HydroTechnics™ Sensor Installation

- HydroTechnics™ sensors provide information on groundwater flow velocity and direction based on propagation of induced thermal gradients.
- Sensors are installed directly into a boring and output data continuously to a datalogger for up to 2 years.
HydroTechnics™ Sensor Installation

- A heating element within the probe heats the groundwater inside the probe to 20-30°C above background.
- The temperature distribution at the surface of the probe provides a 3-D interpretation of groundwater advection following computer processing of the data.
HydroTechnics™ Sensor Installation

- Data can be collected manually or remotely using a dialup connection
- Datalogger can store up to several months of output.
HydroTechnics™ Sensor Installation
## HydroTechnics™ Power Settings

### Dover AFB Funnel & Gate

<table>
<thead>
<tr>
<th>Probe ID</th>
<th>R (ohms)</th>
<th>V (volts)</th>
<th>I (amps)</th>
<th>P (Watts)</th>
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### Lowry Campus Funnel & Gate

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Calibration and Post-Processing HydroTechnics™ Sensor Data

- Run one 8-hr test where probe response is monitored as temperature ramps up; HT processes and returns calibration files
- Restart power to sensors and datalogger, then begin acquiring signal
- Download datalogger (before loop ends)
- Run PC-based programs to convert temperature data into velocity vectors
- Dump data into spreadsheets for storage and developing graphical representations.
HydroTechnics™ Results – Dover AFB

- After an initial stabilization period, the average velocity was \(~0.02-0.03\) ft/day
- Sensors in the two Fe gates responded rapidly to precipitation events
HydroTechnics™ Results – Dover AFB

- After stabilization, the flow direction was directly through the gate.
- Precipitation events briefly affected flow direction, and sometimes led to momentary reversals.
Water Level Measurements – Dover AFB

Water level maps provide evidence for asymmetric flow through both gates.

Groundwater Flow Direction Line
Velocity Measurements with a Colloidal Borescope

Schematic of the Colloidal Borescope in-situ.

Photo of the borescope.
Use of Colloidal Borescope at Lowry AFB

- Portable instrument
- Needs 2-inch-diameter completed wells
- Tracks movement of colloids in the well bore
- One instrument can be used in several wells
- Works only when flow is stable
Real-Time Acquisition of Colloidal Borescope Data
Colloidal Borescope Data – Lowry AFB

Velocity ~ 0.8 ft/day

Direction ~ North
Comparison of Results – Lowry AFB

Asymmetric Capture Zone Caused by Stream Flowing on East Side

Groundwater Flow Direction Line
Comparison of HydroTechnics™ and Borescope Results – Dover AFB
Evaluation of HydroTechnics™ Sensor Performance

- Continuous data recording over many months
- Able to record effects of rainfall events, seasonal and annual groundwater fluctuations
- HydroTechnics™ sensor measures very localized flow
- Provides velocity and direction for a single point in space, but also get temporal data
- Performance inside ZVI barrier not fully explored; e.g., did not try to optimize power input to sensor
Evaluation of Colloidal Borescope Sensor Performance

- Colloidal borescope measures particle movement along preferential flow paths
- Results biased toward high conductivity zones
- Works only when flow is stable
- Data collected over period of one day (so it’s better not to use probe during atypical conditions)
- Are borescope measurements representative of overall flow conditions? Results are uncertain.
Potential Flow Problems at PRB Sites

- The plume could pass over, under, or around the PRB

- Flux may be non-uniform, thereby creating variable velocity conditions and shifting hydraulic gradient directions

Residence time is a function of particle velocity
Implications for Designing a PRB

- There is a tradeoff between safety factors (plume breakthrough/bypass) and future risk of having to make changes to the PRB to improve hydraulic performance.
- Water-level measurements remain the best indicator of bulk groundwater flow.
- Selective use of HydroTechnics™ sensors (measures very localized flow) and colloidal borescope (measures preferential flow) may be useful at some highly heterogeneous sites.