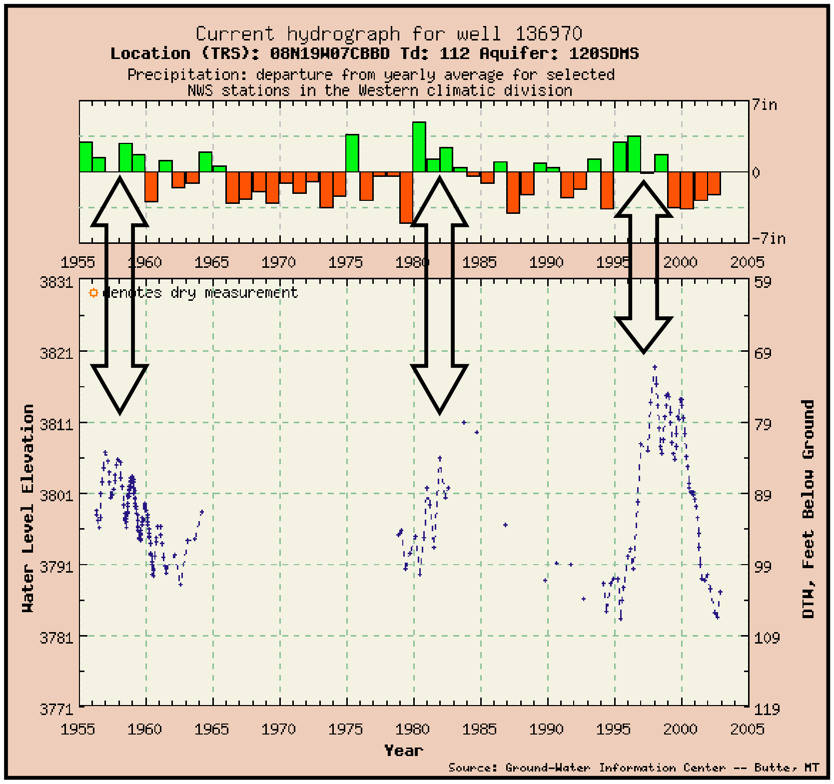
The hydrographs above illustrate water-level changes in selected wells in the Helena, Gallatin, and upper Beaverhead River valleys.

Well 65432 in the Helena Valley (current departure from fourth quarter average is -2.2 feet) is represented by a circle on the map. A water-level recorder was installed on this well in late 2001 and the almost daily measurements in 2002 overwhelm the significance of previous measurements and causes the point to not be shown on the map. Water-level measurements began in this well in 1996 near the peak of the last wet period. Water levels rose about 10 feet in this well during the last half of 2002.

Well 133176 in the Gallatin Valley is located near a subdivision where a number of wells have been deepened. Water levels began declining in late 1998 and reached a record low in early 2002. The most recent measurement is about 5 feet above the record-low water level. Average water-level altitudes in 2000-2002 are about 10 feet lower than average water-level altitudes in 1992-1998, but the rate of decline appears to have decreased during the last 2 years.

The hydrograph for well 133375 in the Blacktail Deer Creek valley south of Dillon is typical of water-level fluctuations in that area. Water levels have fluctuated about 10 feet in the last 2 years but are about 13 ft below the 1993-2000 average. The overall trend in water levels is downward. The area is heavily dependent on ground water for irrigation.

Long-term record and climate



Long-term record and climate

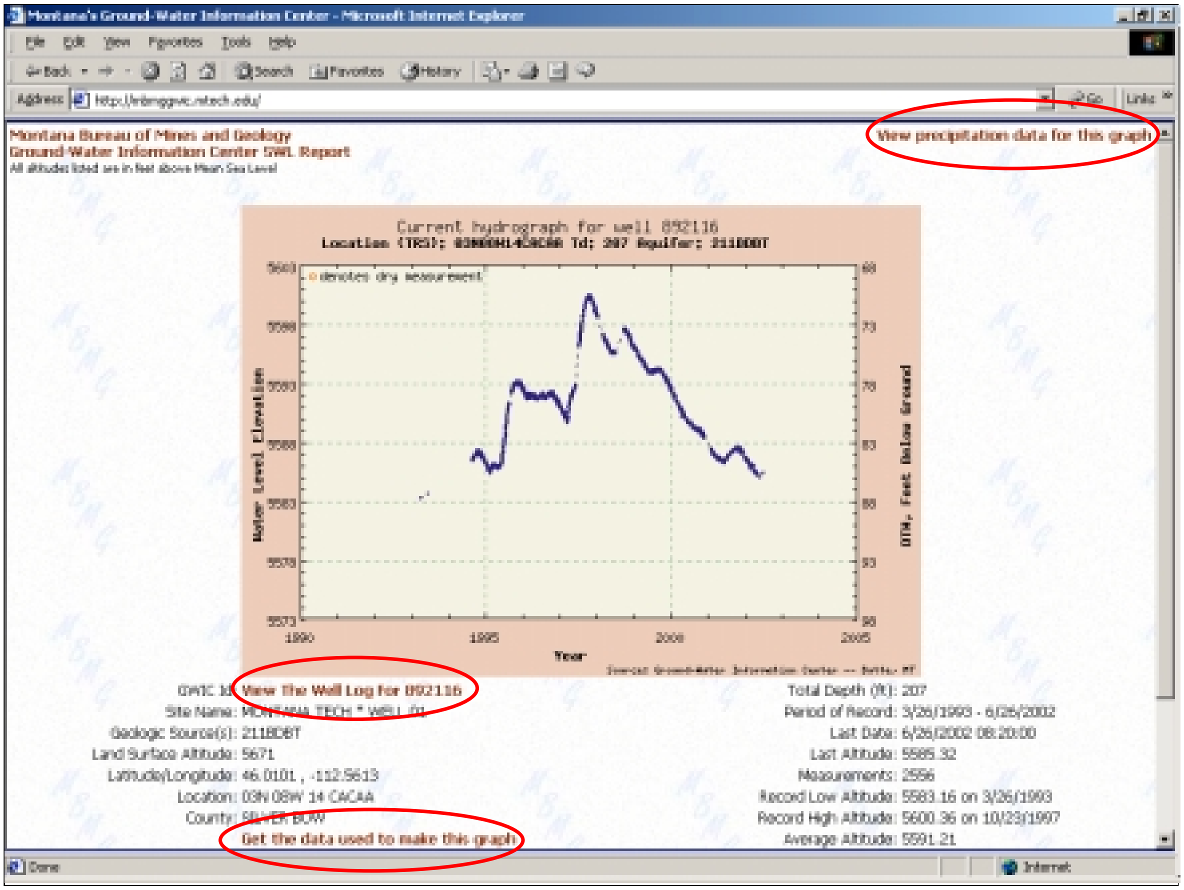
Water-level data from well 136970 in the Bitterroot valley seems to correlate well with precipitation data in the Western Montana Climatic Division. Peaks in water level have occurred in 1956, 1984, and 1997 during or shortly after periods of wetter than average annual precipitation. Current water levels are about 4 feet above the record low water level observed in 1995. Long gaps in the record for the years 1964-1978 and 1984-1994 illustrate the impact of inconsistent inclusion of the well in monitoring programs. A much stronger correlation between climate and water level could be drawn if the water-level record were more complete.

Ground-Water Information Center:

Accessing water-level information

Use your internet browser to view the the GWIC website at http://mbmggwic.mtech.edu. You can see water-level data for Ground-Water Monitoring Program statewide network wells by clicking on the hydrograph. The website will produce a map on which well locations are shown. Clicking on a well location with your computer's mouse will cause the hydrograph for that well to appear.

Water-level data for wells being measured by other projects can be viewed by logging into the database and selecting the "*SWL Menu*" tab.



Ground-Water Information Center:

On-line hydrograph

An example hydrograph is shown above. Each hydrograph is calculated at the time of the query so the image always shows that well's most current measurements.

Below the graph, additional information such as the period of record, the depth of the well, the dates and altitudes of record lows and highs are reported. At the bottom of the page is a link that produces the data used to make the graph. Those data can be downloaded to your computer.

You can also select a link to display the well log and from the well log you can link to water-quality information or to the Natural Resource Information System's *Topofinder* application. The *Topofinder* allows you to see the well's location plotted on a topographic map or on an orthophotoquad.

Another feature of the hydrograph is a link (upper right hand corner of the image) that will show precipitation data for the climatic division in which the well is located.