

**Title:** Investigation of Hydrogeology and Groundwater Geochemistry in the Shallow Fractured Dolomite Aquifer in Door County, Wisconsin (Study No. 13)

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**Period of Contract:** March 6, 1986 through June 30, 1990

**Objectives:** This study had two parts. Objectives of the first part were to quantify, delineate and interpret well water quality in Door County and address spatial and temporal variations in groundwater quality parameter concentrations. The objectives of the second part of the study were to characterize groundwater flow in the shallow fractured dolomite aquifer and evaluate methods for monitoring the impacts of contaminant sources on groundwater quality in Door County.

**Background/Need:** Door County has a history of elevated nitrate, chloride, bacteria, lead and arsenic levels in groundwater samples. Such contamination is believed to be a direct result of agricultural and other land-use practices in areas where fractured dolomite is overlain by thin soils. Little research had been done on the relationships between the fracture system, groundwater movement and groundwater geochemistry in the dolomite of northeastern Wisconsin, and no long-term monitoring data existed.

**Methods:** Well water samples were taken from 65 wells over a 36 square-mile area in central Door County from early in 1986 to June of 1990. The area has dairy and fruit farms which produce potential groundwater contamination from manure, fertilizers and pesticides. The water samples were tested for coliform bacteria, nitrate, chloride, specific conductivity, sulfate and turbidity. Eight monitoring wells were installed in a small area to characterize groundwater flow and evaluate groundwater impacts of contaminants. Rock cutting samples were collected during drilling of the wells. Four of the wells were piezometers designed to measure changes in water elevations and water chemistry and isotopes with depth. Geophysical logs were obtained at all monitoring wells prior to casing installation. Two pumping tests were conducted to test the hydraulic properties and vertical continuity of the aquifer.

**Results:** Nitrate-nitrogen concentrations in water from individual wells can be extremely variable with time. The dolomite aquifer possessed continuity of contaminant concentrations at a useful scale for delineating areas of

groundwater contamination. The maximum distance contaminants could be traced from activities on the land surface was three miles. The groundwater flow system exhibited characteristics of both diffuse and conduit flow. Major periods of groundwater recharge have a larger impact on contaminant concentrations than does infiltration from individual storms. The primary ions present in the water samples were calcium, magnesium and bicarbonate. Iron and manganese were present only in trace concentrations. Sodium, potassium, chloride, total sulfur and nitrate all showed great variations with depth, though were not present in elevated amounts in the aquifer material and were introduced to the groundwater by human activities on the land. Conductivity measurements were variable with time and depth. A strong correlation existed between chloride and conductivity, though weaker correlations were found between sulfate and chloride, turbidity and conductivity and nitrate and chloride. Water throughout the vertical extent of the aquifer was younger than 34 years. Nitrate-nitrogen levels ranged from not detected to 72 milligrams per liter (mg/l) with a median value of 6 mg/l. The shallow and deep parts of the aquifer have differing hydraulic properties; the transmissivity of the shallow zone was about sixty times less than the transmissivity of the deeper zone.

**Conclusions/  
Recommendations:**

Investigators concluded that the overall background groundwater quality parameter concentrations were generally within Wisconsin Department of Natural Resources limits. However, data from some individual wells frequently exceeded standards for nitrate and coliform bacteria. Horizontal continuity of indicator parameters existed up to a distance of 1000 feet and possibly up to 4000 feet, and this finding supports the validity and usefulness of installing monitoring wells to monitor changes in contaminant concentrations in this part of Door County. The Silurian dolomite aquifer of Door County behaves as a diffuse flow system rather than a conduit flow system regarding chemistry, though both systems exist. Specific conductivity values can be used to screen nitrate contaminated wells. The concentration of indicator parameters vary aurally between sites and over time. Extended periods of recharge resulting from multiple precipitation events are more important in transporting contaminants to groundwater than individual precipitation events. The top of the saturated zone in the dolomite may be shallower than previously assumed, and should be based on measurements taken in shallow monitor wells. This means that groundwater monitoring can sometimes be accomplished using fairly shallow wells. Traditional methods of groundwater monitoring can be used in Door County. Elevated nitrate values suggest surface-water contamination of the aquifer. Geochemical evolution of the groundwater occurs rapidly within the top portion of the aquifer.

**Availability of Report:**

This report is available for viewing and loan at:

The Water Resources Center  
1975 Willow Drive  
Madison, WI 53706  
(608) 262-3069  
Publication 050845

**Key Words:**

Bacteria, dolomite, Door County, fractured rock, hydrogeology, nitrate-nitrogen

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