Slide 1

Welcome to Our Webinar:

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

This presentation will start soon…

Slide 2

Using HPT Logs in Site Characterization Studies

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

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HPT >>> High Resolution Site Characterization

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The HPT probe is an injection tool that provides data about formation lithology, permeability and the piezometric profile. HPT logs provide high resolution site characterization data, giving 20 data points for each foot of log. So a data point about every 15mm for HPT pressure, flow and electrical conductivity.

Slide 3

Webinar 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
- Using HPT Logs for Subsurface Interpretation
  (conceptual site model … CSM)

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The primary topics we will cover include …

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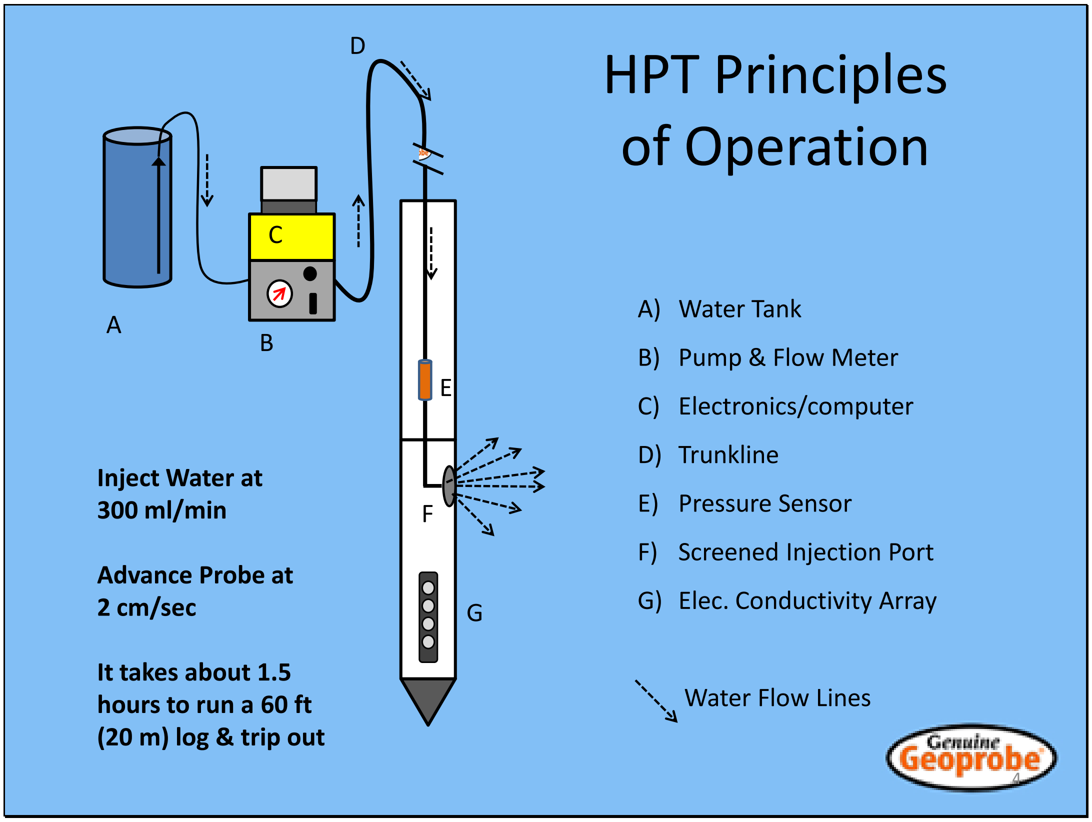


The pump in the HPT flow module (B) draws water from the supply tank and pumps water down the trunkline at a constant flow rate. An inline flow meter measures the flow rate. The downhole pressure sensor (E) monitors the pressure generated by injecting water into the formation matrix. The HPT probe includes an electrical conductivity (EC) Wenner array. The EC, pressure and flow rate are logged every 0.05 ft (15 mm) and displayed onscreen as the probe is advanced.

Slide 5

How Much Injection Flow ?

300 ml

300 ml/min

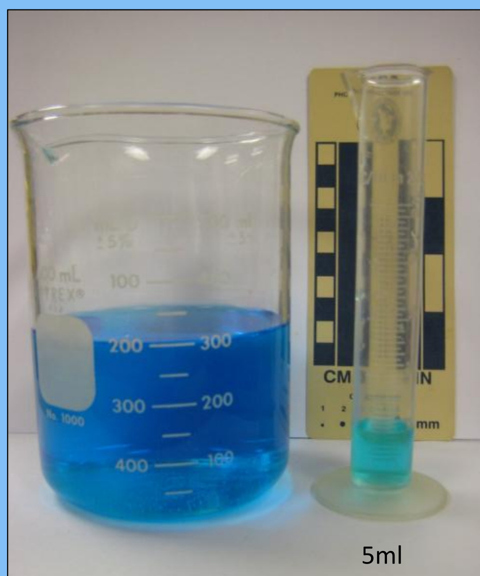
= ? ml/sec

How much per log?

As noted above the typical flow rate for HPT logging is about 300ml/min. About the volume of a large coffee cup.

Slide 6

How Much Injection Flow ?



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

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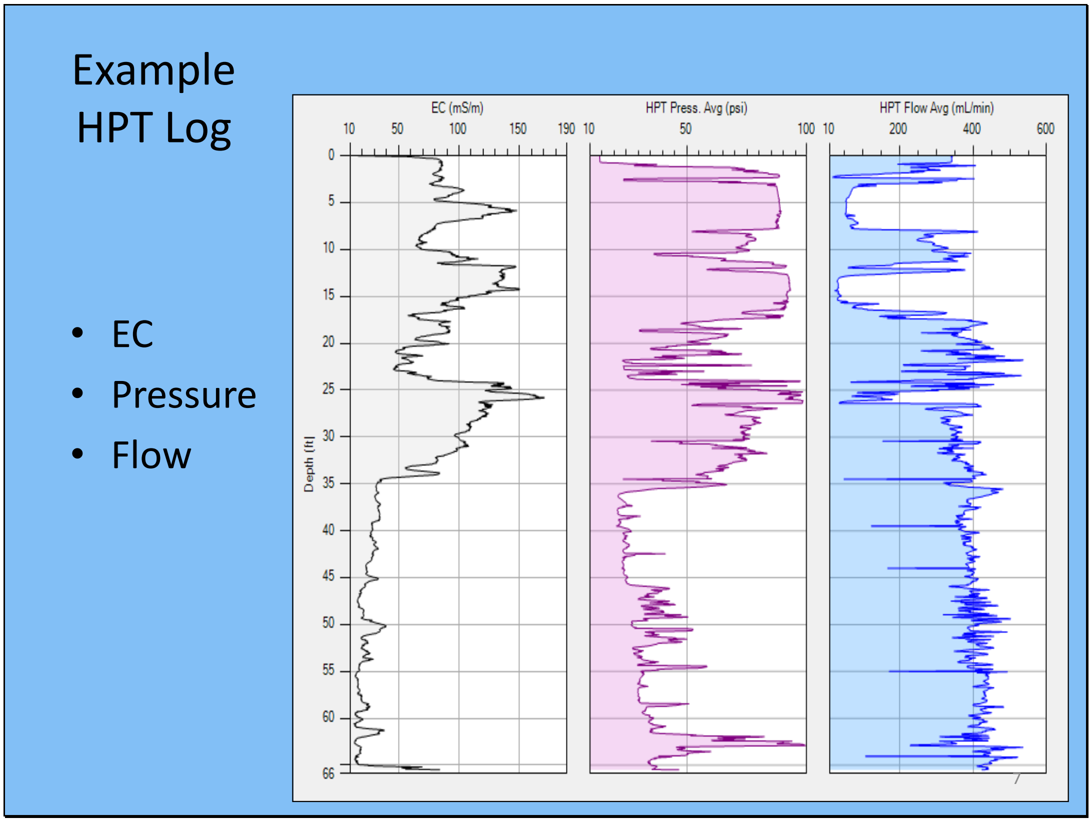
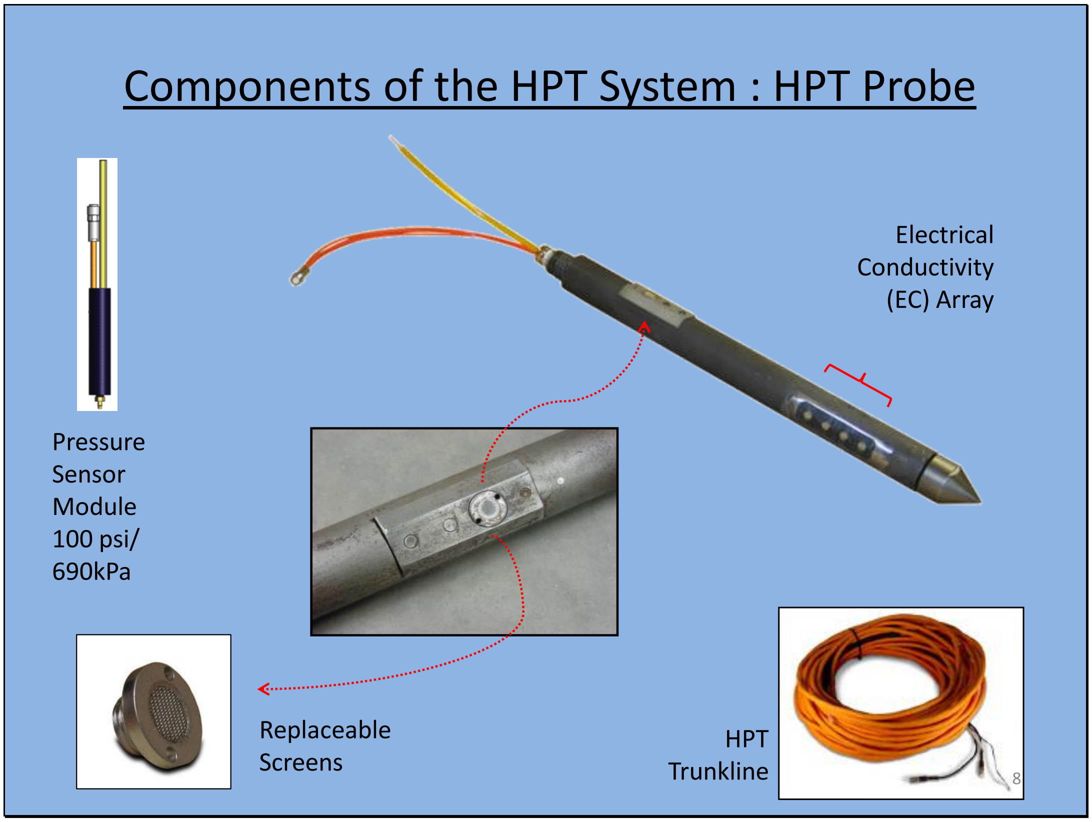
When you include time for adding rods on the way down the hole and maintaining flow as you trip the tools out it usually takes about 5 gallons of water for a 60 ft log (~20 liters for a 20 meter log). Keeping flow through the screen as the tools are tripped out is required to prevent clogging and damamge to the transducer.

Slide 7



This is a typical HPT log that was run in Salina, KS in the Smoky Hill River valley. Units for electrical conductivity are milliSiemens per meter, pressure may be presented in pounds per square inch or kiloPascal, and flow is graphed in milliliters per minute. We will learn to interpret these logs as we proceed.

Slide 8



The HPT screen can be removed for cleaning, or replacement. The trunkline is pre-strung through the probe rods and connections are made at the probe and field instrument before logging is started. Good trunkline connections are important. The pressure sensor is plumbed inline in the connection tube just above the probe.

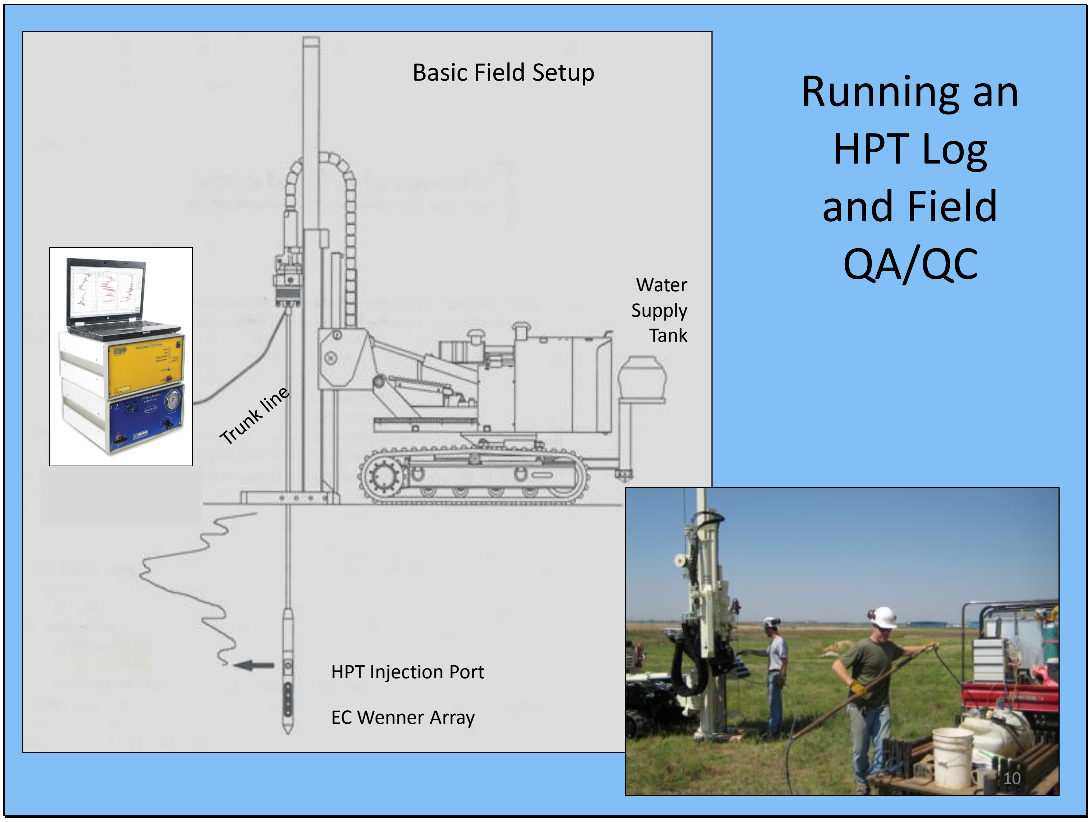
Slide 9

HPT System Components: Electronics

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

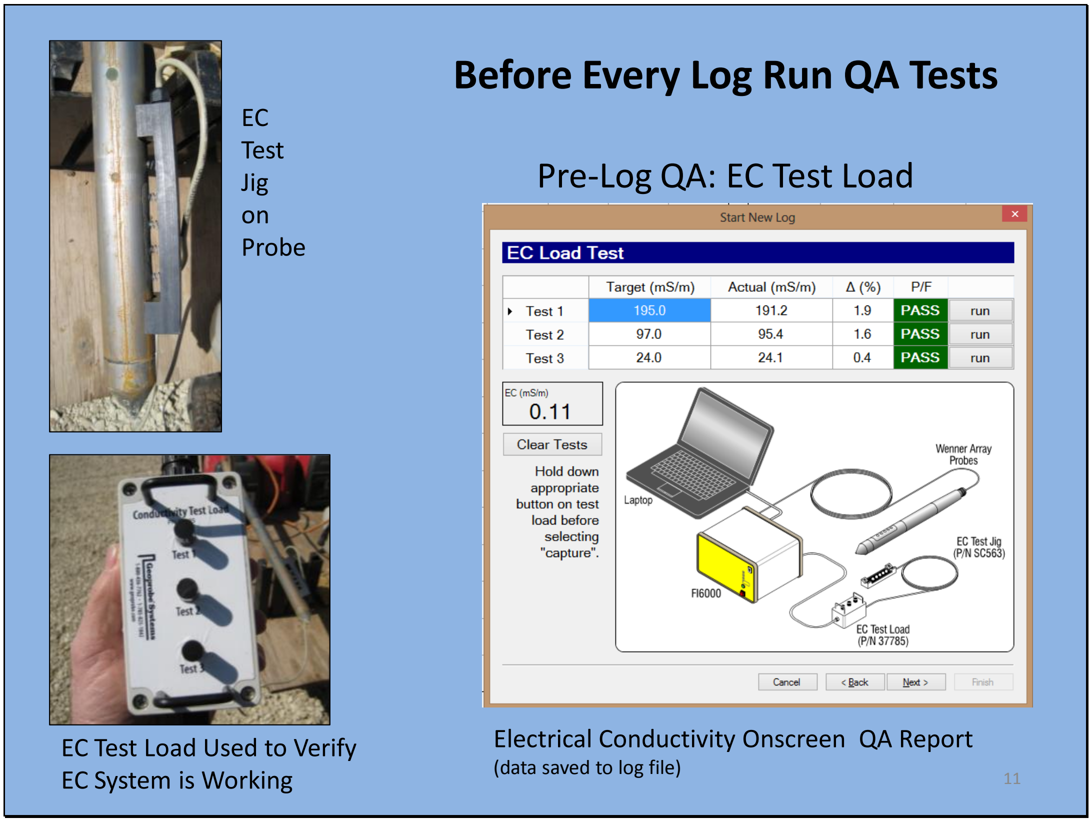
The Direct Image (DI) Acquisition software enables the operator to run logs in the field with a conventional lap top computer. Logs are viewed onscreen in live-time as the probe is advanced. Later the DI Viewer software lets the project manager view logs and conduct post log activities such as viewing dissipation tests, plotting hydrostatic pressure lines and determining water levels, etc. The FI6000 takes analog input from the flow controller and probe and provides digitial output to the computer. The flow module contains the HPT pump and flow meter and pressure transducer for the line pressure.

Slide 10



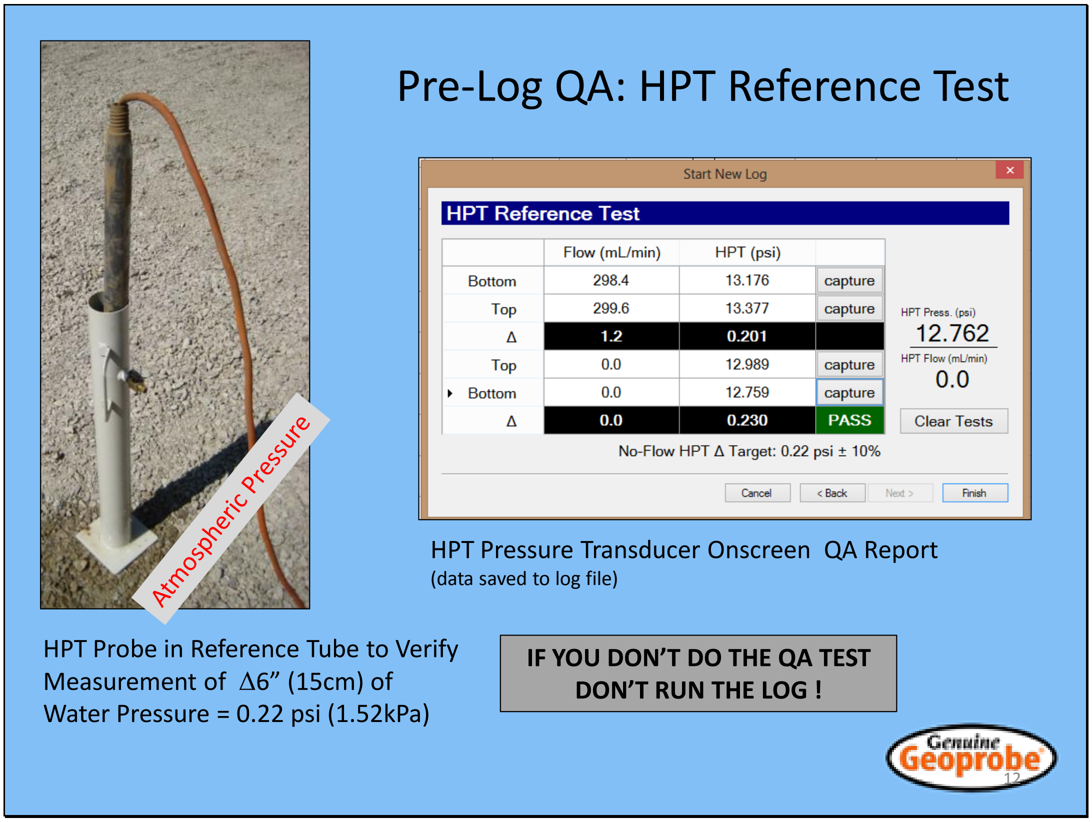
Basic setup in the field for running HPT logs. Rods are prestrung with the trunkline to facilitate easier logging. The rods are carried in a rack on the probe machine or trailer, etc. Trunkline management helps with your daily workout.

Slide 11



The HPT probe and system are tested before and after each log to verify performance. The QA & QC test results are saved in the log file for later review and reporting. Here the EC probe is tested with the test jig and test load to verify the probe and system are working properly.

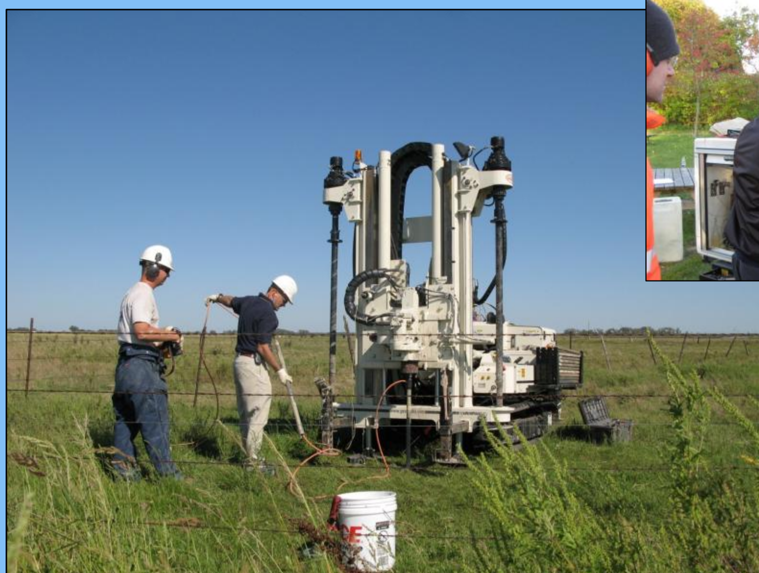
Slide 12



After the EC test the HPT probe is set in the Reference Tube and the water level over the injection screen is changed by six inches to verify that the sensor can correctly measure a difference of 6-inches of water pressure. The "NO FLOW" test is used to QA the transducer. The results of the reference test is saved to the log file for later review and reporting. This test also provides the atmospheric pressure at the time the log was run. The atmospheric pressure is used later to determine the corrected HPT pressure.

Slide 13

Running an HPT Log : Advancing the Probe

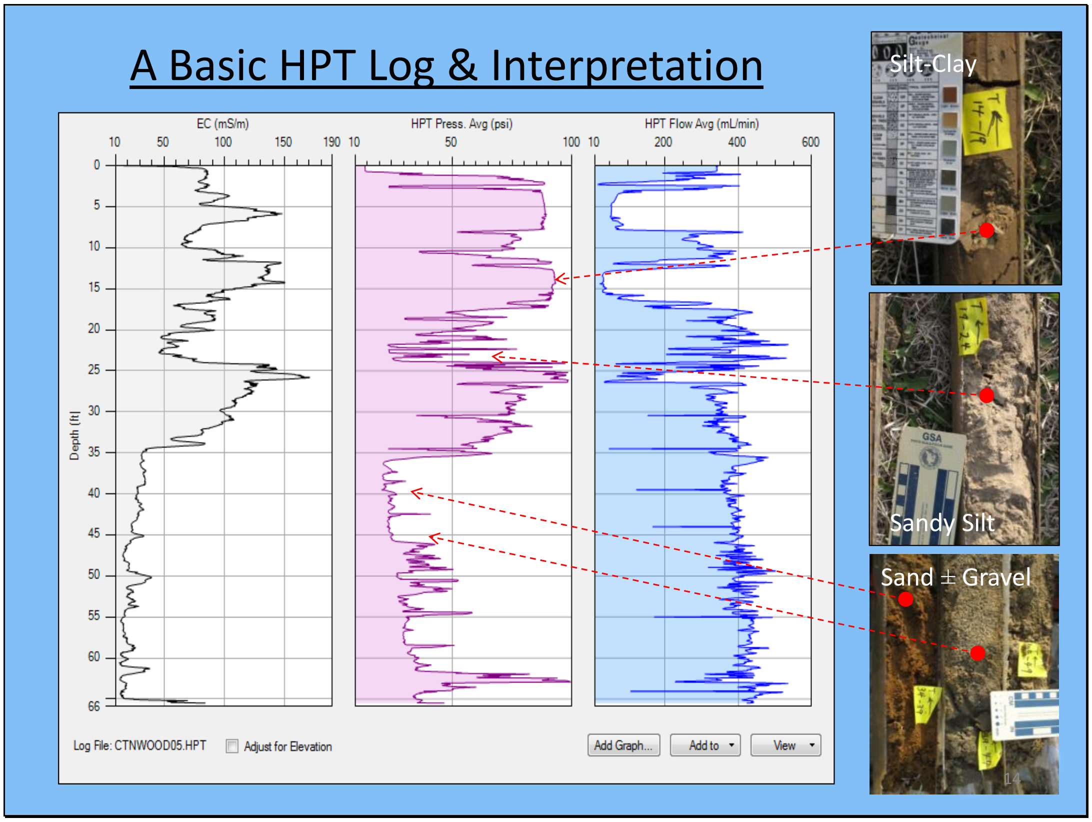


Live time
data review

Trunkline
Managment

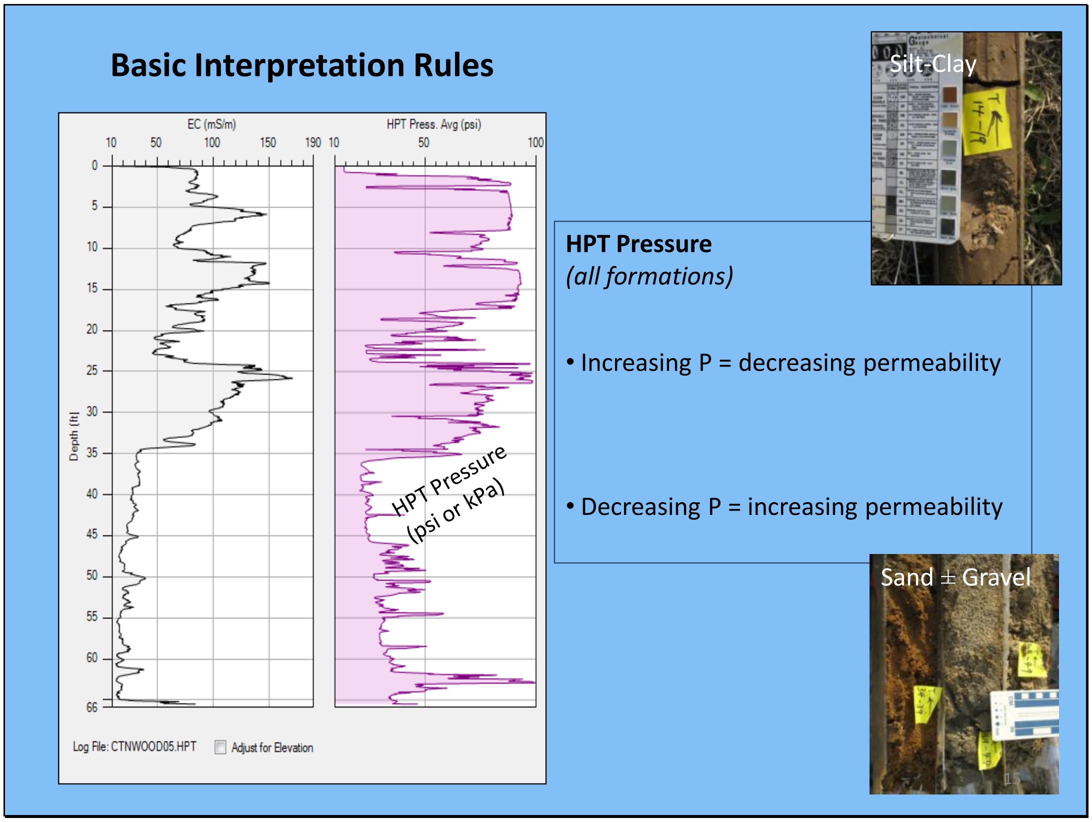
Once the log is started you simply add rods to the top of the tool string incrementally. The trunk line is pulled through each rod as it is prepared for addition to the rod string. The probe is advanced at about 2cm/sec using the hydraulic cylinders and hammer. Live-time data review provides for field discussion and Triad type field decisions to modify the investigation program as necessary to obtain the needed data.

Slide 14



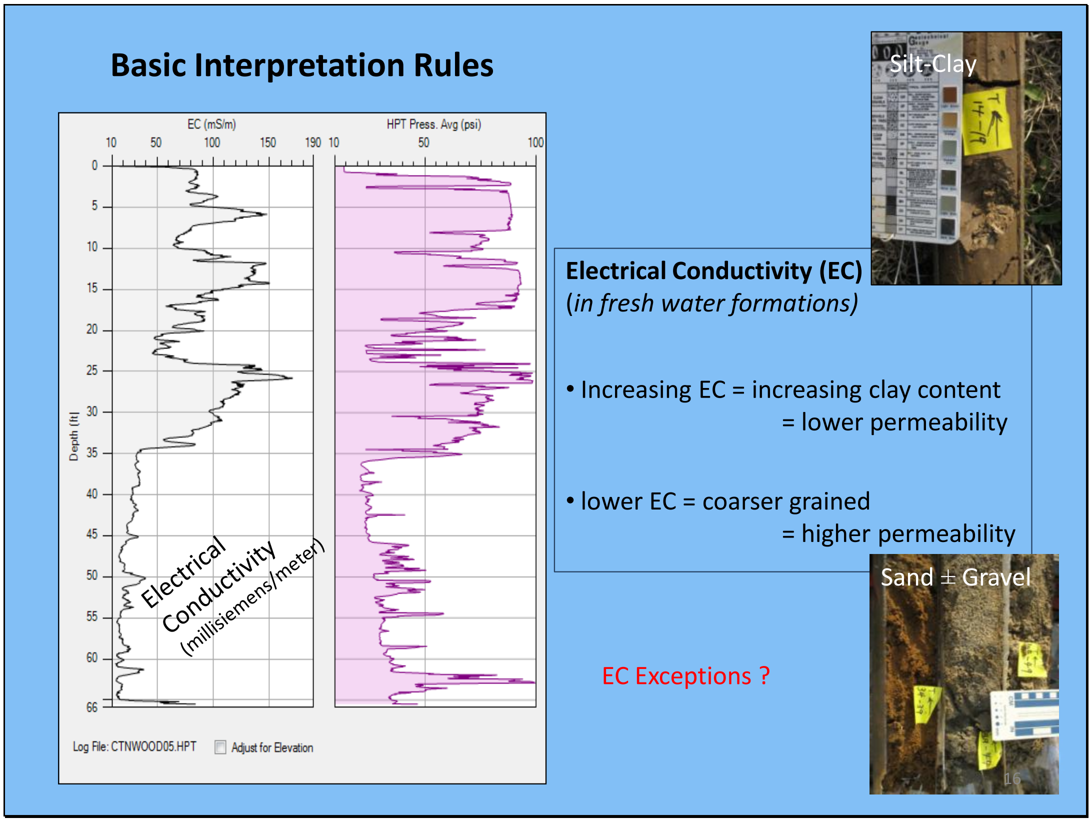
First lets just look at correlating a few core samples with log responses. This is a log from the Smoky Hill alluvial aquifer in Salina, KS. Co-located core samples are: 15ft = firm dense clay, 23ft = sandy silt ± clay, 39 & 44ft = sand & gravel. In general we see that high EC and high pressure correlate with fine grained, lower permeability materials. Conversely, lower EC and lower pressure correlate with coarse grained sands & gravels.

Slide 15



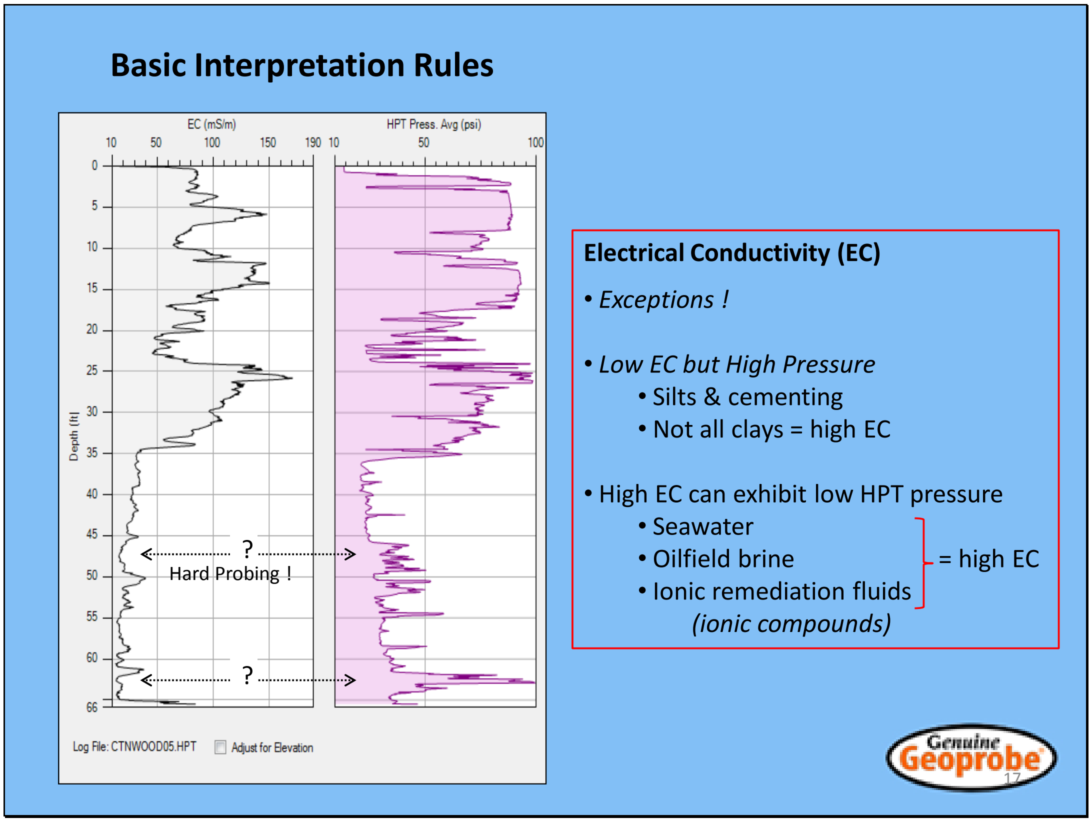
The rules for HPT pressure are pretty consistent either in fresh water formations or formations when seawater or ionic contaminants are present.

Slide 16



In fresh water formations EC response is usually controlled by clay content. Clays usually are much more electrically conductive than sands and silts.

Slide 17



Note that pressure and EC do not always correlate. Some possible causes for lack of correlation are outlined here.

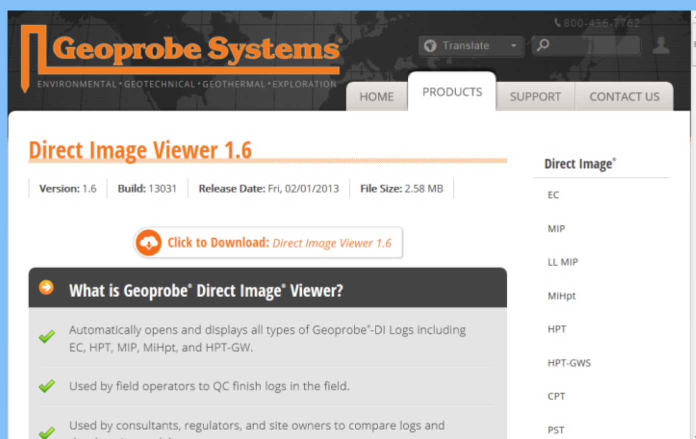
Between 45-50ft on this log we encountered hard driving with the probe. EC is lower but HPT pressure went up, not the usual behavior. In this interval cementing with calcium carbonate in the sand has reduced the permeability but the EC remains low.

At about 63ft again we see relatively low EC but the HPT pressure goes up significantly. Again not the normal relationship. At this depth there is a silty-clay that exhibits low EC but the permeability is low so the HPT pressure goes high.

EC can be very high, even in a sand, when ionic contaminants are present in the groundwater. This can produce a high EC anomaly with low HPT pressure. More on this later.

Slide 18

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 down load at:
http://geoprobe.com/downloads/direct-image-viewer-16

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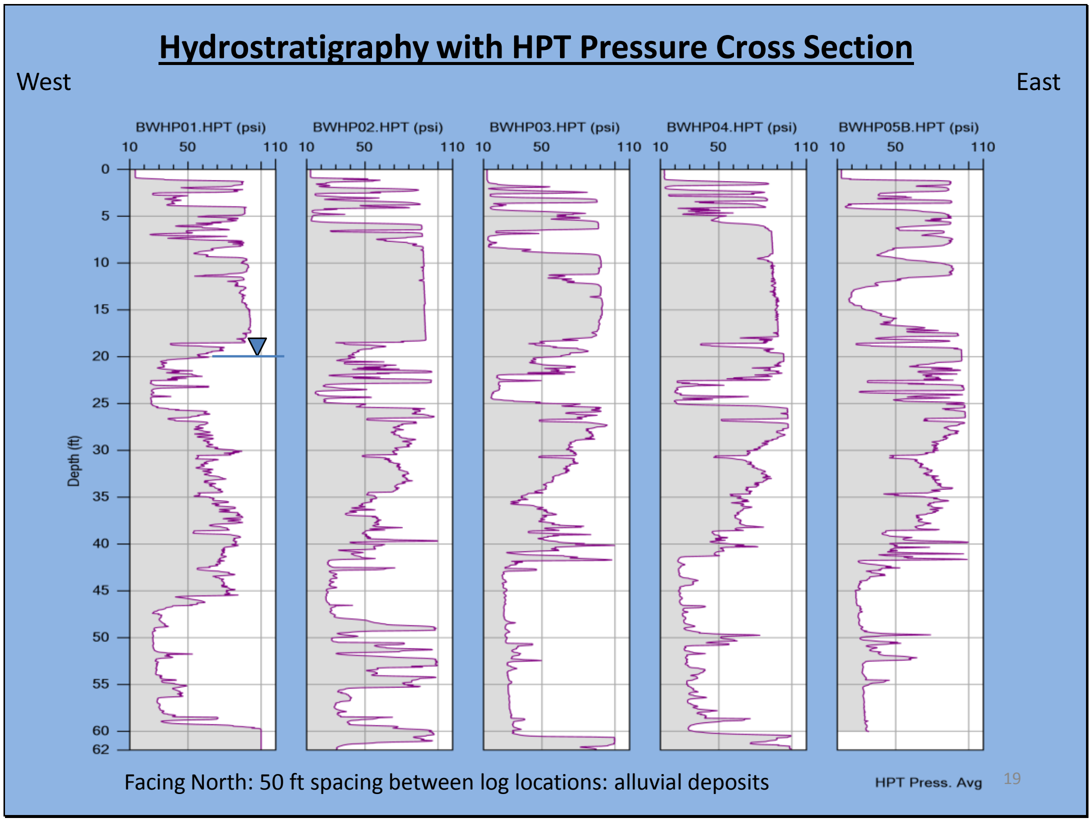
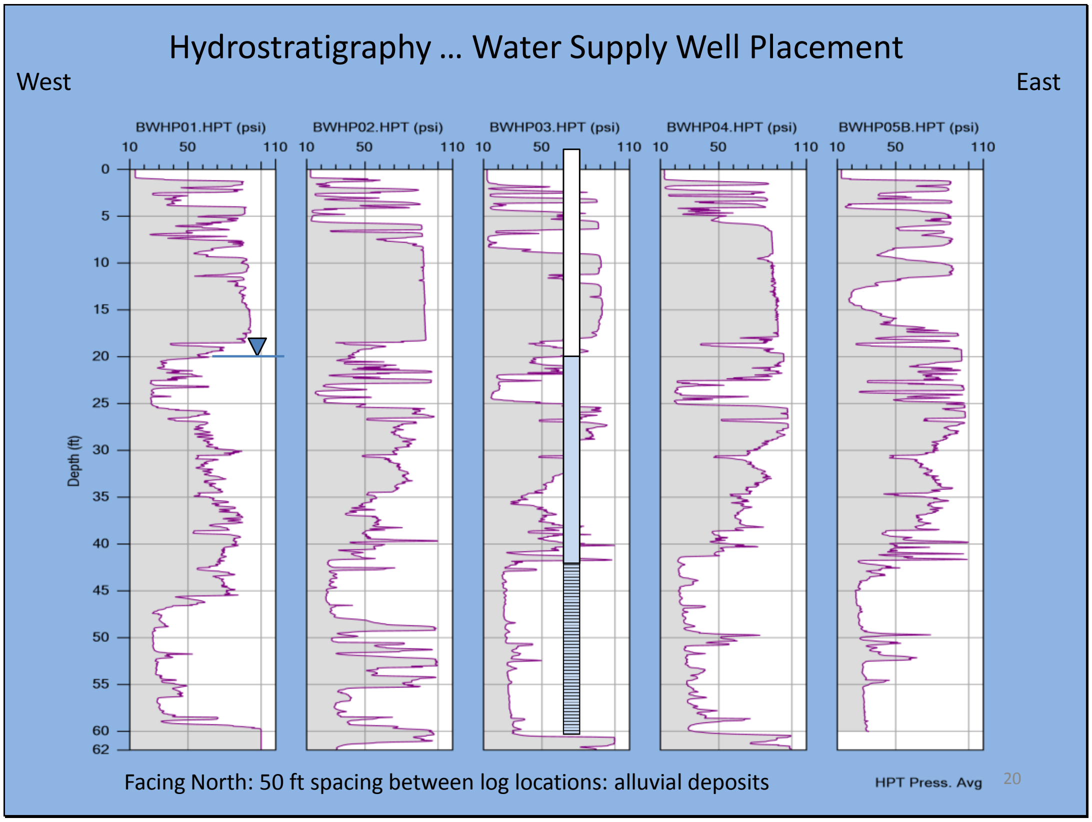
The following slides discuss the HPT pressure cross section …

Slide 19



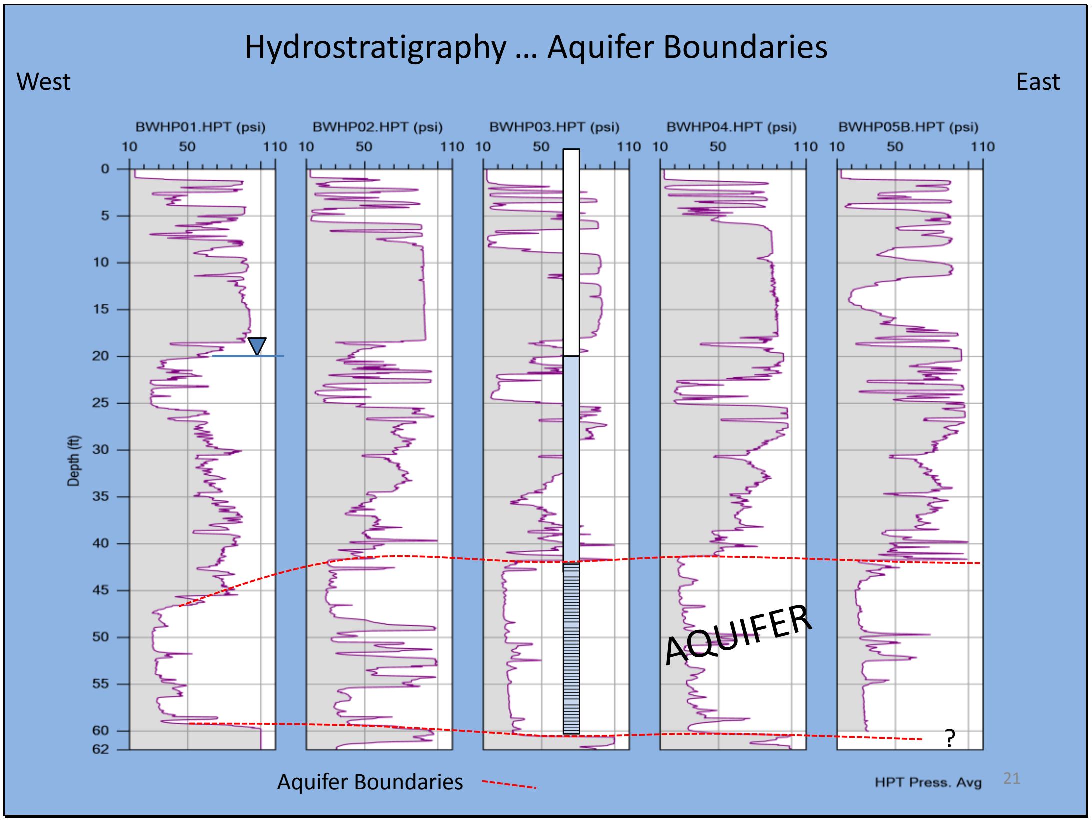
The high pressure zone between 10-15ft is consistent along the cross section (left to right) until the last log where a significant decrease in pressure is observed in this zone. Between 20-25ft lower pressure shows increased permeability across the section, decreasing to the right (East) where the sandy zone appears to be "pinching out". Lower pressure below 40-45 ft in these logs correlates with the sand and gravel alluvial aquifer. Where would you put a water supply well in this formation?

Slide 20



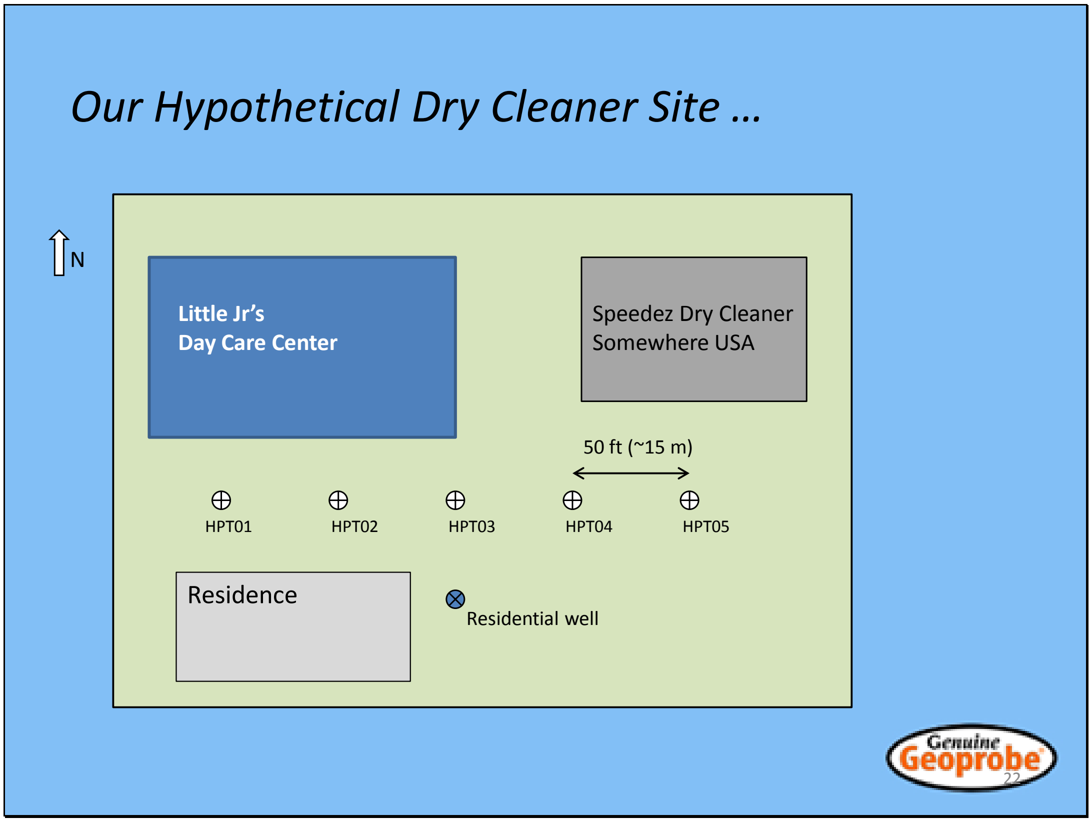
Based on the HPT pressure logs it looks like log BWHP03 between about 43 and 60 ft may be optimal for yield and minimal development. The low HPT pressure in this zone indicates fairly clean coarse grained, high permeability materials, ideal for a modest supply well.

Slide 21



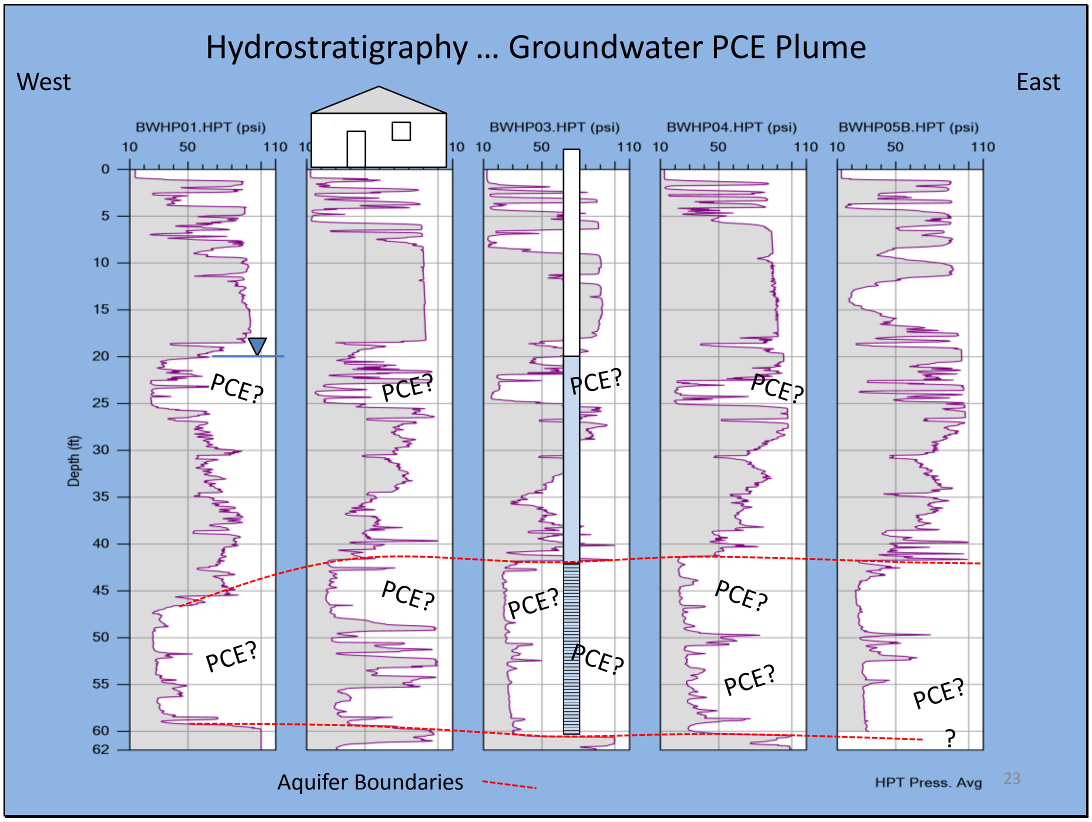
So HPT pressure defines the boundaries of our aquifer. This is actually part of the Smoky Hill alluvial aquifer that supplies about 8 million gallons per day for drinking water. There are 15 PWS wells in this aquifer located 1 to 2 miles southeast from where these logs were obtained.

Slide 22



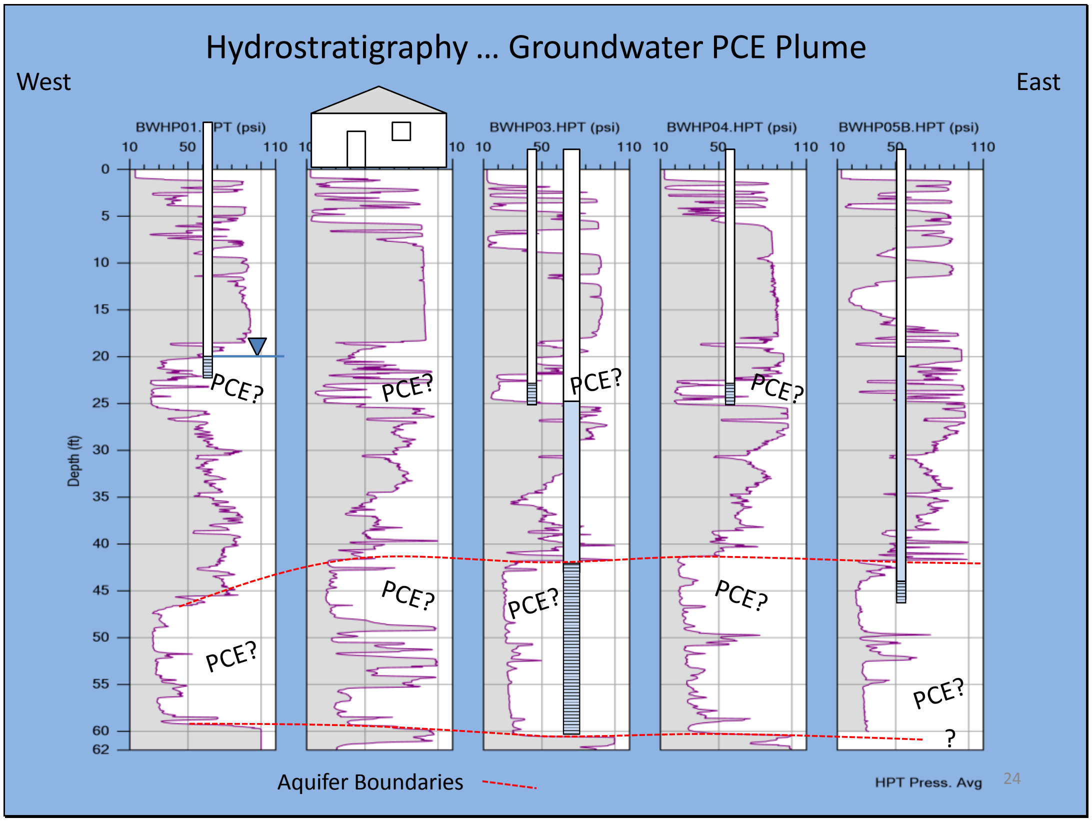
We will use this hypothetical dry cleaner site to explore use of the HPT logs for site assessment and investigation. Now if …

Slide 23



If there was a PCE release to the environment where would you first monitor groundwater to see if it had been impacted? Water level is at 20ft.

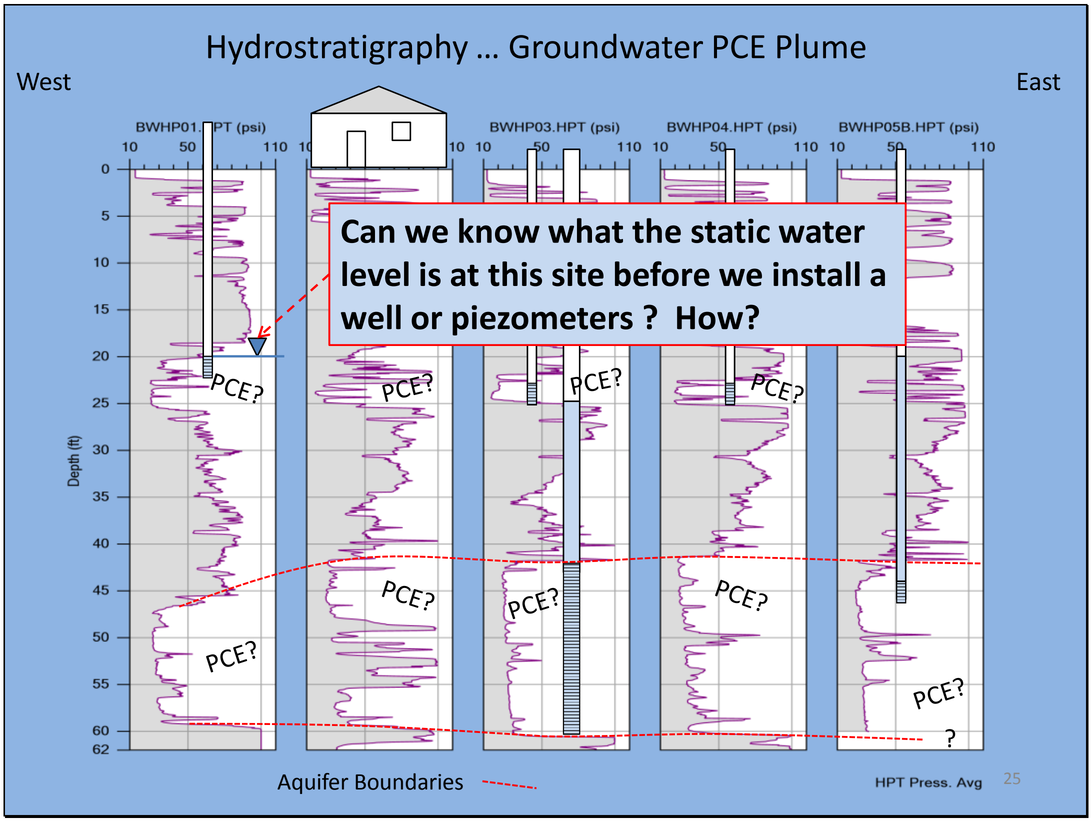
Slide 24



You would probably want to start near log 4 in the saturated, lower pressure, permeable zone between about 23 to 25 feet. If PCE is detected there you may want to move further west to see if migration is occurring. It would be reasonable to check the deeper aquifer near the dry cleaner and see if it has been impacted there. If you were going to conduct a vapor intrusion assessment would you try to sample soil gas at 15 feet below grade here? Probably not. HPT pressure is high across most of the site at 15ft , so low permeability. Therefore 15 feet is probably not a good depth for soil gas sampling at the site, though it could work at the 05 location on the east side where HPT pressure is much lower.

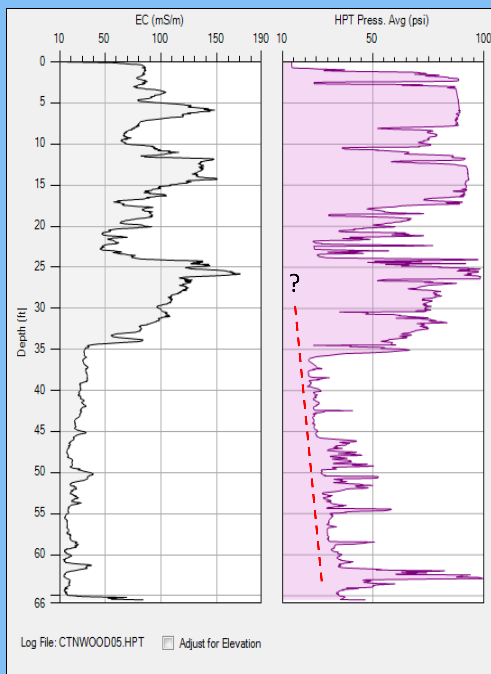
Remember this is a single cross section of logs and you would really want to run additional logs over the site area to get a three dimensional picture of the site hydrostratigraphy to determine if more locations and depth intervals should be targeted for groundwater sampling.

Slide 25


Hydrostratigraphy … Groundwater PCE Plume
West
East
BWHP01.HPT (psi)
BWHP03.HPT (psi)
BWHP04.HPT (psi)
BWHP05B.HPT (psi)
Depth (ft)
Can we know what the static water level is at this site before we install a well or piezometers ? How?
PCE?
?
Aquifer Boundaries
HPT Press. Avg
25

Slide 26

Hydrostatic Pressure, Dissipation Tests, Water Levels & More



Hydrostatic Pressure =
- 2.31 ft of water = 1 psi
- 0.433 psi/ft water
- 1 meter of water = 9.81 kPa

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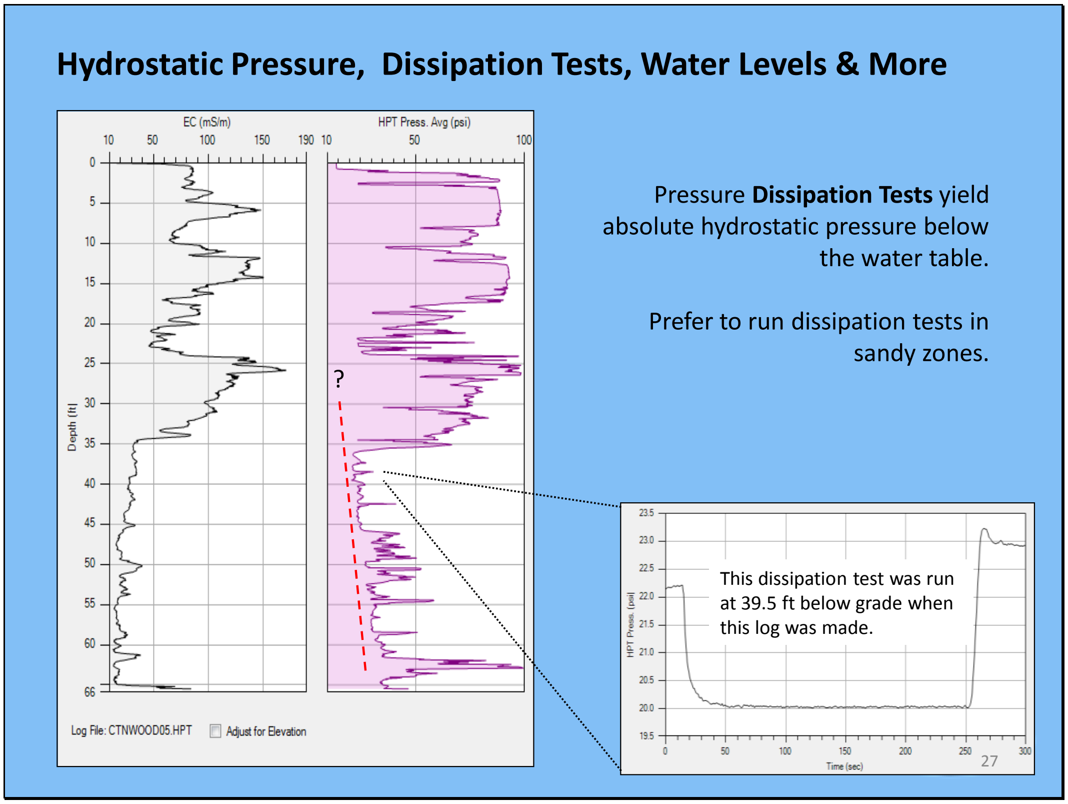
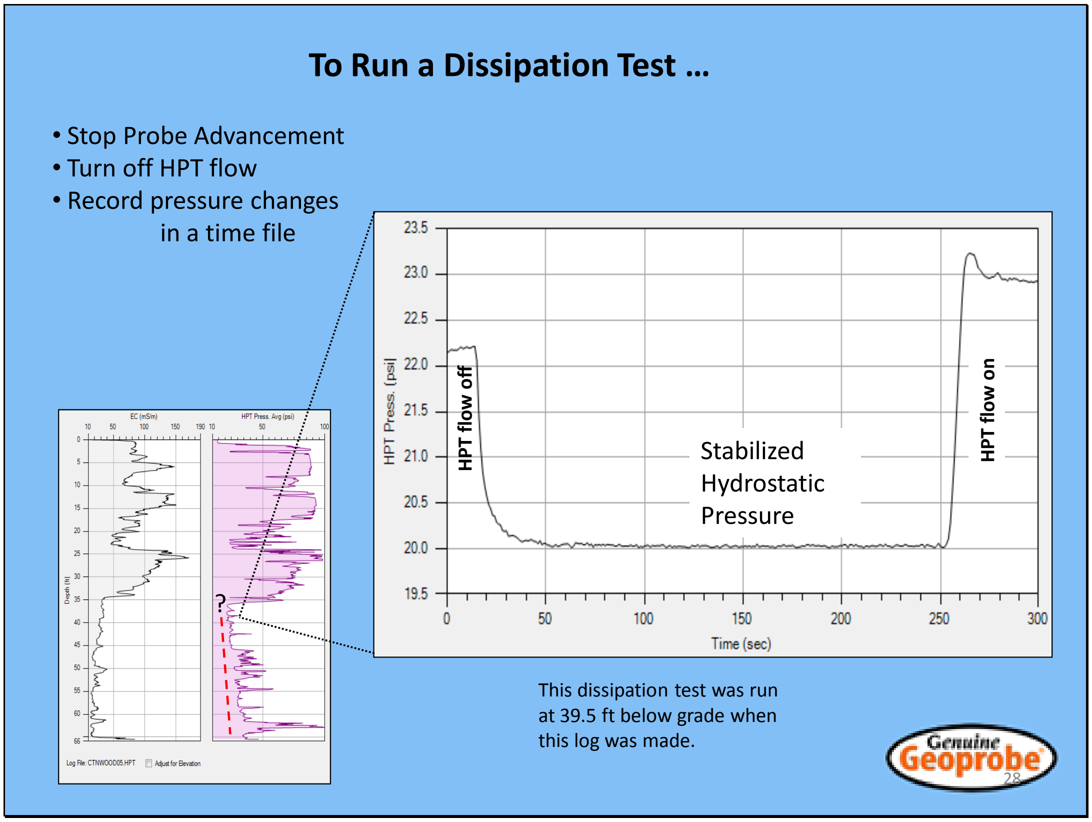
As the HPT probe advances below the water level the hydrostatic pressure increases. This produces a "baseline rise" in the HPT pressure (see red dashed line). We can measure the piezometric (or hydrostatic) pressure below the water table by running a dissipation test with the HPT probe and system.

Slide 27



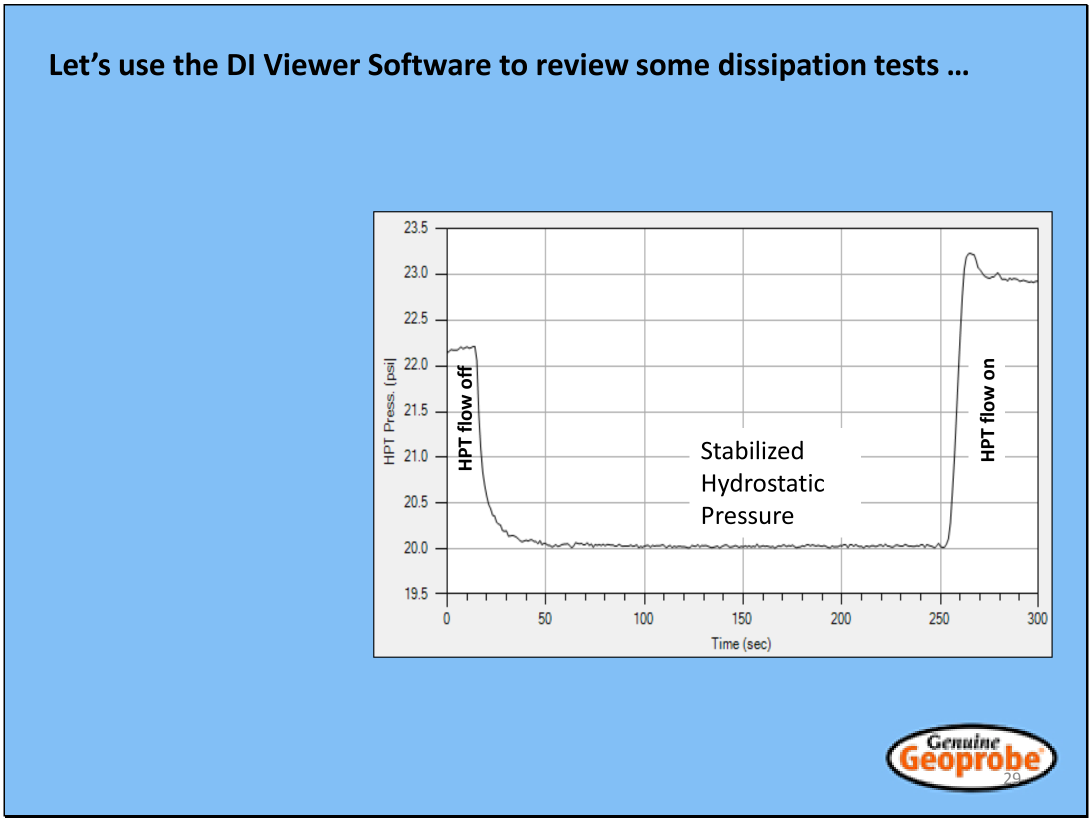
Since the transducer used to obtain the pressure measurements is not vented to atmosphere we see hydrostatic plus atmospheric pressure in these dissipation tests. The QA Reference Test run on the probe before starting the log provides us with the atmospheric pressure observed at the time the log was run (see slide 12). It is best to run dissipation tests in sandy materials as the pressure will drop quickly to the ambient piezometric pressure.

Slide 28



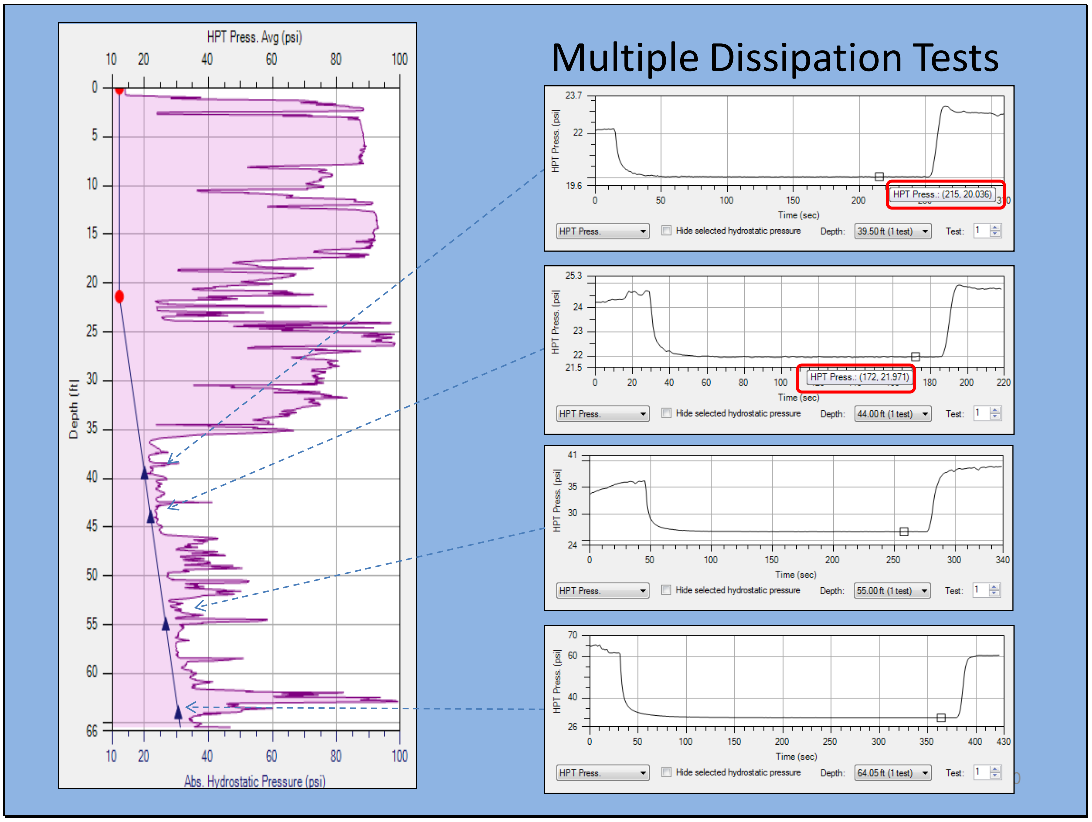
We can measure the hydrostatic (or piezometric) pressure below the water table by running a dissipation test. Simply stop probe advancement, turn off the HPT injection flow at the flow module. The Acquisition software is used to record the pressure dissipation in a time file. This dissipation test was run at a depth of 39.5 ft when this log was obtained. In sandy formations the HPT pressure drops quickly when the flow is turned off and stabilizes quickly to the ambient piezometric pressure.

Slide 29



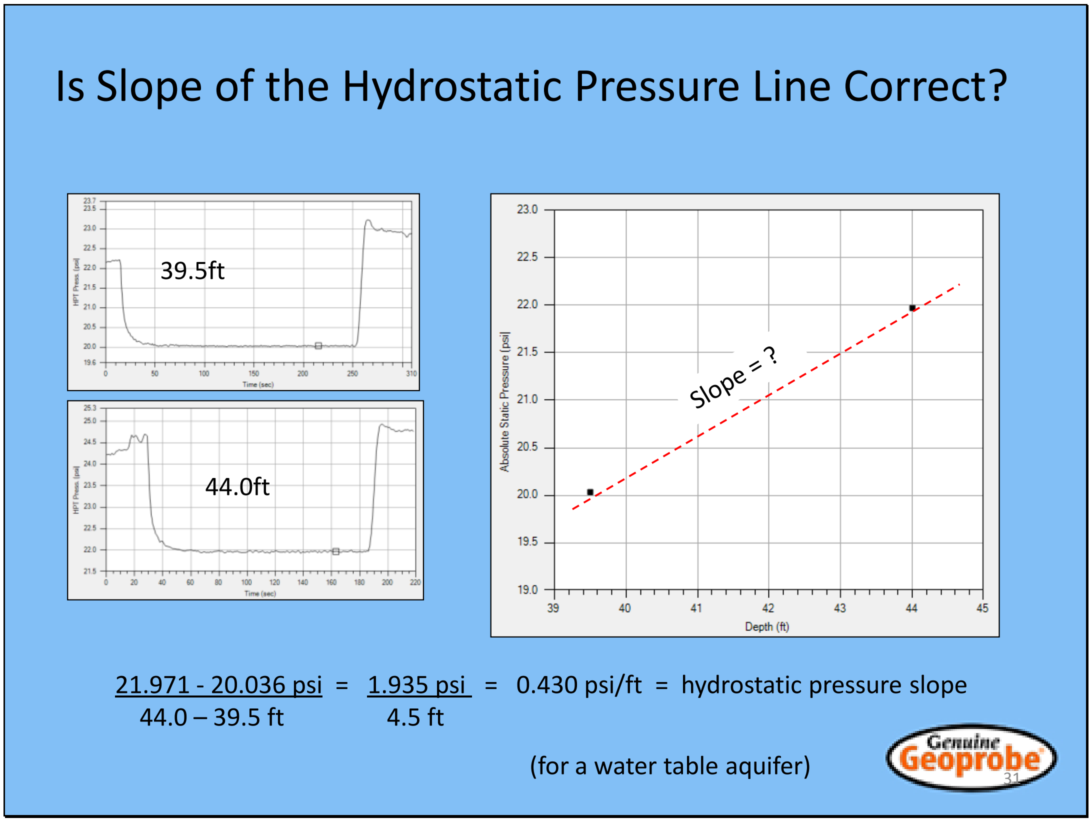
The following slides review the use of dissipation tests in HPT logs …

Slide 30



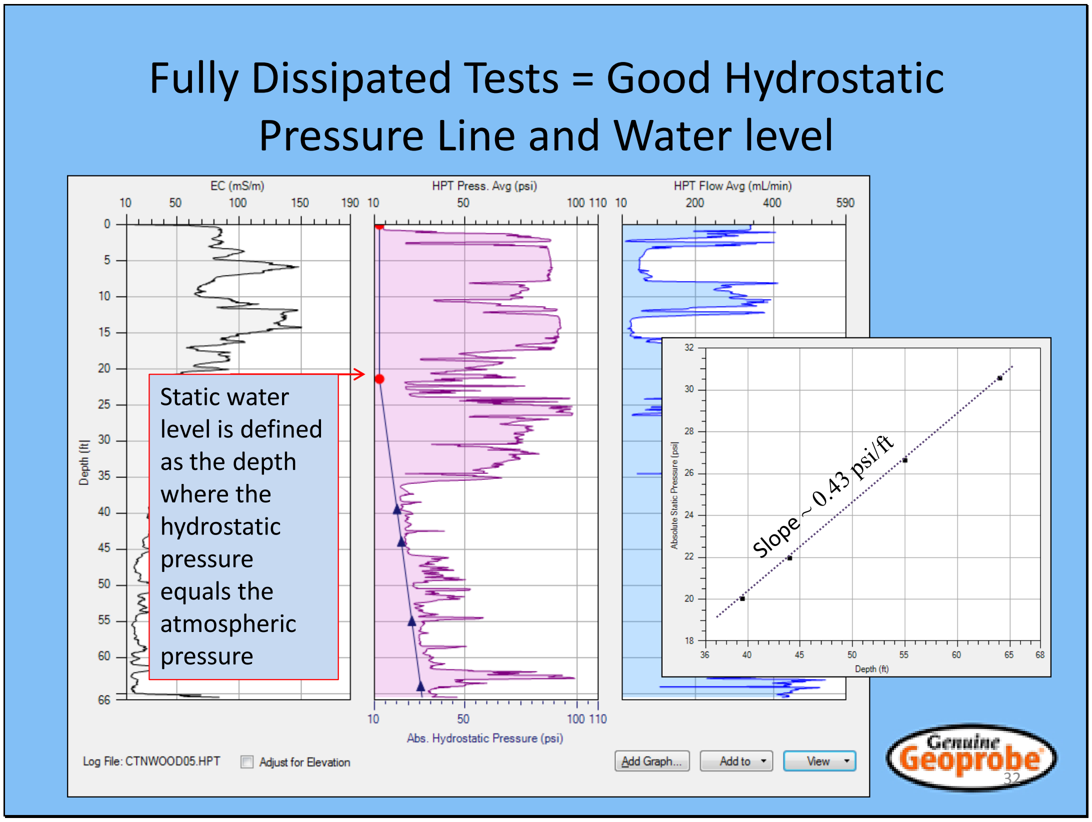
Multiple dissipation tests can be run in one log to see if the piezometeric slope is linear or if changes in slope do occur. . It is useful to run dissipation tests between clay layers/potential aquitards. Changes in slope may indicate vertical gradients in piezometeric head. Be sure that all dissipation tests used for the piezometeric (hyrdostatic) line are fully dissipated. [Note stabilized pressure values in red boxes for the 39.5 ft and 44.0 ft dissipation tests]

Slide 31



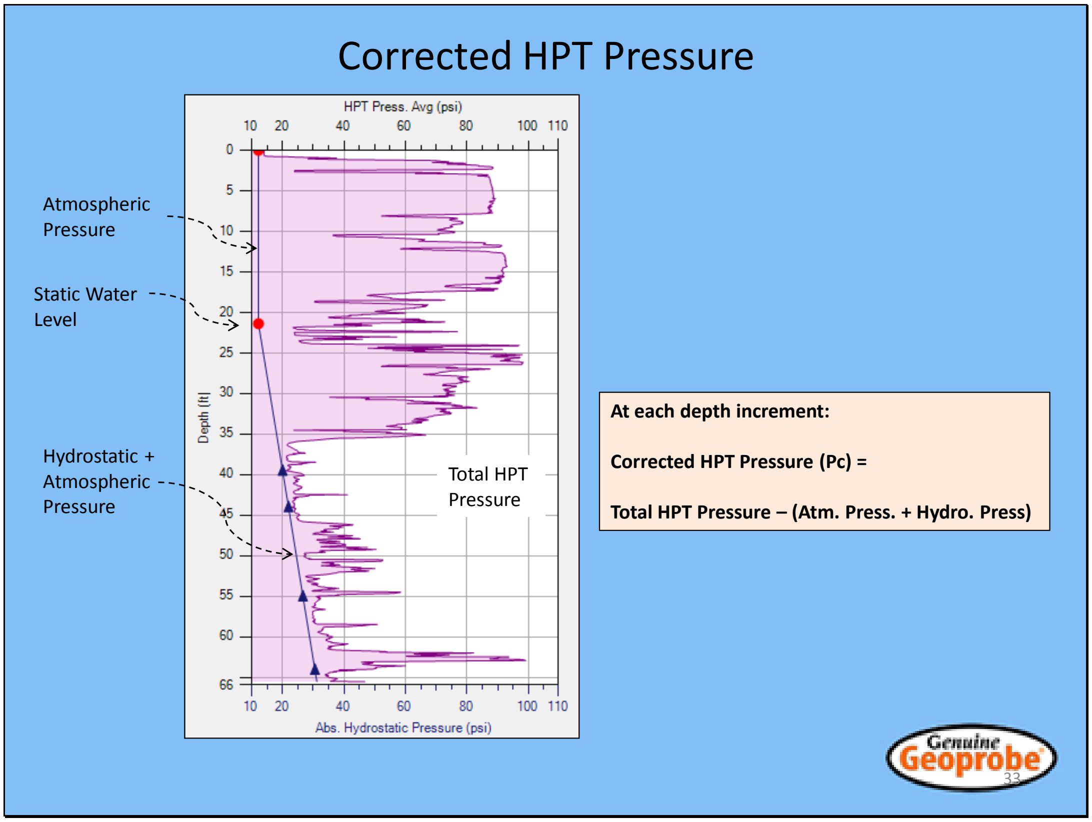
If we are in a water table aquifer the slope of the absolute static pressure line with depth should be approximately 0.43 psi/ft. This is a quick QC check on the piezometric (here hydrostatic) pressure line. [See stabilized pressure values in red boxes on previous slides.]

Slide 32



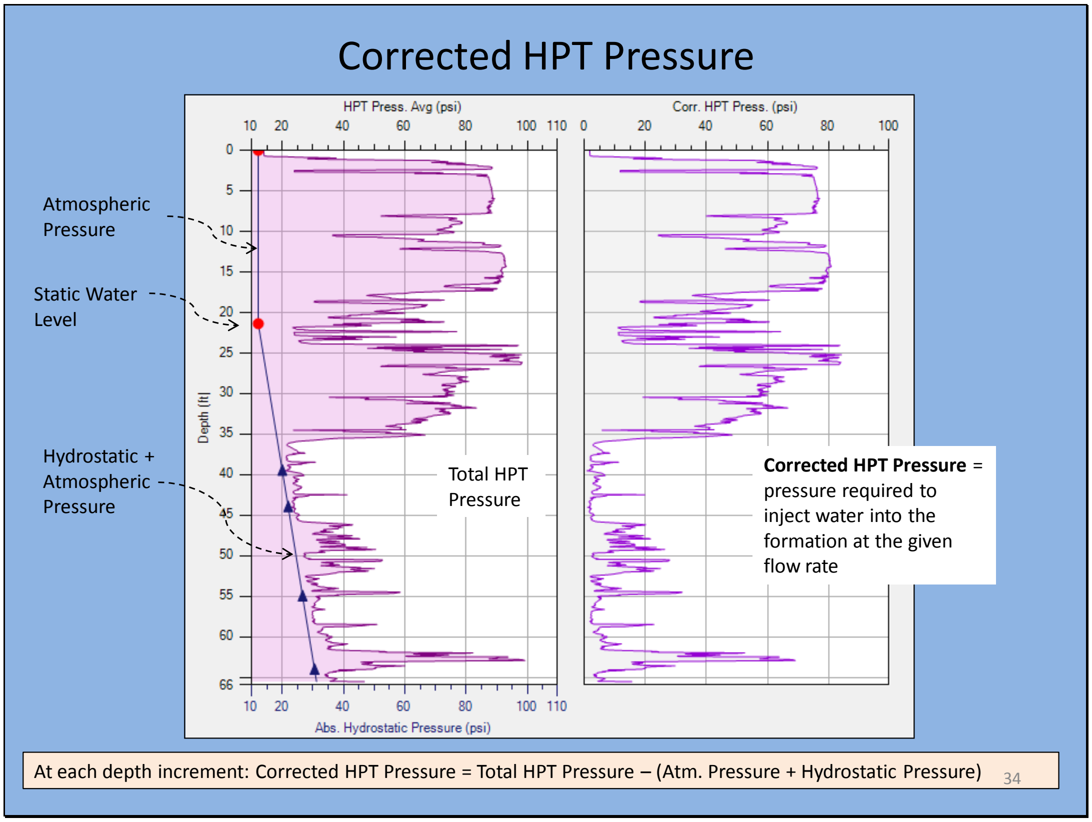
This definition is correct for water table aquifers.

Slide 33



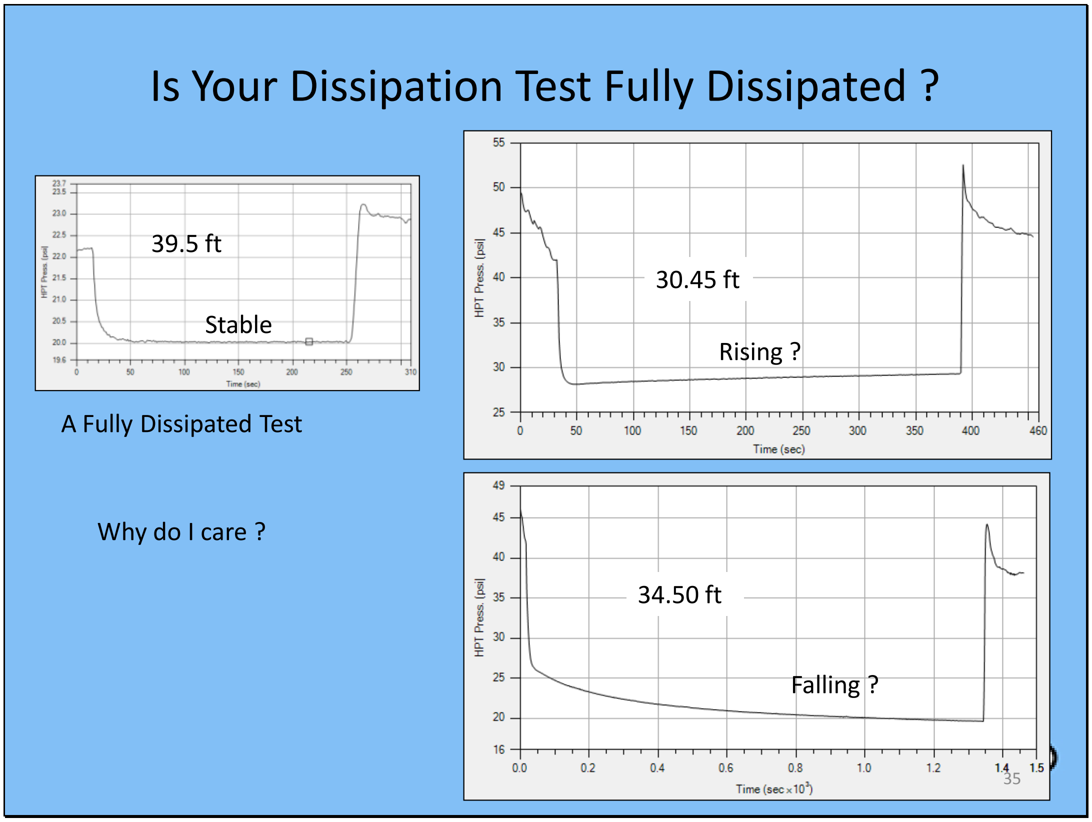
Simply subtracting the Hydrostatic + Atmospheric pressure from the HPT Avg. Pressure (Total Pressure measured during logging) gives the corrected HPT pressure.

Slide 34



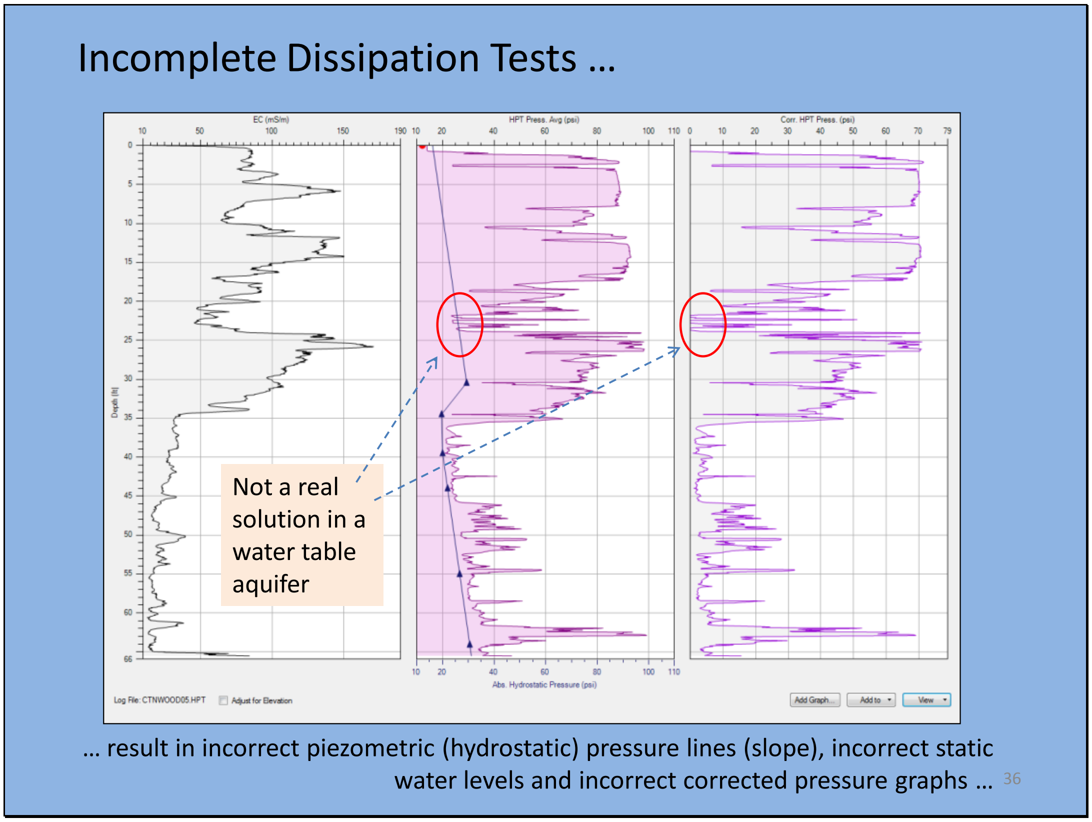
The corrected HPT pressure is the actual pressure required to inject water into the formation so provides us with a more accurate view of the relative permeability of the formation materials with depth.

Slide 35



At the 30.45ft depth the dissipation pressure is rising in the fine grained/high pressure material after the probe was pushed into the formation. At the 34.5ft interval the dissipation test is falling slowly, over 1000 seconds and still dropping here. Complete dissipation could take several hours or more at these two locations. You may want to run dissipation tests in low permeability zones to confirm that pressure dissipation is really slow and that the formations are indeed low permeability formations, but you will probably not want to wait for full dissipation … 5 to 7 minutes is usually more than sufficient to demonstrate the formation behavior in these zones.

Slide 36

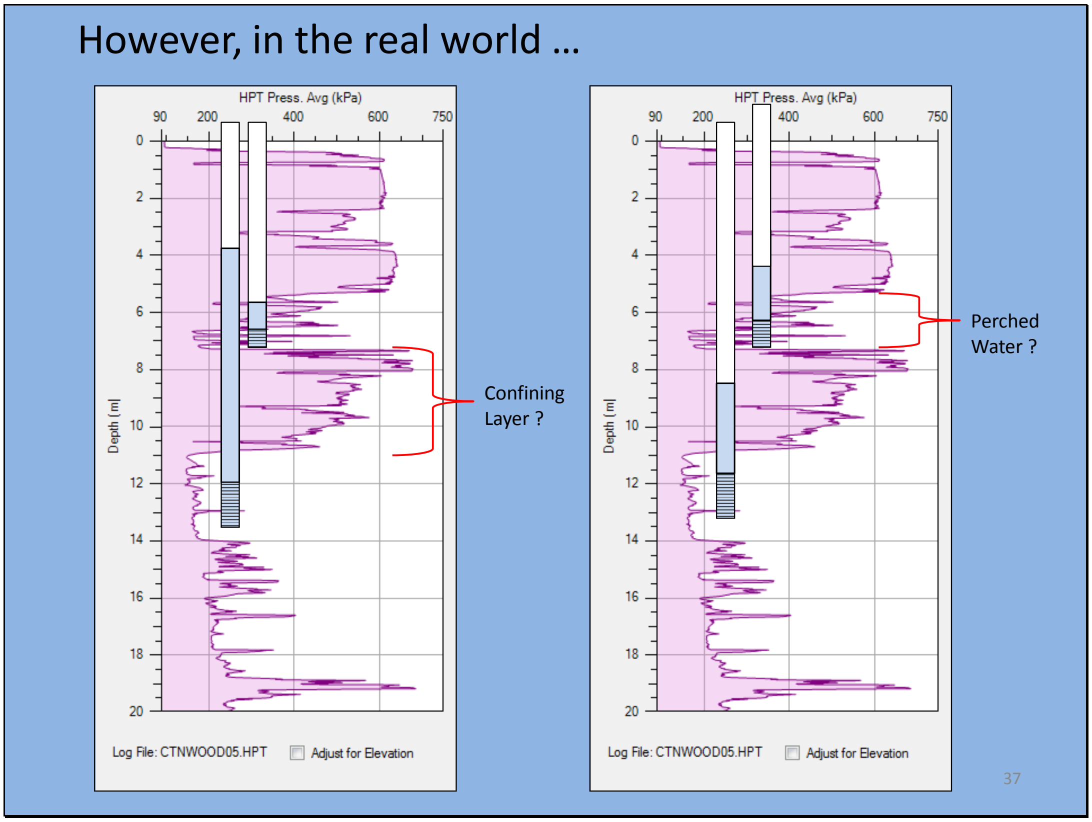


If used in plotting your piezometric (hydrostatic) pressure line incomplete dissipation tests will cause errors in the piezometric line and water table calculations. Notice here that the static water level would be several feet above the ground surface based on the piezometric pressure line (red arrow). We know this is not true for this site based on water level measurements in wells and piezometers.

In a water table aquifer the piezometric pressure cannot be greater than the total HPT pressure measured in the formation (20 to 25ft interval on center panel, red oval). So a piezometric line indicating higher pressure than the total HPT pressure is an indicator that something is not as it should be in this piezometric line plot.

Under hydrostatic conditions the corrected HPT pressure should always be greater than zero (it may be a small difference !). It would be possible to detect vertical piezometric gradients in the formation with the HPT system. We recommend installing appropriately sealed, discrete interval piezometers to confirm vertical gradient interpretations based on HPT pressure logs.

Slide 37



If the zone from 7 to 11 meters is a confining layer the piezometric (hydrostatic) pressure in the upper and lower zones can be different. Then you would need to do separate piezometric pressure lines and water levels for each water bearing zone. We also have found artesian conditions with the HPT probe where the water level did plot above the ground surface.
Of course perched water zones may have a very different head than the primary aquifer they are sitting above. It could be higher or low pressure.

A pumping supply well nearby in an aquifer can also cause low HPT pressure readings. We did observe a downward curved HPT pressure log run next to a supply well. The well started pumping after the log was in progress.

Slide 38

Estimating Hydraulic Conductivity (K) with HPT Log Data

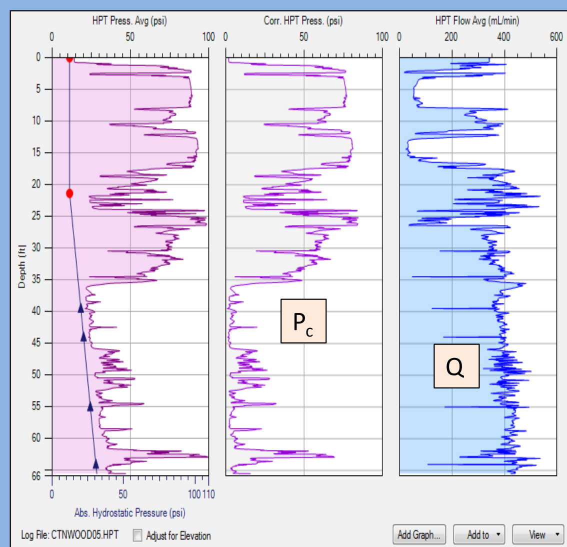
From Darcy's Law:

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

HPT logs provide both:

Corrected Pressure (P_c)

And Flow Rate (Q)



Now that we have learned about Dissipation tests and HPT corrected pressure (Pc) we can use this data to calculate an Estimated K log.

Slide 39

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.

Study area next to cottonwood tree

Performing a Pneumatic Slug Test

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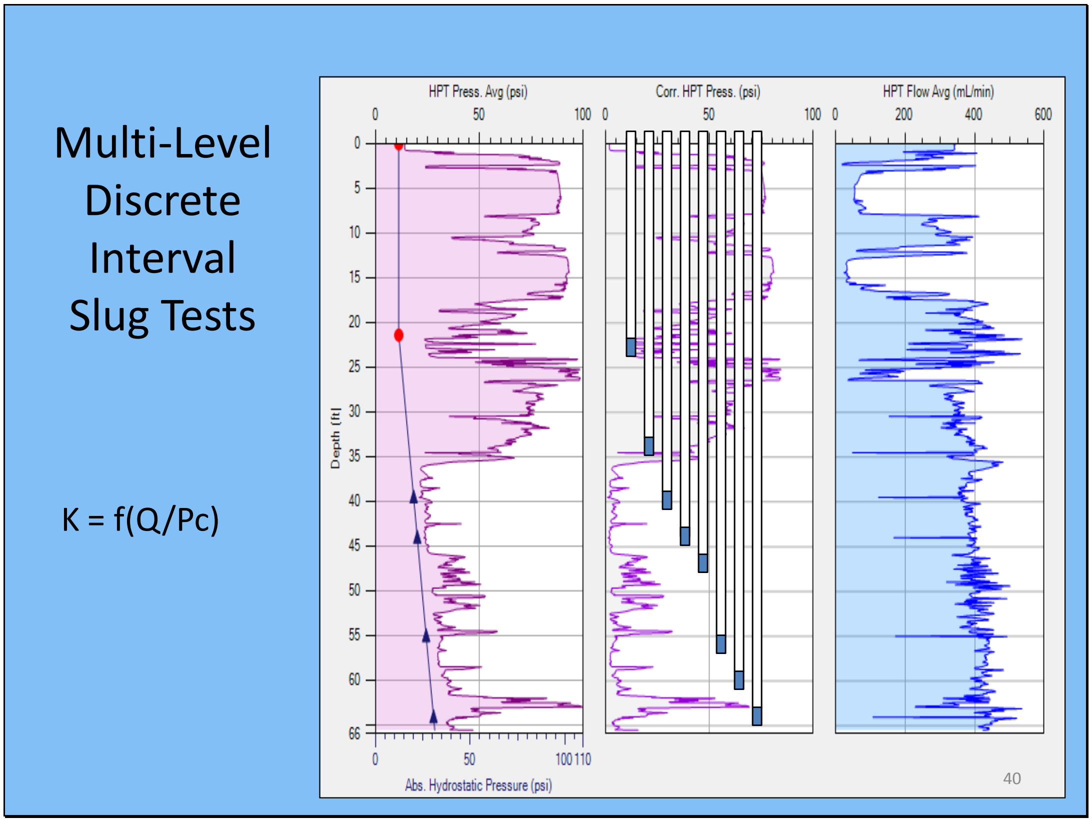
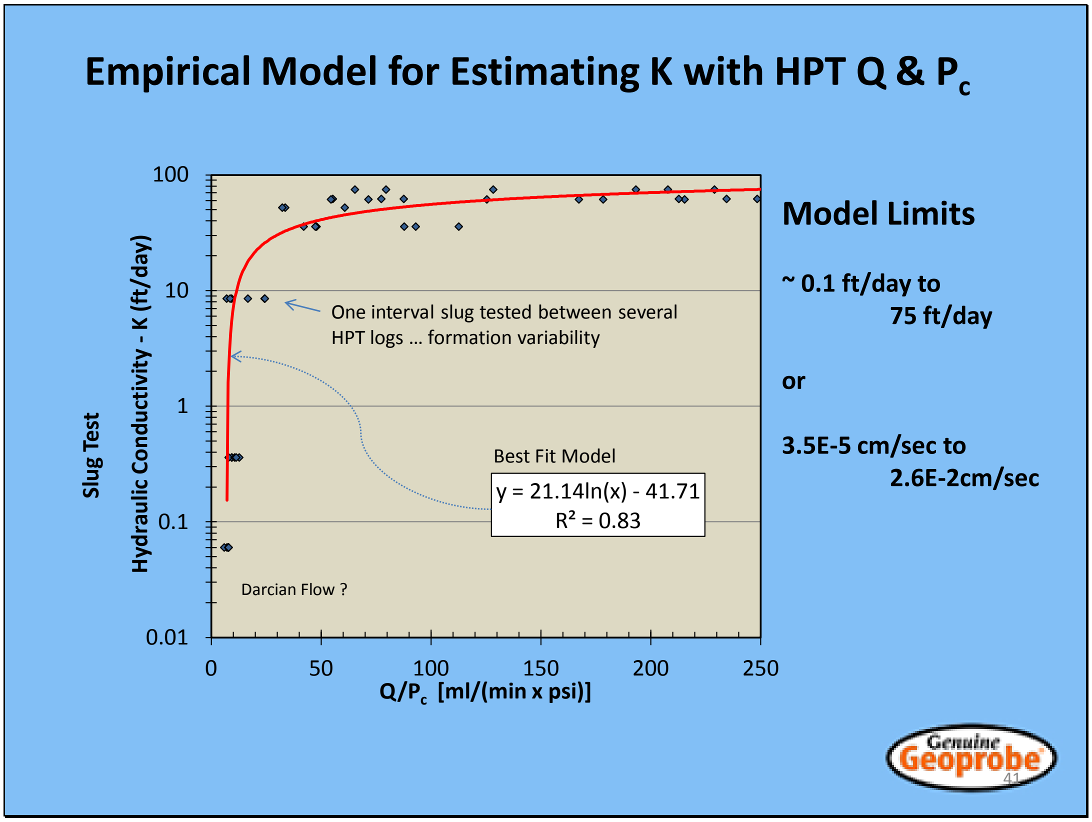
We ran several HPT logs in an area and then set several piezometers with discrete screen intervals at different targeted depths. The photo at left shows the pneumatic set up used to perform the slug tests (ASTM D7242).

Slide 40



The piezometers were installed with one foot (30 cm) screen intervals, developed, and slug tested. Then the HPT corrected pressure and flow rate over each slug tested interval was averaged and the average Q to P_c ratio was calculated for each interval.

Slide 41

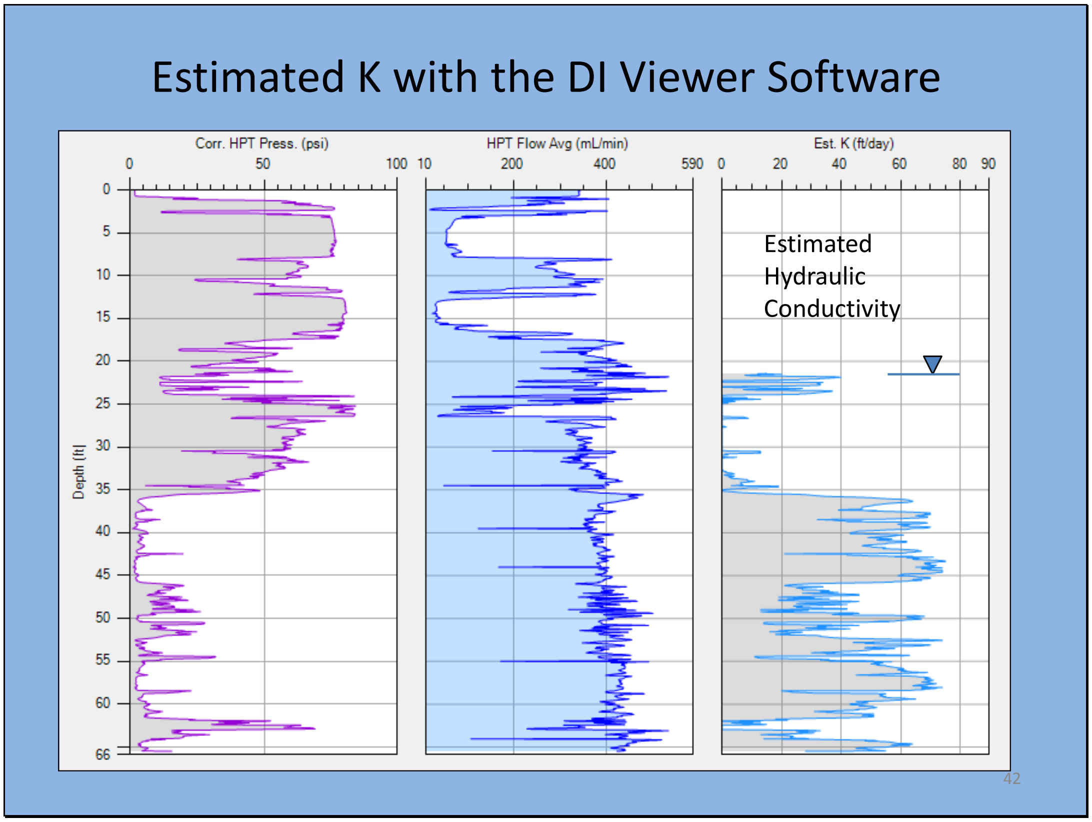


Here the ratio of Q/Pc is plotted against slug test K values measured over the same intervals. The best fit curve to this paired data set provides a **general** model for estimating K from HPT data. This model is used in the DI Viewer software to calculate the Est. K values based on the HPT flow rate (Q)and corrected HPT pressure (Pc) at each depth interval.

The Est. K model has upper and lower bound limits.

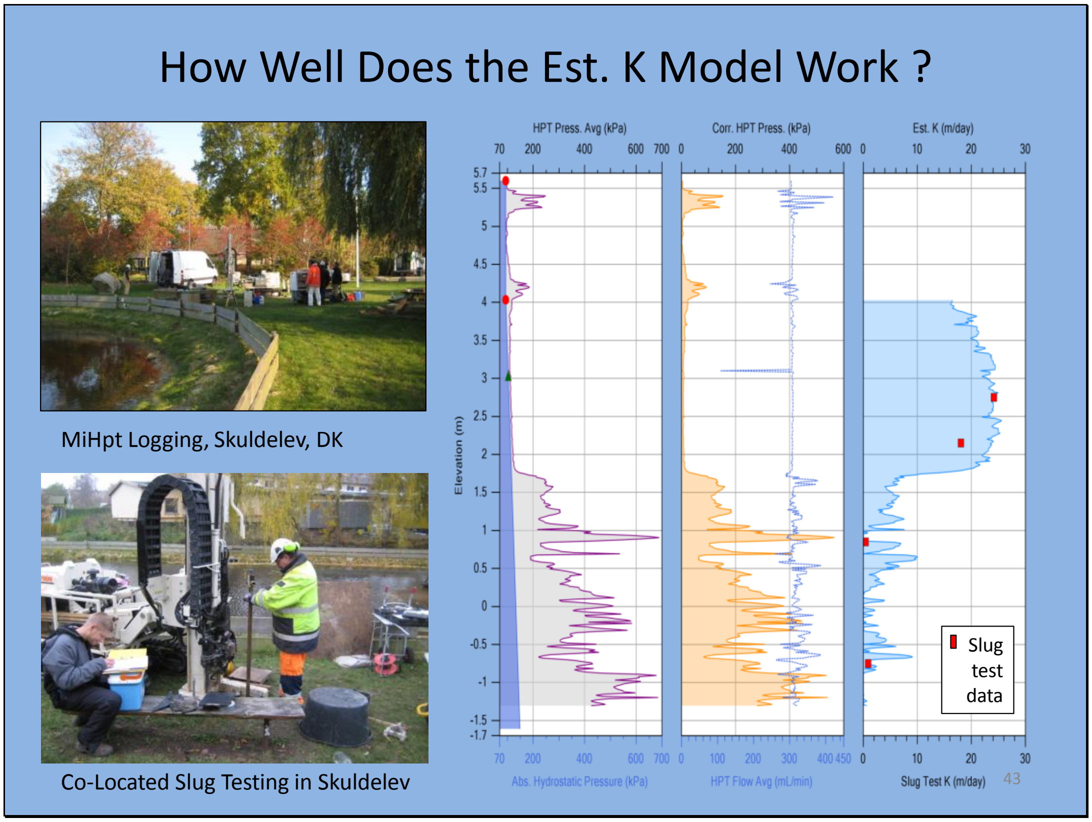
If the Est.K log is at or above the 75ft/day upper limit in a zone, install a piezometer and run a slug test over that discrete interval. This will enable you to determine an accurate K value for that zone. If the Est K log is at or above 75 ft/day it could be 500ft/day or more … you have to slug test the interval to verify the maximum K. But now you know where to run that slut test!

Slide 42



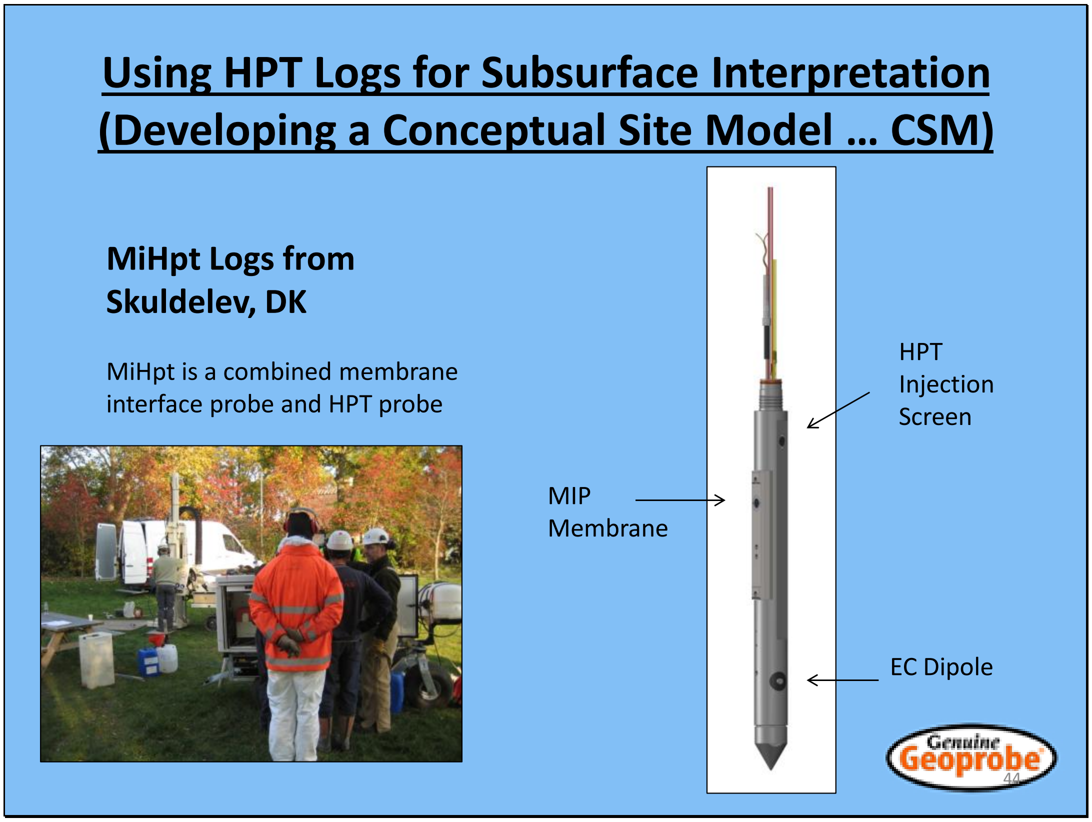
Once you have determined corrected pressure in the DI Viewer software you can then calculate an estimated hydraulic conductivity log for the saturated formation at this location. The software calculates and plots the Est. K log with a few clicks of the mouse. This is HIGH resolution data for hydraulic conductivity !

Slide 43



Geoprobe worked with NIRAS A/S of Denmark to run some MiHpt logs at a PCE/TCE contaminated site in Skuldelev, Denmark. These are the results of co-located slug tests (red boxes) run over 30cm intervals compared to the Est. K model results (right panel on the log).

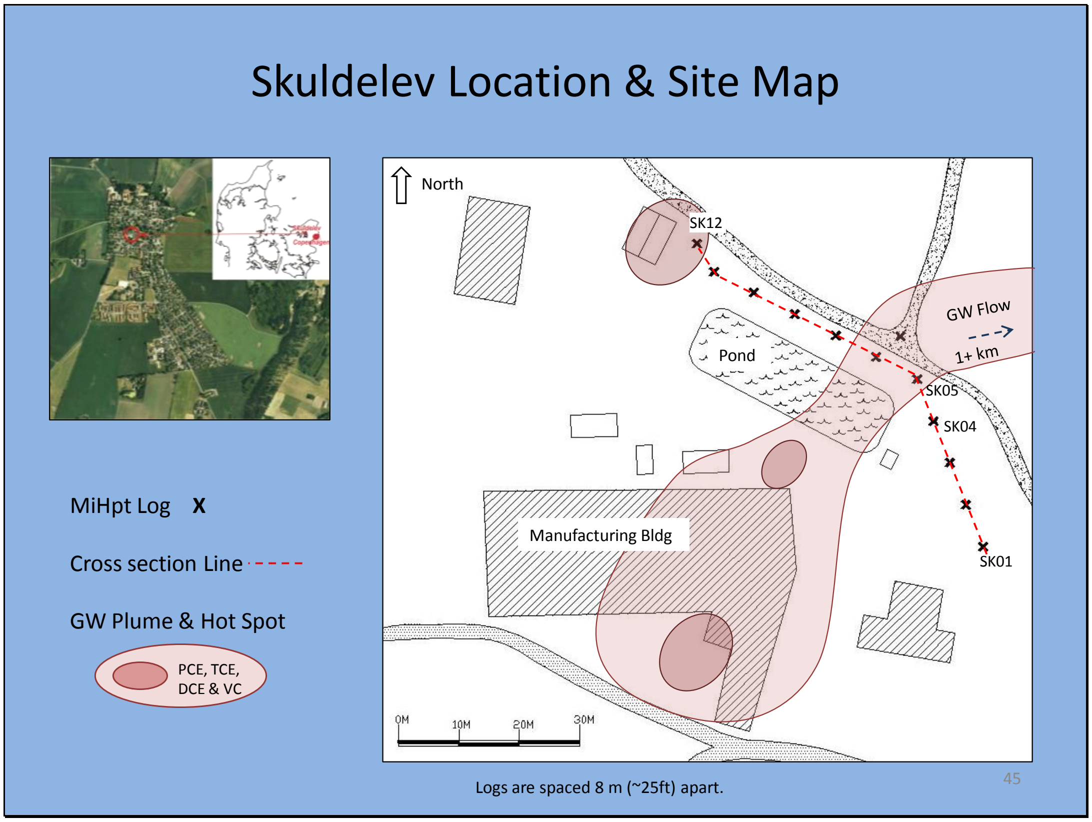
Slide 44



Let’s look a little more at the Skuldelev site. As mentioned above we ran MiHpt logs with the NIRAS team at the site. This probe includes the MIP membrane for detection of volatile contaminants, the HPT screen for measurement of flow and HPT pressure and an EC array.

(MIP = membrane interface probe. To learn more about MIP and MiHpt go to this link: http://geoprobe.com/mihpt)

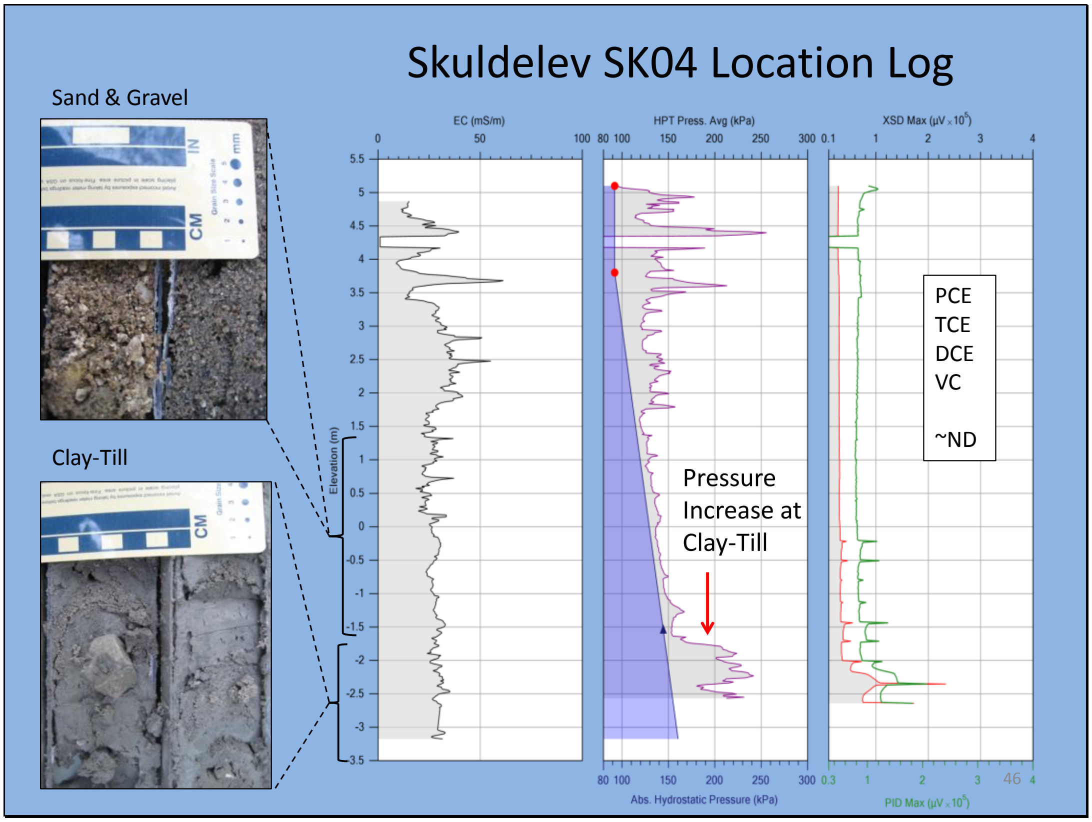
Slide 45



Previous work with the MIP system found that the associated electrical conductivity logs were not able to distinguish between the coarse grained materials and fine grained materials in the subsurface at this site. The EC logs displayed little change in EC and poor correlation was observed with targeted soil cores. So we ran some MiHpt logs in a transect across the site to see if the HPT pressure logs could help us understand the local hydrostratigraphy.

To date it was unclear why the groundwater plume was migrating in the direction it was following.

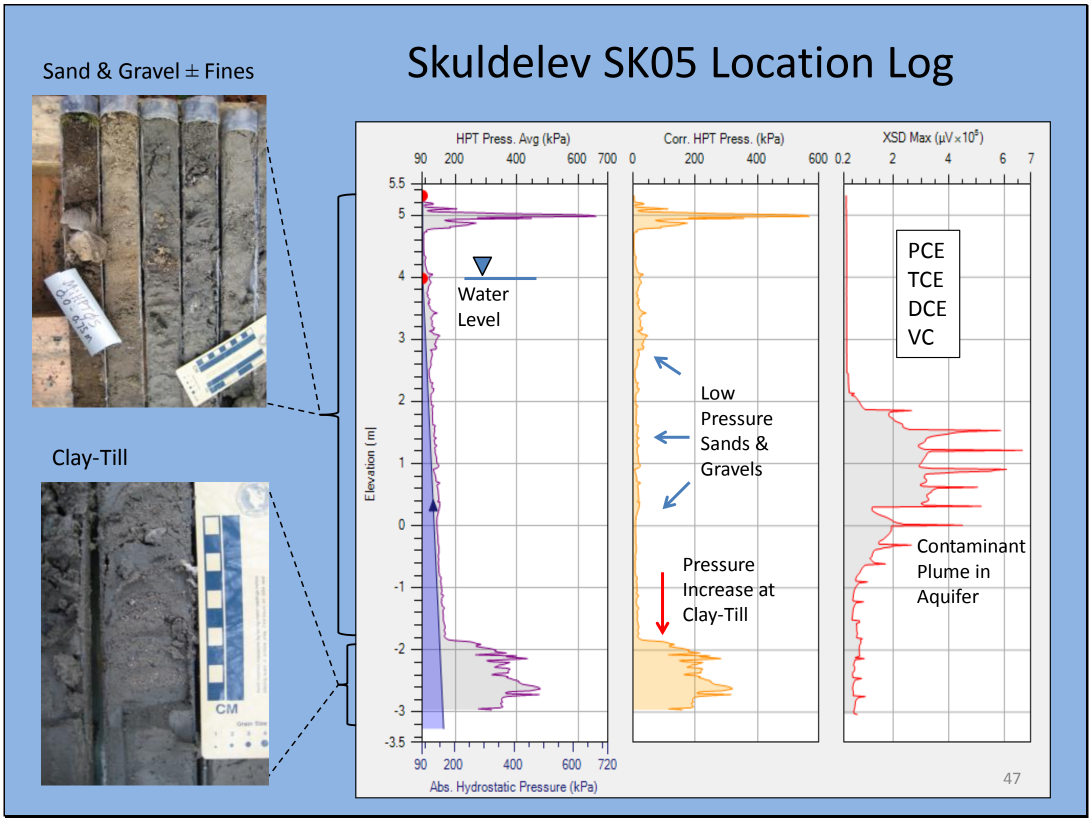
Slide 46



At Skuldelev the EC of the clay-till was essentially the same as the EC of sands and gravels. The EC logs could be described as essentially “featureless”.

However, the HPT pressure increased significantly in the clay-till, clearly defining the change from the sands & gravels to the low permeability till. At this location, outside of the main groundwater plume, the halogen specific detector (XSD) found only minor detects of contamination.

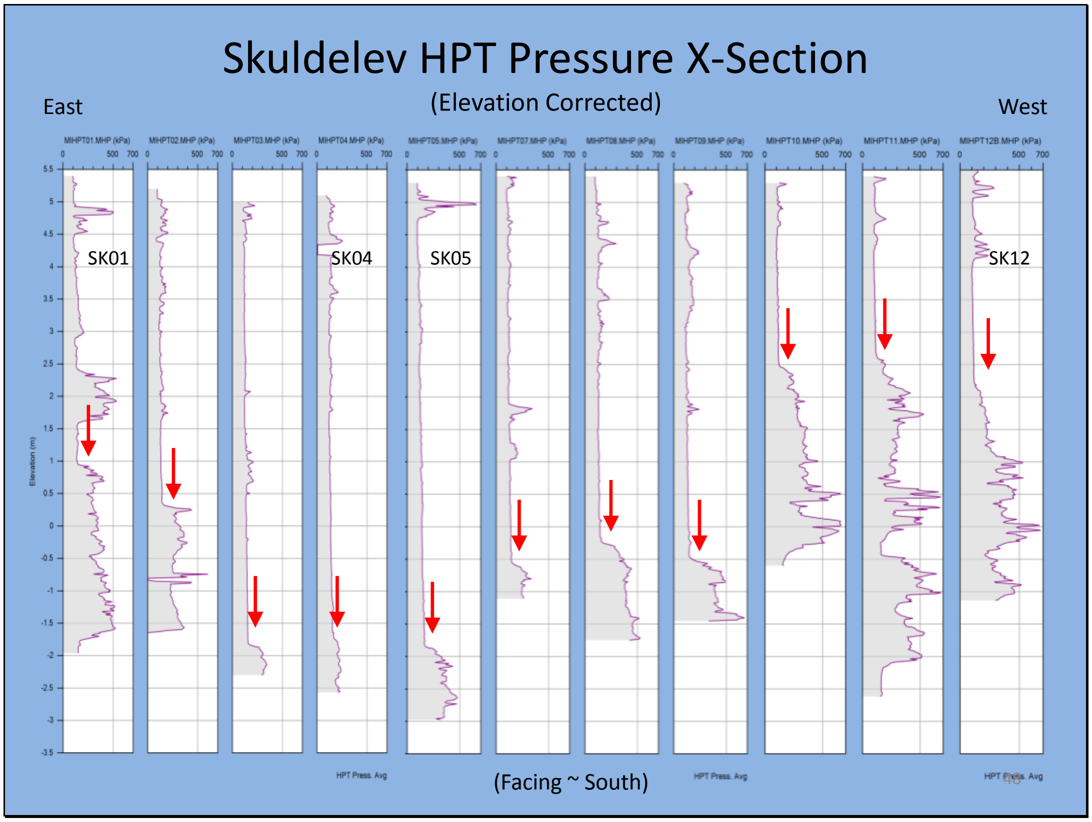
Slide 47



At the SK05 location again we found the HPT pressure log clearly distinguished between the clay-till (high pressure) and the sands and gravels (low pressure) as verified by continuous soil cores.

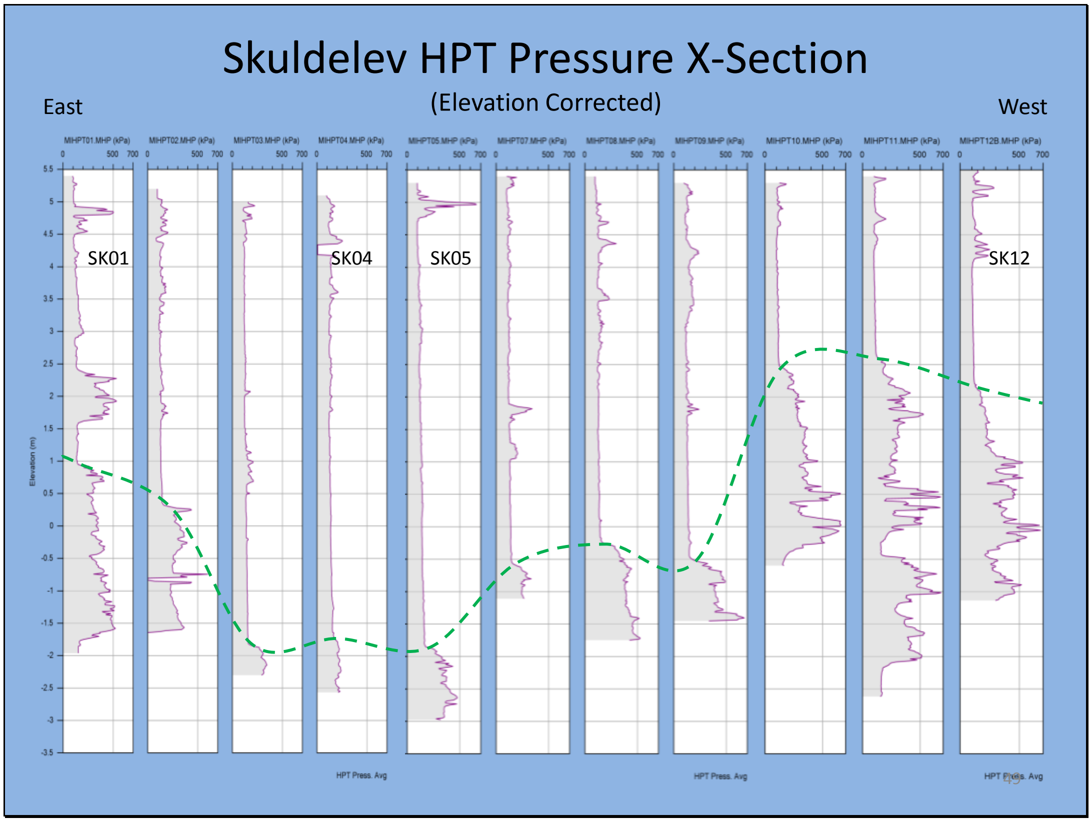
Also at the SK05 location the XSD indicated the presence of elevated concentrations of X-VOCs within the sand & gravel aquifer. Soil and groundwater sampling found that perchloroethylene (PCE) was the primary contaminant with degradation products (TCE,DCE and vinyl chloride) also present in the groundwater.

Slide 48



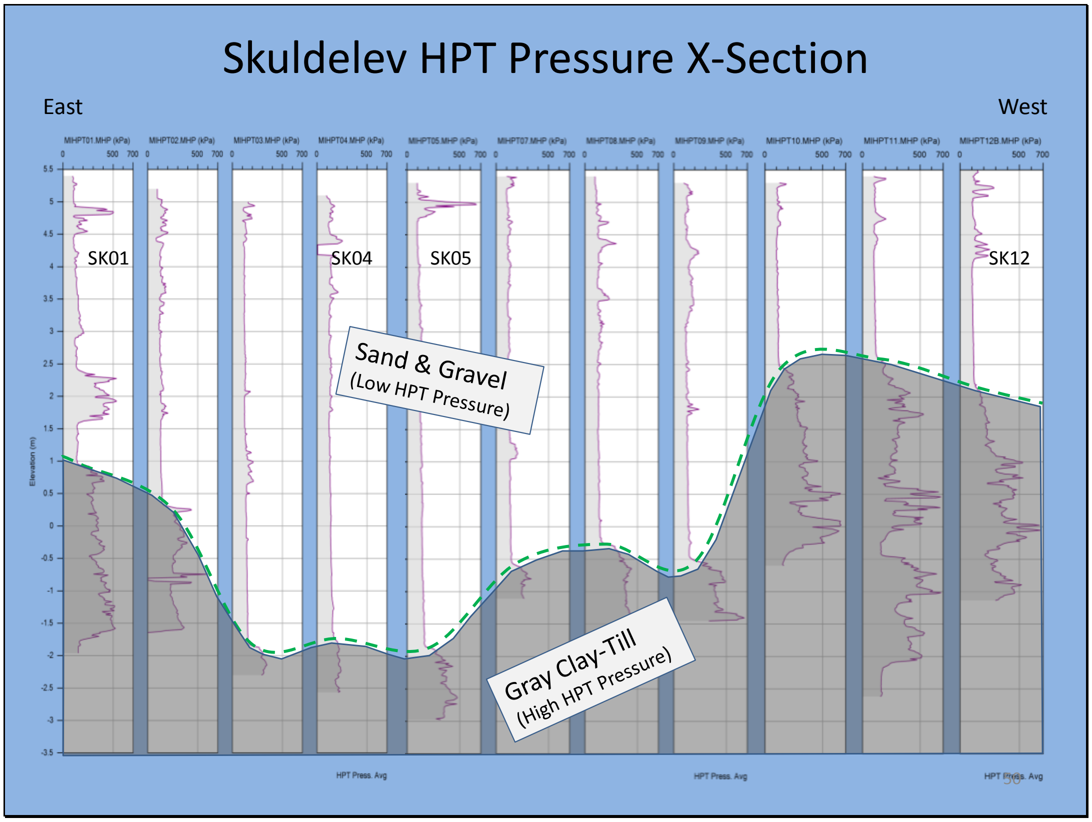
Now look at a cross section of the HPT pressure logs. East is to the left, west to the right, and we are facing generally South in the view. We can see the top of the clay-till in the subsurface across the site where the HPT pressure increases in each log (red arrows).

Slide 49



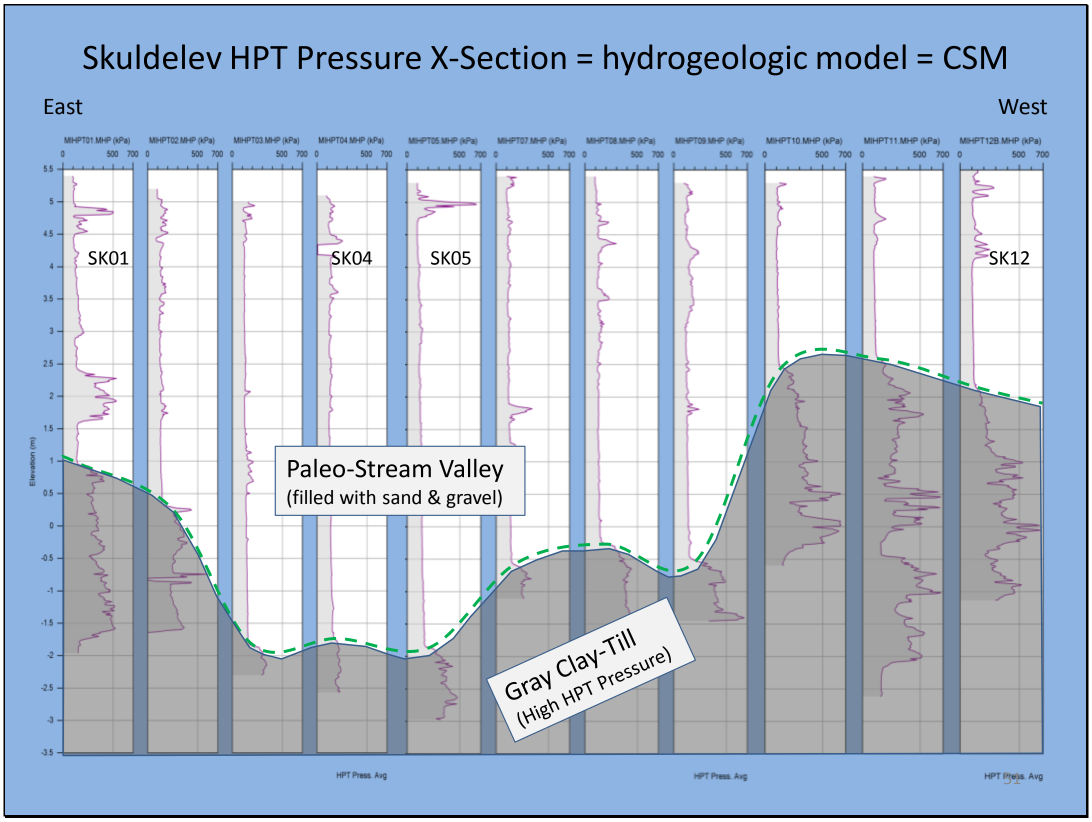
If we draw a line between each log connecting the elevation where the HPT pressure increases we define a surface of contact …

Slide 50



This surface separates the top of the high pressure clay-till from the low pressure, sands and gravels (Aquifer materials).

Slide 51

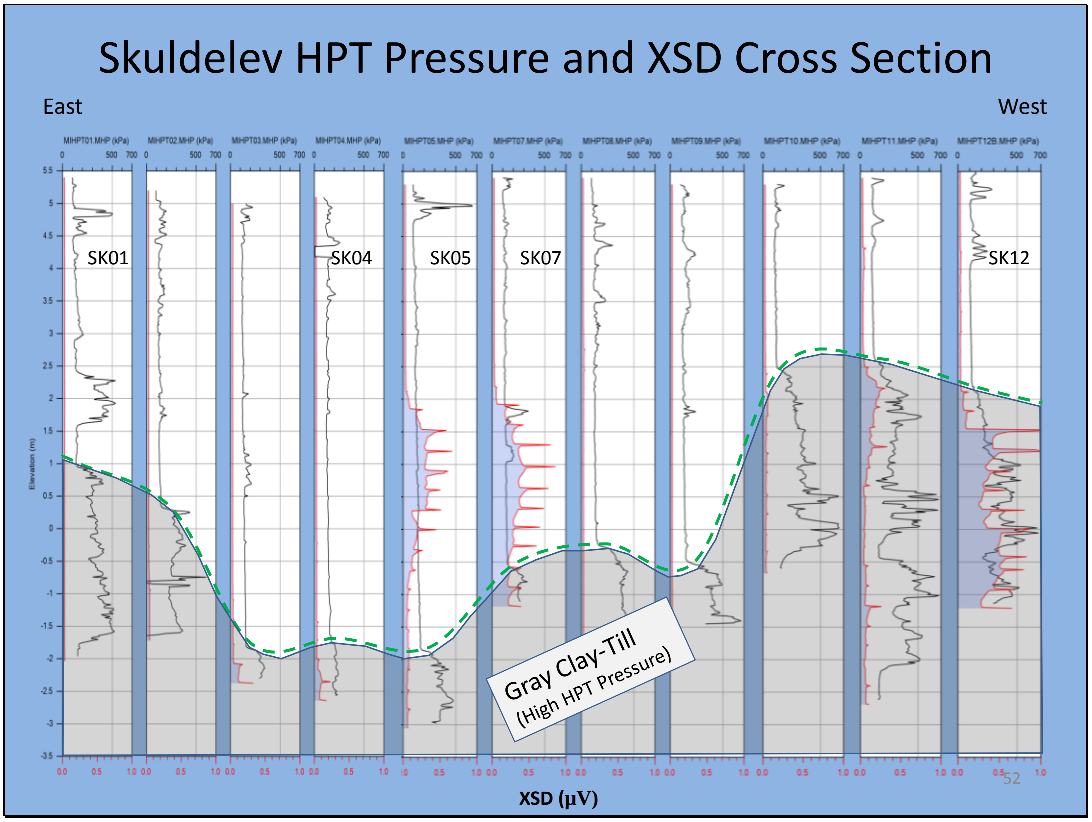


Remembering that this region was glaciated …..

It appears that a post-glacial stream eroded a small valley in the surface of the clay-till. This buried valley is outlined by the line connecting the HPT pressure increase. We see that this valley was later filled with sand and gravel, probably from outwash streams as the glaciers receded.

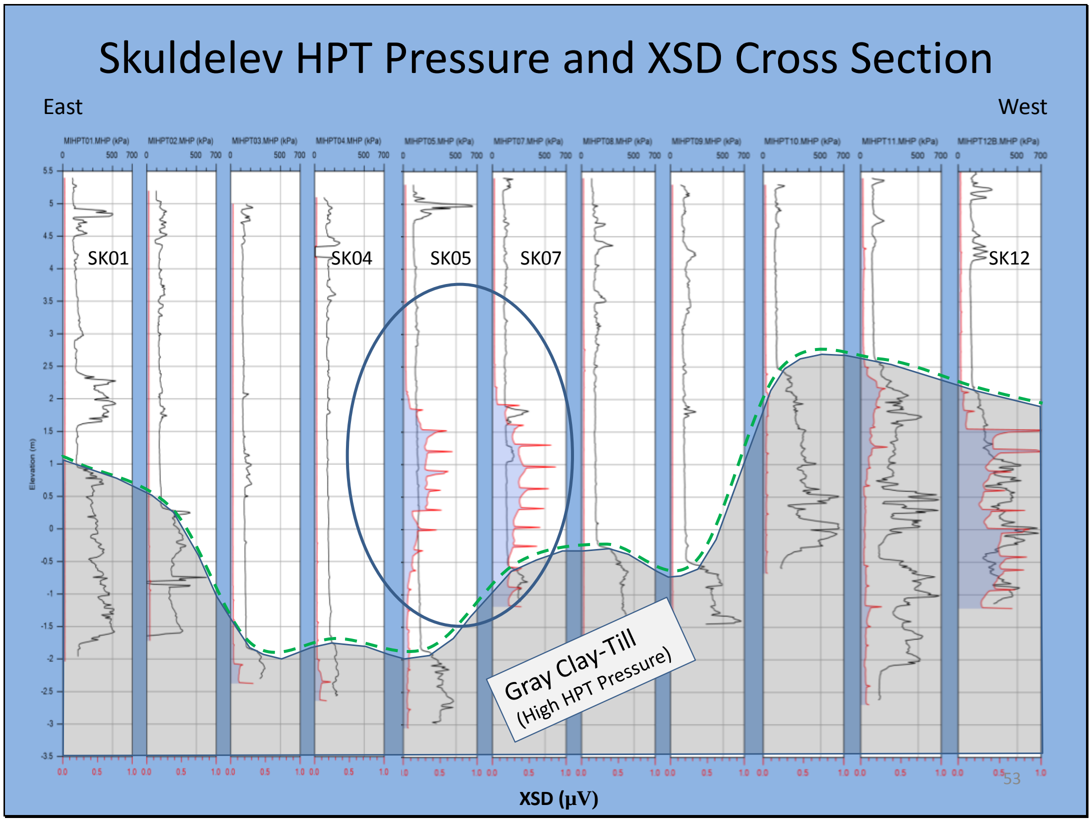
Now we have created a detailed hydrogeologic model of the subsurface based on the HPT pressure logs. This becomes the foundation for our high resolution hydrogeologic conceptual site model (CSM).

Slide 52



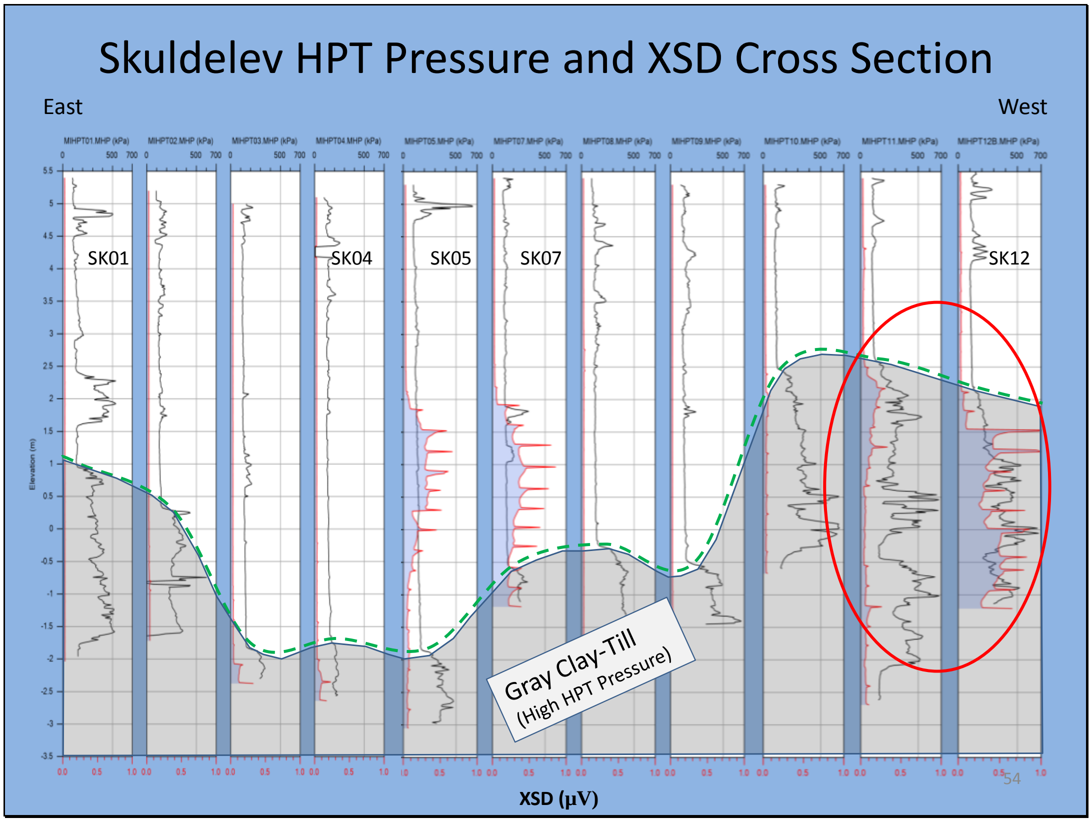
In this hydrogeologic cross section the MIP XSD detector response (red with blue fill) for chlorinated VOCs has been placed over the HPT pressure logs (black) at each location.

Slide 53



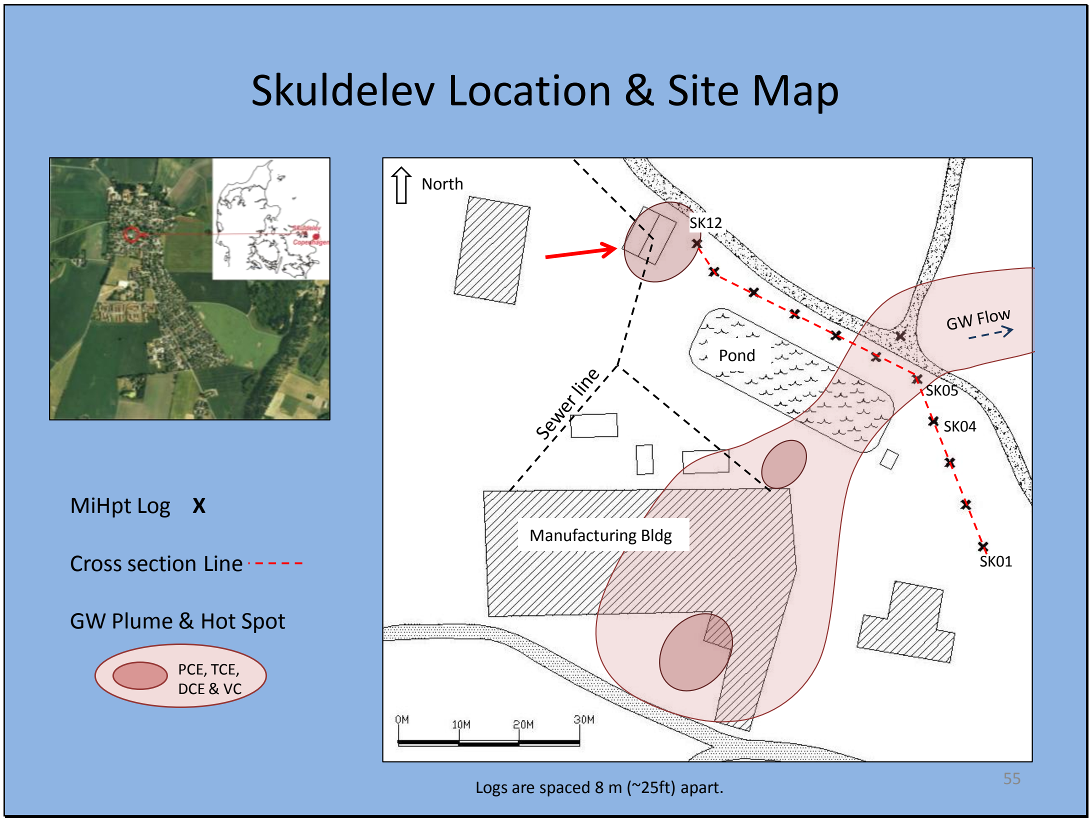
It becomes apparent that the X-VOC groundwater plume is migrating down the buried stream valley at locations SK05 and SK07. This hydrostratigraphic control on the plume migration was not understood until we had run the MiHpt log transect and constructed this HPT pressure cross section.

Slide 54



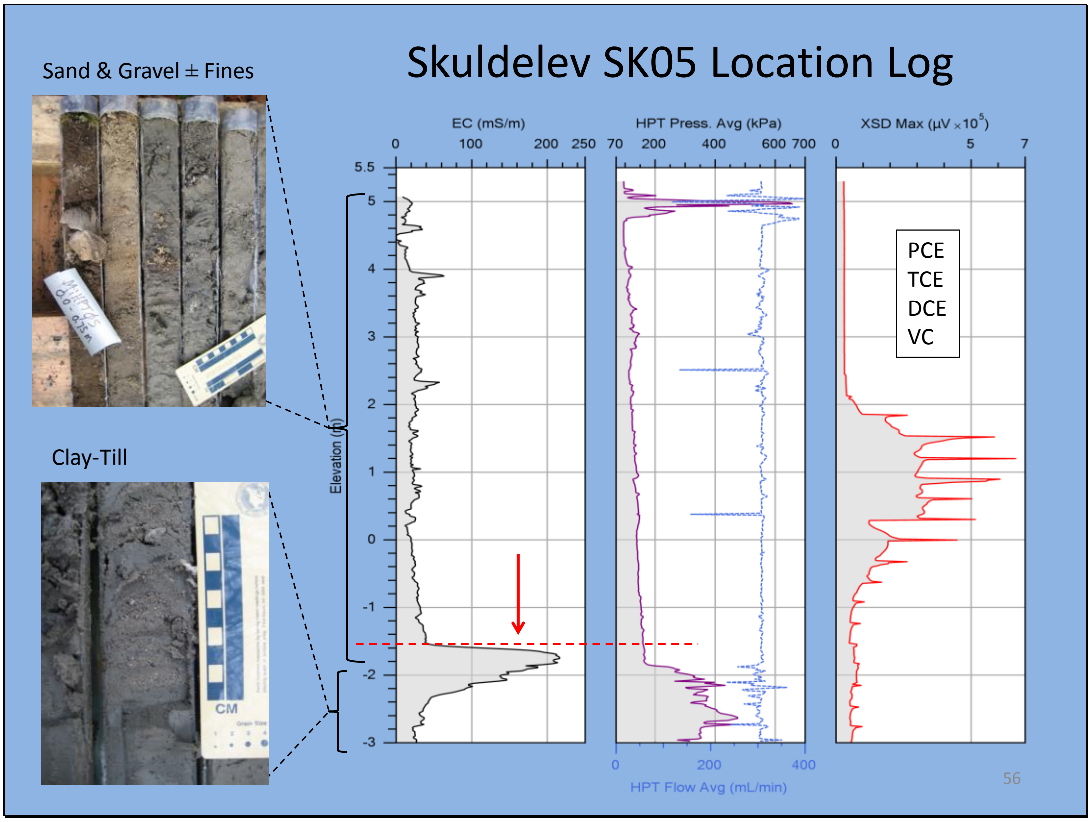
Over at the west end of the cross section (SK11 & SK12) X-VOC contamination is present in the clay-till. This “hot spot” formed as the result of a sewer leak after solvents were disposed of in the facility sewer, and is not associated with the groundwater plume.

Slide 55



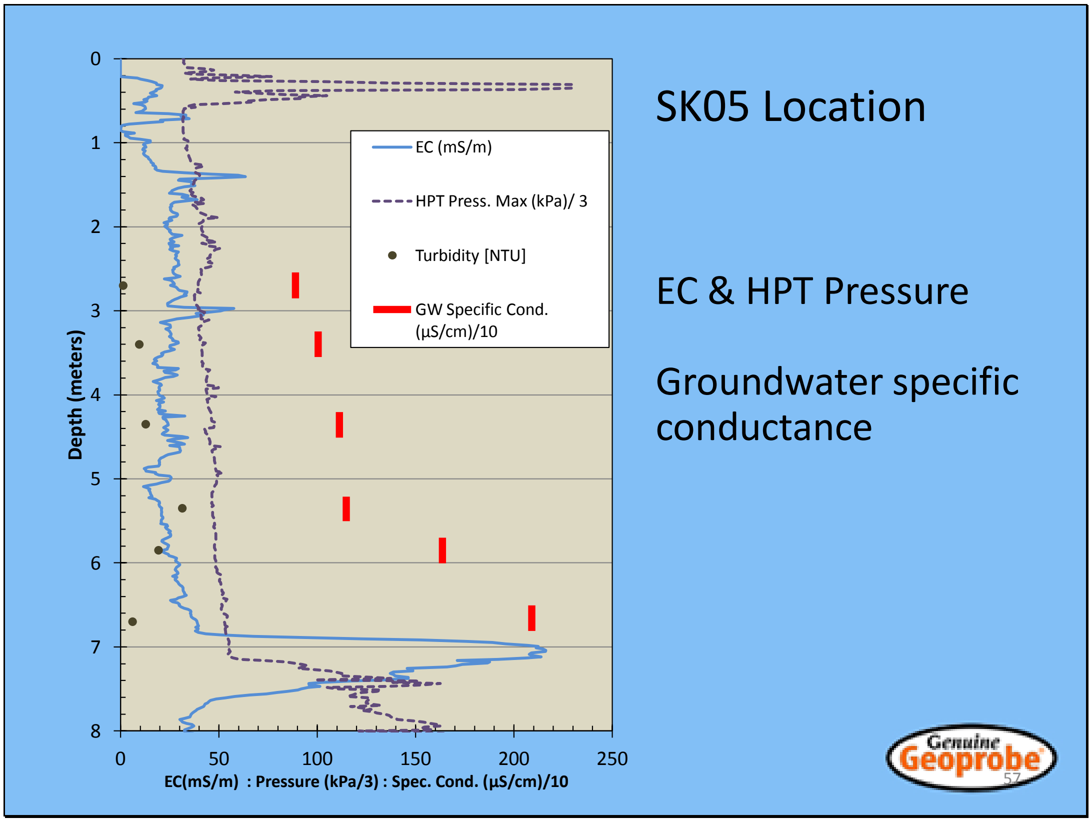
Here the sewer line juncture where the leak occurred that resulted in the hot spot at SK12 is shown on the map (red arrow). Lets look again at the SK05 log, especially the EC response.

Slide 56



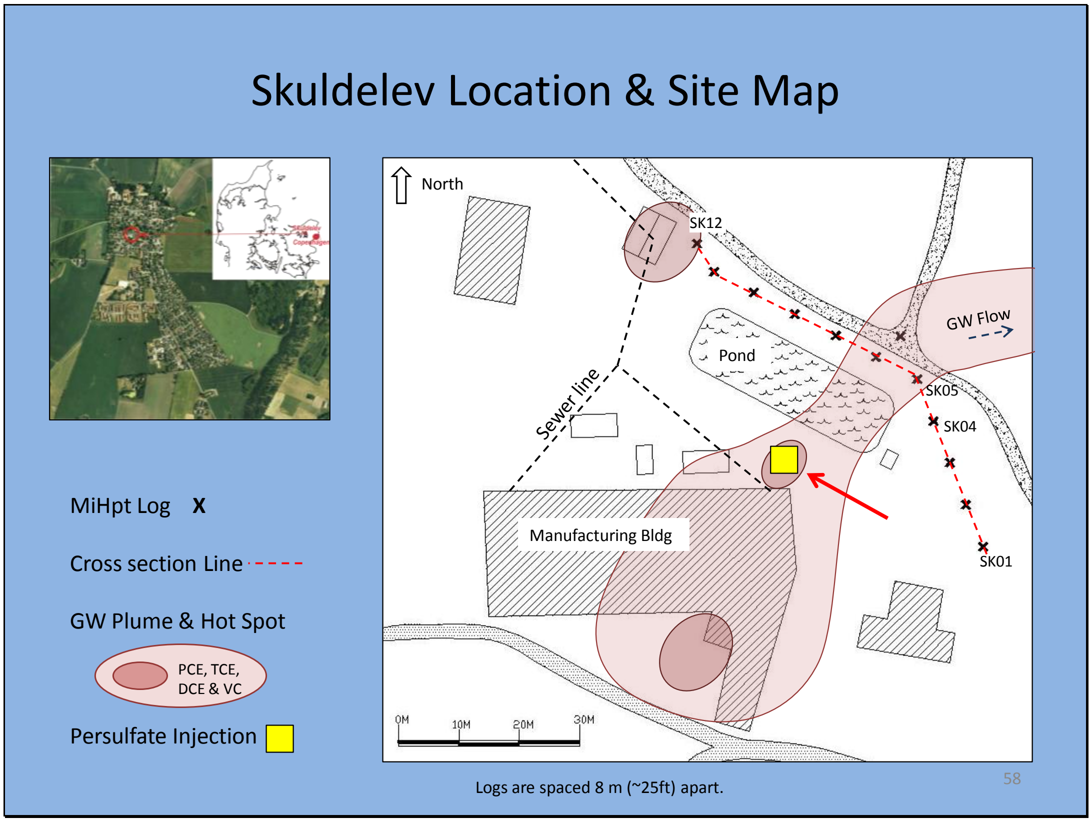
After reviewing several logs at Skuldelev we noticed what appeared to be an EC anomaly. Here the EC increases about ½ meter above the HPT pressure increase. Also, at the adjacent SK04 log we did not see any change in EC between the sands & gravels and the underlying clay-till (see above). So based on the SK04 location, and the core samples at SK05 it is apparent that the EC increase here is not related to lithology change.

Slide 57



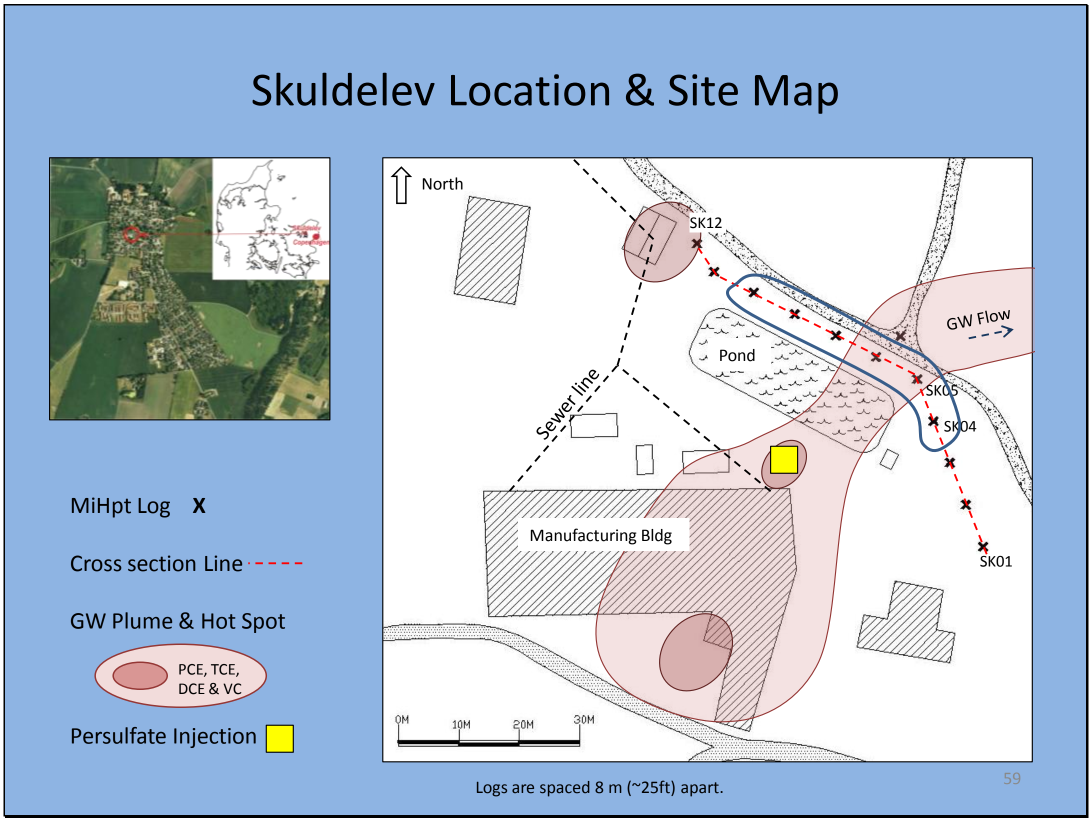
We conducted groundwater profile sampling at SK05 for X-VOCs with SP16 groundwater samplers. The 30 cm (1 ft) piezometer screens were developed prior to sampling. Water quality parameters, including specific conductance, were monitored to stability at each interval. Here we see the specific conductance is increasing as we approach the EC anomaly. This suggests that an ionic contaminant in the formation is causing an increase in the bulk formation electrical conductivity.

Slide 58



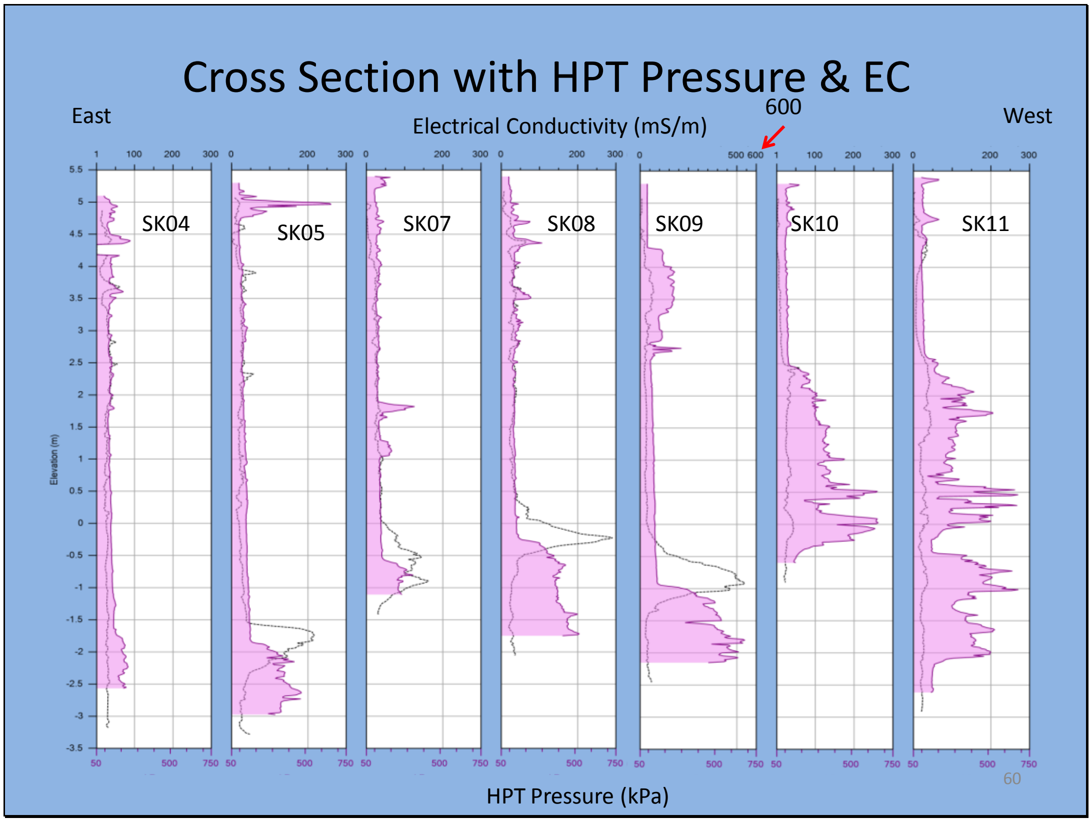
During discussions with the NIRAS project managers (Klaus Weber and Anders Christensen) we learned that a pilot study with persulfate injection had been conducted at one of the DNAPL hot spots upgradient of the MiHpt cross section. Anders indicated that well sampling after the injection program had confirmed the presence of persulfate in several monitoring wells. Well and boring logs appeared to indicate it was moving in a thin basal conglomerate present at the top of the clay-till in some areas across the site.

Slide 59



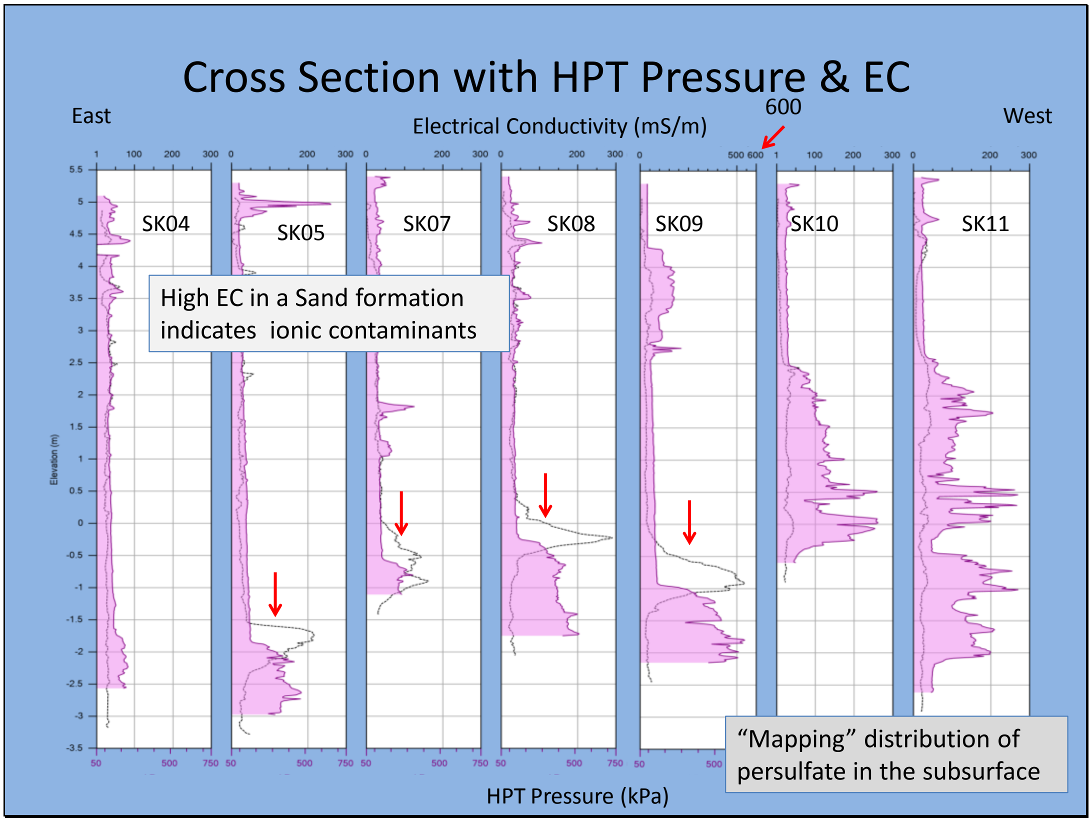
Now, let’s look at a cross section from SK04 over to the SK10 location, focusing on EC and HPT pressure.

Slide 60



HPT pressure is in purple and EC is black dashed line. Background EC at SK04 and SK10 & 11 are relatively flat (featureless), and below HPT pressure.

Slide 61



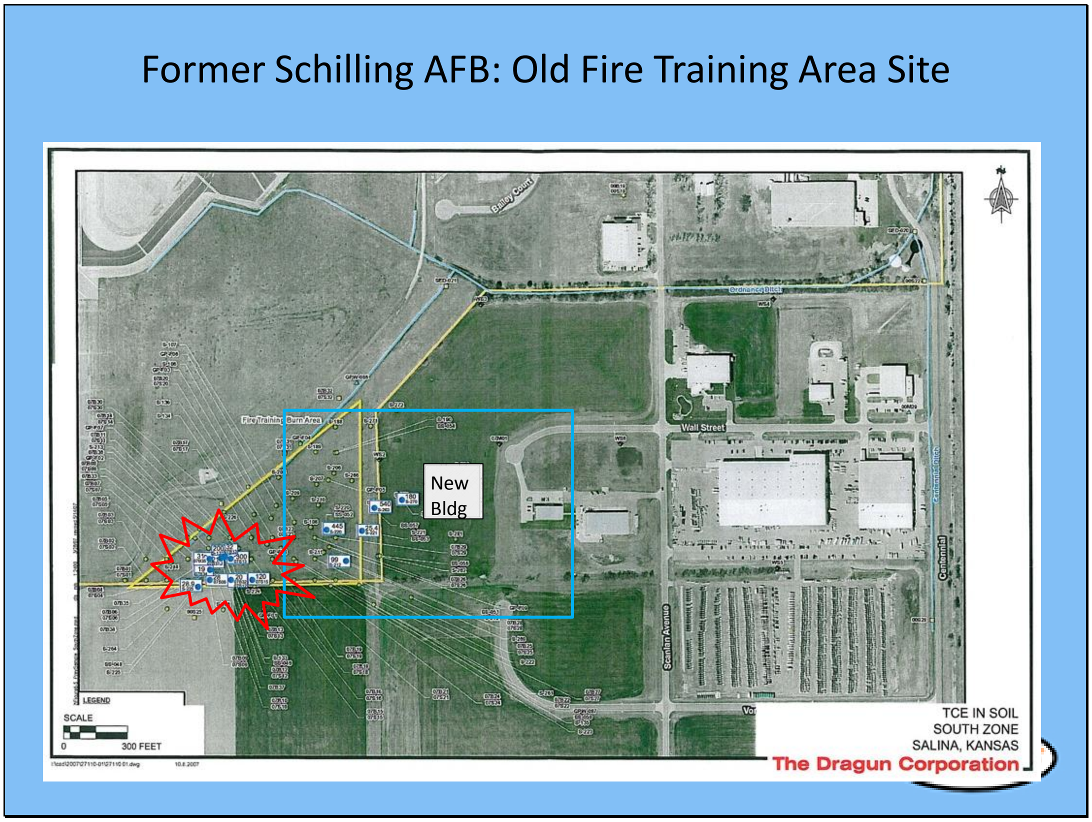
However, between the SK05 to SK09 locations we see that EC clearly increases above the clay-till. In several cores across the area we observed a "basal conglomerate" at the boundary between the clay-till and the overlying sands and gravels. It appears this very permeable layer maybe providing a conduit for rapid movement of the persulfate in the subsurface. Detecting the EC amomaly by combining HPT pressure and EC logs provides a method for mapping ionic contaminants in the subsurface. For high concentration brines the bulk formation EC can be several hundred or even a few thousand milliSiemens/meter, becoming very obvious in the EC logs.

Slide 62

The Following slides about the low permeability site at the former Schilling AFB are an addendum to the original webinar …

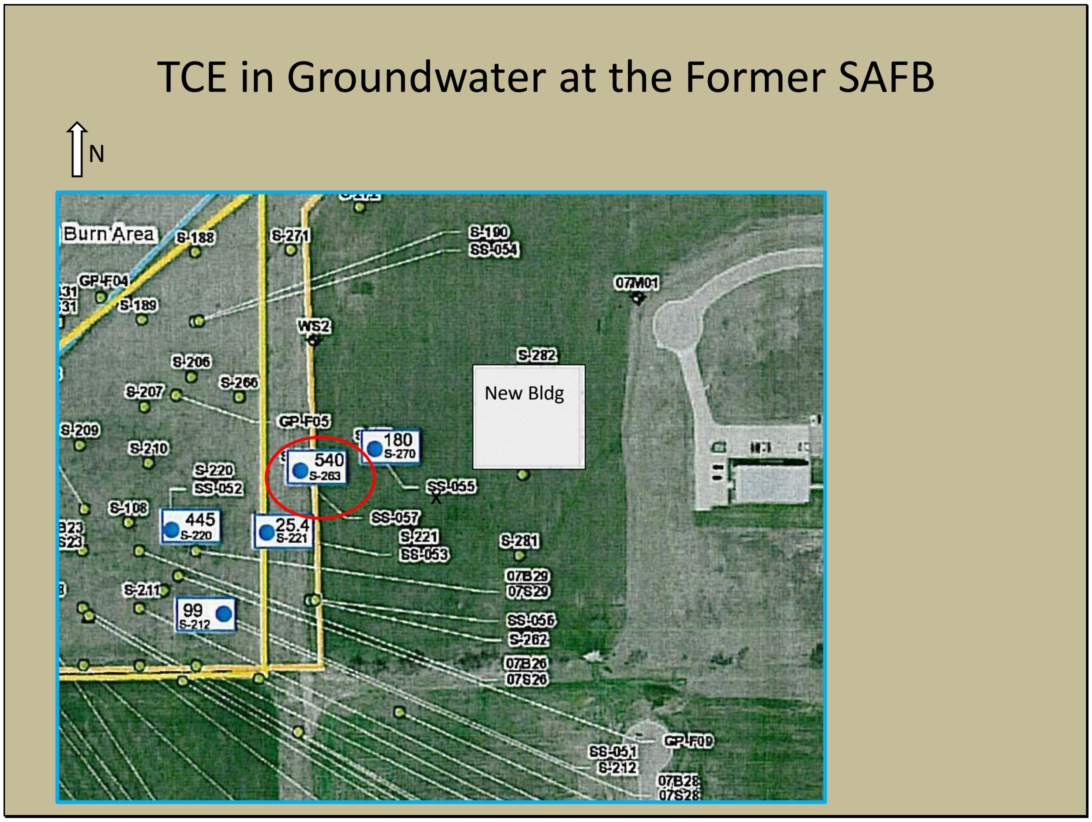
Genuine Geoprobe

Slide 63



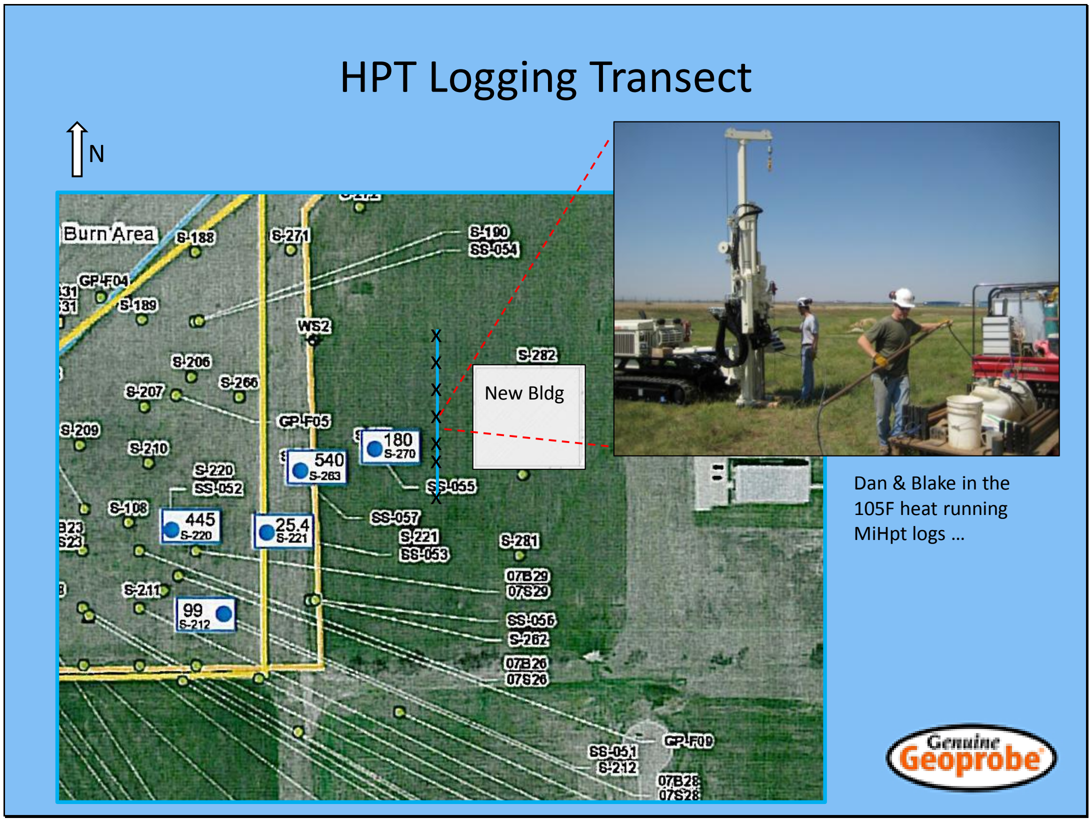
Let's look at another site using MiHpt logs. This is at the former Schilling AFB in Salina, KS (thousands of gallons of TCE per month were used here to clean B42 bomber engines during WWII so the engines could be serviced and repaired). The red "explosion" outlines the primary area that was used for fire training activities, and of course solvent was used in these activities. We will zoom in to the blue box in the next slide.

Slide 64



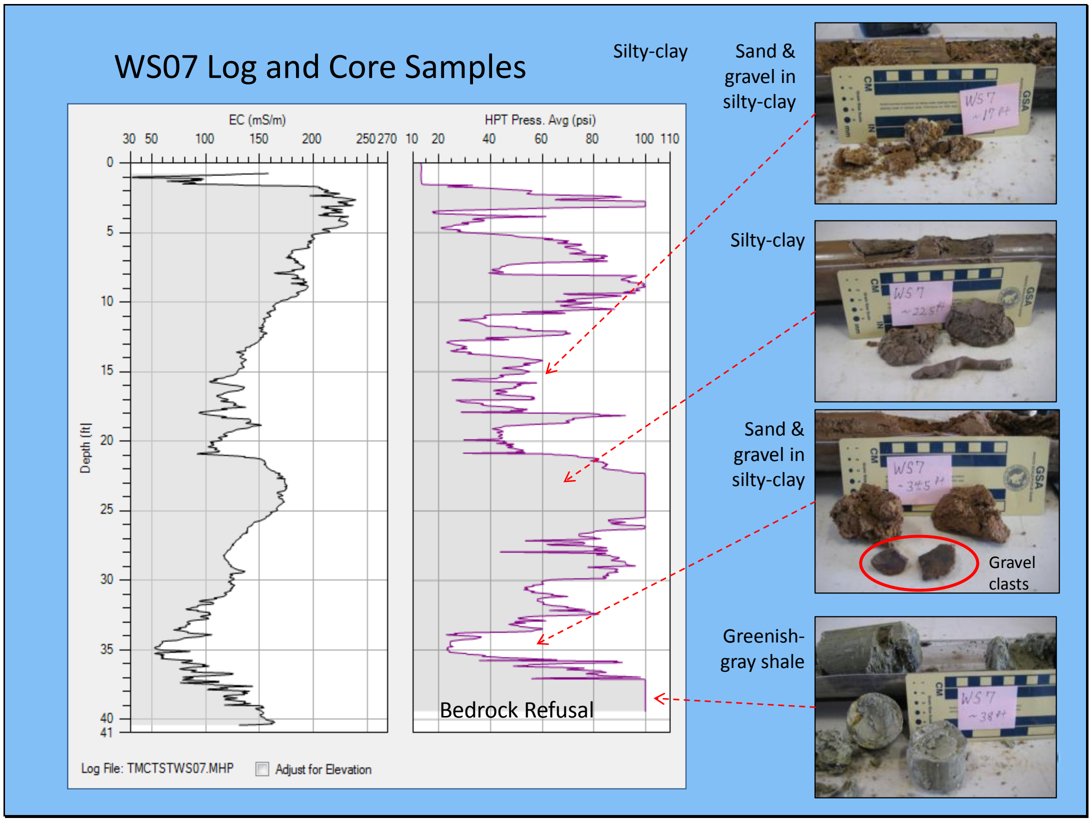
The results shown here are from an earlier investigation conducted by the ACOE at this area of concern. Note the highest concentration observed in groundwater samples from this area is 540 µg/l (parts per billion). It appears they are tracking a plume that is trending to the northeast, toward the new building (constructed after the aerial photo was taken).

Slide 65



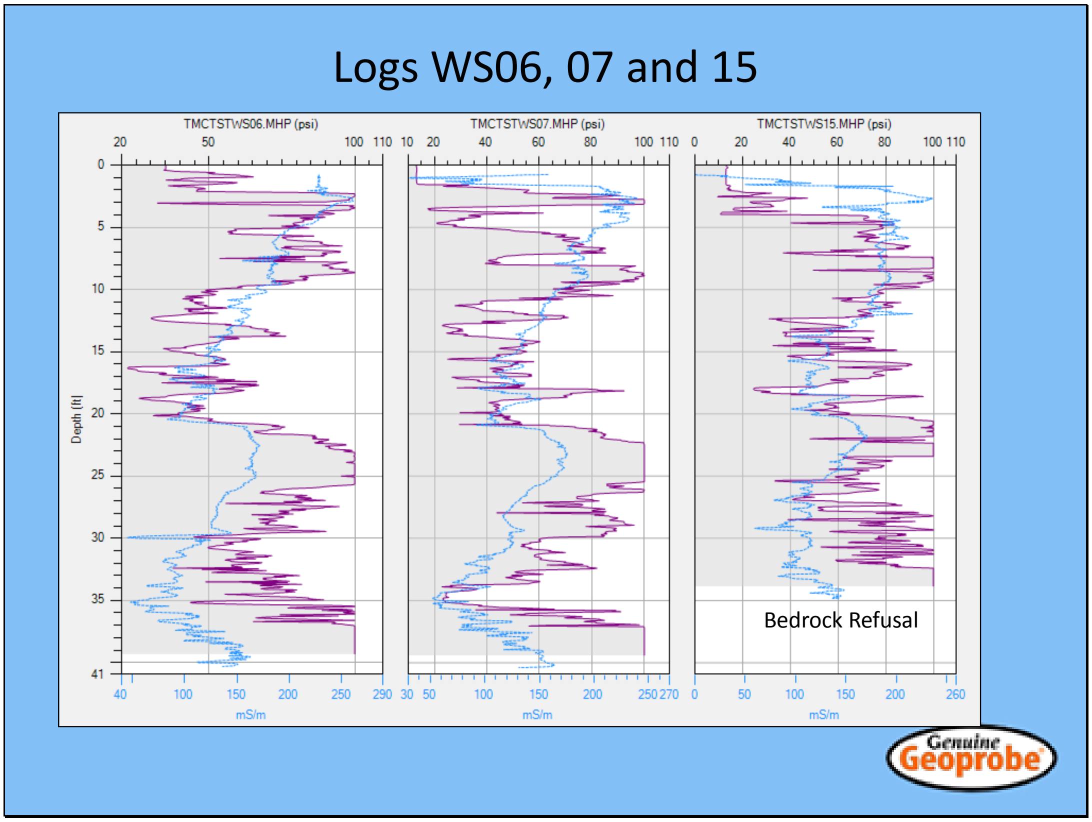
We ran a transect of more than 20 HPT logs about 100ft west of the new building (only a few locations are indicated on this map due to space limitations here, black X's on the blue transect line). Let's look at one log (WS07) obtained near the center of the transect.

Slide 66



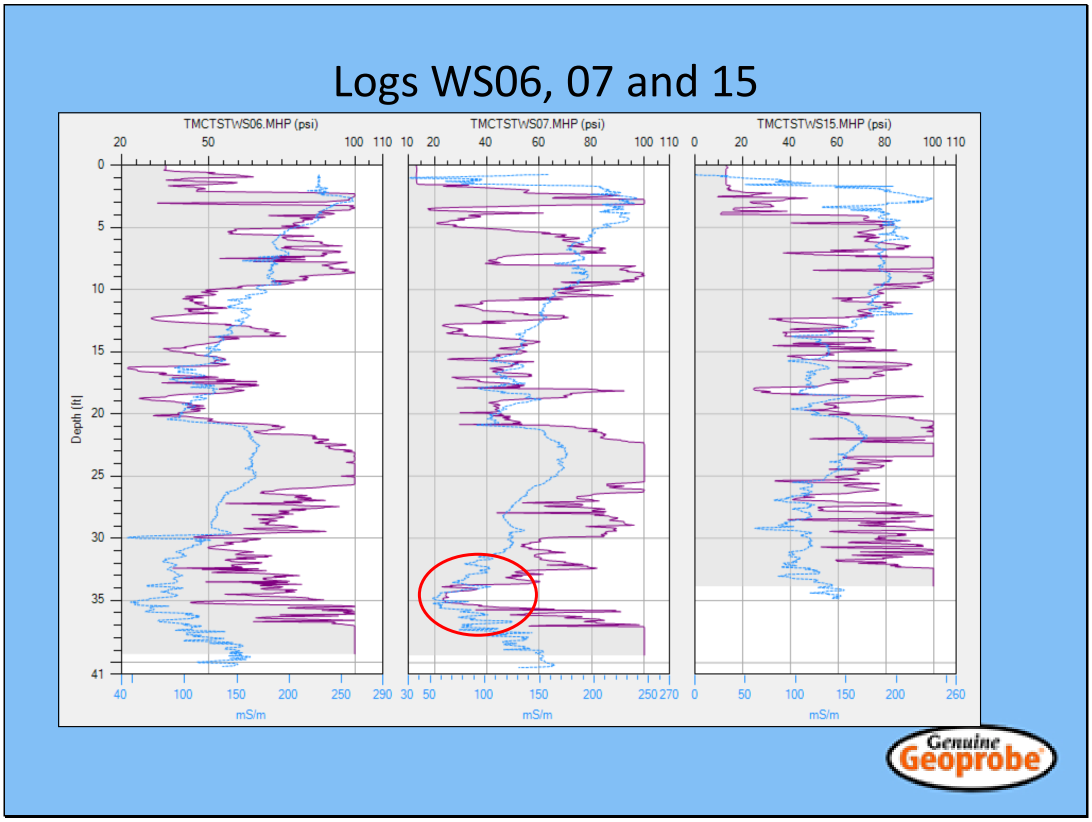
Let’s compare the log to a few samples from a co-located continuous core. In this log HPT is purple with gray fill, EC is the black with gray fill. Here EC and HPT pressure correlate pretty well, so EC does provide a good general indication of permeability at this site. Looking at the core samples also lets us see that the EC and HPT pressure logs define the lithology/ hydrostratigraphy at the site. All the logs ended at bedrock refusal in the weathered-to-fresh shale bedrock (Permian Age, Ninnescah shale, Wellington formation).

Slide 67



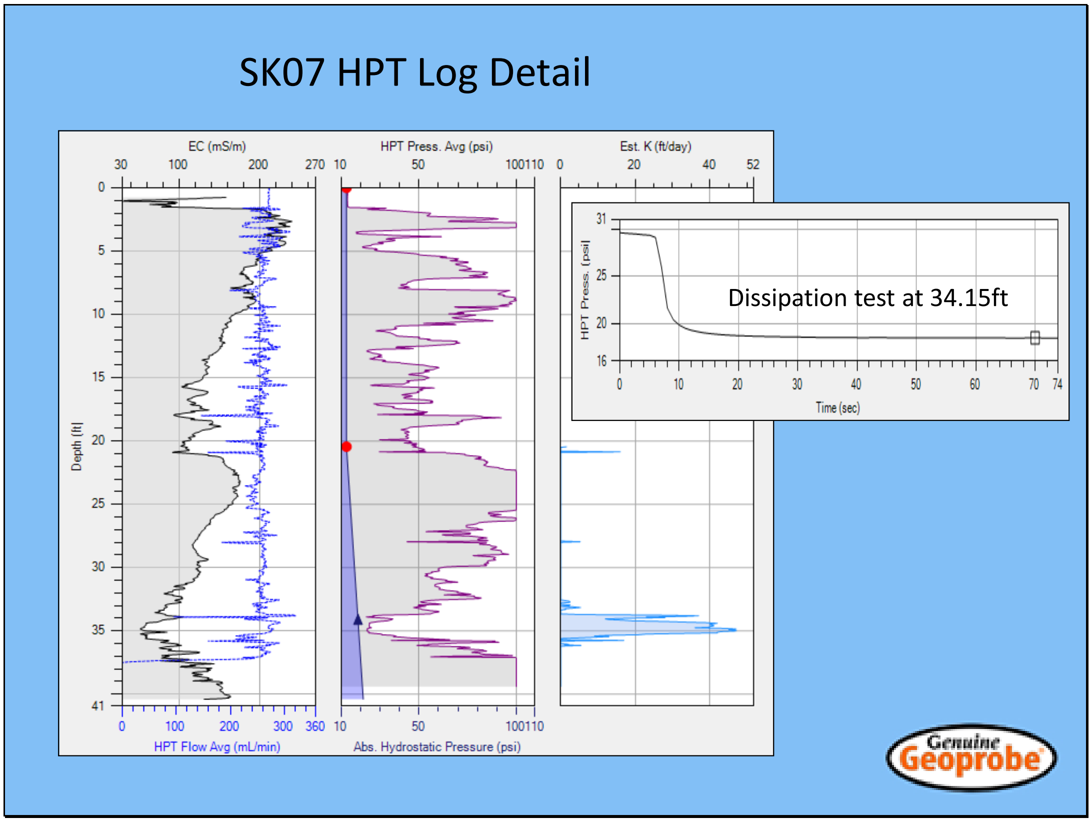
Now let's look at a short cross section of logs centered at the WS07 location. In these logs HPT is purple with gray fill, EC is the blue dashed line. Again it is evident that EC and HPT pressure correlate pretty well, and EC does provide a good general indication of permeability at this site. All the logs ended at bedrock refusal in the weathered shale around 35 to 45ft below grade.

Slide 68



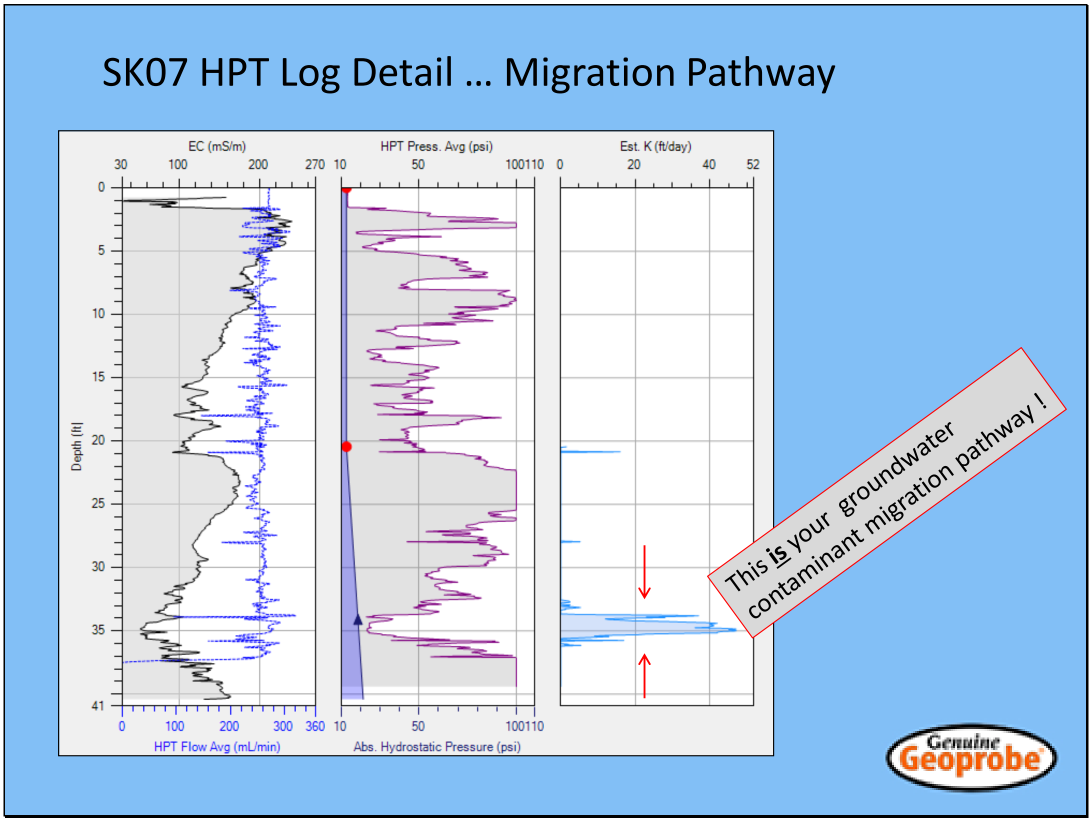
The only place in this transect of over 20 logs where we found HPT pressure low enough to run a good dissipation test was at the WS07 log between ~34-36ft below grade.

Slide 69



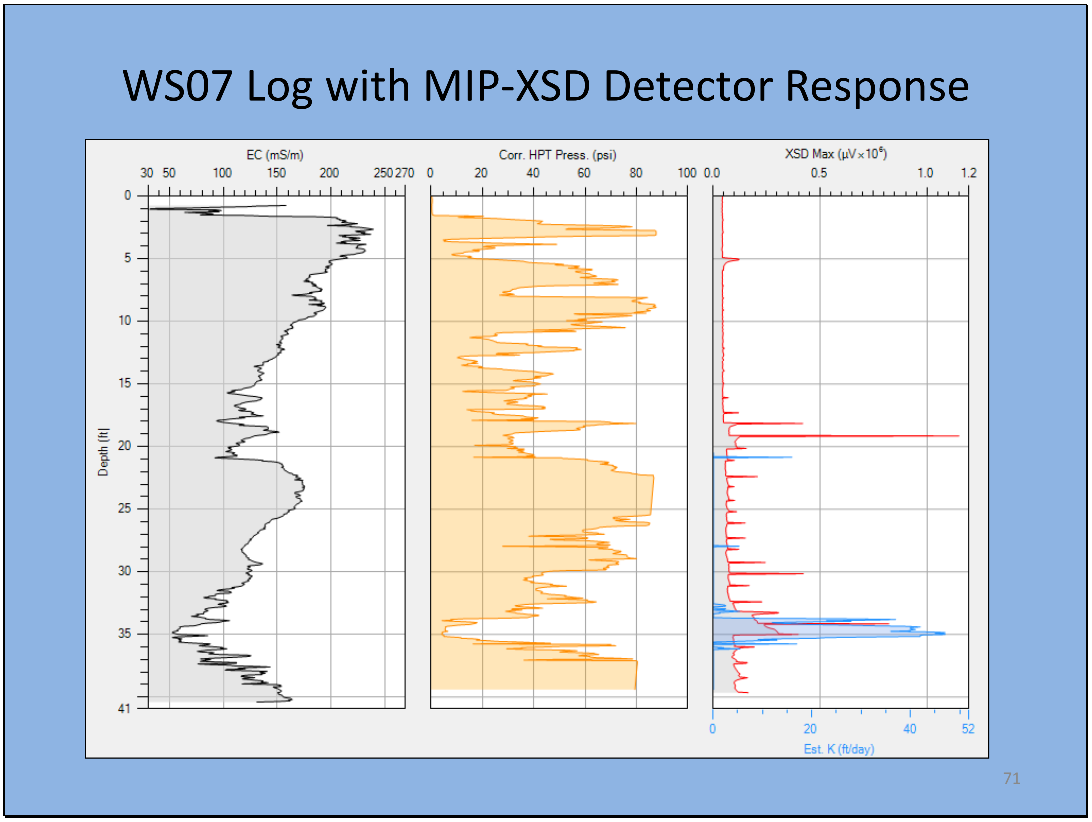
Getting a good dissipation test allowed us to calculate the Est. K log at this location. The Estimated K log enables us to see that the zone between approximately 33.5 to 36 ft is the only interval in this formation that has sufficient permeability for significant groundwater flow. This is the only zone that would yield enough water to obtain a good groundwater sample. (Not just a trickle allowed to collect in the piezometer over days to then be sampled)

Slide 70



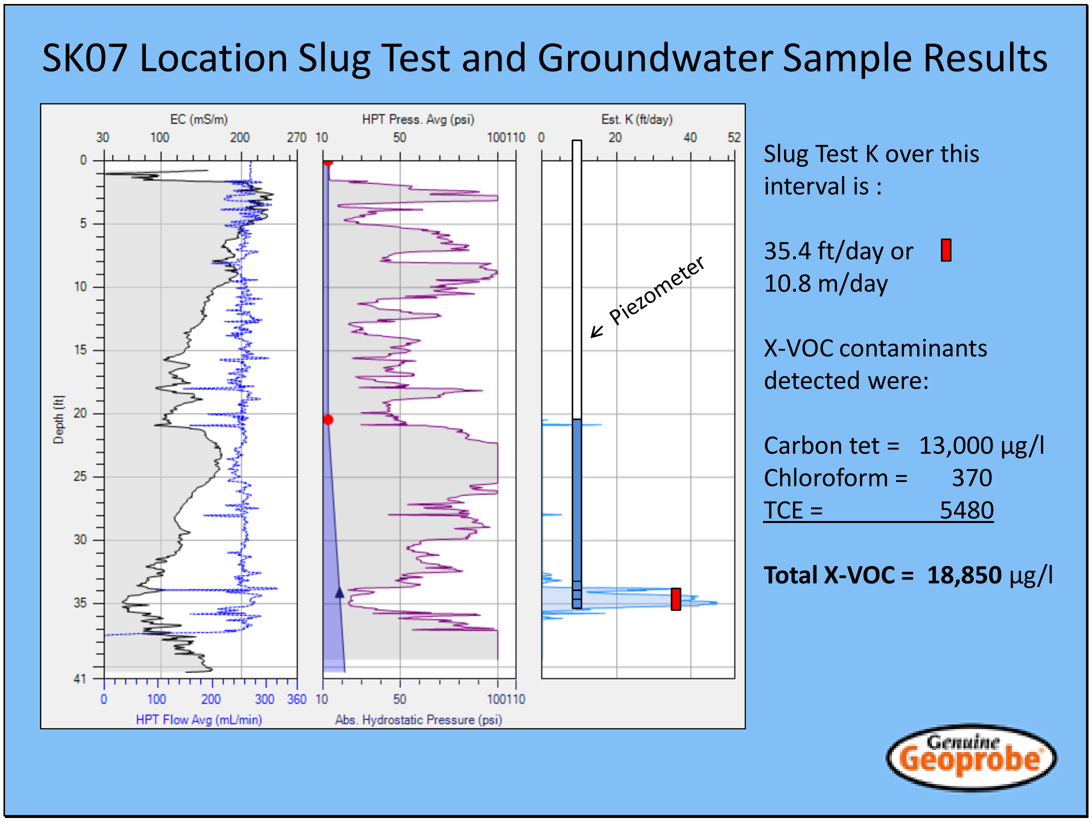
This small permeable zone (restricted both vertically and laterally) appears to be the primary contaminant migration pathway for groundwater at this site.

Slide 71



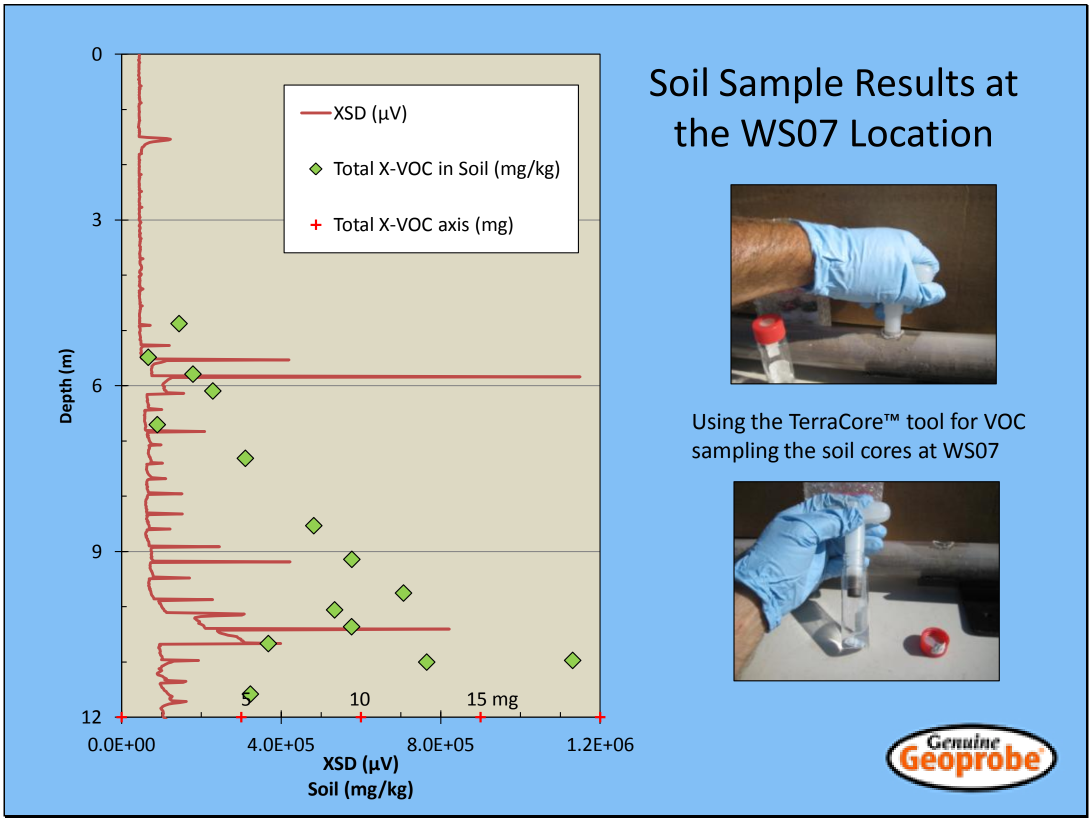
This log includes the corrected HPT pressure log (center) and the halogen specific detector (XSD) log (red with gray fill) overlying the Est. K log. It is clear that where the HPT pressure and EC logs are low (18-21ft and 34-36ft), the chlorinated VOC response on the detector is highest. Indicating that lower EC and Lower HPT pressure are defining the primary migration pathways in the vadose and saturated zones.

Slide 72



Installing an SP16 Groundwater sampler allowed us to run slug tests and sample groundwater in the saturated 34-36ft zone. We used a 2 ft (~60cm) screen interval. Looking at just the TCE at this location we see it is almost exactly 10 times higher than that detected in the earlier investigation by the ACOE. The HPT pressure and Est K logs enabled us to locate and target the very restricted contaminant migration pathway at this site. Miss this and your understanding/interpretation of the CSM is not very good

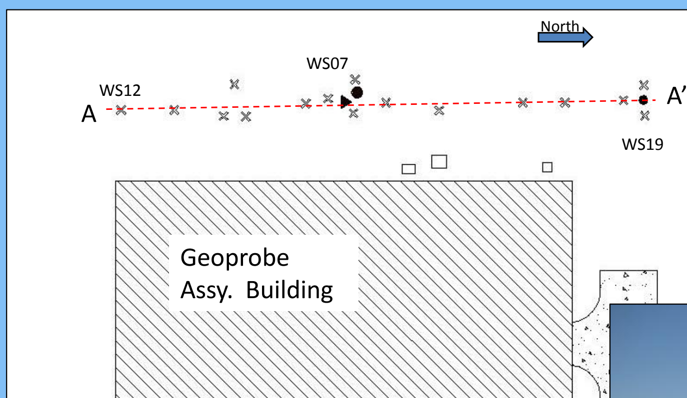
Slide 73



This figure displays the XSD detector log with soil sample total VOC results plotted (green diamonds). The soil cores demonstrate a generally increasing trend of total X-VOCs with depth at the WS07 location, similar to the XSD log trend. Carbon tetrachloride, chloroform and TCE were detected in the soil samples. . Next let's look at a cross section of the site using EC and XSD detector logs.

Slide 74

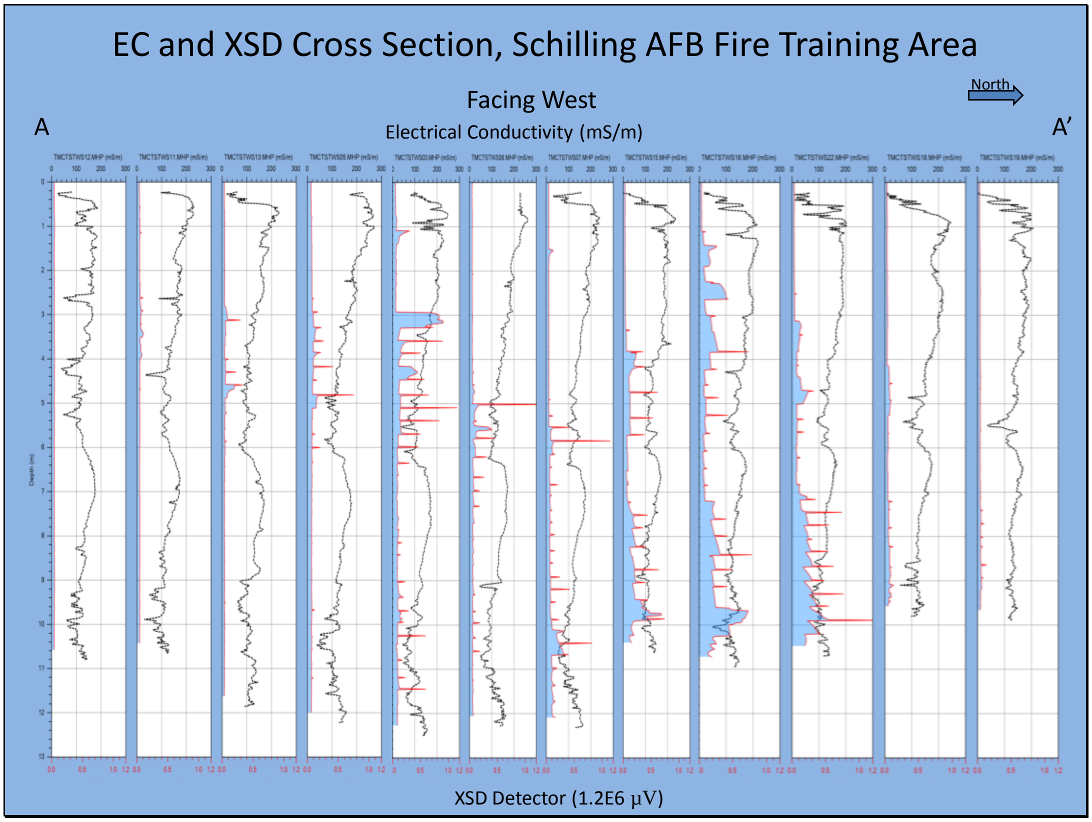
MiHpt Cross Section Map with Log Locations



A-A' shows cross section to be viewed in following slide

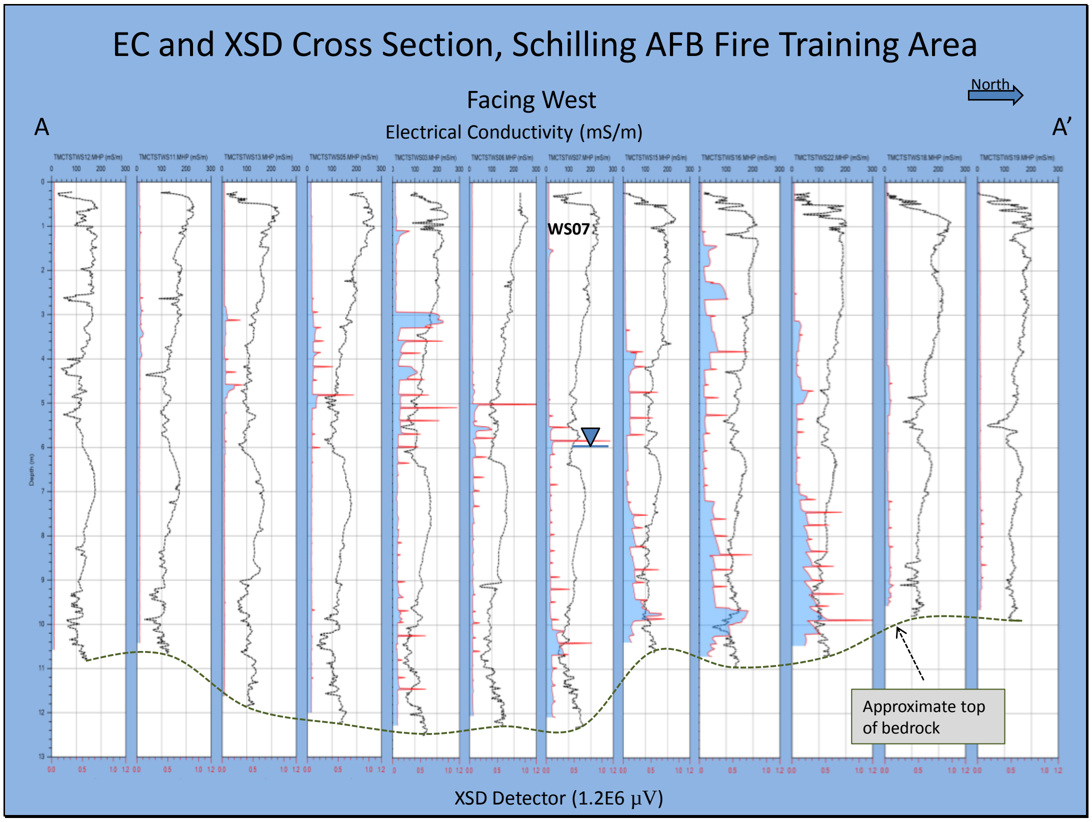
The red dashed line shows the cross section trend we will look at in the next slide … approximately south to north, left to right, in this site sketch map view. The logs were not run sequentially across the site so the log numbers in the cross section are not in an increasing order but do reflect the south to north placement of the logs on the ground.

Slide 75



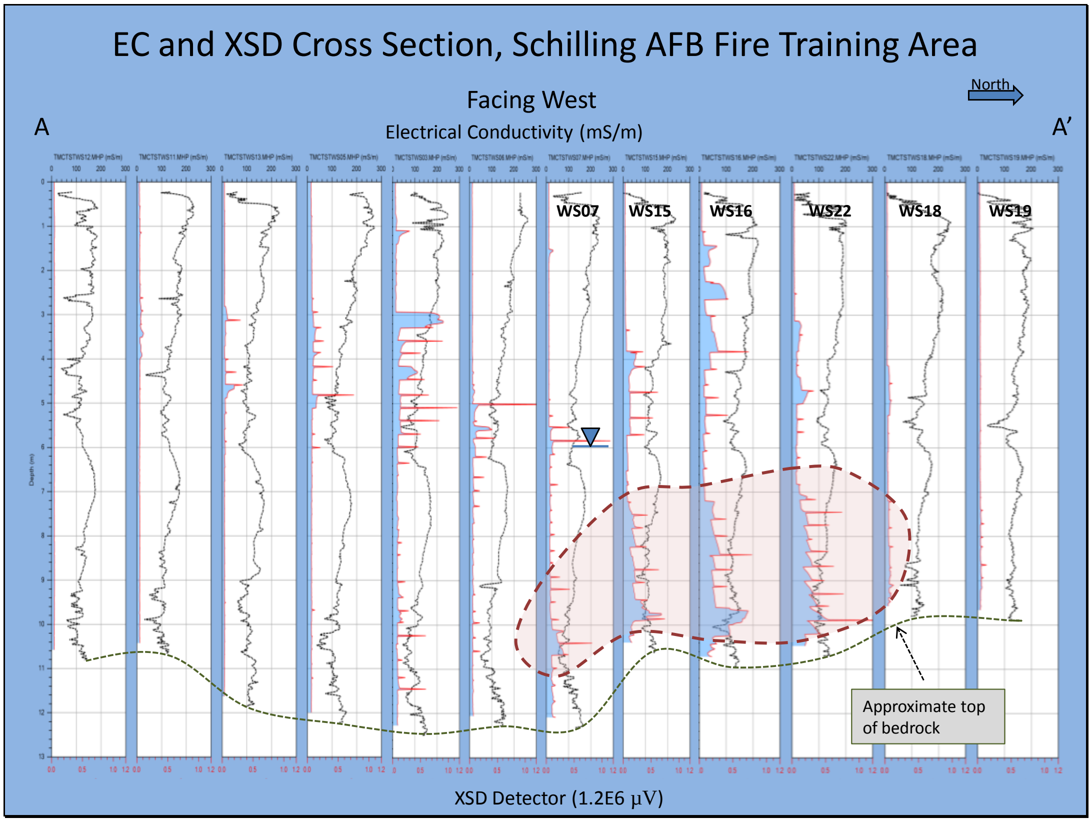
The logs are spaced approximately 30ft apart, EC = black dash line, XSD is red line with blue fill. Advancement on each log was stopped at refusal in the shale bedrock. The logs are not elevation corrected but the transect area is pretty flat … it is Kansas !

Slide 76



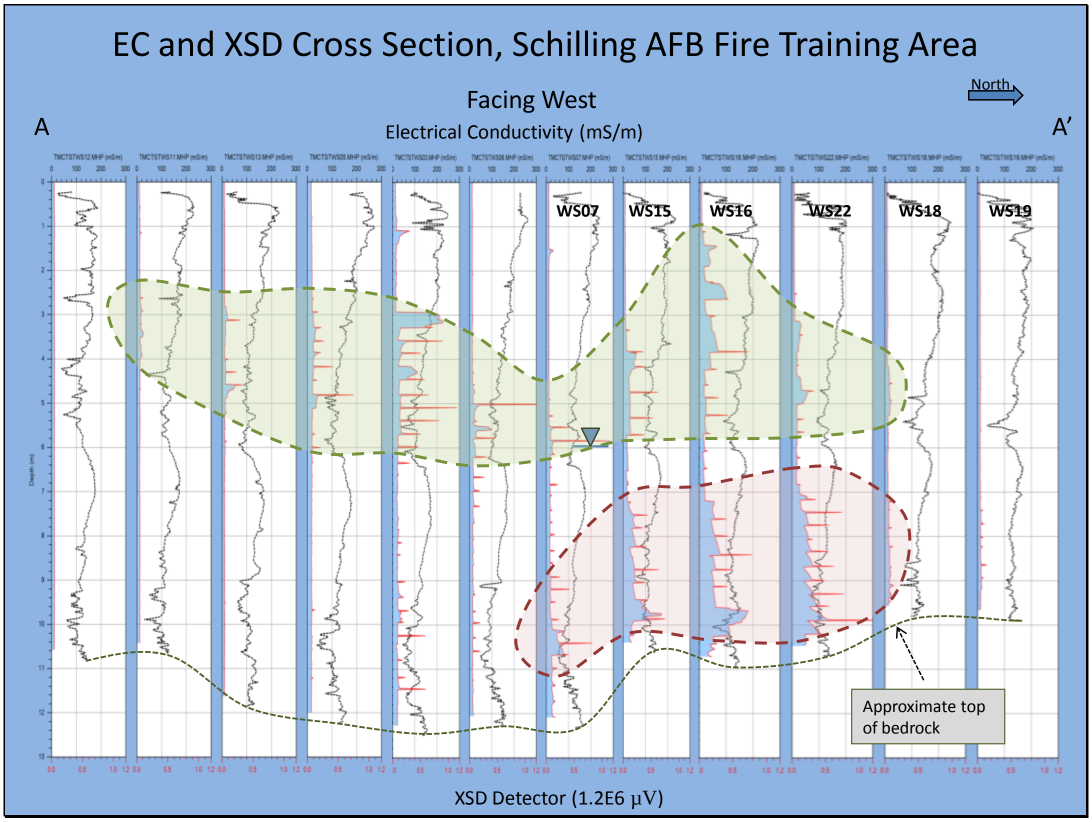
The green dashed line here roughly defines the top of competent bedrock based on targeted core samples, EC log and probe refusal. Water level is shown at log SK07, it is about 20ft or 6m below grade.

Slide 77



The red dashed line with light pink shading outlines what appears to be the core of the groundwater X-VOC plume in this area. The XSD logs indicate that lower X-VOC concentrations trend further to the south (left here).

Slide 78



The green dashed line traces out the primary soil vapor plume based on the XSD detector response. Based on these log results and the cross section it appears the soil vapor plume is moving south (left here) in the lower EC (higher permeability zone) ahead of the groundwater plume. I am glad my office is not sitting above log location WS16! About a weeks worth of MiHpt logging and a few targeted soil and groundwater samples taught us more about the site hydrostratigraphy and contaminant migration in the vadose and saturated zones than several weeks of work using more traditional methods in the previous investigation.

Slide 79

Summary

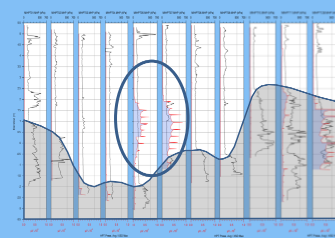
- HPT Principles of Operation
- Equipment Required for Logging
- Basics of HPT Log Interpretation
- Making a Cross Section with HPT Logs
- Interpreting Hydrostratigraphy with HPT
- Dissipation Tests, Hydrostatic Pressure & Water Levels

HPT >>> High Resolution Site Characterization

Genuine Geoprobe

To summarize what was covered in the Webinar today …

Summary



- Correcting HPT Pressure (Pc)
- Estimating Hydraulic Conductivity from Pc and Q (flow)
- Developing a CSM with HPT Pressure Cross Sections
- Tracking an ionic contaminant by combining HPT and EC logs
- Locating X-VOC migration pathways
  at a low permeability site with MiHpt logs

Slide 81

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

You may also contact Doug Koehler (koehlerd@geoprobe.com), Dan Pipp (pippd@geoprobe.com) or Wes McCall (mccallw@geoprobe.com) at Geoprobe to learn more about these systems. Phone 1-800-436-7762