Montana Bureau of Mines and Geology
Hydrogeologic Map11

Principal Aquifers of Montana

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HYDROGEOLOGIC FRAMEWORK DATABASE DERIVED FROM GEOLOGY

The principal aquifers in Montana are geologic units, or groupings of geologic units, that have similar water-bearing characteristics (fig. 1). The aquifer types are closely tied to the geology of the State's two prominent physiographic regions: (1) the intermontane basins of the northern Rocky Mountains, and (2) the northern Great Plains (fig. 2). Each physiographic province represents broad differences in geology, geologic history, and climate, which in turn create different hydrogeologic settings. The Rocky Mountain region is characterized by a series of north–south-trending mountains separated by valleys, while the Great Plains region is characterized by a broad expanse of low-relief landscapes with some isolated mountain ranges. Continental glaciation in north-central and northeastern Montana created a few buried channel aquifers and deposited a thin layer of glacial sediments over the Tertiary and Cretaceous rocks (fig. 2).

Groundwater moves from areas of recharge to areas of discharge in response to hydrostatic forces. Recharge comes from precipitation and/or through interaction with surface-water bodies. In the snowmelt-dominated intermontane basins of western Montana, groundwater recharge mechanisms include: (1) direct infiltration of precipitation and snow melt (diffuse); (2) loss from ephemeral or perennial streams, especially along mountain fronts/blocks (focused); and (3) percolation of excess irrigation water below canals and fields (irrigation). The extensive sedimentary aquifers in eastern Montana are recharged by diffuse infiltration of precipitation in outcrop areas and by focused recharge through streambeds. Groundwater discharge is the loss of water from an aquifer to surface water, atmosphere, or wells. The residence times between recharge and discharge areas can range from days in shallow alluvial aquifers, to tens of thousands of years in deep bedrock aquifers.

Within the Rocky Mountain intermontane basins, groundwater occurs in shallow unconfined alluvial aquifers as well as in deeper confined to semi-confined aquifers buried at depth within several thousand feet of Quaternary and Tertiary basin-fill sediments (QTbf, fig. 1). These aquifers contain large amounts of groundwater, are highly productive, and are heavily used. The western basins are bounded by mountains composed of meta-sedimentary rocks (e.g., Belt Supergroup and Precambrian gneiss and schist), intrusive rocks [e.g., Idaho and Boulder batholiths (p_fb)], and volcanic rocks [e.g., Lowland Creek and Elkhorn Mountain Volcanics (TKig)] that host less productive fractured-rock aquifers. Tertiary sandstones and siltstones (e.g., Renova and Six Mile Creek Formations) crop out locally near basin margins and can be productive aquifers (Ts). Figure 3a is a cross section that illustrates the relationship between the basin-fill and fractured-rock aquifers in western Montana.

In the northern Great Plains of central and eastern Montana, principal aquifers occur in layers of Tertiary and Cretaceous sedimentary sandstone, Mississippian limestone, and Quaternary and Tertiary alluvium. The Quaternary and Tertiary deposits are grouped as "alluvial" aquifers (QTal). Most of these aquifers are in the major river valleys, localized gravel terraces or "benches," and in buried stream channels. The alluvial aquifers are thin (generally less than 100 ft) and unconfined, with a few exceptions such as the buried channel gravels in northeastern Montana (the Clear Lake aquifer). The sedimentary bedrock aquifers underlie large parts of central and eastern Montana; although these aquifers are not as productive as the alluvial aquifers, they are heavily utilized. The Tertiary Fort Union Formation (Tfu) and the Hell Creek and Fox Hills Formations of late Cretaceous age (Kfhhc) underlie large parts of eastern Montana. Beneath the Fox Hills Sandstone is a thick shale layer (Bearpaw/Pierre—Kshale) that serves as a regional confining layer. Beneath the Bearpaw Shale is the upper Cretaceous Judith River Formation (Kjr), whose sandstone layers produce water to wells, mostly in north-central Montana. The Claggett Shale (Kshale) separates the Judith River Formation from the upper Cretaceous Eagle Sandstone (Kegle), which is an important aquifer in central Montana from the flanks of the Pryor Mountains to the Big Snowy Mountains to the Sweet Grass Hills. The upper Cretaceous Colorado Group of shale units (Kshale) underlies the Eagle Sandstone. In much of north-central Montana, the Colorado Group is at the surface and is as much as 2,000 feet thick, making groundwater scarce. In some areas, local sandstones within the shale may produce water to wells; however, water quantity and quality are generally poor. The lower Cretaceous Kootenai Formation (Kkton) occurs below the Colorado Group. The Kootenai is an important aquifer in central Montana. In the Judith Basin and near the mountains, the Kootenai is artesian, but unchecked flowing wells have decreased the artesian pressure. The Mississippian Madison Limestone (Mmdsn) is the lowermost aquifer in eastern and central Montana. The Madison Limestone is exposed along the flanks of mountain ranges, and near the mountains dips steeply into the subsurface. It is most utilized in the Great Falls and Lewistown areas. There are other sandstone and limestone units that produce water in areas where they outcrop or are close to the surface; for the purposes of this map, these units are grouped together as Mesozoic–Paleozoic sedimentary rocks (MPsed). A schematic cross section of the Plains region's major sandstone and limestone aquifers and Cretaceous shales is shown in figure 3b.

REFERENCES

Vuke, S.M., Porter, K.W., Lonn, J.D., and Lopez, D.A., 2007, Geologic Map of Montana, Montana Bureau of Mines and Geology Geologic Map 62-A, 73 p., 2 sheets, scale 1:500,000.

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*Revised to separate Livingston Group aquifer from the Eagle Aquifer in the Livingston Area

Table 1. Major aquifer and confining units.

Era	Period	Unit Symbol	Unit Name	Occurence and Description of Map Units
CENOZOIC	Quaternary Tertiary	QTbf	Cenozoic basin-fill aquifers	Western Montana intermontane basins. Alluvial and basin-fill deposits: unconsolidated sand, gravel, silt, and clay. Unconfined surficial aquifers with semi-confined to confined aquifers in deep basin-fill.
		QTal	Cenozoic alluvial, terrace, and glacial aquifers	Eastern Montana river valleys and terraces. Unconsolidated sand and gravel, silt and clay. Generally less than 50 feet thick, unconfined.
		Ts	Tertiary consolidated sedimentary rock aquifer	Western Montana. Consolidated sandstone, siltstone, and mudstone. Includes the Renova and Sixmile Creek Formations.
		Tfu	Tertiary Fort Union aquifer	Eastern Montana. Includes Wasatch and Arikaree Formations. Moderately consolidated and interbedded shale, siltstone, sandstone, and coal. Unconfined to confined.
		TKig	Tertiary and Cretaceous igneous fractured-rock aquifers	Southwestern Montana and Bears Paw and Little Rocky Mountains. Includes the intrusive rocks of the Boulder and Idaho Batholiths and the extrusive rocks of the Lowland Creek Volcanics, Huckleberry Ridge Volcanics, Absaroka Volcanics, Adel Mountain Volcanics, Sliderock Volcanics, and Lava Creek Volcanics. Characterized by fracture flow, unconfined near outcrop areas, confined at depth.
MESOZOIC	Cretaceous	Kfhhc	Cretaceous Fox Hills–Hell Creek aquifer	Eastern Montana. Includes Lance Formation. Sandstone with some siltstone and shale. Confined except near outcrop areas.
		Klvgs	Cretaceous Livingston aquifer	Central Montana. Volcanoclastic conglomerate sandstone, volcanic flows, breccia, tuff, mudstone, and siltstone. Includes the Hoppers, Billman Creek, Miner Creek, Cokedale, Maudlow, and Sedan Formations.
		Kshale	Cretaceous Bearpaw/Pierre shale confining unit	Eastern Montana. Dark gray fissle shale, thin sandstone beds near the top. Confining unit.
		Kjr	Cretaceous Judith River aquifer	North-central Montana. Sandy shale, sandstone, mudstone, and coal. Confined except near outcrop areas.
		Kshale	Cretaceous Claggett Shale confining unit	Central Montana. Brownish gray fissle shale with minor clayey sandstone. Confining unit.
		Kegle	Cretaceous Eagle aquifer	Central and south-central Montana. Includes basal Virgelle Sandstone Member and the Telegraph Creek Formation. Sandstone, siltstone, and shale. Confined except near outcrop areas.
		Kshale	Cretaceous Colorado Group shale confining unit	Central Montana. Includes equivalents of Marias River, Blackleaf, and Niobrara formations. Confining unit. Dark-gray shale and siltstone.
		Kkotn	Cretaceous Kootenai aquifer	Central Montana in foothills and mountain ranges. Includes Second and Third Cat Creek sands, Sunburst and Cut Bank sands. Sandstone, siltstone, and shale. Confined except near outcrop areas.
	Jurassic Triassic	MPsed	Jurassic through Pennsylvanian consolidated sedimentary-rock aquifers	Central Montana in foothills and mountain ranges. Includes the Morrison Formation, Ellis Group, and theTensleep, Amsden, and Alaska Bench Formations. Sandstone, siltstone, limestone, and conglomerates. Confined except near outcrop areas.
PALEOZOIC	Permian Pennsylvanian			
	Mississippian	Mmdsn	Mississippian Madison aquifer	Central Montana in foothills and mountain ranges. Limestone, dolomite, anhydrite, and halite. Includes Mission Canyon and Lodgepole Formations. Areas of karst formation and fracture flow. Confined except near outcrop areas.
	Devonian Silurian Ordovician Cambrian	Pzl	Lower Paleozoic Aquifer	Mostly central Montana. Includes the Jefferson, Three Forks, Bighorn, Flathead, Pilgrim, Snowy Range, Wolsey, and Shedhorn Formations. Variable sandstone, limestone, and dolomite. Sometimes utilized as an aquifer where present in outcrop.
PRECAMBRIAN	Proterozoic Archean	pCfb	Precambrian fractured-rock aquifers	Western Montana. Includes meta-sediments of the Belt Supergroup and Precambrian gneiss and schist in the Absaroka and Beartooth Mountains. Characterized by fracture flow, unconfined near outcrop areas, confined at depth.

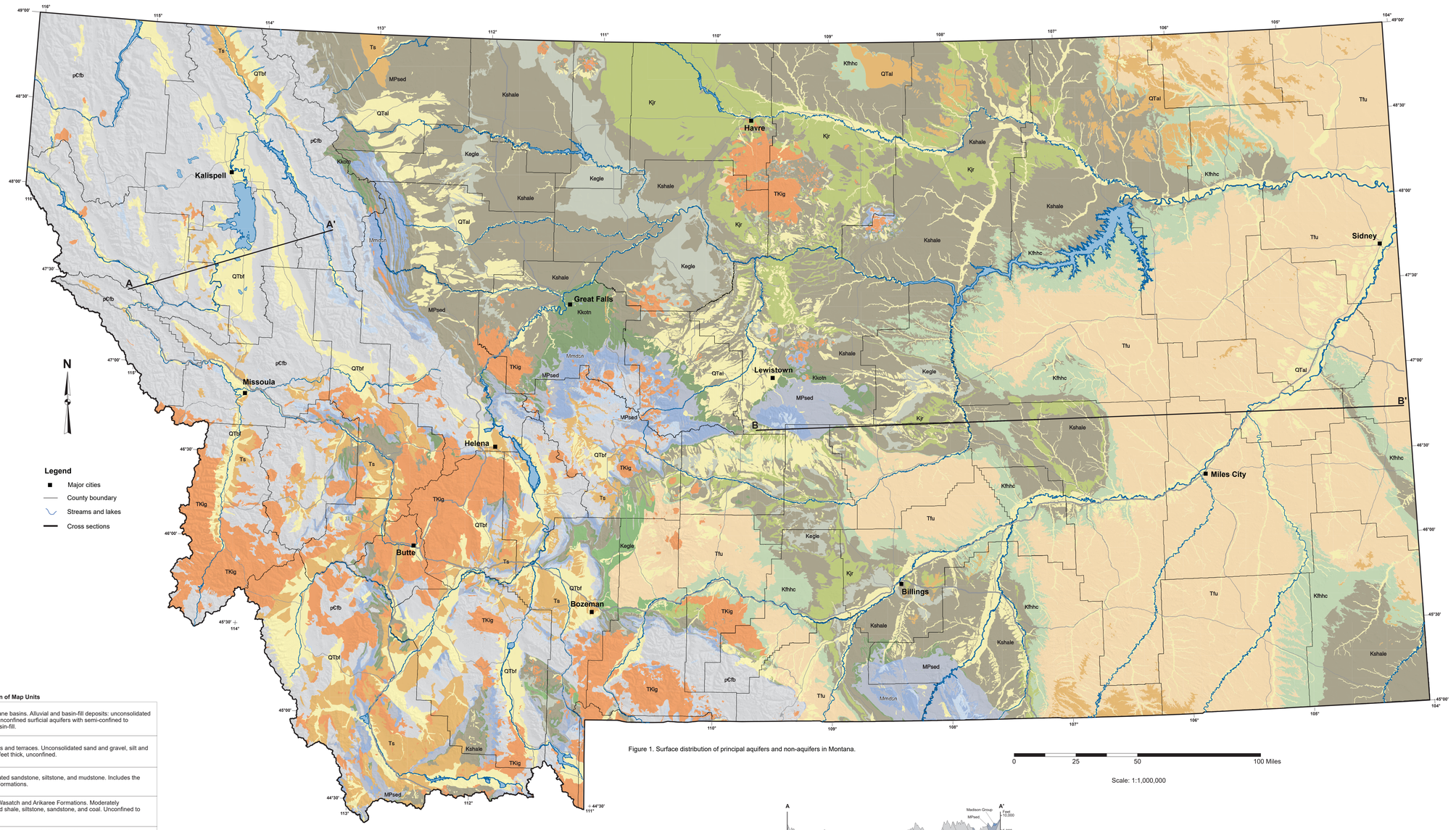
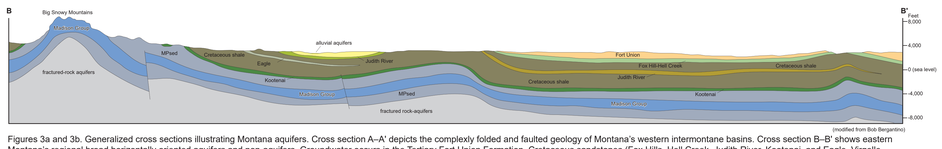


Figure 1. Surface distribution of principal aquifers and non-aquifers in Montana.



Figures 3a and 3b. Generalized cross sections illustrating Montana aquifers. Cross section A–A' depicts the complexly folded and faulted geology of Montana's western intermontane basins. Cross section B–B' shows eastern Montana's regional broad horizontally oriented aquifers and non-aquifers. Groundwater occurs in the Tertiary Fort Union Formation, Cretaceous sandstones (Fox Hills–Hell Creek, Judith River, Kootenai, and Eagle–Virgelle formations), and the Mississippian Madison Group.

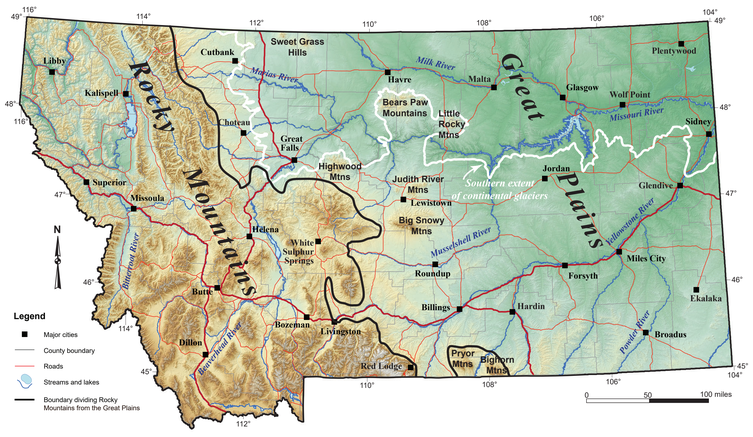


Figure 2. Index map showing major cities and rivers, county boundaries, southern extent of continental glaciation, and the boundary between the Rocky Mountains and the Great Plains.

Giant Springs issuing from the Kooteani Formation near Great Falls.
Photo by Thomas Patton, MBMG.

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