

REINHOLD ENVIRONMENTAL Ltd.



**2018 NO_x-Combustion Round Table
& Expo Presentation**

February 19-20, 2018, in St. Louis, MO / Hosted by Dynegy

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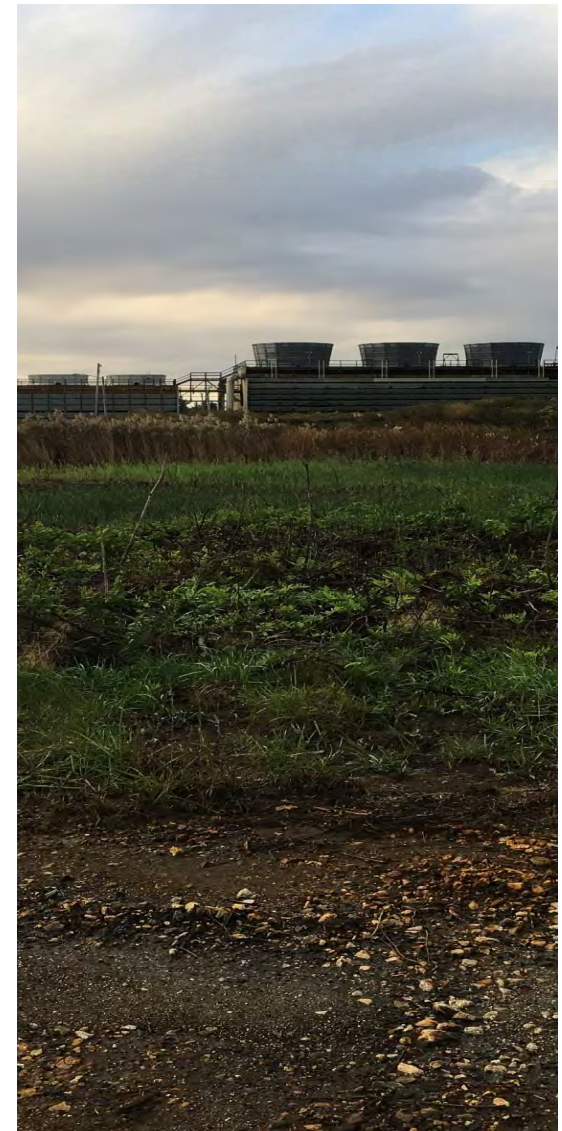


gai consultants

MORETRENCH

Dewatering Pilot Tests and Geotechnical Design Considerations for CCR Impoundment Closures

February 20, 2018

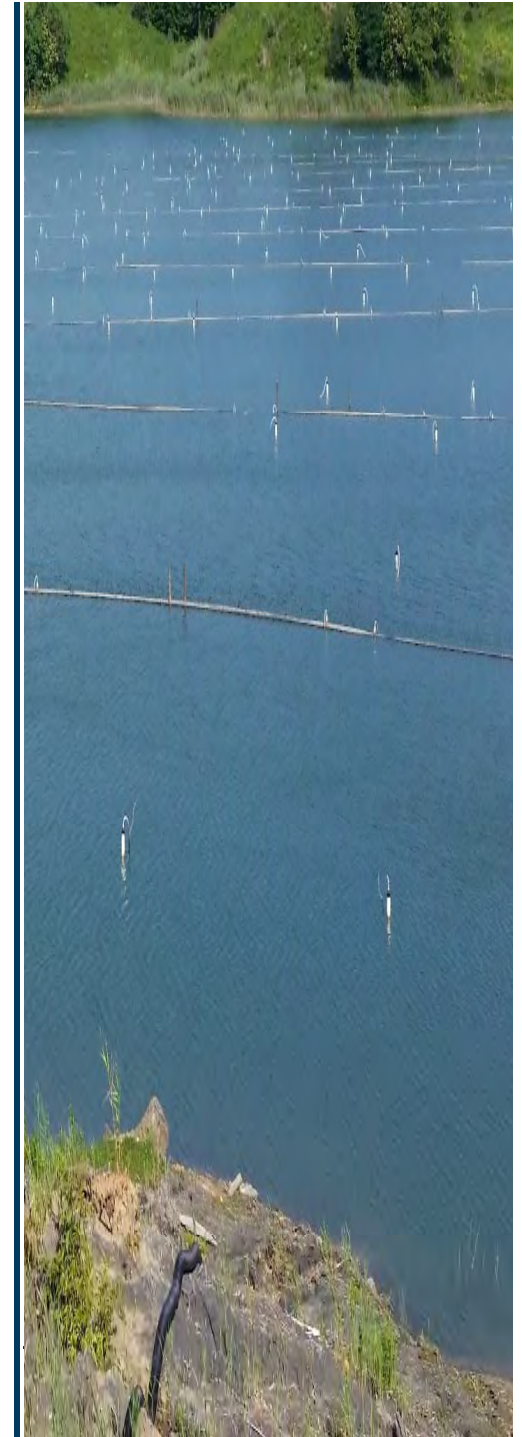


*2018 NOx – Combustion – CCR
Roundtable/PCUG Meeting*

Introduction

Speakers

- ▶ John Klamut, P.E.
Engineering Manager, GAI Consultants
- ▶ Greg Landry, P.E.
Chief Dewatering Engineer, Moretrench



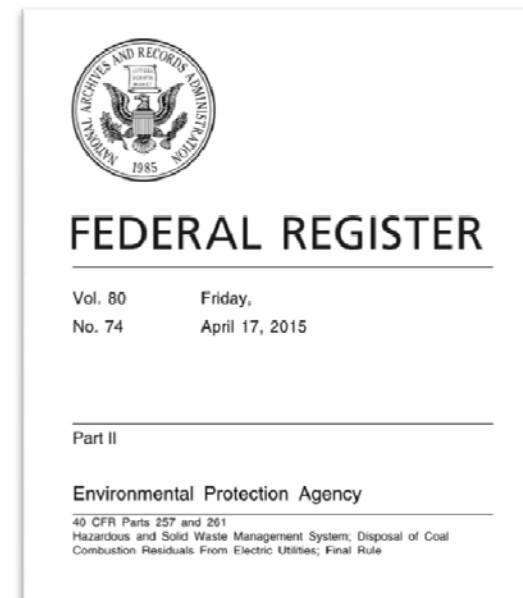
Presentation Outline

- ▶ Background and Need - GAI
- ▶ Dewatering Methods & Pilot Tests - Moretrench
- ▶ Design Considerations – GAI
- ▶ Conclusion and Questions – GAI and Moretrench

Background

CCR Impoundment Enclosure

- ▶ CCR Rule Published in 2015 set new federal design and reporting requirements for CCR Landfills and Impoundments.
- ▶ Requires existing unlined impoundments to retrofit or close:
 - If location restrictions are not met.
 - *Location Restriction Demonstrations (Due in October 2018 for active impoundments).*
 - If factor of safety requirements are not met.
 - Were due in 2016 for active impoundments.
 - If groundwater monitoring requirements are not met.
 - *For active impoundments, Background Sampling is **BS1** Complete, in Detection Monitoring. First Annual Groundwater Monitoring and Corrective Action Report was due January 31, 2018.*
 - 5 years to close impoundments per 257.102(f)(1).
 - *Time extension allowed for certain situations including dewatering 257.102(f)(2)(i).*



Slide 4

BS1

Not sure that this makes sense? Do we need all the capital letters? Maybe "For active impoundments, background sampling is complete in detection monitoring"

Brittany Strobel, 2/15/2018

Background

CCR Impoundment Closure Options

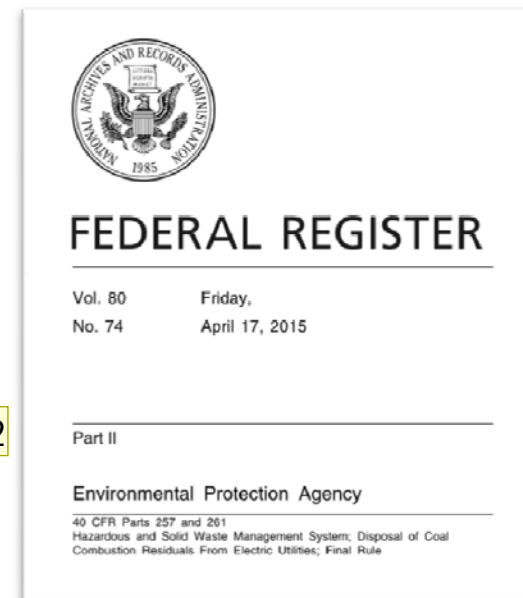
- ▶ Closure by removal of CCR
- ▶ Closure leaving CCR in-place (Cap)
 - Both methods may require dewatering
 - Dewater 'Free Liquid' and 'Pore Water'



Background

CCR Impoundment Closure

- ▶ Closure leaving CCR in-place
 - 257.102(d)(2) Drainage and Stabilization of CCR Surface Impoundments:
 - Free liquids must be eliminated by removing liquid wastes or solidifying the remaining waste.
 - Remaining wastes stabilized sufficient to support final cover system. BS2
 - 257.102(f)(3) - Certification requirement that closure was completed in accordance with:
 - Closure Plan
 - Requirements of Section 257.102



Slide 6

BS2

Maybe "Remaining wastes must be sufficiently stabilized to support the final cover system."

Brittany Strobel, 2/15/2018

Background

Pond Dewatering

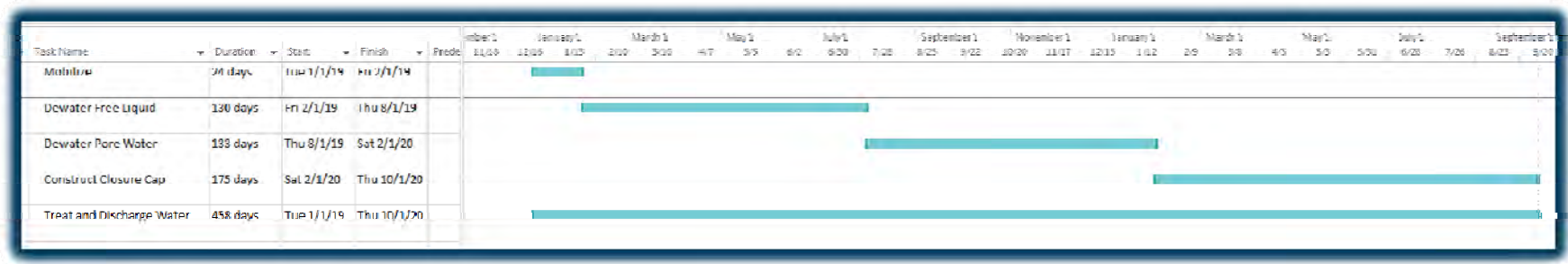
- ▶ Rim Ditches, Shallow Well Points, Deep Wells
- ▶ Dewatering Variables
 - Pond water levels, groundwater levels, topography, pond thickness
 - Recharge Rate
 - Horizontal and Vertical Permeability
- ▶ Constructability
 - Barge
 - Mats
 - Geosynthetics



Dewatering Considerations

Information Needs

- ▶ How long will it take to dewater?
 - Provide Contractor information to reduce uncertainty and impact to schedule
 - Better bids
 - CCR Rule allows for time extension
- ▶ Water treatment
- ▶ Pilot Test



Dewatering Considerations

Estimate Dewatering Time

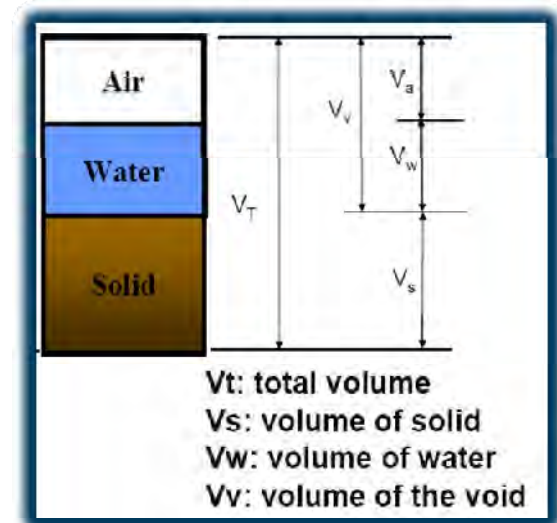
- ▶ Estimate Pore Water Volume
 - Estimate from Geotechnical Investigation Data
- ▶ Estimate Recharge
 - Hydrologic Estimates
 - Groundwater Impacts
- ▶ $(\text{Pore Water Volume} + \text{Recharge Volume}) / \text{Dewatering Rate} = \text{Time}$
- ▶ Dewatering Rate - Pilot Test



Dewatering Considerations

Estimating Dewatering Volume – Pore Water Volume

- ▶ Estimating Dewatering Volume – Pore Water Volume
- ▶ Porosity (n) = Volume Voids / Volume Total (V_v/V_t)
- ▶ Degree of Saturation (S) = Volume Water / Volume Voids (V_w/V_v)
- ▶ $n (S_i - S_f) V_t = \Delta V_w$
- ▶ $\frac{V_v}{V_t} \left(\frac{V_{w_i}}{V_v} - \frac{V_{w_f}}{V_v} \right) V_t = \Delta V_w$



Dewatering Considerations

Example

▶ Estimating Dewatering Volume – Pore Water Volume

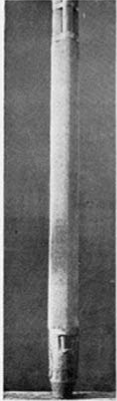
| In-Situ Ash Water | | | | |
|-------------------|---------------------------------------|-------------------------------------|---|--|
| Porosity n | Initial Degree of Saturation S_i | Final Degree of Saturation S_f | Estimated Ash Volume (acre-ft) V_t | In-Situ Volume to be Dewatered (million gallons) ΔV_w |
| 0.6 | 1 | 0.50 | 500 | 49 |
| 0.6 | 1 | 0.70 | 500 | 29 |

Dewatering Considerations

Estimate Dewatering Volume – Recharge Volume

- ▶ Hydrologic Impacts – Water Budget Example
 - 50 Acres = ~ 50 Million Gallons Total Per Year
 - Watershed Area
 - Diversions
 - Evaporation
 - Contact Water
 - Polymer Treatment





MORETRENCH WELLPOINT.

THE A. J. PENOTE COMPANY

ENGINEERING, CONCRETE AND GRAD DRAINAGE
WATER, GAS AND STEAM HEATING
ELECTRICAL CONNECTIONS
3020 25th STREET AVE.
CLEVELAND, O.

February 17th, 1930.

Mr. Charles F. Drake,
President,
Hague - Town Justice Company,
Hudson, New Jersey

Dear Mr. Drake:

I cannot refrain from telling you of the wonderful success we had with your well points at Thebarton, Indiana during the past year.

We started this job with well points generally used in this locality, which are heavy. It was very slow and it was necessary to remove the casing and put in new fittings, which was very costly.

We found that use of your well points was equal to five of the ordinary well points and besides it was much easier to get your points down.

I would recommend your points to any Contractor who was work of this nature.

With best wishes, I am

Very truly yours,

The A. J. PENOTE COMPANY.

A. J. Penote

The ordinary wellpoint (as shown on the right) was designed for the purpose of supplying water to houses. It has a pointed end and from this the name "wellpoint" was given to it. By pumping a

large number of ordinary wellpoints, it was found that ground water level could be lowered on sand excavation.

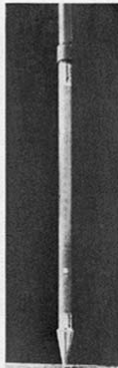
The view at lower right shows a section cut from an ordinary wellpoint, 1 1/4" in diameter by 30" long. The water enters through the small holes. The area of all the holes in a point of this size amounts to less than ten square inches.

The MORETRENCH Wellpoint (shown on the left) draws water through 270 square inches. While a MORETRENCH Wellpoint, with necessary fittings, may cost twice as much as an ordinary wellpoint with similar fittings, it will be found that the cost of the useful filter area of an ordinary wellpoint is at least \$1.25 per square inch, as compared with a cost of less than 9 cents per square inch on the MORETRENCH Wellpoint.

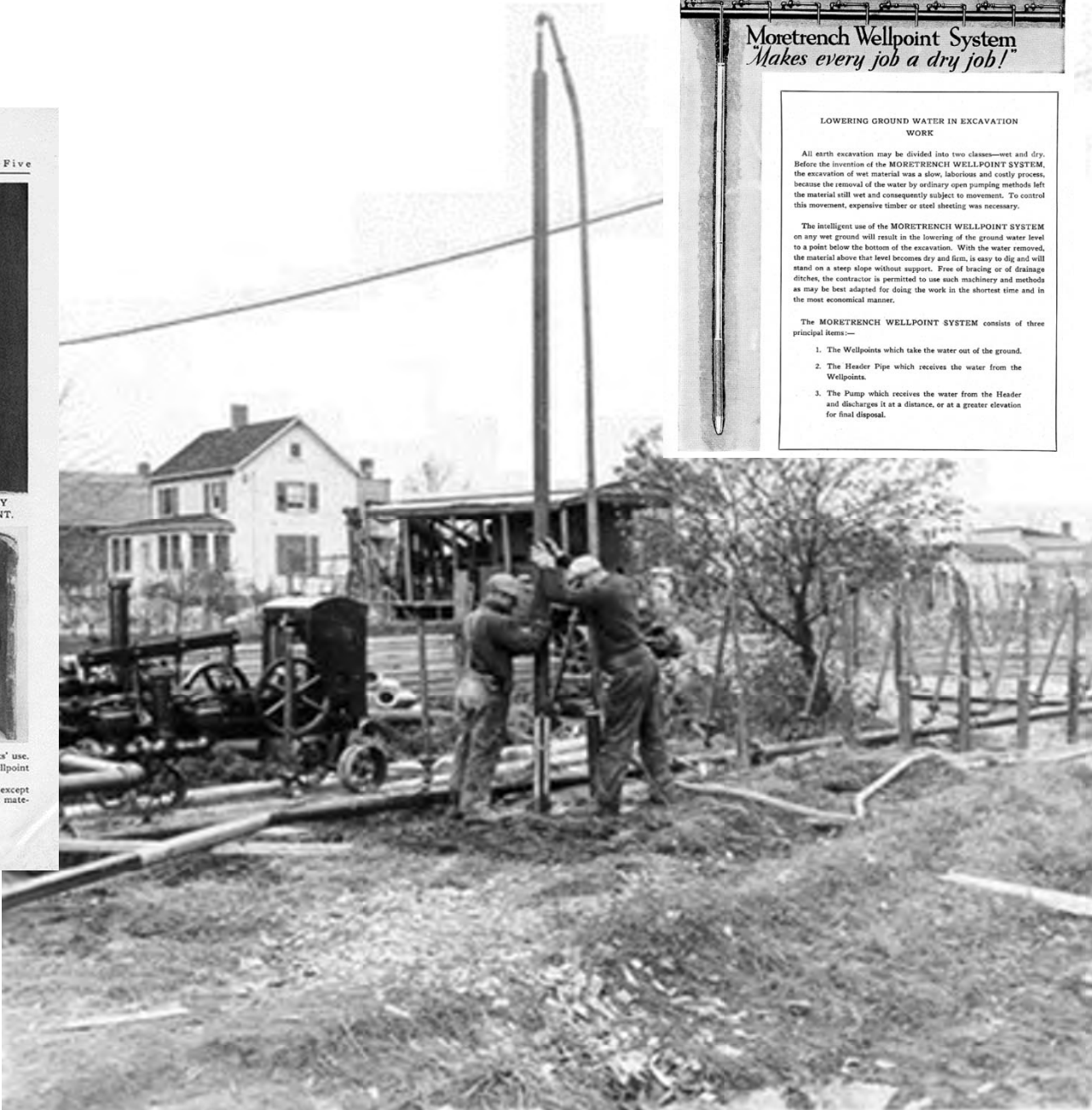
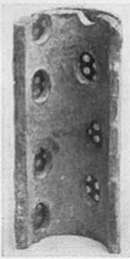
The MORETRENCH Wellpoint is used successfully in any kind of soil and Mr. Penote (in the testimonial above) says that one MORETRENCH Wellpoint is equal to five ordinary wellpoints. He also says it is easier to get the MORETRENCH Wellpoint down, because it is self-jetting. It would be well for contractors to remember that when using a MORETRENCH WELLPOINT SYSTEM they save the expense of putting down four or more ordinary wellpoints every time a MORETRENCH Wellpoint is installed. As the work progresses, the difference in cost is wiped out by the saving in installation in the first few weeks' use.

The MORETRENCH Wellpoint can be easily repaired and will last for years. The ordinary wellpoint cannot be repaired and its useful life is short.

Our information and experiments seem to prove that an ordinary wellpoint will not draw water except from clean sand. The MORETRENCH Wellpoint, if properly installed, will draw water in any wet material. Its use always insures a dry job.



ORDINARY WELLPOINT.



Moretrench Wellpoint System
Makes every job a dry job!

LOWERING GROUND WATER IN EXCAVATION WORK

All earth excavation may be divided into two classes—wet and dry. Before the invention of the MORETRENCH WELLPOINT SYSTEM, the excavation of wet material was a slow, laborious and costly process, because the removal of the water by ordinary open pumping methods left the material still wet and consequently subject to movement. To control this movement, expensive timber or steel sheeting was necessary.

The intelligent use of the MORETRENCH WELLPOINT SYSTEM on any wet ground will result in the lowering of the ground water level to a point below the bottom of the excavation. With the water removed, the material above that level becomes dry and firm, is easy to dig and will stand on a steep slope without support. Free of bracing or of drainage ditches, the contractor is permitted to use such machinery and methods as may be best adapted for doing the work in the shortest time and in the most economical manner.

The MORETRENCH WELLPOINT SYSTEM consists of three principal items—

1. The Wellpoints which take the water out of the ground.
2. The Header Pipe which receives the water from the Wellpoints.
3. The Pump which receives the water from the Header and discharges it at a distance, or at a greater elevation for final disposal.

MORETRENCH

No one has seen more.™

Wellpoints





Deep Wells





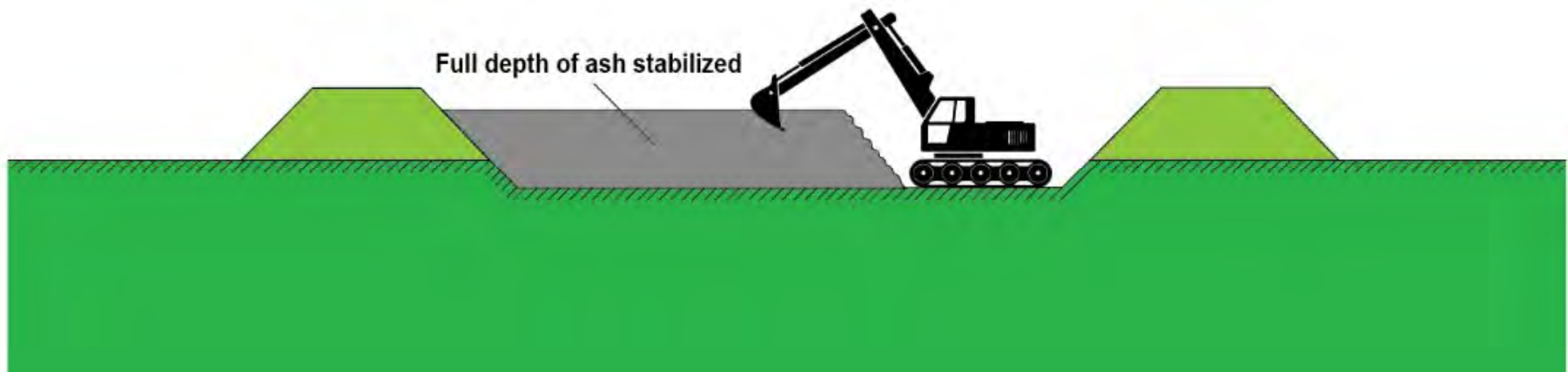
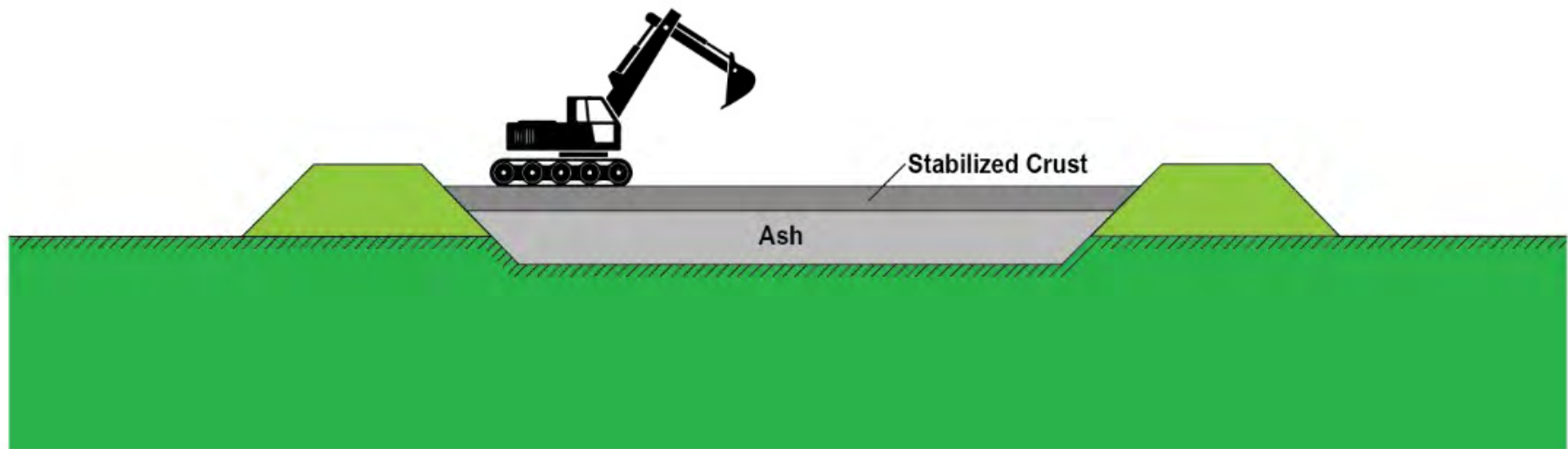
Why Dewater?

- Improved safety
- Improved schedule
- Reduced contractor risk
(better pricing)





How much do you need to dewater?



Crust Thickness



MORETRENCH

No one has seen more.™

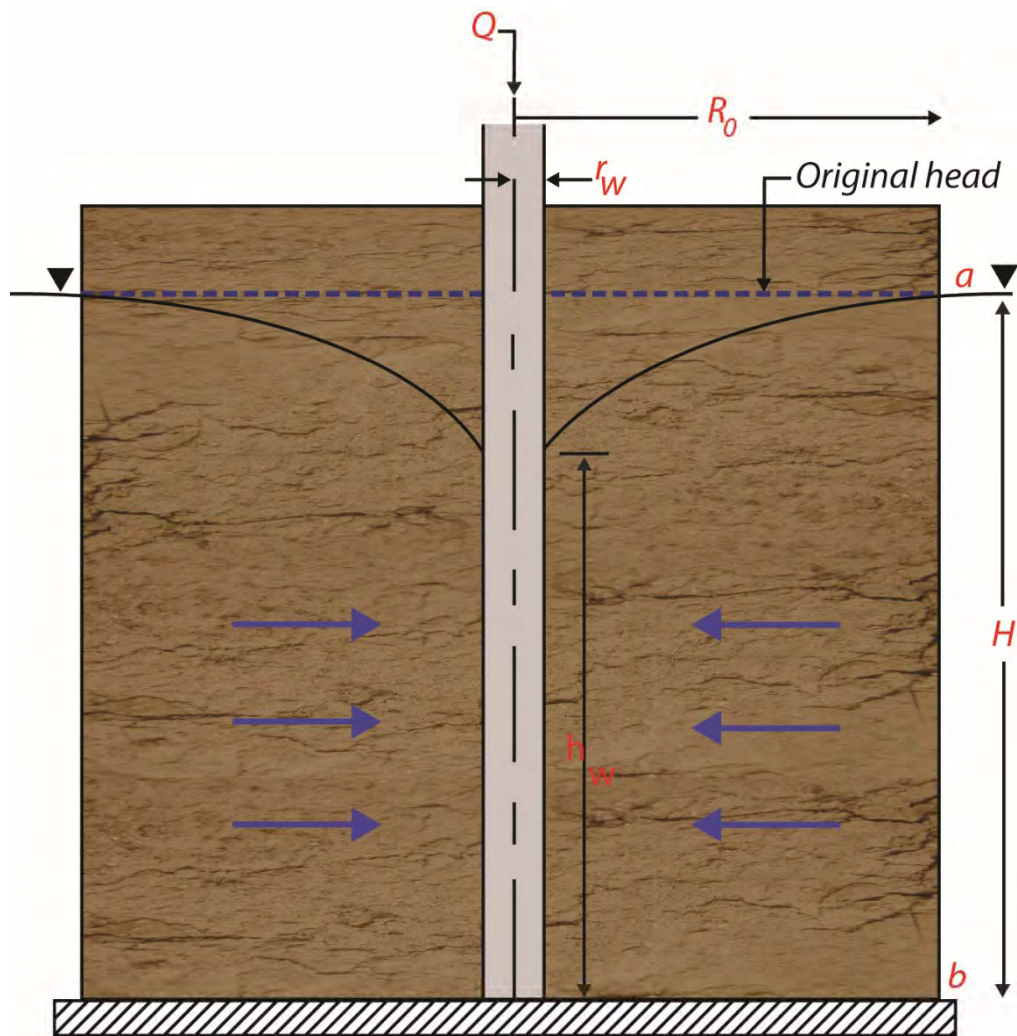
Crust Thickness



MORETRENCH

No one has seen more.™

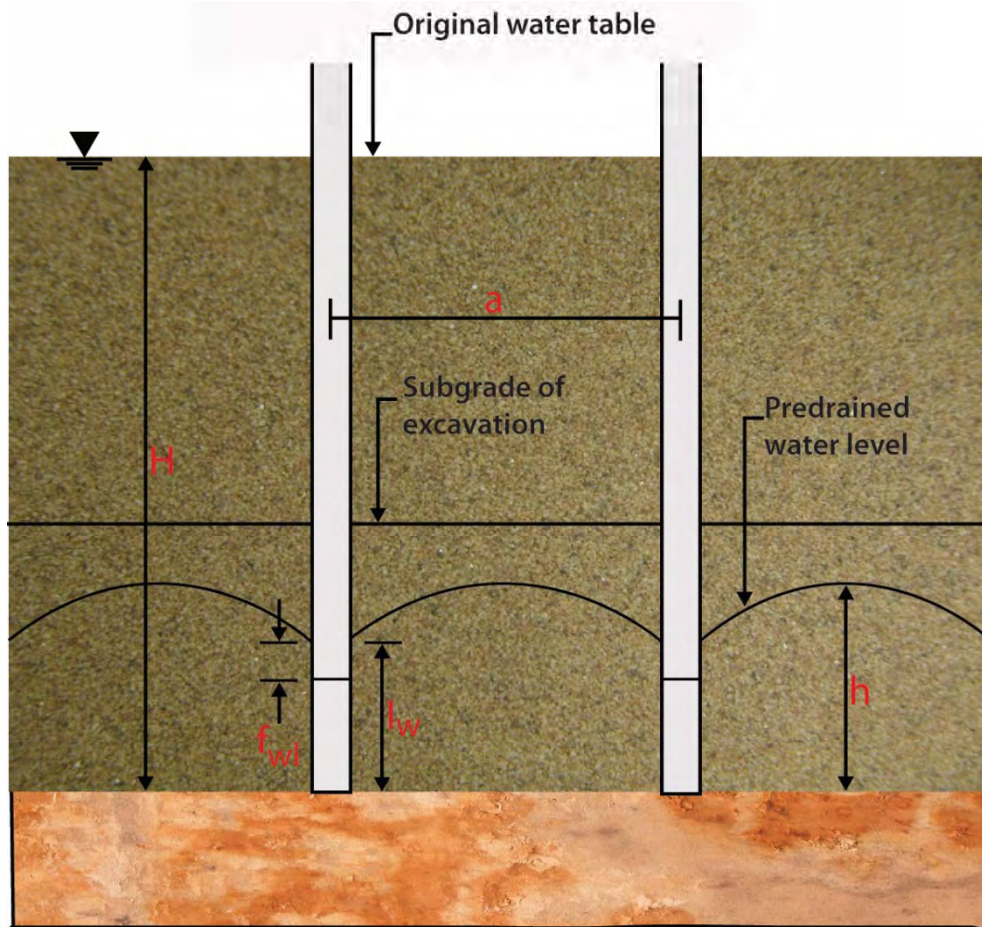
Radial Flow to Well in an Unconfined Aquifer



$$Q = \frac{\pi K (H^2 - h_w^2)}{\ln\left(\frac{R_0}{r}\right)}$$

- Q is flow rate in gpd
- K is hydraulic conductivity in gpd/ft²
- H is the initial piezometric level in ft
- h_w is the lowered head in the aquifer in ft
- R_0 is the radius of influence in ft

Well Capacity, Q_w



- Sichart's empirical relationship is useful for calculating theoretical Q_w :

$$Q_w = 0.035 l_w r_w \sqrt{K}$$

- where Q_w is in gpm
 l_w is in feet
 r_w is in inches
 K is in gpd/ft²

Pump Test Logistics

- Discharge point
- Power source
- Instrumentation
- Site presence during test?

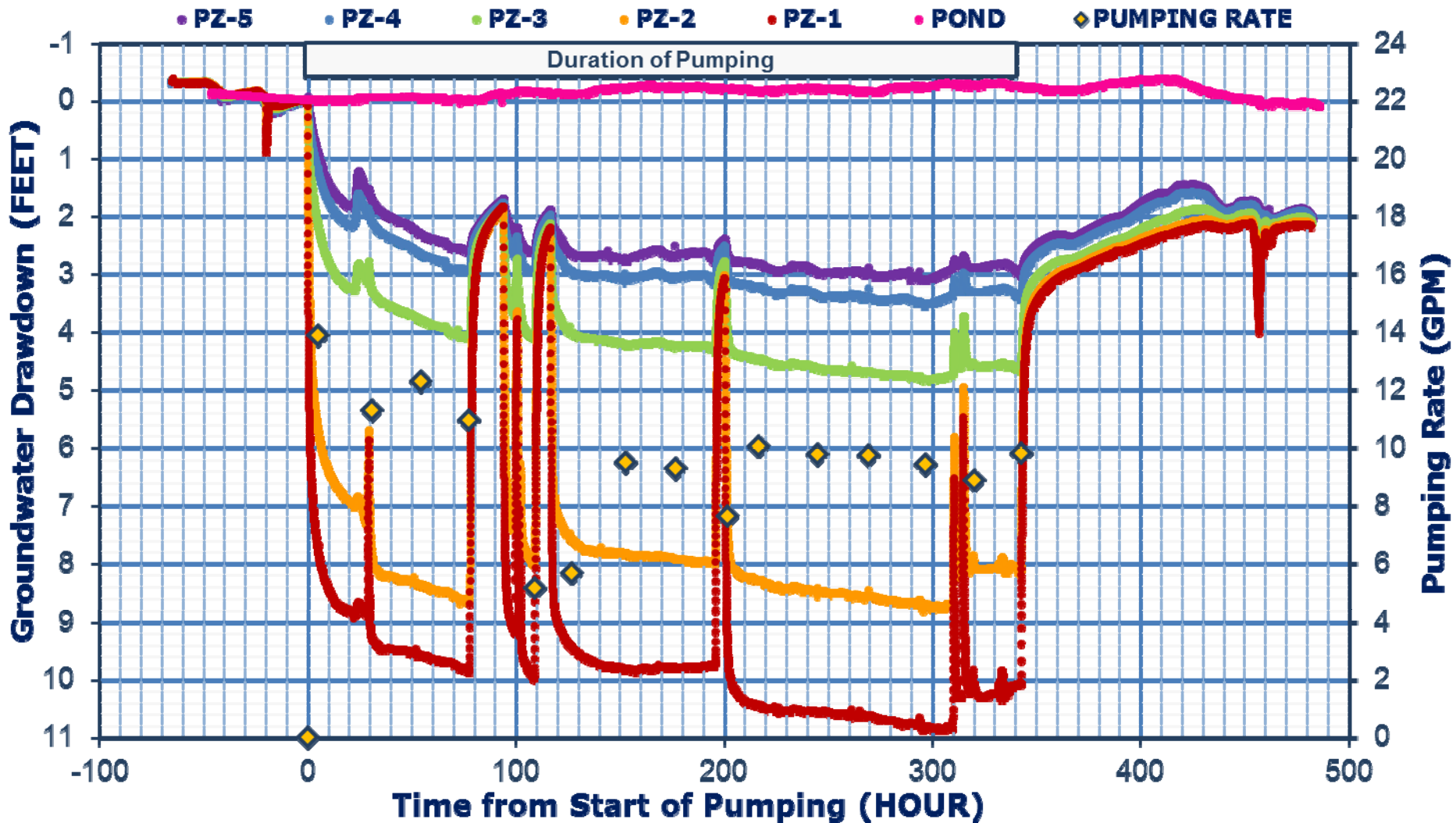
Wellpoint Layout



Wellpoint Layout

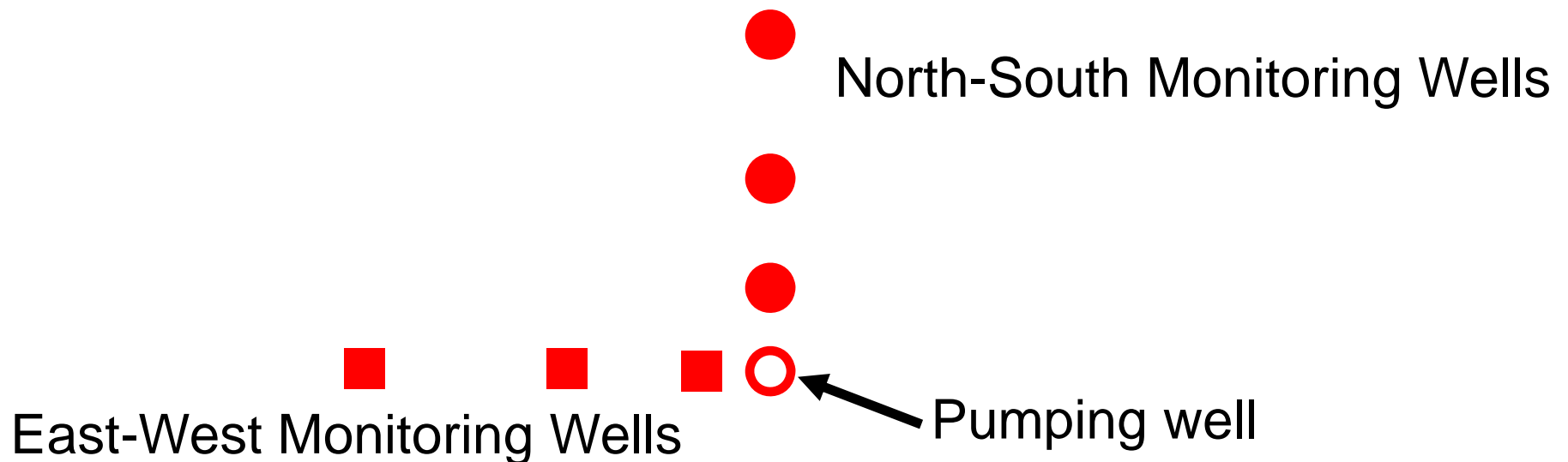


Wellpoint Pilot Results

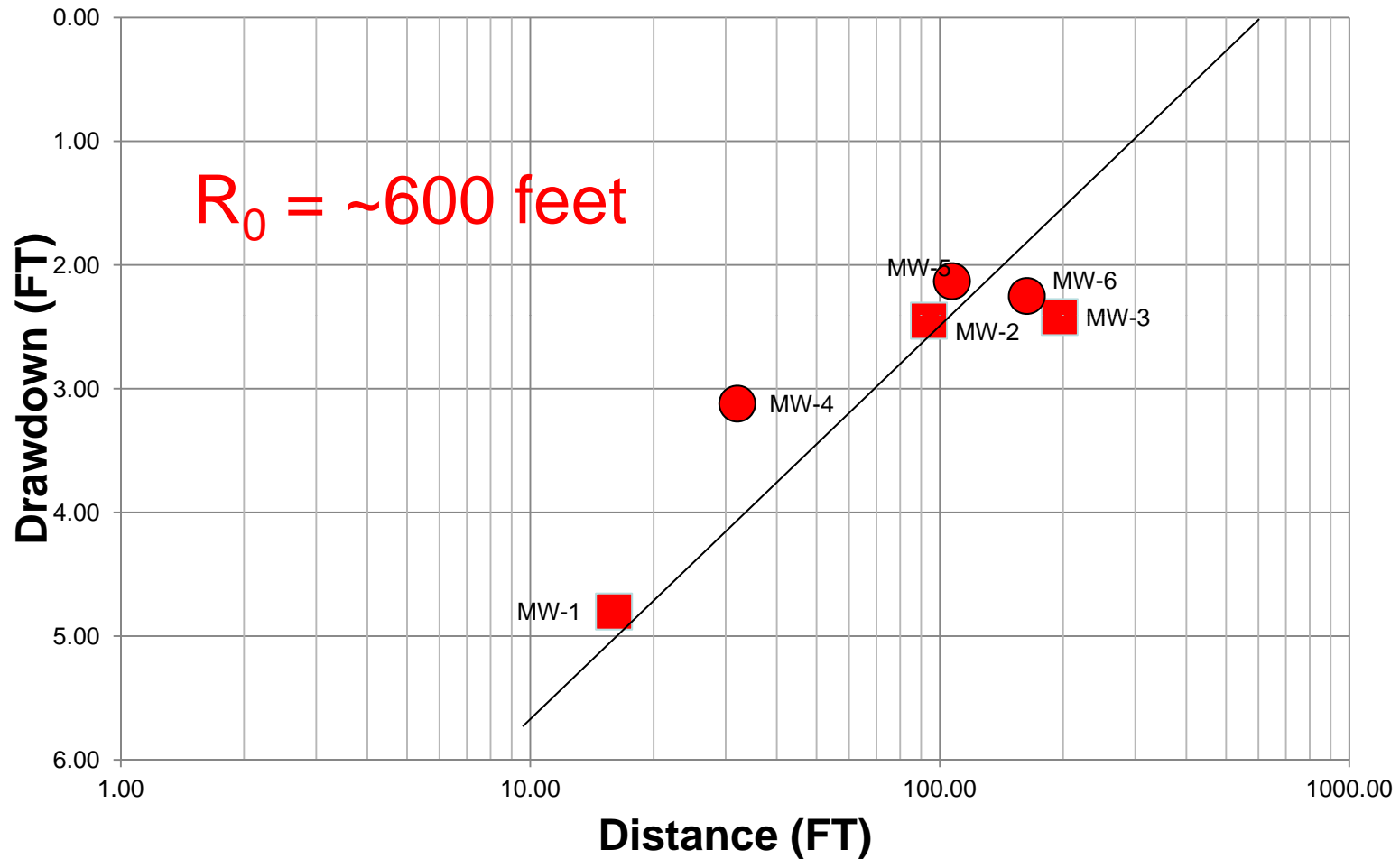


Pump Test Layout

Q = ~40 gpm
(could have been 80 gpm!)



Deep Well Pump Test



■ Monitoring Wells North & South of DW-1.2

● Monitoring Wells East & West of DW-1.2

Consider Dewatering During Design Steps

- ▶ Field Investigations
 - Gather information for dewatering design
- ▶ Grading
 - Consider diversions
- ▶ Engineering Analyses
 - Stability Analysis based on dewatering assumptions
- ▶ Permitting
 - Meet state and CCR Rule requirements
- ▶ Constructability and Safety
 - Schedule and Access for Dewatering and Cap Construction

Safety Considerations

- ▶ Access on Impoundment
 - Geotechnical Investigations
 - Dewatering System Installation
 - Cap Construction
- ▶ Consider Geosynthetic Reinforcements

ZERO
ACCIDENTS

ZERO
COMPROMISES

NO EXCUSES

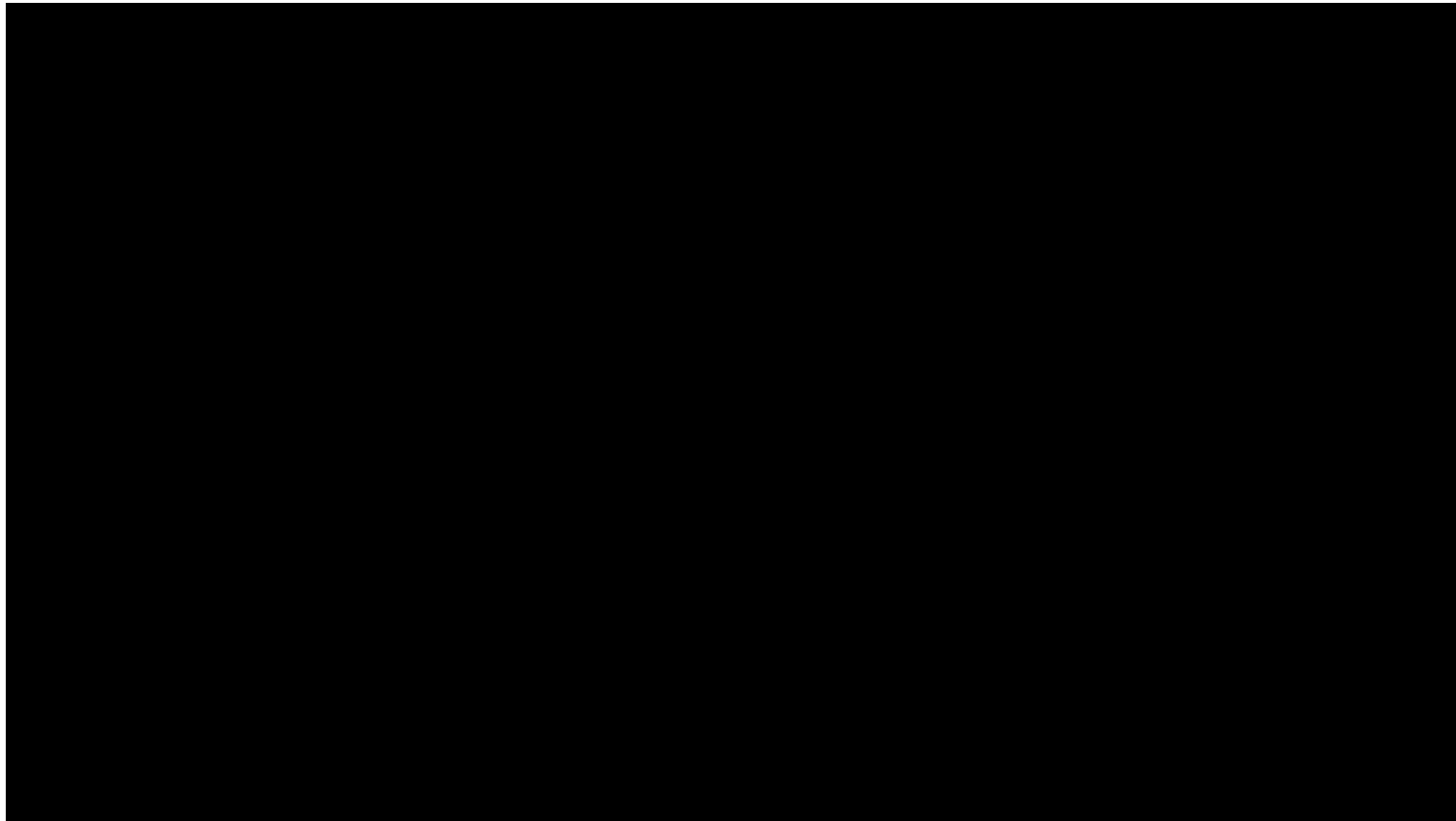
Geosynthetic Reinforcements

- ▶ High Strength Woven Geosynthetics
- ▶ Geogrids



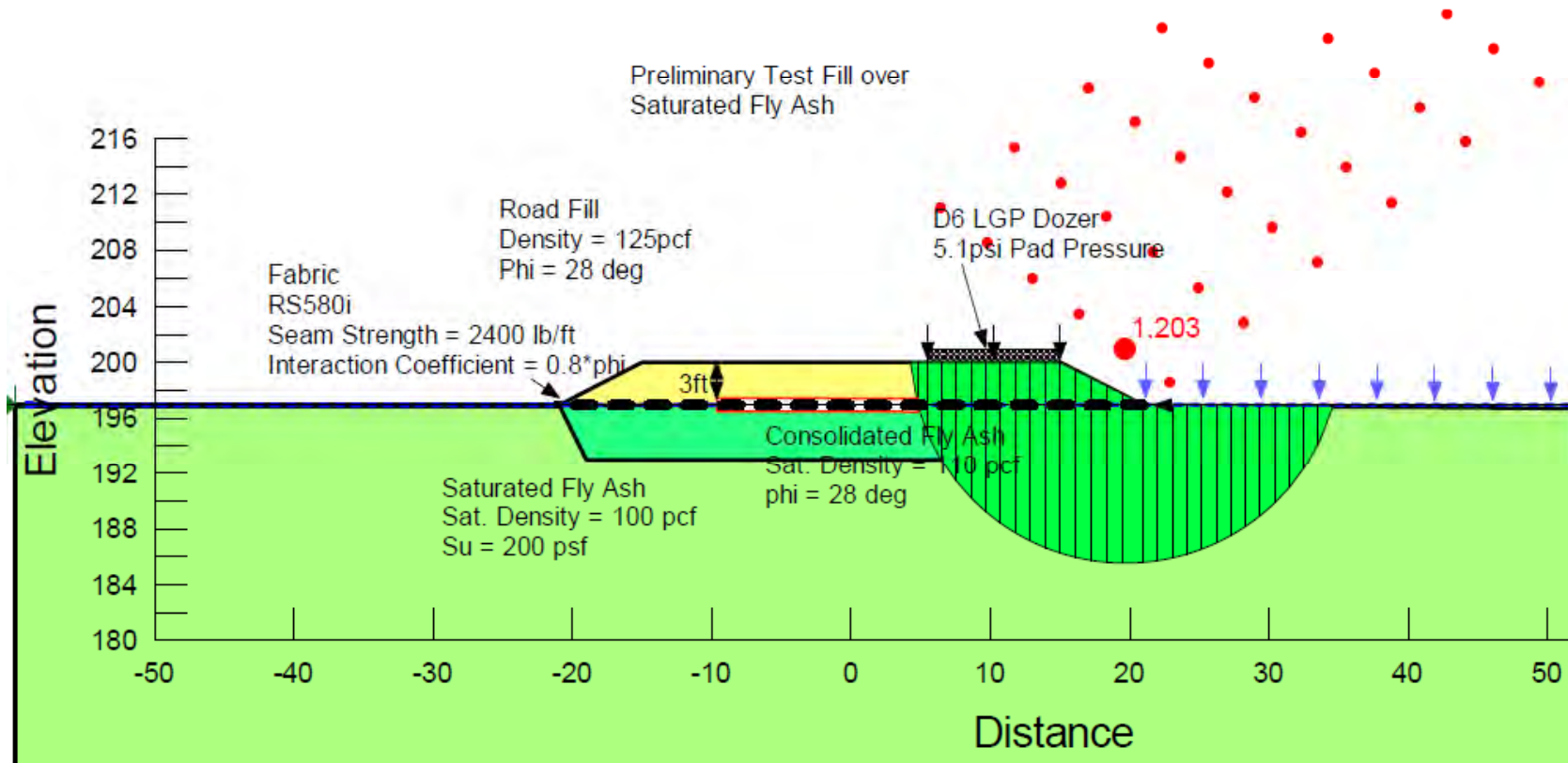
Presented with permission by Tencate Geosynthetics Americas

Geosynthetic Reinforcements for Access



Presented with permission by Tencate Geosynthetics Americas

Geosynthetic Reinforcements



Presented with permission by Tencate Geosynthetics Americas

Typical Minimum Laboratory Testing Program

- ▶ Testing should include performing (at a minimum):
 - Natural water content;
 - Grain size analyses;
 - Atterberg limits;
 - Specific gravity;
 - Unit weight;
 - Consolidated-undrained (CU) triaxial testing;
 - 1-D consolidation testing; and
 - Permeability testing.
- ▶ Testing performed on selected undisturbed ash samples.

Laboratory Testing Program

- ▶ Index testing provides for sand-like and/or clay-like material characterization.
- ▶ CU triaxial testing estimates peak and steady-state undrained shear strength and peak axial strain for stability analyses.
- ▶ 1-D consolidation testing estimates parameters for settlement and loading rate analyses.
- ▶ CU and 1-D consolidation testing provides data to assess diagenesis (cementing) properties.
- ▶ Permeability testing estimates hydraulic conductivity and correlates CPT PPD-derived permeability.

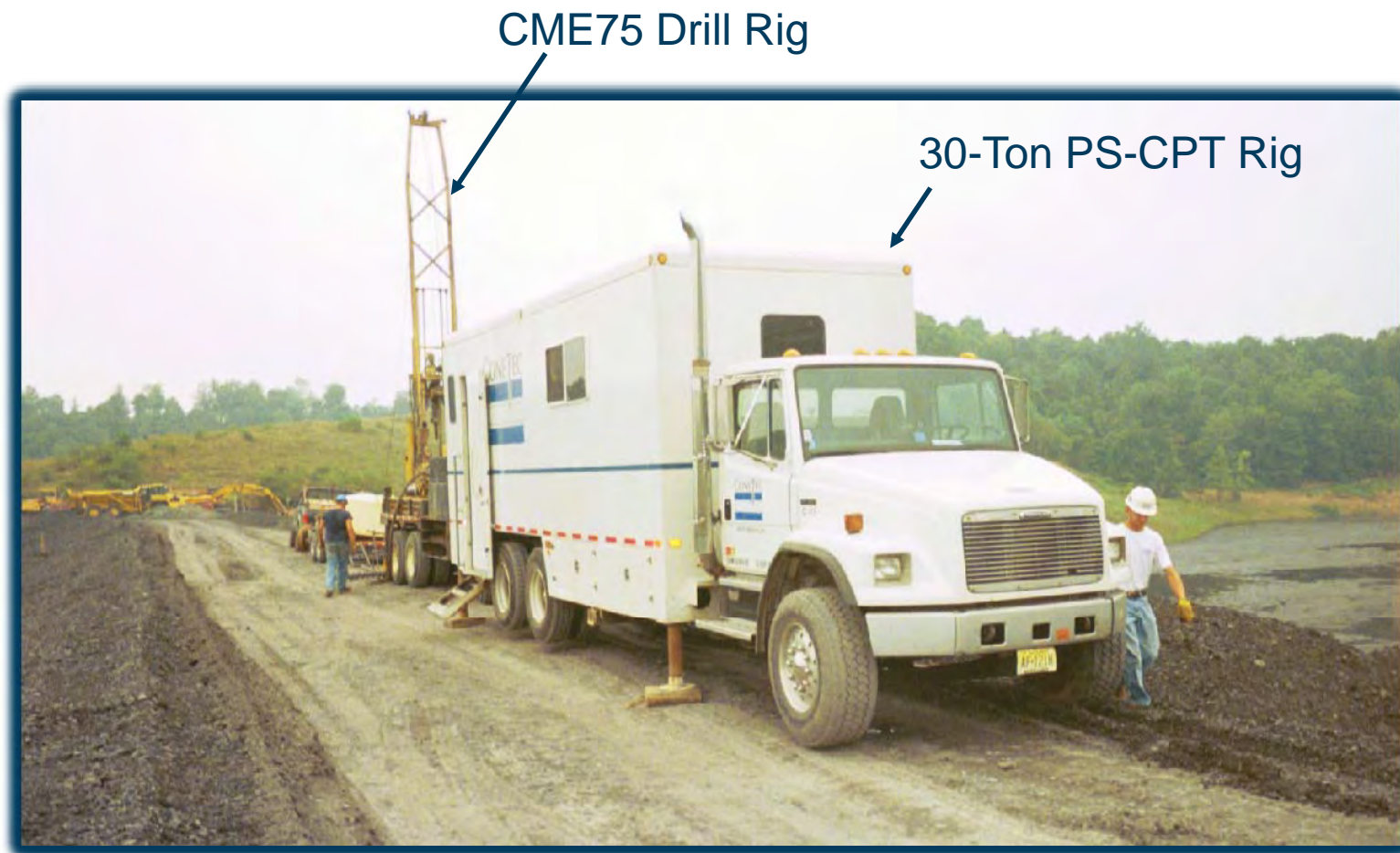
CCR Field Testing Methods

- ▶ Field Testing method:
 1. Piezo-Seismic Cone Penetration Testing (PS-CPT)
- ▶ Ideal in hydraulically-placed materials.
- ▶ Performed in-situ, and measures tip stress, sleeve stress (friction), and pore pressure.
- ▶ Should also include performing:
 - Shear wave velocity testing to correlate dynamic properties; and
 - Pore pressure dissipation tests to estimate permeability.

CCR Field Testing Methods

- ▶ Field Testing method:
 - 2. Mud rotary drilling
- ▶ Perform SPT and undisturbed sampling to collect samples and evaluate material interfaces due to:
 - Varying deposition environments, outlet locations;
 - Above/below water deposition; and
 - Variations in fly ash, bottom ash, calcilox additions.
- ▶ Obtain high quality, undisturbed samples of ash for laboratory testing.

CCR Field Testing Methods



CCR Field Testing Methods

- ▶ Use CPTu dissipation test to calculate horizontal permeability for dewatering estimate and well point placement.

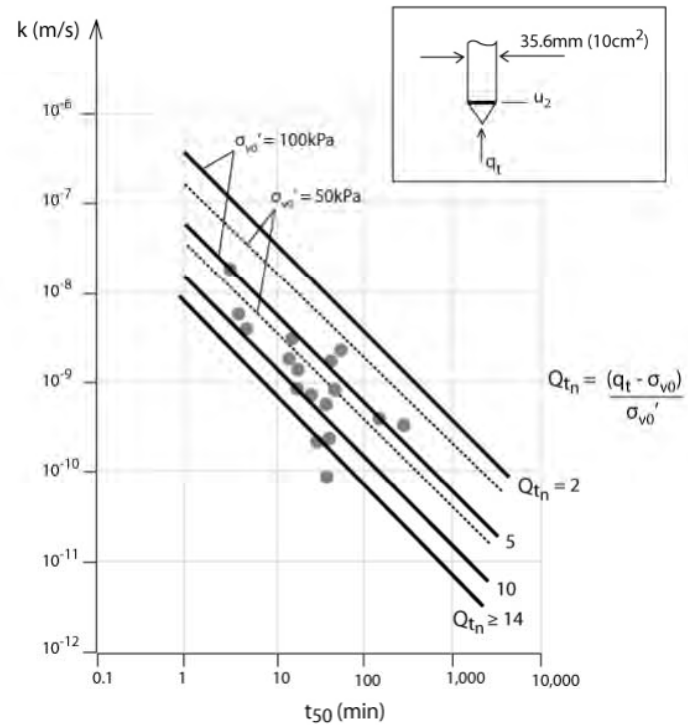


Figure 3. Proposed relationship between CPTu t_{50} (in minutes) and soil permeability (k) and normalized cone resistance, Q_m .

Robertson, 2010, *Estimating in-situ soil permeability from CPT & CPTu*

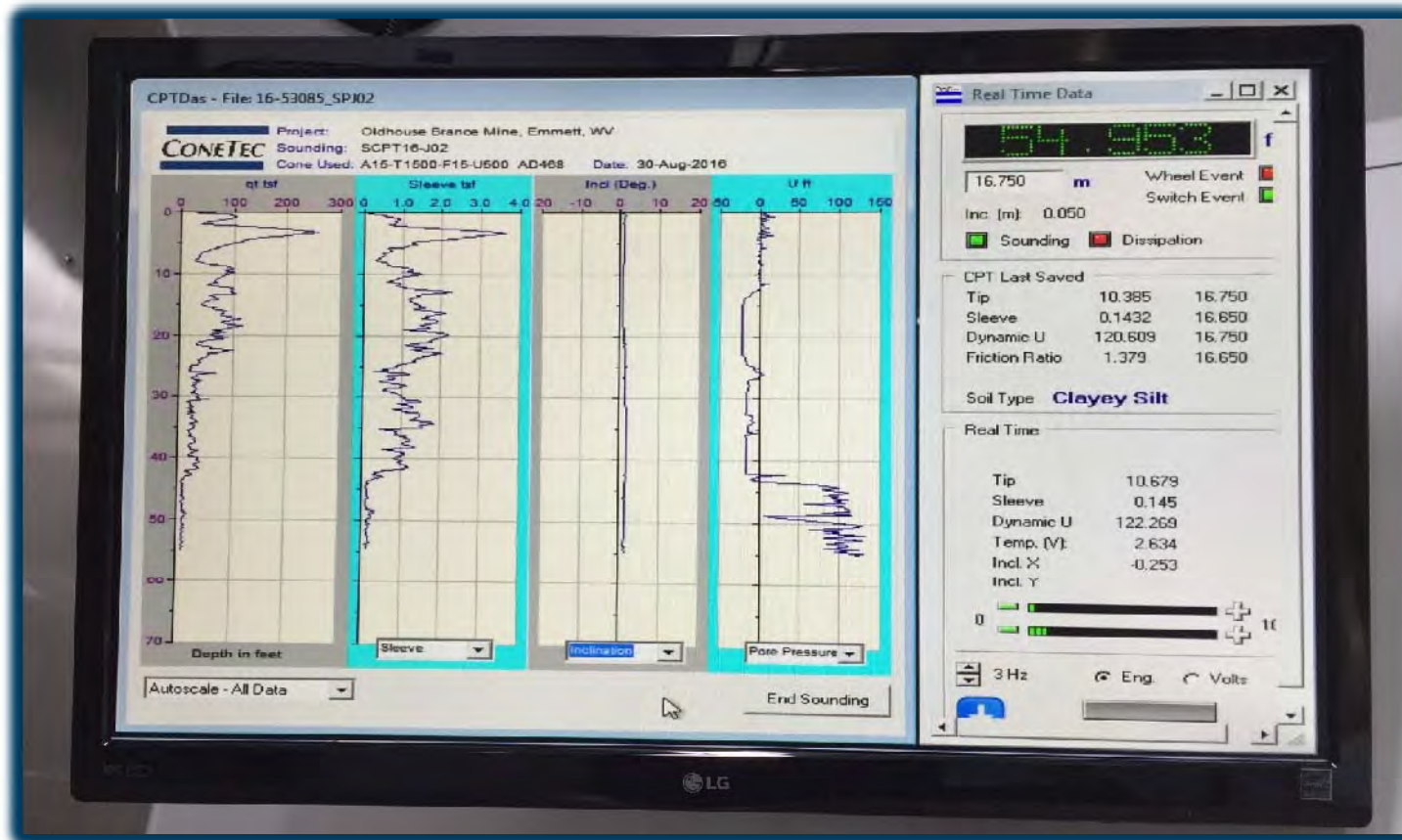
CCR Field Testing Methods

PS-CPT

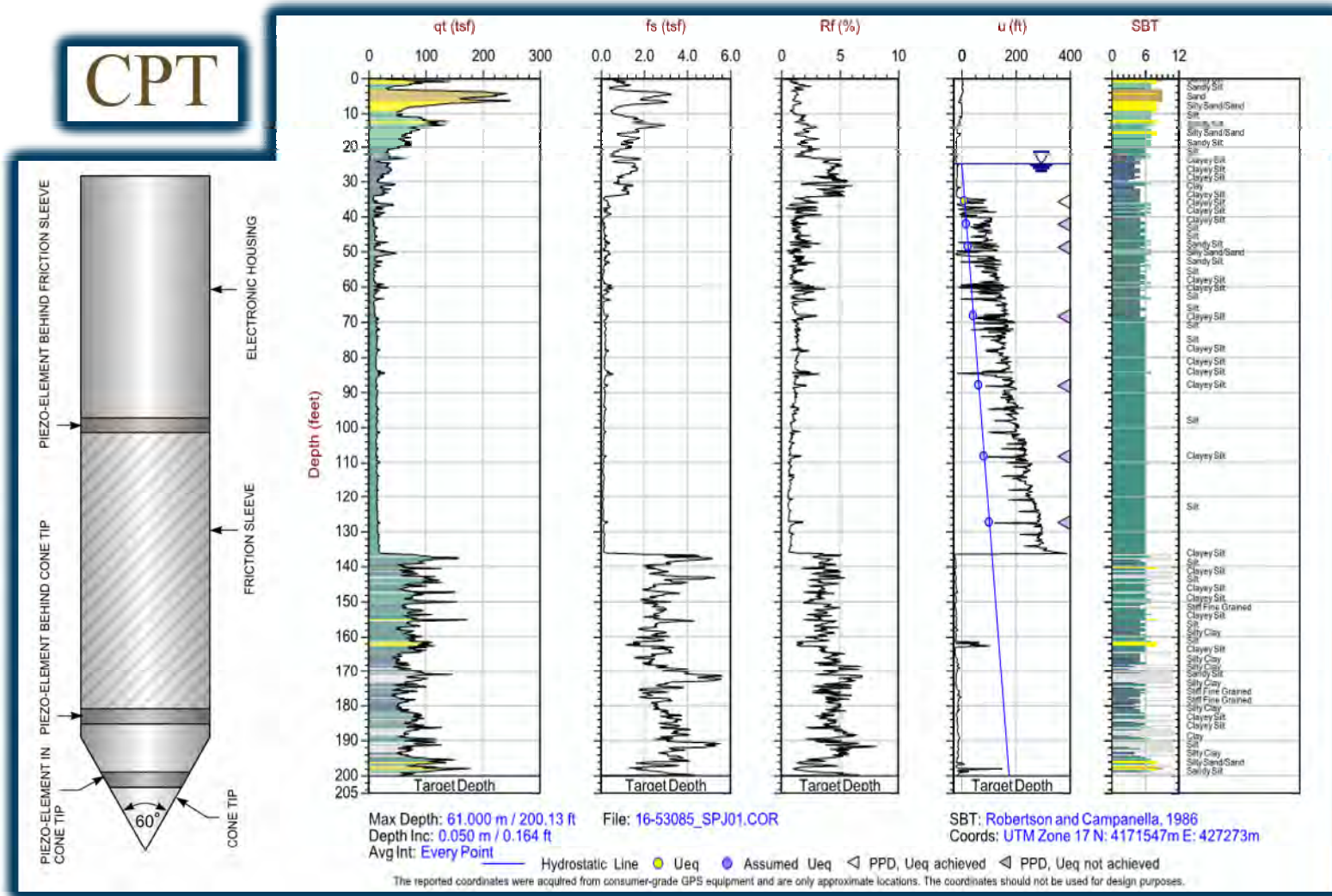


CCR Field Testing Methods

PS-CPT



PS-CPT Field Testing Data



Questions



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