Montana Bureau of Mines and Geology

Ground-Water Resources of the Flathead Lake Area: Flathead, Lake, Sanders, and Missoula Counties, Montana

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January 2003

Ground water is an important resource for about 100,000 people living in the Flathead Lake area.

Introduction

As part of the Montana Ground-Water Assessment Program, the Montana Bureau of Mines and Geology (MBMG) has completed a baseline investigation to characterize the ground-water resources in the Flathead Lake area (including Flathead and Lake Counties and parts of Missoula and Sanders Counties within the Flathead Indian Reservation). The area covers about 7,800 square miles and is home to about 100,000 people. Figure 1 shows typical urban and rural development in the northern end of the Kalispell valley. All major communities (Kalispell, Evergreen, Polson, Columbia Falls, Big Fork, Ronan), with the exception of Whitefish, rely on ground water for their municipal water supplies; most rural residences rely on ground water for their domestic needs. Ground water is also an important source of irrigation water in the Kalispell, Mission, and Little Bitterroot valleys. As part of this investigation, more than 850 wells were visited to measure water levels and collect basic water-quality information. The data were used to compile a series of interpretive maps and prepare a report of the area's geology and ground-water resources. The information will help local land owners and public officials make decisions regarding ground-water development, protection, and management.

The area's landscape is characterized by a series of north-to northwest-trending mountain ranges separated by intermontane valleys. The mountains surrounding the valleys are mostly Precambrian bedrock (>1 billion year old Belt Supergroup rock); sediment filling the valleys is dominated by thick sequences of geologically young unconsolidated glacial or glacial-lake deposits, and post-glacial alluvial sediments.

Aquifers

Although the general framework of each valley in the Flathead Lake area is similar, the nature and distribution of the basin fill and the aquifers vary. The last southward advance of glacial ice terminated at Polson, and north of Polson, much of the basin fill was deposited by glaciers. The deposits include outwash (sand and gravel deposited by streams flowing from the glacier), till (unsorted clay, silt, sand, and boulders deposited directly by ice), and minor amounts of glacial-lake silt and clay. South of Polson, Glacial Lake Missoula inundated the valleys, and thick layers of gravel, silty sand, silt, and clay were deposited. The characteristics of individual beds or groups of beds within these deposits control ground-water flow. Because of differences in geology and ground-water flow, the valleys in the Flathead Lake area are addressed separately as subareas (fig. 2).

Figure 1. Urban and rural development in the northern end of the Kalispell valley is apparent in this view from the Swan Range.

There are multiple hydrogeologic units within each subarea's basin fill, or in the bedrock surrounding each subarea. Of most interest are the distribution of aquifers (water-producing materials) and confining units (non-water-producing materials). Five hydrogeologic units are common to most subareas:

1. shallow alluvium (gravel, sand, silt, and clay deposited by streams) either exposed at or near the land surface (shallow alluvial aquifers),
2. till and fine-grained glacial-lake sediments (confining units),
3. alluvium within or below the confining units (intermediate or deep alluvial aquifers),
4. Tertiary sedimentary rock (Tertiary aquifers), and
5. fractured bedrock (bedrock aquifers).

General characteristics of each hydrogeologic unit are described below and the aquifer characteristics are summarized in table 1.

Shallow alluvial aquifers are present in all major valleys. They are important sources of water locally but are generally limited in their areal extent to surficial deposits associated with modern rivers or streams and to glacial outwash. Because they are shallow and areally limited, these aquifers are often susceptible to surface sources of contamination and drought. Within the study area, about 3,400 wells have been completed in shallow aquifers; however, the rate of new development in shallow aquifers in some subareas has declined in favor of the more deeply buried aquifers.

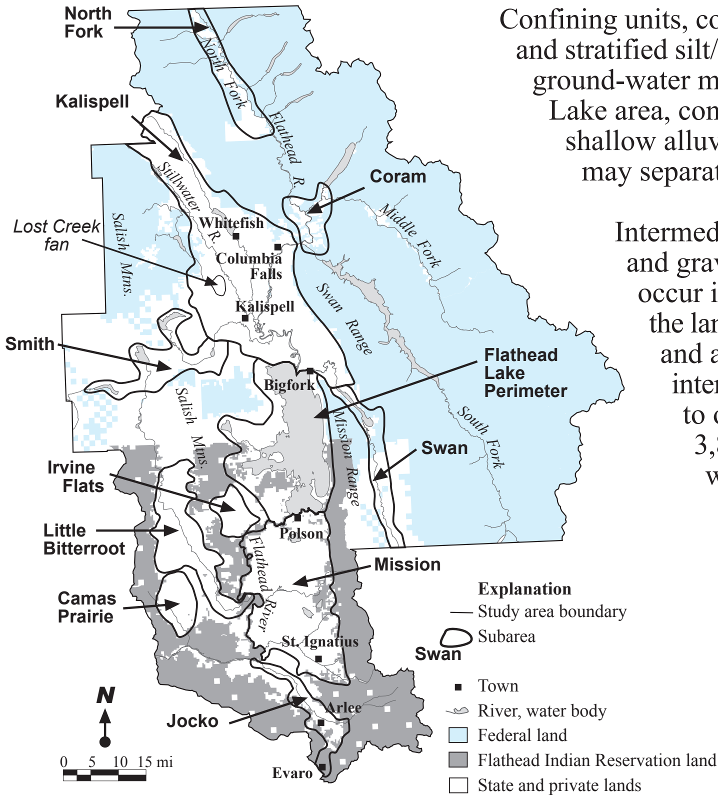


Figure 2. Division of the Flathead Lake area into subareas assists with describing the ground-water resources.

Confining units, composed mostly of gravelly silt/clay deposited by glaciers (till) and stratified silt/clay (glacial-lake deposits), have low permeability and impede ground-water movement horizontally and vertically. Throughout the Flathead Lake area, confining units may be exposed at the land surface, may separate shallow alluvial aquifers from underlying intermediate alluvial aquifers, or may separate intermediate alluvial aquifers from deep alluvial aquifers.

Intermediate alluvial aquifers, defined as distinct water-bearing sand and gravel deposits separated above and below by confining units, occur in all the subareas, generally between 50 and 100 feet below the land surface. These aquifers are local features of variable thickness and are discontinuous across large distances. In some places, intermediate aquifers interfinger with or are hydraulically connected to other intermediate aquifers or to deep alluvial aquifers. About 3,800 wells have been completed in intermediate aquifers, mostly within the Kalispell and Mission subareas.

Deep alluvial aquifers occur as areally extensive, thick deposits of sand and gravel that are generally found beneath confining units and are between 75 and 300 feet below the land surface. Deep alluvial aquifers (together with intermediate aquifers) are the most utilized aquifers in the Flathead Lake area and form the major ground-water flow system in many subareas. In the Kalispell and Mission subareas the deep alluvial aquifers are the most productive sources of ground water; most of the high-capacity irrigation and water-supply wells are among the more than 5,000 wells completed in these aquifers. In many areas the deep alluvial aquifers appear to be well protected from surficial contamination sources

Table 1. Hydrogeologic properties of aquifers in the Flathead Lake area.

Aquifer	Well Yield	Thickness and Depth	Materials	Water Quality	Important Locations
Shallow alluvial	Max: 2,000 gpm Median: 25 gpm	~50 feet thick At land surface	Sand and gravel deposits along modern stream valleys Gravelly outwash deposits from glacial meltwater	Median dissolved constituents concentration: 350 mg/L Major constituents: calcium, magnesium, and bicarbonate May be easily contaminated from surface sources	Evergreen aquifer in Kalispell subarea Mud Creek and Post Creek aquifers in Mission subarea; Flathead River alluvium below Kerr Dam in Mission subarea Jocko River alluvium in Jocko subarea
Intermediate alluvial	Max: 3,000 gpm Median: 20 gpm	5–30 feet thick 50–100 feet below land surface	Distinct sand and gravel deposits bounded above and below by till or glacial-lake deposits	Median dissolved constituents concentration: 344 mg/L Major constituents: calcium, magnesium, and bicarbonate	North and east sides of the Kalispell subarea Eastern and southern parts of the Mission subarea, southeastern part of the Jocko subarea Southeastern part of the Jocko subarea
Deep alluvial	Max: 3,500 gpm Median: 25 gpm Lonepine aquifer: Max: 1,100 gpm Median: 75 gpm	60–400 feet thick Top of aquifer: 75–300 feet below land surface	Extensive sand and gravel deposits beneath till or glacial-lake deposits (and some intermediate aquifers)	Median dissolved constituents concentration: 347 mg/L (Lonepine aquifer: 393 mg/L) Major constituents: calcium, magnesium, and bicarbonate (Lonepine aquifer: sodium and bicarbonate)	Kalispell, Little Bitterroot, and Mission subareas
Tertiary	Max:165 gpm Median: 9 gpm	Max. well depth: 852 feet Median depth: 158 feet	Sand and gravel lenses within silt and clay deposits	Dissolved constituents concentration less than 400 mg/L based on three samples Major constituents: calcium, magnesium, and bicarbonate	North Fork and Coram subareas
Bedrock	Max: 850 gpm Median:18 gpm	Max. well depth: approx. 2,000 feet Median depth: 250 feet	Fractured bedrock	Median dissolved constituents concentration: 375 mg/L Major constituents: calcium, magnesium, and bicarbonate	Bounds all subareas Locally in the Mission subarea near the Moiese and Valley View Hills Flathead Lake perimeter subarea

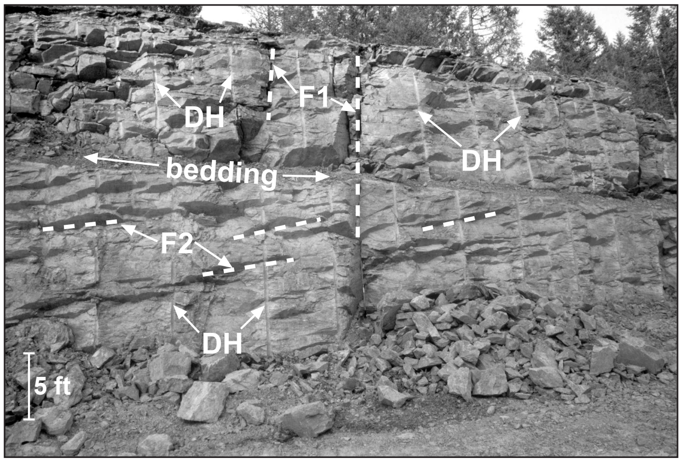


Figure 3. Belt Supergroup rock (bedrock) underlies mountains and foothills along the perimeters of the valleys, and yields water to wells through fractures and bedding planes. Two sets of fractures in this roadcut are shown by "F1" and "F2." Drill holes used to create the roadcut (denoted by DH) are analogous to water wells that intersect subsurface fractures. Location: T. 27 N., R. 21 W., sec 6.

by nearly continuous confining units of till and glacial-lake deposits. However in localized areas, such as near the Lost Creek fan northwest of Kalispell, where the protective cover may be missing, deep alluvial aquifers may be susceptible to contamination.

Aquifers in Tertiary sedimentary rock are relatively little used in the Flathead Lake area. About 120 wells have been completed in Tertiary aquifers, and more than 50 percent of these wells are located in the North Fork subarea. About 20 percent of the wells are located in the Coram subarea (fig. 2).

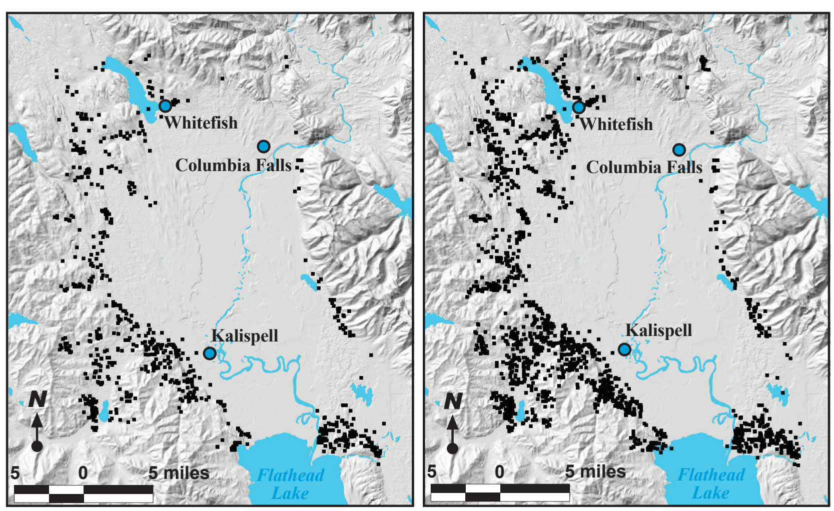
Bedrock forms the mountains that frame the valleys and also underlies the basin-fill deposits; it contains sufficient fracture permeability (fig. 3) in many places to yield water to wells. However, the permeability is variable because of the irregular distribution of fractures and their differing capabilities to transmit water. Therefore, ground-water availability in bedrock can be unpredictable; well depths and yields can vary widely across short distances. Where bedrock fractures are directly connected to the land surface, bedrock aquifers can be susceptible to surface contamination sources. The fractures can act like conduits to transport water from the land surface (including contributions from septic systems and other contamination sources) to depths where wells obtain water. About 4,300 wells have been completed in bedrock aquifers in the Flathead Lake area. Most of the bedrock wells are in the Salish Mountains, along the margins of the major valleys, and in the Flathead Lake Perimeter subarea. In the Kalispell subarea, about 50 percent of all bedrock wells (more than 1,000) have been drilled since 1985, showing the emergence of the bedrock as an important aquifer (fig. 4).

Water Quality

Flathead Lake area ground water is high quality and is generally suitable for domestic consumption, crop irrigation, and most other uses. Except for a slightly different type of water in the Lonepine aquifer of the Little Bitterroot subarea (table 1), little difference can be found between the chemical make-up of ground water from the shallow alluvial, intermediate alluvial, deep alluvial, and bedrock aquifers. The predominant ions in water from all the aquifers (with the exception of the Lonepine) are calcium and bicarbonate. The ground water is characterized by dissolved constituents of less than 500 milligrams per liter (mg/L).

Excessive nitrate concentrations in drinking water can be toxic to infants. In ground water, elevated nitrate concentrations can indicate contamination from sewage effluent or leaching of fertilizers. Nitrate concentrations in ground water of the Flathead Lake area are generally low; none of the 158 samples collected for this study (1993–1997) exceeded the 10-mg/L nitrate-N limit established by the U.S. Environmental Protection Agency as the maximum contaminant level for public drinking water supplies. In some local areas, however, nitrate concentrations that are elevated over background levels were detected that might suggest a surface source of contamination. One such area is northwest of Kalispell in the Lost Creek fan, a relatively thick accumulation of glacial outwash, where confining units of till and glacial lake deposits may be locally absent and the deep alluvial aquifer may be vulnerable to surface contamination.

Radon in household air has been linked to lung cancer and a minor source of the gas can be well water. The U.S. Environmental Protection Agency estimates that <2 percent of radon in household air comes from radon in water. Ground water samples from 62 wells were analyzed for this naturally occurring radioactive gas. Radon concentrations in 57 of the samples (92 percent) were above the provisional U.S. Environmental Protection Agency maximum contaminant level of 300 picoCuries per liter (pCi/L) proposed in 1999.



1985 — 770 bedrock wells

2001 — 1,800 bedrock wells

Figure 4. Since 1985, more than 1,000 wells have been completed in bedrock around the perimeter of the Kalispell subarea. Most wells are related to new residential development in mountainous areas.

The median radon concentration in water samples obtained from bedrock aquifers was 1,420 pCi/L. The median concentration in samples from shallow alluvial, intermediate alluvial, and deep alluvial aquifers was 655 pCi/L.

Water Levels

Water-level data from wells in the Flathead Lake area typically show annual fluctuations that range from 1 to more than 20 feet. Analysis of hydrographs shows that annual water-level fluctuations generally fall into three patterns (fig. 5):

1. *Runoff response* in which water levels generally are highest in the spring, decline during the summer and fall months, and reach lowest levels in winter when recharge is negligible. Many wells completed in shallow alluvial aquifers throughout the Flathead Lake area display this type of response.

2. *Pumping response* in which water levels drop sharply during the summer, reach seasonal lows in the late summer, and recover during the fall and winter months. Water levels in wells completed in the deep alluvial aquifers in the Kalispell, Mission, and Little Bitterroot subareas near ground-water-supported irrigation areas display this response.

3. *Irrigation response* in which water levels peak in the late spring and early summer, remain elevated during the summer months while irrigation is ongoing, and fall after irrigation ceases. This response is common in shallow alluvial aquifers near irrigation canals in the Mission and Jocko subareas.

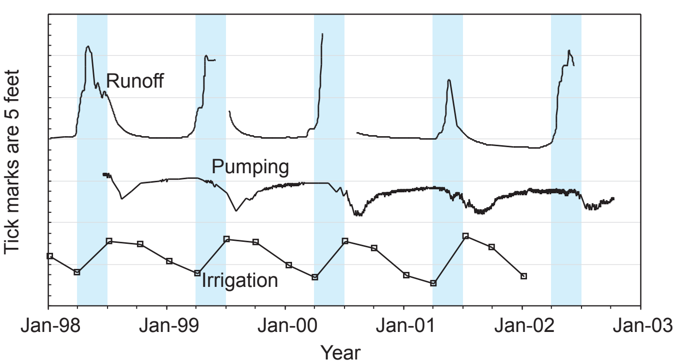


Figure 5. Water levels in wells typically respond to seasonal runoff, nearby pumping, or irrigation in the Flathead Lake area. Vertical shaded bars highlight the April–June quarter of each year when stream flow and precipitation are highest.

Historic water-level data from the deep alluvial aquifer in the Kalispell subarea show that annual water-level fluctuations changed from a *runoff* to a *pumping* pattern (both the timing and amount of water-level fluctuation changed) between 1970 and 1979. The new pattern coincides with an increased number of irrigation wells completed in the aquifer.

Water levels in wells completed in many aquifers, but especially bedrock aquifers, rose significantly in response to the above-average precipitation in 1996–1998. Locally, many years of downward decline were reversed with water levels rising more than 30 feet in less than a year. Since 1998 however, water levels in the same wells have declined steadily. Large fluctuations in bedrock wells result from the relatively low volume of water actually stored in fractured bedrock aquifers (fig. 6).

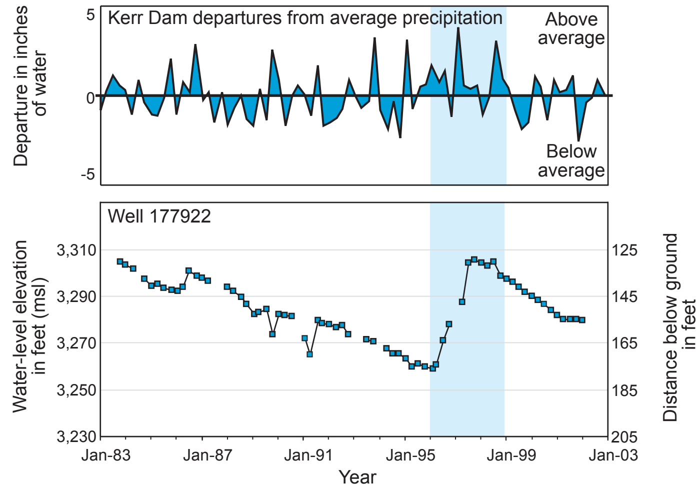


Figure 6. Records from a well completed in fractured bedrock (well 77922–total depth 300 feet) demonstrate water-level changes during a period of above normal precipitation (1996–1998), vertical shaded bar highlights the wet period.

Long-Term Monitoring Continues

Water levels in the Flathead Lake area continue to be monitored in a network of about 90 wells maintained by MBMG's Ground-Water Monitoring Program and the Confederated Salish and Kootenai Tribes; updated hydrographs and data from these wells can be viewed at the Ground-Water Information Center web site (http://mbmggwic.mtech.edu).

Information Products

A comprehensive atlas describing the ground-water resources in the Flathead Lake area is available from the Montana Bureau of Mines and Geology. The atlas consists of two parts; Part A (Ground-Water Assessment Atlas No. 2, "Ground-Water Resources of the Flathead Lake Area: Flathead, Lake, Sanders, and Missoula Counties, Montana" by John I. LaFave, Larry N. Smith, and Thomas W. Patton) is a descriptive overview; Part B contains 11 maps that offer expanded discussions of the hydrogeology.

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