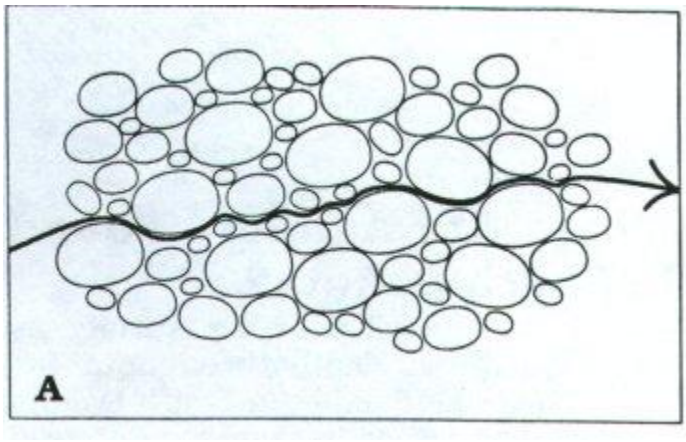
South Dakota Aquifers

What Is An Aquifer?

An aquifer is any rock or sediment with spaces that hold water, and through which significant quantities of water move. The water contained in these underground spaces is called ground water . Although ground water can flow freely through large underground spaces, more often it seeps slowly through the intricate small pores of rock or sediment. Examples of aquifer s include: sand and gravel layers (i.e., buried river systems and flood plains); fracture systems in brittle rocks (i.e., granite or quartzite); and fracture systems or solution cavities in easily dissolved rocks, such as limestone. Aquifer s have connected pores or open fractures through which fluid may flow (see Figure 1). As an analogy, consider a glass filled with crushed ice and soda pop, with a straw in it. The ice is equivalent to the sand and gravel aquifer , the soda pop is like the ground water that flows around and between the "grains," and the straw is like a well. It can be used to "pump" water out of the aquifer .



As illustrated in a cross sectional view of the earth shown in Figure 2, aquifer s are generally classified as either unconfined or confined. In an unconfined aquifer , the water table is not separated from the surface of the ground by a layer that is impermeable to water. In a confined aquifer , the water is under pressure.

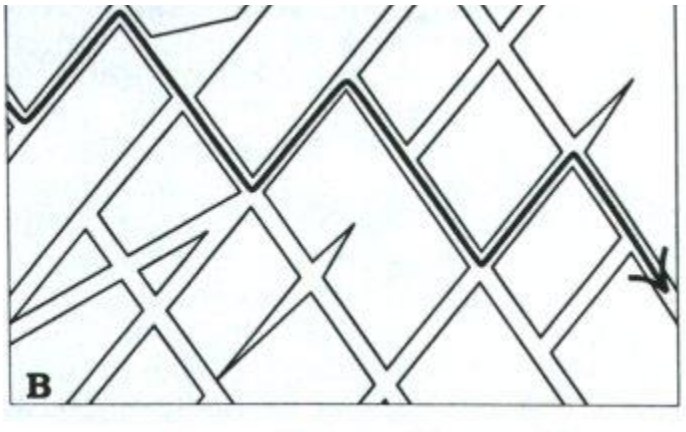
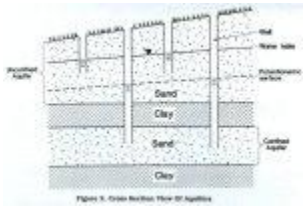


Fig. 1: How Water Flows Through Rocks; A. porous material; B. rock fractures.

because it is "confined" between impermeable layers. When a confined aquifer is tapped, the ground water will rise in the well to a level above the top of the aquifer . Under certain conditions, when the pressure is sufficiently high, water will be forced higher than the surface of the earth. In this case, the effect produces a flowing well at the surface of the earth.

Where Are Aquifers Found In South Dakota?

Aquifer s are found near the surface as well as at great depth throughout the state. The ground water in South Dakota aquifers has either flowed underground from surrounding aquifers or has percolated through the soil as a result of runoff and precipitation. Aquifer distribution in South Dakota is complex. In some areas, aquifer s are present at several different depths. Therefore, all of the aquifer s in the state cannot be shown on one map. In many areas, maps that show a particular aquifer are available on a regional or county-wide basis. For example, Figure 3 illustrates the extent of the Big Sioux aquifer in Eastern South Dakota. People can contact the South Dakota Geological Survey or the United States Geological Survey for specific information about local aquifer maps.



In Western South Dakota, the largest aquifer s are located in sandstone and in fractured rock deposits. In Eastern South Dakota, most wells are placed in aquifer s located in glacial drift deposits. Table 1 lists the major aquifer s found in the state and some of their characteristics.


Figure 3. Big Sioux Aquifer

Significance

Most of the state is underlain by one or more aquifer s (see Table 1). It has been estimated that 42 percent of all water used in
South Dakota is from ground water supplies. This total is equivalent to approximately 251 million gallons of water per day. (If hydroelectric use along the Missouri is removed, this percentage increases significantly).

Aquifer s are a very important resource in the state. They offer a large, reliable source of water for many uses. For example, the public drinking water supplies from ground water serve 545,104 people, or 78 percent of the total population (696,000) of the state of South Dakota.

Table 2 lists estimates of total ground water use in South Dakota. Public water supply withdrawals include any ground water
supply that serves more than 25 people or has more than 15 hook-ups for more than 60 days per year.

Table 1. Aquifer and Well Characteristics in South Dakota

Aquifer Name / Description	**Well Depth**	**Well Yield in Gallons/Minute**		**Remarks**
	Depth in Feet	Range of Yield	May Exceed	
GLACIAL DRIFT AND ALLUVIAL AQUIFERS: Outwash and alluvium; unconsolidated sand, gravel and silt.	0-400	3-50	2,000	Glacial drift underlies most of state east of Missouri R. Alluvium found along major streams. Water fresh to moderately saline; commonly suitable for irrigation. Big Sioux aquifer in SE South Dakota yields supplies for Sioux Falls.
SEDIMENTARY BEDROCK AQUIFERS:				
High Plains Aquifer: sand, fine to medium, unconsolidated to poorly consolidated sandstone, silt, gravel, and clay.	10-570	5-100	1,500	Most common source of water on Pine Ridge and Rosebud Indian Reservations. Supplies towns of Martin and Pine Ridge. Some irrigation development. Quality generally suitable for most uses.
Fort Union-Hell Creek-Fox Hills Aquifers: Sandstone, very fine to fine-grained, poorly consolidated; soft clay; lignite beds.	100-1,000	2-40	500	Most common source of water in NW South Dakota. Fox Hills aquifer supplies Bison, Lemmon, and Timber Lake. Water commonly fresh.

Niobrara-Codell Aquifer: Shale, chalky, and fine-grained quartz sandstone.	150-300	2-30	300	Used extensively for livestock and domestic purposes in Central South Dakota and Southern James River basin. Water generally soft and moderately saline.
Dakota-Newcastle Aquifer: Sandstone, interbedded with shale and siltstone	300-4,000	2-50	1,500	Major source of water for domestic and stock use. Supplies many small public supply systems. Water commonly moderately saline to very saline.
Inyan Kara Aquifer: Sandstone, interbedded with shale and siltstone.	200-4,900	5-40	1,000	Underdeveloped source of water for domestic and stock use. Quality ranges from fresh in west to moderately saline in east to very saline in north.
Sundance Aquifer: Shale interbedded with fine-grained sandstone, limestone, and sandy shale.	100-5,400	5-100	1,000	Important water source for livestock in West-central South Dakota. Water commonly saline except near surface in the west.
Minnelusa Aquifer: Five major sandstone units separated by limestone, dolomite, shale and anhydrite beds.	100-6,800	5-100	4,000	Major ground water reservoir. Source for stock and domestic wells in Central and Western South Dakota. Suitable quality for irrigation (slightly saline or fresh) obtained from several wells near outcrops in Black Hills.
Madison Aquifer: Limestone and dolomite containing beds of shale, anhydrite, and halite.	100-9,000	10-100	2,000	Comprises one or more aquifers that can yield large quantities of fresh to saline water under significant hydraulic pressure. Several producing wells are more than 4,000 feet deep. Supplies Western South Dakota towns of Philip, Midland, Tri-County

				Rural Water System, and Missouri Rural Water System.
Red River Aquifer: Dolomite and dolomitic limestone.	1,100-9,700	5-100	1,000	Although not being used as a principal source of water in South Dakota, considered a major artesian aquifer. Dissolved- solids concentrations may exceed 60,000 mg/L. Maximum water temperatures of about 250 degrees F. reported.
Deadwood Aquifer: Sandstone, soft, thin-bedded, slabby dolomite and limestone; limestone-pebble conglomerate; and beds of glauconitic shale.	40-10,200	3-50	500	Except in the Black Hills area, aquifer not used. Potential for development, although probably significant, is not known. Salinity may range from moderaly saline to very saline.

Table 2. Ground Water Use In South Dakota

Percent * Type of Use
1.....Irrigation
2.....Public drinking water
3.....Commercial
4.....Livestock
5.....Mining
6.....Domestic drinking water
7.....Industrial
8.2.....Thermoelectric
*Data are rounded to two significant figures and therefore percentages may not add to 100% because of independent rounding.

What is the Quality of S.D. Ground Water?

Ground water quality varies significantly throughout South Dakota. Although most ground water is quite safe to drink, much of it exceeds the Environmental Pro-tection Agency's recommended limit of 500 milligrams per liter for total dissolved solids (TDS). In most cases, the TDS value is high because the water contains an excess of calcium, magnesium, bicarbonate or sulfate ions .

In some ground water supplies, nitrate concentrations have been found to be above the drinking water standard of 10 milligrams per liter of nitrate-nitrogen. Excessive amounts of nitrate can be harmful, especially to small children and pregnant women. High nitrate levels can reduce the body's ability to carry oxygen in the blood. Please refer to the fact sheet on ground water quality for additional information.

Management Considerations

South Dakota is, in legal terms, a prior-appropriation state. This means that water is, in general, allocated on a "first come, first served" permit system. Ground water resources are regulated and protected by statutes administered by the South Dakota
Department of Environment and Natural Resources (DENR).

The water quality of municipal and rural water system supplies is routinely checked by the water system operator. Ensuring safe water quality in a private water well is the responsibility of the owner/user. For a fee, analyses may be completed by the South Dakota Department of Health. As a minimum, the bacteria and nitrate levels should be checked annually in a private well. All water-quality records should be kept to prove a history of the water quality in that well.

What Are Some Potential Threats To Ground Water?

Aquifer s located very close to the earth's surface are very susceptible to contamination from a variety of sources. Point sources (such as gasoline spills or leaking underground storage tanks) as well as nonpoint sources (such as urban and agricultural runoff) are potential contaminants. These nonpoint sources may include contaminants such as grease, oil, deicer salts, and heavy metals in municipal storm sewers. Pesticide runoff from golf courses, domestic use, and agricultural applications may also contribute. Confined aquifer s may be contaminated via poor well construction, improperly abandoned wells, and underground waste injection. Waste injection is the process of disposing of liquid wastes by pumping them down a well into spaces underground. Waste injection permits are regulated by the state.

Glossary

Glossary terms are adapted from the Glossary of Geology, Bates,R.L., and Jackson, J.A., 1987. American Geological Institute, Alexandria VA., and from Applied Hydrogeology, C.W. Fetter, 1980. Merrill Publishing Co., Columbus, Ohio.

Aquifer - rock or sediment that is sufficiently permeable to ground water and yields economically significant quantities of water to wells and springs.
Bedrock - the rock under soil or glacial deposits.
Confined aquifer - an aquifer in which the ground water is under pressure significantly greater than that of the atmosphere.
Fracture systems - networks of cracks in rocks.
Glacial drift - a general term applied to all material transported by a glacier and deposited directly by or from the ice, or by meltwater from a glacier.
Ground water - all water below the land surface.

Impermeable - not open to the passage of fluids.
Ion - the electrically charged form of an atom.
Permeable - able to transmit fluid.
Porous - having numerous open spaces, whether connected or isolated.
Potentiometric surface - an imaginary surface representing the level to which water will rise in a well.
Solution cavities - spaces that are left in rocks when minerals dissolve.
Total dissolved solids - the total amount of all minerals and solids dissolved in water.
Unconfined aquifer - an aquifer not covered by an impermeable layer.
Water table - the surface between the zones of saturation and aeration; that surface of a body of unconfined ground water at which the pressure is equal to that of the atmosphere. (See Fig. 2).

References

The data in Tables 1 and 2 have been adapted from National Water Summary, 1984, a publication of the U.S. Geological Survey (Water-Supply Paper 2275), or from Rick Benson, hydrologist with the U.S. Geological Survey in Huron, unpublished 1990 data for the National Water Summary.

Selected Resources for Teachers

Hidden Treasure , a 1993 video on South Dakota ground water, produced by the S.D. Geological Survey, and available in all high school libraries and in the S.D. State Library, grades 9-12.
Study and Interpretation of the Chemical Characteristics of Natural Water, Hem, J. D., 1985, United States Geological Survey
Water-Supply Paper 2254.
Numerous brochures and pamphlets are available from the United States Geological Survey.

Outreach (Resource Agency Personnel)

South Dakota Geological Survey, USD Campus, Vermillion, SD 57069.
South Dakota School of Mines and Technology, Geology Department, Rapid City, SD 57701.
South Dakota State University, Water Resources Research Institute, Brookings, SD 57007.
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