Characterization of fracture connectivity in a siliciclastic bedrock aquifer near a public supply well (Wisconsin, USA)

Electronic supplementary material

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Standard operating procedure for using the light weight straddle packer

Construction: The system was built in August 2011 by Pete Chase (Wisconsin Geological and Natural History Survey) and Christopher Gellasch using Lansas Multi-Size Flow Through packers (www.lansas.com) and a one-foot (0.30 m) long steel, 2-inch (5.1 cm) diameter well screen. The top packer was custom built with connectors and air ports on both ends and the bottom packer is a standard part number 092-48 packer. The bottom of the assembly is sealed with an expanding well plug. The two packers are connected in series to an airline and inflate at the same time. The top of the assembly is a 2 inch (5.1 cm) diameter schedule 80 PVC connector with National Pipe Thread (NPT) threads on the bottom. Two inch (5.1 cm) diameter schedule 80 PVC pipe is used as a riser to the surface. For measurement purposes, the top of the assembly is the seam between the PVC connector and the riser pipe.

Important measurements (see Figure ESM1):
A. Total length of packer assembly: 4.33 feet (1.29 m)
B. Length from center of well screen to top of assembly: 2.44 feet (0.744 m)
C. Length of open interval during packer inflation: 2.31 feet (0.704 m)

Technical data:

- Minimum well diameter: 3.8 inches (9.65 cm)
- Maximum well diameter: 6.25 inches (15.9 cm)
- Packer inflation pressure: 30 psi (0.207 MPa) at surface*
- Maximum head difference across packer: 15 psi (0.103 MPa) or ~35 feet (10.7 m)
- Bypass diameter: 2 inches (5.1 cm). Note: upper packer bypass contains an inflation line and may not allow pumps to pass.

*If inflating packer below water level the following calculation must be used

[Depth of packer below water (ft) x 0.43 psi/ft] + 30 psi
[Depth of packer below water (m) x 9.73×10^{-3} MPa/m] + 0.207 MPa

Example: At 100 feet below water, the packer must be inflated to (100 ft x 0.43 psi/ft) + 30 psi = 73 psi

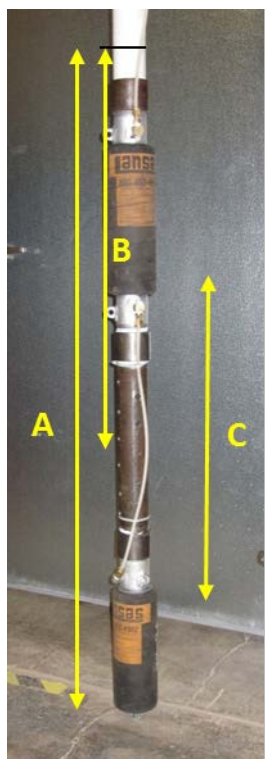

Figure ESM1 Straddle packer. Measurements for *A*, *B* and *C* are given above

Before deployment in borehole:

1. Secure a safety line to the eyelet on the top packer.

2. Connect the air line from a compressed nitrogen tank to the packer air port.

3. Connect the assembly to a 10-foot (3.05 m) PVC riser pipe followed by a lifting cap with eyelet. Connect the chain from the lowering winch to the lifting cap.

4. Use electrical tape to attach a measuring tape to the PVC riser pipe with 2.44 feet (0.744 m) aligned with the seam between the bottom of the riser and the top of the PVC to NPT connector. This will allow for accurate depth determination for the center of the screen. Fold up the first 2+ feet of the tape and secure it to the riser.

Packer deployment:

1. Lower the packer assembly to the desired depth in borehole. When adding additional riser sections, use a well pipe clamp to secure the assembly. Also ensure the safety line is taut before disconnecting the lifting cap. Use electrical tape to secure the measuring tape and a zip tie to secure the air line and measuring tape to the top of each section of riser.

2. Once at the proper depth, use the clamp and safety line to secure the assembly before removing the lifting cap. Use an electric tape to measure the water level inside the riser. Subtract the height of the PVC riser above the reference point (i.e. top of steel casing) to have a consistent water level measurement.

3. Calculate required pressure for inflation of the packers (see above) using the difference between the depth to water from top of casing and the packer depth. Multiply this depth by 0.43 psi/ft and then add 30 psi.

4. Insert a Solinst Levelogger connected to real-time cable into the riser until it is approximately 10 feet (3.05 m) below water level. Use electrical tape to secure the cable to the riser to prevent movement. Record this depth and also log the data on the laptop using the real-time data feature and/or internal logger data collection. It is recommended to record data at one second intervals.

5. Inflate the packer assembly with compressed nitrogen. Ensure the pressure does not exceed the calculated value to avoid damaging the packers. Use the Solinst Levelogger real-time data display to determine when the head in the packed interval has reached equilibrium. Use the electrical tape to record the water level.

6. Conduct slug testing once the head reaches equilibrium. Ensure the slug is fully submerged and be aware that riser height above the datum will vary at different depths, which will require new calculations and measurements for rope length. Save slug testing data to a file.

7. Conduct well sampling. If using a Grundfos submersible pump, the Solinst Levelogger will have to be removed because the pump is too large to accommodate the real time data cable. The pump can be lowered only to the top of the packer assembly because the pipe inside the packer contains fittings that prevent the pump from being lowered to the level of the well screen.

8. Deflate the packer by closing off the regulator and opening the bleed valve. Ensure the line pressure is at 0 psi.

9. Attach the lifting cap, remove the clamp, double check the packer is deflated, and move the assembly to the next depth.