

GENERAL GEOLOGY

The characteristics of the present land surface in Blue Earth County, including the topography and nature of surface materials, are the result of the action of glacial ice and flowing water from the melting glacial ice sheets. The surficial materials known as drift are glacial deposits from continental glaciers that covered Blue Earth County during the last million years. The glaciers were centered over southern Canada and extended into southern Minnesota. They expanded and contracted several times, and the intervals between glacial episodes allowed deep erosion and weathering of the drift and bedrock surfaces.

The glacial drift is composed mainly of glacial till, which is characterized by a matrix of sand, silt, and clay with scattered pebbles, cobbles, and boulders. The drift deposits overlie the bedrock surface and range in thickness from less than 150 feet to more than 300 feet. Areas along the Minnesota, Blue Earth, and Le Sueur River Valleys have bedrock exposed at the surface where the drift has been removed. Before glaciation, erosion of the bedrock surface produced deep valleys, most of which are now filled with glacial drift.

The glacial drift includes all materials deposited directly by glacial ice or by meltwater streams flowing from the ice. Glacial meltwater streams laid down water-sorted sediments, called outwash deposits, along drainage channels than extended beyond the glacier's margins. Glacial outwash deposits are usually coarse-grained sands and gravels which form good aquifers in the drift. Many outwash deposits were laid down during the retreat of various ice sheets and were not destroyed by the advance of subsequent ice sheets. Inter-glacial erosion may have produced ancient glacial terrain valleys that contained sand and gravel deposits that are now buried and provide productive aquifers. Some of these deposits may be important local aquifers if they are extensive enough and the recharge is large enough. However, glacial outwash deposits form the most important aquifers in the glacial drift.

Materials of low permeability, such as thick clay layers, may exhibit confined conditions in the glacial drift. However, clay layers may have a discontinuous distribution that make unconfined conditions possible. Confined flow may occur in hydraulically isolated lenses of sand and gravel under sufficiently high pressure. The water pressure in glacial aquifers with unconfined conditions will be influenced by the local topography.

Geologic History

The bedrock that underlies Blue Earth County is part of a sequence of Late Cambrian to Early Ordovician sedimentary rock which consists of three major rock types: Sandstone, shale, and carbonates. The bedrock was deposited layer upon layer in shallow marine waters that flooded southern Minnesota about 500 million years ago. The ancient intruding sea followed a shallow depressional lowland that extended into southern Minnesota from a larger basin to the south.

In a shallow marine environment, the material that is transported by water is sorted according to the weight and size of the individual particles. Because of different settling rates, coarse (heavy) materials are deposited in turbulent water while the finer (light weight) materials are transported by waves, currents, or winds and deposited in quiet waters.

The relationship between sandstone, shale, and carbonate deposits correspond to a seaward gradation of sediment size. Sand is deposited along the turbulent shoreline environment, where it becomes cemented into sandstone over time. Clay and silt are transported by wave and current action to a deeper, lower energy environment where they are deposited to form shale.

Still farther off shore, where sand and clay are not transported by wave and current action, calcite is precipitated to form limestone.

The rise of sea level, during Late Cambrian time, resulted in a progressive overlap of sediment types. As the sea advanced landward, sandy beach deposits were overlain by offshore muds which were in turn overlain by carbonates. Thus, the advancing sea is recorded in bedrock layers by the sequence: sandstone overlain by shale overlain by carbonates. The lithologic character of the bedrock varies with such factors as sediment source, distance from the shore line, depth of the water, and transporting agent (waves, currents, and winds).

In the southeastern quarter of Blue Earth County the St. Peter Sandstone forms the bedrock surface beneath the glacial drift. The St. Peter Sandstone is the youngest bedrock unit and gives way to progressively older dolomite, sandstones, and shales to the north and west. This pattern reflects the general dip of the bedrock structure toward the southeast. Deep erosion of the bedrock surface, prior to glaciation, also influence this pattern.

The Cretaceous time period saw the rise of sea level from the west, which resulted in a different kind of progressive overlap. Sediments resulting from this overlap may be lacustrine and alluvial fan deposits as well as marine sediments. The western border of Blue Earth County is thought to represent the eastern shoreline of the advancing sea while the central and eastern portions of the county are viewed as being a coastal plane that was crisscrossed by rivers and streams. In Blue Earth County the Cretaceous age sediments overlie the much older Cambrian and Ordovician age bedrock units and are limited to isolated patches of loosely consolidated clays and sands that were primarily derived from the weathering of the underlying bedrock surface.

Bedrock Units

The following descriptions of the bedrock units that underlie Blue Earth County are primarily derived from water well driller's logs. They are supplemented by more detailed descriptions presented by Mossler (1987). For the purpose of this plan, some of the stratigraphic units currently recognized as individual geologic units are combined.

Cretaceous Rock -- generally composed of white, red or brown clay that may represent the weathering of the underlying bedrock. White Cretaceous sand may be reworked St. Peter or Jordan Sandstone that was deposited along the advancing shoreline of the Cretaceous Sea.

Decorah Formation -- limited to erosional remnants in the extreme southeast corner of the county. Its presence in Blue Earth County is only inferred from maps prepared for the Waseca County Geologic Atlas. The Decorah Formation is primarily a uniform bed of green shale.

Platteville-Glenwood Formations -- limited to erosional remnants in the southeastern corner of Blue Earth County. For convenience, the Platteville and Glenwood Formations are treated as a single geologic unit. The Glenwood Formation is a thin shale unit that directly overlies the St. Peter Sandstone. The Glenwood shale represents a low energy sedimentary environment, offshore from the beaches where the St. Peter Sandstone was being deposited. The Platteville Formation is a thin bed of limestone that contains thin shale partings at its top and base. The Platteville limestone represents a more seaward sedimentary environment of the Glenwood shale.

St. Peter Formation -- measured as thick as 100 feet, its presence is limited to the southern margin of Blue Earth County. The St. Peter Formation is primarily a medium-grained pure quartz sandstone. The lower part of the St. Peter may contain beds with varying amounts of silt or shale. The St. Peter Sandstone marks the advance of the Middle Ordovician Sea into southern Minnesota. The sandstone was deposited along the turbulent shoreline of the advancing sea. The St. Peter Sandstone was deposited on top of the Prairie du Chien Dolomite and its base marks a major erosional unconformity.

Prairie du Chien Group -- will vary greatly in thickness, from a feather edge at its erosional limits to as thick as 230 feet. The Prairie du Chien consists primarily of dolomite and sandy dolomite with some thin shale layers and a few units of quartz sandstone. The Prairie du Chien Dolomite is exposed at the surface along the Minnesota River Valley where it is quarried extensively from the city of Mankato north to the town of Kasota. The massive nature of the Prairie du Chien Dolomite indicates a low-energy sedimentary environment where carbonate deposition was the dominant rock forming process. Carbonate deposits were terminated by the retreat of the shallow sea from the continent. The retreat of the shallow sea exposed the Prairie du Chien Dolomite to the forces of erosion. Consequently, the top of the Prairie du Chien group represents a major erosional surface and its thickness may vary greatly from place to place.

Jordan Formation -- varies between 70 to 90 feet in thickness. The Jordan Formation is characterized as a medium to coarse-quartzose sandstone. The top of the Jordan Sandstone may contain hard-cemented layers and its base may contain minor amounts of shale. The Jordan Sandstone is exposed at the surface as bedrock outcrops along the Minnesota, Blue Earth, and Le Sueur river valleys in north central Blue Earth County. The Jordan Sandstone indicates the return to a high-energy, near shore sedimentary environment, perhaps a beach.

St. Lawrence Formation -- is generally between 60 and 100 feet thick. The St. Lawrence contains several rock types including dolomite, siltstone, shale, sandstone, and glauconite. It is usually characterized by layers of shale, siltstone, and dolomite. Its transition with the underlying Franconia rock is gradational. The dolomitic units of the St. Lawrence Formation would signify a low energy depositional environment; however, the interbedded clay, silt, and sand indicate an environment with fluctuating conditions.

Franconia Formation -- is generally about 80 to 120 feet thick. The Franconia is commonly characterized as a fine-grained, glauconitic sandstone. The upper part of the Franconia Formation may contain substantial amounts of shale and dolomitic layers that are similar to those found in the overlying St. Lawrence Formation. The similarity of rock type makes it difficult to distinguish the Franconia from the overlying St. Lawrence Formation in well drillers' logs. The fine-grained glauconitic sandstone suggest a low-energy sedimentary environment. Glauconite forms on the sea floor in oxygen-poor water where the rate of sedimentation is very slow.

Ironton-Galesville Group -- generally 60 to 80 feet thick, is a medium to coarse-grained quartz sandstone with some glauconite and minor amounts of silt. The Ironton and Galesville Sandstone's are normally classified as separate bedrock formations; however, the two sandstone units are difficult to separate in driller's logs and both are sources of ground water. For the purpose of this study, the Ironton and Galesville Sandstone's are treated as a single geologic unit and for convenience called the Ironton-Galesville Sandstone. The Ironton-Galesville Sandstone may indicate the return to a higher energy near shore or beach environment of sedimentation.

Eau Claire Formation -- is between 80 and 123 feet thick. The Eau Claire consists primarily of shale and siltstone with minor amounts of fine-grained, glauconitic sandstone. Its contact with the underlying Mt. Simon Sandstone is transitional. The fine-grained sediments of the Eau Claire Formation suggest a low energy environment of sedimentation, either relatively deep and quiet water or shallow water tidal flats.

Mt. Simon Formation -- is the lowest mapped unit of bedrock, several hundred feet thick. The Mt. Simon is generally characterized as a medium to coarse-grained quartzose sandstone. The upper parts of the Mt. Simon contain varying amounts of siltstone and shale while the middle part is primarily quartzose sandstone. Its base marks a major erosional surface with the underlying Precambrian age Hinckley Sandstone. The Mt. Simon Sandstone marks the advance of the Late Cambrian sea into southern Minnesota.

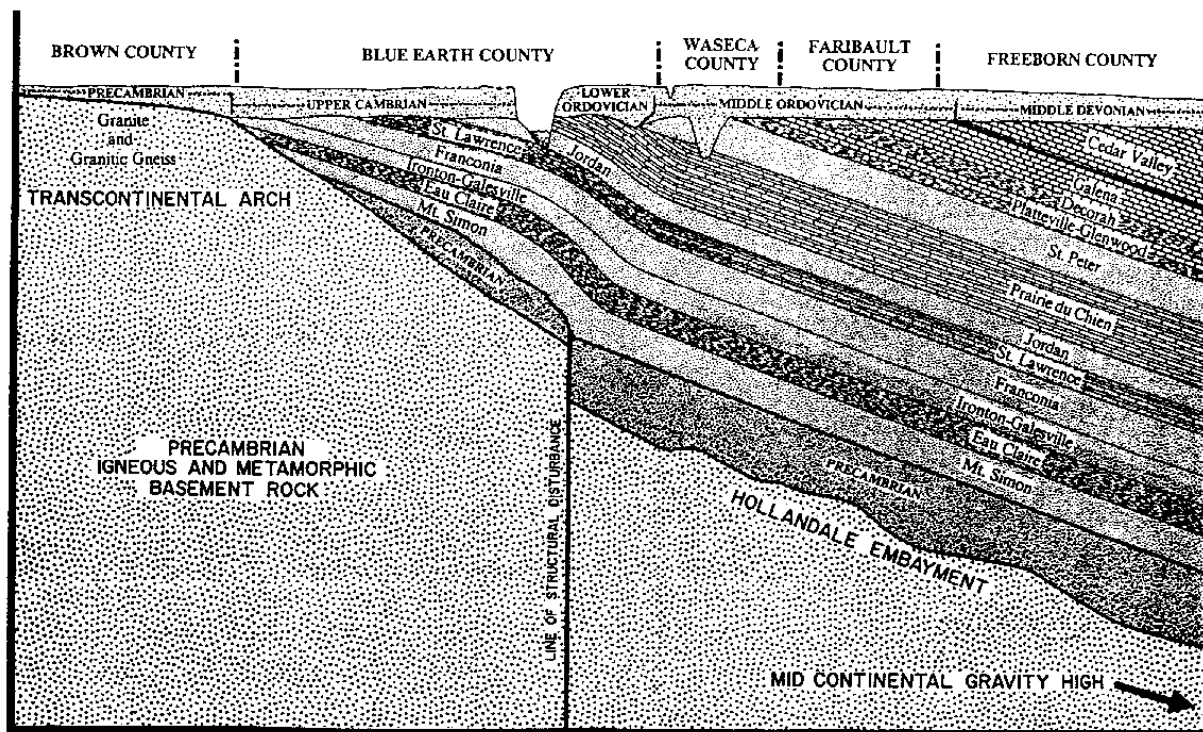


Diagram 1 Highly generalized cross section showing the variation of subsurface conditions along a line extending from Brown County to Freeborn County Minnesota. The above diagram illustrates the lateral variations and distribution of sediments in the Hollandale Embayment. The geologic structure is much more complex than shown here. Note: the vertical scale is grossly exaggerated; if drawn at true scale the thickest part of the sedimentary basin would be 0.05 inches thick.

BEDROCK GEOLOGIC COLUMN

STRATIGRAPHIC CLASSIFICATION				DESCRIPTION OF ROCK UNITS		DESCRIPTION OF AQUIFERS		
SYSTEMS SERIES	GROUP OR FORMATION NAME	MAP SYMBOL	GRAPHIC COLUMN	THICKNESS	DOMINANT ROCK TYPES	AQUIFER SYSTEM	AQUIFER	AQUIFER CHARACTERISTICS
MIDDLE ORDOVICIAN	DECORAH FORMATION	Odc		Uncertain; presence inferred	Shale, greenish gray, limited to erosional remnants	CONFINING LAYER	DECORAH SHALE	Limited to erosional remnants in extreme southeastern part of the county. Its presence is only inferred.
	PLATTEVILLE & GLENWOOD FORMATIONS	Opg		Limited to erosional remnants	Carbonate rock over shale; limited to erosional remnants.	NOT AN AQUIFER	PLATTEVILLE & GLENWOOD	Limited to erosional remnants in the southeastern corner of the county.
	ST. PETER FORMATION	Osp		90 to 100 feet	Quartzose sandstone; white or yellow; may be thin shale or siltstone beds in lower part of formation. Basal contact with Prairie du Chien is unconformal.	ST. PETER - PRAIRIE DU CHIEN - JORDAN AQUIFER SYSTEM	ST. PETER SANDSTONE	Highly permeable quartzose sandstone; has direct hydrogeologic contact with surficial glacial deposits. Used primarily as a source for domestic wells that require moderate water supplies.
LOWER ORDOVICIAN	PRAIRIE DU CHIEN GROUP	Opc	Upper contact is unconformal; ranges from feather edge at erosional limits to as thick as 230 feet	Dolomite and sandy dolomite with beds of quartzose sandstone; may contain thin beds of soft shale or sediment filled crevasses. The top of the Prairie du Chien marks a major erosional unconformity; it disappears as an erosional edge in extreme southwestern part of the county.	PRAIRIE DU CHIEN DOLOMITE		Carbonate rock, dolomite; has direct hydrogeologic connection with surface and shallow groundwater systems. Wide zones of fractures and crevices generally yield moderate quantities of water. Well-cemented dolomite is partly responsible for local high water yields. Limited shaly layers may form localized confining conditions. The top of the Prairie du Chien marks a major erosional unconformity; it may vary greatly in thickness.	
			JORDAN FORMATION	Cj	70 to 90 feet	Quartzose sandstone; white, yellow or brown. In eastern the Jordan is fine to coarse grained, soft-poorly cemented sandstone.	JORDAN SANDSTONE	Highly permeable quartzose sandstone; has direct hydrogeologic contact with surficial water. Provides moderate supplies where the Jordan flows the bedrock surface; contains negligible water supplies where the sandstone crops out and perennial rivers act as drains.
UPPER CAMBRIAN	ST. LAWRENCE FORMATION	Cal	60 to 100 feet	Interbedded dolomite, siltstone and shale; may contain thin beds of sandstone. Transition with the underlying Franconia is gradational.	CONFINING LAYER	ST. LAWRENCE DOLOMITE & SILTSTONE	Rocks of low permeability; act as confining bed at the base of the St. Peter-Prairie du Chien-Jordan aquifer system.	
	FRANCONIA FORMATION	Cfn	80 to 120 feet	Fine-grained quartzose sandstone; greenish gray, glauconitic; may contain thin beds of dolomite, siltstone, or shale. Transition with overlying St. Lawrence is gradational.	FRANCONIA - IRONTON - GALESVILLE AQUIFER SYSTEM	FRANCONIA SANDSTONE	Glauconitic sandstone; comes in direct hydrogeologic contact with surficial glacial deposits. Used primarily as a source for domestic wells that require moderate water supplies. Yields artesian flow where local elevations are low.	
	IRONTON & GALESVILLE FORMATIONS	Cig	60 to 80 feet	Quartzose sandstone; white, buff, or pink.		IRONTON & GALESVILLE SANDSTONE	Highly permeable quartzose sandstone; has direct hydrogeologic connection with surface and shallow groundwater systems. Yields large volumes of water for domestic, commercial, municipal, and industrial use.	
	EAU CLAIRE FORMATION	Cec	80 to 120 feet	Mainly shale and siltstone with some beds of sandstone; transition with the underlying Mt. Simon is gradational.	CONFINING LAYER	EAU CLAIRE SHALE	Shales are generally not water yielding; act as confining bed at the base of the Franconia-Ironton-Galesville aquifer system.	
	MT. SIMON FORMATION	Cmt	100 feet to several hundred feet	Quartzose sandstone; may contain shale and siltstone. Transition with the overlying Eau Claire is gradational; its base marks a major erosional unconformity.	MT. SIMON - HINCKLEY AQUIFER SYSTEM	MT. SIMON SANDSTONE	Permeable quartzose sandstone; has an direct hydrogeologic connection with surface and shallow groundwater systems. Yields large volumes of water for public, municipal, and industrial use.	
	HINCKLEY & FOND DU LAC FORMATIONS	Pc	Unknown; may exceed 1000 feet	Data sparse; mainly quartzose sandstone and shale. In base marks a major disconformity.		HINCKLEY SANDSTONE	Data absent; water contribution for aquifer use is unknown.	
PRECAMBRIAN	METAMORPHIC ROCKS	Pe	Unknown; several miles	Igneous and metamorphic rocks; undifferentiated.	BASEMENT ROCK	NOT AN AQUIFER	Not water bearing rock; represents the base of all aquifers and aquifer systems.	

EXPLANATION

	LIMESTONE
	SANDY SHALY
	DOLOMITE
	SANDY SHALY
	SANDSTONE
	SHALY
	SHALE
	SILTY
	SILTSTONE
	EROSIONAL UNCONFORMITY
	DISCONFORMITY

Aquifer Systems

An aquifer is any geologic unit that is capable of storing and yielding ground water in usable quantities. Ground water is usually held at significant pressure in an aquifer by a confining bed above the aquifer. In most cases confined water is equivalent to artesian water. A flowing artesian well is a well that yields water at the land surface, under its own pressure, without pumping. In a non-flowing artesian well, the pressure is not sufficient to lift the ground water above the land surface.

Glacial Drift Aquifers

The possibility of developing adequate supplies of ground water for farm and domestic use from wells finished in the glacial drift of Blue Earth County is generally good. The potential for development of moderate to large ground water supplies from the glacial drift ranges from poor, as in the north central part of the county, to favorable in the western and eastern row of townships and in the southern tier of townships in Blue Earth County.

A study of the geologic portions of water well drillers' logs resulted in the recognition of three general hydro-stratigraphic units that were used to construct a geologic framework for describing the hydrologic system within the glacial drift. The glacial drift consists of alternating layers of impermeable, semi-impermeable and permeable materials, forming a series of aquitards and aquifers. The three hydro-stratigraphic units defined here have different properties in relation to the occurrence and movement of ground water through the glacial drift. Mostly clay and silty clay deposits are fine-grained sediments and considered to be impermeable. A heterogeneous mixture of clay, silt, sand and gravel are considered to be semi-impermeable. Sand and gravel bodies within the glacial till are considered to be permeable.

Few of the water wells that are finished within the glacial deposits draw water directly from till; most obtain water from sand and gravel bodies within the till. Generally, the glacial tills have low permeability and, in many places, the till is sufficiently impermeable that it forms an aquitard between productive sand and gravel aquifers. Ground water supplies generally occur in sand and gravel deposits under semi-confined or confined conditions within the glacial till. Therefore, the water-yielding deposits are considered to represent an artesian condition with the water level rising above the level at which it was first encountered.

Ground water in the glacial deposits is derived from precipitation or from underflow into the area through bedrock aquifers. In Blue Earth County, perennial streams and rivers act as drains on the ground water along most of their distance, with the ground water gradient toward the river or stream valley. The Blue Earth, Le Sueur, and lower Watonwan River Valleys drain a particular linear region along their courses and leave a trough of depression that makes the permeable drift deposits less desirable as an aquifer due to low water content. Water wells drilled within these areas may penetrate large amounts of glacial sand and gravel deposits; however, these deposits are often ignored in favor of more productive bedrock aquifers. These conditions are very site specific and occasionally a very adequate supply of water can be found.

Bedrock Aquifer Systems

Three major bedrock aquifer systems, separated on the basis of hydrogeologic properties, are present in Blue Earth County. They are the St. Peter - Prairie du Chien-Jordan aquifer system, the Franconia-Ironton-Galesville aquifer system, and the Mr. Simon-Hinckley aquifer system.

A bedrock aquifer is a geologic formation that is capable of storing and yielding ground water in usable quantities. A bedrock aquifer system is actually a multi-aquifer system that is composed of two or more bedrock units that are bound on the top and bottom by aquitards or aquicludes. Bedrock aquifer systems are a connected set of individual bedrock aquifers that act as a single hydrologic unit. The data suggests that there is good hydraulic connection between the bedrock units within each of the three aquifer systems in Blue Earth County. Individual bedrock aquifers range from coarse-grained deposits such as sandstone to hard fractured sedimentary rocks such as limestone or dolomite (carbonates).

Ground water is usually held in a bedrock aquifer, at significant pressure, by the presence of a confining bed above the aquifer. High water pressure is sometimes the result of continuous bedrock strata with recharge areas at higher elevations. Water pressure will change in response to varying patterns of recharge, discharge, and pumping. In Blue Earth County, the water pressure in bedrock aquifers is not sufficient to lift the water above land surface except within the Minnesota River Valley and the lower Blue Earth and Le Sueur River Valleys where the bedrock is at or near the surface.

In Blue Earth County, the uppermost bedrock aquifer supplies water for farm and domestic use. In the eastern three-fourths of Blue Earth County, bedrock units included in the St. Peter-Prairie du Chien-Jordan aquifer system represent the uppermost bedrock aquifers. In the western quarter of the county, the Franconia and Ironton-Galesville Sandstones occupy the uppermost bedrock aquifer position. The Mt. Simon Sandstone is overlain by the Eau Claire confining bed throughout Blue Earth County.

The St. Peter-Prairie du Chien-Jordan aquifer system directly underlies the glacial drift and forms the bedrock surface throughout the eastern three-fourths of Blue Earth County. The St. Peter Sandstone is generally limited to the southeastern quarter of Blue Earth County where it directly underlies the glacial drift. The Prairie du Chien Dolomite is present throughout the eastern half of Blue Earth County where it forms the bedrock surface or underlies the St. Peter Sandstone. The Jordan Sandstone forms the bedrock surface in the west central portion of the County and has been dissected by past and present stream erosion. These three bedrock units function as a single aquifer system because all three are sources of ground water with no regional confining bed separating them. The bedrock aquifers in this system are the St. Peter and Jordan Sandstones, which yield water from between individual grains and the Prairie du Chien Dolomites, which yield water from between fractures and crevices. Rocks and shales of low permeability in the St. Lawrence Formation underlie the Jordan Sandstone and separate the St. Peter-Prairie du Chien-Jordan aquifer system from the underlying Franconia-Ironton-Galesville aquifer system.

The shallow bedrock has the advantage of local and rapid recharge, particularly in areas where the overlying drift is thin, or where there are permeable materials within the drift that are in direct hydrologic connection with the bedrock and will permit the downward movement of water into the bedrock. One disadvantage of the shallow bedrock aquifers is their susceptibility to contamination. Variability in the quality of the water may limit the use of a shallow bedrock aquifer when the aquifer is near the surface.

The Franconia-Ironton-Galesville aquifer system is overlain by the St. Lawrence confining bed except within the western row of townships in Blue Earth County. The upper bedrock aquifer unit in this system is the Franconia glauconitic sandstone which yields moderate supplies of ground water. The lower bedrock aquifer unit is the Ironton-Galesville Sandstones which are

generally a more productive aquifer than the overlying Franconia. Rock of low permeability of the Eau Claire Formation directly underlie the Iron-ton-Galesville Sandstone. The Eau Claire separates the Franconia-Iron-ton-Galesville aquifer system from the Mt. Simon-Hinckley aquifer system.

The Mt. Simon-Hinckley aquifer system is deepest of the three bedrock aquifer systems in Blue Earth County. These deep sandstone aquifers are overlain by the confining conditions of the Eau Claire formation. Within Blue Earth County less information is available on the geology and hydrology of the Mt. Simon-Hinckley aquifer system because it is utilized by only a few deep water wells.

Historically, wells that required high pumping capacity were often drilled through two or more bedrock aquifers. This presents a potential for contamination of lower aquifers and is no longer permitted by Minnesota Rule 4725, "Rules regulating wells and borings," nor by the Blue Earth County Well Ordinance.

Map 21 State Hydrogeologic Areas Map

