Evaluation of Cone Penetrometer Testing (CPT) for Use with Transportation Projects Phase I

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for the
Ohio Department of Transportation
Office of Research and Development

State Job Number 134371

July 1, 2008

THE OHIO STATE UNIVERSITY

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RESEARCH & DEVELOPMENT

Evaluation of Cone Penetrometer Testing (CPT) for Use with Transportation Projects

Phase I – Feasibility Study

FINAL REPORT

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July 1, 2008

Sponsoring Agency:
Office of Research
Ohio Department of Transportation

Prepared in cooperation with the Ohio Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration

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Acknowledgments

Jason D. Ross worked on this project as a graduate research assistant at Ohio State University. His contributions to the work completed and this report are greatly appreciated. The author also thanks the project liaisons, Kirk Beach and Gene Geiger, and the staff of the ODOT Office of Research, Monique Evans, Vicky Fout and Jill Martindale, for their professional and courteous assistance with this project.

TABLE OF CONTENTS

1. INTRODUCTION

The ODOT Office of Geotechnical Engineering (OGE) currently uses conventional drilling methods (e.g., hollow stem auger, solid stem auger) to perform subsurface investigations in unconsolidated materials. These techniques have been used for decades and have the advantage of a long track record of experience and success within the state. These methods are, however, time-consuming and expensive to perform, do not provide continuous data, and are not well suited to some types of geologic and environmental conditions. Over the last 20 years, cone penetration testing (CPT) has been gaining acceptance in the U.S. and is now widely used as an alternative or complementary procedure to perform subsurface investigations. ODOT has funded this **Phase I** project to investigate how this new technology might be utilized to improve the quality and efficiency of ODOT's subsurface investigation program. This report presents the findings of this investigation and recommendations concerning **Phase II** implementation.

The adoption of CPT for ODOT's subsurface investigation programs will save money through faster collection of data, collection of better and more consistent data, and collection of data that can be used directly in design work. An important upcoming need for ODOT is the mandate to move to LRFD design methods. CPT data can be used more directly with these methods, which will result in improve designs and savings on construction costs. The routine availability of a CPT rig will complement the existing conventional drilling equipment that ODOT now uses for subsurface investigation. For some projects, CPT will be used to replace conventional equipment. For others, CPT will be used in addition to conventional equipment to provide more accurate and different types of information and soil properties. For still others, the CPT may not be used at all. It is envisioned that the CPT rig will be used for major projects that require more detailed and extensive information about the subsurface. It will also be used to save money on a variety of projects.

The successful completion of this project will provide the following benefits:

- Provide high quality and complete CPT equipment that can be routinely used by ODOT for subsurface investigations,

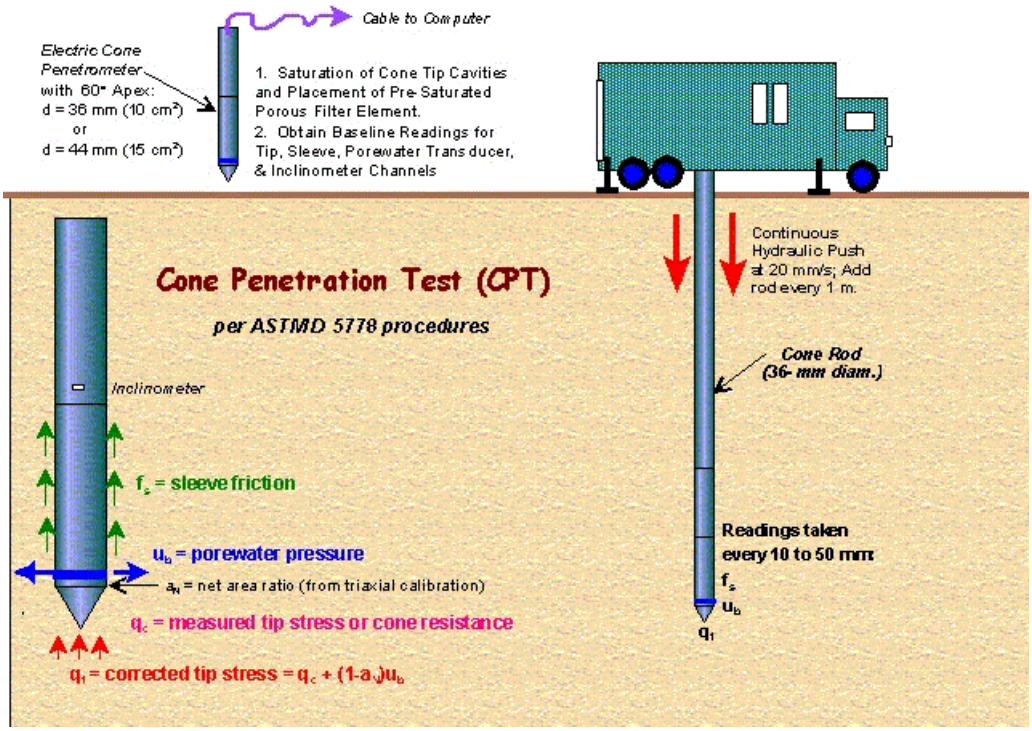
- Provide training on use of this equipment for ODOT personnel and interpretation of CPT data for Ohio soils and pavements,
- Produce faster and improved measurements of soil profiles and properties, including correlations with conventional SPT N values,
- Provide a method for rapid evaluation of possible subsurface contamination conditions,
- Provide the means to measure new soil properties (e.g., shear wave velocity, hydrocarbon screening) that cannot be currently measured using conventional drilling equipment,
- Provide ability to assess subgrade conditions for poorly-performing pavements,
- Increase the efficiency and reduce the time required for subsurface investigations,
- Provide the impetus to upgrade ODOT design methods to include CPT information, and to familiarize ODOT personnel with the advantages and limitations of CPT,
- Provide better access to some types of difficult locations and better testing of difficult soils,
- Expand capabilities and services to the Districts and Central Office,
- Save ODOT money as a result of faster investigations, better data, and more direct use of data in design (e.g., LRFD methods), including resistance factors for pile design, and
- Allow ODOT to rapidly conduct environmental safety assessments of prospective highway development sites.

2. BACKGROUND INFORMATION

The cone penetration test (CPT) test has become one of the most common and economical methods for subsurface exploration. The equipment is more complicated and more expensive than conventional drilling equipment, but the speed at which soundings can be performed and the accuracy and continuity of the data can lead to large cost savings over the long run. A cone penetrometer is pushed into the ground at a constant velocity and data is recorded at regular intervals (typically 10 or 50 mm) during penetration. The results provide excellent stratigraphic detail and repeatability as long as the equipment (transducers and electronics) is maintained in proper calibration. The penetrometer is instrumented to record a number of different

measurements simultaneously, with the most common being the force at the cone tip, shear force on the friction sleeve, and pore water pressure. Geophones are commonly included to allow for the measurement of shear wave velocity (and thus shear modulus *G*) as a function of depth. Cone penetrometers have also been fitted with other sensors to measure electrical resistivity, visual images of the soil, and temperature. Different probes are now available to obtain samples of soil, groundwater, and soil gas for environmental testing. The data is read and displayed in real-time using a field computer and stored at regular depth intervals. Figure 1 shows the general concept of the CPT and Figure 2 shows a CPT probe with three pore pressure measurement locations. By far, the most common pore pressure measurement is made at the u_2 location (just behind the cone). Predrilling is used in some cases involving hard soils to reach greater depths (Wroth 1984, Lunne et al. 1994).

The CPT has numerous applications for geotechnical and geoenvironmental engineering. CPT measures the thicknesses and quantifies the physical properties of individual geologic units. CPT is well suited for mapping the elevations of stratigraphic layers, as well as for identification of thin zones of weak or soft soil. CPT soundings aligned along a highway profile, for example, can provide detailed cross-sectional information, including lateral variations in composition and elevation changes of layers. CPT is useful for environmental studies by measuring pore pressure, measuring in-situ hydraulic conductivity, and sampling ground water and soil gas. For environmental site investigations, volatile-organic-compound (VOC) sensors in the cone can identify the composition of contaminant plumes and map their distribution and extent (Costanza and Davis 2000). Subsurface video images can be obtained with a cone-mounted camera that can provide grain size information by viewing the soil through a sapphire "window" (Hyrciw et al. 2002, 2003). When compared to conventional drilling techniques, the advantages of CPT are: 1) rapid measurements, 2) no drilling waste, 3) real-time data acquisition and analysis, 4) higher spatial resolution, 5) continuous profiling, 6) capability to provide environmental measurements, and 7) results that can be used directly for design (e.g., deep foundations).



Source: GA Tech

Figure 1 – General concept of cone penetration testing.

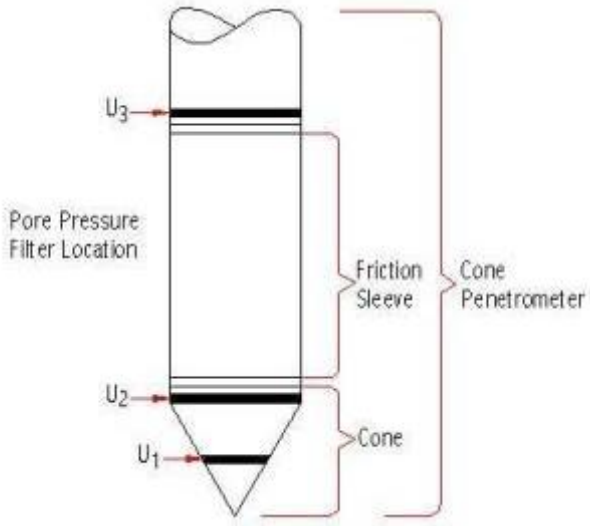


Figure 2. CPT probe with three pore pressure measurement locations.

A CPT probe consists of a 60° cone with face area of 10 cm^2 (or 15 cm^2) and a 150 cm^2 friction sleeve that is hydraulically pushed into the ground at a constant rate of 2 cm/s (ASTM D 5778). The force required to maintain this penetration rate and the shear force acting on the friction sleeve are recorded continuously with depth. Using these measurements, several parameters are obtained,

Cone Resistance: $q_c = F_c / A_c$

Side Friction: $f_s = F_s / A_s$

Friction Ratio: $R_f = f_s / q_c$

where F_c = pushing force, A_c = cone plan area, F_s = shear force on friction sleeve, and A_s = area of friction sleeve. The cone resistance and friction ratio can be used to indicate soil type using, for example, correlations provided by Robertson (1990) or as shown in Figure 3. In general, a combination of low q_c and high friction ratio suggest a clay or clayey soil. In sand, q_c tends to be high and friction ratio tends to be low. All other soils fall somewhere in between.

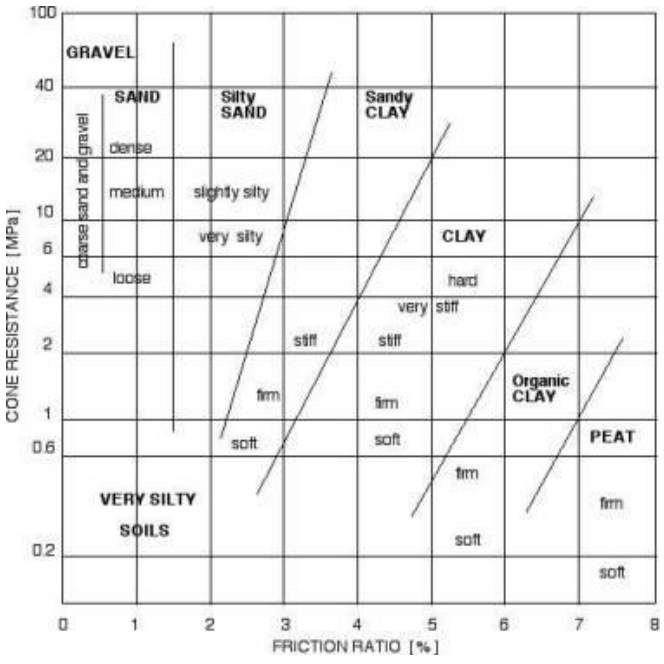


Figure 3. Chart for soil classification using CPT results (Lunne et al. 1997).

Other useful correlations have also been developed for:

- Undrained shear strength s_u (e.g., $q_c = N_k\, s_u + \sigma_v$), where N_k is the cone factor. The cone factor is approximately 10 to 12, but can range as high as 25 (Salgado 2007). Higher N_k values are often associated with higher sand contents or high OCR values.

- Compressibility and rate of consolidation have both been correlated with q_c, however compressibility cannot be accurately determined. The coefficient of consolidation has been estimated from pore pressure dissipation tests and can be predicted using cavity expansion theory (Carter et al. 1979). Lunne et al. (1997) present correlation charts for horizontal coefficient of consolidation as obtained from pore pressure dissipation (t_{50}).

- Relative density D_r of sands has been correlated with horizontal effective stress σ_h' and critical state friction angle ϕ_c (Salgado and Prezzi 2006). The accuracy of these equations is approximately 30% (Salgado 2007).

- Equivalent SPT N-values have also been correlated with q_c. The most widely accepted correlation between CPT cone resistance and SPT corrected blow count (N_{60}) is shown in Fig. 4, where p_A is a reference stress (= 100 kPa). The ratio $q_c / p_A N_{60}$ is larger for sands than clays because clays have an additional component of dynamic (i.e., rate dependent) shear strength for SPT that increases the value of N_{60}.

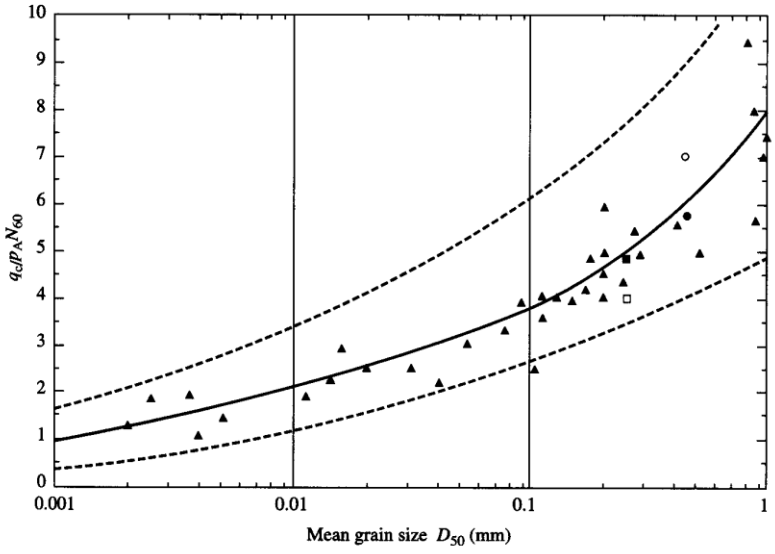


Figure 4. Correlation between CPT cone resistance and SPT blow count (Robertson et al. 1983).

3. RESEARCH OBJECTIVES

The objectives of the project are to:

1. Evaluate the expected use of CPT in Ohio's geologic setting,
2. Determine the requirements of a CPT rig for ODOT,
3. Develop specifications for purchase of a CPT rig,
4. Purchase the equipment,
5. Conduct research testing on Ohio soils and pavement subgrades, and
6. Provide training to ODOT for routine use of the rig in their subsurface investigation program.

The work will be conducted in two phases. **Phase I** will consist of a feasibility study to evaluate ODOT's needs for subsurface investigation and to determine how CPT can be used to improve and expand current exploratory methods. Detailed specifications for purchase will also be provided as part of **Phase I**. **Phase II** will consist of purchasing, research testing, and training for all CPT equipment, including quality assurance/quality control (QA/QC) procedures and methods for data transfer and analysis. A final report will be submitted to the OGE that includes a complete summary of the work performed and a training program will be conducted for ODOT personnel covering safety and operation of the equipment. An executive summary will also be submitted in accordance with ODOT requirements.

The review team consisted of Dr. Fox, OSU graduate student Jason Ross, and Kirk Beach from the ODOT OGE. Gene Geiger, also from the ODOT OGE, participated in some of the meetings with potential vendors.

4. GENERAL DESCRIPTION OF PROJECT

The objectives of **Phase I** were achieved by completing the following tasks:

a) definition of CPT requirements
b) initial vendor screening – literature and interviews
c) determination of vendor short list

d) visit to Vertek manufacturing facility
e) visit to Van den Berg manufacturing facility
f) compilation of CPT vendor matrix
g) interviews of CPT equipment owners
h) solicitation and evaluation of quotes for similar CPT equipment

5. RESULTS

The findings of the project are discussed in the following sections on a task-by-task basis.

a. Definition of CPT Requirements

The definition of CPT requirements for ODOT evolved over the course of **Phase I** as the review team learned more about CPT methods in general and more information was obtained from manufacturers regarding new CPT technology.

The review team concluded that the first ODOT CPT rig should be a crawler (i.e., track vehicle). Although a crawler is less convenient than a truck for moving around the state, a crawler allows the OGE to perform subsurface investigations for off-road conditions that would be inaccessible to a truck-based rig. In addition, the following features were considered essential for the crawler:

- Total vehicle weight of 20 to 23 tons,
- Vehicle dimensions within Ohio requirements for standard vehicle width and height (height assessed using standard ODOT Lowboy trailer),
- Minimum push depth of 100 ft.,
- Cone equipment capable of measuring tip resistance, sleeve resistance, inclination, pore pressure and shear wave velocity,
- Automatic (push button) shear wave generation,
- Standard steel tracks,

- An American-made engine, such as John Deere or Caterpillar, with USEPA Tier 3 emissions,
- Fully enclosed van body with heat, air conditioning, and vandalism protection,
- Remote control operation (belly pack) as well as permanent control console inside with engine controls and indicators,
- Video camera under van body to observe ground penetration, and
- Software for data analysis and interpretation, including real-time data monitoring.

b. Initial Vendor Screening

A thorough search was conducted to identify manufacturers that provide CPT equipment to users in the United States and satisfy the above requirements. Sources included the internet and word-of-mouth from other CPT equipment purchasers, such as the Minnesota Department of Transportation (MNDOT). Five possible suppliers of CPT equipment were identified. Two vendors have their base of operations in the U.S., one in Canada, and two in the Netherlands.

Two of the vendors were eliminated quickly. Adara Systems, located in Richmond, British Columbia, was not interested in manufacturing equipment for new customers at this time. The other vendor, Geoprobe Systems located in Salina, Kansas, specializes in lightweight (pull-behind) CPT trailers that do not have sufficient push capacity to meet ODOT requirements.

The only U.S. manufacturer that makes CPT equipment suitable for ODOT requirements is Vertek, located in Randolph, VT. After a request for information, Vertek sales associate, Carl Tracy, and Project Manager, Todd Bauder, agreed to visit Columbus to meet with the review team. The meeting was held on October 31, 2007, at the ODOT OGE with Kirk Beach, Gene Geiger, Jason Ross, and Dr. Fox in attendance. A general overview of CPT equipment was provided with an emphasis on Vertek products. Many questions were answered and the team agreed that Vertek was capable of supplying CPT equipment that would meet ODOT requirements. It was also decided that further investigation of the company and their equipment would be conducted by a site visit to the manufacturing facility in Vermont.

One of the two suppliers with manufacturing facilities in the Netherlands visited the ODOT OGE on November 5, 2007. Gerald Verbeek, owner of Verbeek Management Services in Tyler, Texas, is a U.S. vendor for CPT equipment manufactured by VMS-GeoMil in the Netherlands. Mr. Verbeek answered many of the same questions that were discussed with Vertek during this meeting. As a result, VMS-GeoMil was eliminated as a possible vendor due to concerns over lack of a strong track record in the U.S. and company capabilities with regard to customer support and equipment maintenance. The review team felt that the equipment was not superior to Vertek's and, with VMS-GeoMil located in the Netherlands, it was not in ODOT's interest to pursue this vendor.

The last company investigated during the initial screening of vendors was A.P. Van den Berg, located in Heerenveen, the Netherlands. Initial contact was made with their U.S. office in Milford, PA. Kirk Beach, Jason Ross, and Dr. Fox participated in a telephone conference with Ed Brylawski on November 15, 2007. Mr. Brylawski provided an overview of Van den Berg, which many agree is the worldwide leader in CPT technology (including some of their competitors). After completing the conference call, it was agreed that Van den Berg should be considered as a possible vendor and further investigation of their equipment would be needed.

c. Determination of Vendor Short List

The initial screening of possible CPT manufacturers produced the following short list of companies that would be further investigated:

- Vertek of Randolph, VT
- A.P. Van den Berg of Heerenveen, the Netherlands (with U.S. office in Milford, PA)

d. Visit to Vertek Manufacturing Facility

Dr. Fox, Kirk Beach, and Jason Ross visited the Vertek manufacturing facility in Randolph, VT, in December 2007 to gain a better understanding of cone penetration technology in general and to further investigate Vertek as a possible vendor of CPT equipment. The review team spent one day (Dec. 20) visiting the facility. The day started with close study of a CPT crawler that was nearly completed in the factory. The review team took pictures and made notes, recorded vehicle dimensions, and asked many questions about rig design, construction, and operation. The team also met with the Vertek project manager to discuss the equipment and the specific CPT needs of ODOT.

Next, the team inspected a variety of Vertek cones. Calibration techniques were demonstrated as well as the procedures that Vertek uses to fix or replace damaged equipment. Most importantly, the team was able to learn of the technology advancements that are taking place at the facility. This is important because the OGE prefers to deal with a company that maintains an active research and development program to keep up with current innovations in CPT technology. Such a company can provide opportunities to upgrade to better technology in the future.

Following a presentation that included an overview of the parent company, Applied Research Associates, the review team observed the same CPT crawler during field testing operations. Vertek engineers and mechanics demonstrated the driving capabilities, maneuverability, and leveling system of the rig. A full demonstration of the CPT hydraulic push and belly-pack control systems was provided. The team was able to view real-time penetration data provided by the Hogentogler software package. As a result of this demonstration, the team was able to further define the specifications for an ODOT crawler along with options that may be useful to improve efficiency or provide additional capabilities.

After the field demonstration, the team reviewed the features of the Vertek and Hogentogler software packages, both offered by the Vertek company. The Hogentogler package is a legacy from its merger with Hogentogler, Inc., a few years ago. Both software packages provide a

viable means of data collection and analysis, but only the Vertek software allows for subsurface environmental investigations using the CPT rig.

The following is a list of advantages and disadvantages for the Vertek equipment:

Advantages:

- Manufacturing facility in the U.S.
- John Deere engine with EPA Tier 3 Pollution Emissions
- Automatic hydraulic clamps for CPT rods
- System simplicity, rugged construction
- Grouting system available
- Roof hatch (i.e., bellows) not necessary for CPT operation
- Data is compatible with gINT using Data Forensics adapter
- Flexible rig construction

Disadvantages:

- Vandalism protection not typically included*
- Exposed hydraulic hoses underneath*
- Minimal security features*
- Everything runs from remote belly-pack; no permanent control console inside*
- No coring system that meets ODOT requirements
- Does not appear to be actively advancing CPT technology as much as some manufacturers
- No plans to develop wireless CPT technology
- No automatic pushing operation for CPT rods
- No automatic rod threading capability
- Depth counter wire more susceptible to damage
- Two software packages that are not integrated

(* indicates feature that can be corrected through custom order)

The trip to Vermont was very successful. The review team learned a great deal about CPT technology and the leading U.S. manufacturer of CPT equipment.

e. Visit to Van den Berg Manufacturing Facility

Dr. Fox visited the Van den Berg manufacturing facility in Heerenveen, the Netherlands, from January 14 – 15, 2008. The trip included a complete tour of the plant as well as a demonstration of Van den Berg's equipment and technology.

During the first day, Dr. Fox was given an overview presentation of the company and its equipment in the conference room. This included detailed discussions of equipment capabilities, CPT cone design, pore pressure measurements, seismic wave generator, wireless technology capabilities (fiber optic), automated push capabilities, and software. He then observed operation (no pushing) of a newly-constructed CPT crawler that the factory has just completed. This unit had "moon lander" jacks that allow the rig to lift itself approximately 5 ft. into the air to facilitate rapid loading/unloading from a trailer. Dr. Fox took pictures and made notes, recorded vehicle dimensions, and asked many questions about rig design, construction, and operation. He also discussed the specific CPT needs for ODOT. At the end of the first day, Dr. Fox had a tour of the plant, which included the construction bay, electronics labs, and rig design areas. The different types of cones were discussed as well as calibration procedures that are used when cones are returned for factory certification.

On the second day, Dr. Fox had a field demonstration of some of Van den Berg's more advanced technologies. At this site (about an hour from the factory), he observed CPT operations from a combination truck-track rig. This vehicle is a truck but also has tracks between the front and back axels to allow it to maneuver over soft ground. The tracks can be retracted for highway driving using hydraulic cylinders. This rig was equipped with the new robotic CPT system that allows for fully automatic operation of CPT pushing, including rod retrieval from a vertical rack, rod placement on the top of the previous rod, rod threading, and rod pushing into the ground. The system was very impressive. After the field demonstration, Dr. Fox returned to the factory

and continued to discuss the Van den Berg equipment, including costs and customized requirements for ODOT. He also had a conference call with Kirk Beach and Jason Ross (7:30 am EST, January 15) to summarize and discuss his findings.

The following is a list of advantages and disadvantages for the Van den Berg equipment:

Advantages:

- Leading CPT technology worldwide
- Vandalism protection included
- No exposed hoses underneath
- Van body security features standard
- Remote control + permanent control console inside
- Good coring system available – cores can be taken without moving vehicle
- Wireless technology available (no cables)
- Automatic rod threading capability available
- Automatic push technology – can be one-person operation
- Depth counter more robust
- Automatic hydraulic clamps for CPT rods
- System simplicity, rugged construction
- Integrated data analysis software for use in field and office
- Flexible rig construction
- Company has longer track record in CPT business

Disadvantages:

- Manufacturing facility and central office located in Europe
- Standard engine is Deutz (Caterpillar or John Deere engines available)*
- No grouting system
- Bellowed roof hatch required
- Data conversion to gINT uncertain
- Longer lead time (couple of months)

(* indicates feature that can be corrected through custom order)

The trip to Heerenveen was very successful. Dr. Fox learned a great deal about Van den Berg's advanced CPT technology and how this technology may benefit ODOT.

f. Compilation of CPT Vendor Matrix

As part of this investigation, a matrix was created in consultation with Kirk Beach to compare the equipment and capabilities of the two vendors being considered – Vertek and Van den Berg. The matrix is presented in Appendix A. A weighted scoring system was developed to compare different features and capabilities to give an overall total score for each manufacturer. Individual items were ranked using a score of 1, 2 or 3 and then weighted using factors ranging from 0 to 2.0 based on their relative importance. The total possible score was 171.3. The total score for Vertek was 111.7 and the total score for Van den Berg was 142.9. A higher total score indicates an overall better system. The CPT vendor matrix focuses on equipment and technology and does not consider cost.

g. Interviews of CPT Equipment Owners

As part of this **Phase I** investigation, the review team contacted both public and private owners of CPT equipment in the U.S. to obtain recommendations for both the Vertek and Van den Berg systems. Some owners had both systems and could provide a direct comparison, which was particularly useful. Each discussion is summarized below.

Herb Garcia – Minnesota Geoservices, Inc., St. Paul, MN
Unit: 20 ton truck-mounted Van den Berg hyson system
Purchased: 2005
Comments: "more than pleased" with equipment
Planning to buy a crawler from Van den Berg
Van den Berg "very responsive" to any issues

Uses 15 cm^2 cones with 10 cm^2 rods – greatly reduces friction

Plans on upgrading to new digital i-cones

Automatic push capability provides a big increase in productivity

"Super pleased" with service from the Netherlands

Dave Surgnier – Argonne National Laboratory, Argonne, IL

Unit: track-mounted Van den Berg coson system

Purchased: 2000

Comments: Company has been really good – would purchase from them again

Hyson push system requires less maintenance than coson

Also has Vertek rig and has retrofitted it with Van den Berg equipment (rods, cones)

Recommended to speak with Lee Shaw at GeoProbe regarding CPT grouting

Brian Brown – Morris Shea Bridge Co., Birmingham, AL

Unit: 20 ton track-mounted Van den Berg hyson system

Purchased: 1997

Comments: One-person operation possible

Used mostly for deep foundation investigations

Totally satisfied with Van den Berg and their equipment

One set of rods lasts 4 – 5 years

Need to move rods around in the drill stem periodically

Goes down to approximately 120 ft. maximum

Uses foot pedal to run hyson automatically

Recep Yilmaz – Fugro, Houston, TX

Units: 10 Van den Berg rigs, 4 Vertek rigs, 1 GeoMil rig

Purchased: variable

Comments: Most satisfied with Van den Berg equipment

No problems with Van den Berg hydraulics

Vertek equipment "not nearly as good" as Van den Berg – Vertek is made "more cheaply", breaks down more often

Not as much maintenance needed with Van den Berg

Mac McNeil – Thompson Engineering, Mobile, AL

Unit: 8 ton Van den Berg mini crawler

Purchased: unknown

Comments: Very satisfied with Van den Berg service and support

Regrets getting a lightweight rig – ground anchors needed

Van den Berg software easy to use

CPT system (aside from vehicle weight) works well

Derek Dasenbrock – Minnesota DOT, St. Paul, MN

Unit: Vertek 11 ton crawler, 13 ton and 30 ton trucks

Purchased: 2001 – 2006

Comments: Overall very good experience

Initially had some "growing pains" with datapacks

Good customer service and support

Pushed as deep as 170 ft.

Grouting with side ports on cone has worked well

More trouble with carriers (rigs) than CPT equipment

2-person operation

Recommends ToughBook Panasonic computer

Summary

All of the Van den Berg equipment owners had nothing but highly positive comments.

Mixed comments were received from Vertek equipment owners.

Owners of equipment from both manufacturers clearly preferred Van den Berg.

h. Solicitation and Evaluation of Quotes for Similar CPT Equipment

Specifications were generated and given to both vendors to obtain cost estimates for similar CPT equipment packages. These quotes are not necessarily representative of the final CPT system that would be purchased by ODOT, but were solicited to allow the review team to compare "apples to apples" such that relative value of the different vendors could be assessed. It is important to note, however, that the capabilities of the equipment are not fully comparable because only Van den Berg offers automated push technology (included in quote).

Quotes for similar equipment packages from Vertek and Van den Berg are provided in Appendices B and C.

The total cost for the Vertek package is **$381,498.44**, which breaks down as follows:

- 22-23 ton CPT crawler unit with John Deere engine = $351,077.00
- Accessories necessary to conduct **Phase II** work, including cones, rods, cables, and software = $30,421.44

The total cost for the Van den Berg package is **$454,701.16**, which breaks down as follows:

- 22 ton CPT crawler unit with John Deere engine = $360,716 + $4,685 = $365,401.00
- Accessories necessary to conduct **Phase II** work, including cones, rods, cables, and software = $81,600.16
- Shipping to U.S. port = $7,700

The Van den Berg quote reflects the current currency exchange rate (approx. 1 Euro = $1.48).

Some of the items in the Van den Berg "accessories" quote, such as heat, air conditioning, work bench and video camera, are included in the price of the Vertek crawler. This explains in part why the Van den Berg accessories quote is much higher than that for Vertek. This also makes it difficult to directly compare the crawler or accessories quotes for these two vendors. Thus, the most accurate cost comparison is made by considering total equipment package prices.

The total cost of the Van den Berg package is $73,202.72 (19%) higher than the Vertek package.

6. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions are reached as a result of a thorough investigation of vendors for possible purchase of CPT equipment for the ODOT subsurface investigation program:

1. Of the five manufacturers originally considered, full investigations including site visits were conducted for Vertek of Randolph, VT, and Van den Berg of Heerenveen, the Netherlands,
2. Vertek makes good quality equipment,
3. Van den Berg makes excellent quality equipment and has industry-leading technology,
4. The capabilities of the Van den Berg equipment package have no significant shortcomings and several important advantages, and
5. The Van den Berg equipment package is more expensive than the Vertek package by 19%.

Recommendations

After careful consideration of the capabilities and costs of CPT equipment from Vertek and Van den Berg, the Van den Berg equipment package is recommended. The Van den Berg package is worth the additional cost in the opinion of the review team because:

- The references were consistently and highly positive with regard to equipment quality and company service support,
- References who owned both Vertek and Van den Berg equipment clearly preferred Van den Berg,
- Higher equipment quality is expected to result in lower maintenance costs,
- The technology is generally superior,
- Automated push technology allows for single-person operation,
- There exists the potential to upgrade to wireless operation in the future,
- The software is superior, and
- The company has a stronger reputation and more experience in the CPT industry.

Automated push technology is considered to be the greatest direct advantage of the Van den Berg equipment. This capability allows an operator to handle rods while the CPT cross beam moves up and down automatically during pushing and pulling. As a result,

- Field operations are simplified as the operator does not have to manually control up-and-down cross beam motion,
- Field operations are faster and likely to be completed with fewer mistakes (estimated savings = 5% time = $5,000/yr), and
- Field operations can be conducted with a single operator, thus saving the cost of a second person in the field (estimated savings = $70,000/yr.)

The total cost savings from Van den Berg's automated push technology is expected to be $75,000/yr. and the additional cost of the Van den Berg crawler is $73,203. Thus, the extra cost of the Van den Berg crawler is expected to be recovered in approximately one year. After the first year, the Van den Berg crawler is expected to save ODOT approximately $75,000/yr. as compared to the Vertek crawler.

7. IMPLEMENTATION PLAN

Implementation of this work will occur on approval by ODOT to proceed with **Phase II**. The final specifications and cost of the CPT crawler will be reviewed and approved by ODOT prior to purchase.

APPENDIX A

CPT VENDOR MATRIX

VERTEK and A.P. VAN DEN BERG

Option	Vertek	Score	A.P. Van den Berg	Score	Weight	V	VDB
Category - Track Carrier							
Track Drive	Driven by a hydraulic motor via a chain/sprocket	2	Hydraulic motor via a Planetary Gear Box. A sprocket is mounted on the gear box.	2	0.5	1	1
Track Supplier	Strickland-Track Supplier in England	2	Either Intertractor (Germany) or VTS (Netherlands). Depends on availability.	2	0.1	0.2	0.2
Track Width	28" wide	2	700 mm = 27.5" wide	2	0.5	1	1
Track Area	42 sq. ft	2	42.4 sq ft	2	0.1	0.2	0.2
Track Construction	Steel or rubber tracks	3	Steel, synthetic material, or domex (high strength steel with a flattened traction side)	3	0.3	0.9	0.9
Track Adjustments	Hydraulic	2	Yes - done by pumping grease into a pressure cylinder which spreads the wheels apart and tensions the tracks.	2	0.5	1	1
Carrier Speed	4-5 mph	3	3.4 km/h = 2.11 mph	2	0.5	1.5	1
Steering	Hydraulic	3	Hydraulic	3	0.2	0.6	0.6
Drive sprockets (Size & Config.)	No information provided	0	D4	2	0.2	0	0.4
Max. Tractive Effort	27.2 kN per track at high speed; 68.1 kN per track at low speed	2	85 kN (at highest speed)	3	0.1	0.2	0.3

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Category - Track Carrier							
Ground Contact Pressure	4 psi	3	4 psi	3	0.3	0.9	0.9
Straight Ahead climb	Able to go over very steep slopes	3	Comfortably at 45°	3	0.3	0.9	0.9
Side Hill Traverse	No specific value provided	1	Comfortably at 45°	3	0.3	0.3	0.9
Brakes	Automatic on tracks	3	Automatic on tracks	3	0.1	0.3	0.3
"0" Turning Radius	Yes	3	Yes	3	0.3	0.9	0.9
Dead Engine Towable	Not standard, but willing to investigate	1	Not available	0	0.5	0.5	0
Center of Gravity	Centered on push point	3	Centered on push point	3	0.5	1.5	1.5
Length	18'-0"	3	5640 mm = 18' - 6"	3	0.1	0.3	0.3
Width	Less than 8'-6" ft wide	3	Less than 8'-6" ft wide	3	0.5	1.5	1.5
Height	Lowboy = 32-34"; Carrier height < 10'-6"	3	Lowboy = 32-34"; Carrier height < 10'-6"	3	0.5	1.5	1.5
Ground Clearance	15" (jacks are lowest structure)	2	300 mm = 11.8"	1	0.3	0.6	0.3
Metal Base Plate	20 ton - 2"; 25 ton - 2 1/2" thickness	3	1-1/2 - 2" thickness	3	0.2	0.6	0.6

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Category - Track Carrier							
All Lines, Hoses, etc. Protected under Skid Plate	Yes, brush guards will be added where necessary	2	Yes - steel pipes used where necessary	3	0.5	1	1.5
Front Winch	Not currently included; could be either hydraulic or electric	1	Not currently included; could be either hydraulic or electric	1	0.3	0.3	0.3
Ballasting	Removable ballasts not typically used	1	Provided, not specified	2	0.1	0.1	0.2
Security	Enclosed engine is specified and designed along with specification for locked caps on engine/ fuel	3	Engine is enclosed; bars on windows; locks on all caps	3	0.5	1.5	1.5
Category - Power Unit							
Type	John Deere - Diesel/ 4-cylinder/ water-cooled	3	Typically Deutz, but will use Caterpillar engine at request	3	0.2	0.6	0.6
Turbo Charged	No	0	Yes	3	0.1	0	0.3
Piston Displacement	276 cubic inches	2	4 X 73.2 in3 = 292.8 cubic inches	2	0.1	0.2	0.2
Horsepower	about 160 hp (drive system)	3	135 hp	2	0.3	0.9	0.6
Torque	9937 Nm per track at high speed; 23,785 Nm per track at low speed	2	544 Nm = 400 ft*lb	1	0.3	0.6	0.3
EPA Tier 3 Emissions	Required already if manufactured in U.S.	3	Standards stricter than U.S.	3	1.0	3	3

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Category - Power Unit							
Powers Both Carrier and CPT	Yes	2	Yes	2	0.5	1	1
Voltage	12 V	2	24 VDC	2	0.2	0.4	0.4
Cold Weather Starting Aid	Yes, if specify block heaters	2	Yes	3	0.2	0.4	0.6
Electric Governor	Yes	3	Yes	3	0.1	0.3	0.3
Two-stage Air Cleaner	No information provided	0	Yes	3	0.1	0	0.3
Full-flow Oil Filter	No information provided	0	Yes	3	0.1	0	0.3
Engine Electronic Control Module	Comes with power plant	1	Yes, includes a black box memory module that records all commands	3	0.3	0.3	0.9
Power Takeoffs	Yes	3	Yes, used for an extra hydraulic pump	3	0.1	0.3	0.3
Fuel Consumption	1.7 gal / hr - low idle; 8 gal/hr - high idle	2	Max. 230 g / Kwh at max. engine speed	2	0.2	0.4	0.4
Fuel Tank	50 gal (diesel) - Can be modified	2	200 Liters = 52.8 gallons	2	0.3	0.6	0.6
12-hour fuel supply	Yes	3	Yes	3	0.3	0.9	0.9
Security	Locks on fuel tank, enclosed engine, general warning light	3	Locks on fuel tank, enclosed engine, general warning light	3	0.2	0.6	0.6
Hydrostatic Transmission Circuits	2 separate circuits	2	No information provided	0	0.1	0.2	0

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Category - Hydraulic System							
Engine Drive System (Belt, Shaft, Chain)	Direct drive from engine	2	Direct drive from engine	2	0.2	0.4	0.4
Independent Torque Converter	No	0	No	0	0.2	0	0
Heavy-duty Auxiliary Hydraulic Pumps (also unloading of auxiliary pumps)	No	0	Yes	3	0.3	0	0.9
Aux. Pumps Indep. Of Torque Converter	No information provided	0	Yes	3	0.1	0	0.3
Hydraulic Pump Cap.	55gpm / 4500 psi continuous max.	2	2 x 60 cm^3/rev + 1 x 16 cm^3 /rev	2	0.2	0.4	0.4
Hydraulic Power Avail.	50 gpm @ 4000 psi	2	91 kW x1,341 = 122 hp (n= 2000 rpm)	2	0.2	0.4	0.4
Filters	Yes	3	Yes	3	0.1	0.3	0.3
Oil Cooler	Yes	3	Hydraulic oil cooler	3	0.3	0.9	0.9
Hydraulic Oil/Water Separator	No	0	Yes, can be supplied if needed. Its use depends on the atmospheric conditions at the work site.	3	0.2	0	0.6
Thermal/pressure Bypass	Yes	3	Yes	3	0.2	0.6	0.6
Location of Hydraulics	Outside cabin (not insulated)	1	Insulated outside cabin	3	0.2	0.2	0.6

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Category - Hydraulic System							
Heat Dissipation	Method - cooling fans, radiator	2	Oil-cooled	2	0.3	0.6	0.6
Category - Leveling Jacks							
Type	Hydraulic	1	Hydraulic	1	0.2	0.2	0.2
Front	Seismic system leveling pad	2	Seismic system leveling pad	2	0.3	0.6	0.6
Back	2 independent jacks	3	2 independent jacks	3	0.3	0.9	0.9
Independently Operated	Controls are on wireless remote, does not automatically level itself	2	Yes, or can be one touch automatic; leveling instrument is alongside the control cabinet	3	0.3	0.6	0.9
Check Valves	Yes (counterbalance also)	3	Yes (brake valves)	3	0.2	0.6	0.6
Jack Pad Size	back - 1'-6" dia., front - meshed in with seismic leveling pad	3	back = 600 mm = 23.6 in. diameter	3	0.1	0.3	0.3
Maximum Cylinder Travel	Approximately 2'-3"; (15" to touch ground, then lift tracks off the ground about 1 ft)	2	750 mm = 29.5 in.	2	0.5	1	1
Maximum Load Capacity	Capable of lifting rig vertically off the ground	2	Capable of lifting rig vertically off the ground	2	0.2	0.4	0.4
Jack Cylinder Diameter	5" on seismic beam; 4" on front jacks	2	Cylinder = 5" ; Piston = 3.5"	2	0.1	0.2	0.2
Category - Drivers Area							
Location	Walk-behind remote control	3	Walk-behind remote control or joysticks next to monitoring station	3	0.4	1.2	1.2

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Category - Drivers Area							
Controls for Carrier	Wireless remote that controls rig when within 300 ft; (Also only on/off for controls)	3	Wireless remote	3	0.4	1.2	1.2
Keyed Ignition	No	1	No	1	0.1	0.1	0.1
Certified Roll Over Protection System	No; very low Center of Gravity - not designed to move with rider	1	No; very low Center of Gravity - not designed to move with rider	1	0.5	0.5	0.5
Parking Brake Controls	No, tracks automatically lock up when not in motion, must be manually removed to push/pull	2	No, tracks naturally lock up when not in motion. During push, the rig is not on tracks and safety mechanisms are in jacks.	2	0.5	1	1
Multi-Speed Control	Low-Medium-High idle (no shifting)	2	Yes	2	0.3	0.6	0.6
Winch Control (Outside/ Inside Cab)	To be determined if specified	1	To be determined if specified	1	0.3	0.3	0.3
Elect. Engine Throttle Switch (Outside/Inside)	Outside - high/low selection on belly pack remote control	2	Yes	2	0.1	0.2	0.2
Outside Lights	No outside lights	0	No outside lights	0	0.3	0	0
Gauges	Pressure - quicker reaction time, Electronic can also be incorporated into design but slower reaction time	2	Pressure Gauges - quicker reaction time	2	0.2	0.4	0.4
Indicator Lights	Yes	3	Automatic shut-offs	3	0.3	0.9	0.9
12 VDC Inverter	Standard is 1,000 watts; larger available	2	1500 watts	3	0.1	0.2	0.3

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Category - General							
Push Monitor	Yes	3	Yes	3	0.5	1.5	1.5
Hydraulic and Engine gauge monitor	Viewable on the control panel on the inside of the rig	3	Viewable on the control panel on the inside of the rig	3	0.2	0.6	0.6
GPS	Use handheld device	2	Use handheld device	2	0.2	0.4	0.4
Cabinets	Yes, Lista Cabinets Recommended	3	Yes	3	0.3	0.9	0.9
Vises	Yes	3	Yes	3	0.1	0.3	0.3
Storage Racks	Vertical or horizontal; (also outside storage boxes available)	2	Yes	2	0.3	0.6	0.6
Category - Body							
Length	10' - 0"	3	4300 mm = 14' - 9"	3	0.1	0.3	0.3
Width (Wide-Load?)	Less than 8'-6" (not a wide-load)	3	2500 mm = 8' - 2 1/2"	3	0.5	1.5	1.5
Height	On lowboy less than 13'-6" overall height	3	On lowboy less than 13'-6" overall height	3	0.5	1.5	1.5
Ceiling Height	7' - 0" ceilings standard	3	2050 mm = 6' - 9"	3	0.2	0.6	0.6

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Category - Body							
Materials	Fiberglass reinforced plywood shell - aluminum is a more expensive option	2	Steel, fiberglass, or plywood laminates; sandwich construction consisting of polyester on the outside and insulation inside	3	0.3	0.6	0.9
Insulation	Full insulation	3	Full insulation	3	0.2	0.6	0.6
Max. Noise Level (dB) Note: Unsafe levels = >85 dB for 8-hours	Range from 69-82 dB inside cabin during use	3	70 dB at 1 meter away from engine	3	0.5	1.5	1.5
Air Conditioning	Yes - mounted to wall	2	Yes - mounted to wall	2	0.3	0.6	0.6
Heat	Yes - mounted to wall	2	Yes - mounted to wall	2	0.3	0.6	0.6
Base	Steel floor (2" thick for 20 ton; 2 1/2" for 25 ton)	3	Steel floor (approx. 1 1/2 - 2"); covered by floor plates, fully water and oil proof; with anti-slip layer	3	0.3	0.9	0.9
Cabinets	Floor and wall cabinets can be placed as requested and needed as space allows	3	Customized cabinets	3	0.2	0.6	0.6
Lighting	120W fluorescent lights inside	2	Four strips, 24V - 18S mounted at ceiling	2	0.1	0.2	0.2
Security	Bars on windows, locks on door	3	Bars on windows, locks on door	3	0.5	1.5	1.5

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Category - Body							
Bellows	Door in ceiling for extra height above push area. Does not need to be opened for operation	3	Yes, required to be open during use	1	0.5	1.5	0.5
Roof of carrier supports weight?	Not designed for, but will hold typical person	2	Not designed for, contains bellow construction and waterproof material.	2	0.3	0.6	0.6
Category - Push Platform							
Head Clamp	Hydraulic	3	Hydraulic	3	0.5	1.5	1.5
Safety clamps with auto sequencing	Yes, automatically lock/unlock as needed	3	Yes (ball clamp); catching clamp, 30-100 mm (1.18 - 3.93 in), pneumatic operated	3	0.5	1.5	1.5
One-touch operation	No - must press button to start down, and press button to come back up	1	Yes, Hyson system - automatically comes back up and begins pushing; better data	3	2.0	2	6
Electronic Control	Yes, on the control panel	1	Control Panel and Remote	3	0.5	0.5	1.5
Auto Leveling	No, controlled by wireless remote, instruments inside cabin tell operator if rig is balanced or not	0	Yes	3	0.6	0	1.8
Accommodations for Soil, Water Sampling	Simple adjustment of bottom hole in clamping system	3	None needed - designed to go straight through	3	0.3	0.9	0.9
Auto Screw (Rods)	No	0	Yes	3	0.6	0	1.8
Coring	Can buy drill and attach to CPT rig	0	Rotap-65	3	0.5	0	1.5

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Category - Push Platform							
Robotic Push Rod Operation	No	0	Yes, robotic operation available	3	0.3	0	0.9
Continuous Push	No	0	Yes	3	0.4	0	1.2
Ground Anchors	Available in many sizes	1	Available in many sizes	2	0.1	0.1	0.2
Wireless Data Transfer	No wireless data transfer, cable only	0	Wireless and digital (cable) data transfer is available for non-seismic. Seismic available in 2-3 years	3	0.8	0	2.4
Overall Ease of Operation	System is original	1	More advanced system	3	1.5	1.5	4.5
Category - Electronics							
PC Requirements	Panasonic toughbook; if purchased separately, it should at least include: 9-pin RS-232 serial com port, Pentium III or above, running windows XP professional	3	Panasonic toughbook; Microsoft windows required	3	0.4	1.2	1.2
Data Acquisition	CPT sound: downhole data is transmitted in ASCII format. Complete package for acquisition, processing, & plotting data.	3	Touch-screen and GOLOG!	3	0.4	1.2	1.2
Controller	2 boxes at computer station	2	Behind control panel	2	0.5	1	1
Software	DataPack 2000 - all-in-one solution	1	GOnsite!, GO4!, & GOview!, or GORILLA logging and plot software	3	0.5	0.5	1.5
Computer backup for hard drive	Possible	1	Possible	1	0.4	0.4	0.4

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Category - Electronics							
Units of measurement	English or Metric	3	English or Metric	3	0.2	0.6	0.6
User Control Panel	All engine and CPT controls accessible with on-board panel	3	All engine and CPT controls accessible with on-board panel	3	0.2	0.6	0.6
Software Demo Avail.	Yes	2	Yes	2	0.1	0.2	0.2
Integration with gINT or .xml, .gml format	Yes, with Data Forensics Rapid CPT	2	Never worked with gINT before	0	0.4	0.8	0
Integration with Equis	Likely capable, though not familiar	1	Not familiar with Equis	1	0.4	0.4	0.4
Safety Monitoring	Watch inclinometer; sounding system shut-off safety feature; potential quit conditions shown in red when they arise, automatic stops can be programmed into system	3	Inclinometer on all systems; built-in safety system is standard, so the system can be stopped immediately	3	0.6	1.8	1.8
Real-time data monitor	Graphical user interface with real-time data on laptop computer	3	touch-screen available	3	0.3	0.9	0.9
Video Recorder	Available for placement under CPT rig to view ready-made holes, & push operations	3	Available for placement under CPT rig to view ready-made holes, & push operations	3	0.2	0.6	0.6
Output format (must be in ASCII or .xml format)	Customizable - data can be output in tabular format in spreadsheets or commercially available software.	3	Yes - output is in ASCII or easily accessible to Microsoft excel	3	0.5	1.5	1.5

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Category - Rods							
Special Advantages	Speedlock rods (only 2.5 turns required); 150 ksi	2	3-turn rods; automatic CPT rod-screwing device are available options; 175 ksi	3	0.2	0.4	0.6
Sizes Available (Diameter)	1.44" (36mm) & 1.75" (44mm) are standard, larger sizes available	2	1.44" (36mm) & 1.75" (44mm) are standard, larger sizes available	2	0.1	0.2	0.2
Rod Threads (Coarse/Fine)	2.5 turns	2	2 types: 1.) round wavelike type (AR) for greater strength 2.) double round wavelike type (2R) for fast adding and removing	3	0.3	0.6	0.9
Pressurized Water System	Yes, environmental method to clean rods, also used for sink if placed in rig	3	Yes, it is available - necessary for ROTAP	3	0.3	0.9	0.9
Category - Cone Options							
Type	5 (mini-cone), 10, & 15 cm^2 cones	2	5 (mini-cone), 10, & 15 cm^2 cones	2	0.3	0.6	0.6
Parameters Available (Note: STD = tip resistance, sleeve friction, & pore pressure)	STD, Seismic (uniaxial or triaxial), soil moisture resistivity, fuel flourescense detector (FFD), and videocone	3	STD, seismic, conductivity, envirocone, memocone (memory and battery), and optocone (wireless)	3	0.5	1.5	1.5
Load Range	10cm^2 -> 20 tons; 15 cm^2 -> 30 tons	2	15 metric tons	2	0.2	0.4	0.4
3rd Party Tips Available	No - must buy from Vertek	0	No - must buy from A.P. Van den Berg	0	0.1	0	0

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Category - Cone Options							
Hard Layers Encountered	Attachable drill bits available at a very high cost; Able to purchase core that will be attached to rig.	1	Rotap-65 drilling unit (to punch through hard layers and resume CPT) along with core sampling	3	0.7	0.7	2.1
Category - Samplers							
Gas	Gas sampler available	2	Wastap sampler (max. depth = 8m and vol. = 0.5L)	2	0.3	0.6	0.6
Soil	Large volume sampler: sample size: dia = 35 mm (1 3/8"), length = 536 mm (21") discrete soil sampler: sample size = 6 in^3, dia. = 1", length = 7 5/8"	2	MOSTAP - 35mm (1 3/8") & 66mm (2 1/2")	2	0.4	0.8	0.8
Grouting System	Yes - slide window during retraction, or PVC piping; Must be used with 15cm^2 cone and rods	2	No	0	0.5	1	0
Requirements of Outer Casing for Soil Sampler	None - soil sampler is attached to the end of the bottom rod	2	None - soil sampler is attached to the end of the bottom rod	2	0.5	1	1
Water	Discrete batch water sampler, conesipper water/gas sampler	2	Wastap sampler (max. depth = 8m and vol. = 0.5L)	2	0.2	0.4	0.4
Additional Samplers	Soil/Gas & Soil/Water sampler for permanent wells	2	Polluted soil sampler (MOSTAP - PS)	2	0.2	0.4	0.4

Option	Vertek	Score	A.P. Van den Berg	Score	Weight	V	VDB
Category - In-Situ Testing							
Seismic Accelerator Or Geophones in Cone	Three geophones (triaxial) mounted inside the penetrometer measures seismic waves generated on the surface. Measure 2 opposing shear waves, and one compression wave. (uni or tri-axial)	3	Available - 2 sets can be used along with touch screen controls	3	0.5	1.5	1.5
Seismic Wave Generator	Yes, built into the front lift pad for enhanced energy transfer into the soil	3	Hammer that produces shear wave left, right, & the compression wave	3	0.5	1.5	1.5
Vane	Not Available	0	Integrated vane tester available (VATAP)	3	0.4	0	1.2
Dilatometer	Capable of pushing	0	Yes	3	0.3	0	0.9
Pressuremeter	Capable of pushing	0	Yes	3	0.3	0	0.9
Permeability	From dissipations, can get permeability	1	No information provided	0	0.3	0.3	0
Inclinometer	Yes, standard on all rigs	3	Yes, standard on all rigs	3	0.4	1.2	1.2
Category - Maintenance							
Carriage	Can be fixed in U.S. by others	3	Can be fixed in U.S. by others	3	0.3	0.9	0.9

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Category - Maintenance							
Tip Calibration	Cones are interchangeable in the field and can be calibrated in the field. All calibration data is contained in the cone. Typically sent back to VT office every 2 years.	1	Cone calibration equipment available	3	0.4	0.4	1.2
Hydraulics	Able to be serviced locally	3	Able to be serviced locally	3	0.4	1.2	1.2
Equipment Repairs	Tracks are made by Strickland (England), Power Unit is made by John Deere	2	All equipment is able to be fixed in United States	2	0.3	0.6	0.6
Parts Availability	Most in-stock	2	Most in-stock	2	0.3	0.6	0.6
Major Repairs	Send technician to the site if problem cannot be solved; equipment has never been required to be shipped back to Vermont	3	CPT equipment - Netherlands ; rig maintenance - suppliers in United States	2	0.3	0.9	0.6
Time Delay (once part is ready)	Varies - supply warehouse in Vermont	3	Varies - no supply warehouse in U.S.	2	0.4	1.2	0.8
User Manual	Provided	2	Provided	2	0.3	0.6	0.6
Repair Manual	Specification of engine and parts provided	2	Provided	2	0.5	1	1
Category - Other							
trailer requirements	Simple flatbed or low-boy	2	Simple flatbed or low-boy	2	0.3	0.6	0.6

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Category - Other							
How long in business	20 years	2	39 years	3	0.4	0.8	1.2
Other clients comments/ recommendations	MNDOT	1	ARGON, Fugro, Thompson Engineering (AL), Morris Shea Engineering(AL)	3	2.0	2	6
How many units sold in U.S.	200+ in last 20 years (some internationally)	2	Manufacture about 15 rigs/ year, 50% for worldwide companies	2	0.2	0.4	0.4
Time for order to delivery	5-6 months	2	5-6 months	2	0.4	0.8	0.8
Support for mechanical, electrical, carrier,	References reported no problems with service and assistance after purchase	2	References have given outstanding ratings for great service from Netherlands engineers	3	0.8	1.6	2.4
On-site Training	Estimated 3 days needed at $720/day + $2845 travel cost	1	Training provided at Heerenveen before equipment is shipped to the U.S.; training in U.S. for 2 days included	3	0.6	0.6	1.8
Warranty	1-year	3	1-year	3	0.4	1.2	1.2

Total Possible Points:	171.3

	Vertek		A.P. Van den Berg
Vendor Score:	111.7		142.9

APPENDIX B

CPT EQUIPMENT QUOTE

VERTEK

A Division of ARA

VERTEK

February 12, 2008

Dr. Patrick Fox
Ohio State University
Columbus, Ohio

Dear Dr. Fox,

The Vertek division of Applied Research Associates, Inc. is pleased to provide this quotation for a CPT push system on a custom built 22-23 ton track rig. Delivery would be 120-150 days from receipt of your order. Price quoted is based on Ex-Works terms. This quote is valid for 60 days.

Quoted Equipment

• Track Chassis	Vertek chassis on Strickland tracks (700mm steel)
• Control for chassis	Wireless remote control
• Control for CPT	Hard mounted console
• Van Body Enclosure	With Air Conditioning, heat, lights, and steps
• Vandalism guarding	To protect engine, valve stand, and tanks
• Brush guards	To protect hydraulic hoses
• 20 Ton Push System Capacity	With Vertek Hydraulic Clamp
• Hydraulic Lift and Leveling	Standard height
• Hydraulic seismic hammer	Incorporated into leveling system
• Hydraulic Safety Clamp	Prevents rod or cone droppage
• Guide tube	To assure rod alignment
• Hydraulic Power	Variable load sense pump for precise control
• Camera system	One camera/monitor for cone location
• Work Bench	Lista cabinet with wood top and vise
• Heavy Duty 12 VDC Inverter	Provides 115VAC for computer and accessories
• Rod Storage Racks	Movable rod rack with 8 trays each
• Water tank and sink	100 gal with 12 vdc pump
• One Year Warranty	Covers defects in materials or workmanship

Price: $351,077

(Instrumentation pricing not included – quoted separately)

250 BEANVILLE ROAD ■ RANDOLPH, VT 05060
1-800-639-6315 ■ (802) 728-4588 ■ FAX (802) 728-9871 ■ WWW.VERTEK.ARA.COM

There are many features that set our CPT Rigs apart from the competition; the efficient and reliable push system, easy electronic hydraulic control of all CPT functions, easy to operate Windows-based data acquisition system and replaceable wear surfaces on all of our cones are just a few.

Please feel free to contact Carl Tracy (ctracy@ara.com) with any additional questions or information requests. Thank you again for the opportunity to quote on this project.

Best regards,

David A. Timian
Vertek Division Manager

DAT/ct

QUOTATION

Applied Research Associates, Inc. - dba Vertek
250 Beanville Road
Randolph, VT 05060
Phone: (802) 728-4588
Fax: (802) 728-9871
E-mail: vertek@ara.com

Quote Number: 3154
Quote Date: 02/01/08
Page: 1
Customer Phone: 614-688-5695
Customer Fax:

B
OHIO STATE UNIVERSITY
495A HITCHCOCK HALL
2070 NEIL AVE.
COLUMBUS, OH 43210
USA

S
OHIO STATE UNIVERSITY
495A HITCHCOCK HALL
2070 NEIL AVE.
COLUMBUS, OH 43210
USA
ATTN: PATRICK FOX

Entered By: CT
Location:
Account Cd: OSU
Salesperson: 127

RFQ Number:
Ship Via: BEST WAY
Taxable: N
Pmt Terms: NET 30

Line	Order Qty	Part Number	Description		Price	UM	Ext Price	Est Ship
1	1	HT-0590	CONTROLLER ASM, DATAPACK FCS	0.00	$5,290.0000	EA	$5,290.00	02/28/08
2	2	HT-0633	CABLE ASM, 45M 10 PIN LEMO BLK (55M BLACK CABLE)	0.00	$1,075.0000	EA	$2,150.00	02/28/08
3	2	HT-D3575	CONE, 15 TON DIG T+LF+I+PP	0.00	$7,190.0000	EA	$14,380.00	02/28/08
5	1	HT-D3999	CHANNEL, CONE SEISMIC	0.00	$440.0000	EA	$440.00	02/28/08
6	2	4118	ADAPTOR, 1.75 F.ROPE/F.M32X1.5	0.00	$315.0000	EA	$630.00	02/28/08
7	40	1232	ROD, 1.75 ROPE THD.	0.00	$133.7900	EA	$5,351.60	02/28/08
8	10	1409	ROD, 1.75 ROPE W.48MM EXPANDER	0.00	$171.9000	EA	$1,719.00	02/28/08
			SPARE PARTS					
9	1	HT-0633	CABLE ASM, 45M 10 PIN LEMO BLK (55M BLACK CABLE)	0.00	$1,075.0000	EA	$1,075.00	02/28/08
10	10	HT-D3565B	TIP, 15 TON CONE 5MM PP	0.00	$87.0000	EA	$870.00	02/28/08
11	4	HT-D3565G	SLEEVE, 15 TON CONE FRICTION	0.00	$259.0000	EA	$1,036.00	02/28/08
12	8	4136	PACKAGE, 1.75 PIEZO FILTER HT	0.00	$84.0000	EA	$672.00	02/28/08
13	4	HT-D3569	KIT, 15 TON CONE O-RING	0.00	$47.0000	EA	$188.00	02/28/08
14	1	DIS-0000	DISCOUNT, 10 % ACADEMIC	0.00	<$3,380.1600>	EA	<$3,380.16>	02/28/08

SOFTWARE IS INCLUDED WITH ITEM ONE FOR USE WITH CUSTOMER SUPPLIED COMPUTER (USING WINDOWS XP)

THIS EQUIPMENT IS QUOTED FOR USE WITH A VERTEK PUSH PLATFORM. ADDITIONAL ITEMS MAY BE REQUIRED FOR OTHER USES.

QUOTE MODIFIED ON JAN 31 2008 TO REMOVE COMPUTER, DRIVE AND SOIL SAMPLER; AND TO CHANGE QUANTITIES ON CONE AND SEISMIC CHANNEL
QUOTE MODIFIED ON FEB 1 TO REMOVE 40 RODS AND GROUTING PARTS
CT

QUOTATION

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S
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COLUMBUS, OH 43210
USA
ATTN: PATRICK FOX

Entered By:	CT	RFQ Number:	
Location:		Ship Via:	BEST WAY
Account Cd:	OSU	Taxable:	N
Salesperson:	127	Pmt Terms:	NET 30

Line	Order Qty	Part Number	Description	Price	UM	Ext Price	Est Ship

Terms: All prices are Ex Works factory and are good for 30 days. All stocked parts are subject to a handling and restocking charge of 15% plus all shipping charges. Custom orders are non-refundable.

Please don't hesitate to call if you have questions. Once you issue a purchase order, a sales acknowledgement will be e-mailed, faxed and/or mailed to you.

Sincerely,

Subtotal:	$30,421.44
Sales Tax:	$0.00
Freight:	$0.00
Total:	$30,421.44

APPENDIX C

CPT EQUIPMENT QUOTE

A.P. VAN DEN BERG

A.P. Van den Berg, Inc.
P.O. BOX 654
109 Greenwood Circle
Milford PA 18337
Tel: 570-296-8224
Fax: 570-296-4886
E-Mail: apvdberg@ptd.net

QUOTE

DATE: 20-Feb-08 **Our REF. No:** Q-4485D

TO:
Ohio State University
Civil & Envr Engrng, 495 Hitchcock Hall
Columbus OH 43210
Dr Patrick Fox
Tel: 614-688-5695 Email:fox.407@osu.edu
Fax 614-292-3780

SHIP TO:
Ohio DOT
Port of New York & New Jersey
Tel:
Attn:

BASIC HYSON 200-kN CPT CRAWLER w/ RECOMMENDED OPTIONS INCLUDED IN TOTAL 2 PAGES

Your Ref No:	Terms:	Rep:	Ship Via:	Inco terms:	Project:
	See Notes	EB	Truck/Ocean freight	EXW Factory, The Netherlands	Ohio DOT

Quantity	Item code	Description:	Price, USD:	Amount, USD:
		HYSON 200-kN CPT CRAWLER FOR OHIO DOT		
1		CPT Crawler - as per tech. Specs. w/ hydraulic push/pull clamp and standard steel track plates	360,716.00	360,716.00
		ACCESSORIES		
		OPTIONAL CATERPILLAR ENGINE		
		Engine recommend - Deutz engines, parts, readily available in Ohio from MacDonald, Willoughby OH. www.mcdonaldequipment.com/product/engines_deutz.phtml		
1		Additional for John Deere engine in lieu of Deutz engine	4,685.00	4,685.00
		OTHER ACCESSORIES		
1		Cabin heater - operates w/ diesel fuel from engine	5,099.00	5,099.00
		Air Conditioning - Recommended - Locally installed - Tom Rapper, Inc. Mr. John Nelson, Richmond, Indiana, 2 x Carrier AC, 13,500 BTU models, Budgetary Price - Preparations for installations made at factory in communication w/ installer/supplier	3,000.00	
1		Window bars - all windows - protection against vandalism & illegal entrance	2,919.00	2,919.00
1		Bench Vice w/ rotatable baseplate	656.00	656.00
1		Sink w/ 60-L (15-gal) water tank	2,591.00	2,591.00
1		Electrical Inverter - provides 1500 VA @ 110-120 VAC w/ USA-type wall receptacles included	4,490.00	4,490.00
1		Video camera and screen - B&W, focused on CPT location on ground below crawler	2,070.00	2,070.00
1		Remote Control Radio-Operated Chest Pack - to operate crawler from ground outside	11,712.00	11,712.00
		EQUIPMENT FOR CPT INCLUDING SEISMIC TESTS		
1	0800884A	I-control data acquisition unit w/ 2-m USB cable to connect to laptop PC	8,277.00	8,277.00
1	Included	Gonsite! Software w/ cable model Bi6m-5-Bi6f & USB software dongle (included w/ I-control data acquisition system)	0.00	0.00
1		Pneumatic seismic triggering unit built into seismic ground beam - located between 2 front leveling jacks	3,904.00	3,904.00
2	18882K5A	I-cone cable w/ LEMO connectors - 2.5-m	367.00	734.00
2	1888030A	I-cone cable w/ LEMO connectors - 30-m	466.00	932.00
2	1888015A	I-cone cable w/ LEMO connectors - 15-m	422.00	844.00
2	0100297A	I-cone model ELCI-CFXYP20-15-AR - measures: qc, f, u2, ix, iy	5,466.00	10,932.00
1		I-cone seismic module - plugs into and threads onto I-cone	13,820.00	13,820.00
1	0000330A	Depth encoder w/ rotating pulse counter & stainless attachment wires	3,147.00	3,147.00
1	0800985A	Proximity switch w/ 4-pole binder connector - used to provide automatic HYSON movement	282.00	282.00
2	1824021A	Cable model Bi6m-5-Bi6f - length: 5 m, for depth encoder & proximity switch signals	235.00	470.00
39	0200006A	CPT rod, 36-1000 2R-2R - double helix round threads - hardened	128.00	4,992.00
2	0200008A	CPT rod, 36-1000 AR-2R - placed above friction reducer - hardened	125.00	250.00
2	0200245A	Lug friction reducer 36-250 AR-AR - placed above I-cone & modules	78.08	156.16
1	0199015A	Lipseal mounting tool, 15-cm²	199.00	199.00
1		Recommended spare parts for CPT operations	3,124.00	3,124.00

A.P. Van den Berg, Inc.
P.O. BOX 654
109 Greenwood Circle
Milford, 18337 PA
Tel: 570-296-8224
Fax: 570-296-4886
E-Mail: apvdberg@ptd.net

QUOTE

DATE:	Our REF. No:
20-Feb-08	Q4485D

Quantity	Item code	Description:	Price, USD:	Amount, USD:

Thank you for your inquiry.

Prices are valid for 30 days.

Terms are 50% on order, balance when unit is ready for shipment.

A. P. Van den Berg, Inc. Standard Sales Regulations including 1-yr warranty apply.

Acceptance testing is performed at the factory immediately before shipment.

Availability is currently August 2008.

SHIPPING
Shipping costs are estimated. Shipping includes local trucking to the Port of Rotterdam, and ocean freight to the Port of New York/New Jersey. From there to Columbus, Ohio DOTcan truck the unit or we can recommend Anderson Trucking. Time in transit is approx. 3-4 weeks factory to port of NY-NJ.

OPERATOR TRAINING
Operator Training at factory (2 days) is included at no charge.
Operator Training in Ohio (2 days) is included at no charge, additional training is charged at $1,230 per day. Travel, meals and Lodging are charged at cost plus 10%.

AIR CONDITIONING
We recommend air condiitioning be installed locally. Tom Rapper, Inc., Richmond, Indiana, is one of the firms that are recommended for the Columbus Ohio area. They provided a budgetary price of $3,000 for twin rooftop air conditioners mounted on the top of the engine compartment. Our factory will make preparations in connection with the local supplier/service firm.

Please call if you have any questions.

Sincerely,
for A.P. Van den Berg, Inc.

(sign.)
_____
Ed Brylawski, P.E.
Vice President

Subtotal (USD):	447,001.16
Shipping cost:	7,700.00
TOTAL (USD):	***454,701.16***