Fractured sandstone karst aquifers, the St. Peter, Jordan and Hinckley Formations: Examples from Askov, Woodbury, Rochester and elsewhere.

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MGWA Spring 2007 Conference
19 April 2007
St. Paul, MN.
Hypogene Speleogenesis: Hydrogeological and Morphogenetic Perspective

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National Cave and Karst Research Institute
Special Paper No. 1 2007

Hypogene Karst

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Figure 1. Epigenic and hypogenic karst in the context of basinal groundwater flow. Adopted and modified from Tóth (1999). The figure shows mainly gravity-driven flow in an idealized homogenous basin. In reality, most sedimentary sequences are highly heterogeneous, and gravity-driven flow interacts with other flow mechanisms.
Figure 2. Evolutionary types of karst and speleogenetic environments (from Klimchouk and Ford, 2000).
Hinckley Sandstone

Askov

Minnesota
Subsurface Profile
Sinkhole D127

Key:
- no vertical exaggeration
- 1 = organic rich soil (black)
- 2 = loess and fine sand
- 3 = mature medium grained sand
- 4 = clay, some gravel and sand
- 5 = gravely sand, some clay
- 6 = till (dark red)
- 7 = weathered bedrock
- 8 = bedrock and boulders
- 9 = fracture in bedrock
- dashed line is limit of excavation
- solid vertical lines are auger holes
Karst features within the Hinckley Sandstone
Rapid Movement of Ground Water

Flow velocities in excess of miles/month.

Multiple flow directions from single tracer inputs.
Take Home Messages

It isn’t what you don’t know that hurts – it’s what you know that isn’t so.

A. Hinckley Sandstone

1. Quartz is soluble and karst features form in sandstone.

2. Karst secondary porosity can transport groundwater at velocities of at least miles per month in sandstone karst.
New Richmond Sandstone
Shakopee Fm, Prairie du Chien Group

Altura, Minnesota, 1976
Lewiston, Minnesota
1991
Take Home Messages

B. New Richmond Sandstone

1. Don’t build waste storage lagoons on top of the New Richmond Sandstone.

2. The fundamental spacing of master joints is on the order of 10 meters – any construction that covers more area than that will be over one or more master joints.
Bedrock Topography Twin Cities Metro
Karst Features in the St. Peter Sandstone
Bedrock Topography
Minneapolis, St. Paul and central Washington Co.
34th St. Sinkhole, Minneapolis
Take Home Messages

C. St. Peter Sandstone

1. In the Metro Area St. Peter Sandstone karst features are strongly associated with current and buried valleys.
Dancing Waters, Woodbury, Minn.
Sinkhole Locations
D42
Master Joint N61°E
D42 Excavation

St. Peter Sandstone heavily fractured

Old sloping fractures with stained, weathered surfaces

Fresh sloping fractures without stained, weathered surfaces

Voids in the St. Peter produced by downward slumping

Pockets of glacial sediments washed into voids in the St. Peter
Sinkhole D38 conceptual model

- St. Peter Sandstone
- Shakopee Formation
- Water filled soft sandy layers and fractured limestone
- One or more regional high transmissive zones

Key features:
- 900 ft elev.
- WT 850 ft elev.
- St. Peter/Shakopee contact at 831 ft
- Collapse Breccia
- Sandstone Joints
- Berm
- ~ 60 ft+
Excavated SW end of D38
Open sloped joints
Grouting cleaned, open joints in the St. Peter benches
Back filling D38 with clayey till lifts
Take Home Messages

C. St. Peter Sandstone

1. In the Metro Area St. Peter Sandstone karst features are strongly associated with current and buried valleys.

2. An effective site investigation should start with a backhoe and a person able (and willing) to recognize evidence of karst.
Rochester Area Karst Features
(in the St. Peter Sandstone)
Chateau Theater Parking Lot 2001
Take Home Messages

C. St. Peter Sandstone

1. In the Metro Area sandstone karst features are strongly associated with current and buried valleys.

2. An effective site investigation should start with a backhoe and a person able (and willing) to recognize evidence of karst.

3. Backfilling sinkholes with transmissive materials is not an effective remediation.
CONDUITS RULE

Fractures Drool

Pores Suck