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# **GEOPHYSICAL CHARACTERIZATION AND BOREHOLE GEOPHYSICAL TOOLS TO AID MONITOR WELL PLACEMENT AND COMPLETION**

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- **Borehole geophysics** is the collection of geologic and hydrologic information in wells by lowering and raising probes on a wire
- Much more can be learned by the analysis of a suite of geophysical logs as a group than by the analysis of the same logs individually

# **GEOHYDROLOGIC CHARACTERIZATION**

- **Fractures and water-bearing zones (location and orientation)**
- **Structural features**
- **Lithology and lithologic contacts**
- **Aquifer hydraulic characteristics**
- **Groundwater flow system**
- **Hydraulic head differences**
- **Well construction**

# BOREHOLE GEOPHYSICS

- **For new monitor wells**
  - **Proper location to set well screen**
  - **Aquifer characteristics**
  - **Hydraulic connections between monitor wells**

# BOREHOLE GEOPHYSICS

- **For existing (domestic) wells**
  - **Well construction characteristics (depth, casing length, water-bearing zones)**
  - **Aquifer hydraulic characteristics**
  - **Water quality**

# BOREHOLE GEOPHYSICS STANDARD LOG SUITE

- Caliper
- Natural gamma
- Single-point electric
- Fluid resistivity
- Fluid temperature
- Flowmeter
- Television
- Acoustic televiewer

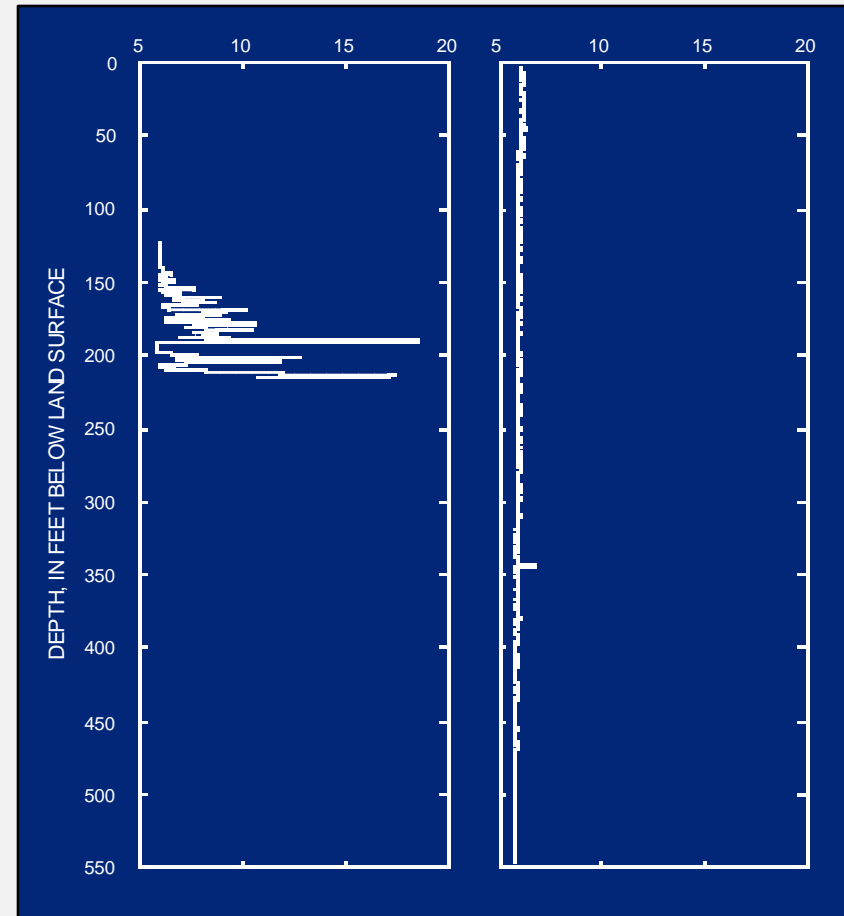


USGS Pennsylvania Water  
Science Center Logger

# CALIPER LOG

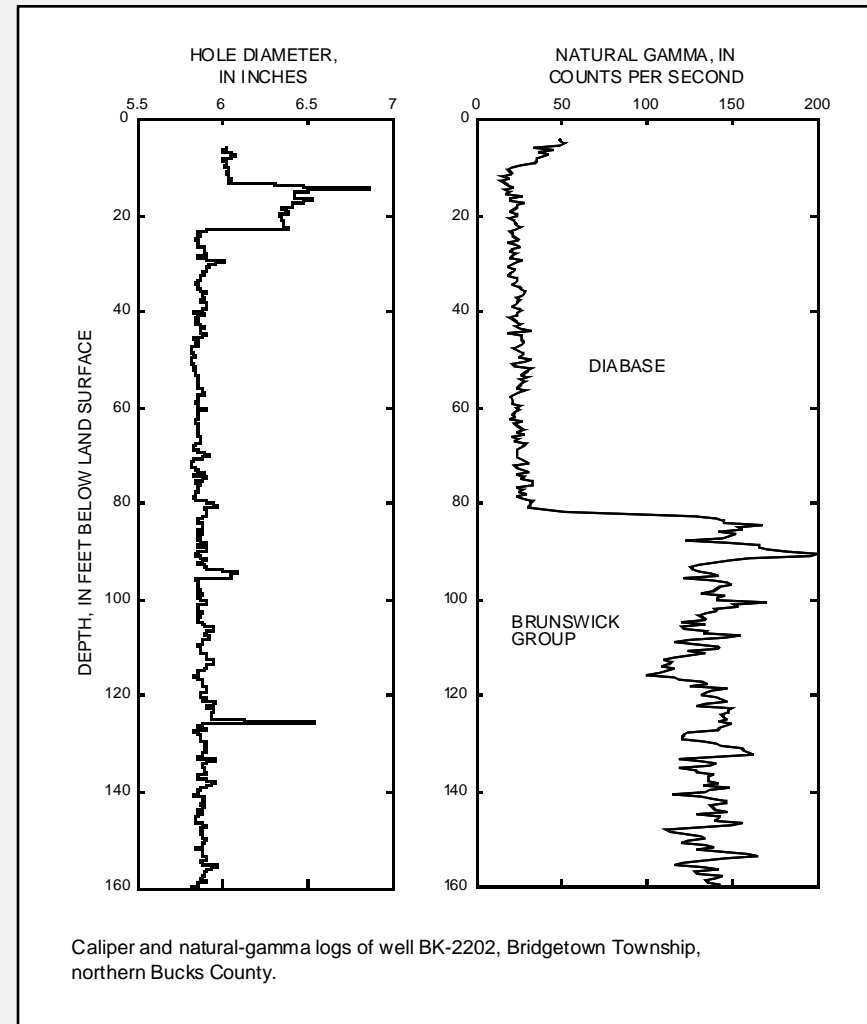
**Provides a continuous record of average borehole diameter**

**Used to identify fractures, water-bearing openings, and changes in lithology**



# GAMMA LOG

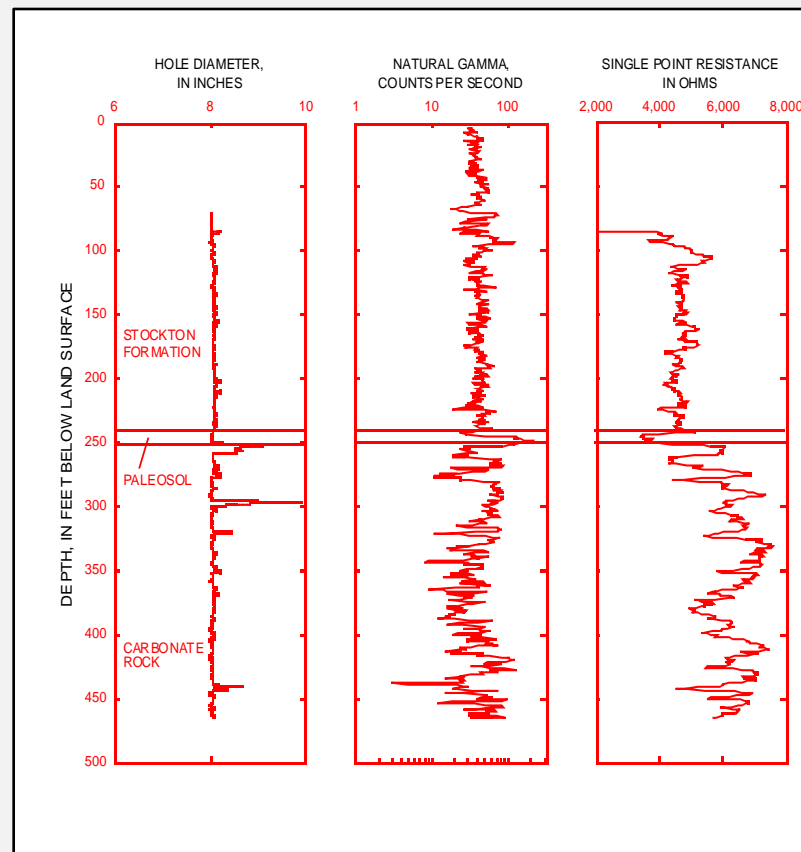
Records the natural-gamma radiation emitted from rocks penetrated by the borehole. The gamma log often is used to define lithology and correlate geologic units between boreholes.





# SINGLE-POINT RESISTANCE ELECTRIC LOG

Electrical resistance increases with grain size and decreases with borehole diameter, density of water-bearing fractures, and increasing dissolved-solids concentration of borehole fluid



## **FLUID TEMPERATURE LOG**

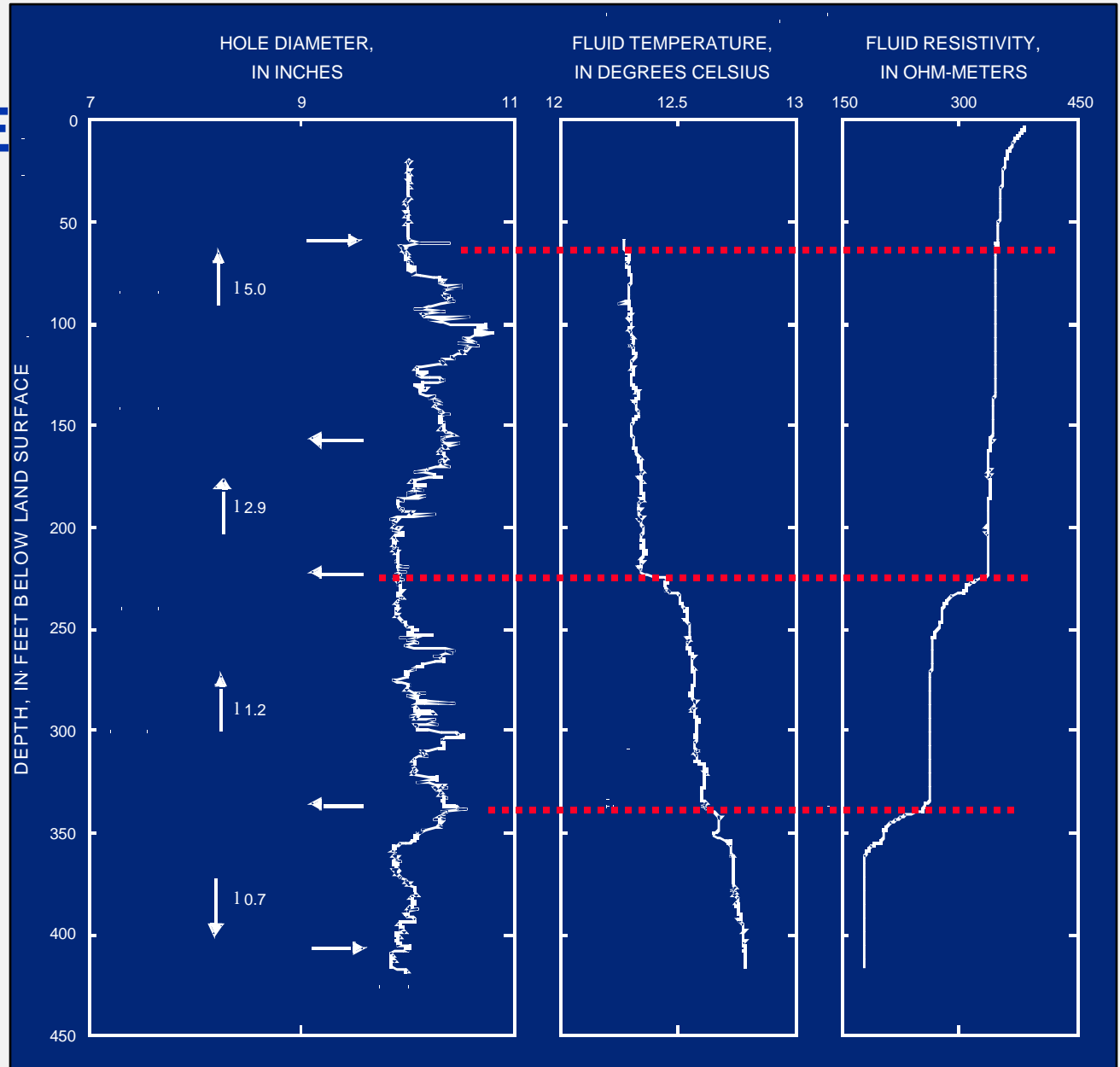
**Provides a continuous record of the temperature of the fluid in the borehole.**

## **FLUID RESISTIVITY LOG**

**Measures the electrical resistance (fluid conductivity) of fluid in the borehole. Logs reflect changes in the dissolved-solids concentration of the borehole fluid.**

# FLUID TEMPERATURE AND FLUID RESISTIVITY LOGS

Where would you set the screen?



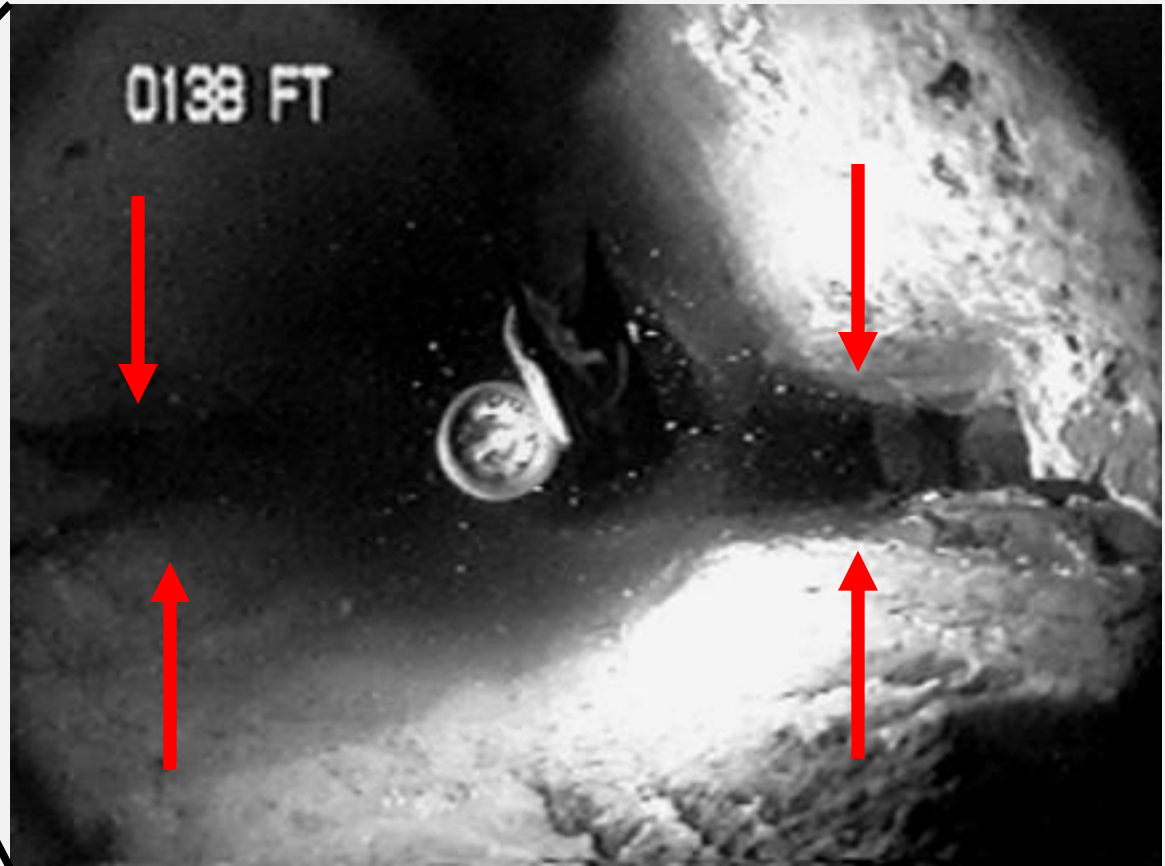
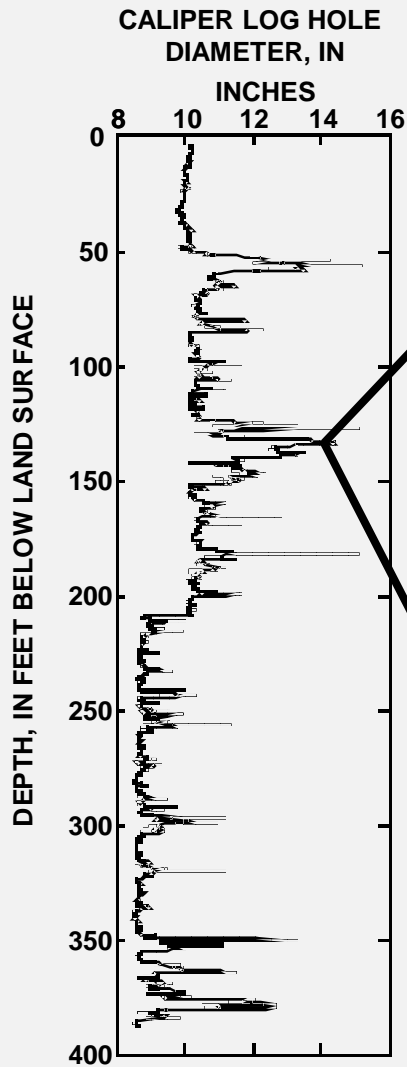
WELL BK-1845, WARMINSTER TOWNSHIP, BUCKS COUNTY

# HEATPULSE FLOWMETER

- Measures rate and direction of borehole flow under static conditions
- Measures contribution of individual fractures under pumping conditions
- Differences in hydraulic head
- Delineates transmissive fractures
- Defines relative vertical hydraulic gradients



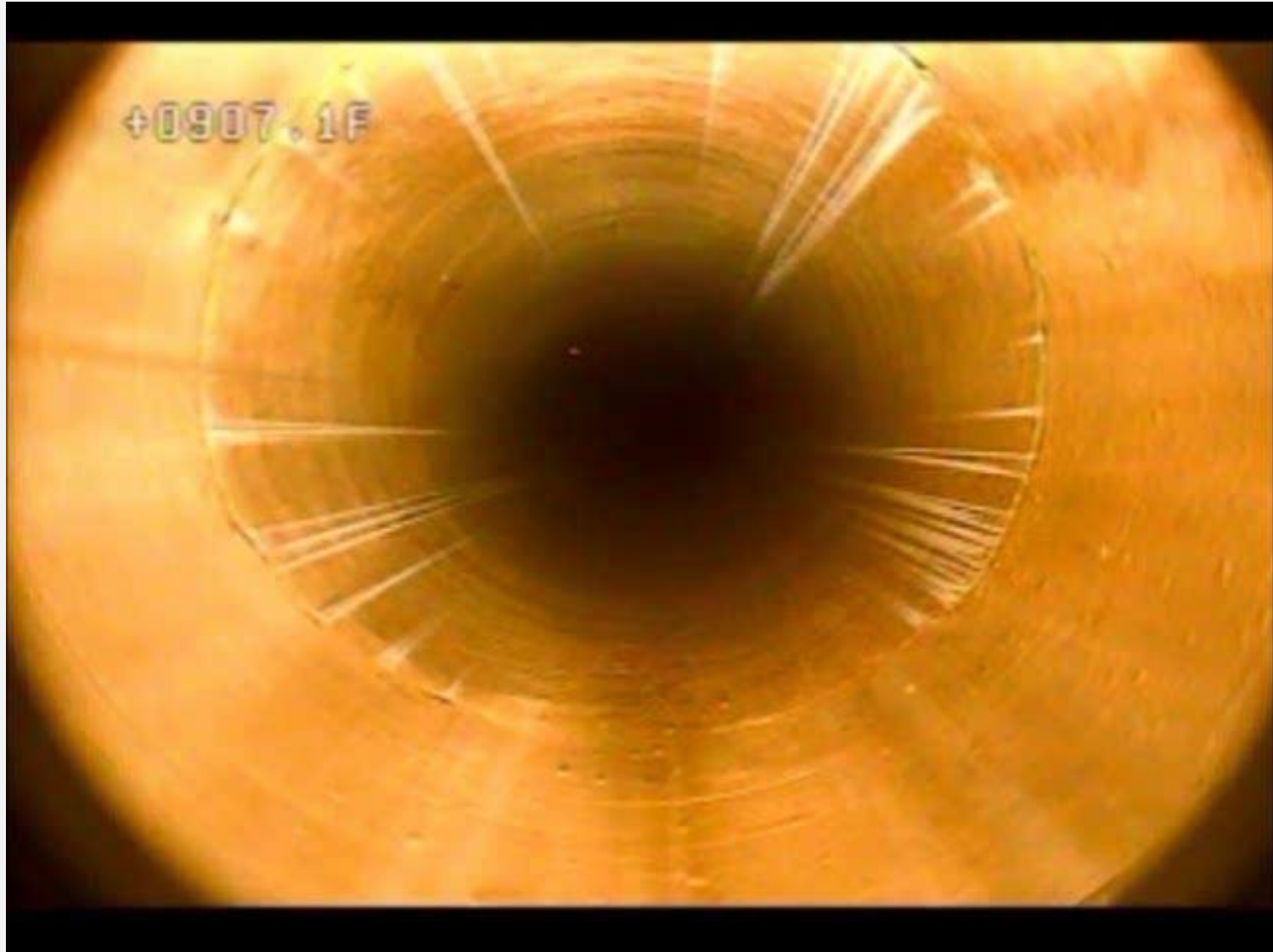
# BOREHOLE TELEVISION



**VERTICAL FRACTURE IN WELL AT 138 FEET BELOW TOP OF CASING**

# BOREHOLE TELEVISION

## Corehole in Marcellus Shale Play



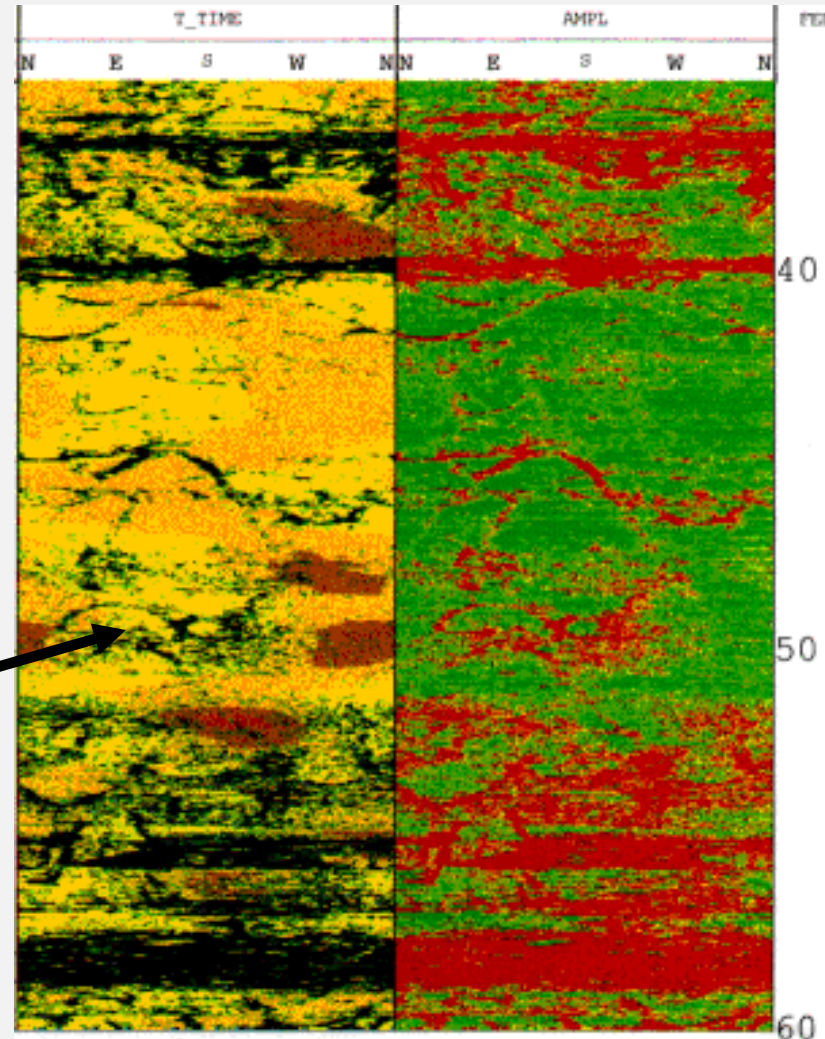
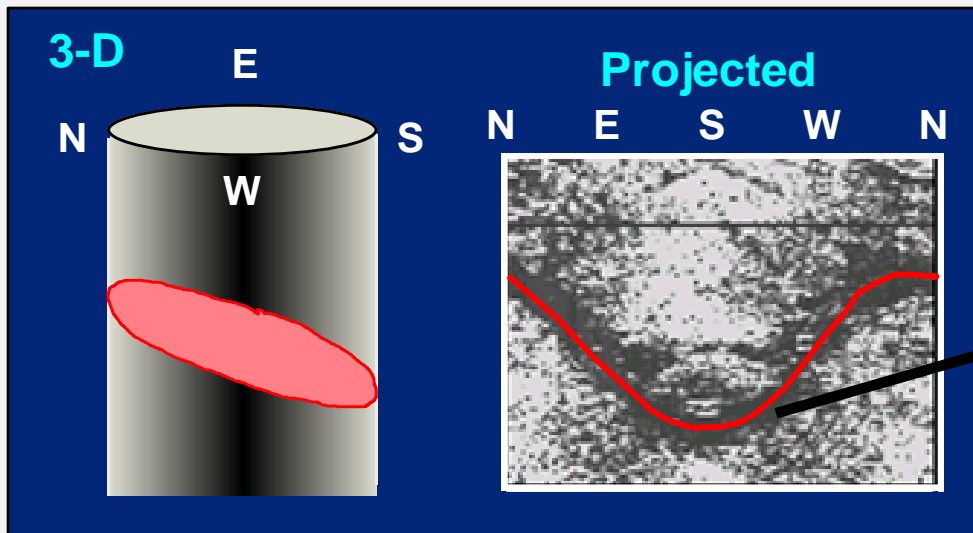


The **acoustic borehole televiewer** log is a magnetically oriented, 360°, photograph-like image of the acoustic reflectivity of the borehole wall. Digital images from the televiewer are recorded by the computer collecting logging data.



# ACOUSTIC TELEVIEWER

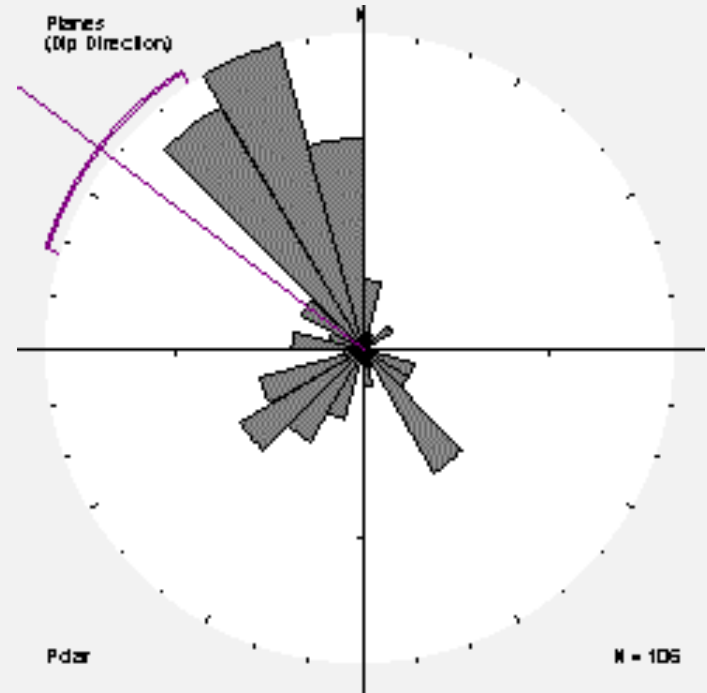
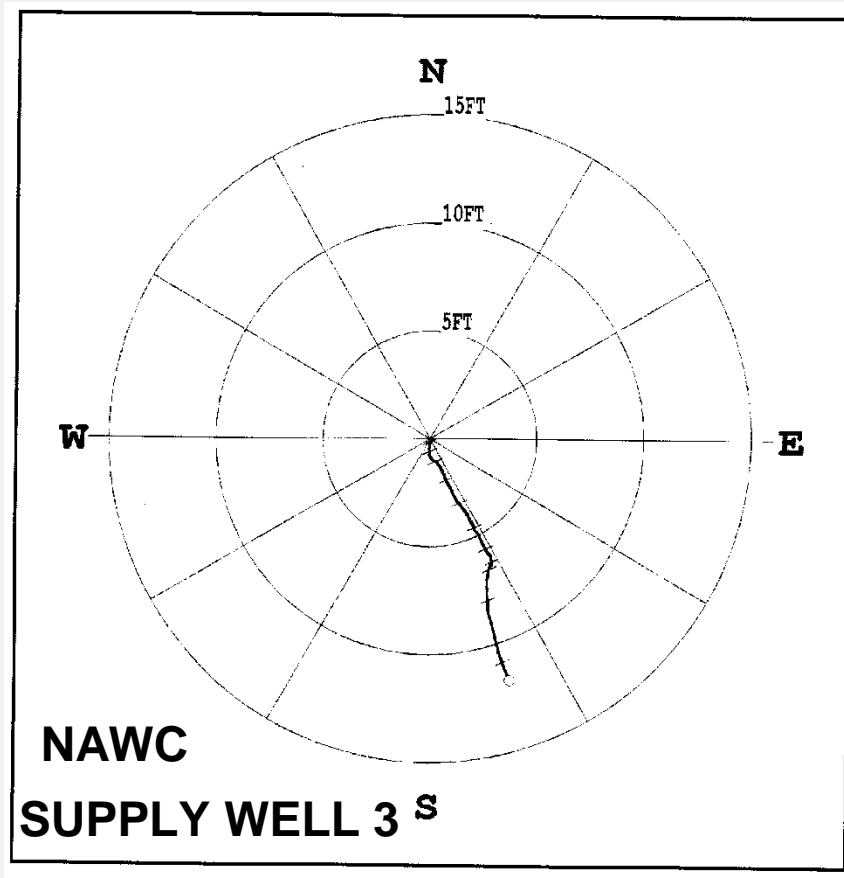
Televviewer logs indicate the location and strike and dip of fractures and lithologic contacts





# BOREHOLE DEVIATION

# STRUCTURAL ORIENTATION



# BOREHOLE FLUID SAMPLER

- **Wireline sampler**
- **Captures borehole fluid from a discrete depth**
- **Largest sampler collects up to 1 liter of fluid**

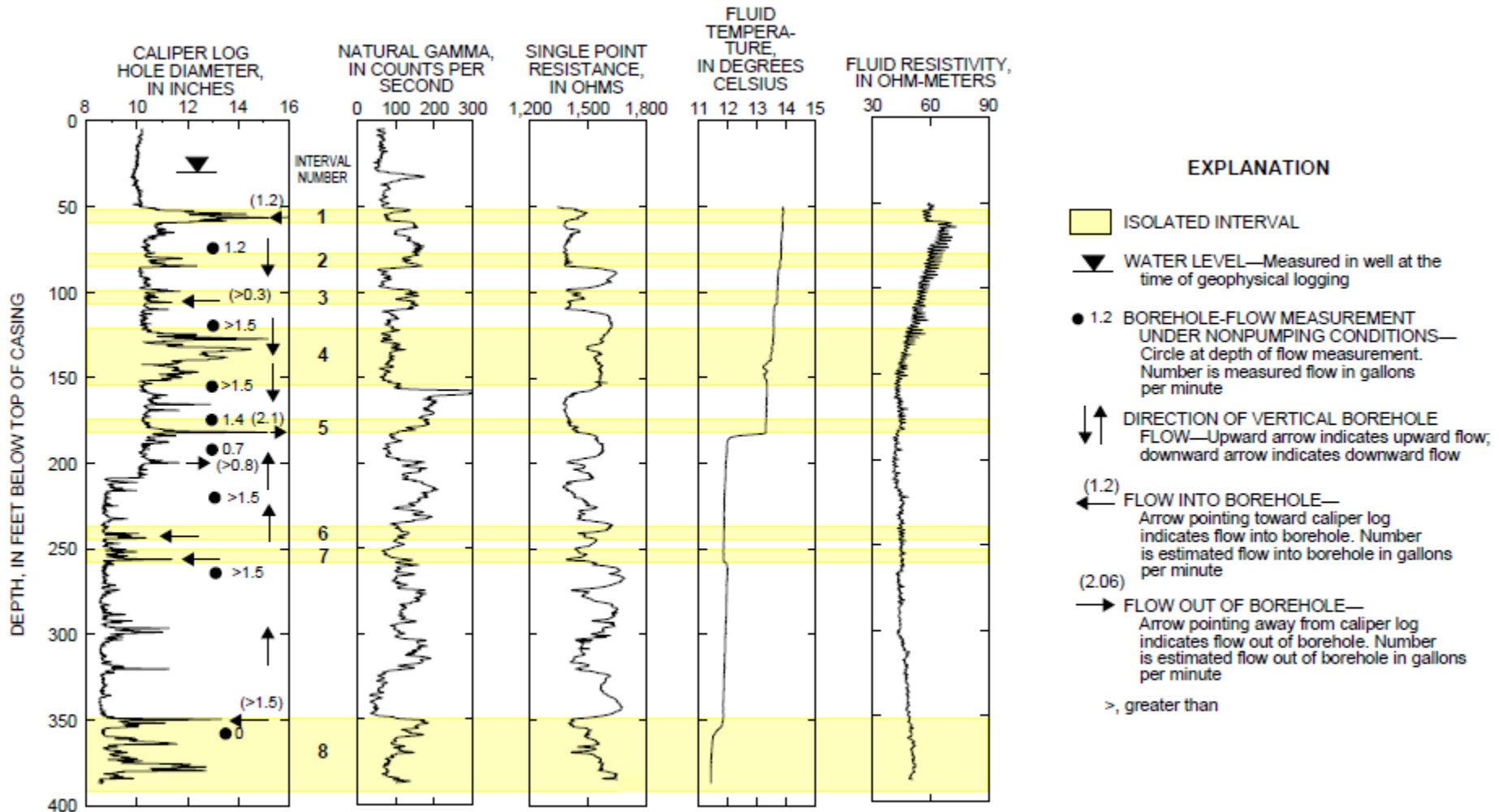


# AQUIFER-ISOLATION (PACKER) TESTS

- Isolation of individual fractures or fracture zones
- Hydraulic properties with depth (K, specific capacity)
- Hydraulic connections
  - Around borehole
  - To other boreholes
- Discrete-depth water samples



# ANALYSIS OF A SUITE OF BOREHOLE GEOPHYSICAL LOGS



**Figure 4.** Borehole geophysical logs for supply well 1 (MG-209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.