Data for Water Wells, Springs, and Streams Visited during the Gallatin–Madison Ground Water Characterization Study

By

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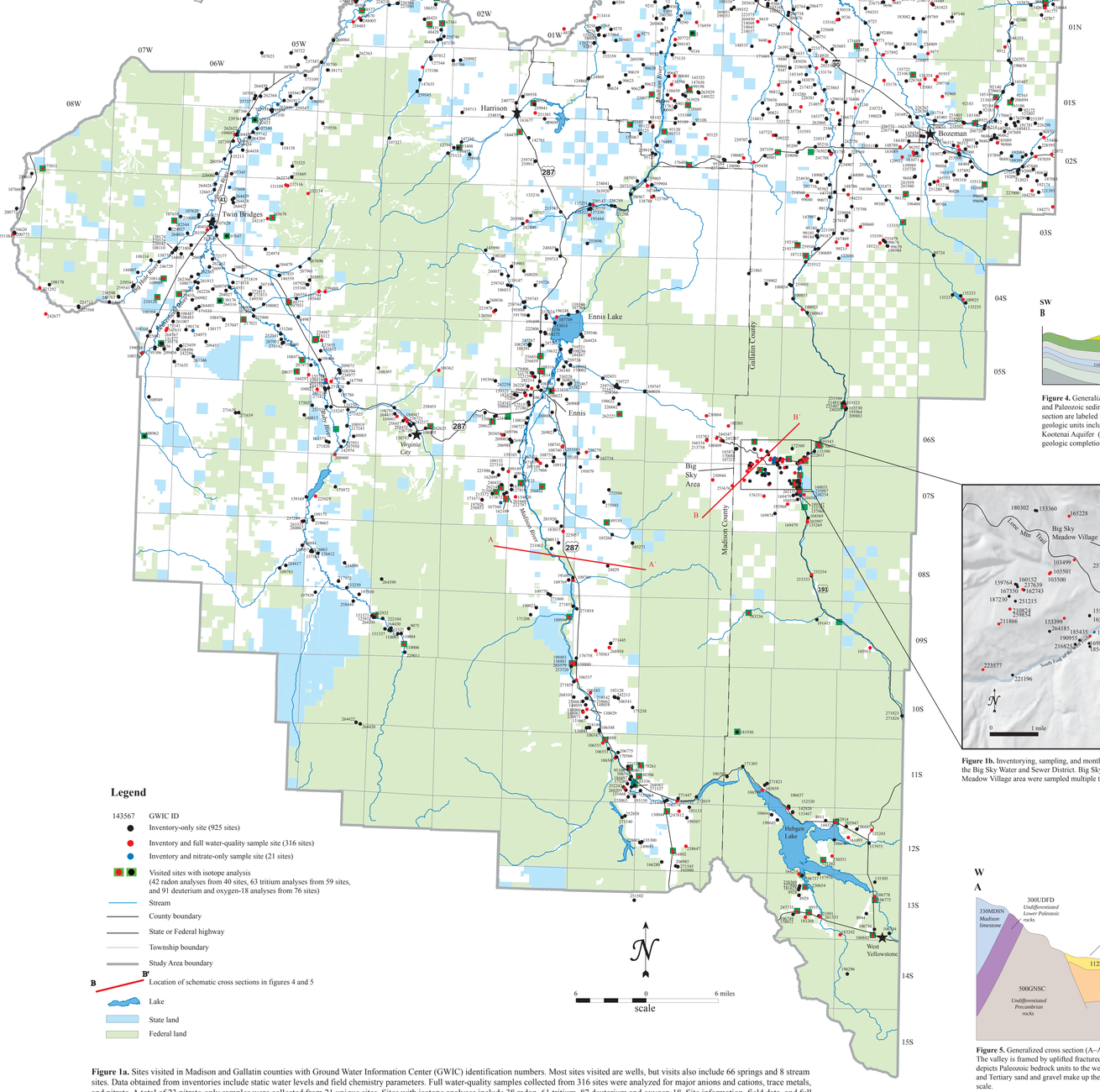

Figure 1a. Sites visited in Madison and Gallatin counties with Ground Water Information Center (GWIC) identification numbers. Most sites visited are wells, but visits also include 66 springs and 8 stream sites. Data obtained from inventories include static water levels and field chemistry parameters. Full water-quality samples collected from 316 sites were analyzed for major anions and cations, trace metals, and nitrate. A total of 23 nitrate-only samples were collected from 21 unique sites. Sites with isotope analyses include 38 radon, 61 tritium, 87 deuterium and oxygen-18. Site information, field data, and full water-quality analyses can be obtained from the GWIC website using GWIC Project Code GWCP08 (http://mbmggwic.mtech.edu). Site information is also available in Appendix 1.

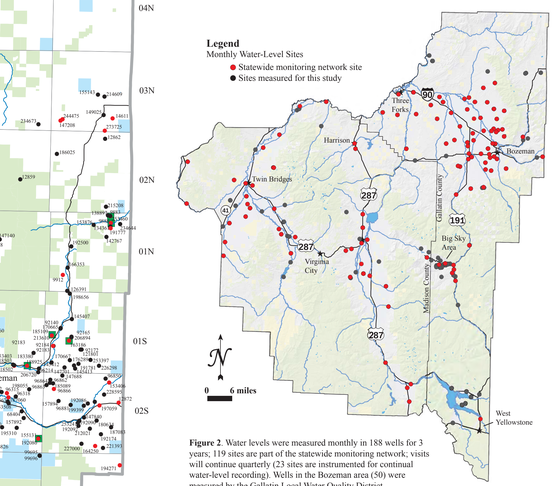

Figure 2. Water levels were measured monthly in 188 wells for 3 years; 119 sites are part of the statewide monitoring network; visits will continue quarterly (23 sites are instrumented for continual water-level recording). Wells in the Bozeman area (50) were measured by the Gallatin Local Water Quality District.

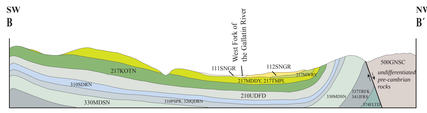

Figure 4. Generalized cross section (B–B´, fig. 1a) through the Big Sky area highlights gently dipping Mesozoic and Paleozoic sedimentary units overlain in places by Quaternary sand and gravel. Geologic units on the cross section are labeled with their corresponding geologic completion code (table 1). Important aquifers formed by the geologic units include sand and gravel along the West Fork of the Gallatin River (hydrologic code, Qc), the Kootenai Aquifer (hydrologic code, Kktn), and the Madison Aquifer (hydrologic code, Pmg). See table 1 for geologic completion code and hydrogeologic unit relationships. Not to scale.

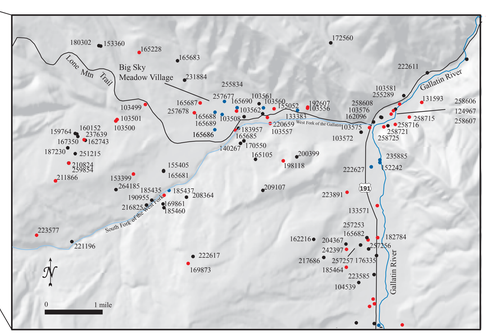

Figure 1b. Inventorying, sampling, and monthly water-level measurements were coordinated with the Blue Water Task Force and the Big Sky Water and Sewer District. Big Sky was a special focus area of data collection. Nitrate sample sites in the Big Sky Meadow Village area were sampled multiple times between 2008 and 2009.

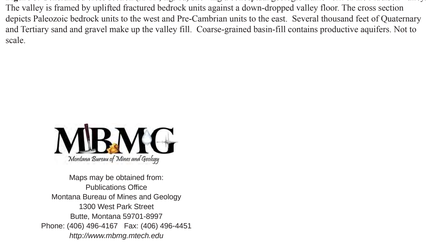

Figure 5. Generalized cross section (A–A´, fig. 1a) showing a conceptual geologic framework of the Madison Valley. The valley is framed by uplifted fractured bedrock units against a down-dropped valley floor. The cross section depicts Paleozoic bedrock units to the west and Pre-Cambrian units to the east. Several thousand feet of Quaternary and Tertiary sand and gravel make up the valley fill. Coarse-grained basin-fill contains productive aquifers. Not to scale.

MBMG
Montana Bureau of Mines and Geology

Maps may be obtained from:
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Author's Note: This map is part of the Montana Bureau of Mines and Geology (MBMG) Ground Water Assessment Atlas for the Gallatin–Madison Area Ground Water Characterization Study. This map is intended to illustrate the distribution of sites visited, the data available from those visits, and other previous and ongoing work in the area. It describes the general hydrogeologic framework for the study area, for a more complete description the reader is referred to the other maps of Montana Ground Water Assessment Atlas 8. (http://mbmggwic.mtech.edu).

INTRODUCTION

As part of the Ground Water Characterization Program's (GWCP's) Gallatin–Madison study, 1,188 water wells, 66 springs, and 8 stream sites were visited from January 2008 through December 2012 in order to obtain a representative dataset of groundwater resources. The locations of visited sites are displayed in Figure 1a. These sites were chosen from approximately 21,000 known wells in Madison and Gallatin counties. Areas of concentrated data collection included Big Sky, the Ruby Valley, and the West Yellowstone area (fig. 1b). Monthly water-level data were collected from a network of 188 wells by the MBMG GWCP in cooperation with the Gallatin Local Water Quality District (GLWQD) and the Yellowstone Controlled Groundwater Area (YCGWA) Long-Term Monitoring Project (fig. 2) to assess seasonal groundwater fluctuations. Field inventory efforts were coordinated with (1) the YCGWA's monitoring in the West Yellowstone area, (2) MBMG's Ground Water Investigation Program (GWIP) studies in the Four Corners and Big Sky areas, and (3) the GLWQD's Gallatin Valley Pharmaceutical Study (fig. 3).

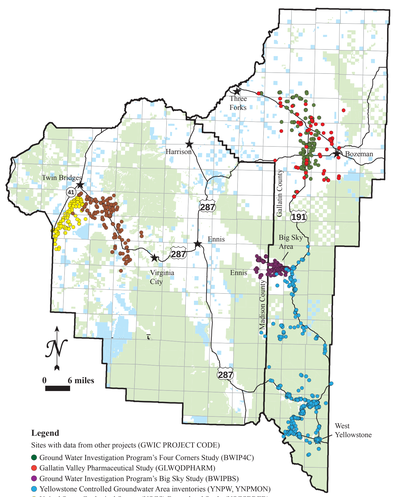

Figure 3. Data available from other investigations can be retreived from the GWIC database by project code.

Table 1. The 1,254 wells and springs visited are completed in 48 geologic units. The geologic units were consolidated into 15 aquifers described in the first column. Hydrogeologic unit codes are used on the Hydrogeologic Framework Map (GWAA 8 Map 2).

Aquifer Description	Geologic Completion Code	Hydrogeologic Code	Number of Visited Wells	Median Depth (ft)	Number of Visited Springs	Number of Sites Sampled
Quaternary coarse: medium sand, silt, and gravel; unconsolidated	110SNGR, 111SNGR, 112OTSH, 112SNGR	Qc	419	58	17	99
Quaternary fine-grained: silt and clay; unconsolidated	111SICL, 112SICL, 112TILL, 120SNGR, 120FWLS	Qf	10	125	2	3
Tertiary fine and coarse; consolidated and unconsolidated	120SDMS, 120TRRC, 123CBGA, 123DBCK,	Tsed	399	140	7	91
Cenozoic and Cretaceous igneous rocks: characterized by fractured bedrock flow	112VLCC, 120VLCC,121VLCC, 123VLCC, 211ELKM, 211TBBT	CMig	38	220	8	14
Tertiary sedimentary rock: Fort Union Formation; medium to fine-grained sandstone lenses; confined	125FRUN	Tfaa	9	182	1	3
Upper Cretaceous sedimentary rocks of the Livingston Group	211HPRS, 211BMCK, 211MRCK, 211CKDL, 211SDAN	Klvgs	61	176	0	12
Cretaceous sandstone of the Eagle Formation	211EGLE	Keta	3	240	0	0
Cretaceous sedimentary rocks: medium to coarse grained; limited productivity; some undifferentiated, the Frontier Formation and the Fall River are Cretaceous sedimentary rocks with productive sandstone lenses	211CODY, 217MDDY, 217MWRY, 217TMPL, 210UDFD, 217UDFD; 211FRNR, 217FLRV	Ksed	70	220	0	26
Cretaceous sandstone of the Kootenai Formation	211KOTN	Kktn	12	370	0	6
Mesozoic sedimentary rocks: the Morrison Formation	221MRSN	Msed	5	90	0	2
Sedimentary rocks of the upper Paleozoic including the Shedhorn and Amsden Formations	300UDFD, 310SDRN, 320AMSD	Pzu	4	283	6	4
Paleozoic Mississippian Madison Formation: massive limestone generally a productive aquifer where accessible	330MDSN	Pmg	21	130	15	16
Sedimentary rocks of the lower Paleozoic including the sandstones and limestones; the oldest unit, the Flathead, is a meta-sandstone with secondary fracture porosity	337MSNC, 337TRFK, 340UDFD, 341JFRS, 370CMBR, 371PLGM, 374MGHR, 374FLTD	Pzl	24	182	0	11
Precambrian rocks: the Lalfood Formation and metamorphic schists and gneiss; characterized by fractured bedrock flow	400LHOD, 500GNSC	FB	113	200	10	29
Totals			**1188**		**66**	**316**

AQUIFERS, GEOLOGIC UNITS, AND THE HYDROGEOLOGIC FRAMEWORK

An aquifer is a geologic unit that can provide adequate quantities of water to a well or spring. The geologic unit, the topographic position, and the well's position in the groundwater flow system (distance from recharge and/or groundwater residence time along groundwater flow paths) all affect water quantity and water chemistry. The distribution and relationships between aquifers and aquitards in a basin are keys to building a regional hydrogeologic framework in order to interpret site data. Geologic completion codes were determined for all sites visited. These codes identify the geologic unit that provide water to the well or spring. Table 1 relates the geologic completion codes to hydrogeologic units. The Hydrogeologic Framework Map (GWAA 8 Map 2) describes the geologic units that form the area's hydeogeologic system.

SITE VISITS

Coordinates for each visited site were determined using a hand-held global positioning system (GPS) receiver and USGS 1:24,000 topographic maps. Coordinates and elevations for wells measured monthly for water levels were determined using a survey-grade GPS; solutions obtained have an accuracy to within 10 cm (for all points the horizontal datum is NAD83, for survey points the vertical datum is NAVD88 using GEOID09, for hand-held GPS points the vertical datum is NGVD29). All latitudes and longitudes are recorded in the NAD83 projection. Where possible, field data collected included a static water level, temperature, pH, and specific conductance. All reported field chemistry parameters represent stabilized readings attained after approximately 30 min of pumping. Some wells either could not be pumped to measure water-quality parameters or were not accessible to measure water levels. Water-quality samples for major ions, nitrate, and trace metals were obtained from 296 wells and 20 springs, of which 59 samples were also analyzed for tritium, deuterium, and oxygen-18 (additional analyses available from previous sampling). Water from 42 wells and springs in the study area have been analyzed for radon. Field and analytical data for the visited sites are available from the Ground Water Information Center (GWIC) website (http://mbmggwic.mtech.edu). Field data collected at each site are also attached as an appendix to this map (Appendix 1).

MONTHLY WATER-LEVEL MONITORING

Monthly water-level measurements were collected at 188 sites from June 2008 through June 2011. Dense groups of monthly sites in the Ruby Valley, West Yellowstone, and Big Sky provided focused data collection. One hundred nineteen of these monitored sites are part of the statewide groundwater monitoring program and continue to be measured at least quarterly, with some sites instrumented for hourly measurements. All water-level data are available through the MBMG's GWIC website (http://mbmggwic.mtech.edu).

DATA FROM OTHER PROJECTS

Data from other groundwater investigations conducted in the study area are also available (fig. 3). Projects that involved collaboration or provided historic data for this investigation include: a pharmaceutical evaluation in the Gallatin Valley and Big Sky, the Four Corners and Big Sky projects of the MBMG's GWIP, a groundwater investigation in the Ruby Valley, a historic project in the Beaverhead River Valley, and sites that are part of a long-term monitoring project around Yellowstone National Park.

Pharmaceuticals in public water supply wells and wastewater-treatment plant effluent around the Bozeman, Belgrade, Four Corners, and Manhattan areas (English and Icopini, oral communication) were evaluated by the MBMG and the GLWQD between June 2008 and June 2009. This project sampled 68 sites including 10 surface-water sites (fig. 3). The project data are available through the GWIC website using the project code GLWQDPHARM.

Site locations from the MBMG GWIP's Four Corners and Big Sky projects are displayed in figure 3. These projects focused on investigating residential development and potential impacts to groundwater and surface-water resources. Additional data have been collected by GWIP in the Logan, Manhattan, and Belgrade areas, although these sites are not displayed in figure 3. All project data and reports are available from the GWIP page on the MBMG website (http://www.mbmg.mtech.edu/gwip/gwip.asp) as well as the GWIC website.

From 2000 through 2003, the Ruby Valley Conservation District and the Ruby Watershed Council collected groundwater data, drafted a management plan, and developed a groundwater-flow model (Payne and Magruder, 2004a, b, 2008). Although this was not an MBMG project, the site data and monthly water levels are available through the GWIC website using the project codes RVCD2000 and RVCD2003 (fig. 3).

Some historic groundwater data from a joint United States Geological Survey (USGS) and Bureau of Reclamation project in the Beaverhead River Valley are also available (fig. 3). The data include water-level measurements collected from 1951 to 1968 with some measurements extending into the 1990s. All historic site data (over 500 sites) are available through GWIC (project code USGSBREB).

Data associated with the Yellowstone Controlled Groundwater Area (YCGWA) include site inventories from 600 wells and springs in the West Yellowstone–Big Sky area (data are also available from the Gardiner and Cooke City areas, outside the GWCP08 Characterization Study Area). Most well visits occurred from 1995 through 1998 (project code YNPW), but most spring inventories were completed in 2000. In the West Yellowstone area, long-term monitoring sites are measured for water levels (or discharge in the case of springs), water temperature, and water quality. Some of these sites have been monitored since 1995 (project code YNPMON). Figure 3 displays only the YNPW and YNPMON sites, although all YCGWA project data are available from the GWIC website (project codes include: SODABUT, YNPINV, YNPC, YNPCSPR, YNPG, YNPMON, YNPMTR, YNPW, and YNPWSPR).

Geothermal waters in the study area were evaluated by Sonderegger (1984) and more recently by an MBMG statewide geothermal project. These sites are not displayed on Figure 3, but all data are available through GWIC. The 1979 data set has a project code of "Geotherm"; the recent data has a project code of "Geothermal2011".

THE GEOLOGIC AND HYDROGEOLOGIC SIGNIFICANCE OF THE DATA

Visited wells were selected to obtain representative data from all the water-bearing geologic units in the study area. Well logs, geologic reports, and geologic maps (Kellogg and others, 2006, 2007; Lonn and English, 2002, Lonn and others, 2000, 2007, O'Neill and Christiansen, 2002; Reynolds and others, 2006; Ruppel and others, 1993; Skipp and McGrew, 1977; Vuke, 2006; Vuke and others, 2002, 2004; and Hanneman and Wideman, 1991) were used to assign geologic completion codes to the visited wells and springs. Table 1 lists the total wells and springs visited, grouped by geologic completion codes; the codes are correlated with hydrogeological units. Stream sites are not included. The table also depicts the number of water-quality samples from each aquifer and the median well depth. The reader is referred to the Hydrogeologic Framework Map (GWAA 8 Map 2) for more detailed information on the stratigraphy, geologic completion code units, and hydrogeologic units.

The hydrogeologic units varied from deep, unconsolidated basin-fill in the intermontane valleys to structurally deformed sedimentary, igneous, and metamorphic fractured bedrock in the mountainous areas. Figure 4 is a cross section through the Big Sky area depicting the relationship among the underlying sedimentary units. Groundwater flows through primary and fracture porosity in these units, some of which act together as aquifers. Productivity varies widely, with the Madison Limestone (330MDSN) being the most productive. Figure 5 is a generalized cross section through the central Madison Valley. Groundwater flows from the edge of the basin through fractured bedrock and into the basin-fill aquifers.

DATA SOURCES

Land ownership, hydrography, public land survey, and road data were obtained from the Natural Resource Information System, Helena, Montana (http://nris.mt.us/).

ACKNOWLEDGMENTS

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