High Resolution Site Characterization – HPT Groundwater Sampling System

Running HPT logs in the Platte River alluvial aquifer, Clarks, NE.

Daniel Caputo
(dcaputo@vironex.com)

Vironex, Inc.

Core Services - Driller → Injection → HRSC → Search & Destroy™

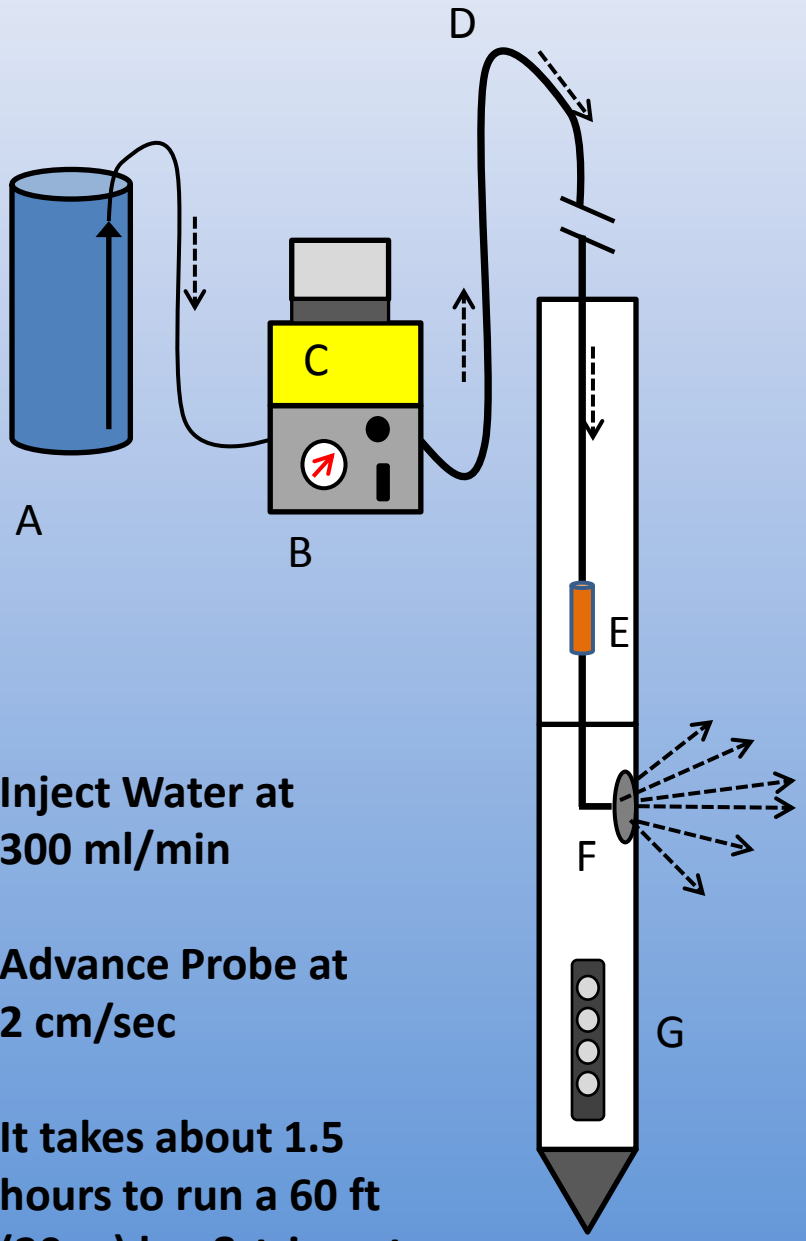
- Direct Push
  - Sampling (Groundwater, Soil, Vapor)
  - Well Installation (Pre-pack and Auger)
- Advanced Site Characterization
  - HRSC Probes targeting hydro/lithologic properties
  - HRSC systems for highly resolved contaminant profiling
  - HRSC 3D Modeling
- Injection/Remediation Services
  - Chemically Compatible Equipment to Inject all ISCO, ISCR and Bioremediation Amendments
  - Experience in all Lithologies (including Bedrock)
  - In Situ Mixing
  - Extraction/Injection Systems

VIRONEX

Presentation Outline

- HPT Principles of Operation
- Equipment Needed and Logging Technique
- Interpreting an HPT log
- HPT Log Cross Section and Hydrostratigraphy
- Dissipation Tests … How and Why?
- Estimating Hydraulic Conductivity (K) with Q & P_c
- HPT-GW Sampler

HPT Principles of Operation



A) Water Tank

B) Pump & Flow Meter

C) Electronics/computer

D) Trunkline

E) Pressure Sensor

F) Screened Injection Port

G) Elec. Conductivity Array

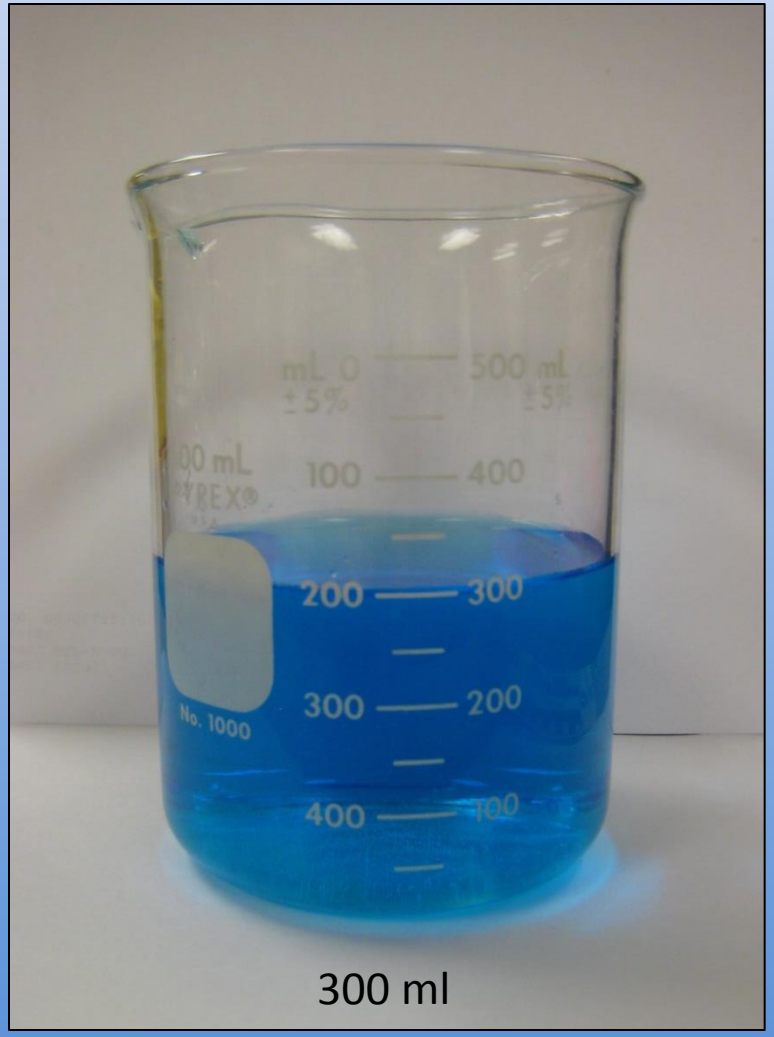
Water Flow Lines

Inject Water at 300 ml/min

Advance Probe at 2 cm/sec

It takes about 1.5 hours to run a 60 ft (20 m) log & trip out

How Much Injection Flow ?



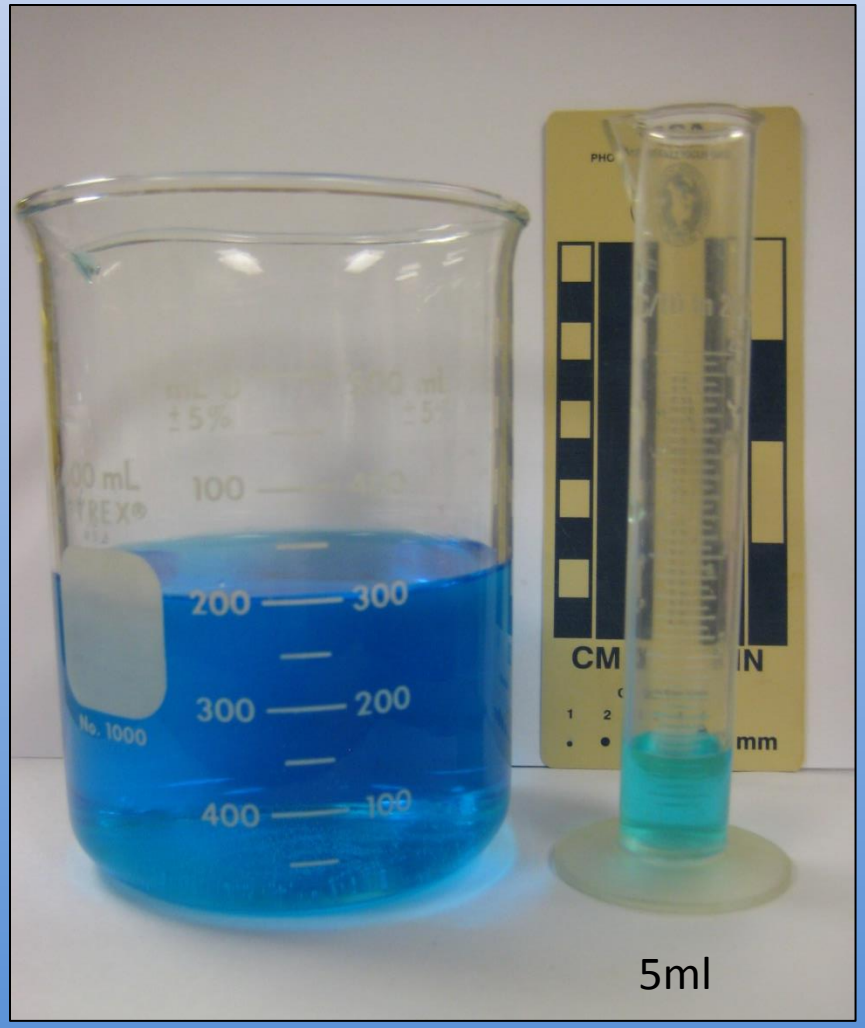
300 ml

300 ml/min

= ? ml/sec

How much per log?

How Much Injection Flow ?



5ml

300 ml/min X 1min/60sec

= 5 ml/sec

Advance probe at 2 cm/sec

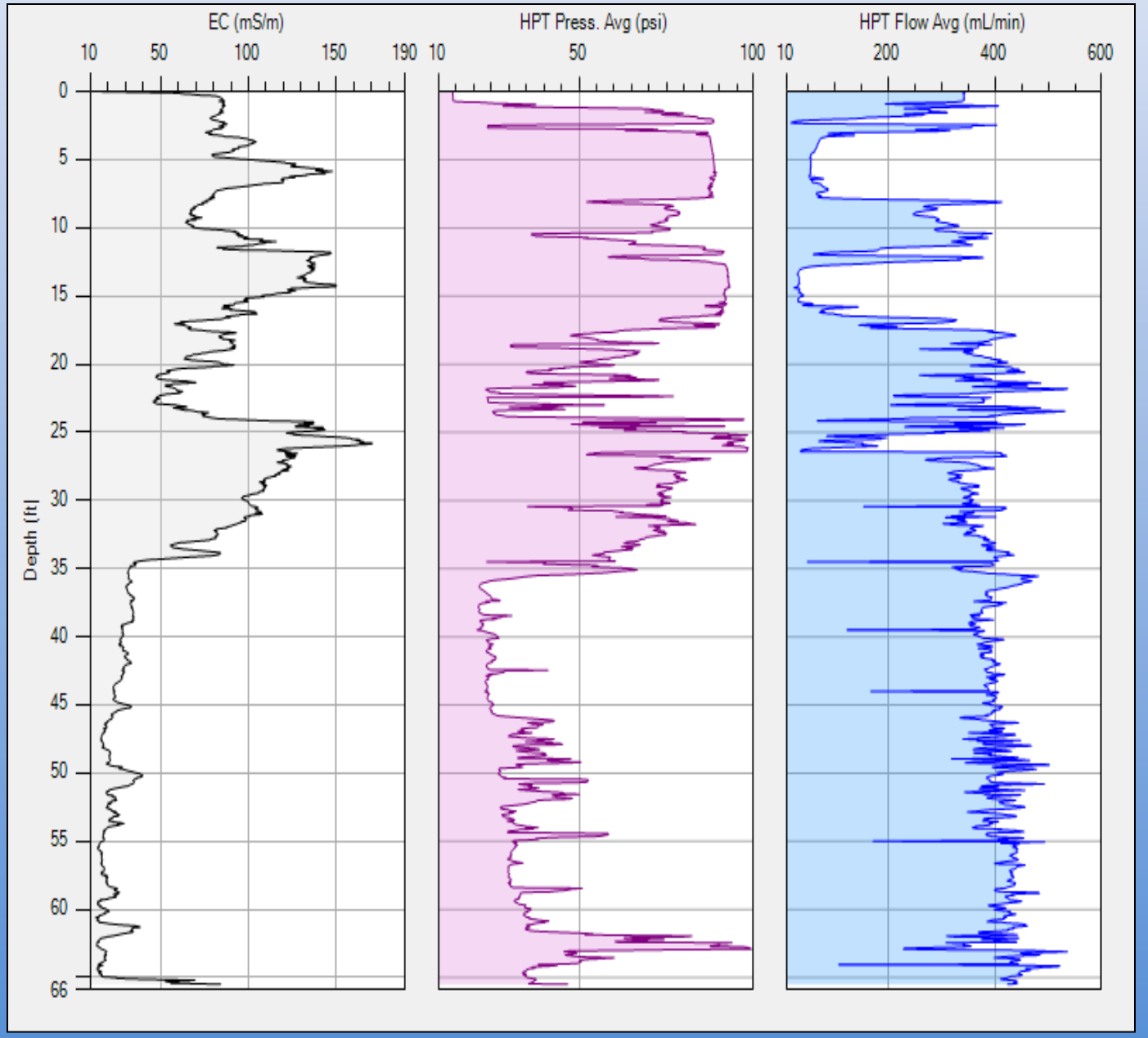
So Inject 5 ml over 2 cm

~ 75 ml/ft of log

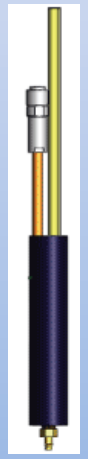
Reality ~ 5 gal (20 l) for 60ft log

Example HPT Log

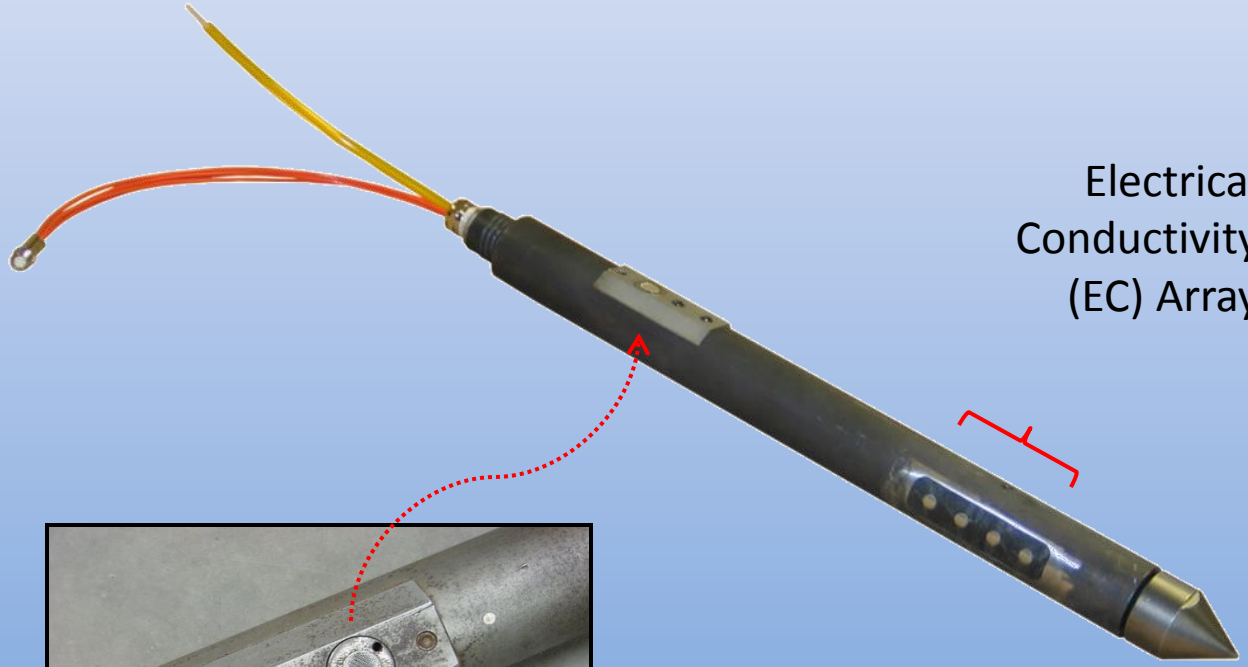
- EC
- Pressure
- Flow



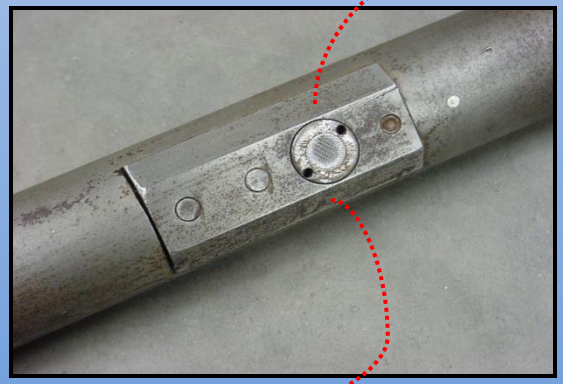
Components of the HPT System : HPT Probe

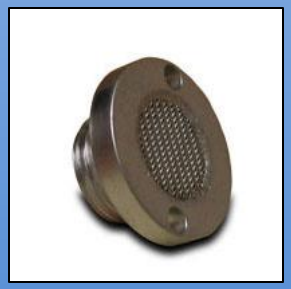


Pressure Sensor Module 100 psi/ 690kPa



Electrical Conductivity (EC) Array





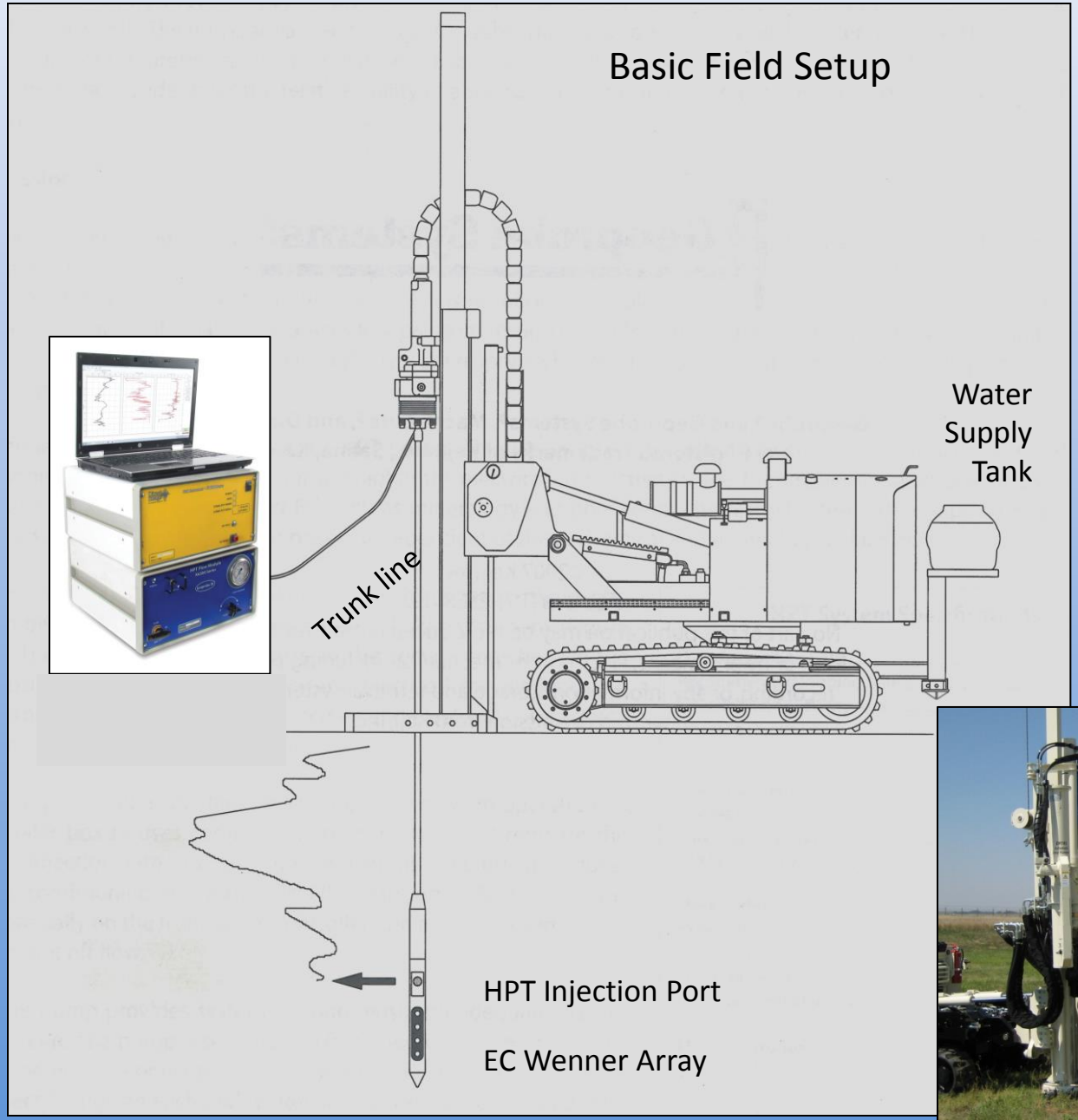
Replaceable Screens

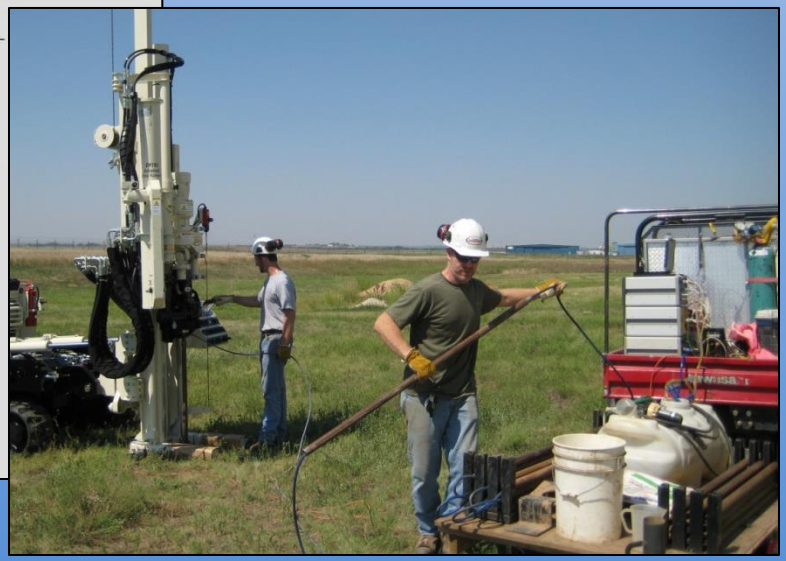
HPT Trunkline

HPT System Components: Electronics

- Laptop Computer (with Acquisition software)
- Field Instrument (FI 6000)
- HPT Flow Module (K 6300)

Running an HPT Log and Field QA/QC

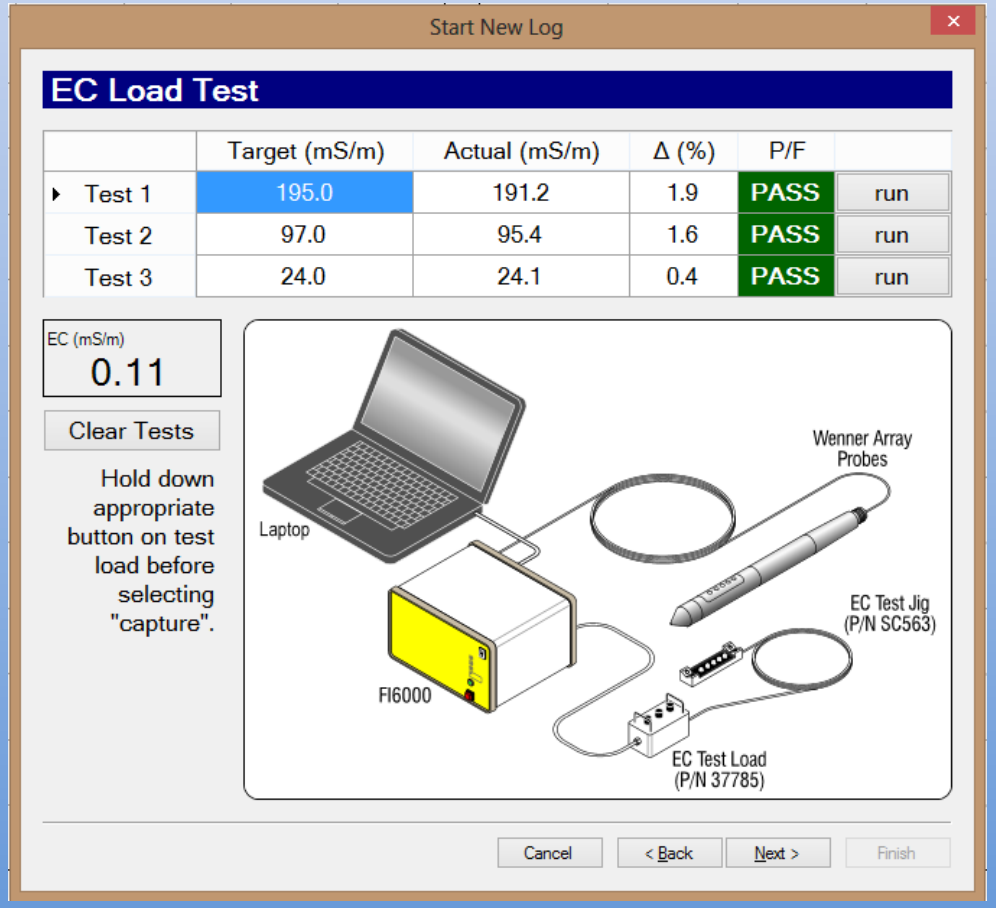




Before Every Log Run QA Tests

EC Test Jig on Probe

Pre-Log QA: EC Test Load

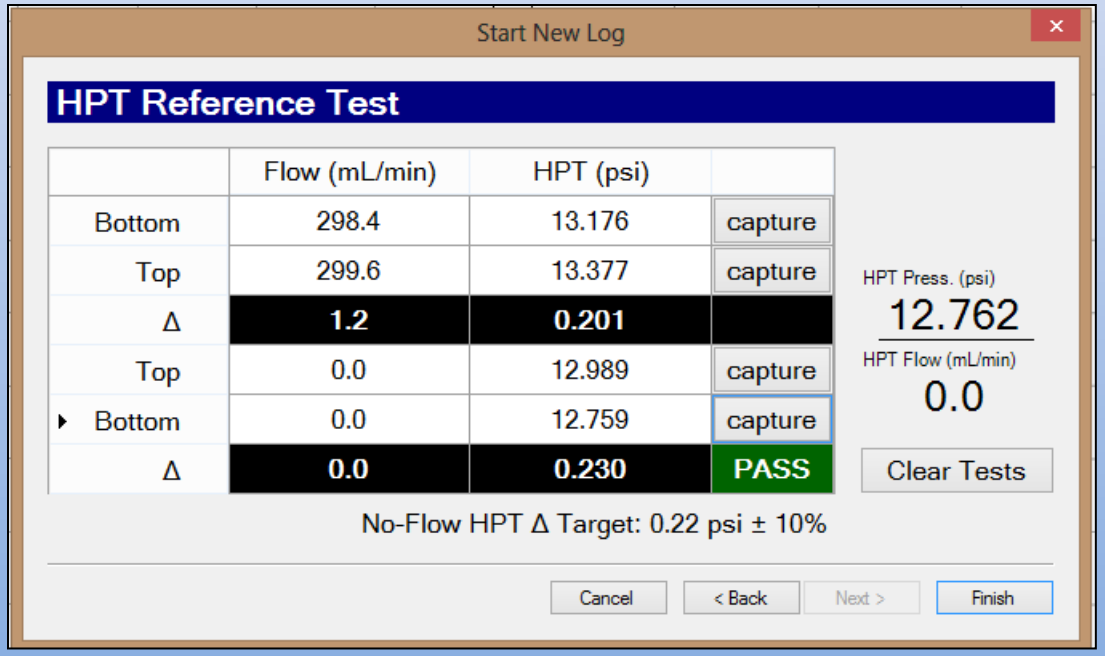


Electrical Conductivity Onscreen QA Report
(data saved to log file)

EC Test Load Used to Verify EC System is Working

Pre-Log QA: HPT Reference Test

HPT Probe in Reference Tube to Verify Measurement of Δ6” (15cm) of Water Pressure = 0.22 psi (1.52kPa)



HPT Pressure Transducer Onscreen QA Report
(data saved to log file)

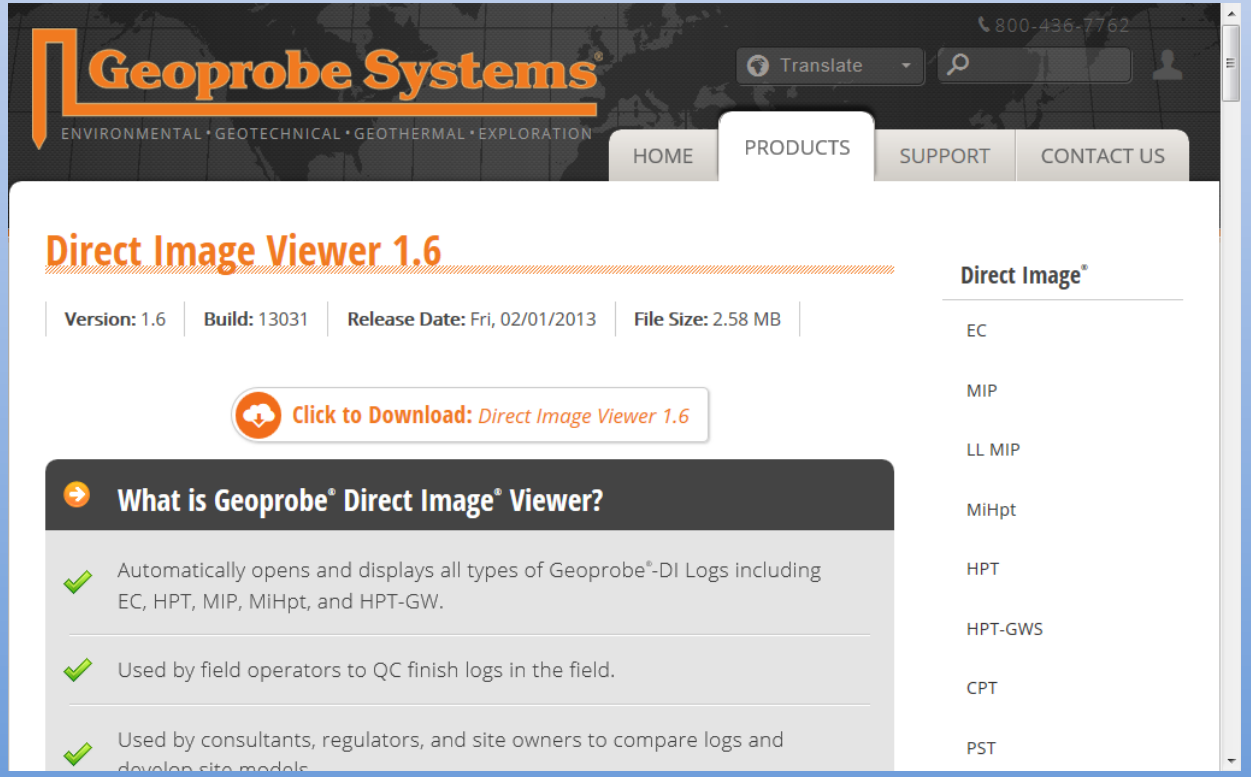
IF YOU DON’T DO THE QA TEST DON’T RUN THE LOG !

Running an HPT Log : Advancing the Probe

Live time
data review

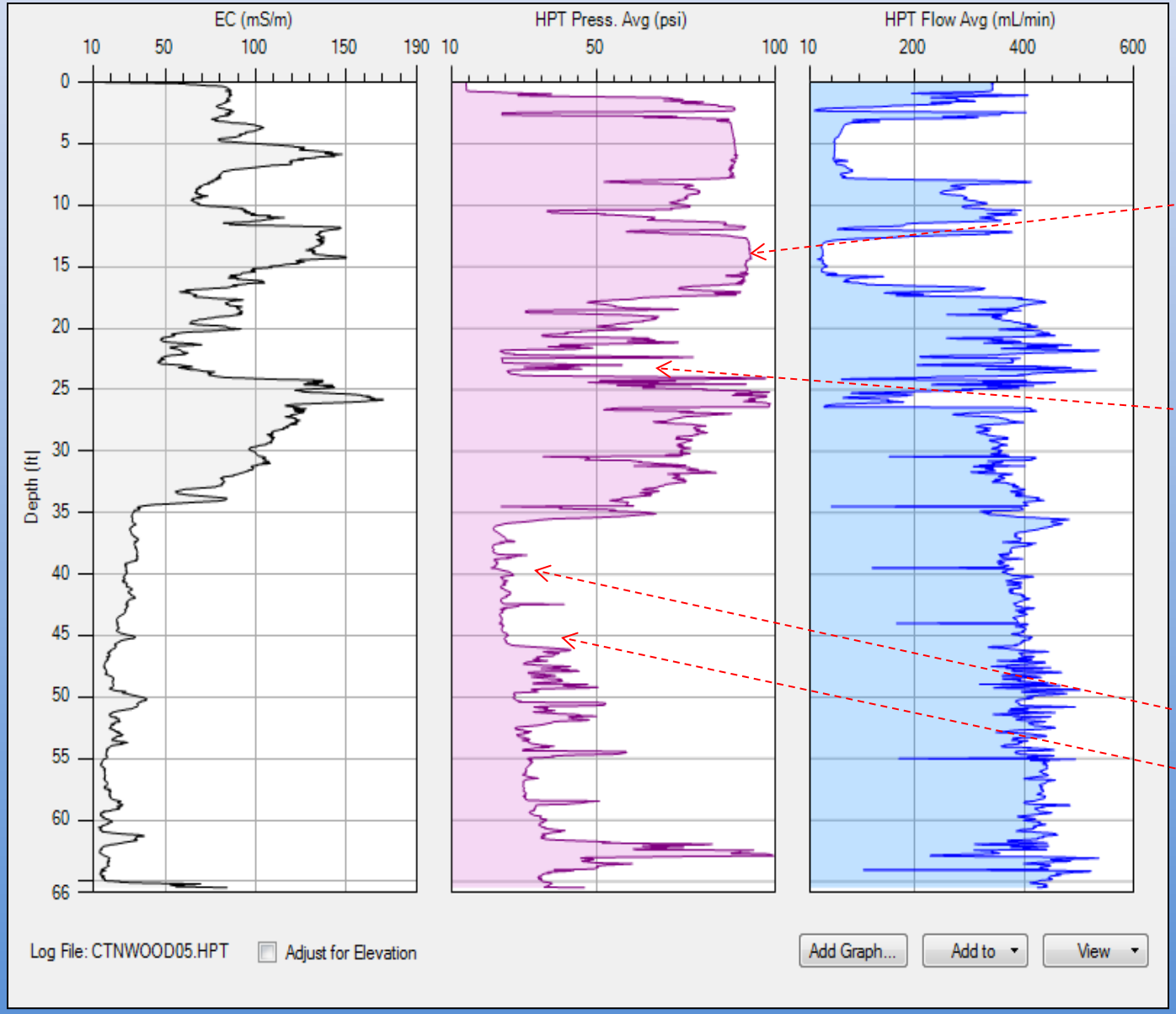
Trunkline
Managment

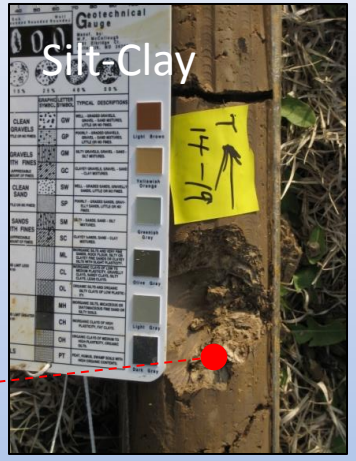
Data Users can use DI Viewer Software to open single HPT logs, cross sections of logs, etc.



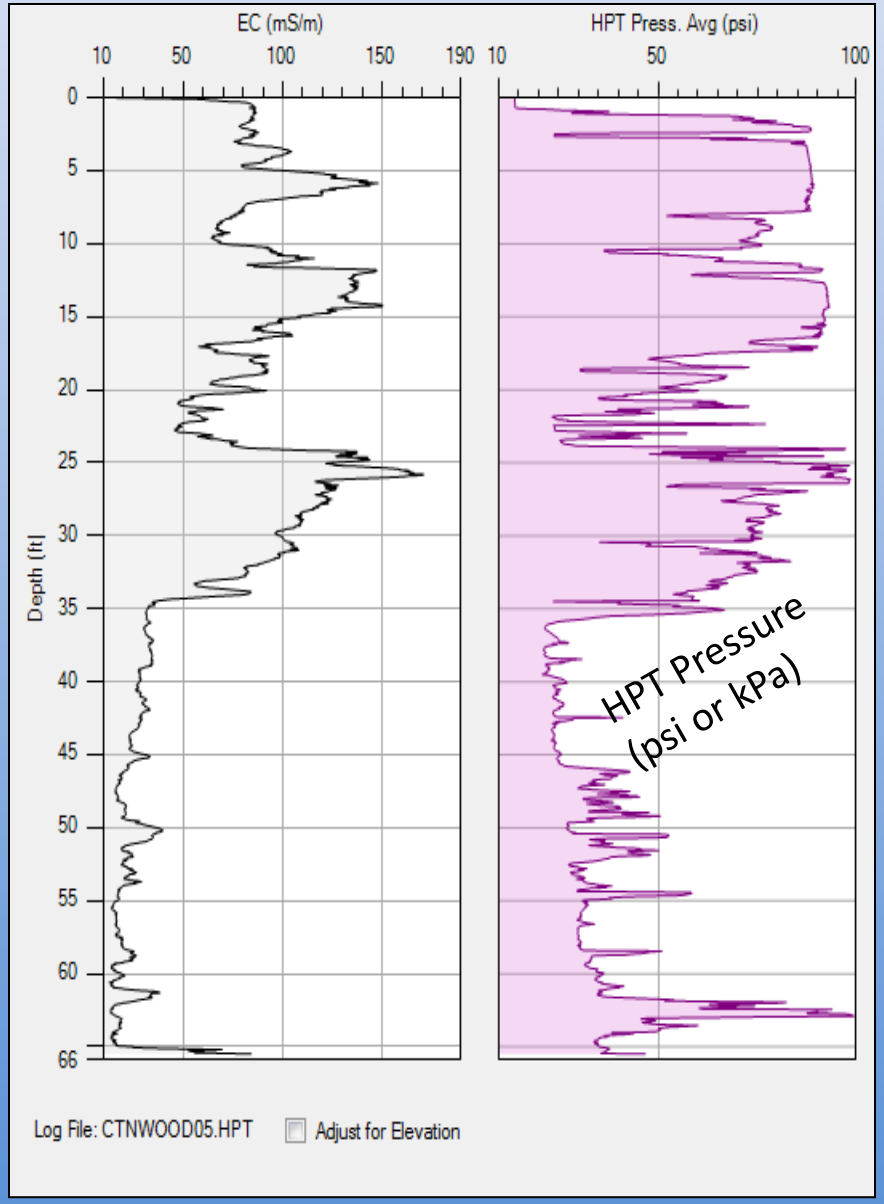
The DI Viewer software is available as a free download at:
http://geoprobe.com/downloads/direct-image-viewer-16

A Basic HPT Log & Interpretation





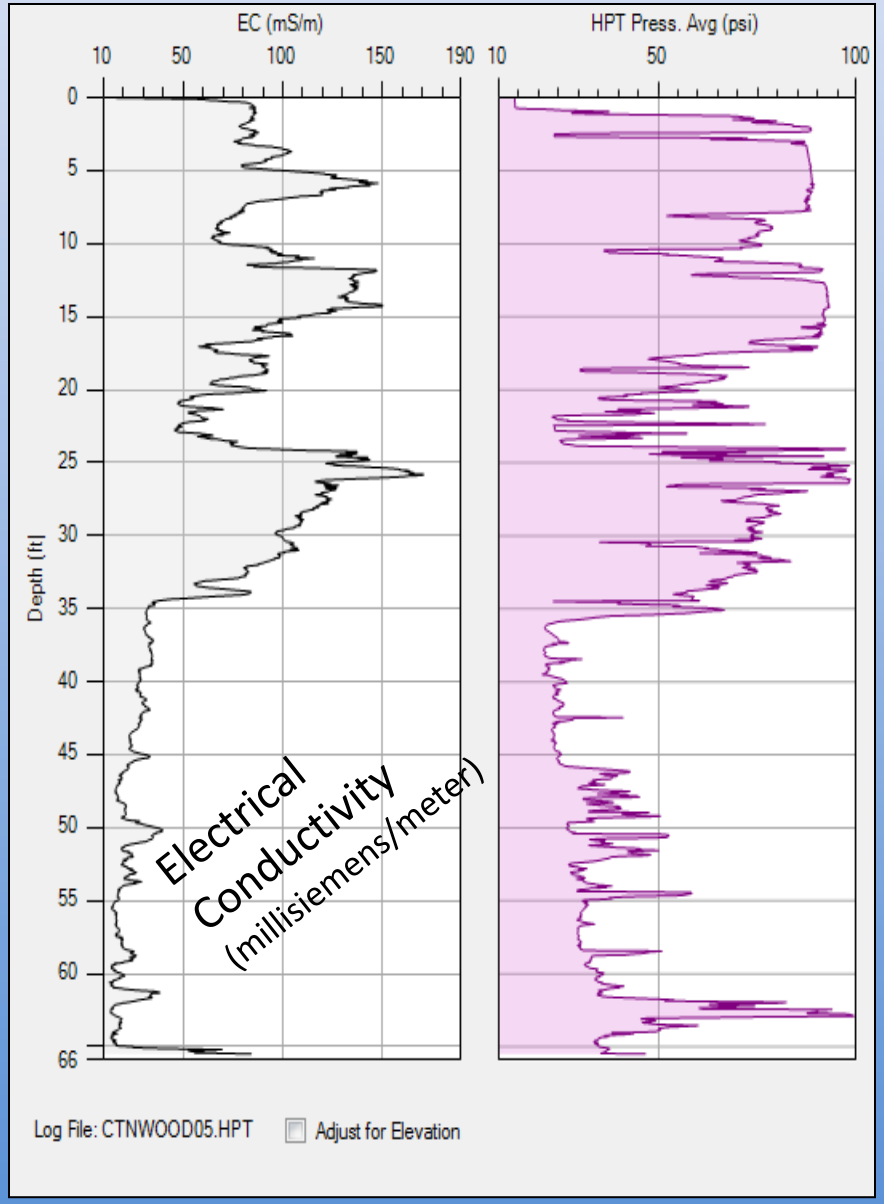
Basic Interpretation Rules



HPT Pressure
(all formations)

- Increasing P = decreasing permeability
- Decreasing P = increasing permeability

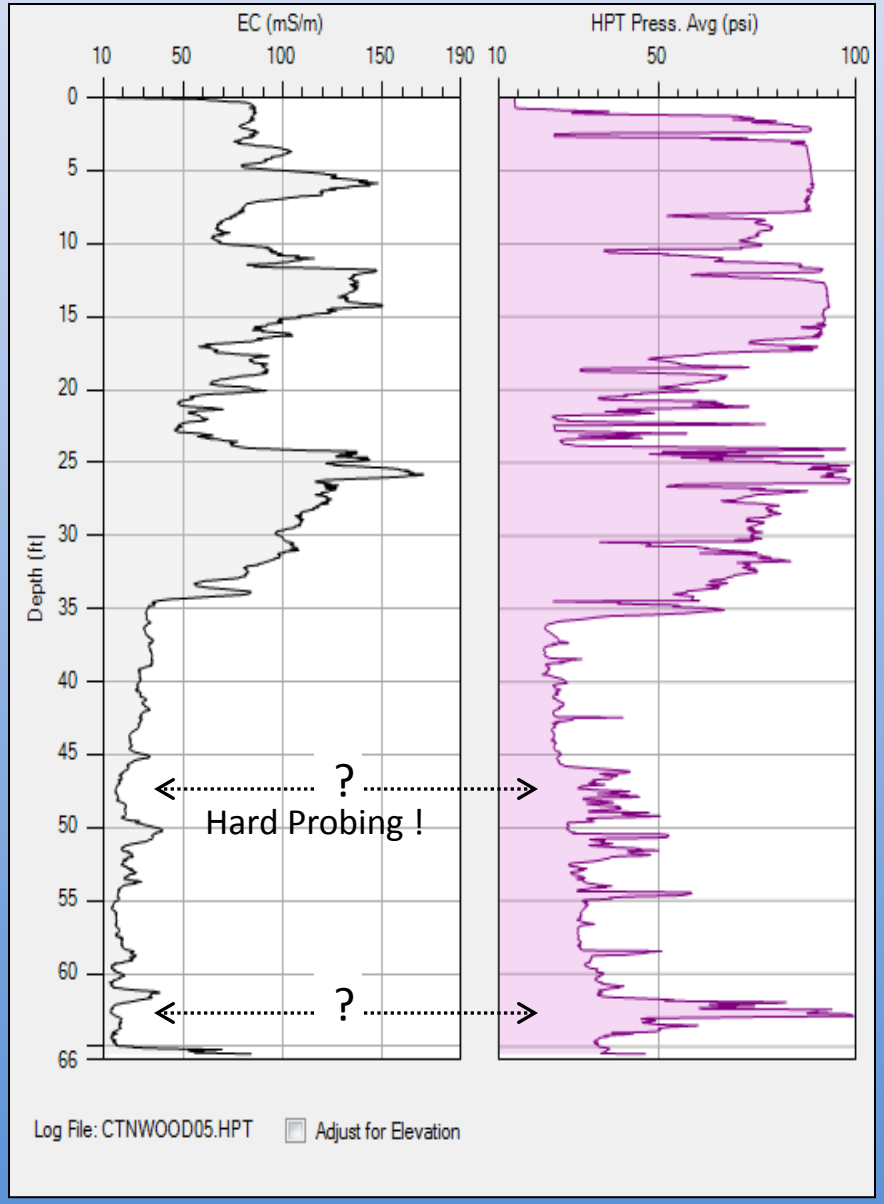
Basic Interpretation Rules



Electrical Conductivity (EC)
(*in fresh water formations)*

- Increasing EC = increasing clay content
  = lower permeability
- lower EC = coarser grained
  = higher permeability

Basic Interpretation Rules



Electrical Conductivity (EC)

- *Exceptions !*

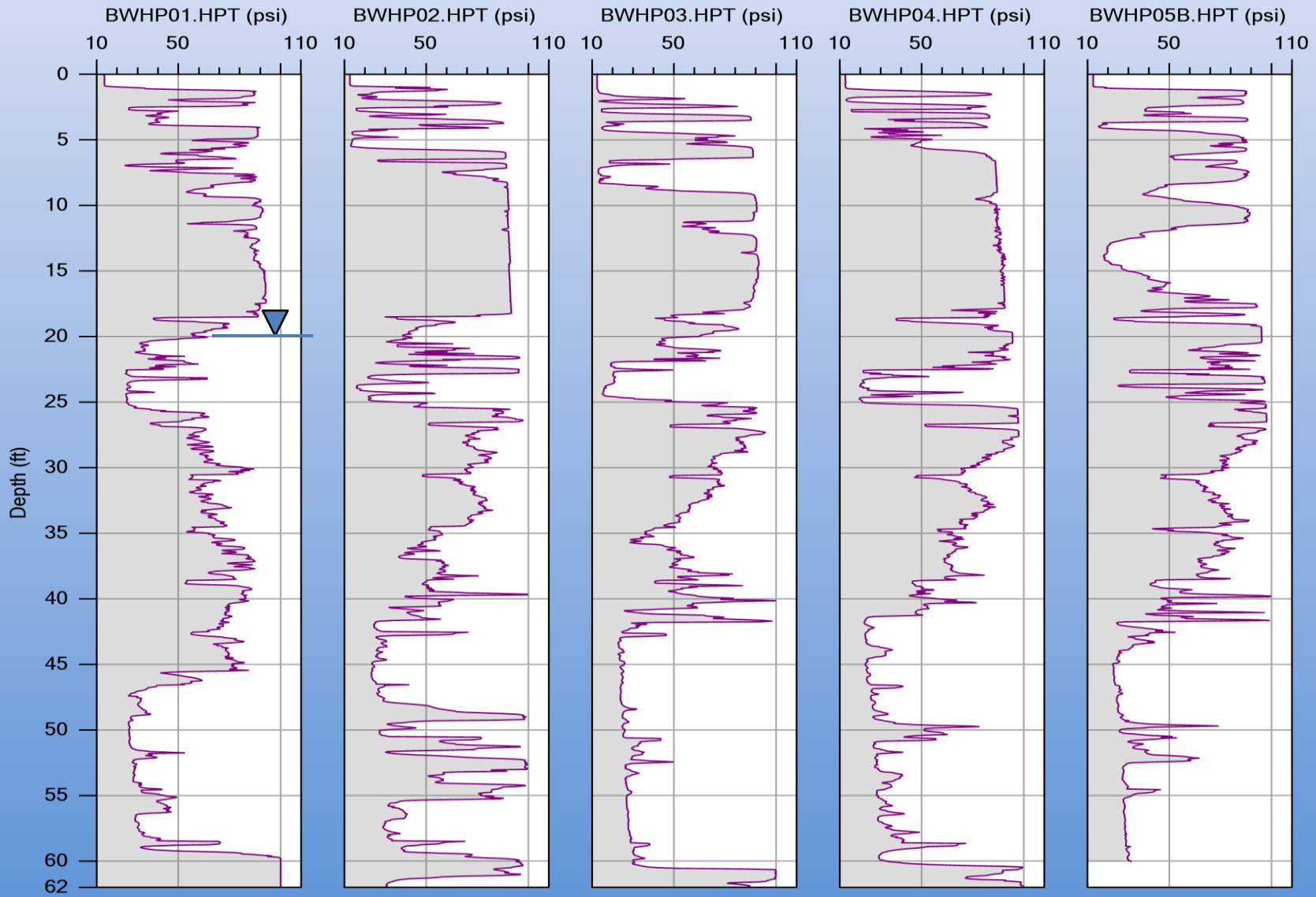
- *Low EC but High Pressure*
  - Silts & cementing
  - Not all clays = high EC

- High EC can exhibit low HPT pressure
  - Seawater
  - Oilfield brine
  - Ionic remediation fluids *(ionic compounds)*

= high EC

Hydrostratigraphy with HPT Pressure Cross Section

West East

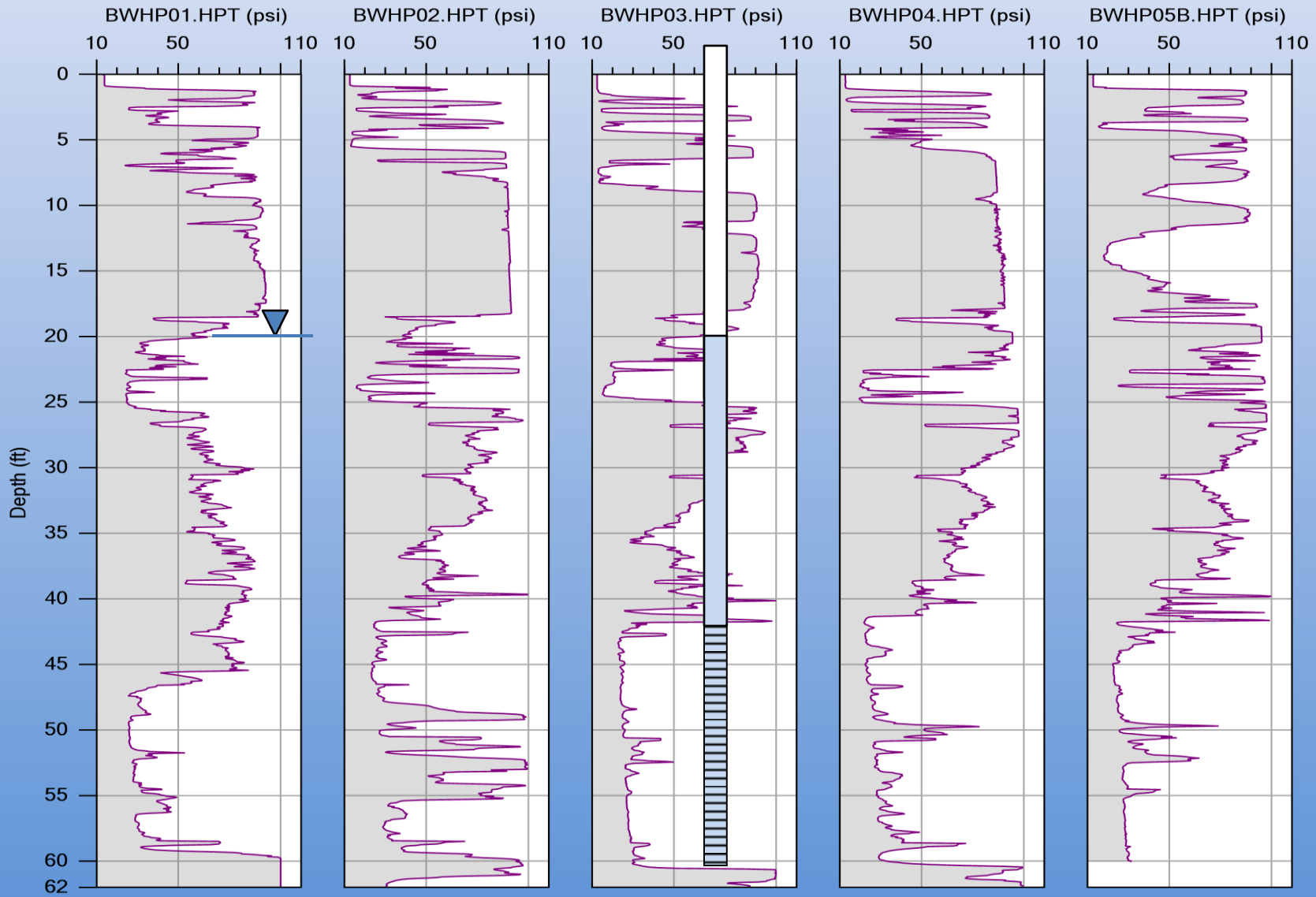


Facing North: 50 ft spacing between log locations: alluvial deposits

HPT Press. Avg

Hydrostratigraphy … Water Supply Well Placement

West East



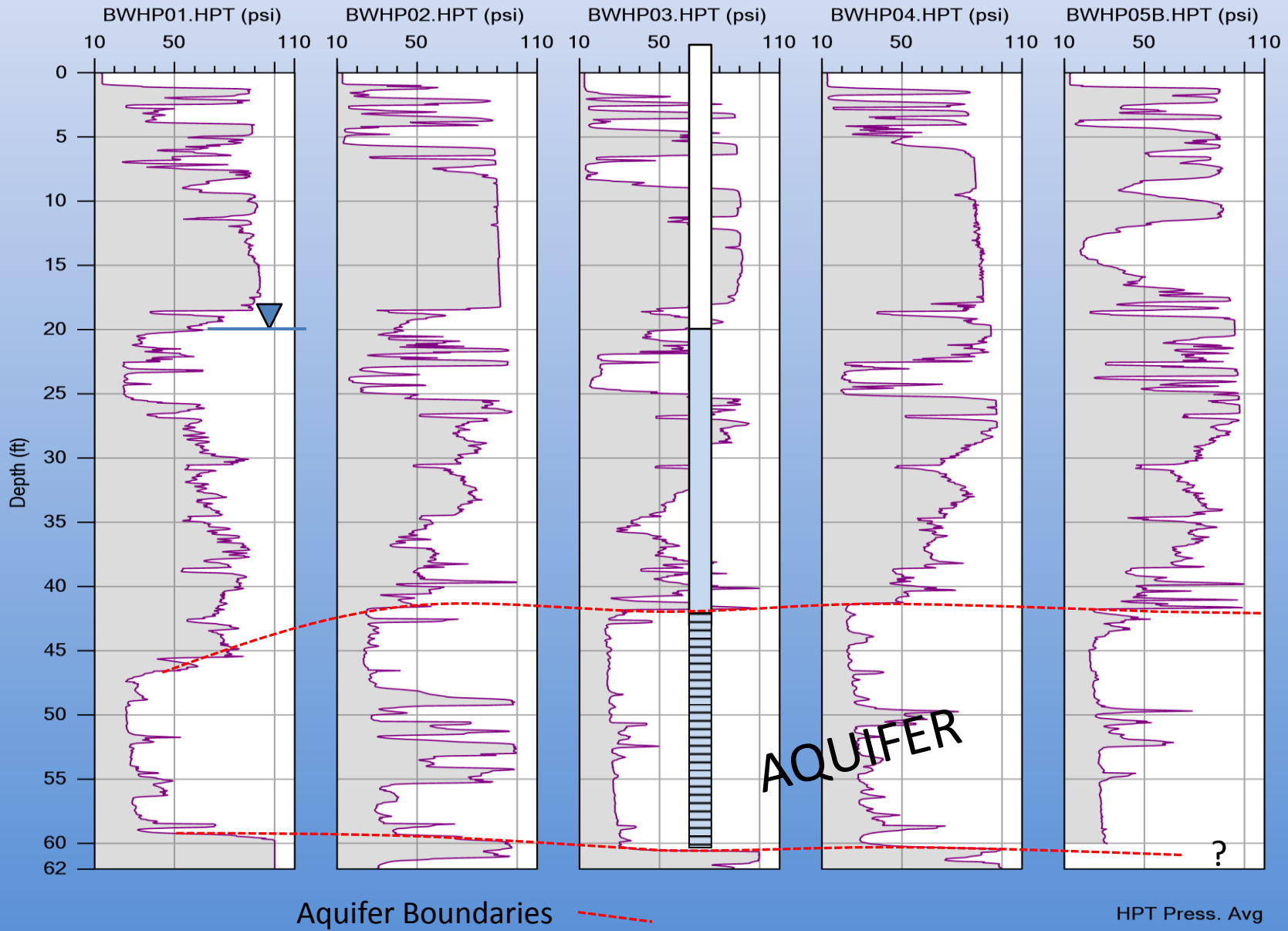
Facing North: 50 ft spacing between log locations: alluvial deposits

HPT Press. Avg

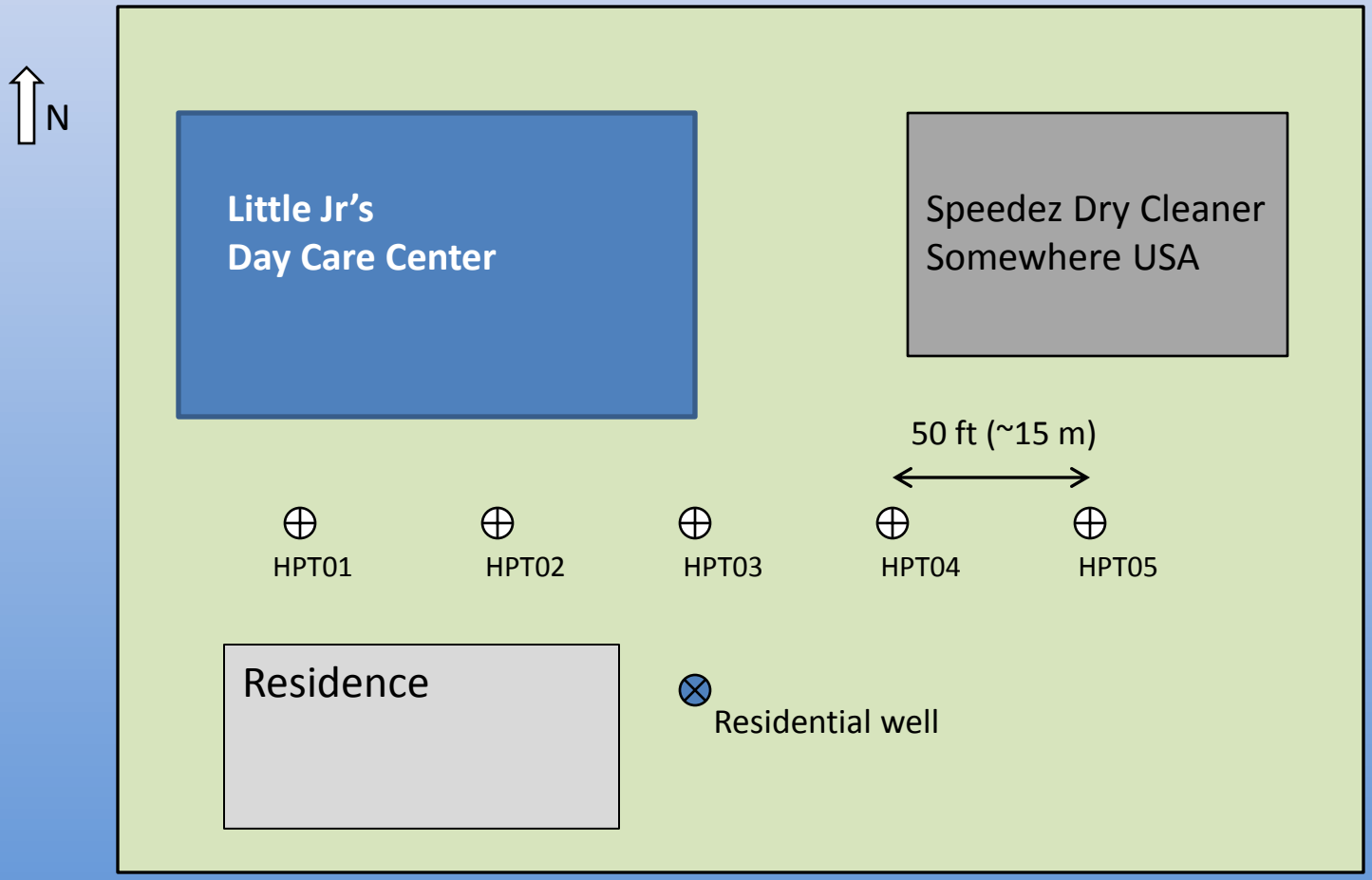
Hydrostratigraphy … Aquifer Boundaries

West

East



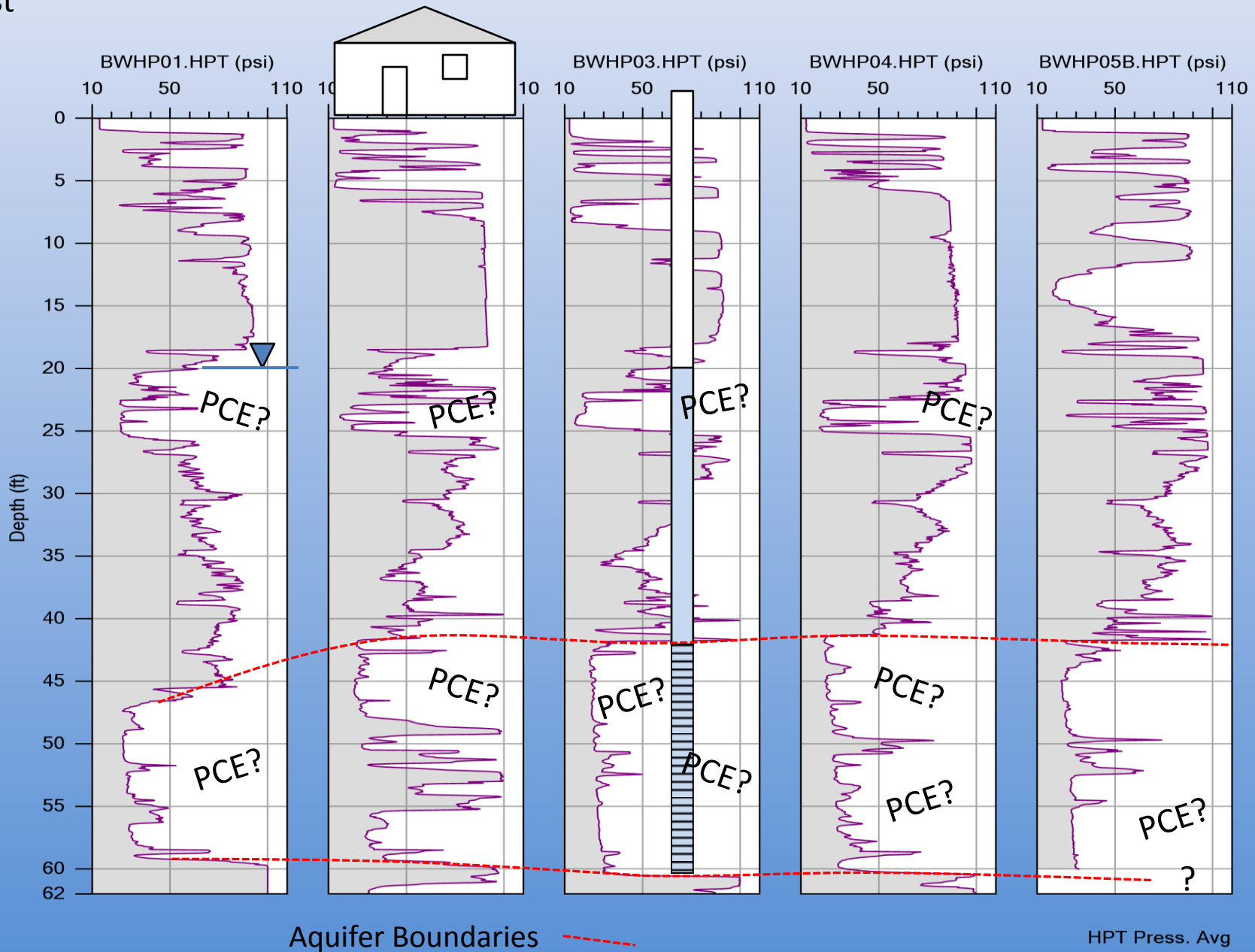
Our Hypothetical Dry Cleaner Site …



Hydrostratigraphy … Groundwater PCE Plume

West

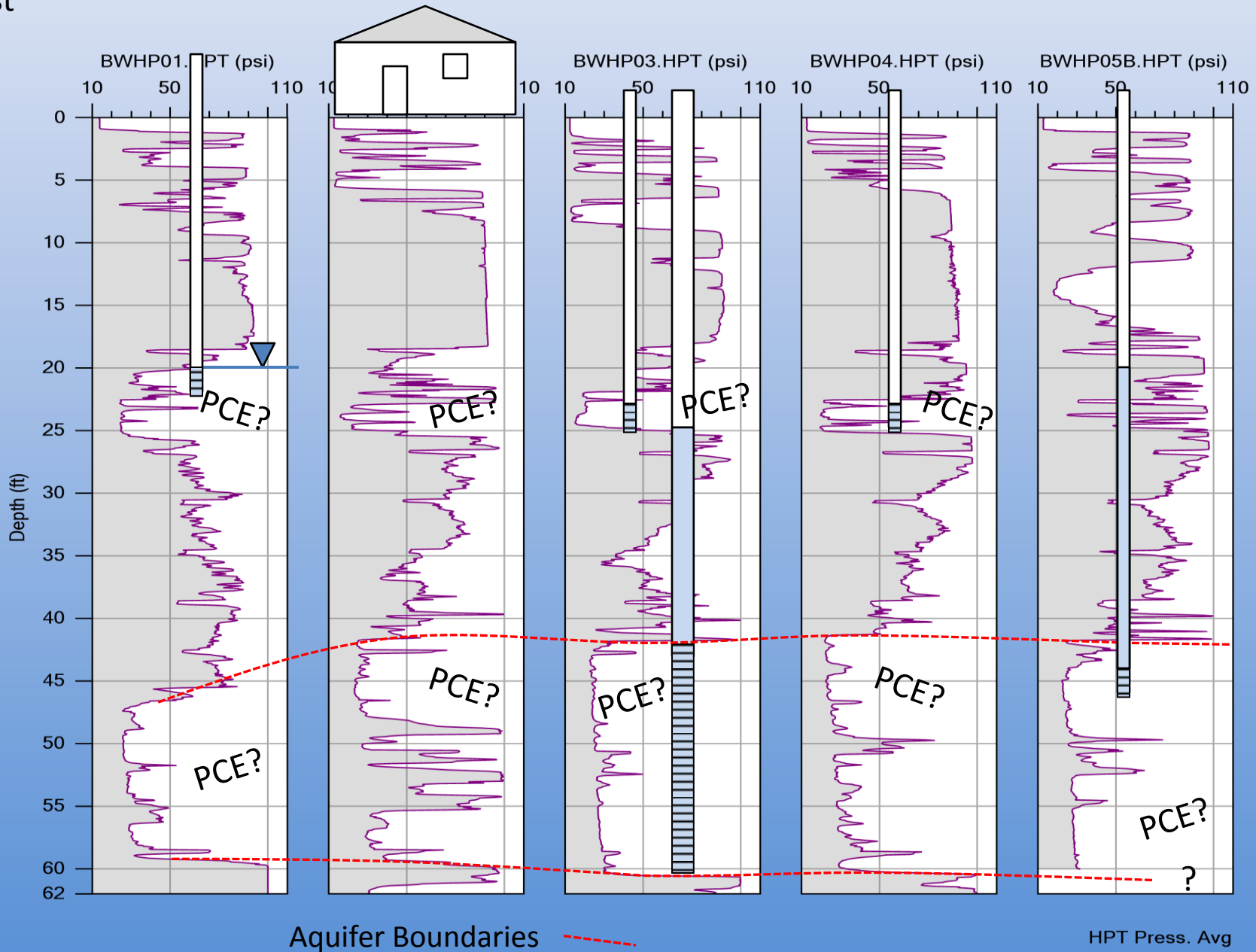
East



Hydrostratigraphy … Groundwater PCE Plume

West

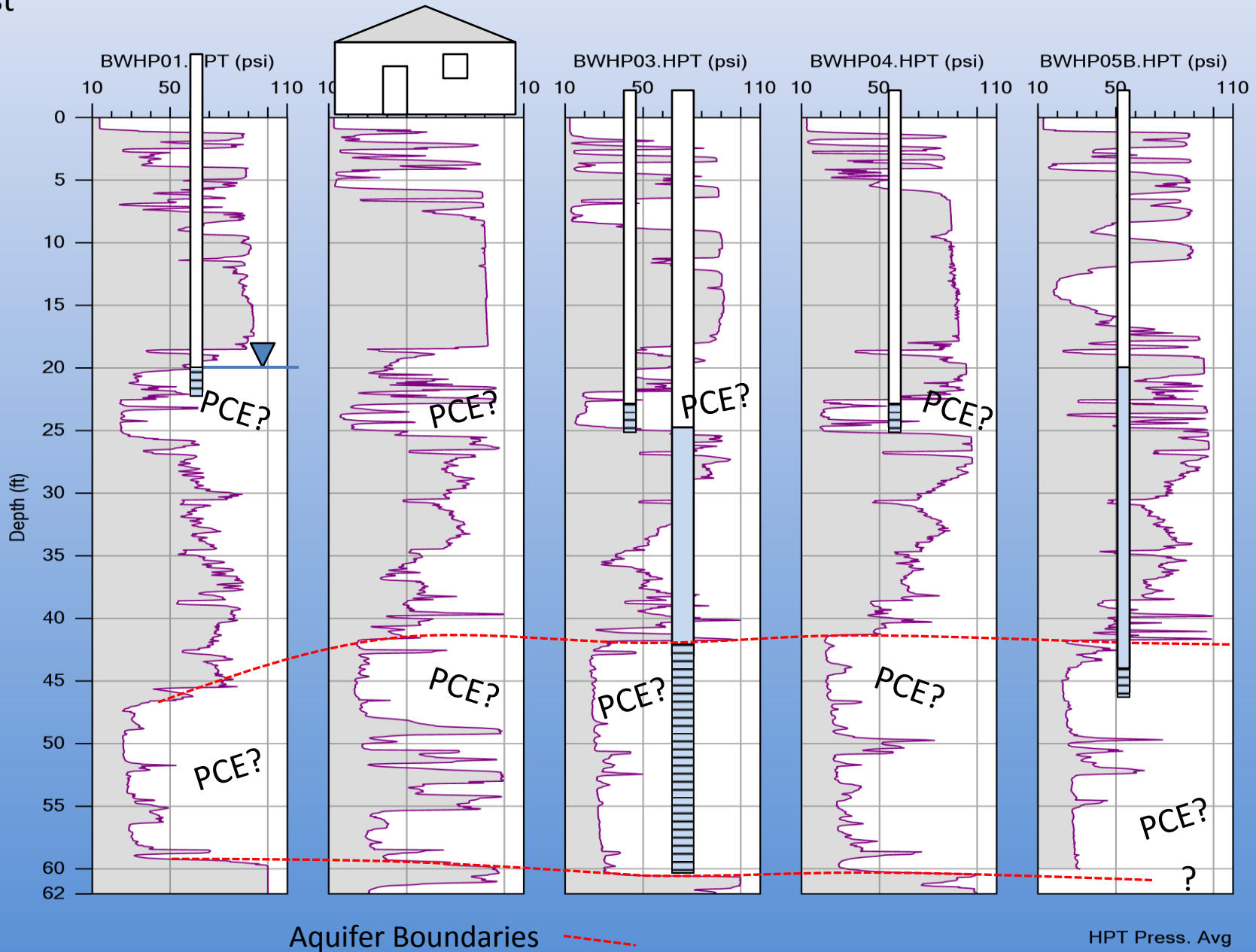
East



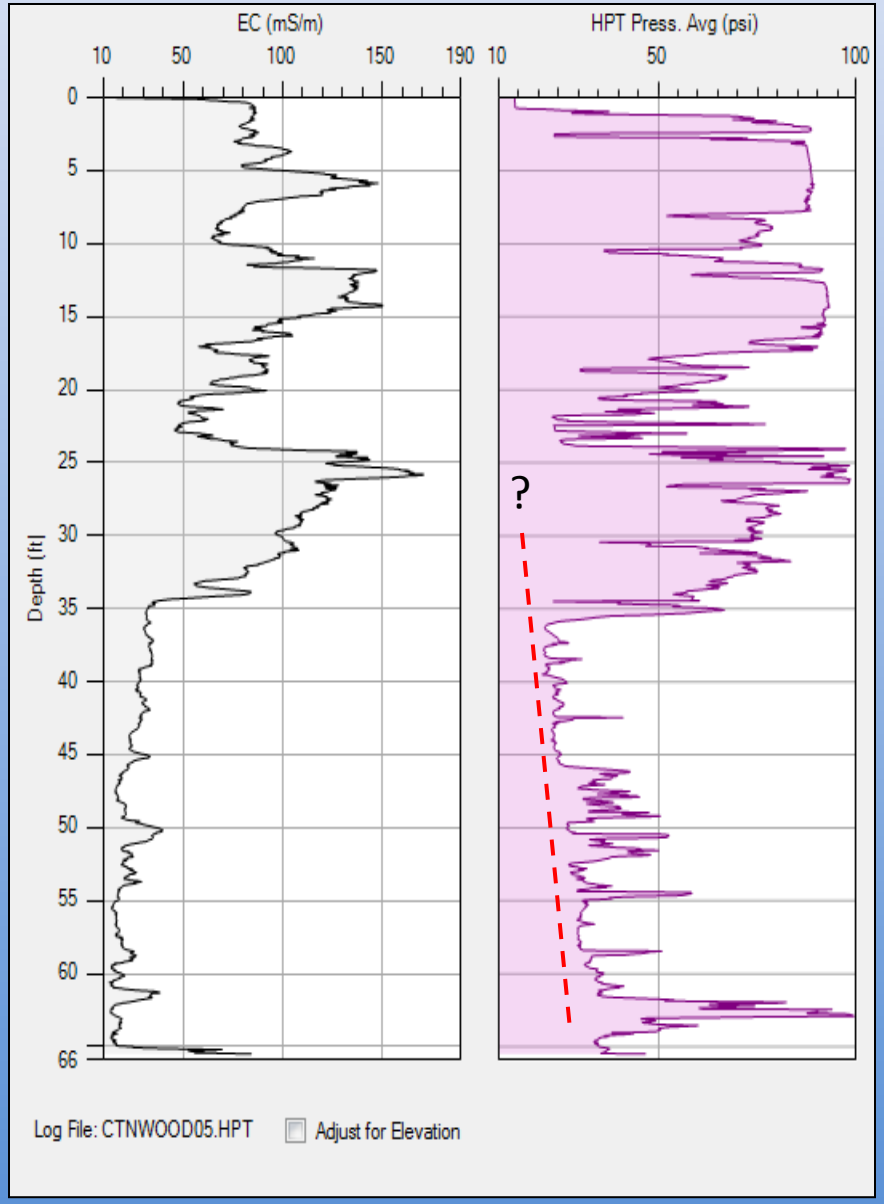
Hydrostratigraphy … Groundwater PCE Plume

West

East



Hydrostatic Pressure, Dissipation Tests, Water Levels & More



Dissipation Tests allow for the applied pressure to the formation to dissipate to equilibrium

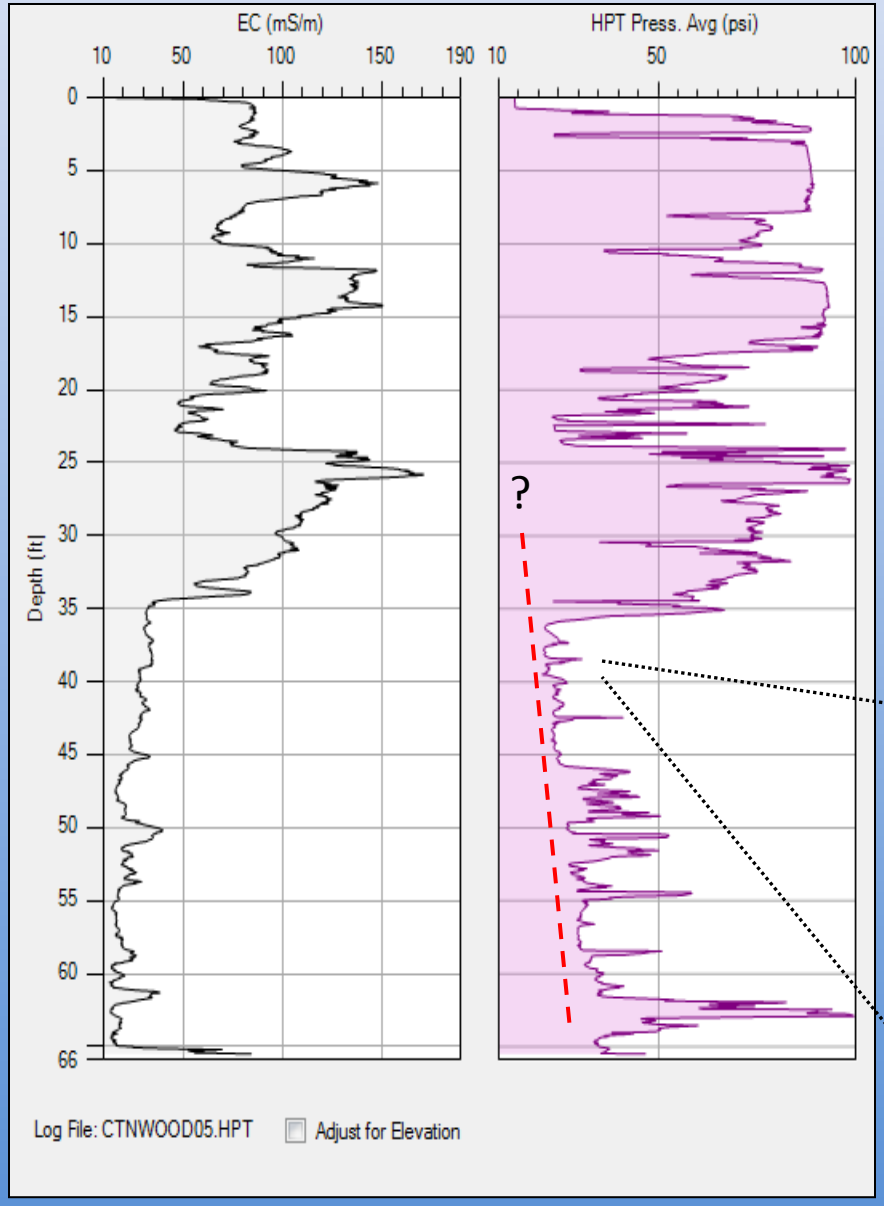
Dissipation Tests Needed to Determine:

- Water Level
- Hydrostatic Pressure
- Corrected HPT Pressure
- Est. Hydraulic Conductivity

Hydrostatic Pressure:

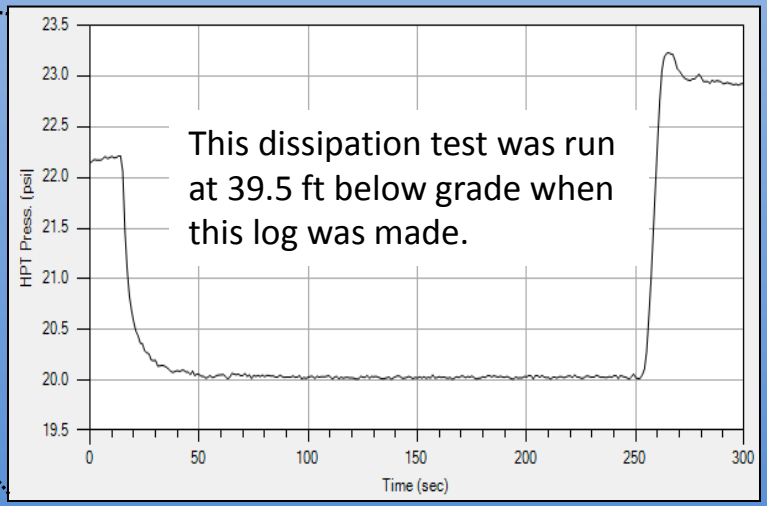
- 2.31 ft of water = 1 psi
- 0.433 psi/ft water

Hydrostatic Pressure, Dissipation Tests, Water Levels & More



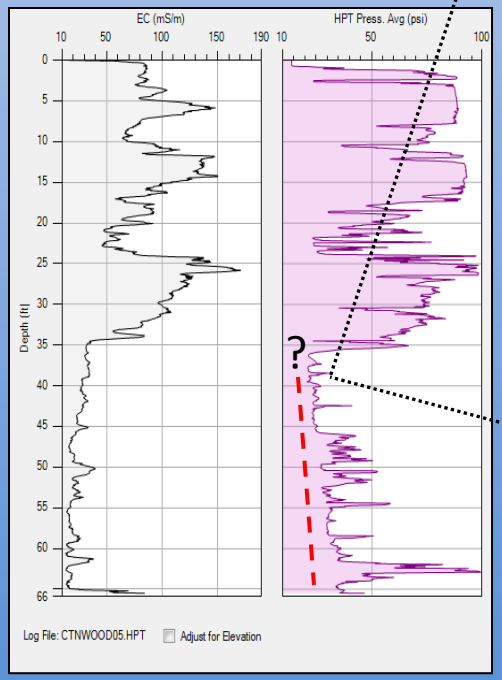
Pressure **Dissipation Tests** yield absolute hydrostatic pressure below the water table.

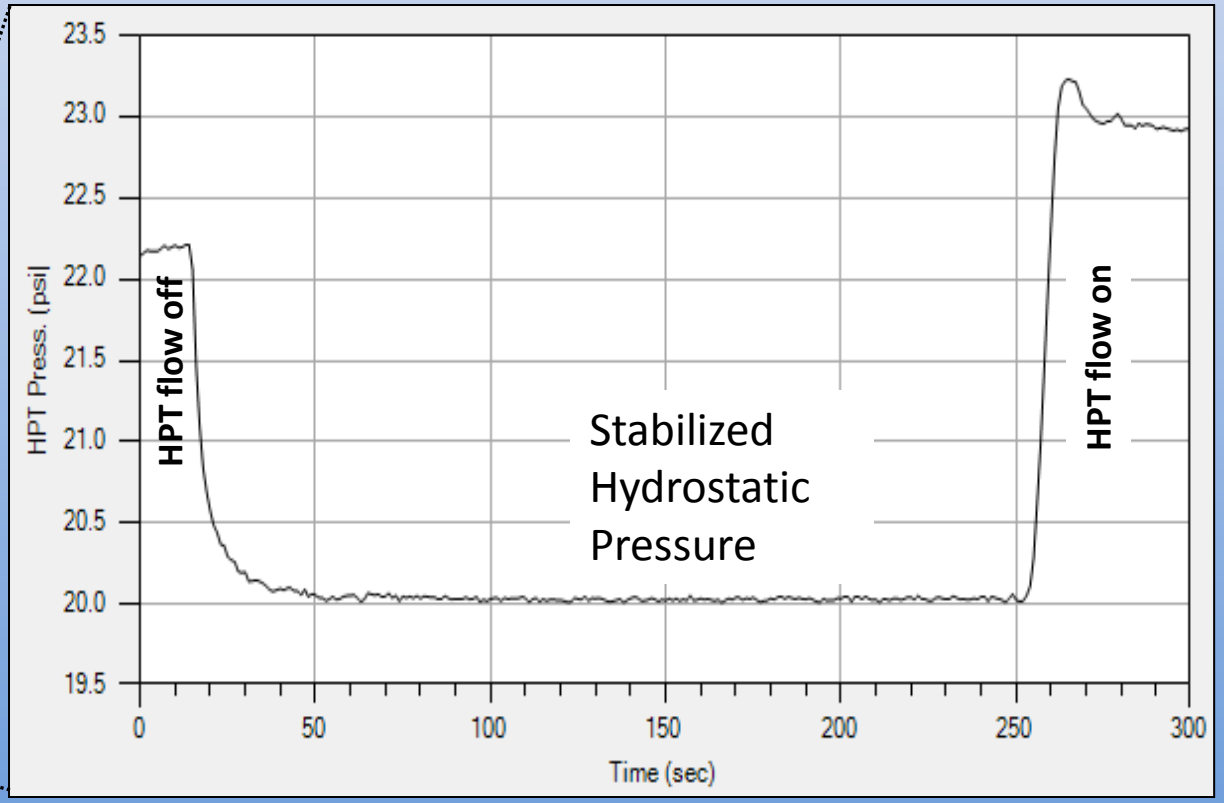
Prefer to run dissipation tests in sandy zones.



To Run a Dissipation Test …

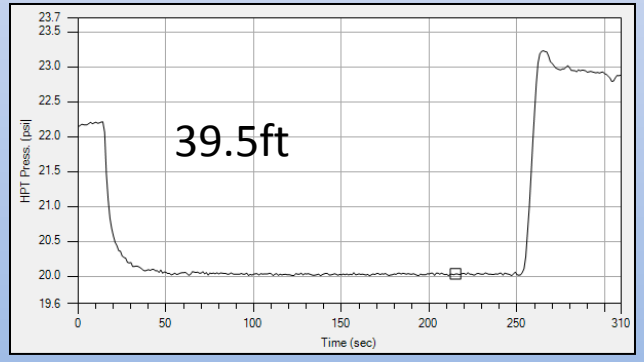
- Stop Probe Advancement
- Turn off HPT flow
- Record pressure changes in a time file

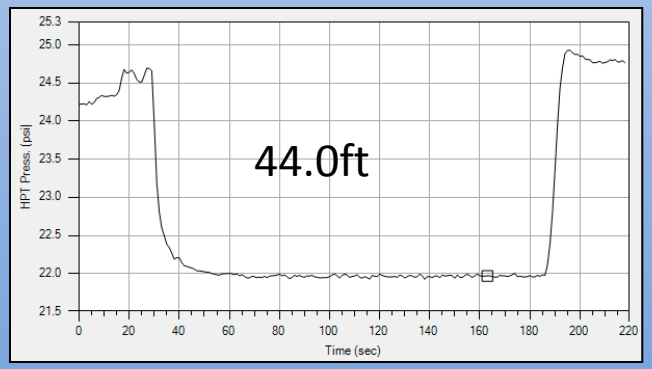


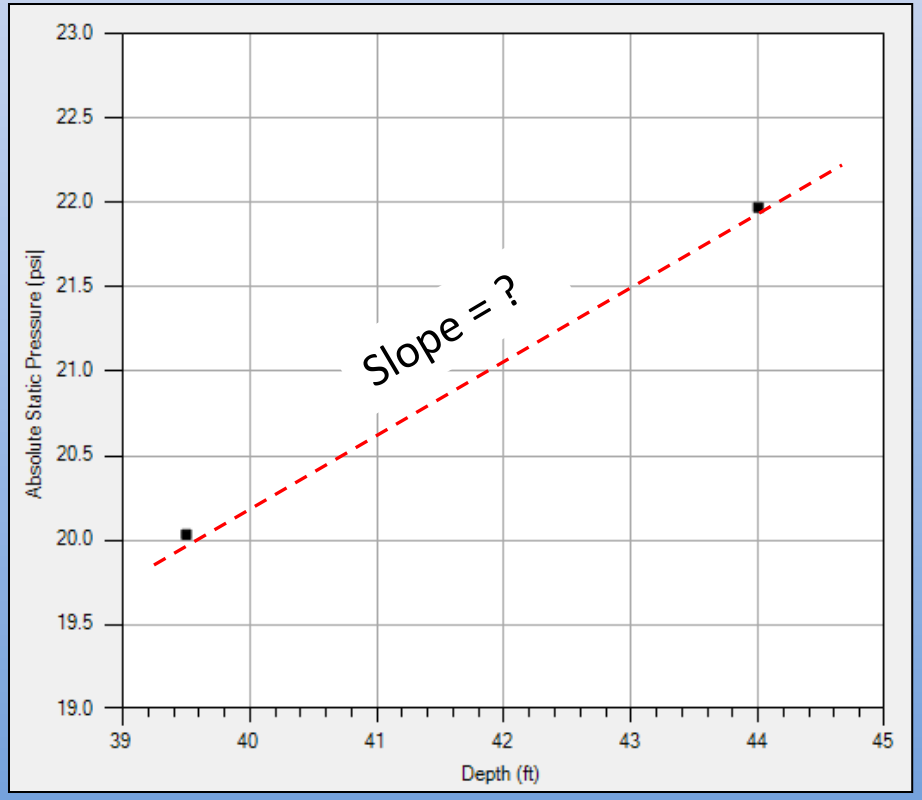


This dissipation test was run at 39.5 ft below grade when this log was made.

Is Slope of the Hydrostatic Pressure Line Correct?



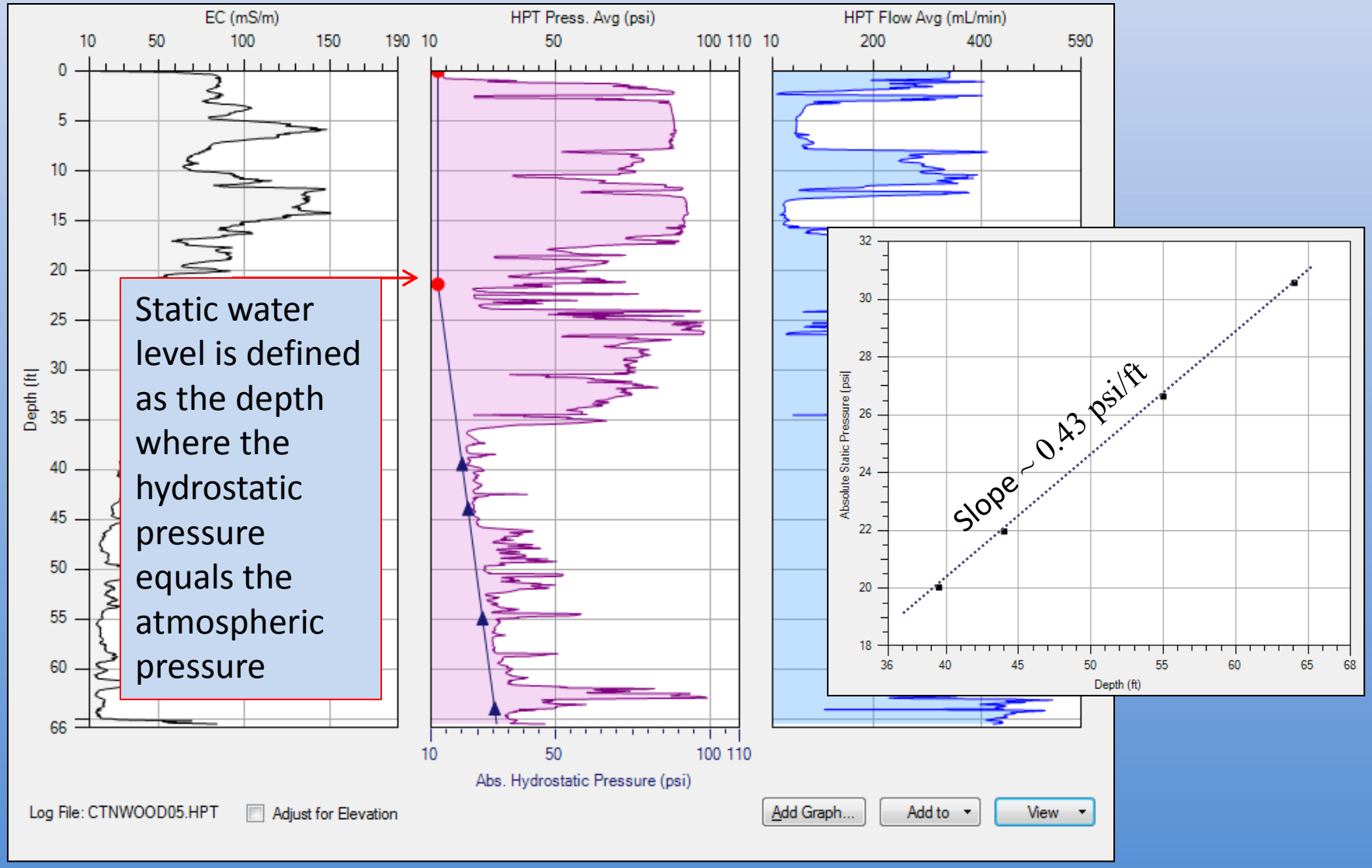




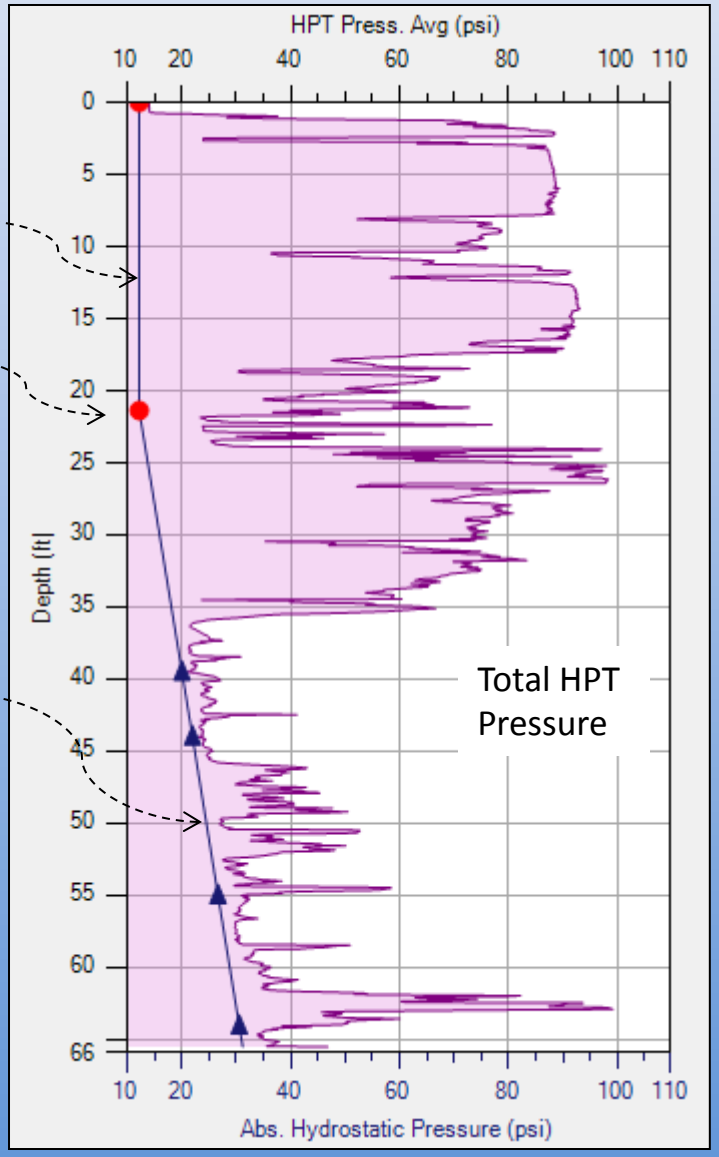
$$\frac{21.971 - 20.036 \text{ psi}}{44.0 - 39.5 \text{ ft}} = \frac{1.935 \text{ psi}}{4.5 \text{ ft}} = 0.430 \text{ psi/ft} = \text{hydrostatic pressure slope}$$

(for a water table aquifer)

Fully Dissipated Tests = Good Hydrostatic Pressure Line and Water level



Corrected HPT Pressure



Atmospheric Pressure

Static Water Level

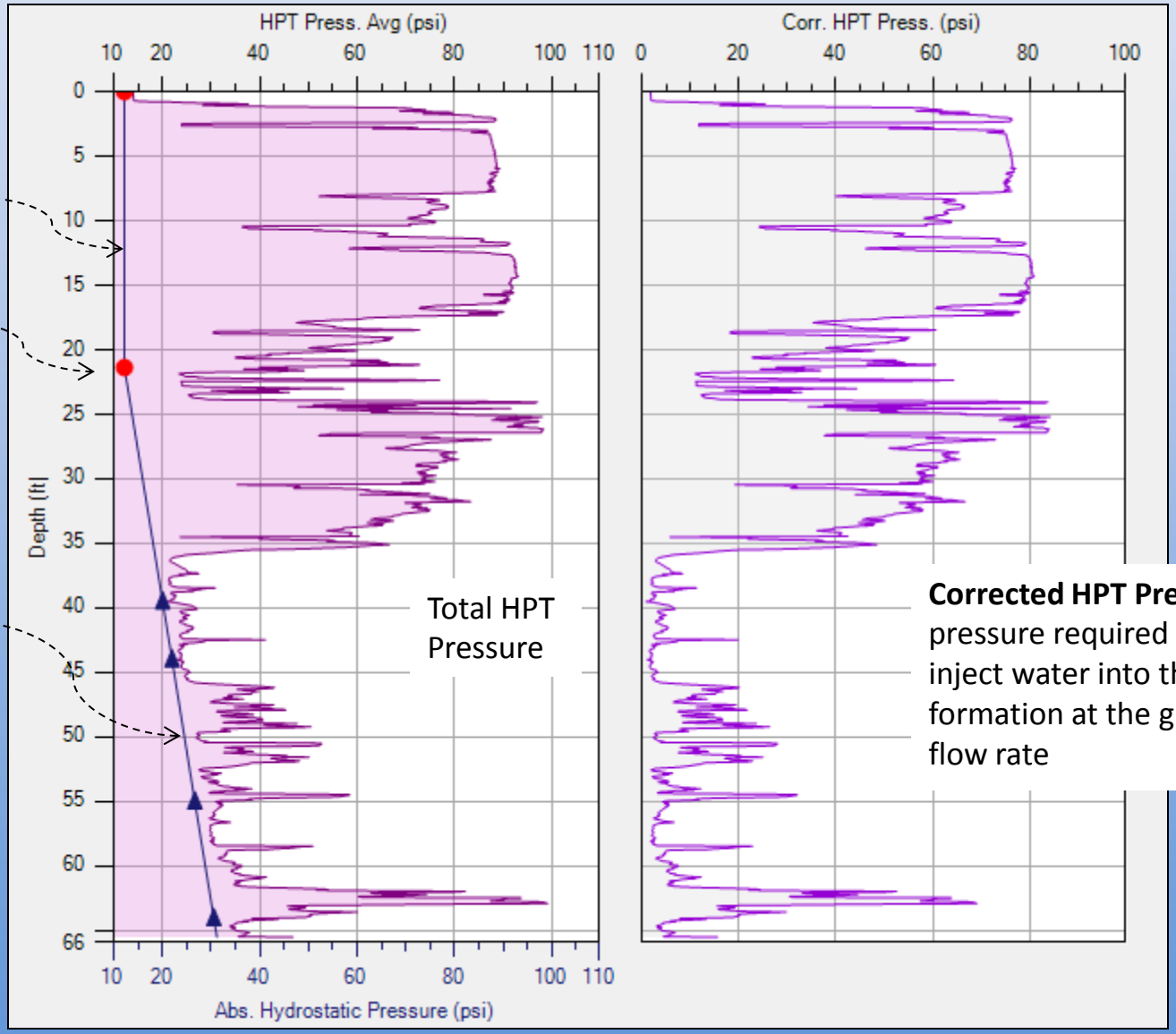
Hydrostatic + Atmospheric Pressure

At each depth increment:

Corrected HPT Pressure (Pc) =

Total HPT Pressure – (Atm. Press. + Hydro. Press)

Corrected HPT Pressure



Atmospheric Pressure

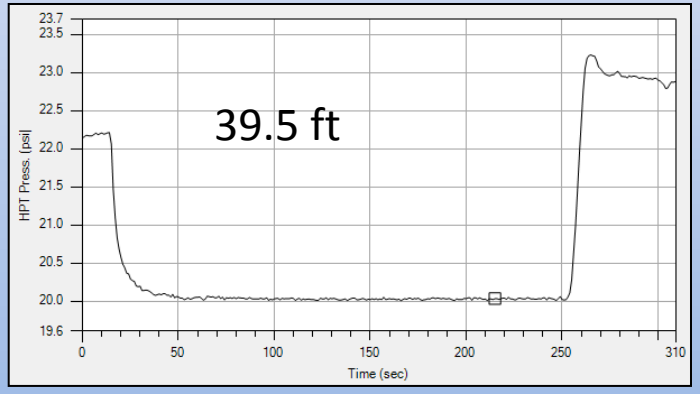
Static Water Level

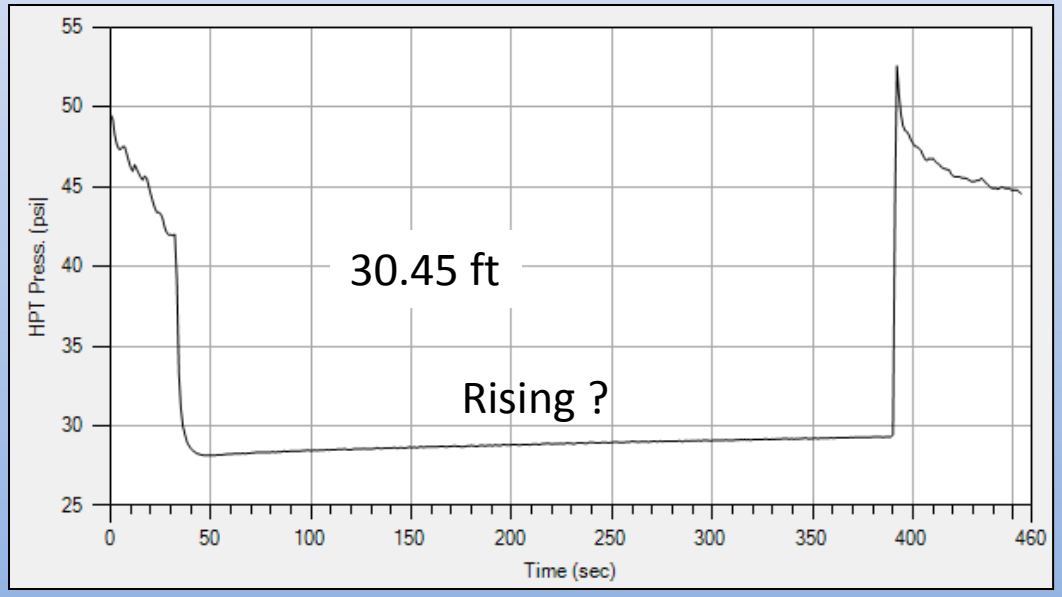
Hydrostatic + Atmospheric Pressure

Corrected HPT Pressure = pressure required to inject water into the formation at the given flow rate

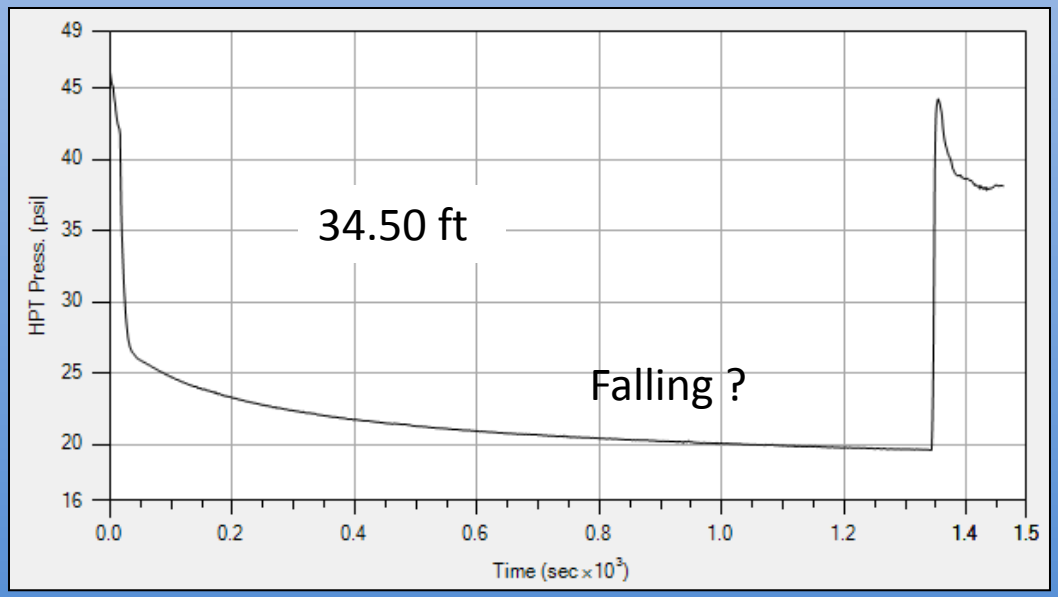
At each depth increment: Corrected HPT Pressure = Total HPT Pressure – (Atm. Pressure + Hydrostatic Pressure)

Is Your Dissipation Test Fully Dissipated ?

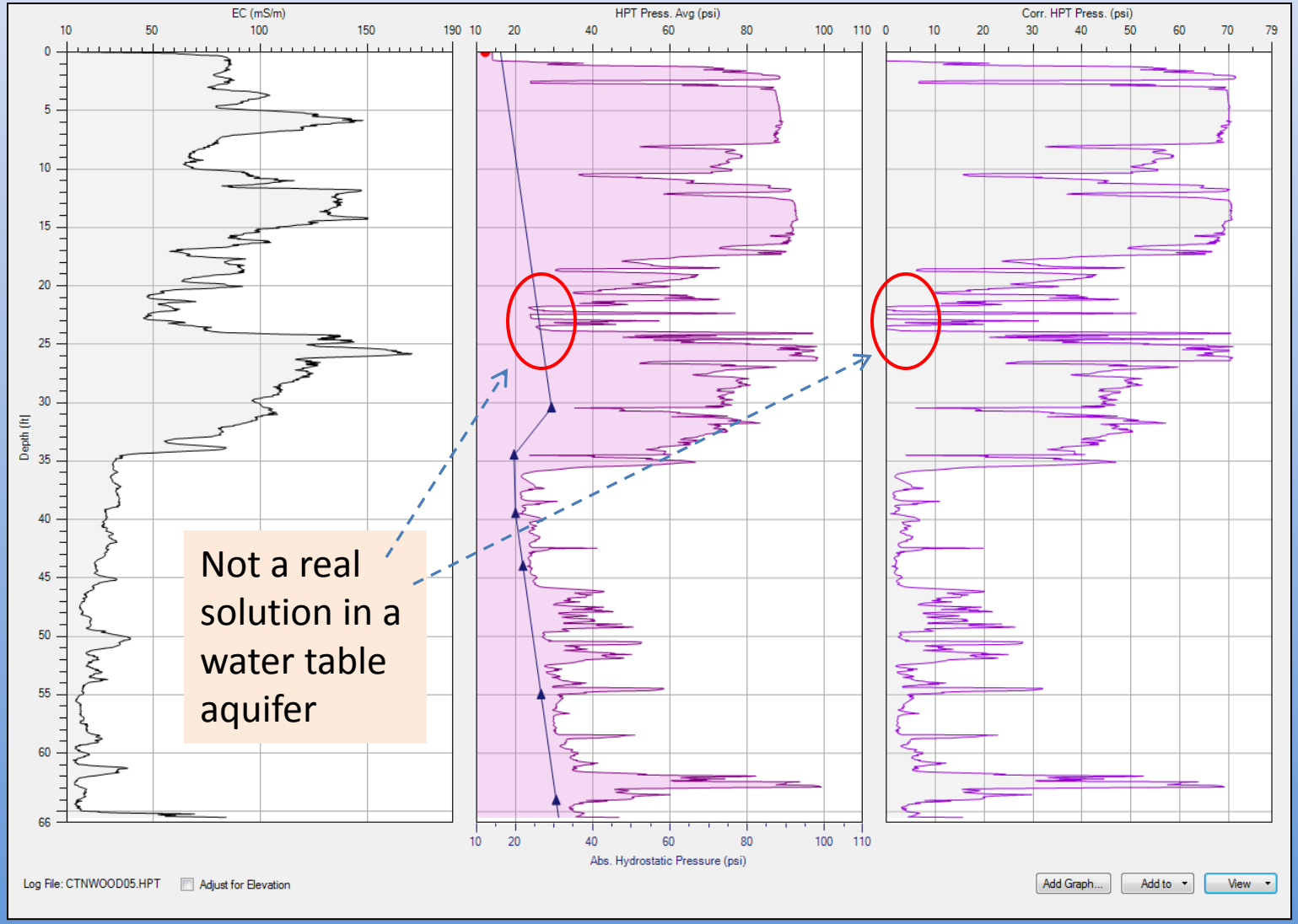




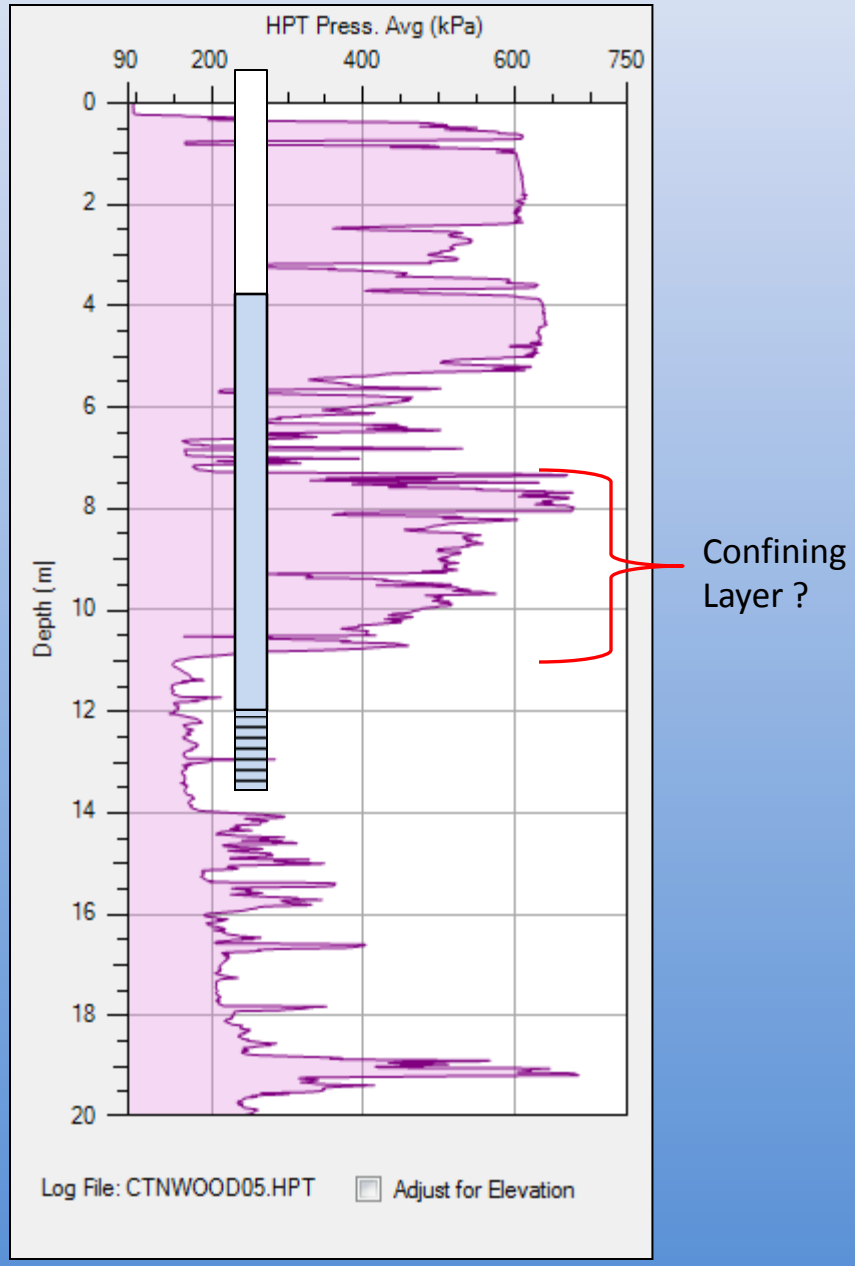
Examples of Unsuccessful Dissipation Tests



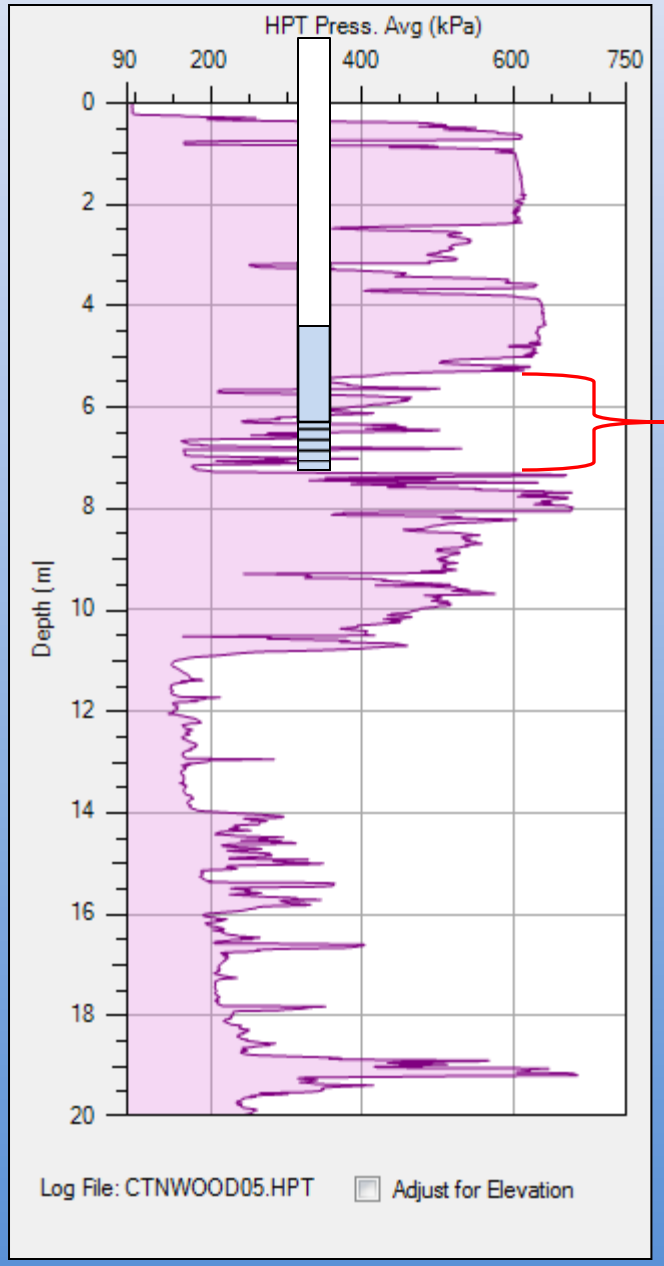
Incomplete Dissipation Tests …



… result in incorrect hydrostatic pressure lines (slope), incorrect static water levels and incorrect corrected pressure graphs …



Confining Layer ?



Perched Water ?

Estimating Hydraulic Conductivity (K) with HPT Log Data

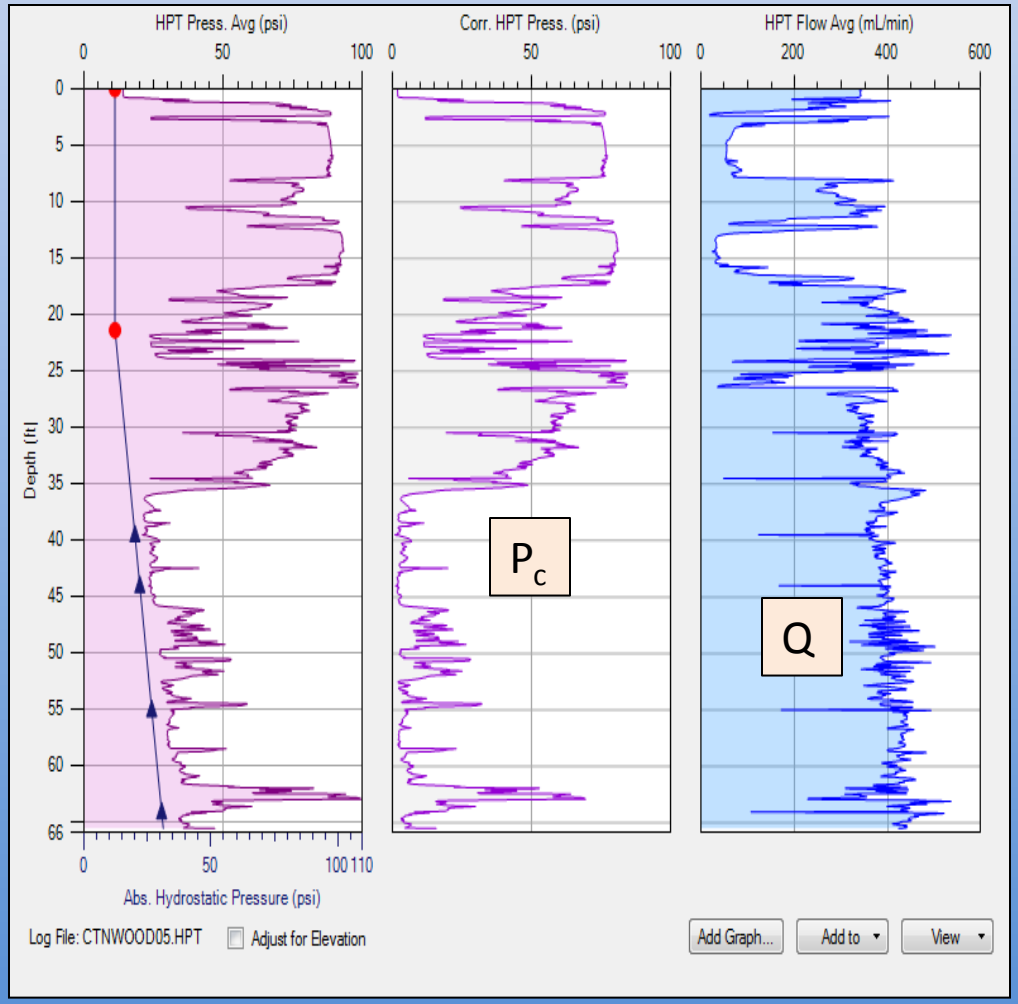
From Darcy's Law:

Hydraulic Conductivity (K) = f(Q/P)

HPT logs provide both:

Corrected Pressure (P_c)

And Flow Rate (Q)



Estimating K with HPT Q and P_c Data

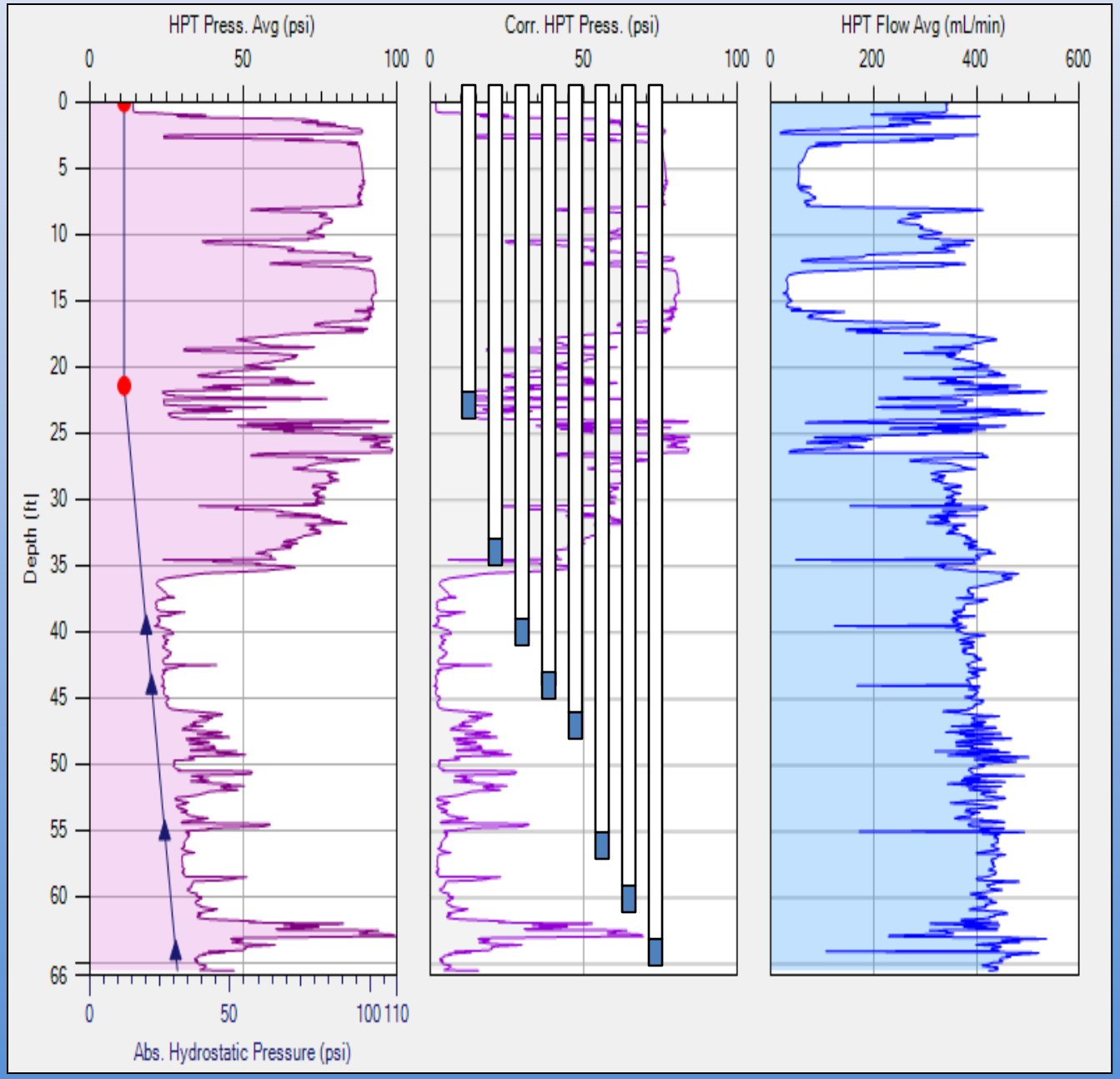
Empirical Model developed from co-located slug tests and HPT logs to calculate K from Q/P_c ratio.

Performing a Pneumatic Slug Test

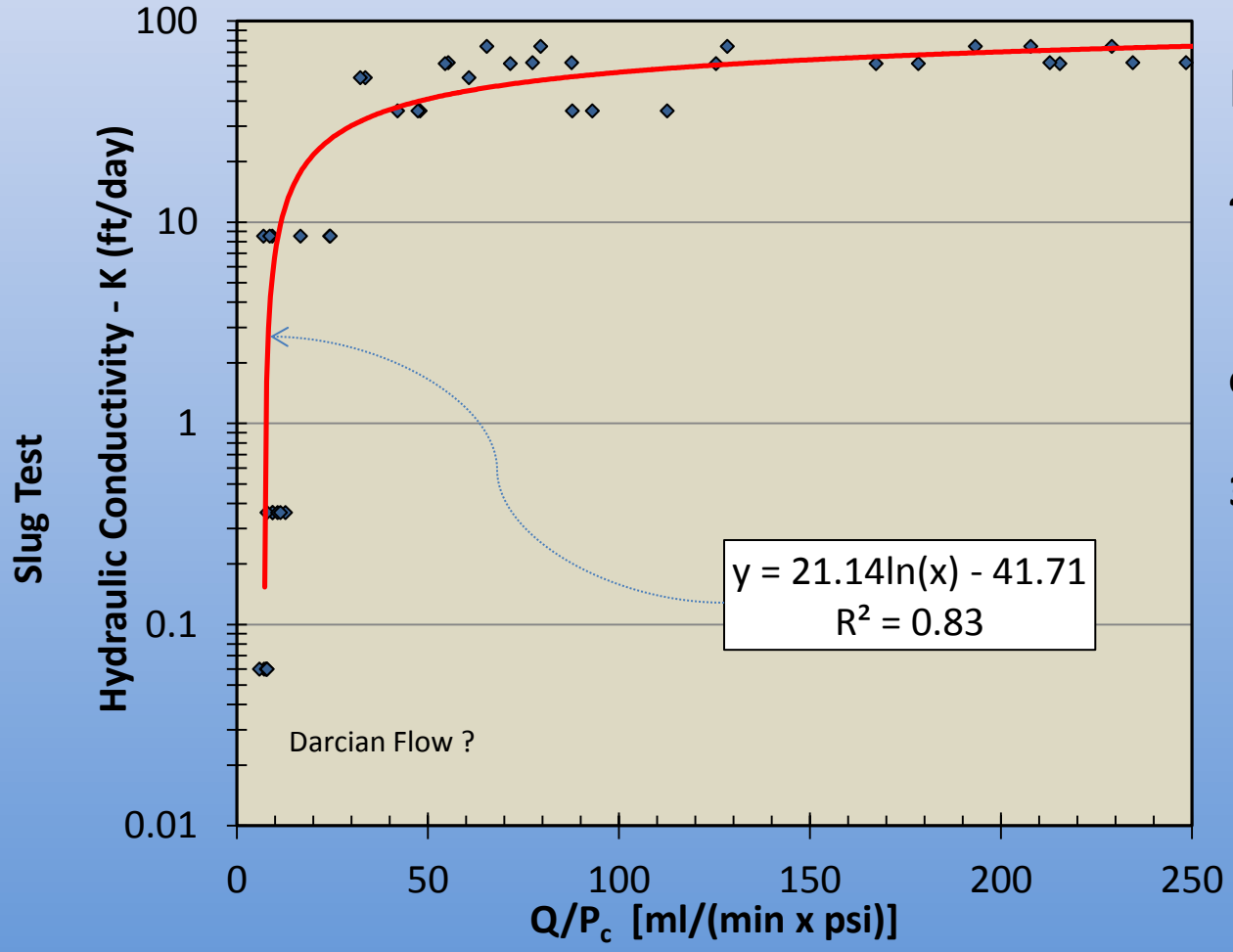
Study area next to cottonwood tree

Multi-Level Discrete Interval Slug Tests

K = f(Q/Pc)



Empirical Model for Estimating K with HPT Q & P_c



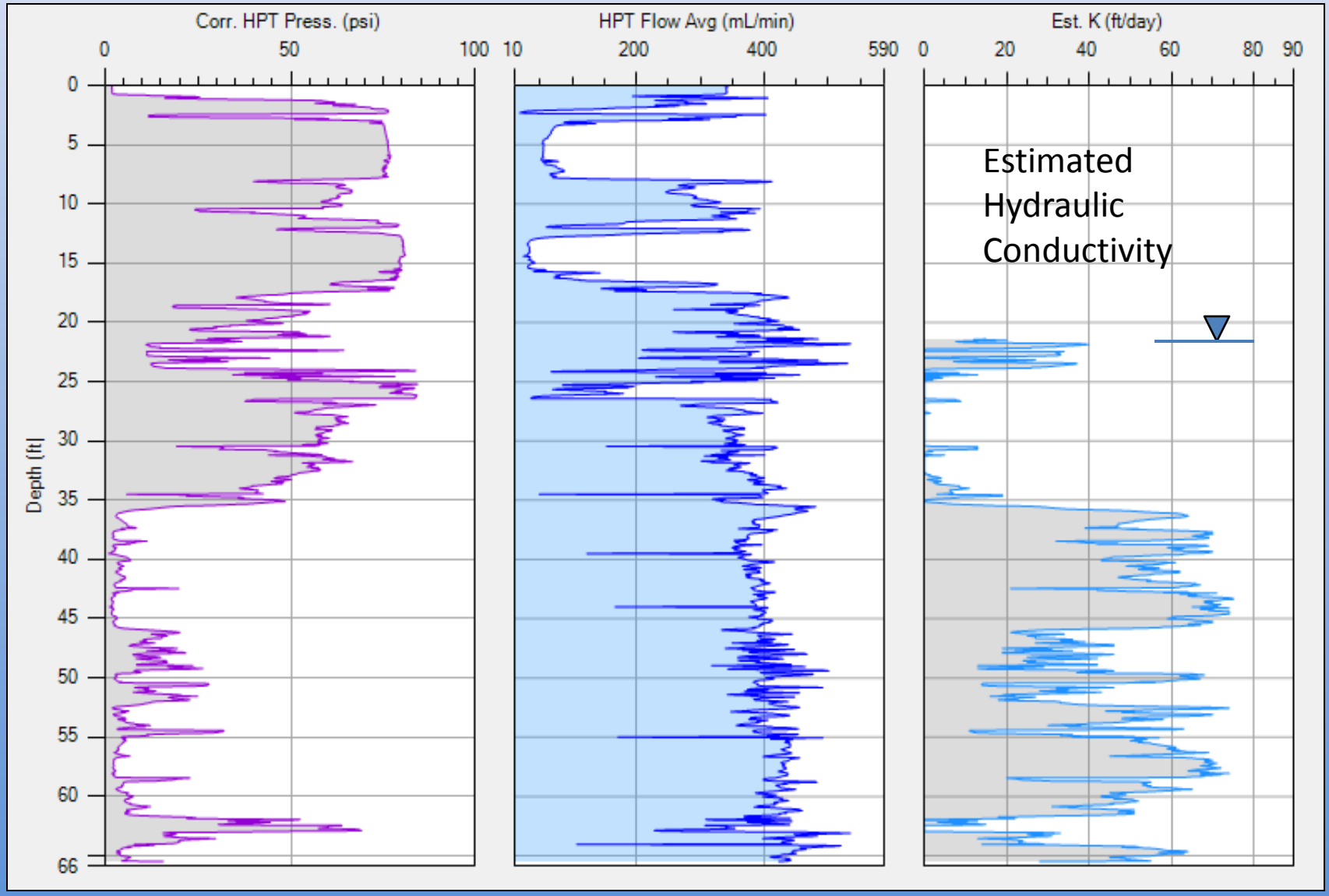
Model Limits

~ 0.1 ft/day to 75 ft/day

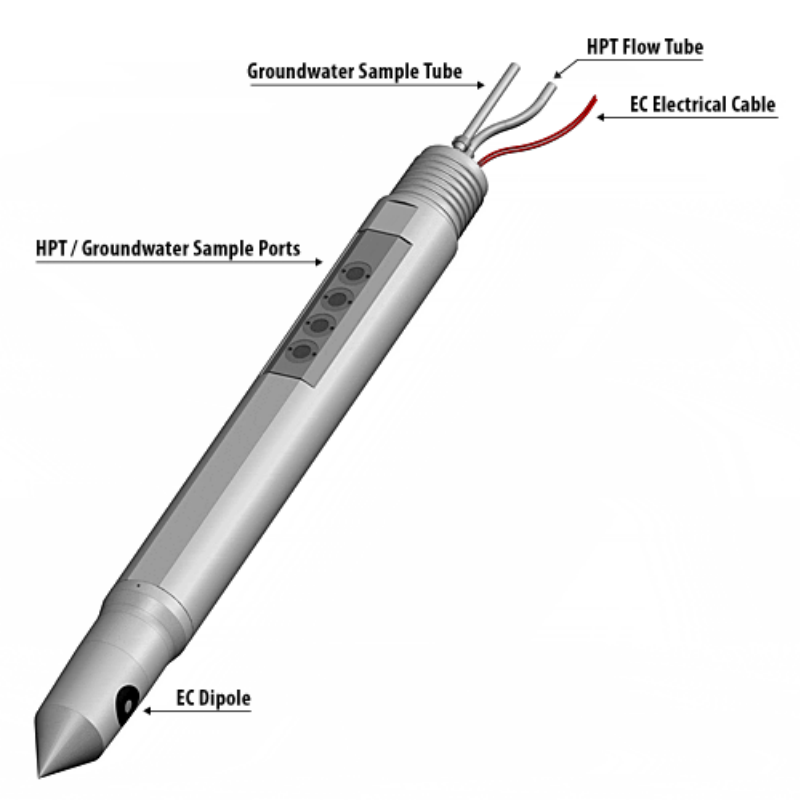
or

3.5E-5 cm/sec to 2.6E-2cm/sec

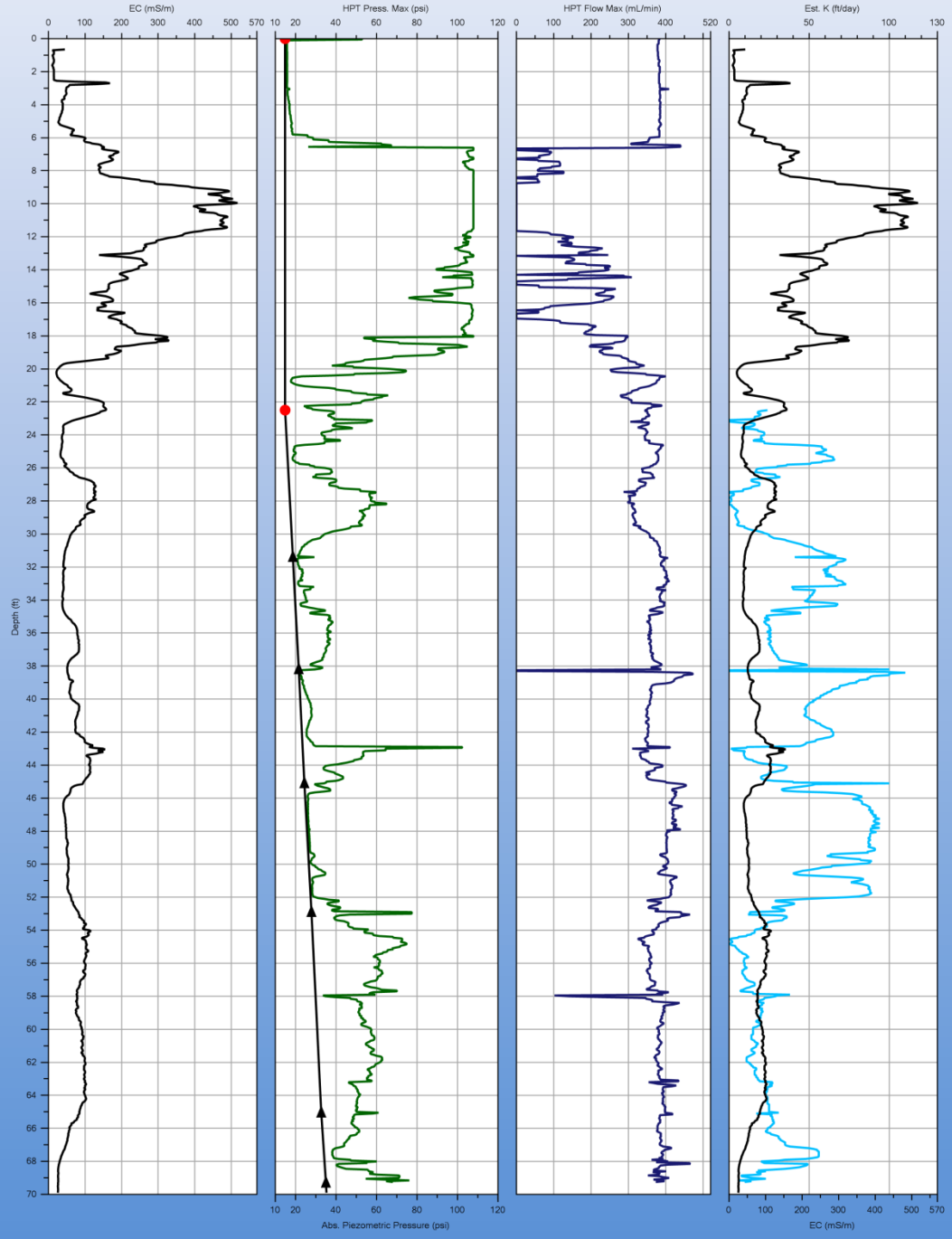
Estimated K with the DI Viewer Software



HPT – Groundwater Sampler



- Same principal of operation as HPT
- Increased Flow to 400 mL/min
- 4 injection ports
- Produces an HPT log similar to the standard tool
- The system is connected to pump/tubing for sample collection
- Bladder or Peristaltic Pumps are used for sampling.



HPT-GWS Log

Maxton, North Carolina

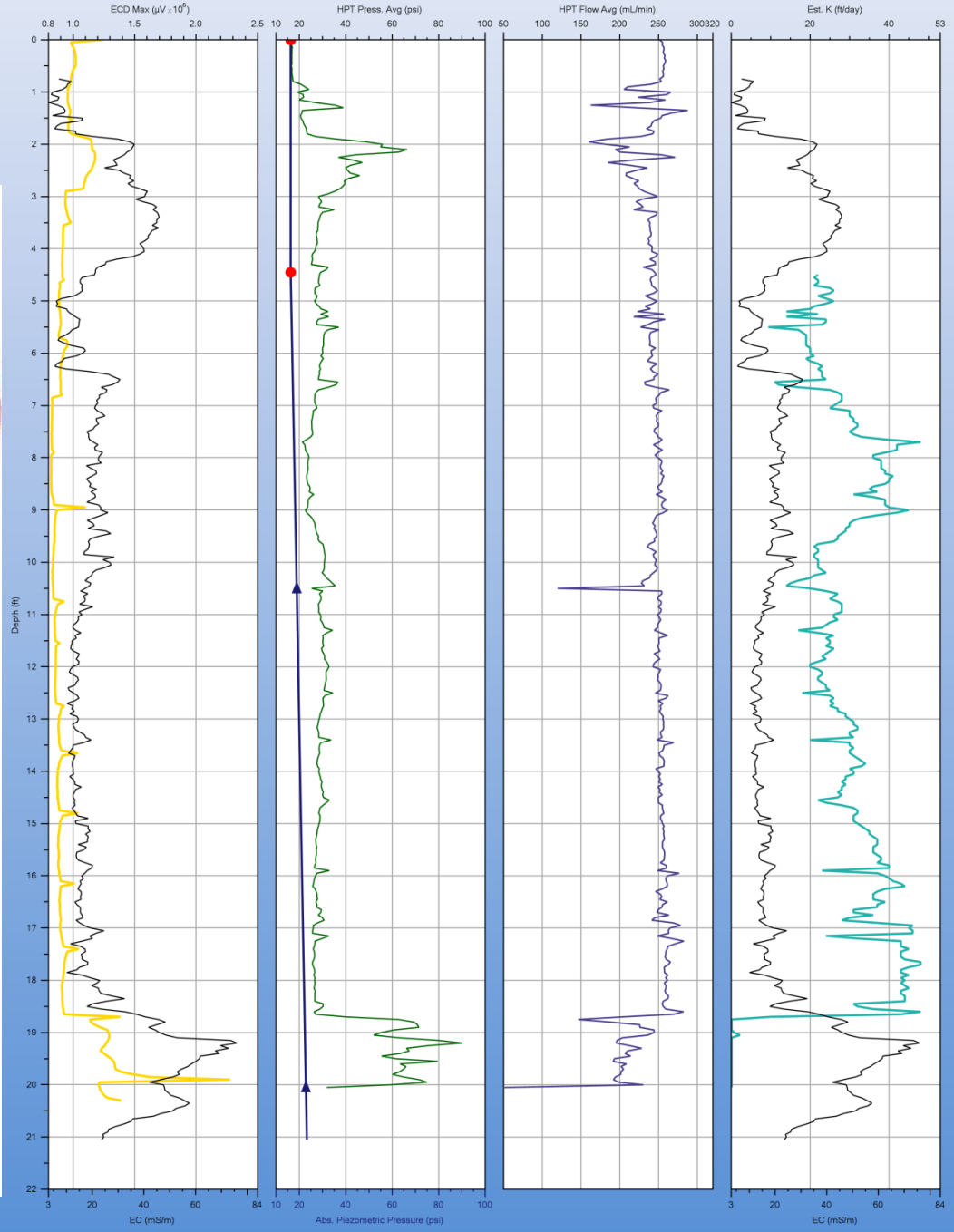
Sample collected at each black triangle

HPT – Groundwater Sampler Benefits

- Collect a large data set in one push – lithology (EC), permeability (HPT), and analytical data (sampler)
- Collect groundwater samples at multiple depths in one push
- HPT pressure and EC data can be utilized to select sampling intervals
- Samples collected from precise intervals – about 4 inches

HPT – Groundwater Sampler Limitations

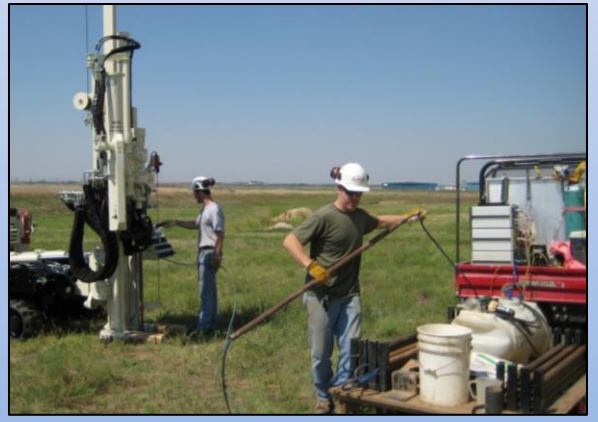
- Larger Tool – 2.25” tool and rod may limit depth over the standard 1.75” tooling
- Samples must be collected from permeable zones
- Decontamination limitations
- 2x the time per boring as standard HPT (dependent on # of samples and sampling procedures)



MIP and HPT or MiHPT

Summary

- HPT Principles of Operation
- Equipment Required for Logging
- Basics of HPT Log Interpretation
- Making a Cross Section with HPT Logs
- Interpreting Hydrostratigraphy with HPT



Summary

- Dissipation Tests, Hydrostatic Pressure & Water Levels
- Correcting HPT Pressure (Pc)
- Estimating Hydraulic Conductivity from Pc and Q
- HPT- GWS Tool Uses and Limitations
- MiHPT

Acknowledgments

Wes McCall and Geoprobe Systems

Geoprobe Systems®

VIRONEX

Questions and Answers …

To learn more about Vironex' Services and Geoprobe's Direct Image systems like MIP, MiHpt, Low Level MIP, EC, CPT and PST check out these links:

http://www.vironex.com/Services/HighResolutionSiteCharacterization.aspx

http://geoprobe.com/geoprobe-systems-direct-image-products