Welcome to Our Webinar:

“Using Hydraulic Profiling Tool (HPT) Logs for Site Characterization”

This presentation will start soon...
Using HPT Logs in Site Characterization Studies

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

HPT >>> High Resolution Site Characterization

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WebinarOutline

- 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 & Pc
- Using HPT Logs for Subsurface Interpretation (conceptual site model ... CSM)
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

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

Water Flow Lines
How Much Injection Flow?

How much per log?

300 ml/min

= ? ml/sec

300 ml
How Much Injection Flow?

300 ml/min \times \frac{1\text{min}}{60\text{sec}} = 5 \text{ 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
- HPT Trunkline
- Replaceable Screens
- Electrical Conductivity (EC) Array
HPT System Components: Electronics

- Lap Top 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

Pre-Log QA: EC Test Load

EC Test Load Used to Verify EC System is Working

Electrical Conductivity Onscreen QA Report (data saved to log file)
Pre-Log QA: HPT Reference Test

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

HPT Probe in Reference Tube to Verify Measurement of $\Delta 6''$ (15cm) of Water Pressure = 0.22 psi (1.52kPa)

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 Management
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

**EC Exceptions?**
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*)

Hard Probing!
Let’s use the DI Viewer Software to open a single HPT log and then create a cross section from several HPT pressure logs ...

The DI Viewer software is available as a free download at: http://geoprobe.com/downloads/direct-image-viewer-16
Hydrostratigraphy with HPT Pressure Cross Section

Facing North: 50 ft spacing between log locations: alluvial deposits
Facing North: 50 ft spacing between log locations: alluvial deposits
Hydrostratigraphy ... Aquifer Boundaries

Aquifer Boundaries

HPT Press. Avg
Our Hypothetical Dry Cleaner Site ...

Little Jr’s Day Care Center

Speedez Dry Cleaner Somewhere USA

Residence

Residential well

HPT01  HPT02  HPT03  HPT04  HPT05

50 ft (~15 m)
Hydrostratigraphy ... Groundwater PCE Plume

West

Aquifer Boundaries

East
Hydrostratigraphy ... Groundwater PCE Plume

West

Aquifer Boundaries

HPT Press. Avg
Can we know what the static water level is at this site before we install a well or piezometers? How?
Hydrostatic Pressure =
- 2.31 ft of water = 1 psi
- 0.433 psi/ft water
- 1 meter of water = 9.81 kPa
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.

This dissipation test was run at 39.5 ft below grade when this log was made.
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.
Let’s use the DI Viewer Software to review some dissipation tests ...
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

Static water level is defined as the depth where the hydrostatic pressure equals the atmospheric pressure.

Slope ~ 0.43 psi/ft
Corrected HPT Pressure

At each depth increment:

Corrected HPT Pressure \( (Pc) = \) Total HPT Pressure \( - (\text{Atm. Press.} + \text{Hydro. Press}) \)
Corrected HPT Pressure

At each depth increment: 
Corrected HPT Pressure = Total HPT Pressure – (Atm. Pressure + Hydrostatic Pressure)
Is Your Dissipation Test Fully Dissipated?

Why do I care?

39.5 ft

30.45 ft

Rising?

34.50 ft

Falling?
Incomplete Dissipation Tests ...

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

Not a real solution in a water table aquifer
However, in the real world ...

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

\[ K = f(Q/P_c) \]
Empirical Model for Estimating $K$ with HPT $Q$ & $P_c$

Model Limits

$\sim 0.1 \text{ ft/day to 75 ft/day}$

or

$3.5 \times 10^{-5} \text{ cm/sec to 2.6E-2 cm/sec}$

$y = 21.14 \ln(x) - 41.71$

$R^2 = 0.83$
Estimated K with the DI Viewer Software

Estimated Hydraulic Conductivity
How Well Does the Est. K Model Work?

MiHpt Logging, Skuldelev, DK

Co-located Slug Testing in Skuldelev
Former Schilling AFB: Old Fire Training Area Site
TCE in Groundwater at the Former SAFB
HPT Logging Transect

Dan & Blake in the 105F heat running MiHpt logs ...
Logs WS06, 07 and 15

Bedrock Refusal
Logs WS06, 07 and 15
SK07 HPT Log Detail

Dissipation test at 34.15ft
SK07 HPT Log Detail

This is your contaminant migration pathway!
Slug Test K over this interval is:

35.4 ft/day or 10.8 m/day

X-VOC contaminants detected were:

- Carbon tet = 13,000 µg/l
- Chloroform = 370 µg/l
- TCE = 5480 µg/l

Total X-VOC = 18,850 µg/l
Using HPT Logs for Subsurface Interpretation (Developing a Conceptual Site Model ... CSM)

MiHpt Logs from Skuldelev, DK

MiHpt is a combined membrane interface probe and HPT probe

- HPT Injection Screen
- MIP Membrane
- EC Dipole

Genuine Geoprobe®
Skuldelev Location & Site Map

MiHpt Log  X
Cross section Line ---
GW Plume & Hot Spot

PCE, TCE, DCE & VC

Logs are spaced 8 m (~25ft) apart.
Skuldelev SK05 Location Log

- Sand & Gravel ± Fines
- Clay-Till

Graph showing data for HPT Press. Avg (kPa), Corr. HPT Press (kPa), and XSD Max (μV x 10⁵) with layers for PCE, TCE, DCE, and VC.
Skuldelev HPT Pressure X-Section
(Elevation Corrected)

East

West

Identity

SK01

SK04

SK05

SK12

Pressure (kPa)

HPT Press. Avg

HPT Press. Avg

HPT Press. Avg
Skuldelev HPT Pressure X-Section

East

West

- SK01
- SK04
- SK05
- SK12

Sand & Gravel (Low HPT Pressure)

Gray Clay-Till (High HPT Pressure)
Skuldelev HPT Pressure X-Section = hydrogeologic model = CSM

Paleo-Stream Valley (filled with sand & gravel)

Gray Clay-Till (High HPT Pressure)
Skuldelev HPT Pressure and XSD Cross Section

East

West
Skuldelev HPT Pressure and XSD Cross Section

Gray Clay-Till (High HPT Pressure)
Skuldelev Location & Site Map

MiHpt Log  X
Cross section Line  
GW Plume & Hot Spot

PCE, TCE, DCE & VC

Logs are spaced 8 m (~25ft) apart.
SK05 Location

EC & HPT Pressure

Groundwater specific conductance
Logs are spaced 8 m (~25ft) apart.
MiHpt Log  X
Cross section Line  
GW Plume & Hot Spot
PCE, TCE, DCE & VC
Persulfate Injection
Logs are spaced 8 m (~25ft) apart.
Cross Section with HPT Pressure & EC

Electrical Conductivity (mS/m)

SK04
SK05
SK07
SK08
SK09
SK10
SK11

HPT Pressure (kPa)
Cross Section with HPT Pressure & EC

Electrical Conductivity (mS/m)

High EC in a Sand formation indicates ionic contaminants
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

HPT >>> High Resolution Site Characterization
Summary

• Dissipation Tests, Hydrostatic Pressure & Water Levels

• Correcting HPT Pressure (Pc)

• Estimating Hydraulic Conductivity from Pc and Q

• Developing a CSM with HPT Cross Sections

• Tracking an ionic contaminant or remediation fluid by combining HPT and EC logs
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To learn more about Geoprobe’s HPT logging system or the NEW HPT-GWS (groundwater sampler) and other Direct Image systems like MIP, MiHpt, Low Level MIP, EC, CPT and PST check out this link:

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