DEVELOPMENT OF AN IMPROVED VERTICAL AND HORIZONTAL INSITU PERMEAMETER (VAHIP)

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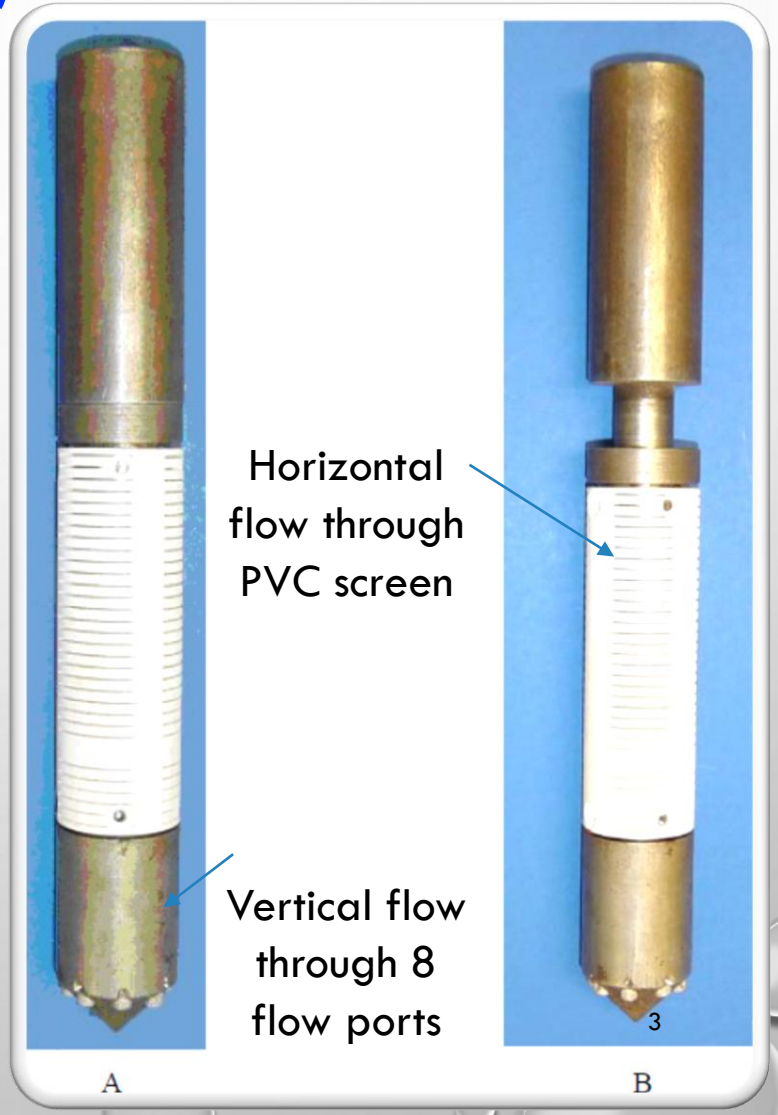
VAHIP
BACKGROUND AND PURPOSE

- The Vertical and Horizontal Insitu Permeameter (VAHIP)
  - Development started in 2004
  - Purpose
    - In situ Permeability test
      - Cheaper
      - faster
      - readings of permeability at different depths at the same location

VAHIP (2004 VERSION)

- Mechanical
  - phase 1 (compressed)
    - Vertical flow
  - Phase 2 ("opened")
    - Horizontal flow
- made of steel
  - 45° cone tip
- procedure to estimate permeability
  - advancing the probe into the subsurface
    - Use of standard penetration test (SPT) rig
- Issues
  - difficulty to return to phase I after completing phase II
  - presence of soil in the gap formed when pulling the probe out (opened position)
  - sand infiltration
    - need to extract the probe, disassemble it, and reassemble it
  - lack of rigidity due to the PVC screen



VAHIP (2005 VERSION)

- IMPROVED RIGIDITY
  - REPLACEMENT OF PVC SCREEN FOR A STEEL SCREEN
- MORE ISSUES WERE OBSERVED WHILE TESTING THE PROBE
  - VERTICAL FLOW PORTS CLOGGING

VAHIP (2006 VERSION)

- CLOGGED FLOW PORTS ISSUE SOLVED
  - REPLACED BY A SINGLE AND LARGER FLOW PORT
    - REMAINED CLOSED DURING ADVANCEMENT
  - HORIZONTAL SCREEN OPENED DURING ADVANCEMENT
- ISSUE
  - DIFFICULT AND PROBLEMATIC TO ADVANCE
    - STIFF CLAY

VAHIP (2013)

- Main Change
  - horizontal screen slits
    - replaced by vertical slits
      - ensure those slits being closed during advancement
        - preventing clogging
- Issue
  - mechanically complicated
    - rotated to open the screen
      - allow water to flow horizontally
    - rotated to close the vertical slits followed by the tip opening
      - allow vertical flow
    - Rotated twice for every depth
  - fabrication was expensive

VERTICAL IN SITU PERMEAMETER (VIP) PROJECT

- Steel probe fabricated during VAHIP (2013) project
  - New permeability probe recently developed by UF and FDOT
  - Measurements
    - good agreement with results from various conventional methods
  - Includes both cased and uncased methods

- Requires far less test time
  - Greatly improves efficiency
  - More data can be collected with less effort
- New Florida Method of Test was developed for the probe
  - FM 5-614
- Issues
  - Delivers some "average" conductivity
    - no independent values of k_v and k_h
  - Difficulty to drive the probe into deeper layer

VAHIP (2019)

- Amendment of VIP project
- Advances in flow theory
  - Potential for estimating vertical and horizontal permeability k_v and k_h under saturated conditions
- Simple mechanical design
  - No moving parts
- Automated data acquisition using pressure transducers
  - No hand readings
- Potentially capable of reaching greater depths
- Potentially insensitive to smearing and compaction near probe surface
  - Use of SPT hammer

VERTICAL AND HORIZONTAL IN SITU PERMEAMETER PROJECT (VAHIP)

- Project Tasks

1. ✓ Identification of an appropriate pressure measurement system
2. ✓ Development of computer-aided drawings (CAD) for the proposed probe
3. ✓ Fabrication of a PVC-prototype and possible adjustments of injection system
4. ✓ Testing of PVC-prototype at the DOT test pit
5. ✓ Fabrication of a steel probe
   - in situ tests with SPT rig
6. Final report

VAHIP (2019)

- Simple mechanical design
  - no moving parts
- Automated data acquisition
  - Use of pressure transducers
    - no hand readings
- Potentially capable of reaching greater depths
  - reduced probe diameter
- Potentially insensitive to smearing and compaction near probe surface

- Based on Model developed by klammler at all (2017)
  - *"Theoretical aspects for estimating anisotropic saturated hydraulic conductivity from in-well or direct-push probe injection tests in uniform media"*
    - mathematical method
      - find the relation between vertical and horizontal permeability
    - Use of this model
      - measure the horizontal permeability
      - calculate the vertical permeability

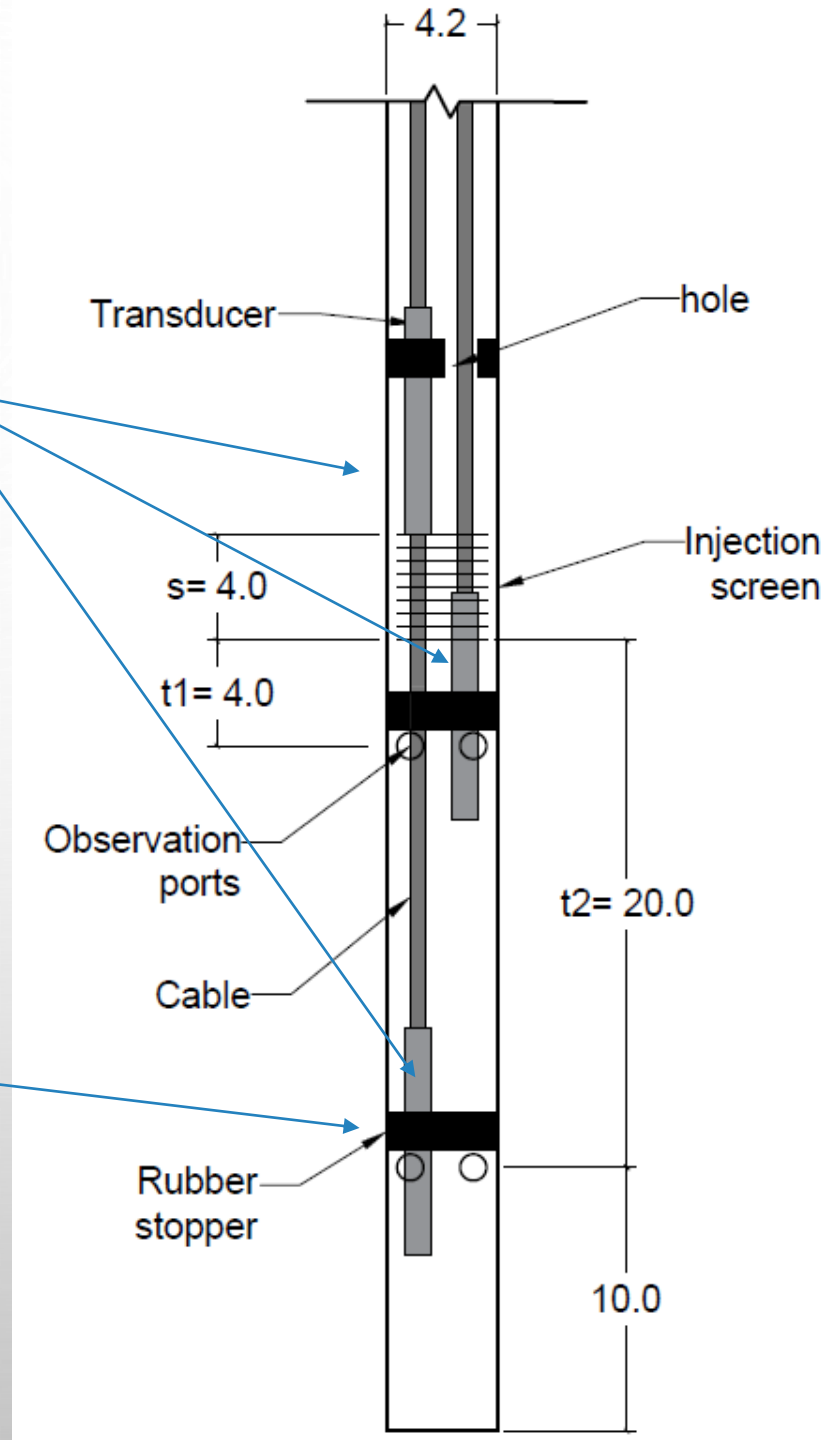
VAHIP 2019

- Selection of pressure measurement system
  - Miniature MTM3000 submersible transmitters
    - PMC Engineering
- Fabrication of a PVC-prototype
  - detailed computer-aided drawings (CAD)
  - possible adjustments of injection system
- laboratory test
  - injection tests in sand-packed barrels

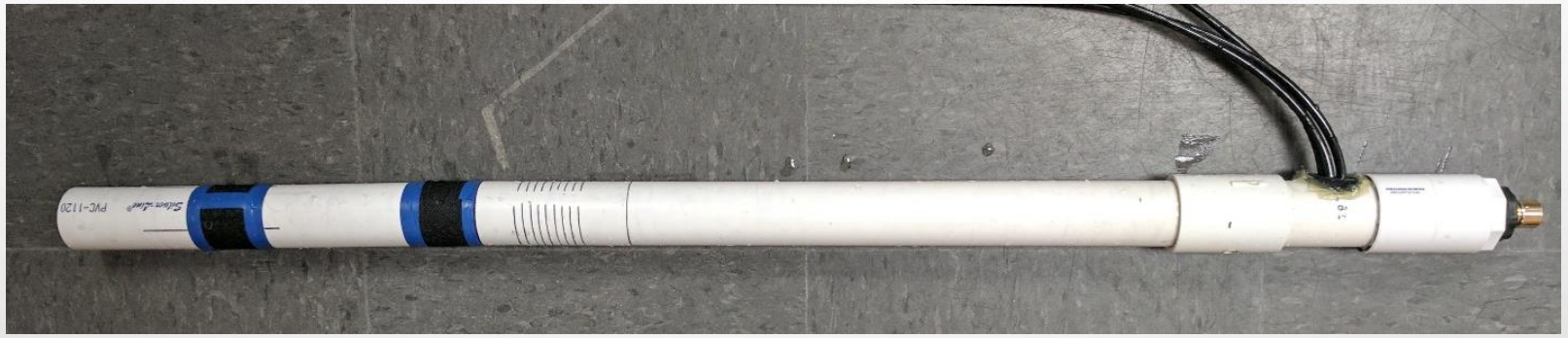
VAHIP (2019)

three pressure transducers

three rubber stoppers that were drilled to allow the transducer's cables to pass upward



VAHIP (2019)



VAHIP PROTOTYPE USED FOR LABORATORY TESTING

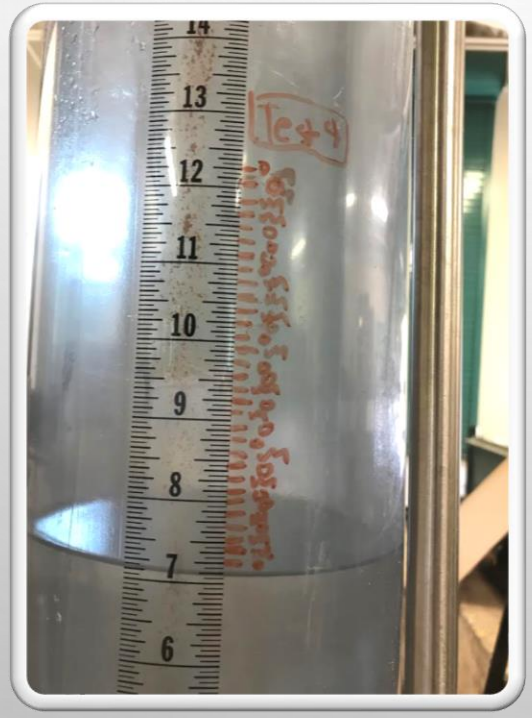
VAHIP (2019)

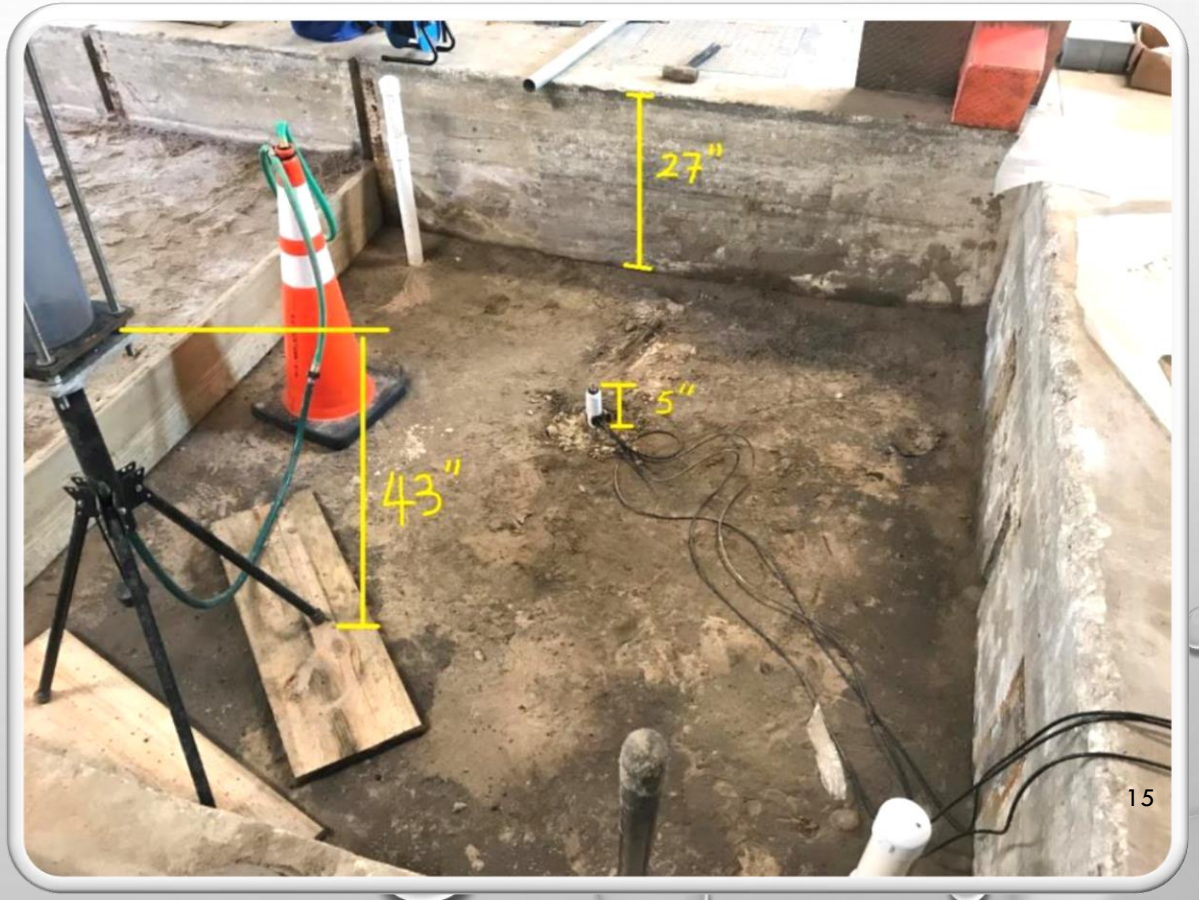
- INJECTION TESTS IN SAND-PACKED BARRELS
  - RESULT COMPARISON BETWEEN PVC PROTOTYPE AND CONSTANT HEAD TEST

From *PVC prototype*	From constant head test
k_h= 0.065 cm/s	k_h= 0.069 cm/s
kv= 0.022 cm/s	kv= 0.025 cm/s

VAHIP (2019)

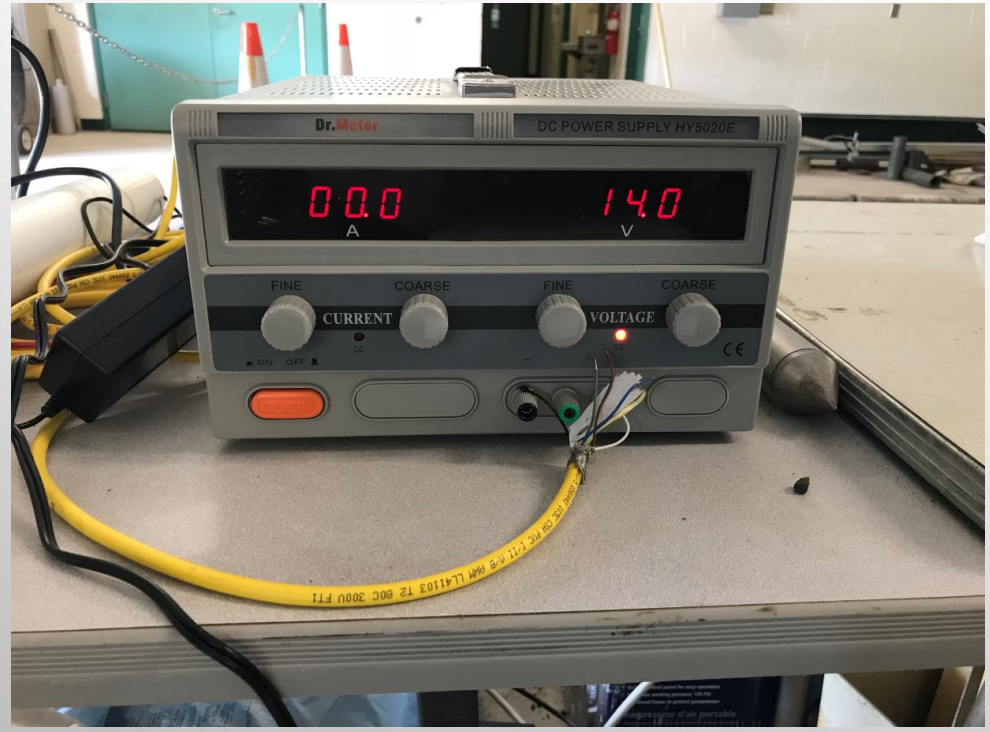
- Prototype probe
  - SMO test pit

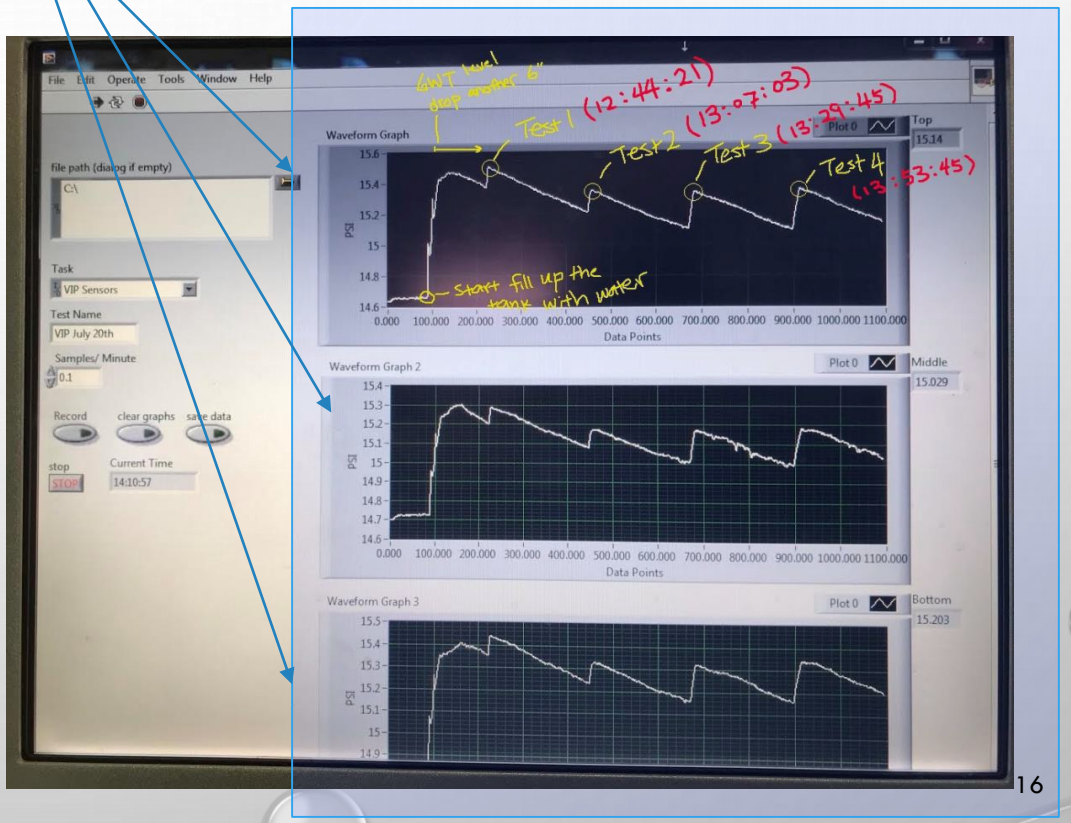




VAHIP (2019)

RECORDED THREE PRESSURES FROM EACH TRANSDUCER BY EVERY 6 SECONDS





VAHIP LABVIEW PROGRAM SCREENSHOT WITH POWER SUPPLY USED FOR THE FDOT TEST PIT

VAHIP (2019)

- RESULTS FROM PVC-PROTOTYPE AT THE SMO TEST PIT
  - UNSUITABLE COMPACTION OF SOIL
    - CAUSED THE SOIL AROUND THE PROBE TO BECOME LOOSER
    - GAP LEAD TO PIPING ISSUES ALONG THE PVC PROBE
  - TEST PIT HAD A LIMITED PVC PROBE DEPTH
    - HIGH HYDRAULIC GRADIENTS AROUND THE PROBE

Table 1- 2. The Q/ΔPtop in two minutes interval for test 1, with calculated kh and kv.

Test 1	Average $Q/\Delta P_{top}$ (m^2/s)	k_h (m/s)	K_v (m/s)
1-5 mins	5.04E-06	1.87E-06	7.50E-04
5-10 mins	5.91E-06	2.20E-06	8.79E-04
10-15 mins	6.03E-06	2.24E-06	8.97E-04

Table 1-2 cont. The Q/ΔPtop in two minutes interval for test 2, with calculated kh and kv.

Test 2	Average $Q/\Delta P_{top}$ (m^2/s)	k_h (m/s)	K_v (m/s)
1-5 mins	6.19E-06	2.30E-06	9.20E-04
5-10 mins	6.70E-06	2.49E-06	9.97E-04
10-15 mins	7.23E-06	2.69E-06	1.08E-03

Table 1-2 cont. The Q/ΔPtop in two minutes interval for test 3, with calculated kh and kv.

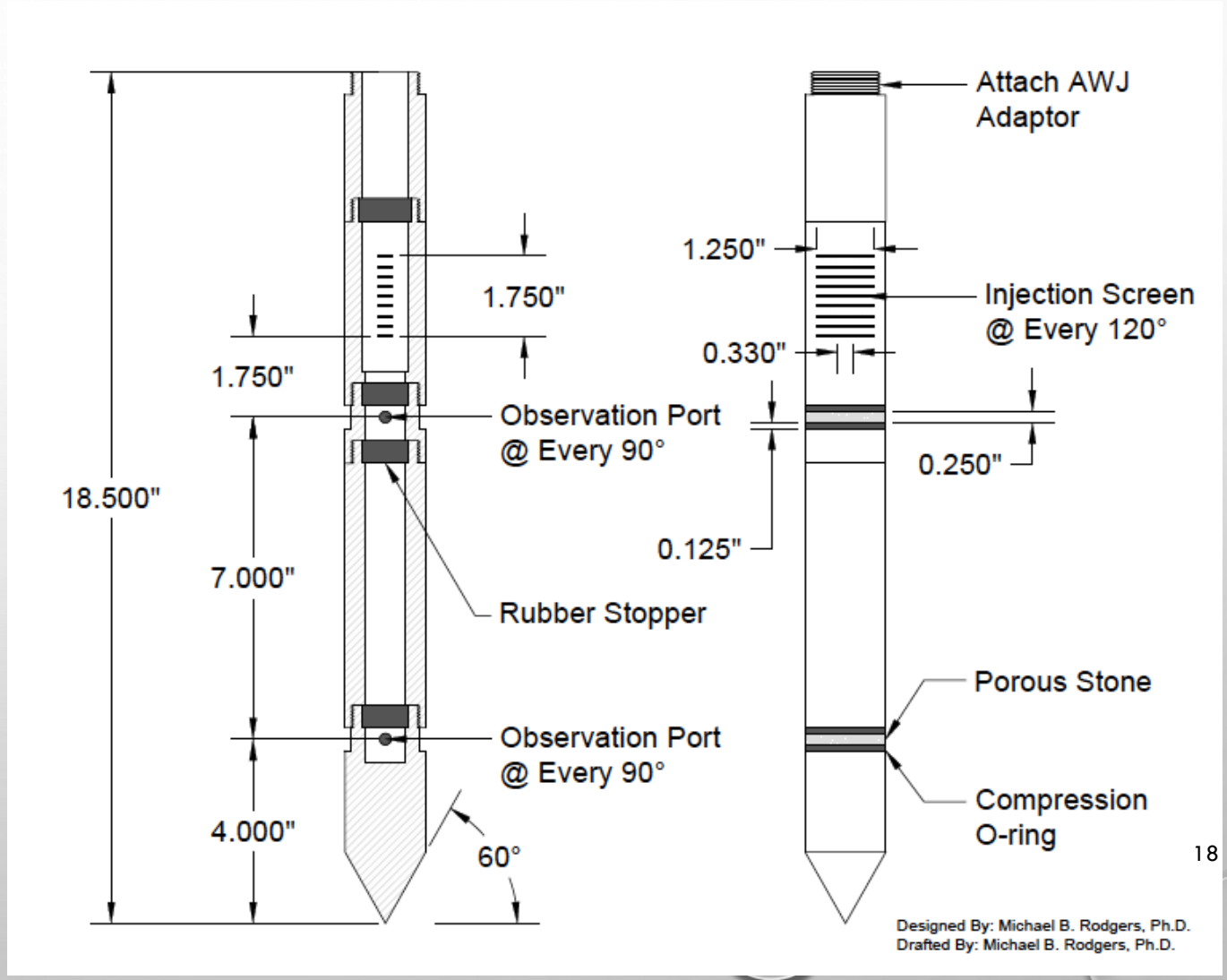
Test 3	Average $Q/\Delta P_{top}$ (m^2/s)	k_h (m/s)	K_v (m/s)
1-5 mins	5.30E-06	1.97E-06	7.88E-04
5-10 mins	5.45E-06	2.03E-06	8.11E-04
10-15 mins	7.95E-06	2.96E-06	1.18E-03

Table 1-2 cont. The Q/ΔPtop in two minutes interval for test 4, with calculated kh and kv.

Test 4	Average $Q/\Delta P_{top}$ (m^2/s)	k_h (m/s)	K_v (m/s)
1-5 mins	5.10E-06	1.90E-06	7.58E-04
5-10 mins	6.83E-06	2.54E-06	1.02E-03
10-15 mins	6.34E-06	2.36E-06	9.43E-04

VAHIP (2019)

- CAD DESIGN FOR STEEL PROBE

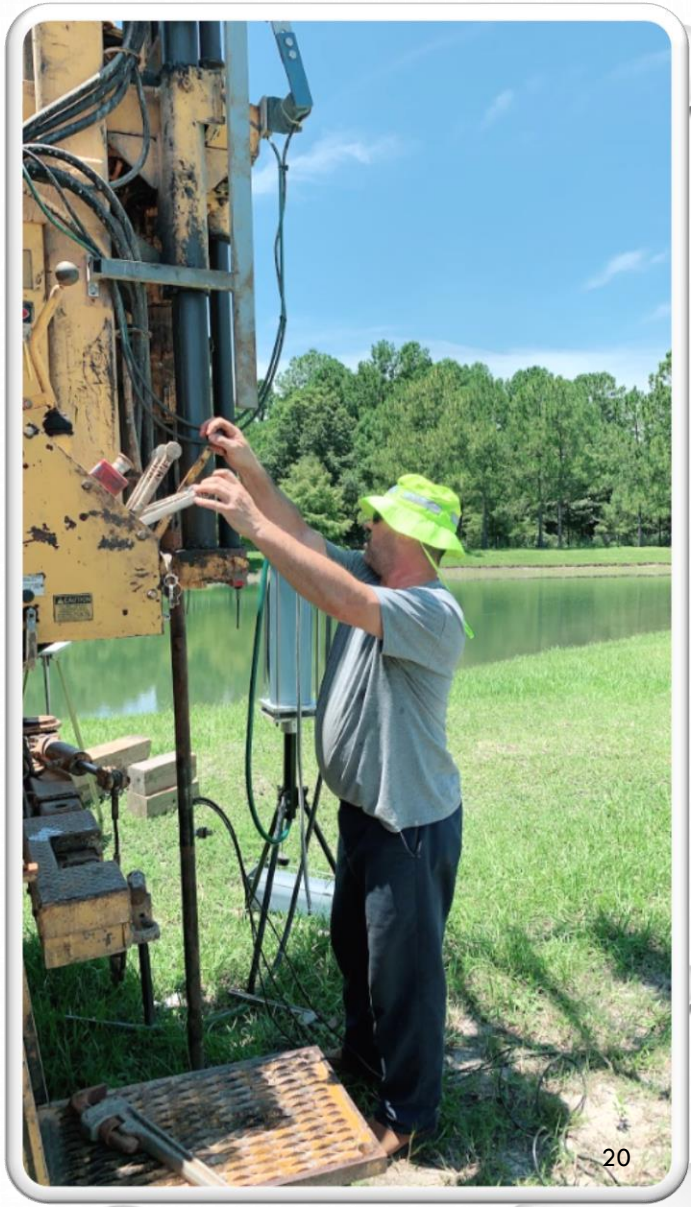


VAHIP (2019)

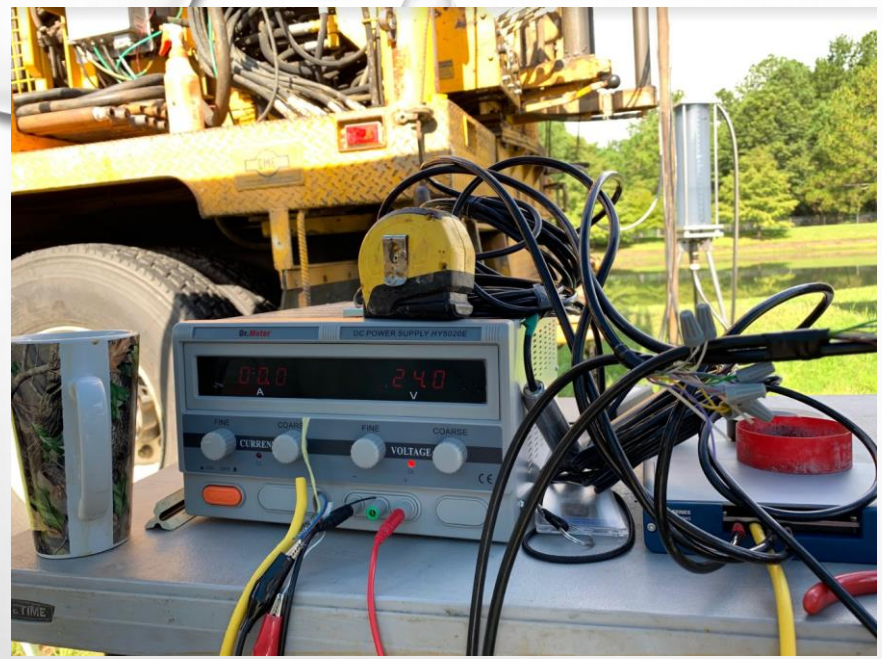
- Steel probe fabrication
  - 1.75” Diameter
  - 18.5” Length
  - 2 porous steel
  - 3 transducers wired to the data acquisition system
  - No moving parts
    - Easier operation

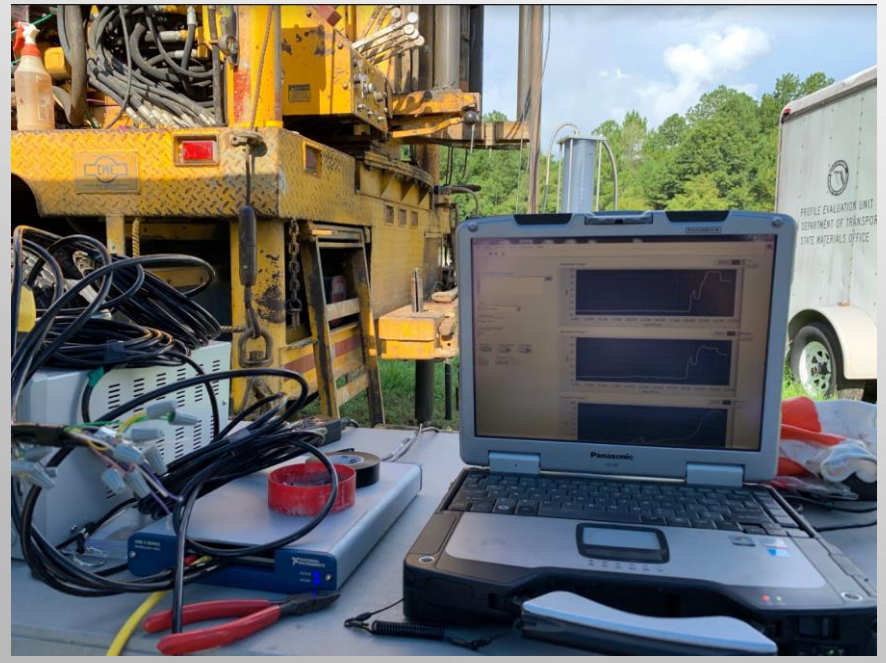
VAHIP (2019)

- In-situ tests
  - Location: backyard of SMO
  - Setup: same as test pit tests
  - Methods: data recording and falling head test



VAHIP (2019)





VAHIP (2019)

- Test performed on 08/07/2019
  - Depth: 11 ft
  - No leaking
  - Good looking readings
  - Properly marked falling head test

VAHIP (2019)

- Analysis of the recorded data
- More field tests on shallow GWT area
- Finish final report