A Joint-Conference with the MGWA

The Sinkhole Conference

Multidisciplinary Conference on Sinkholes & the Engineering and Environmental Impacts of Karst

5-9 October 2015

Rochester, Minnesota

www.sinkholeconference.com

National Cave and Karst Research Institute

Eleven Orders of Magnitude: The Range and Implications of Karst Recharge Rates

George Veni, Ph.D.
Executive Director
National Cave and Karst Research Institute
Carlsbad, New Mexico USA

Karst: A Major Global Terrain

The first draft of the World Karst Map was shown on this slide, but it is not ready for public distribution and has been deleted from this distributed version. Apologies! Please watch for the final version to be published in 2016!

Why Should I Care About Caves and Karst?

- **Critical water supply**

  About 41 million people in the USA depend on karst aquifers as their only or primary source of water

What is Karst?!

Karst is a landscape, formed primarily by dissolution of the bedrock, typically:

- limestone
- dolomite
- marble
- gypsum
- halite

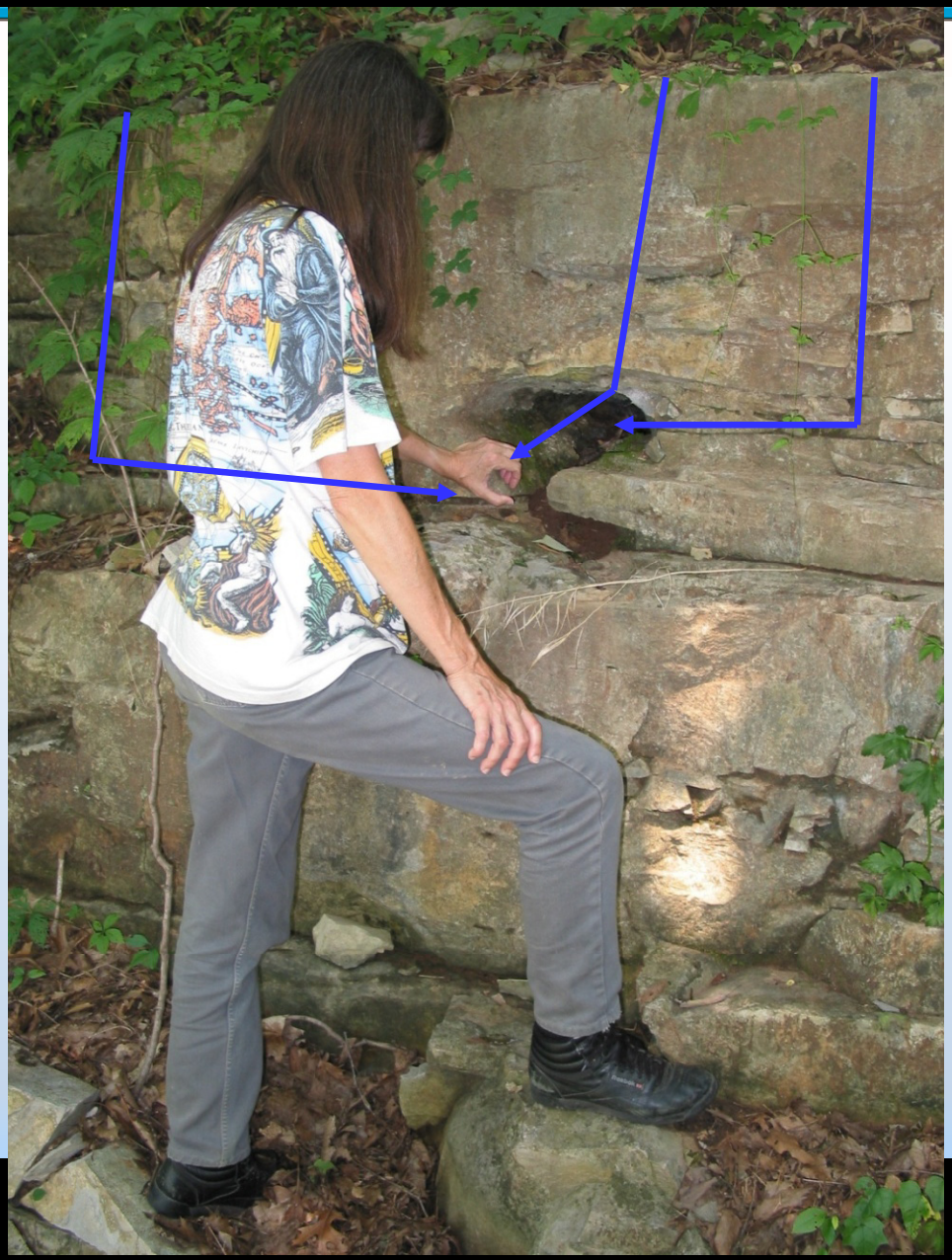
How do Karst Aquifers Form?

Fractures capture water and are enlarged into conduits

How do Karst Aquifers Form?

Fractures capture water and are enlarged into conduits

As conduits enlarge, they capture water from surrounding fractures and enlarge at ever-increasing rates



How do Karst Aquifers Form?

Fractures capture water and are enlarged into conduits

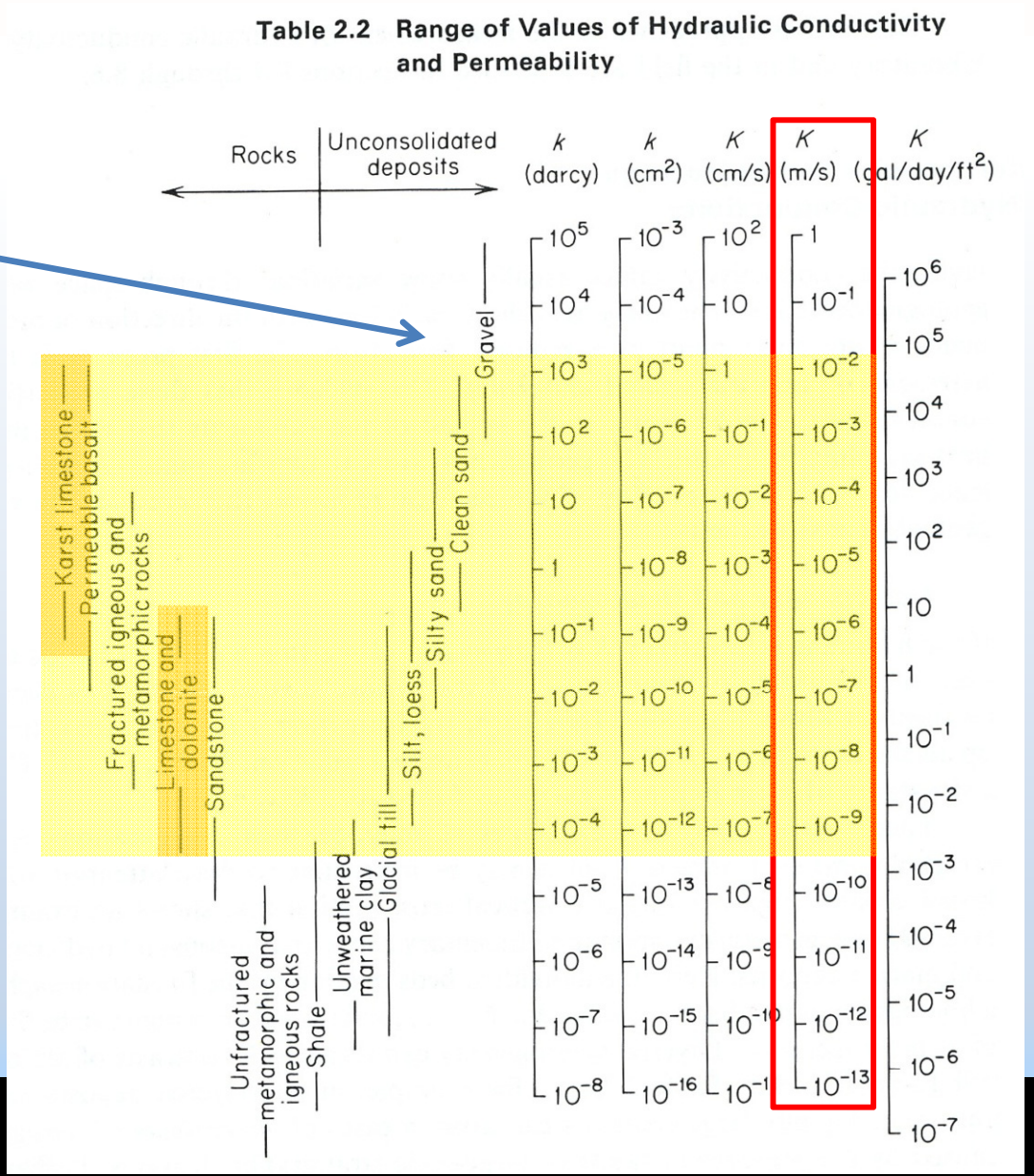
As conduits enlarge, they capture water from surrounding fractures and enlarge at ever-increasing rates

When the conduit becomes large enough for human entry, it is called a "cave"

Permeability of Karst Aquifers

Karst is comparable to sand and less permeable than gravel?

"Typical" range of karst permeability



Adapted from: Freeze and Cherry (1979)

Permeability of Karst Aquifers

Which sinking stream is more permeable?

Triple-Permeability Flows in Karst Aquifers

Diffuse flow

Laminar and very slow groundwater movement within small voids of primary and secondary porosity, excluding conduit and fracture flow; "intergranular" flow.

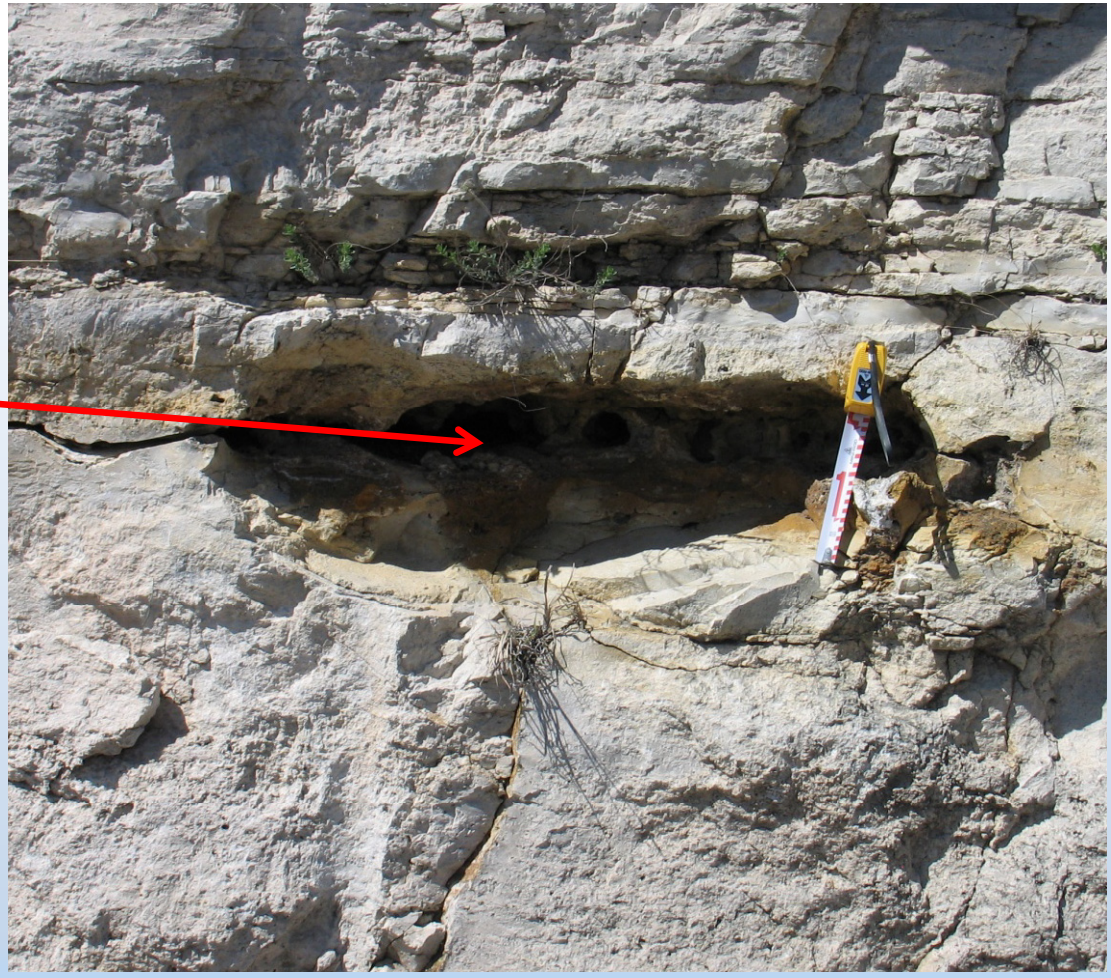
Triple-Permeability Flows in Karst Aquifers

Fracture flow

Groundwater movement along fractures and bedding planes that usually have been enlarged by solution. Flow is laminar to turbulent, and generally constitutes a moderate to large volume of groundwater in karst aquifers.

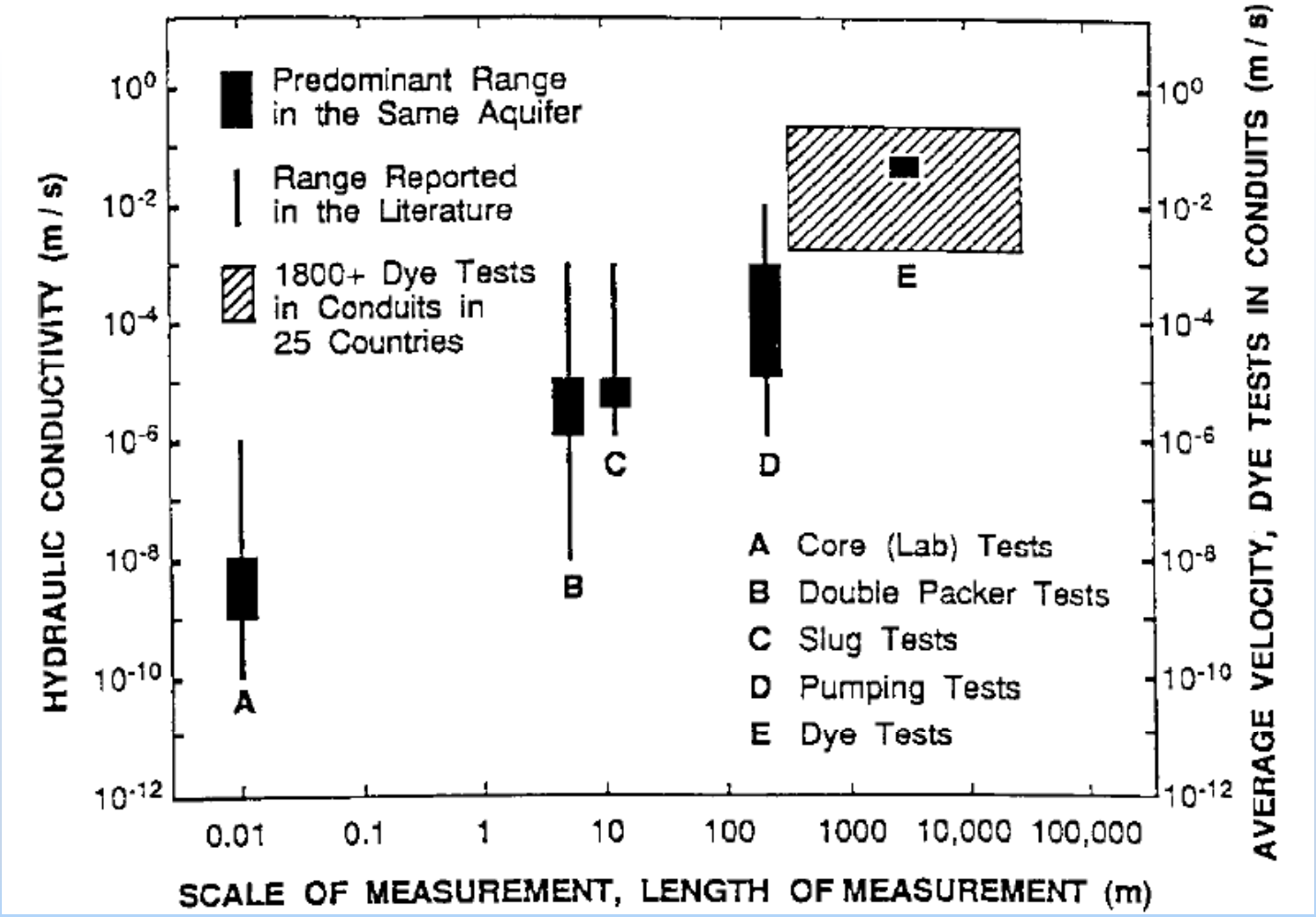
Triple-Permeability Flows in Karst Aquifers

Conduit flow
Groundwater movement along conduits; usually rapid and turbulent.
Conduit: *Subsurface bedrock channel formed by solution to transmit groundwater; often synonymous with cave and passage, but generally refers to channels either too small for human entry and >5-10 mm in width.*



Triple-Permeability Flows in Karst Aquifers

Groundwater problems: sampling bias

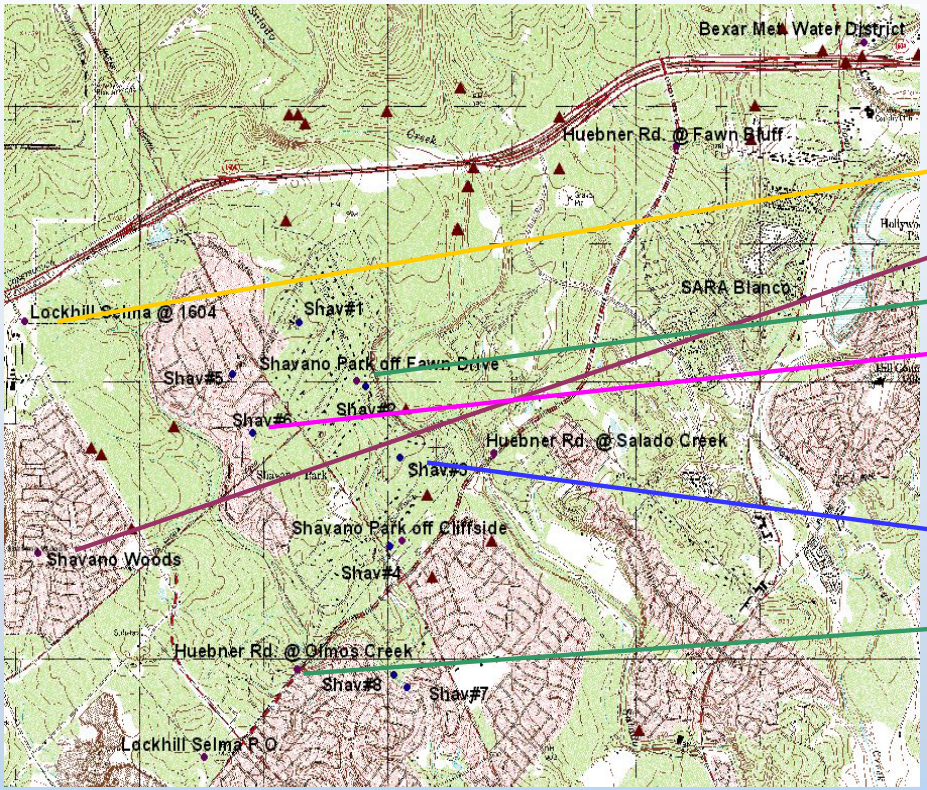


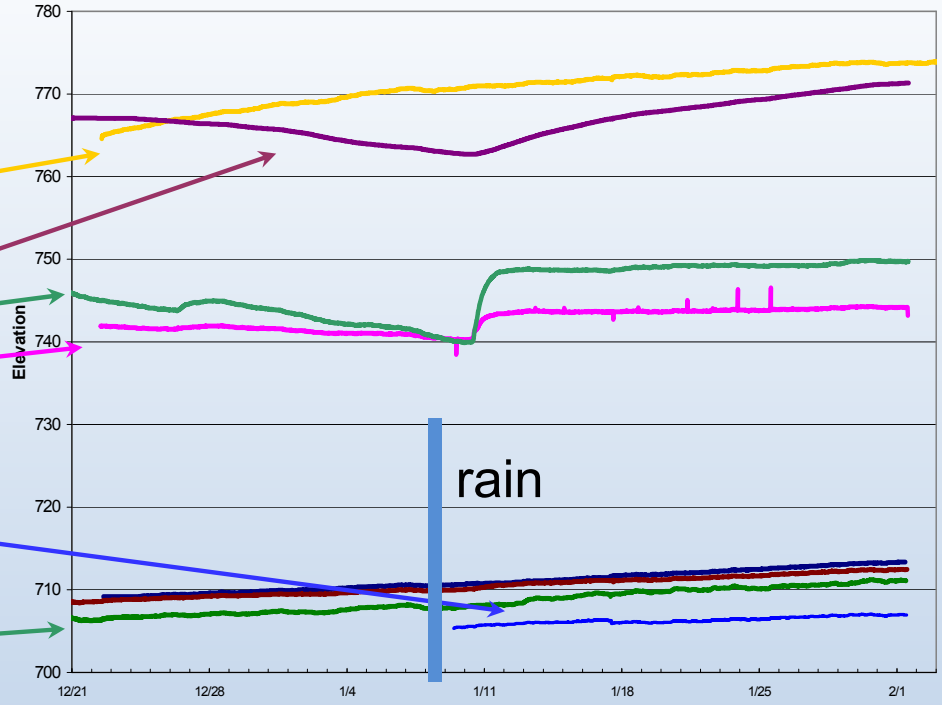
From: ASTM (1998)

Triple-Permeability Flows in Karst Aquifers

Well vs. spring data

- Wells give site-specific data
- High variability exists between adjacent wells



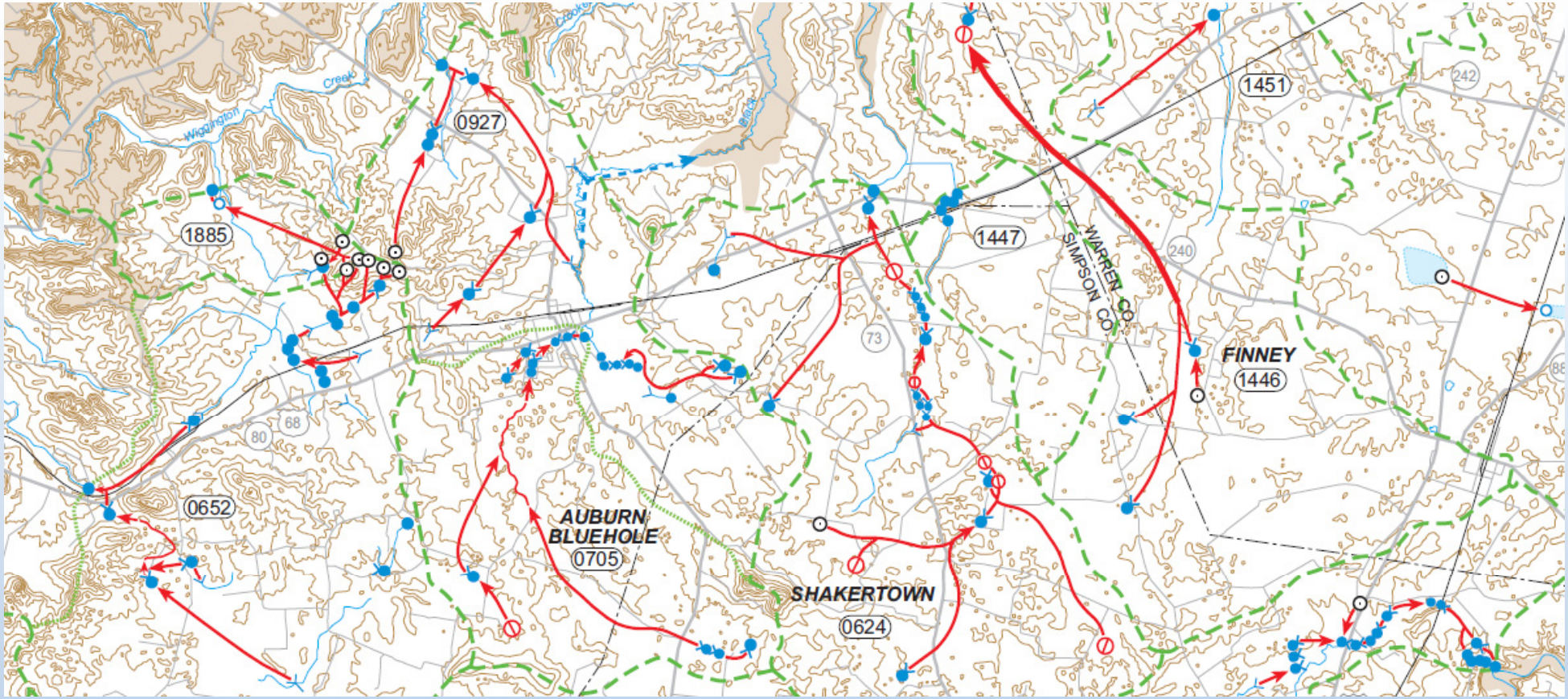


Map and data courtesy of Edwards Aquifer Authority (2001)

Triple-Permeability Flows in Karst Aquifers

Well vs. spring data

- Springs give drainage basin data

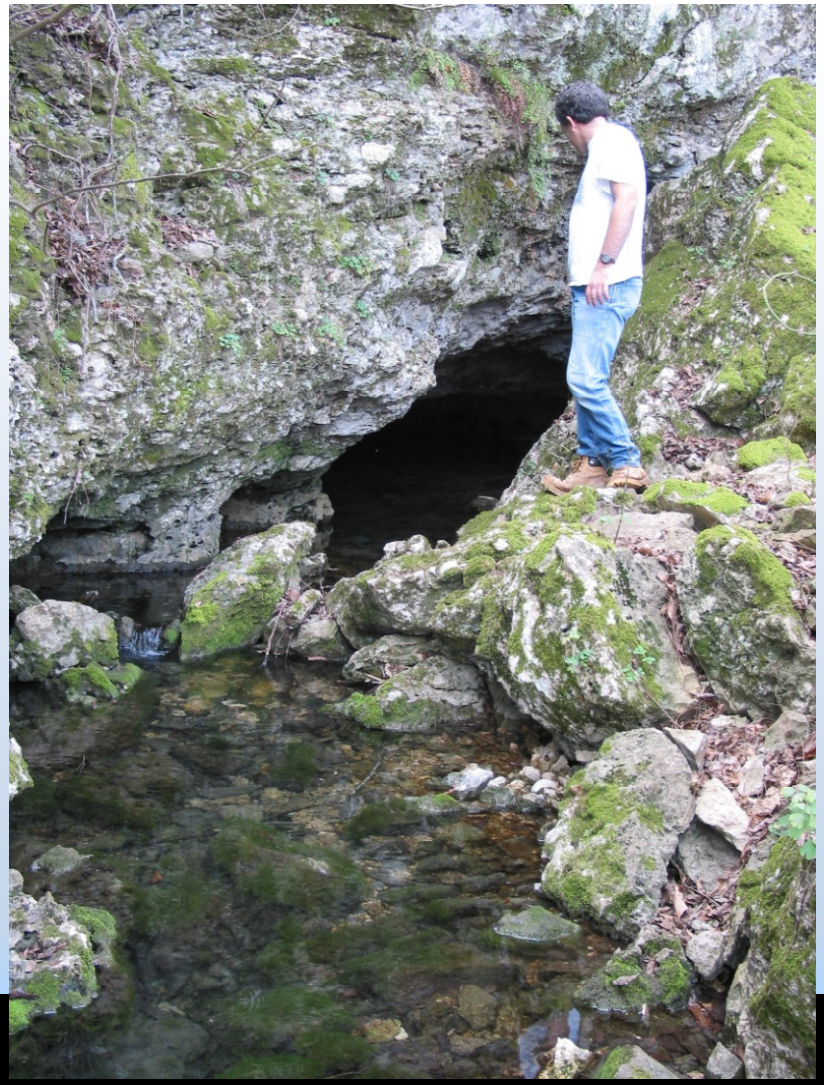


From: Ray and Currens (2001)

Permeability and Groundwater Storage

Storage of groundwater in conduits vs. diffuse and fractures

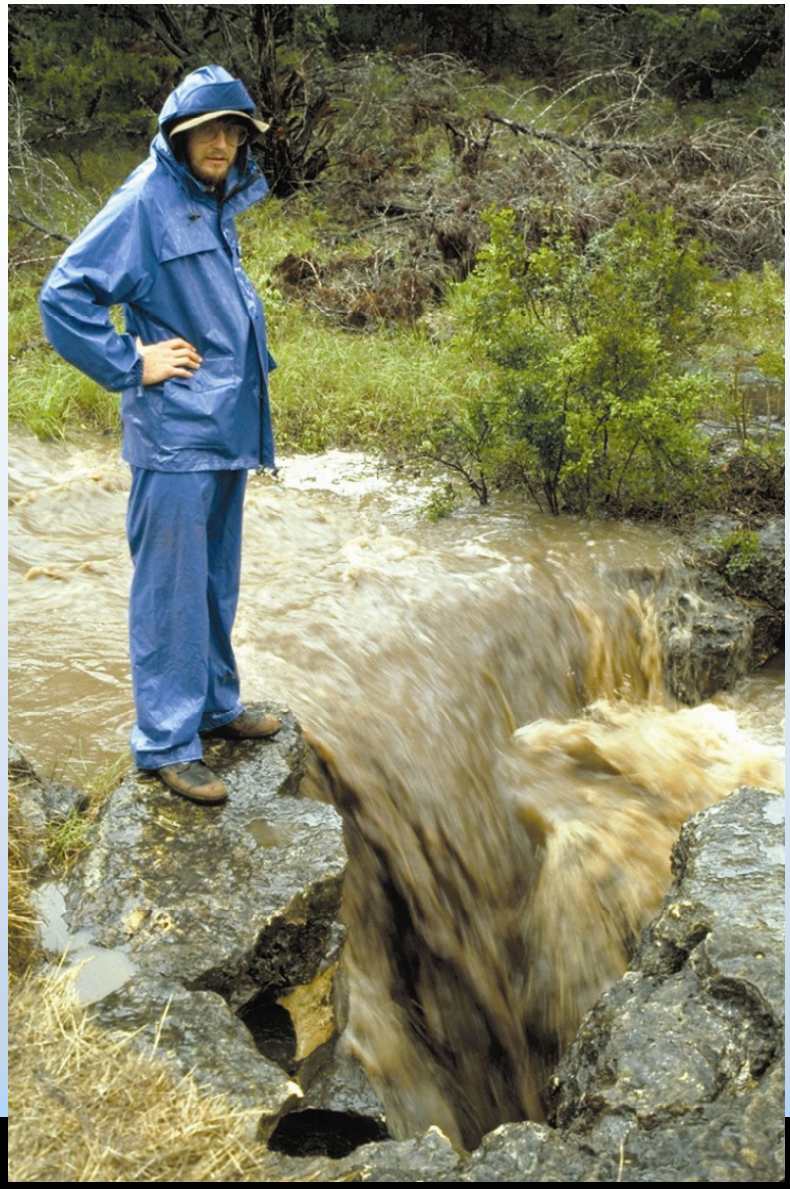
- How much waters occurs in conduits?
  Conduits store ~6%
  Conduits move ~99%



Environmental Implications of Karstic Permeability

Groundwater problems: contamination

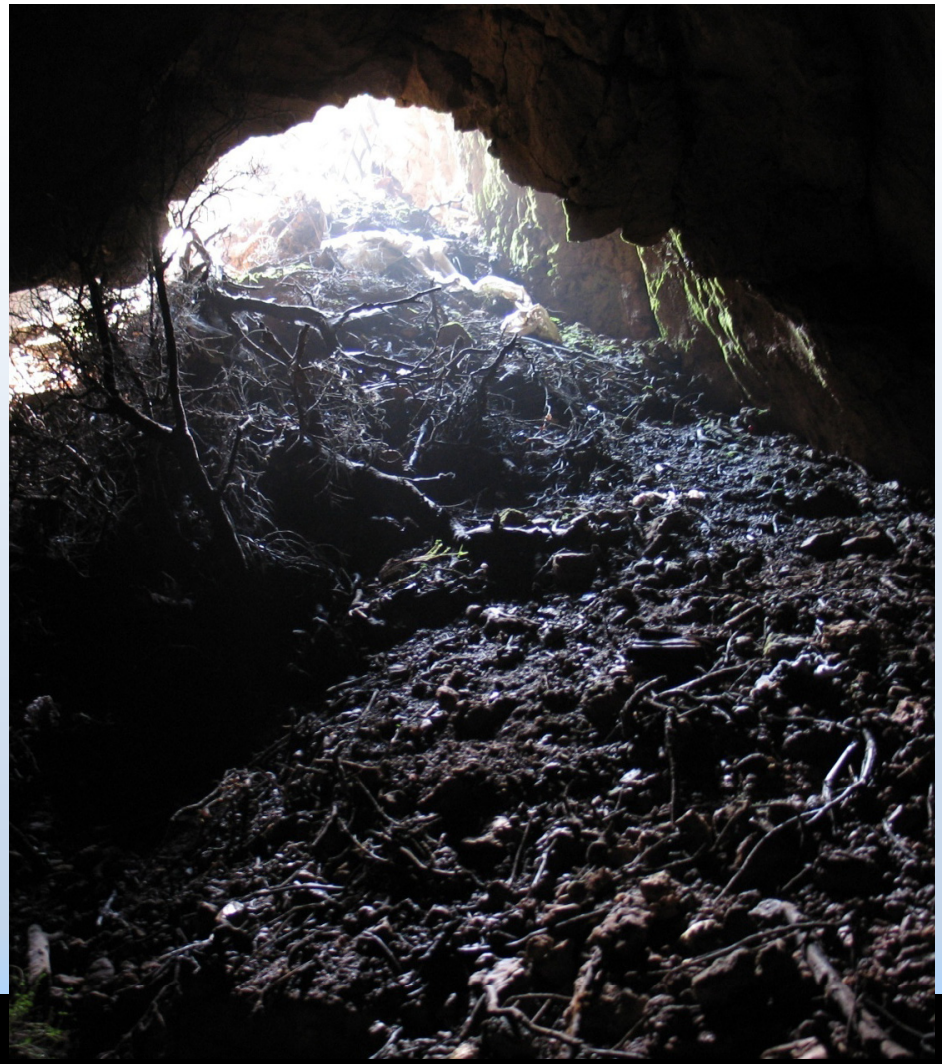
- Rapid recharge and groundwater travel time
- Effectively no filtration



Environmental Implications of Karstic Permeability

Groundwater problems: contamination

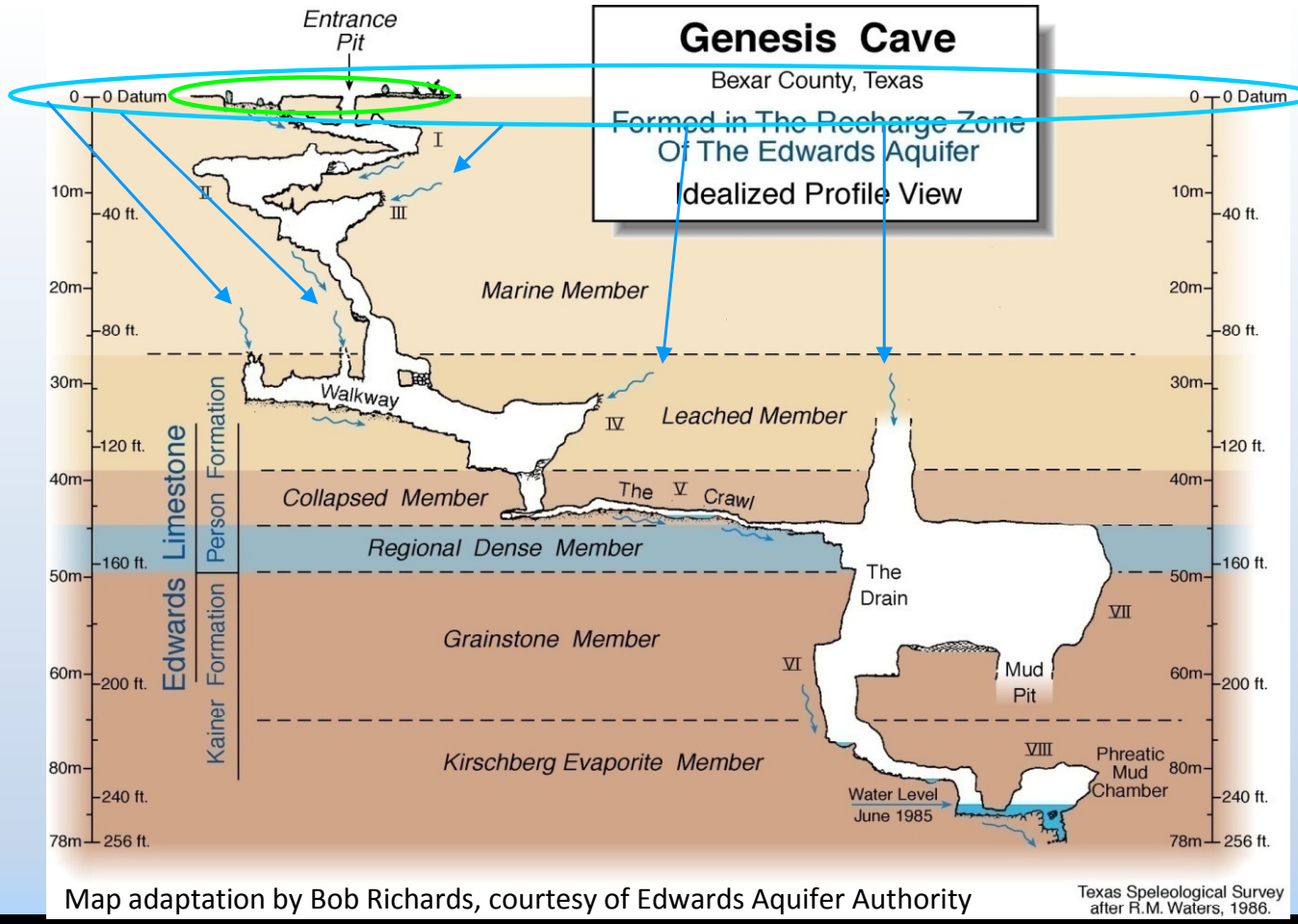
- Karst recharge allows groundwater contamination from solid waste



Environmental Implications of Karstic Permeability

Groundwater problems: contamination

- Conduit size is not a factor in preventing contamination



Map adaptation by Bob Richards, courtesy of Edwards Aquifer Authority

Texas Speleological Survey after R.M. Waters, 1986.

Environmental Implications of Karstic Permeability

Groundwater problems: contamination

- Conduit size is not a factor in preventing contamination
- Neither is the absence of caves and sinkholes

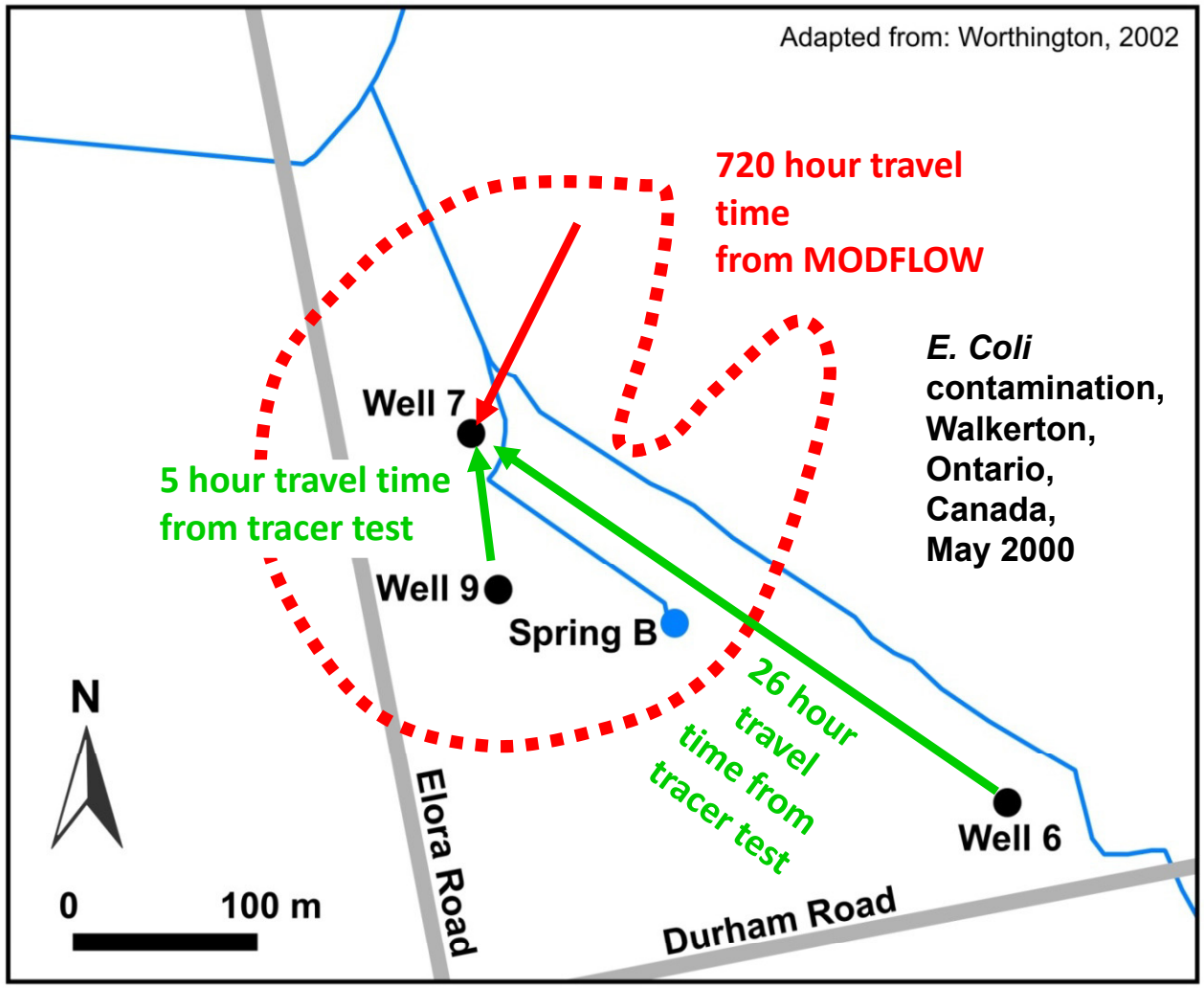
Recharge rate:
2 L/minute
Total recharge:
86,400 L
(22,810 gallons)

Environmental Implications of Karstic Permeability

Groundwater problems: contamination

- Conduit size is not a factor in preventing contamination
- Neither is the absence of caves and sinkholes

7 dead, 2,300 ill



For more examples, come to…

The Sinkhole Conference

Multidisciplinary Conference on Sinkholes & the Engineering and Environmental Impacts of Karst

5-9 October 2015

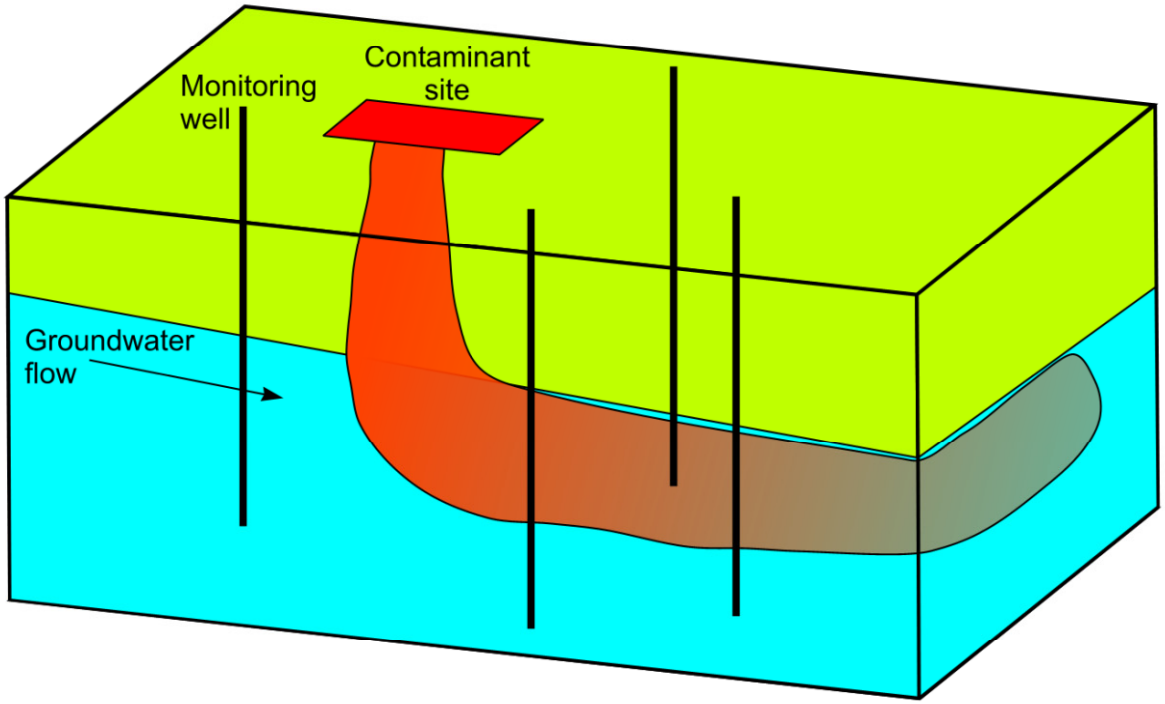
Rochester, Minnesota

www.sinkholeconference.com

Environmental Implications of Karstic Permeability

Monitoring contaminant movement

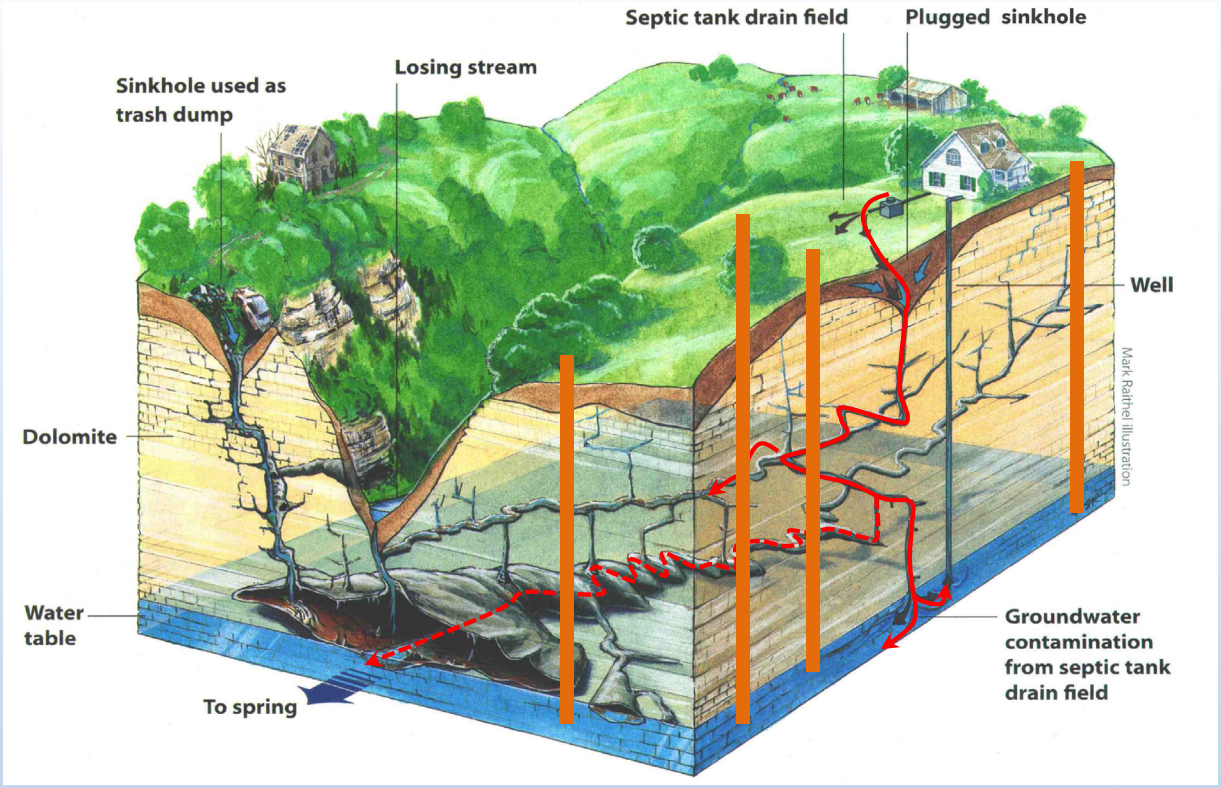
- Typical contaminant monitoring in porous media aquifers



Environmental Implications of Karstic Permeability

Monitoring contaminant movement

- No true plumes in karst aquifers
- Spring and conduit monitoring is necessary

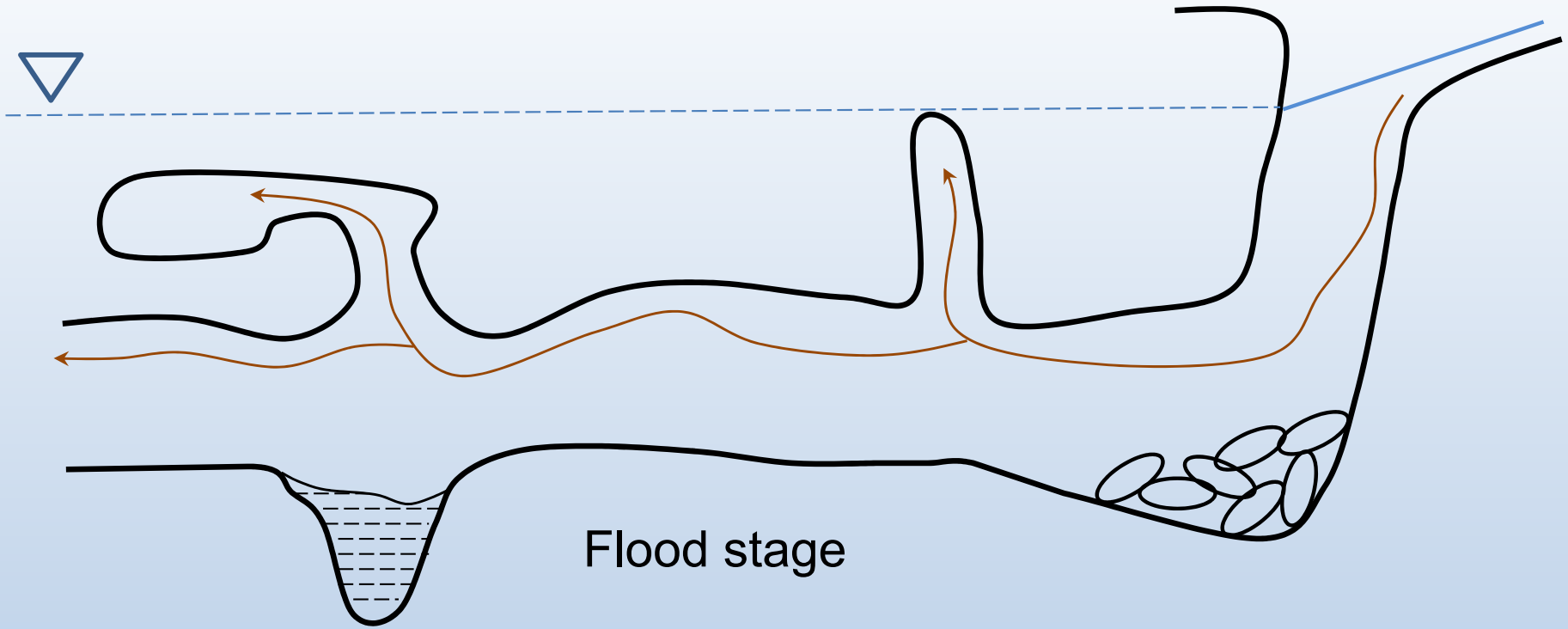


Adapted from: Missouri Department of Natural Resources

Environmental Implications of Karstic Permeability

Monitoring contaminant movement

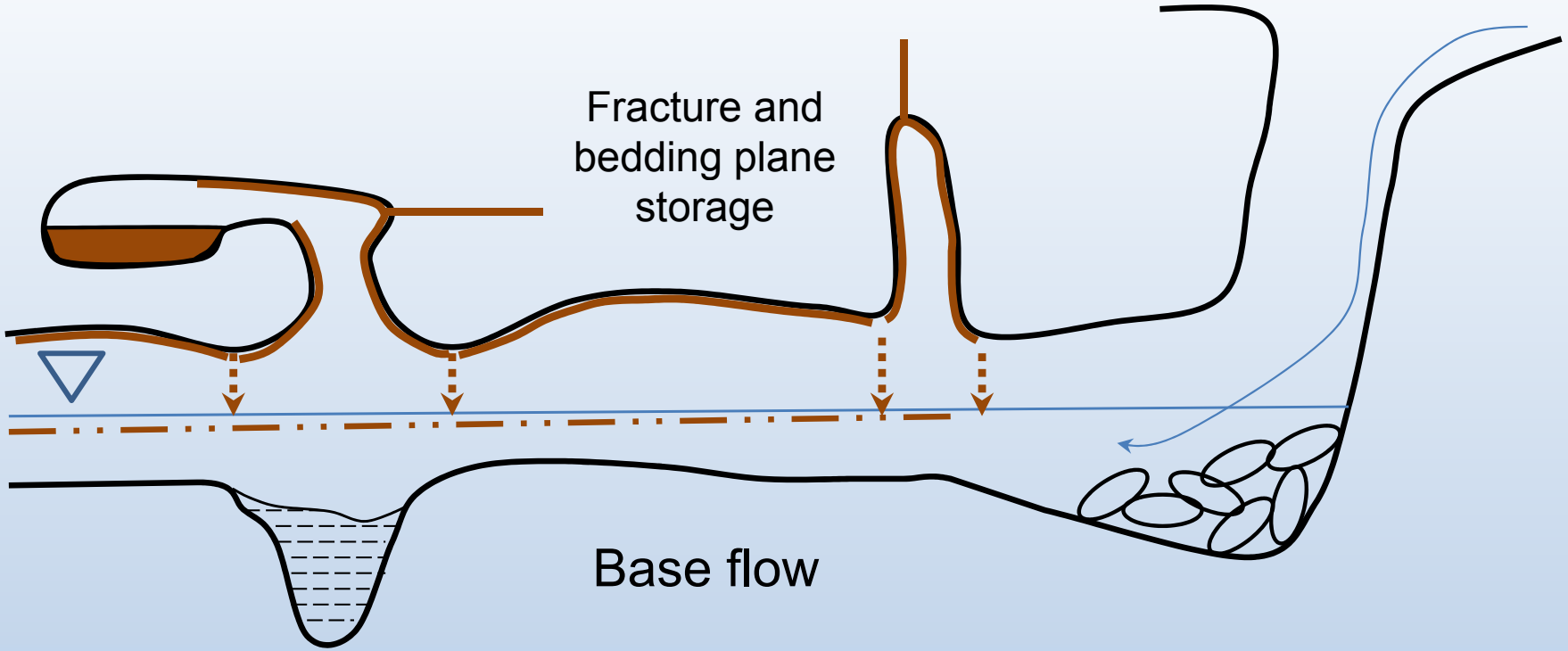
- Variable movement depending on which flowpaths the contaminants move and are stored



Environmental Implications of Karstic Permeability

Monitoring contaminant movement

- Variable movement depending on which flowpaths the contaminants move and are stored



Environmental Implications of Karstic Permeability

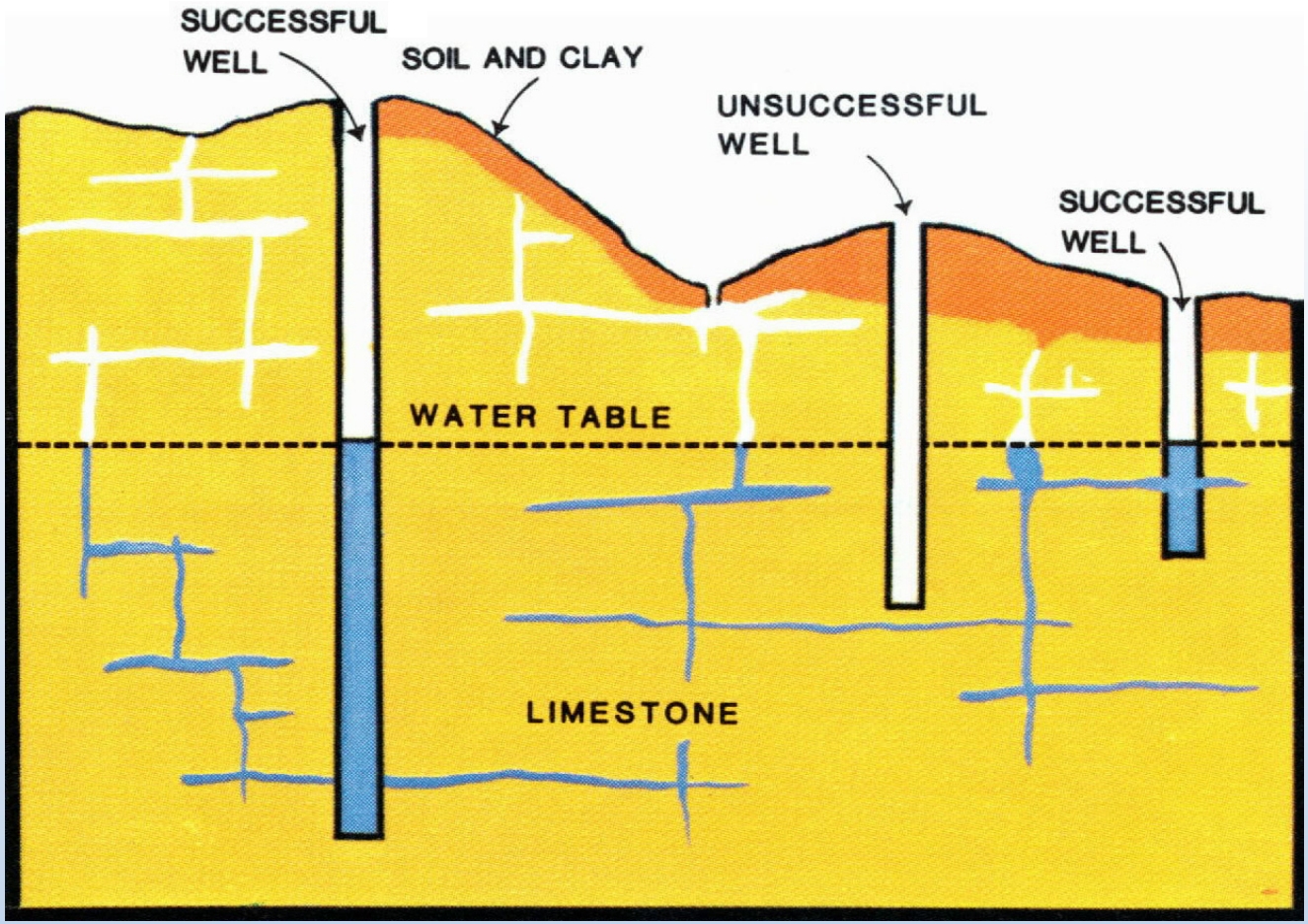
Groundwater problems: water quantity

- Karst aquifers have a high capacity for rapid recharge and rapid discharge

Environmental Implications of Karstic Permeability

Groundwater problems: water quantity

- Finding water
- Dry wells
- Water table??



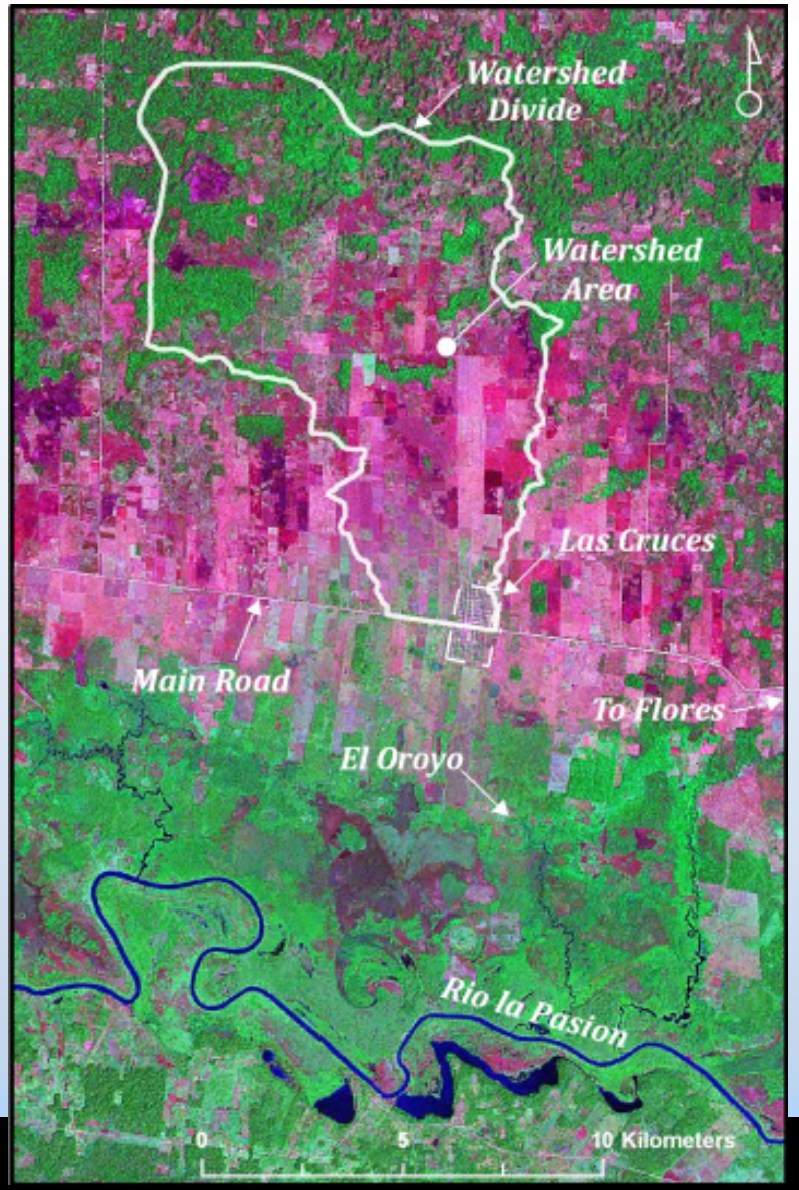
From: Edwards Underground Water District & Edwards Aquifer Research and Data Center, 1981

Environmental Implications of Karstic Permeability

Groundwater problems: water quantity

- Karst flooding

Photo and figure: Engineers Without Borders (2010)



Environmental Implications of Karstic Permeability

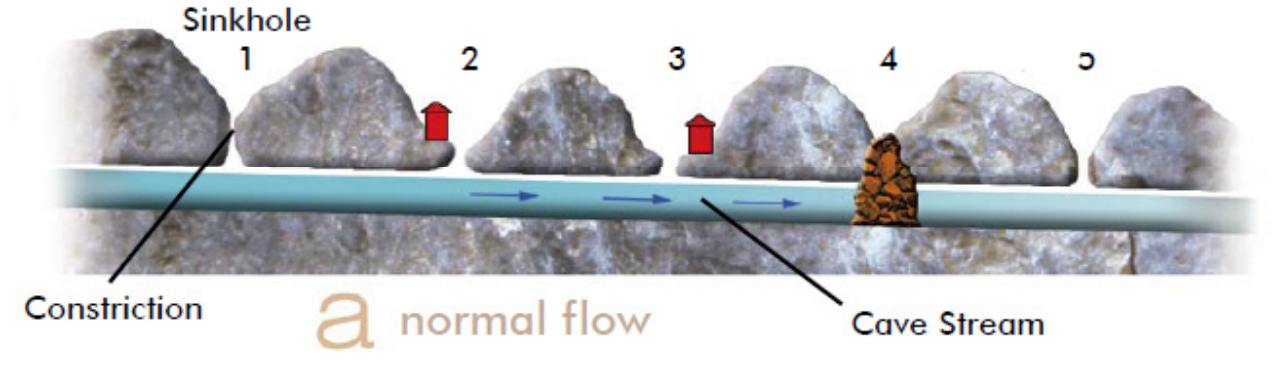
Groundwater problems: water quantity

- Karst flooding
- Sedimentation
- Increased runoff
- Decreased sinkhole volume

Environmental Implications of Karstic Permeability

Groundwater problems: water quantity

- Karst flooding
- Sedimentation
- Increased runoff
- Decreased sinkhole volume
- Upgradient stormwater injection

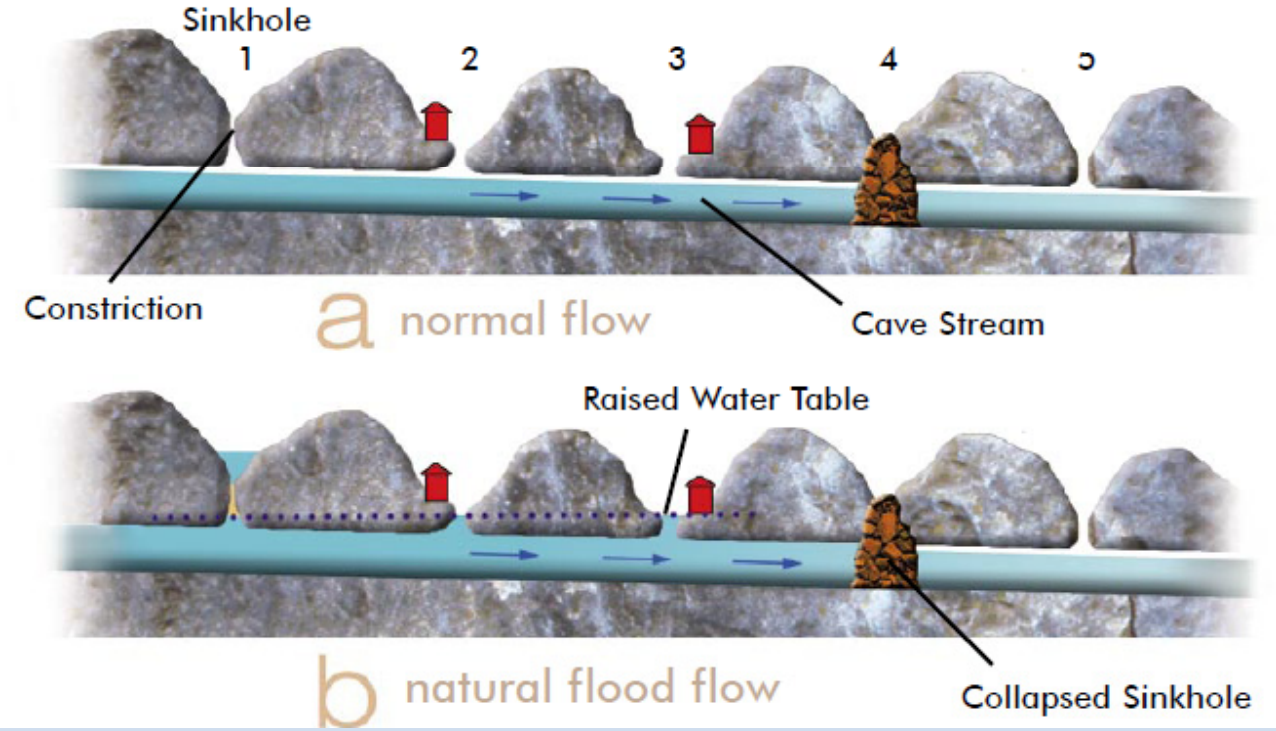


From: *Living with Karst*
(Veni and DuChene, 2001)

Environmental Implications of Karstic Permeability

Groundwater problems: water quantity

- Karst flooding
- Sedimentation
- Increased runoff
- Decreased sinkhole volume
- Upgradient stormwater injection

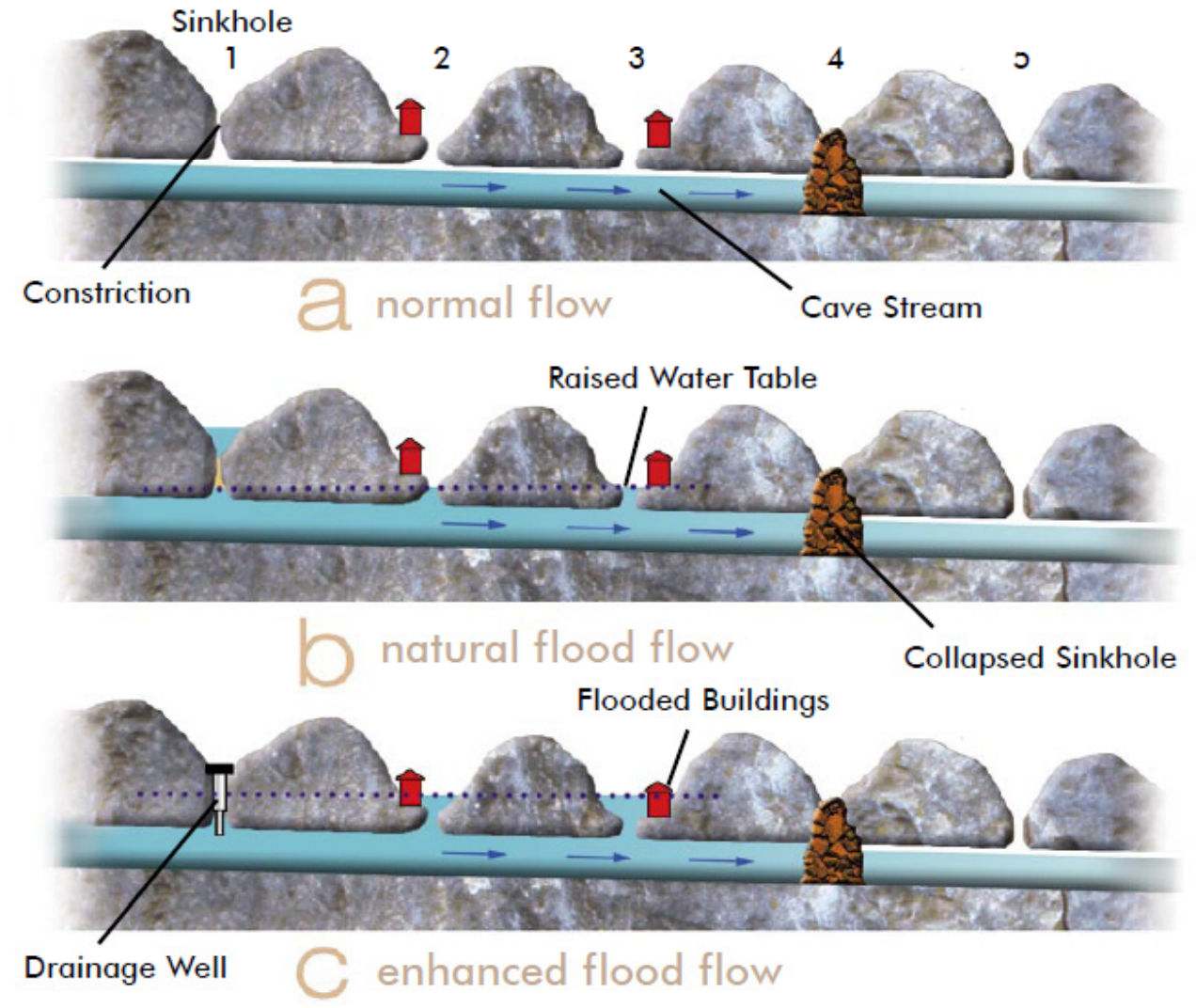


From: *Living with Karst*
(Veni and DuChene, 2001)

Environmental Implications of Karstic Permeability

Groundwater problems: water quantity

- Karst flooding
- Sedimentation
- Increased runoff
- Decreased sinkhole volume
- Upgradient stormwater injection



From: *Living with Karst*
(Veni and DuChene, 2001)

Environmental Implications of Karstic Permeability

Land management problems: sinkhole collapse

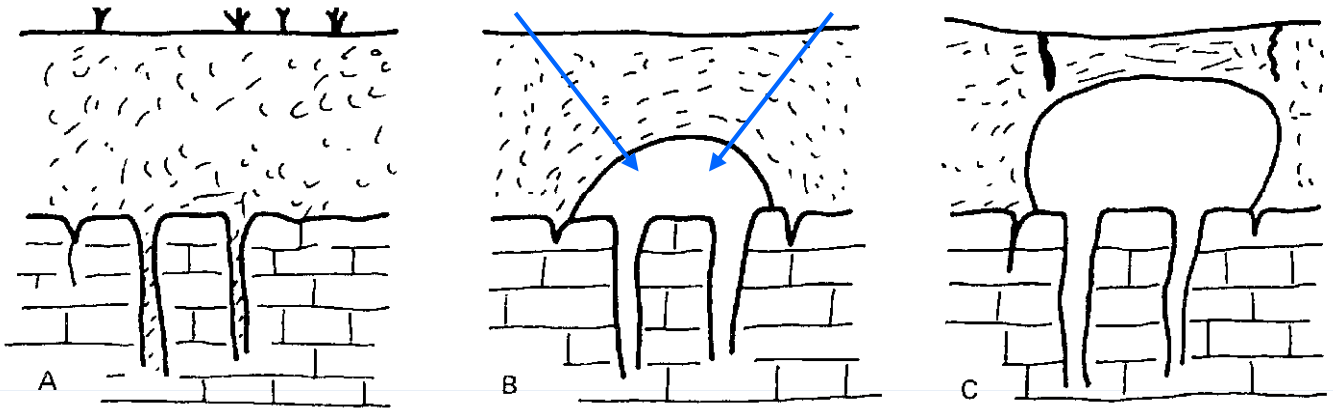
- Natural
- Induced

Winter Park Sinkhole, Florida, USA.
Source: unknown, worldwide web

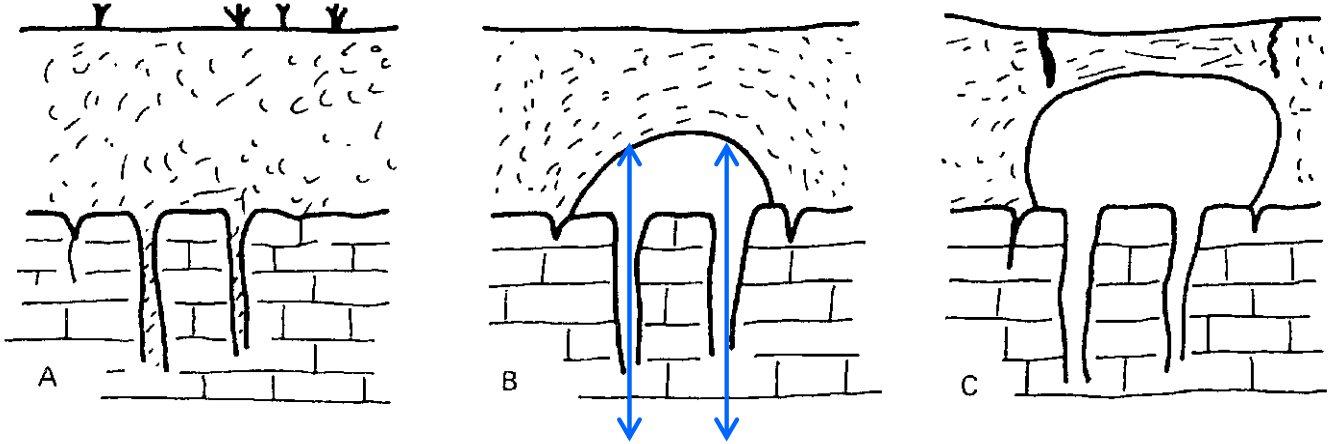
Environmental Implications of Karstic Permeability

Land management problems: sinkhole collapse

- Induced
  - ➢ Cover collapse



Induced recharge



Fluctuating water table

Adapted from: *Geomorphology & hydrology of karst terrains* (White, 1988)

Curious about karst groundwater and…

Then for that and more, we'll see you at…

The Sinkhole Conference

Multidisciplinary Conference on Sinkholes & the Engineering and Environmental Impacts of Karst

Jointly organized with the MGWA

5-9 October 2015

Rochester, Minnesota

www.sinkholeconference.com