Mapping Regional Flow Systems in Minnesota with Natural and Anthropogenic Tracers—

Implications for sustainable ground water resource management

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Minnesota Water Use 1985-2003



1985 to 2003 - - Total appropriated use increased 55%



Ground Water Sustainability Issues for Minnesota

Long term water supply
Managing expected growth
Sustained streams, lakes, and wetlands
Healthy ecological systems
Balancing needs and expectations
Values and public policy



Sustainable Water Use

"Sustainable use of ground water is the use of water to provide for the needs of society, now and in the future, without unacceptable social, economic, or environmental consequences."



Components of Sustainable Water Use

Quantitative analysis of system
Water demands
Use constraints
Public values
Time



Natural and Anthropogenic Tracers

Selected Natural Tracers Selected Anthropogenic Tracers

Carbon-14
Stable isotopes of H, O
Boron

Tritium Chloride Nitrate



Ground water residence time Ground waters sensitive to contamination Ground water flow paths Surface water-ground water interaction

County Geologic Atlas and Regional Hydrogeologic Assessment Project Areas





Carbon-14 Age Dating of Ground Water

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Carbon-14 Age Classes years before present Modern 500 – 5000 5000 – 10,000 More than 10,000

Ground Water Provinces

Drift type Sandy Clayey Thin clayey Thick sandy Thick clayey Very thin Bedrock type Sedimentary

Sedimentary

Sedimentary

Crystalline

Crystalline

Crystalline

Stable O H Isotopes Lake - Ground Water Interaction





Hummocky moraine

Ground moraine

Boron as Ground Water Tracer



DNR Waters





Boron as Recharge Area Tracer





Bedrock hydrogeological features

- (1) (3) (4) Thin drift: important bedrock recharge area
 - (2) Thin drift: important bedrock recharge area, sinkholes common
 - (5) Hinckley fault: fracture porosity, zone of preferential lateral and vertical ground-water flow
 - (6) Volcanic rock ridge: bedrock recharge area

Vintage

Bedrock surface elevation

Bedrock surface—Feet above mean sea level

1290

Tritium Profile in Thick Glacial Drift





Tritium age Recent (> 10 TU) Mixed (1 - 10 TU) Vintage (< 1 TU)

Profile location



Tritium Profile in Fractured, Faulted Sedimentary Bedrock







Elevated Chloride as Indicator of Human Activity

Natural ground waters generally low in chloride
Increased anthropogenic release of chloride

-- fertilizer

-- road salt

- -- water conditioning
- -- wastewater treatment
- -- industrial

• Relatively conservative in ground water



Elevated Chloride as Indicator of Recently Recharged Ground Water



DNR Waters

2000 to 2030

27% projected population increase
Population increase expected in areas of limited supply

Minnesota Water Sustainability Issues

- -- Long term water supply
- -- Managing expected growth
- -- Sustained streams, lakes, and wetlands
- Healthy ecological systems
- -- Balancing needs and expectations
- -- Values and public policy







- water quality
- fishery, forestry, agriculture

Summary

- Population and water use increasing
- Expect conflicts and impacts
- Natural and anthropogenic tracers:
 - -- Ground water residence time
 - -- Surface water-ground water interaction
 - Ground water flow paths
 - -- Impacts of land use management
 - -- System constraints for more detailed studies



For more information www.dnr.state.mn.us/waters www.geo.umn.edu/mgs