

# Plate 2. Lithostratigraphic and Hydrogeologic Units of the Gallatin Local Water Quality District, Gallatin County, Montana.

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March 2002

Modified from: Hackett et al., 1960; Roberts, 1963; Groff, 1965; Balster, 1971; Kuenzi and Fields, 1971; Skipp and McManis, 1971; Roberts, 1972; Montagne, 1976; Skipp and McGrew, 1977; Aram, 1979; Bonnet, 1979; Balster, 1980; Hughes, 1980; Levings et al., 1981; Chadwick, 1982; Smith and Welker, 1982; Smith, 1983; Moore, 1984; Lambing et al., 1987; Custer et al., 1991; Hiza, 1994; Dyman et al., 1995; Vuke et al., 1995; Kandy and Tresch, 1996; Skipp et al., 1999.

Eratem System	Series	Unit Name	Map Symbol	MBMG Geologic Source Codes	Unit Thickness (meters)	Lithology	Lithologic Description	Hydrogeologic Units	Water-yielding characteristics	Transmissivity Data																		
										Number of Observations	Measurement units	Geometric Mean	Geometric Median	Geometric Mode	Geometric Mean ± 1 Standard Deviation	Geometric Mean ± 1 Standard Error												
Cenozoic	Quaternary	West Gallatin River Alluvium	Qwgal	110ALVM	0-100 (0-300 ft)		Unconsolidated gravel deposits interbedded with lenses and some beds of sand, silt, and clay deposited by the West Gallatin River.	West Gallatin Alluvial Aquifer	Yields excellent to good expected to be ample for municipal, commercial, irrigation, domestic, and stock uses.	501	m <sup>2</sup> /day	17	14	11	5.6-52	16-17												
		Small Stream and Fan Alluvium	Qssf	110ALVM 110ALVF			Mixture of unconsolidated lenticular gravel, sand, silt, and clay deposited by streams smaller than the West Gallatin River.	Small Stream and Fan Aquifer	Yields generally good to fair, water supplies for light irrigation, industrial use as well as domestic and		515	m <sup>2</sup> /day	8.5	8.0	8.0	3.4-22	8.2-8.9											
	Tertiary	Pliocene	Old Alluvium: Fan, pediment, stream deposits	QTbf	120SDMS 120UFD	0-100 (0-300 ft)		Similar to small stream and fan alluvium, but in high landscape position well above other alluvial deposits and sometimes more coarse grained.	Quaternary-Tertiary Basin Fill Aquifer	Variable, generally fair to good, water supplies expected to be good for light irrigation, domestic and stock use.	98	m <sup>2</sup> /day	3.4	3.9	4.0	0.75-16	2.9-4.0											
			Bozeman Group (includes Sixmile Creek, Madison Valley Formation, and Renova Formation)			0-1525 (0-5000ft)		Sixmile Creek and Madison Valley Fm: Lenticular pebble conglomerate, arkose, and cross-bedded sandstone surrounded by mudstone and siltstone. Locally volcanic ash beds. Some fine-grained ostracode-bearing limestone; less lenticular (more extensive) beds to the west.		Generally fair to good, in channel gravels and sandstones, less so in silty and muddy units.		gpd/ft	2.70	3.10	3.20	60-1300	230-320											
		Eocene	Gallatin-Absaroka Volcanics			Tv	124VLCC	0-2745 (0-9000ft)		Light to dark grayish brown andesite and basalt flows, flow breccia, debris flow deposits, and tuff.	Volcanic Aquitard*	Not an aquifer, except where jointed and fractured	No Data															
	unamed gravels, sands, and siltstone			0-1.7 (0-50ft)	Loosely consolidated conglomerate of Precambrian rock and Paleozoic and Mesozoic sedimentary rock. Matrix is poorly sorted sand and silt derived from similar rocks.																							
	Paleocene	Fort Union Formation	KThf	125FRUN	0-185 (0-600ft)		Massive to thin-bedded, fine to coarse grained, slightly calcareous, andesitic greenish-gray sandstone, and massive olive-gray mudstone. Lower Conglomeratic Sandstone-massive to thin-bedded, cross-bedded fine-grained to conglomeratic andesitic yellow green sandstone with interbedded siltstone and claystone. Pebbles of volcanic rock, quartzite, gneiss and limestone.	Hoppers-Fort Union Aquifer*	Fort Union: Variable, but generally good, conglomerates and sandstones especially where not cemented should be good water yielding units.	8	m <sup>2</sup> /day	0.94	0.88	19	0.07-13	0.37-2.4												
							Massive to thin-bedded, cross-bedded, poorly sorted andesitic yellow-green sandstone with interbedded claystone and siltstone. Locally conglomeratic. Contains fresh-water mollusks and wood and plant fragments.		Hoppers: Generally good where adequate thickness, possible poor zones are intermittent claystones and siltstones.		gpd/ft	75	71	1500	5.4 - 1100	30 - 190												
	Mesozoic	Cretaceous	Montana Group	Livingston Group	Kbc	211BMCK	765-915 (2500-3000ft)		Sedan Formation: Olive gray to brownish gray volcaniclastic sandstones, mudstones, and minor ash-flow tuffs. Formation consists of five members: Lennep Sandstone Mbr., Mudstone Mbr., Middle Sandstone Mbr., Ash-Flow Mbr., Lower Sandstone.	Billman Creek Aquitard*	Used as a local aquifer, but water quantity and quality is poor to very poor throughout unit.	3	m <sup>2</sup> /day	1.7	0.92	N/A	0.07-41	0.27 - 11										
													Hoppers Formation	211HPRS	460-735 (1500-2400ft)	Massive to thin-bedded, cross-bedded, poorly sorted andesitic yellow-green sandstone with interbedded claystone and siltstone. Locally conglomeratic. Contains fresh-water mollusks and wood and plant fragments.	gpd/ft	75	71	1500	5.4 - 1100	30 - 190						
													Miner Creek Formation	211MRCK 211SLPF (Sulphur Flats)	0-915 (0-3000ft)	Miner Creek: massive tuffaceous olive-gray siltstone with interbedded fine-grained andesitic sandstone. Contains petrified wood, leaf impressions, spores, and small plant fragments. Flats Sandstone: massive cross-bedded poorly sorted grayish green andesitic sandstone with interbedded tuff and bentonite.	Sedan: Variable from poor to good, the sandstone members have the greatest potential for good water yield while the mudstone and Ash-flow tuff members should have the poorest water yield.	m <sup>2</sup> /day	4.7	1.8	N/A	0.27 - 81	1.1 - 20					
													Cokedale Formation	211CKDL	0-185 (0-600ft)	Cokedale Formation: Massive to thin-bedded poorly sorted andesitic olive-gray siltstone and sandstone with interbedded conglomerate, claystone, and tuff. Thin beds of bentonite and lignite in lower part of formation. Contains petrified wood, leaf impressions, spores, fresh water mollusks, and dinosaur bones.	Miner Creek: Variable from poor to good, in the Sulphur Flats mbr. of the Miner Creek Fm.	gpd/ft	380	150	N/A	22-6500	90-1600					
													Eagle Sandstone	211EGLE	0-185 (0-600ft)	Light gray, thin to thick bedded, locally cross-bedded, fine to medium grained, white and black chert bearing sandstone with some intercalated carbonaceous shale and coal beds.	Telegraph Creek-Eagle Aquifer*	No Data										
			Colorado Group	Cody Shale	Kc	211CODY	15-185 (50-600ft)		Upper Shale mbr.	Medium to dark gray and brown thin bedded shale with some beds of siltstone and sandstone, especially in middle part. Locally fossiliferous.	Cody Aquitard*	Not an aquifer, shales nearly impermeable	No Data															
									Eldridge Creek mbr.					Frontier Formation	211FRNR	15-70 (50-200ft)	Buff to medium gray, thin to medium bedded, fine to coarse grained arkosic sandstone, locally silty.	Frontier Aquifer*	Possible aquifer, sandstones may yield water.	6	7.1 m <sup>2</sup> /day 570 gpd/ft							
Lower Shale mbr.									Mowry Shale						217MWRY	10-125 (30-400ft)	Grayish-brown and green shale and siltstone with some sandstone beds. Locally carbonaceous.	Thermopolis-Mowry Aquitard* (basal water)	Not an aquifer, shales nearly impermeable. Locally lower sandstone of Thermopolis may contain water as may local sandbeds in Mowry.	2	m <sup>2</sup> /day	0.2	0.2	N/A	0.045 - 1	0.07-0.63		
Muddy Sandstone mbr.															217MDDY	15-120 (50-380ft)	Medium gray to black shale with numerous fine to medium grained arkosic sandstone beds. Locally arkosic, glauconitic, or carbonaceous. Lower resistant siliceous cemented quartz sandstone.				gpd/ft	17	17	N/A	3.6 - 80	5.7 - 52		
Shale mbr.															217TMPL	15-120 (50-380ft)	Upper interbedded fine-grained gastropod-bearing limestone interbedded with red or black mudstone. Middle red mudstone with interbedded buff to white chert bearing sandstone. Lower chert pebble conglomerate interbedded with sandstone and red mudstone locally absent.				Kootenai Aquifer*	Upper portion of formation not considered an aquifer. Lower portion of unit is a potential aquifer, sandstone and conglomerate units may be good water yielding units where not cemented.	No Data					
Elliots Group			Swift Formation	Ju	221SWFT	30 (100ft)		Upper carbonaceous shale, variegated red, locally green, thin to thick bedded mudstone and siltstone with intercalated yellowish-brown calcareous siltstone and sandstone often in lenses. May contain dinosaur bones.	Jurassic Aquitard*	Not an aquifer, locally Swift Formation may contain small amounts of water.	No Data																	
								Rierdon Formation				221RRDN	60 (200ft)	Yellowish-brown, medium bedded, fine-grained, calcareous, glauconitic, sandstone. Local basal chert conglomerate.	Upper Mississippian-Permian Aquitard*	Potential aquifer, sandstone beds may yield water. In the Phosphoria Formation only the sandy Shedhorn is known to exist in area. Quadrant may be a potential aquifer if the sandstones are not cemented.	No Data											
								Piper Formation				221PIPR	(200ft)	Upper calcareous mudstone and thin-bedded fine limestone, lower resistant oolitic limestones.				Mission Canyon Aquifer*	Potential aquifer if solution channels are extensive.	No Data								
								Phosphoria Formation				310PSPR	0-10 (0-30ft)	Pale yellowish-brown, carbonate or chert cemented sandstone, may locally contain chert and chert-cemented breccias in Southern Gallatin County near base of formation.							Cambrian, Devonian, and Lower Mississippian Aquitard*	Jefferson may contain water, but because of its high hydrocarbon content it is expected to produce poor quality water.	No Data					
								Quadrant Formation				320QDRN	40-80 (130-250ft)	White to pinkish-gray, medium to thick-bedded (locally cross-bedded), subrounded, fine to medium-grained silica or carbonate cemented quartz sandstone; and a lower dolostone.														
Paleozoic	Mississippian	Madison Group	Mmm	337MSNC	130-290 (430-950ft)		Upper dark-gray to black, cherty, fossiliferous shale and limestone. Middle, pink-bluff, platy to massive-bedded sandstone and siltstone. Lower pink to buff dolomite and siltstone.	Upper Mississippian-Permian Aquitard*	Generally not considered an aquifer. Lower dolomite may contain water of poor quality.	No Data																		
							Big Snowy Group				331BGSN	0-80 (0-250ft)	Light gray, massive or poorly bedded, resistant fossiliferous limestone with solution breccias at top. Locally contains chert nodules.	Mission Canyon Aquifer*	Lacks the collapse breccia and evaporite zones where solution channels could develop, probably not an aquifer.	No Data												
							Mission Canyon Limestone (includes Charles Formation, collapse breccia)				337LDGP	185-250 (600-810ft)	Dark gray thin to medium-bedded fossiliferous, limestone. Lower medium to dark gray, thin-bedded, sparsely fossiliferous limestone with occasional chert nodules. Black shale at the base.				Cambrian, Devonian, and Lower Mississippian Aquitard*	No Data										
							Lodgepole Limestone				337TRFK	30-50 (100-150ft)	Upper gray, thin-bedded silty yellow limestone. Middle buff, medium to thick bedded, brecciated limestone. Basal, red-orange limonite-nodule shale, and siltstone.						No Data									
							Three Forks Formation				341JFRS	120-190 (400-620ft)	Light and dark-brown, medium to thick-bedded, fine to medium-grained, dolostone and limestone. Often petrifoliferous and containing stromatoporoids and amphipora. Locally contains chert nodules.															
	Devonian	Maywood Formation	CDIM	344MYWD	10-30 (40-90ft)		Red, yellow or brown, thin-bedded calcareous siltstone with some dolomite, trilobite-brachiopod fossil hash in lower part	Cambrian, Devonian, and Lower Mississippian Aquitard*	No Data	No Data																		
							Yellow-brown to olive, thin to medium bedded, fine to coarse grained, commonly glauconitic and fossiliferous limestone and limestone pebble conglomerate with columns, magna beds at base.				No Data																	
							Gray-green shale with intercalated pale-orange to buff calcareous siltstone and sandstone.					No Data																
							Dark and light-gray mottled, medium-thick bedded, ledge-forming, oolitic limestone.						No Data															
							Gray to yellow-brown, thin to medium-bedded limestone with limestone-pebble conglomerate and interbedded green shale. Gray, limestone-pebble conglomeratic massive oolitic, limestone.							No Data														
	Cambrian	Park Shale	374PARK	30-60 (100-200ft)		Gray-green and maroon shale with interbedded brown very fine grained quartz sandstone, arkosic limestone and arkosic conglomerate.	Cambrian, Devonian, and Lower Mississippian Aquitard*	No Data	No Data																			
						Light to dark-gray, thin-bedded, fine-grained, trilobite and brachiopod bearing mottled limestone with some interbedded green shale. Dark gray massive resistant limestone. Gray, thin-bedded, fine-grained, limestone with interbedded green shale. Blue and gold mottled.				No Data																		
						Green and maroon, micaceous shale with interbedded micaceous sandstone and siltstone. Locally contains glauconitic, arkosic limestone.					No Data																	
						White, buff, and orange, thin- to medium-bedded, fine- to coarse-grained quartz sandstone. Locally highly feldspathic, glauconitic beds and conglomerate.						No Data																
						Dark grayish-green, coarse- to very coarse-grained, poorly bedded arkose and conglomeratic arkose. Interbedded dark-gray argillite and siliceous limestone beds in northern part of area. Thickens to the north.							No Data															
Precambrian	Crystalline Metamorphic	Am	400PRBL 400MPC	0-3050 (0-10000ft)		Gneiss, schist, metaquartzite, marble, injection gneiss, amphibolite, numerous pegmatite dikes and veins.	Crystalline Aquitard*	Potential aquifer if fractured and the fractures are interconnected or rock is weathered to grus even in subsurface.	No Data	4	m <sup>2</sup> /day	1.7	1.5	N/A	0.5 - 5.6	0.9 - 3.1												
						LaHood Formation (Belt)	Yl	400LHOD	0-3050 (0-10000ft)	Dark grayish-green, coarse- to very coarse-grained, poorly bedded arkose and conglomeratic arkose. Interbedded dark-gray argillite and siliceous limestone beds in northern part of area. Thickens to the north.	LaHood Aquitard*	Potential aquifer if fractured and the fractures are interconnected.	No Data															

\*Insufficient well data available for statistical analysis. Designation based on regional hydrogeologic interpretation.