

Why are liners useful for karst?

by

Carl Keller

**5th Conference on Hydrogeology, Ecology,
Monitoring and Management of Ground Water
in Karst Terrains**

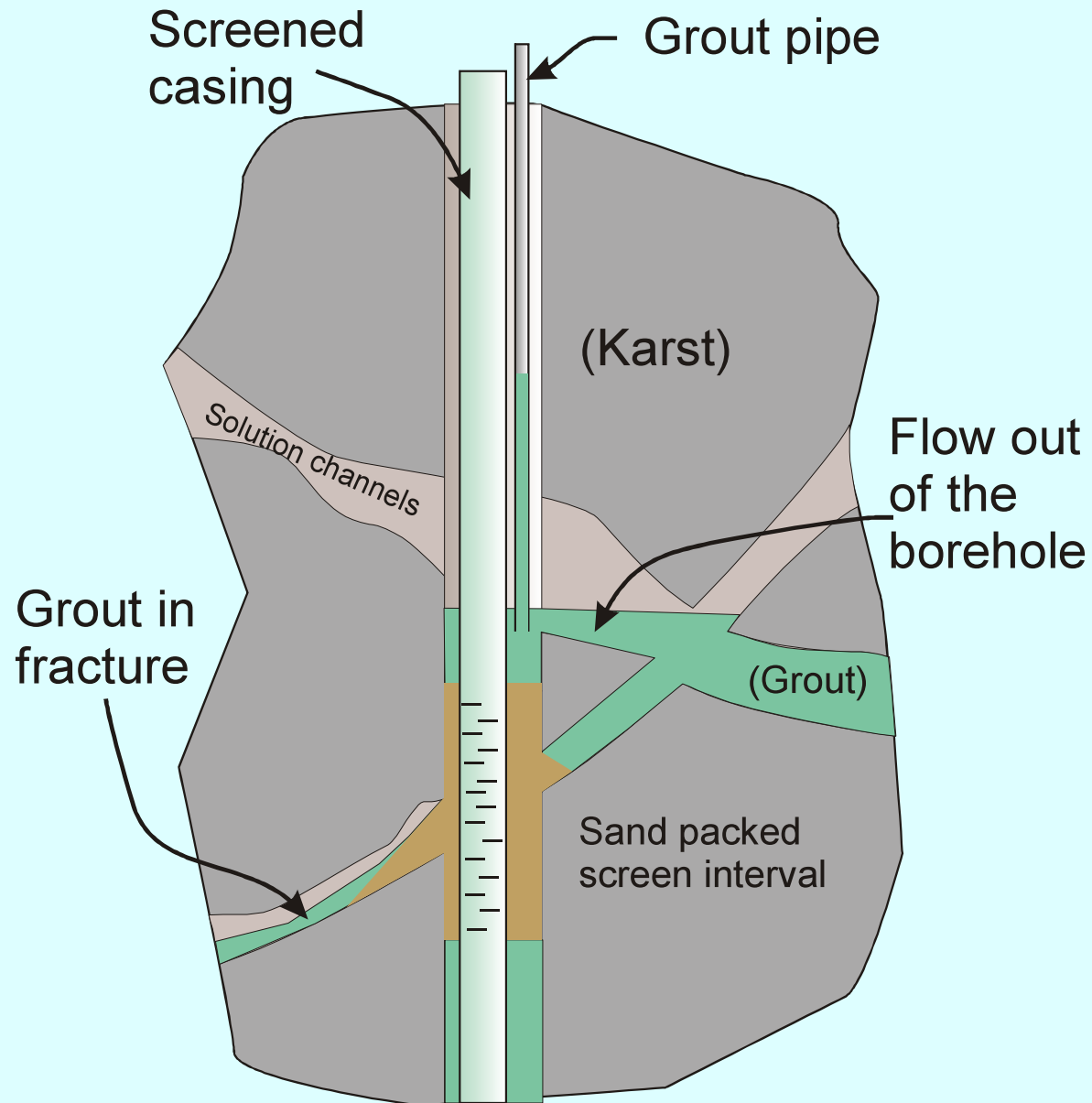
February 23-24, 2009

**Safety Harbor Resort and Spa, Safety Harbor,
Florida**

Topics

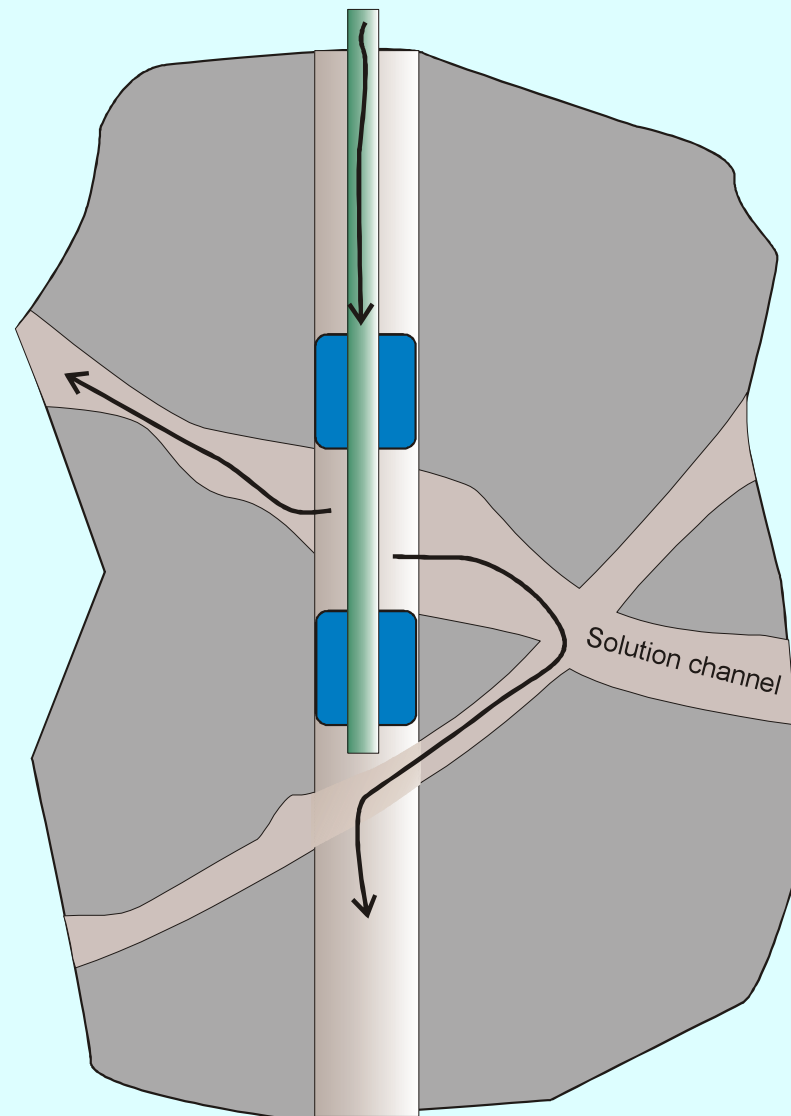
- **Problems in karst formations**
- **How liners work**
- **Sealing of boreholes**
- **Transmissivity measurements**
- **Multi level sampling systems**
- **Mapping of NAPLs**
- **Summary of advantages to karst investigations**

The grout problem in karst

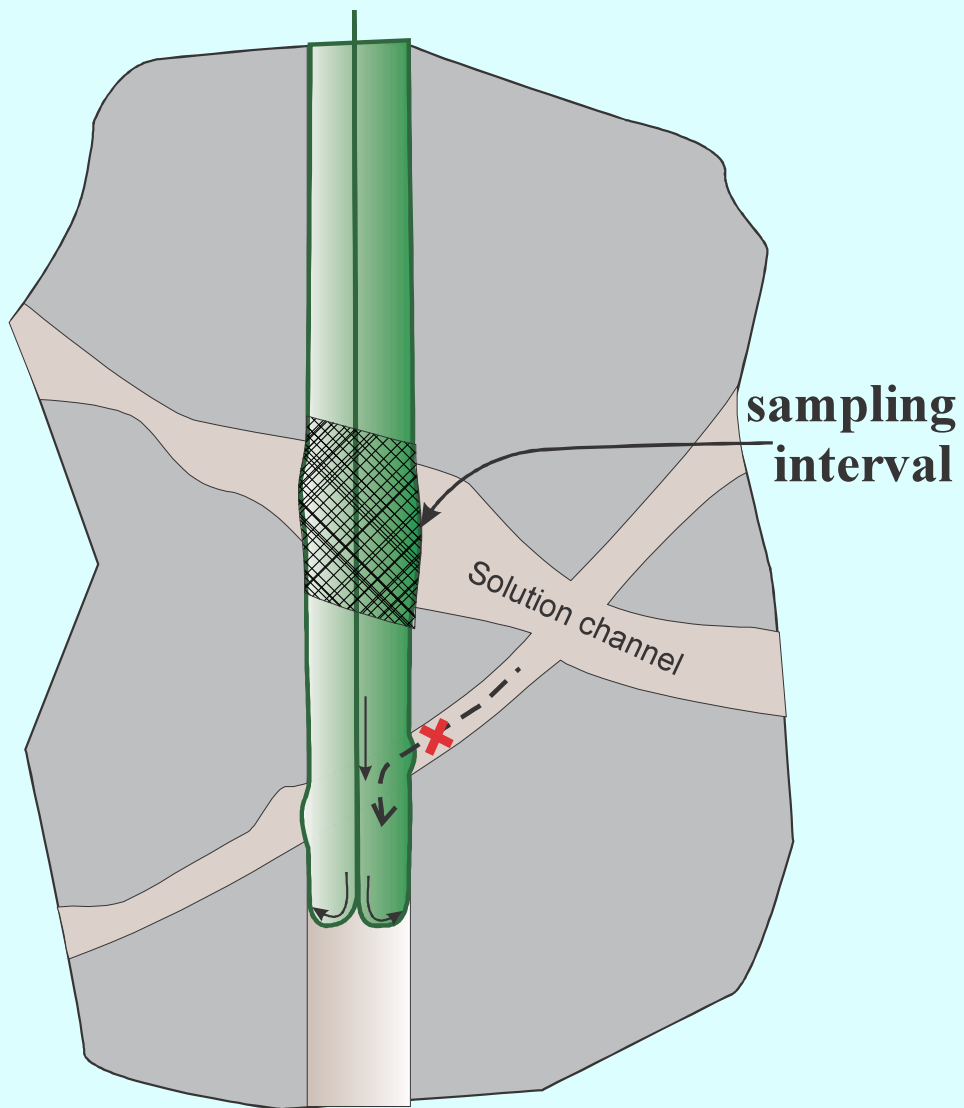


Potential packer problem in karst

The packer seal is bypassed in the formation



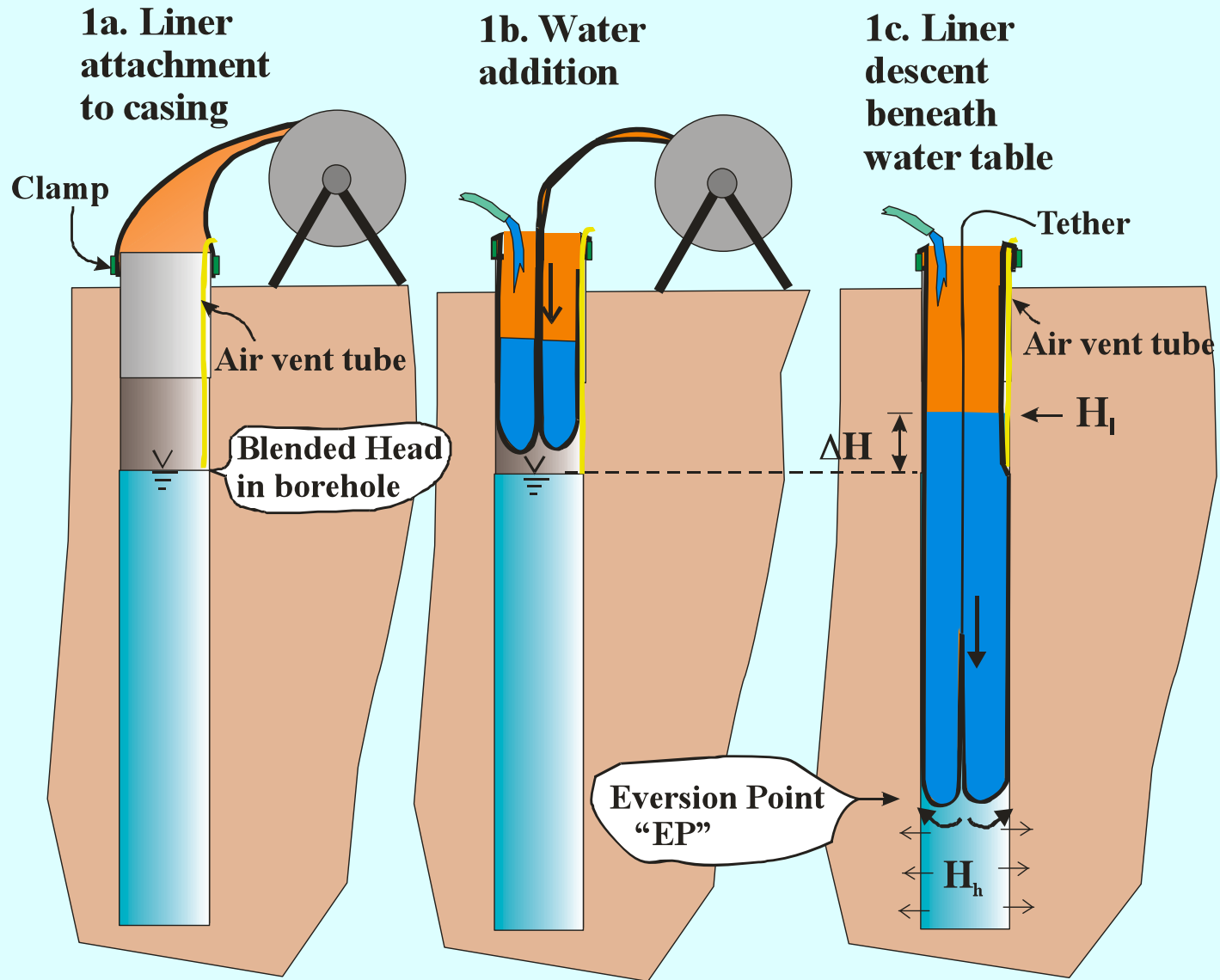
The Water FLUTe multi-level sampling liner avoids bypass



Other common karst problems

- Large vertical flow rates in the open hole, and cross connection obscure contaminant distribution.
- High flow rates in the fractures and other transmissive features exceed the limits of many measurement devices.
- Tracer tests are frustrated by both of the above, and by the open hole storage volume.

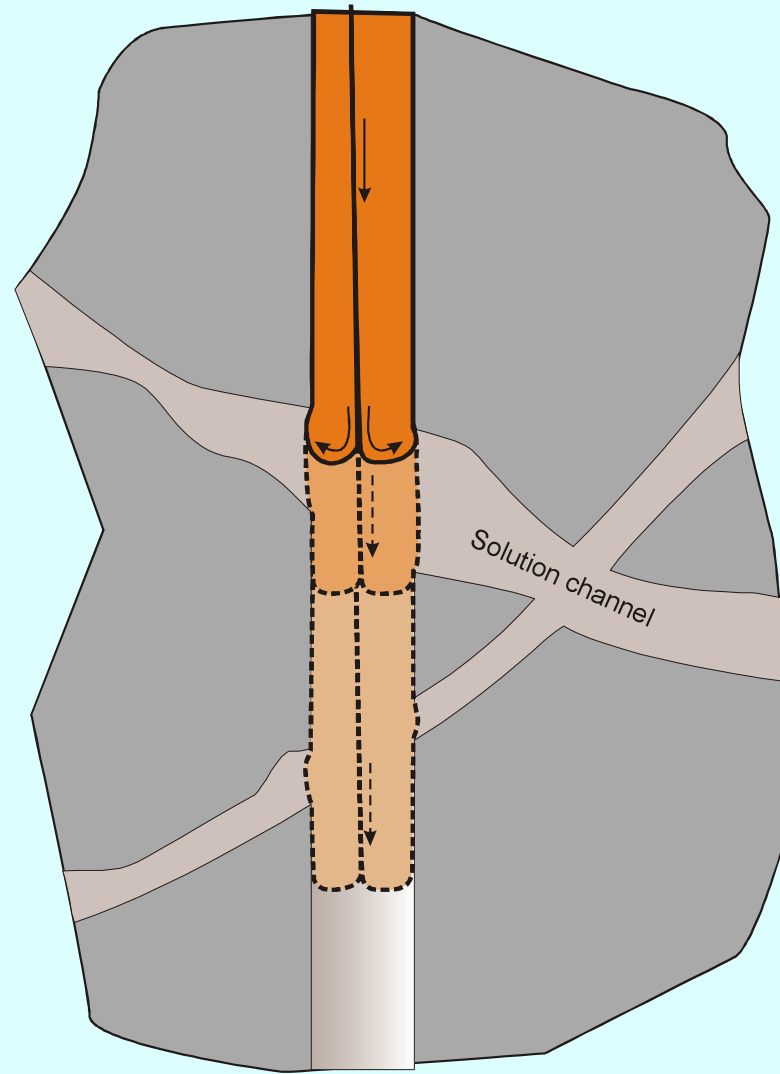
The blank liner quickly seals the hole



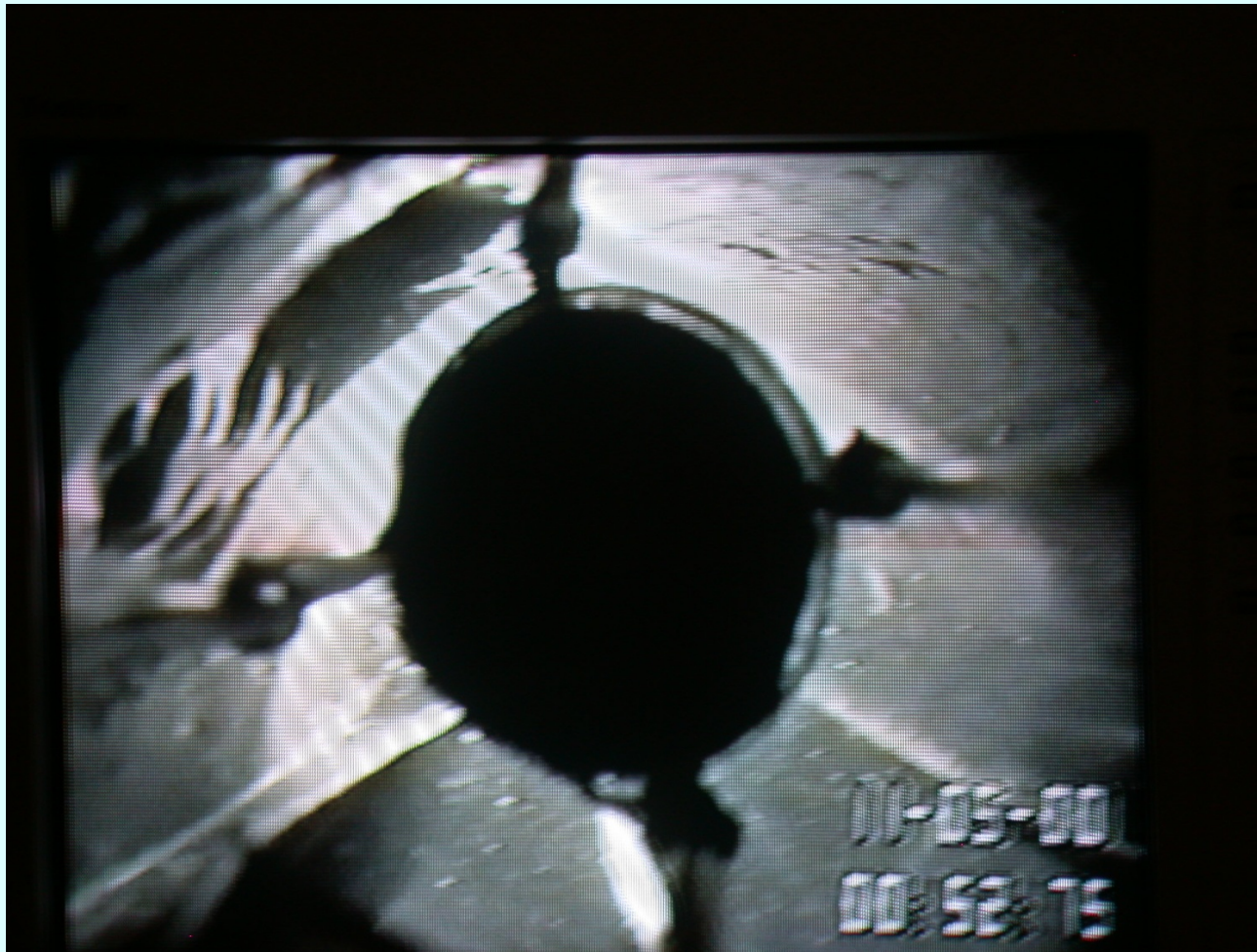
The flexible liner everts through large openings in the borehole

No grouts or bentonite are required to seal the borehole.

The liner can not be bypassed in the formation



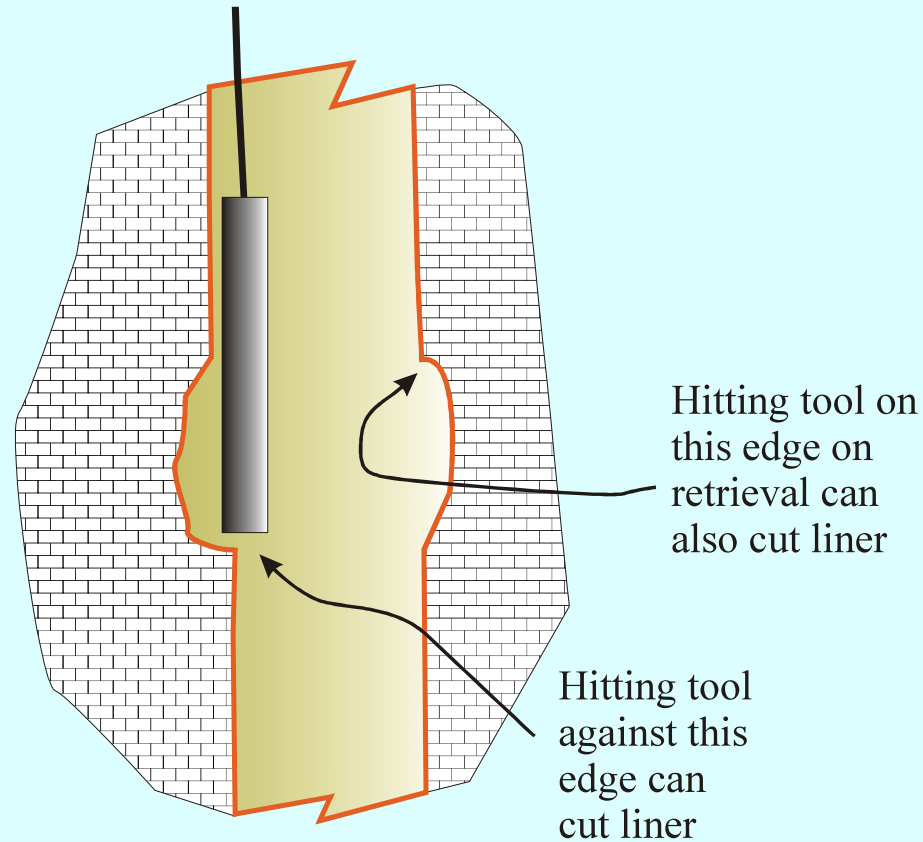
The liner melds with the borehole structure



Many logging tools can be run inside the sealing liner

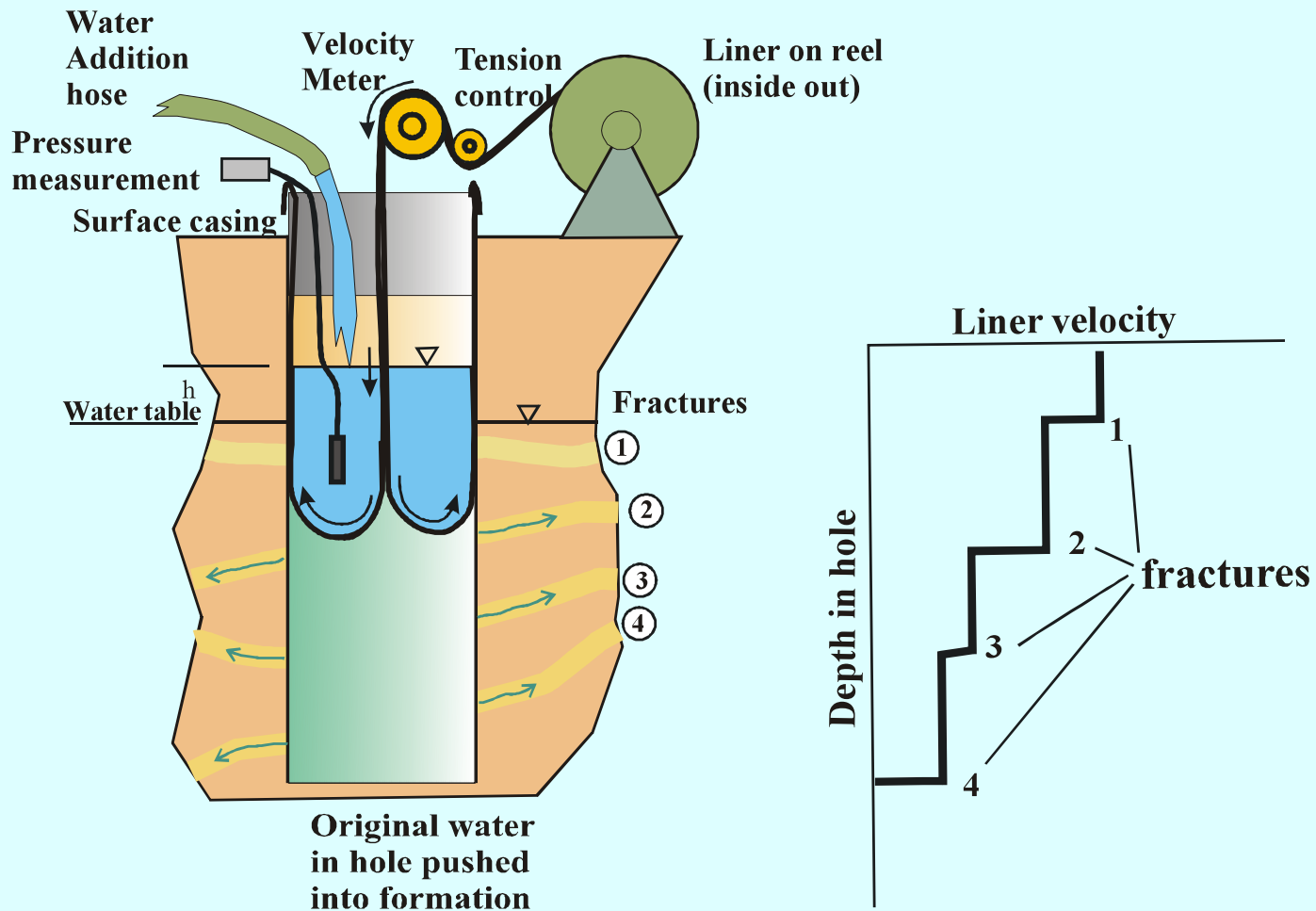
1. High resolution temperature logs
2. Sonic logs
3. Radiation logs of several kinds
4. Radar
5. Induction coupled electric logs

However, the sondes must be padded and "faired" to avoid damage to the liner

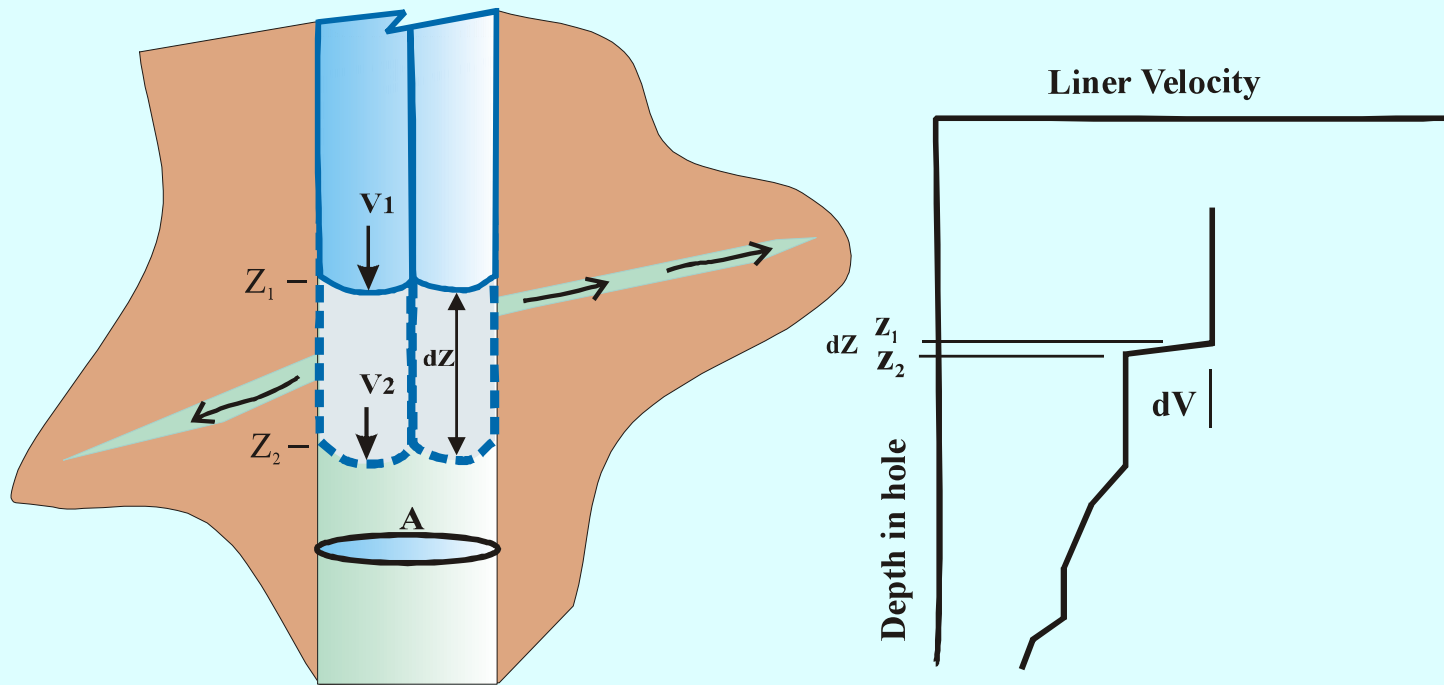


Pad the top and bottom of tools to reduce impact on ledges and damage to liner

Measurement of the blank liner installation velocity gives a transmissivity profile in 1-2 hrs typically



Each time a fracture is sealed, the liner velocity drops

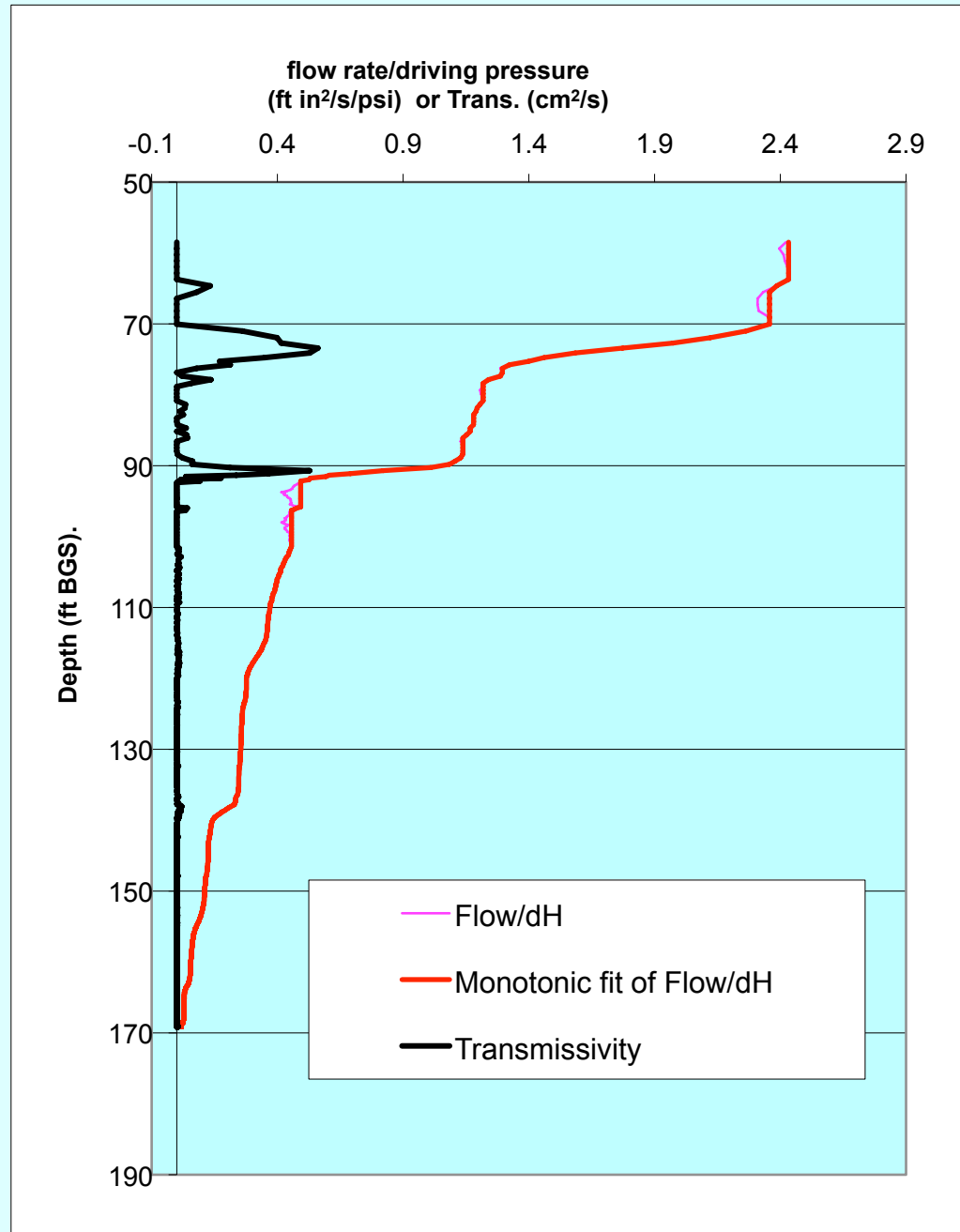


Flow rate into the fracture, $dQ = A(V_1 - V_2)$, where $V_1 > V_2$

$$T = 2 \int dQ \ln(r/r_0) dH$$

A velocity history in NJ produced this transmissivity profile

Flow rates of 50-100 gal/min are common in karst boreholes



An occasional difficulty in karst is the propagation of the liner through a large void into the hole beyond

One solution is to drop the driving pressure in the liner to allow it to hang more nearly vertical.

In some cases, “eversion aids” have been used to aid the liner propagation through voids.

Rarely has the presence of a large void prevented the liner installation.

By the way, no liner has ever been trapped by slough of the hole wall.

Once the sampling intervals are defined, the blank liner is replaced with a multi level sampling system

- The MLS liner seals the entire hole
- All of the water in the borehole is inside the liner
- The samples are drawn directly from the formation
- Up to 15 ports are installed in a 6 inch diameter hole
- All ports can be purged and sampled simultaneously
- It is fully removable

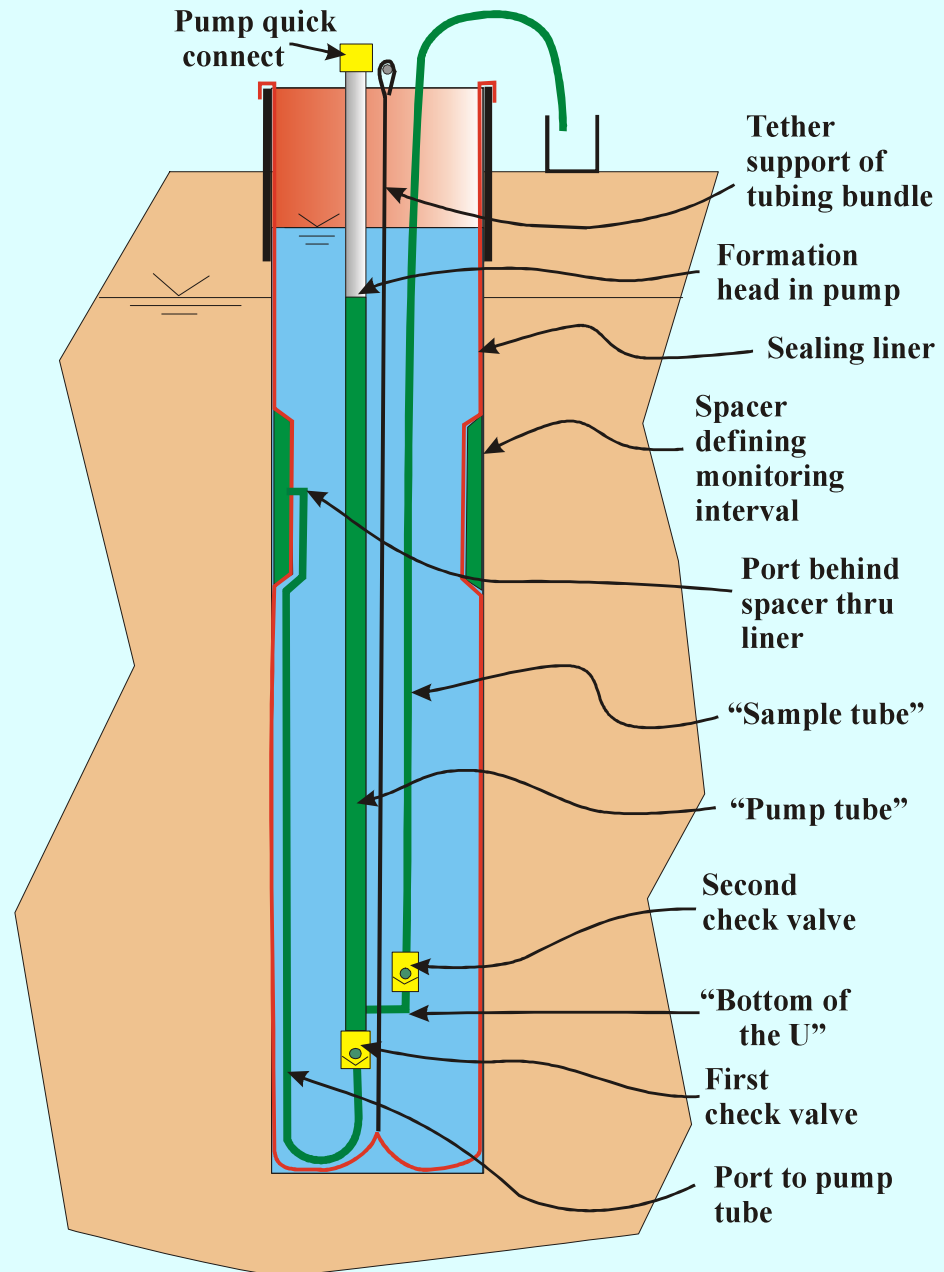
Here is how it is done:

Multi level sampling system in a liner

No grout or sand is required

The liner seal can not be bypassed to an open hole

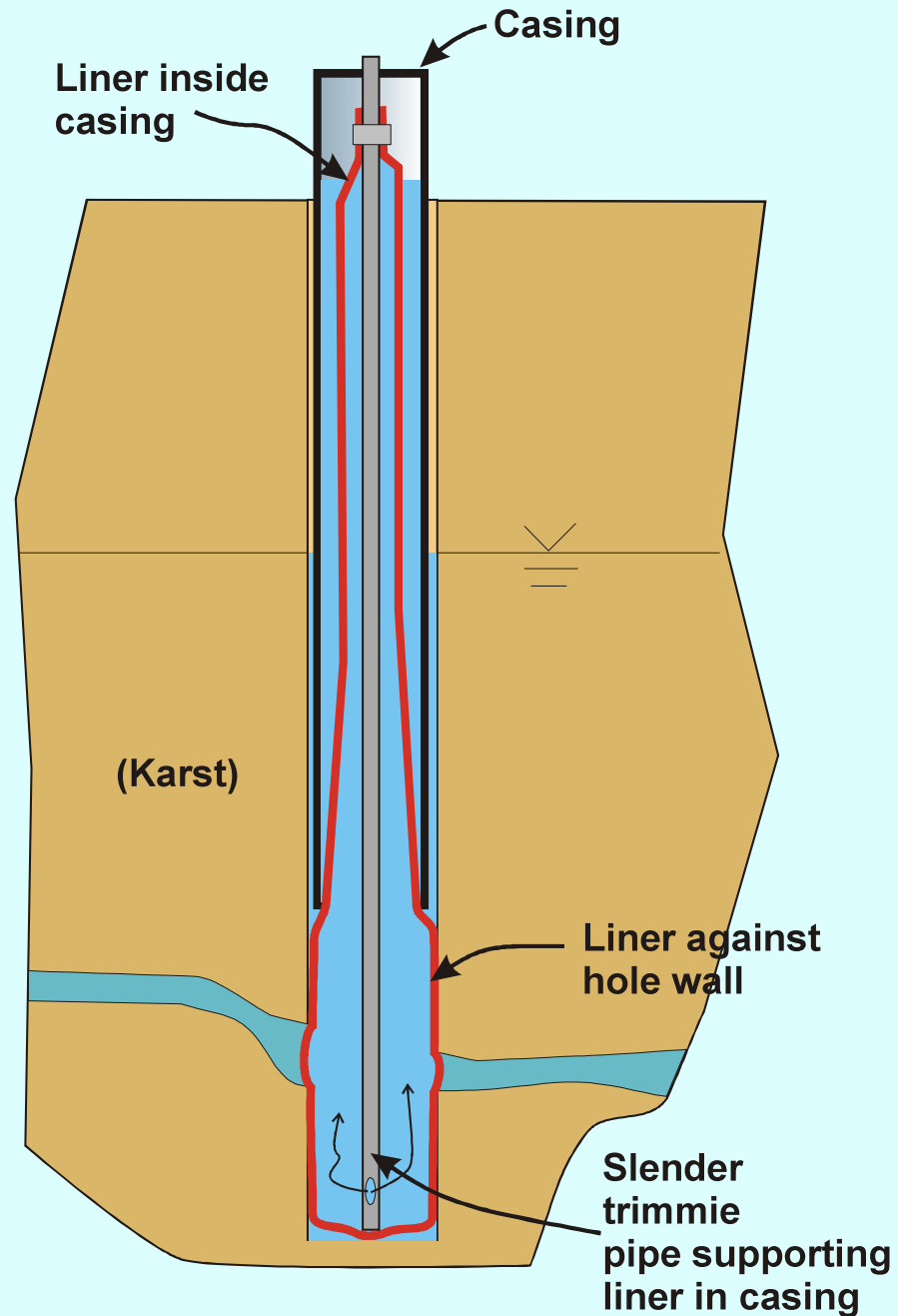
(Single port system shown for clarity)



Liner systems have been used at many karst sites

- Knoxville, TN
- Huntsville, AL
- Pittsburg, PA
- Fort Erie, Ontario, Canada
- Kokomo, IN
- Rome, GA
- San Antonio, TX
- Plus many other sites with karst like conditions.

Some multi-level systems have been installed through driven casing in unstable formations



**A color reactive cover on a blank liner
can map NAPL pure product**



In summary:

- A liner can propagate through voids, providing a continuous seal of the hole.
- Some geophysical logs can be run inside the sealing liner.
- The transmissivity profiling method works in karst formations.
- The liner systems require no annular sealing material to be added to the borehole, and therefore none is lost to the formation.
- All the water in the borehole is inside the liner and the sampling system can be short stroked to monitor for tracers.
- The systems are fully removable and not entrapped by hole slough.
- Use of the several liner systems minimizes the total time the hole is open to cross connection.

Thanks for your attention

More details are available on our website
www.flut.com

Note, the liner methods described are protected by several patents.