# “That Sinking Feeling”

## Sinkholes and Remediation in Hillsborough County, Florida

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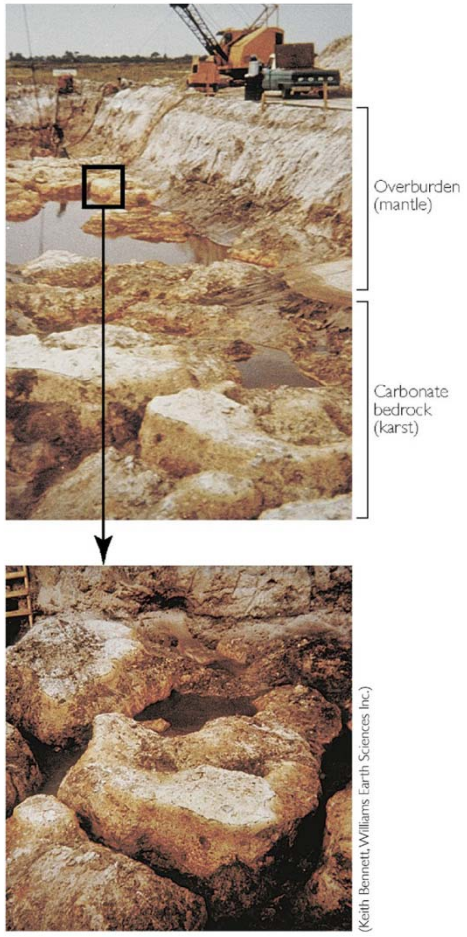
Ardaman & Associates, Inc., Tampa

Walt Williams
Hillsborough County Public Works

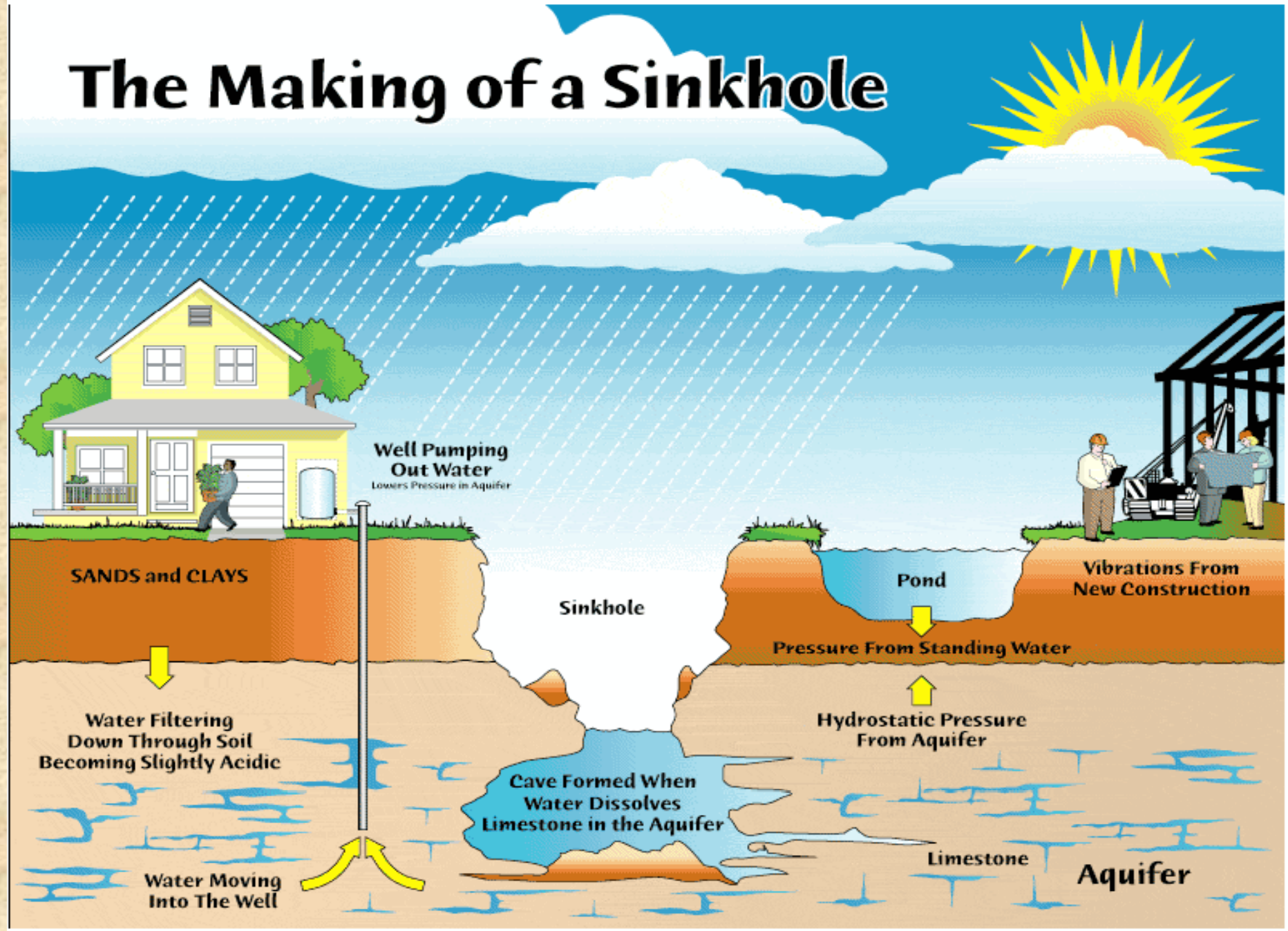
# Look Out Below!


# High Risk to Drivers and Travelling Public

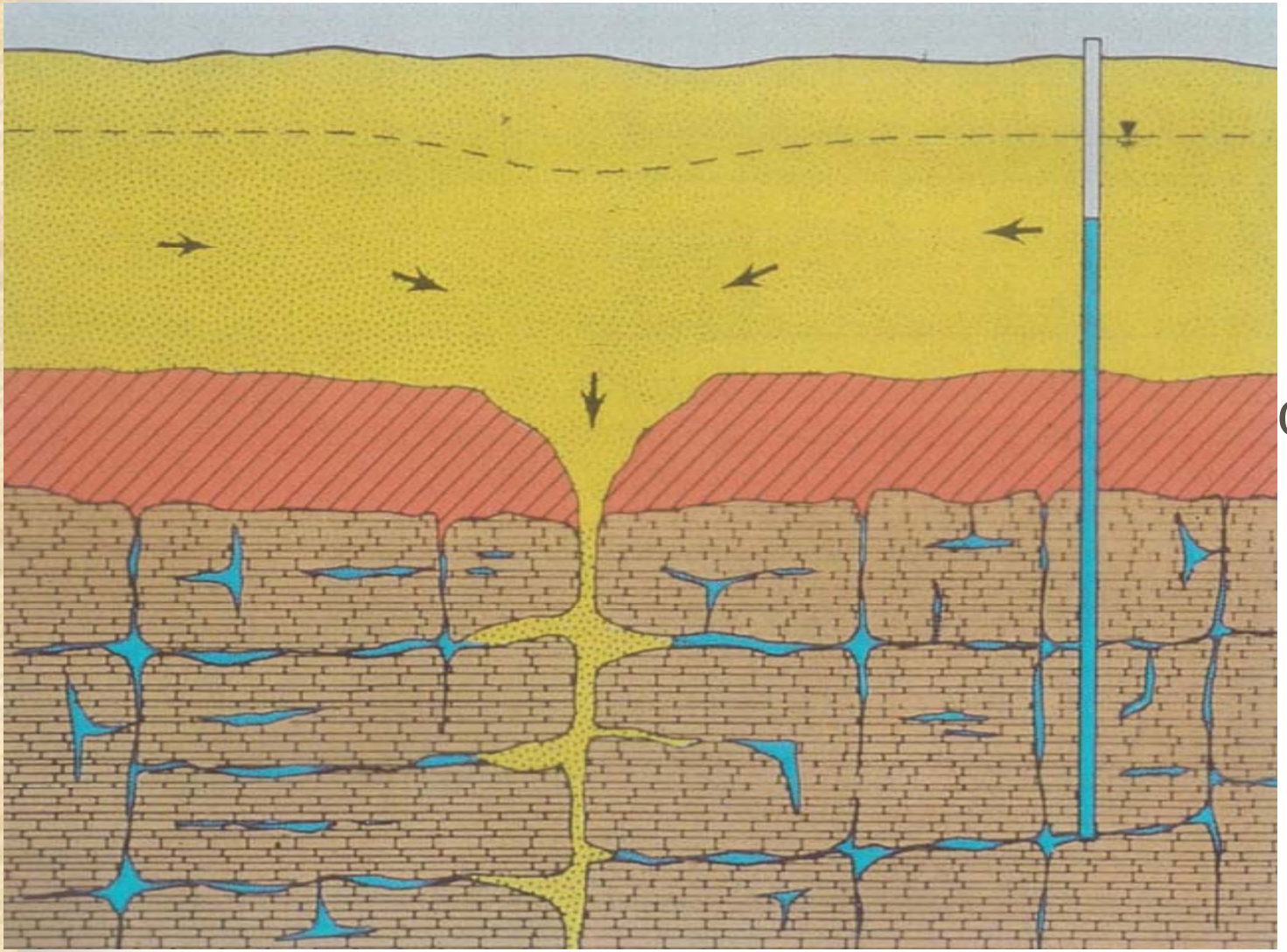
# Soluble Rock



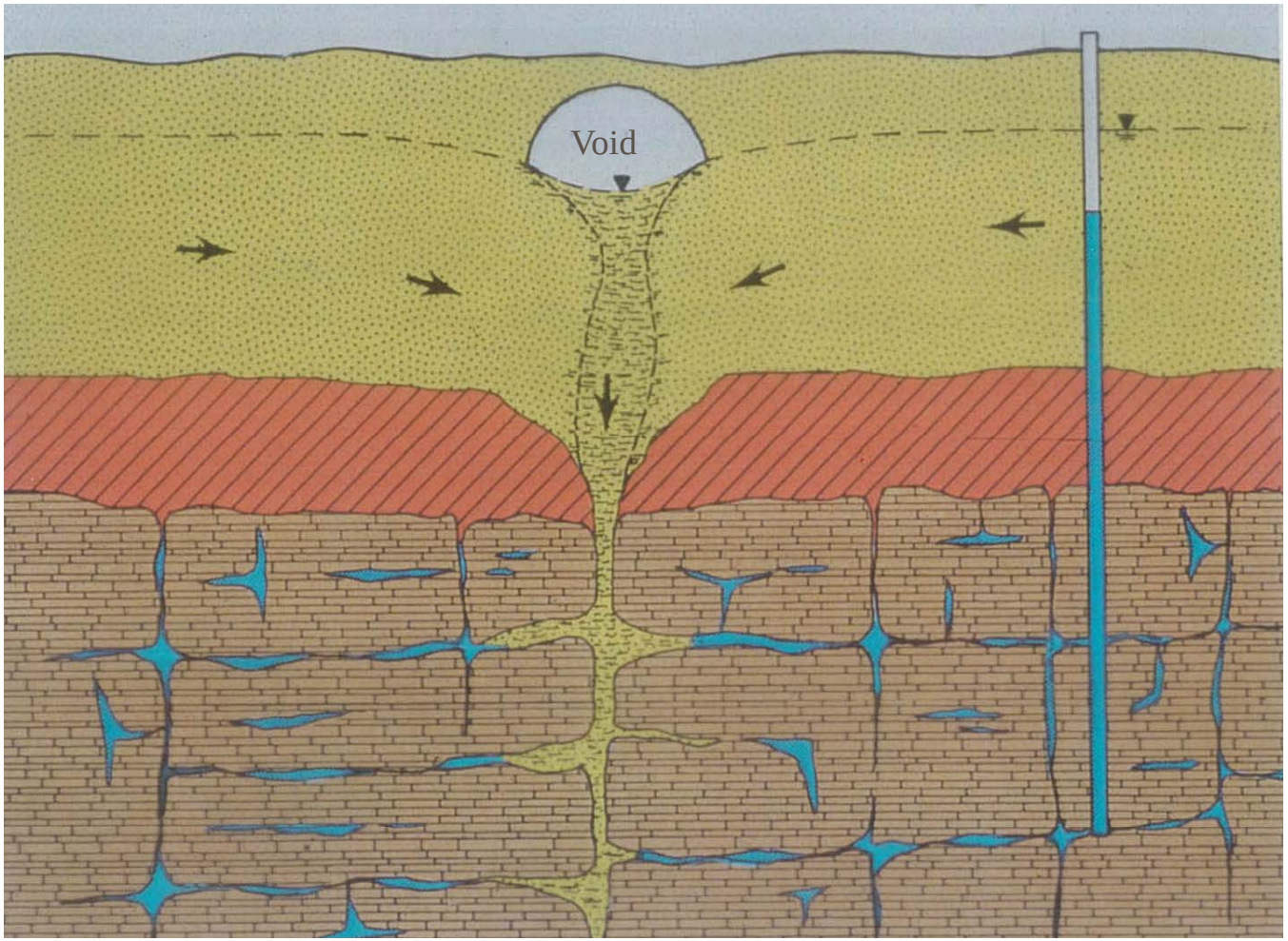

Graphic Courtesy of SWFWMD



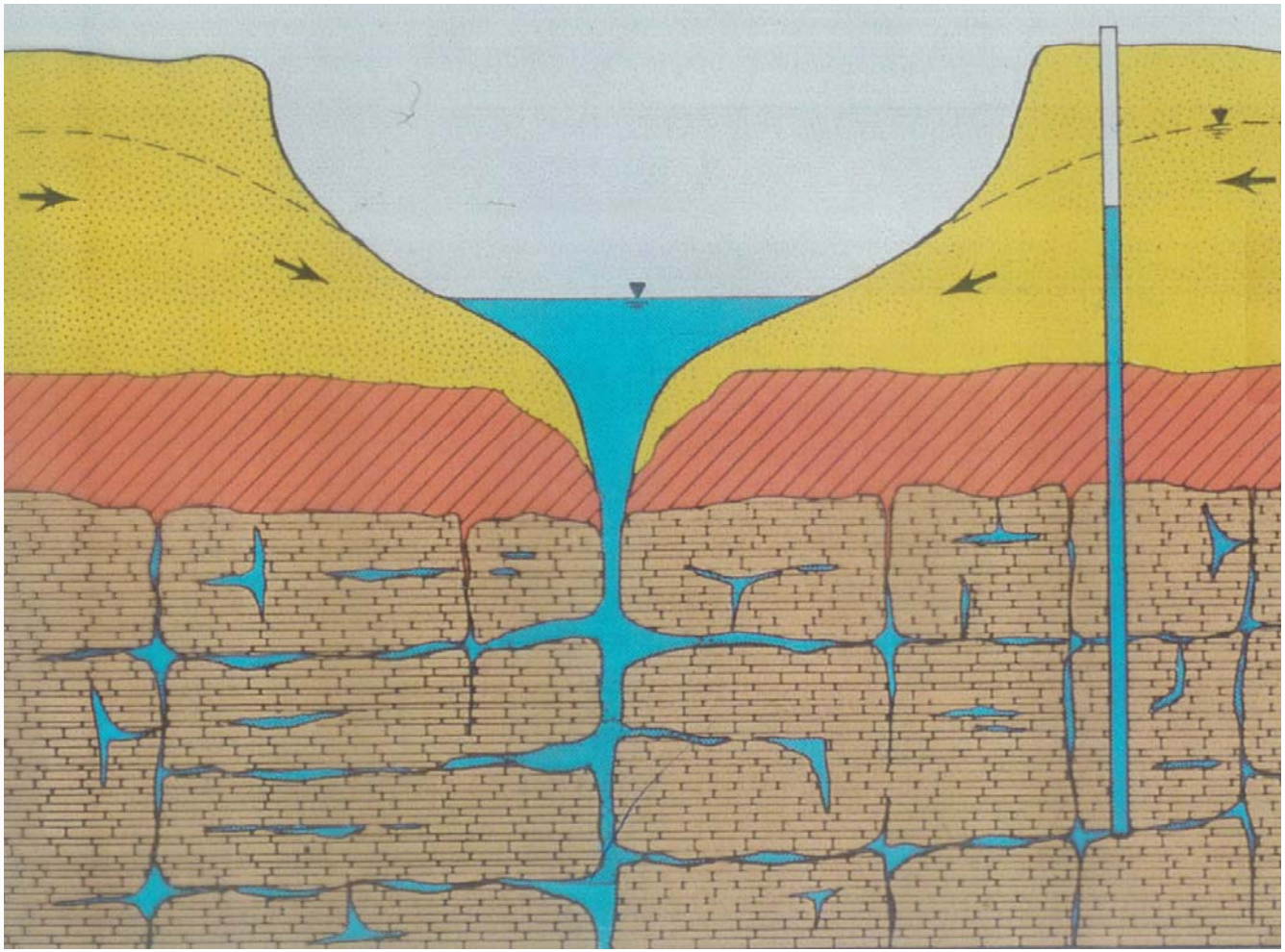
# General Stratigraphy in a Sinkhole Prone Area



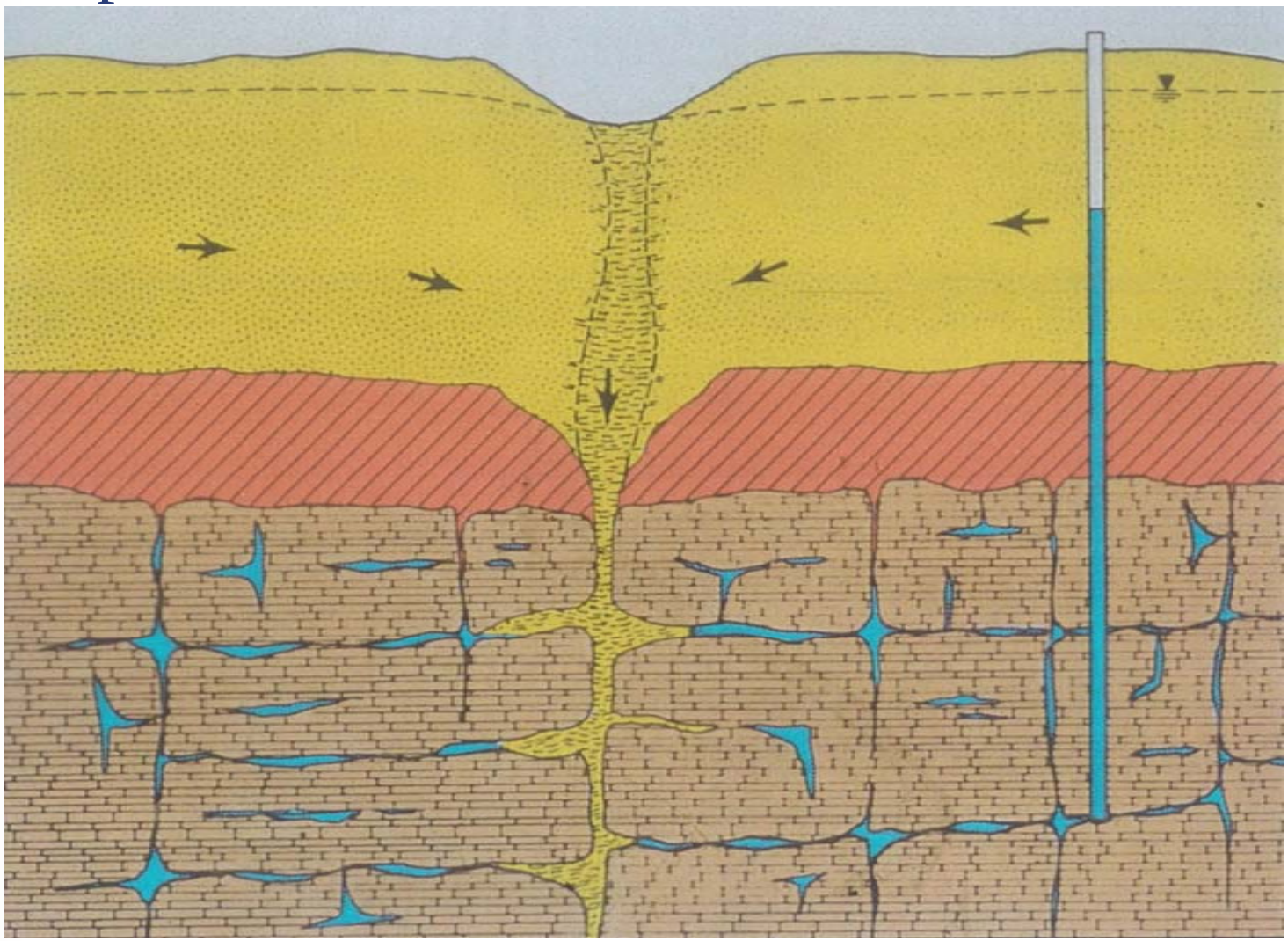
# Early Stage of a Cover Collapse Sinkhole



# Ultimate Cover Collapse Sinkhole



# Development of a Subsidence Sinkhole



# What Do Sinkholes Look Like?


North 50th Street

Wallace Branch Road

# What Do Sinkholes Look Like?


Chitty Road

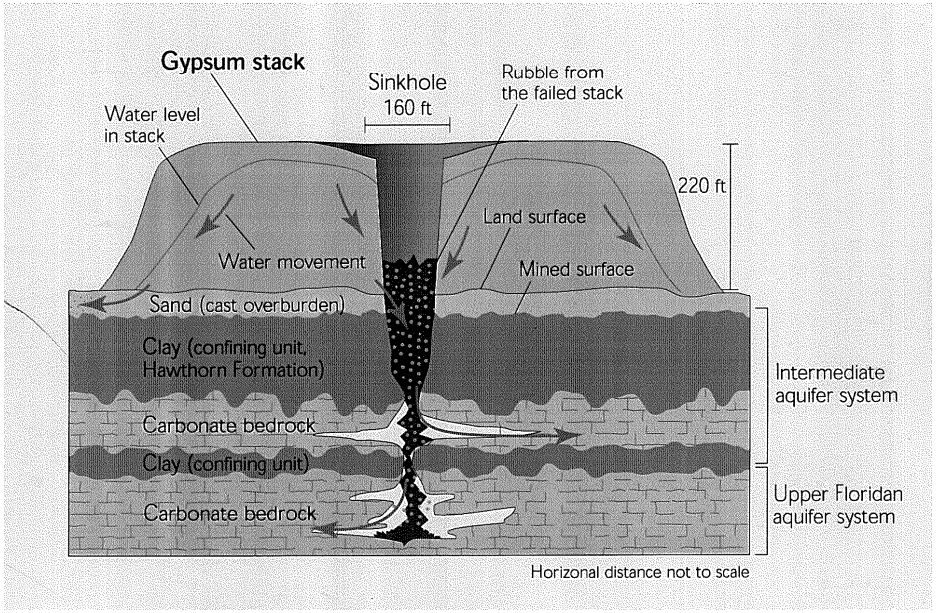
# Some Hide Pretty Well

# Some Are Pretty Famous

Winter Park
Sinkhole

# Another Famous One

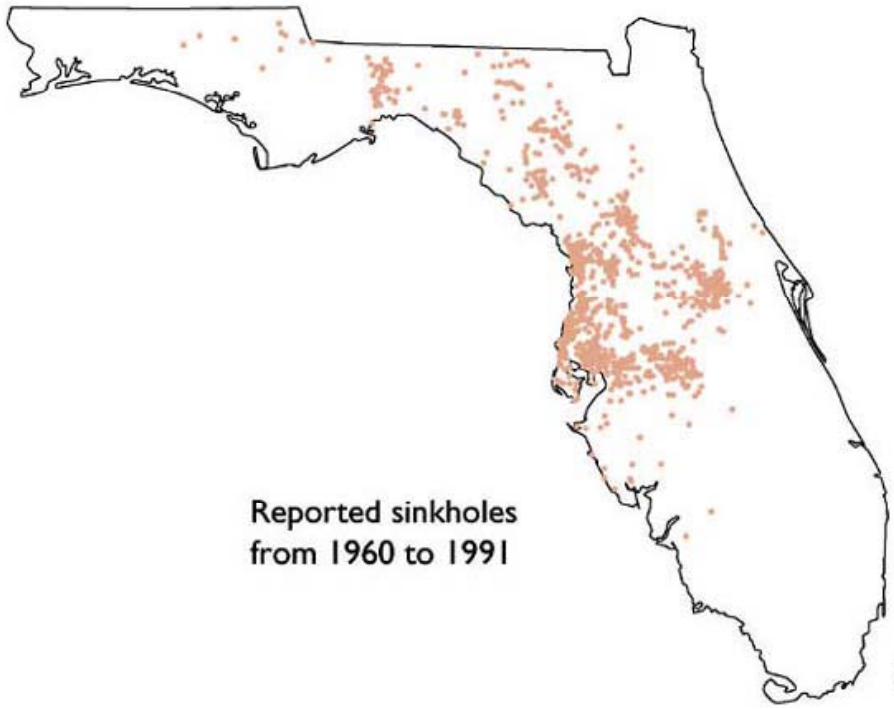
IMC Sinkhole
Polk County, FL



# Exploration for Sinkholes

- Historical information
- Published maps
- Geophysical exploration
- Subsurface exploration

# Historical Information

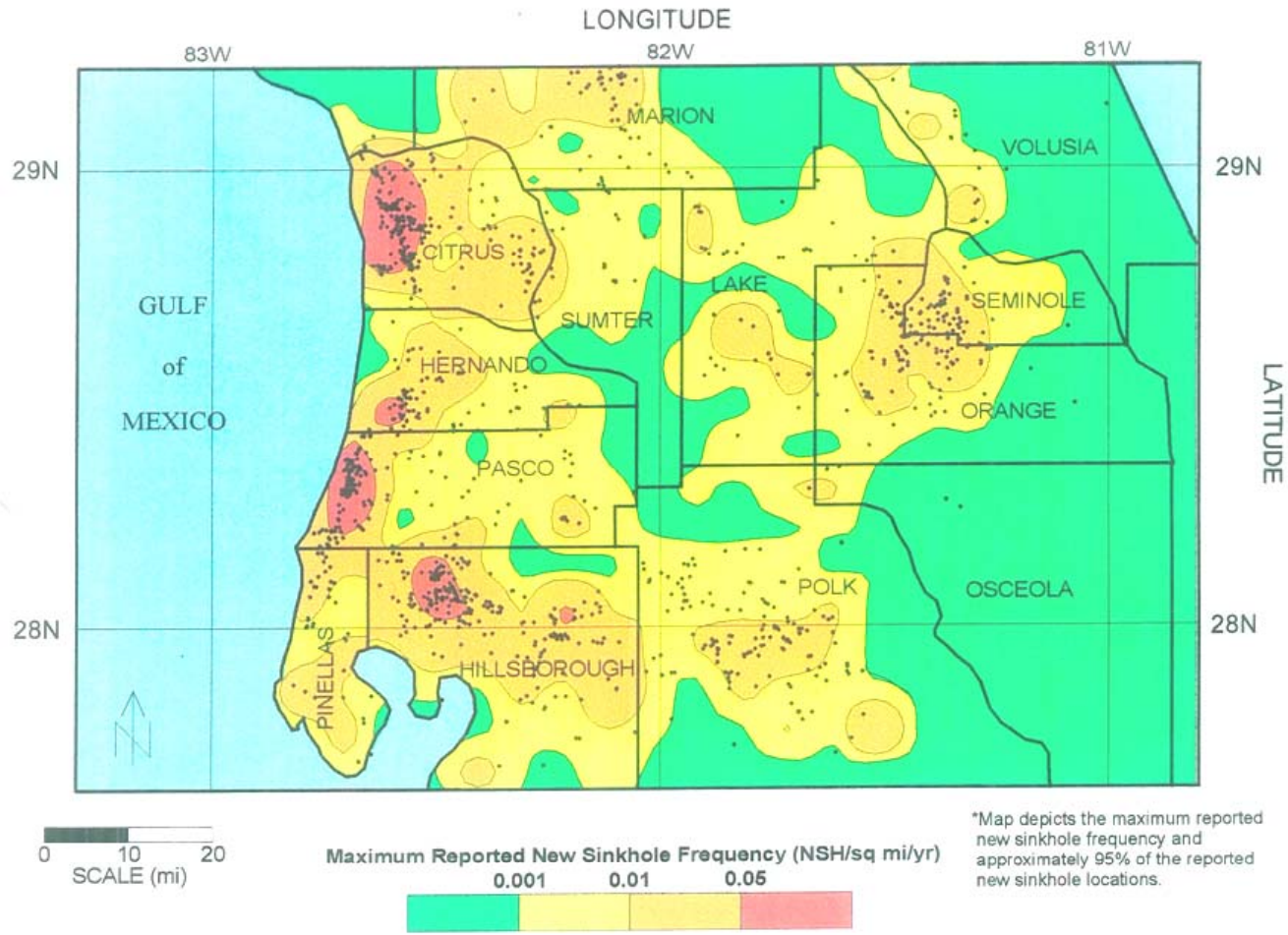


Reported sinkholes
from 1960 to 1991

(Wilson and Shock, 1996)

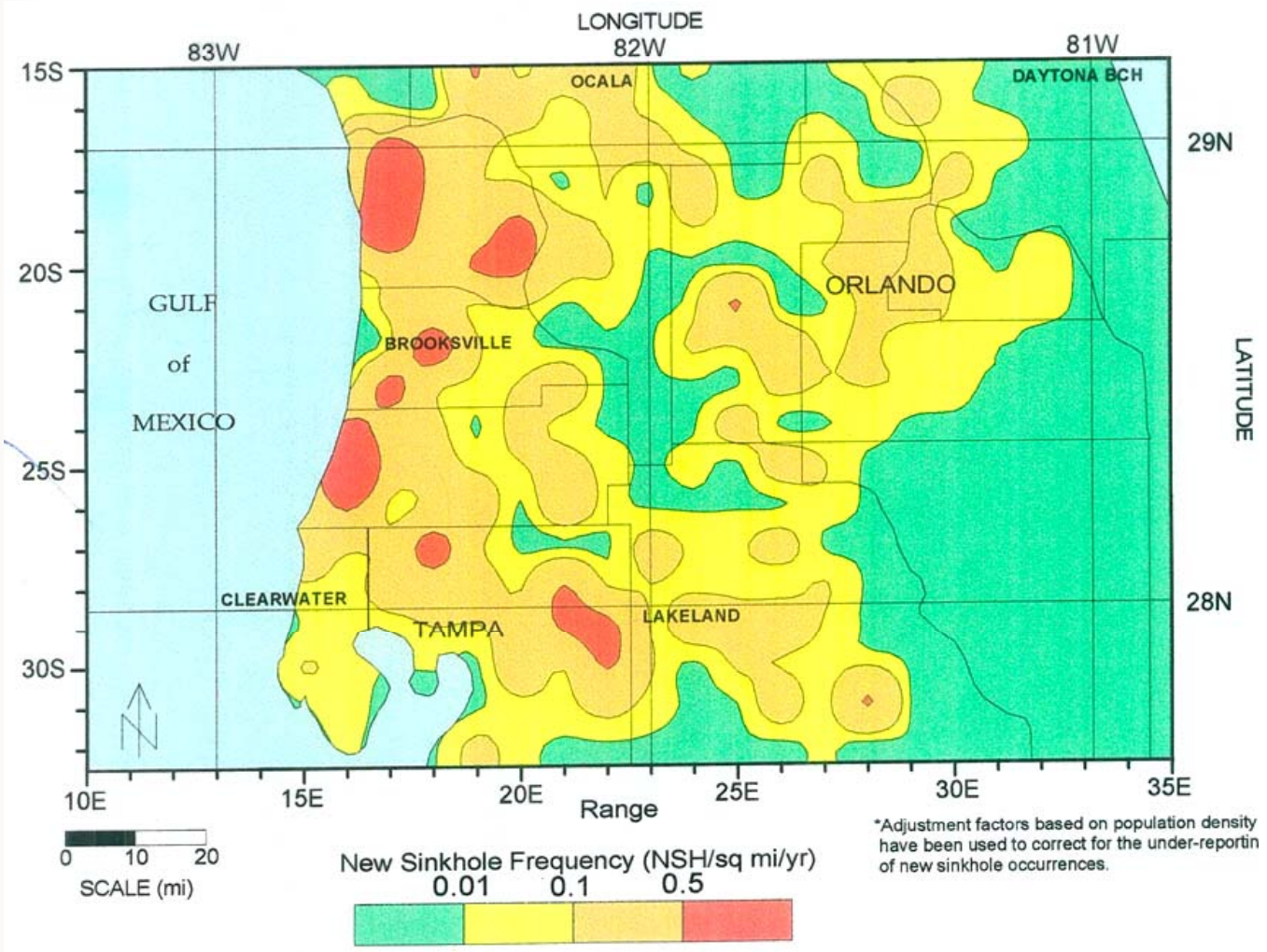
Graphic Courtesy of FSRI

# New Sinkhole Frequency



Graphic Courtesy of FSRI

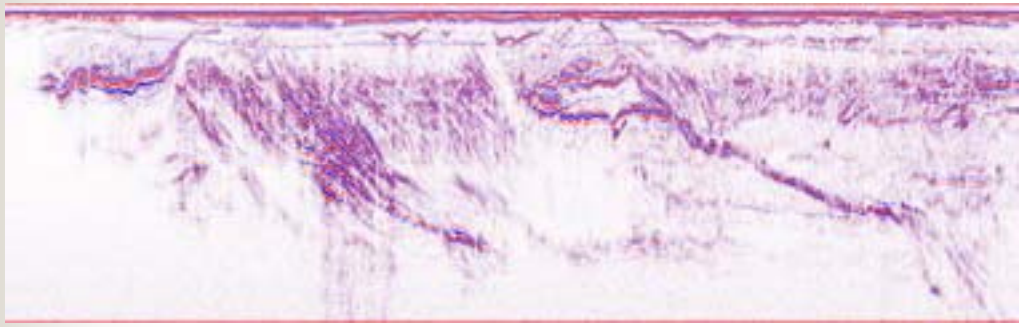
# Predicted Frequency (adjusted)



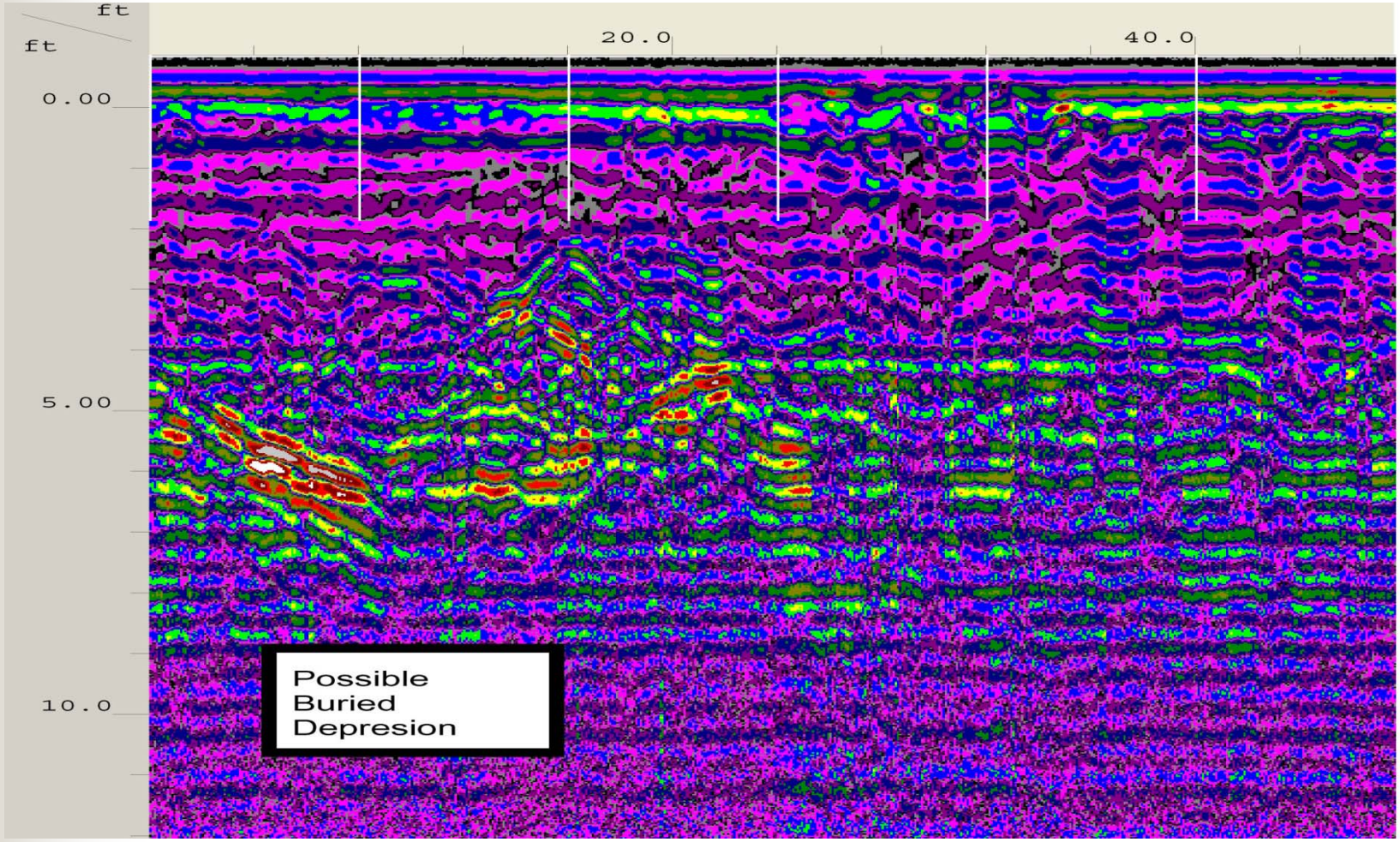
# Geophysical Exploration

- Ground Penetrating Radar (GPR)
- Electrical Resistivity (ER)

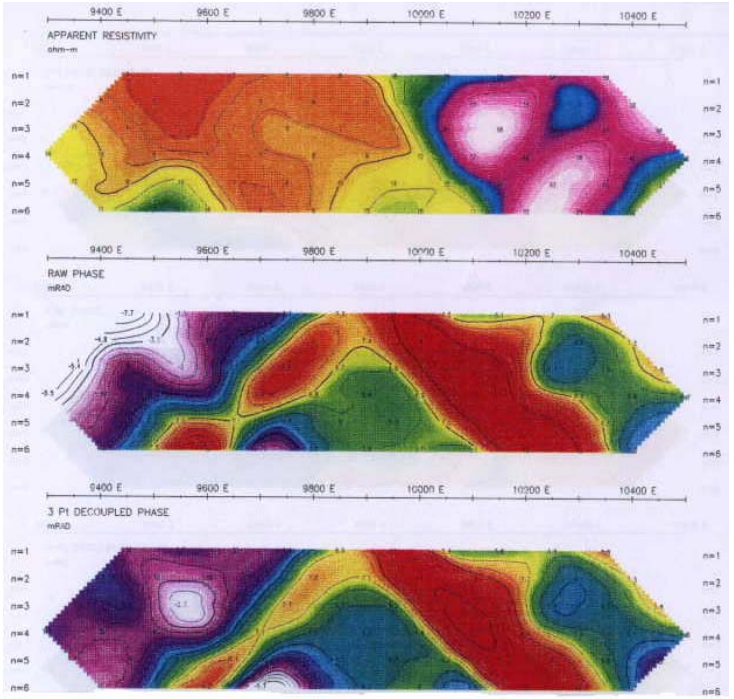
# Ground Penetrating Radar

# GPR Scan



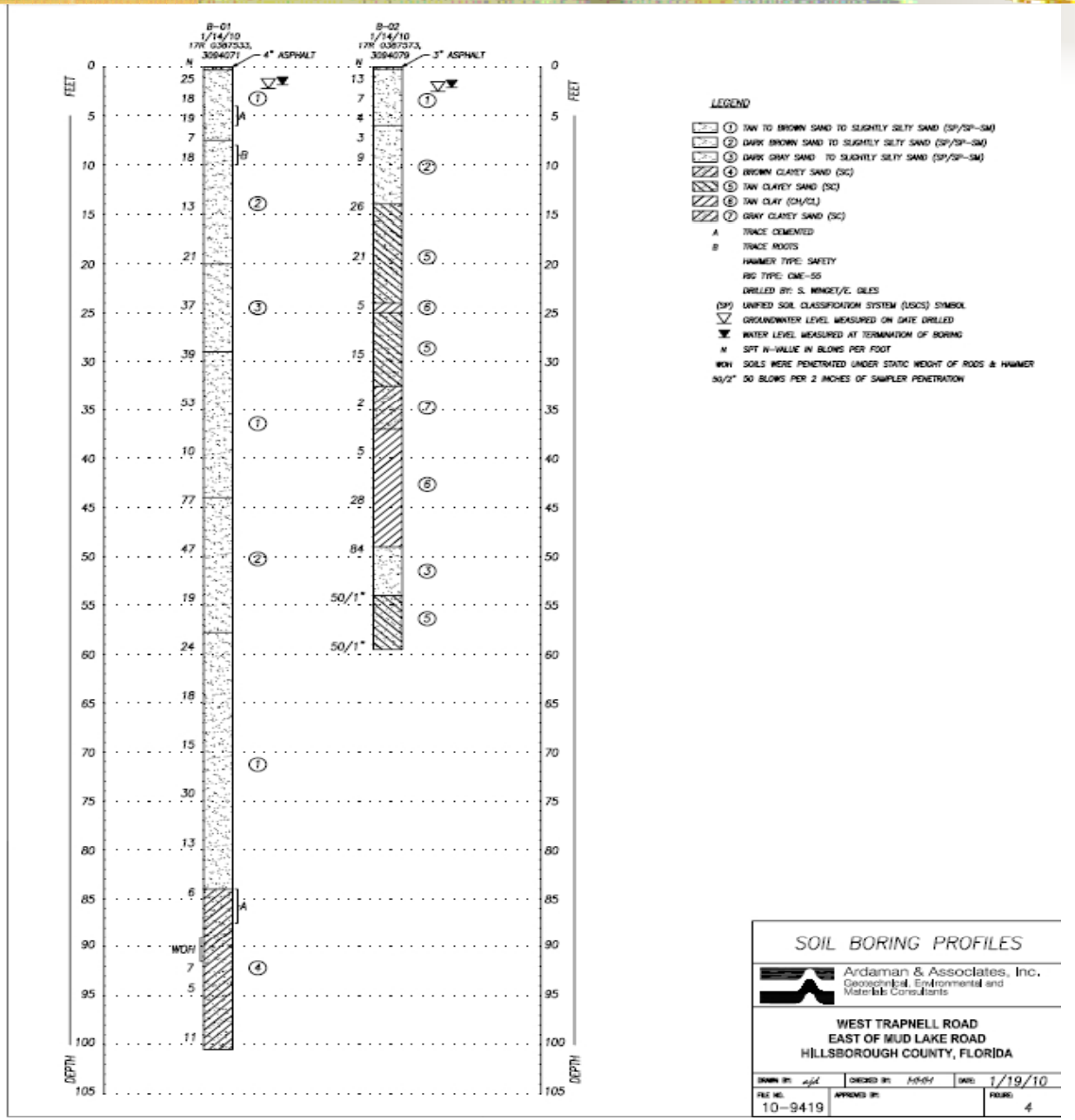
# Electrical Resistivity



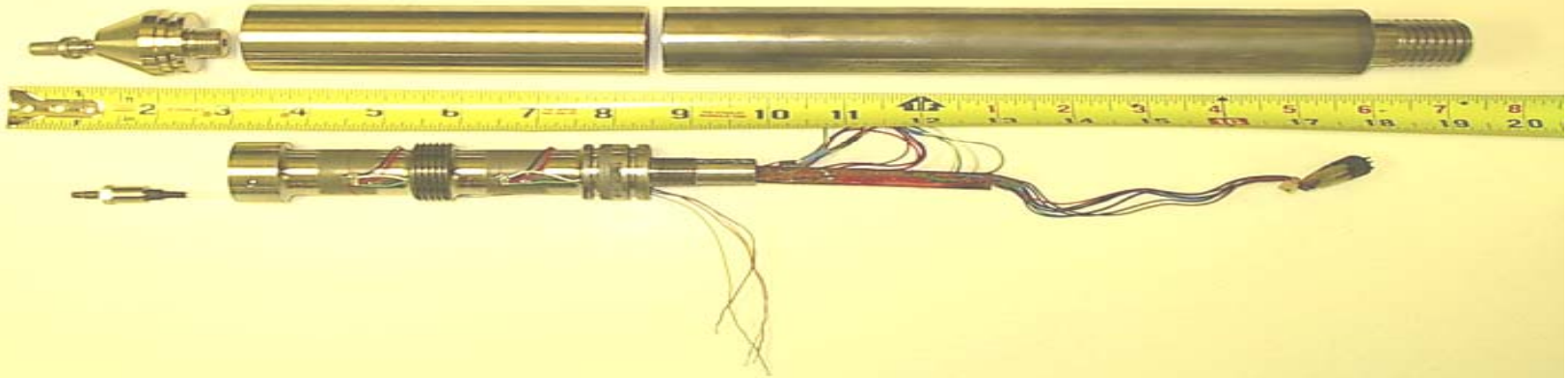
# Subsurface Exploration

- Soil Borings (Standard Penetration Test, SPT)
- Cone Penetrometer Test Soundings (CPT)

# Creating an Underground Picture

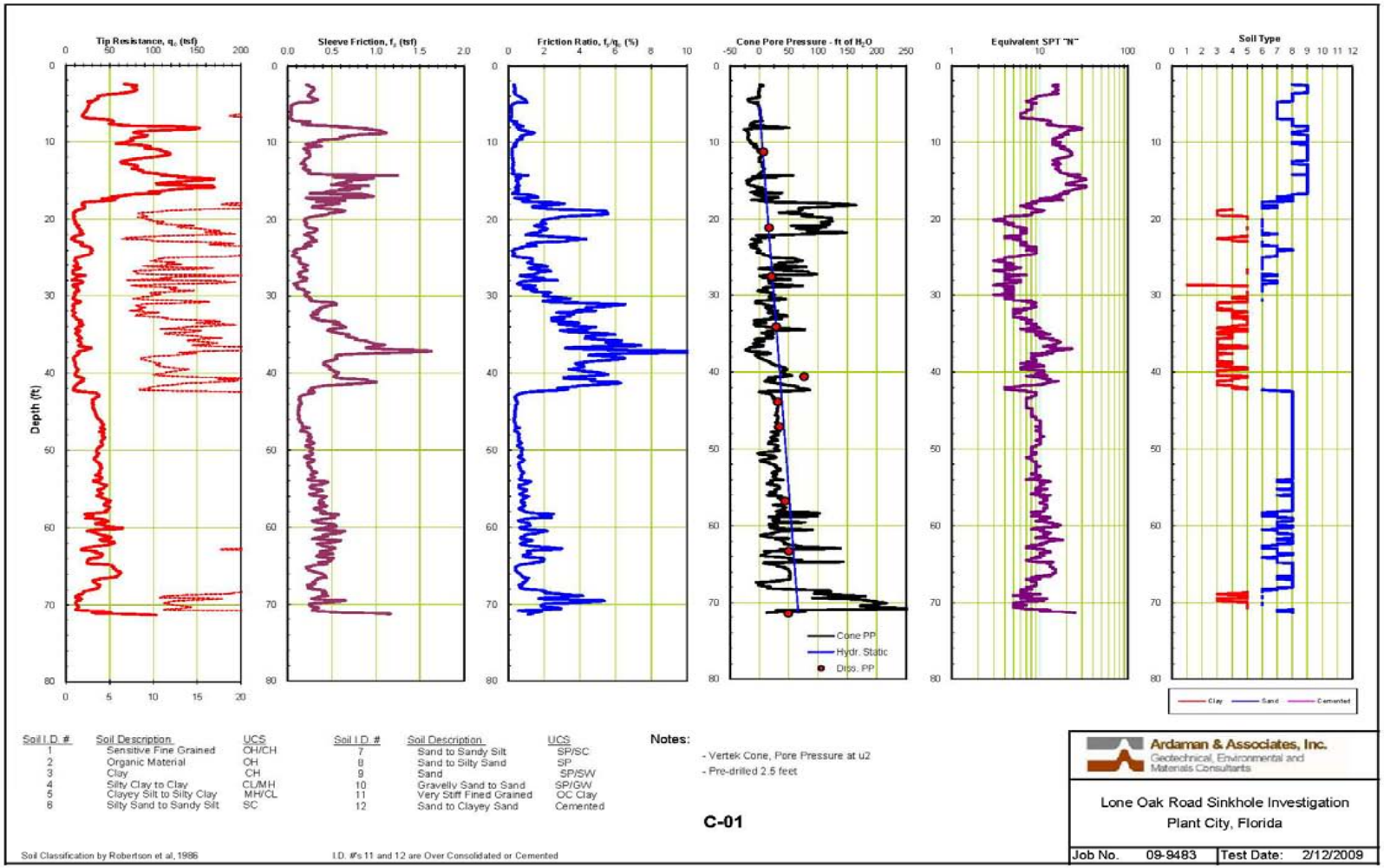


# CPT Probe



# Creating an Underground Picture

## Typical CPTu Log in a Sinkhole




| Soil I.D. # | Soil Description | UCS |
|---|---|---|
| 1 | Sensitive Fine Grained | OH/CH |
| 2 | Organic Material | OH |
| 3 | Clay | CH |
| 4 | Silty Clay to Clay | CL/MH |
| 5 | Clayey Silt to Silty Clay | MH/CL |
| 6 | Silty Sand to Sandy Silt | SC |
| 7 | Sand to Sandy Silt | SP/SC |
| 8 | Sand to Silty Sand | SP |
| 9 | Sand | SP/SW |
| 10 | Gravelly Sand to Sand | SP/GW |
| 11 | Very Stiff Fined Grained | OC Clay |
| 12 | Sand to Clayey Sand | Cemented |

Notes:
- Vertek Cone, Pore Pressure at u2
- Pre-drilled 2.5 feet

C-01

Soil Classification by Robertson et al, 1986

I.D. #'s 11 and 12 are Over Consolidated or Cemented

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

Lone Oak Road Sinkhole Investigation
Plant City, Florida

Job No. 09-9483 Test Date: 2/12/2009

Figure 4

# Creating an Underground Picture

## Evaluation of Sinkhole Formation from u Measurements

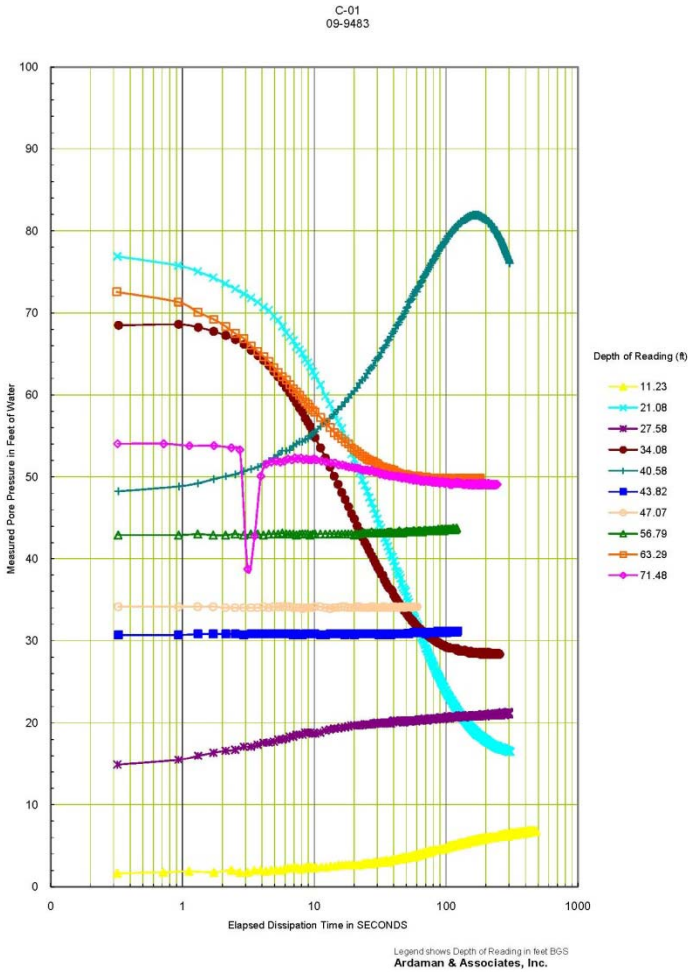



Figure 7

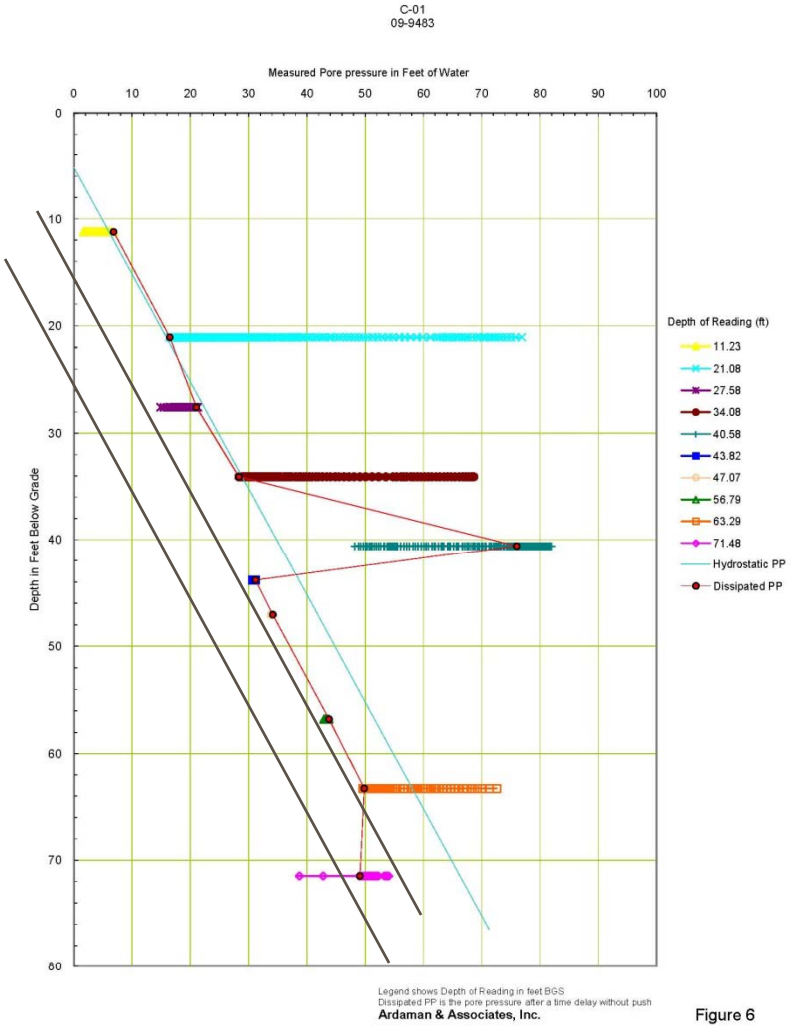



Figure 6

Check the u Dissipation

Then Evaluate the Water Table Drawdown

# Sinkhole Remediation

- “Do Nothing”
  - Monitor
  - Risk Evaluation
  - Road Closure
- Remediation
  - Subsurface Grouting
  - Other Alternatives

# Grouting

# Grouting

# Developing an Alternative Grout Geofoam

The Geofoam Lightweight Fill shall meet the following:

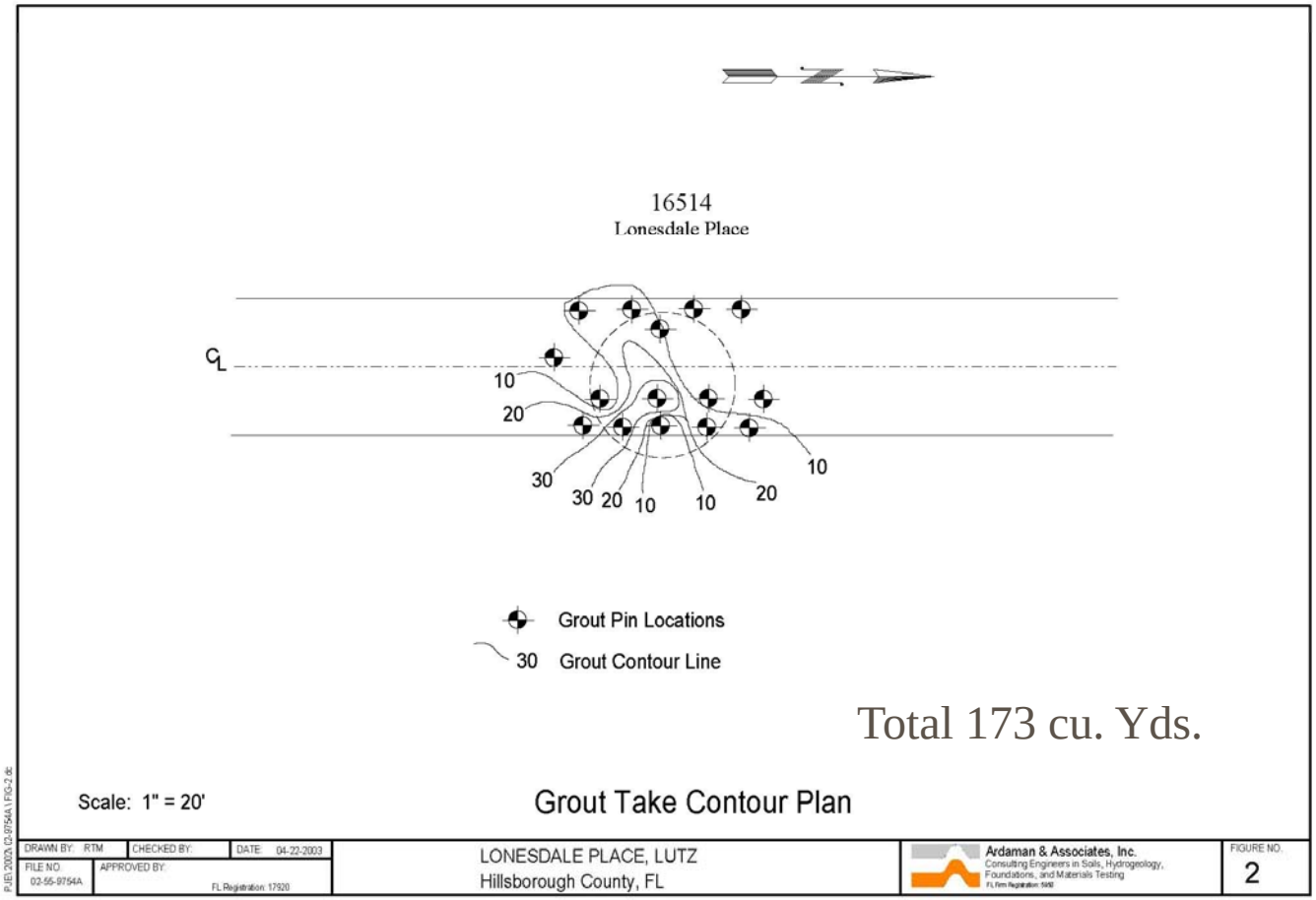
| | CATEGORY | | |
|---|---|---|---|
| | II | III | IV |
| Maximum Cast Density, pcf | 30 | 36 | 42 |
| Maximum Compressive Strength, psi | 40 | 80 | 120 |
| Freeze-Thaw Resistance, Cycles Relative E not less than 70% per ASTM C666, modified | 330 | - | 330 |
| Shear Modulus, G. psi per ASTM D4015 at confining stress of 3 psi | 27,670 | 41,800 | - |
| Young's Modulus, E, psi based on Poisson's Ratio u=0.22 and E=2G (1+u) | 67,500 | 101,900 | - |
| % Water Absorption, after 120 days, maximum | 20 | 16 | 14 |
| Coefficient of Permeability, kcm/sec., per ASTM D2434 | | | |
| Confining stress, 2.5 psi | 4.7x10-5 | 1.5x10-6 | |
| Confining stress, 18 psi | 1.9x10-5 | 5.4x10-7 | |

# The Development Effort of Geofoam

Ron Broadrick, EarthTech
Walt Williams, HDPW
Ross McGillivray, Ardaman

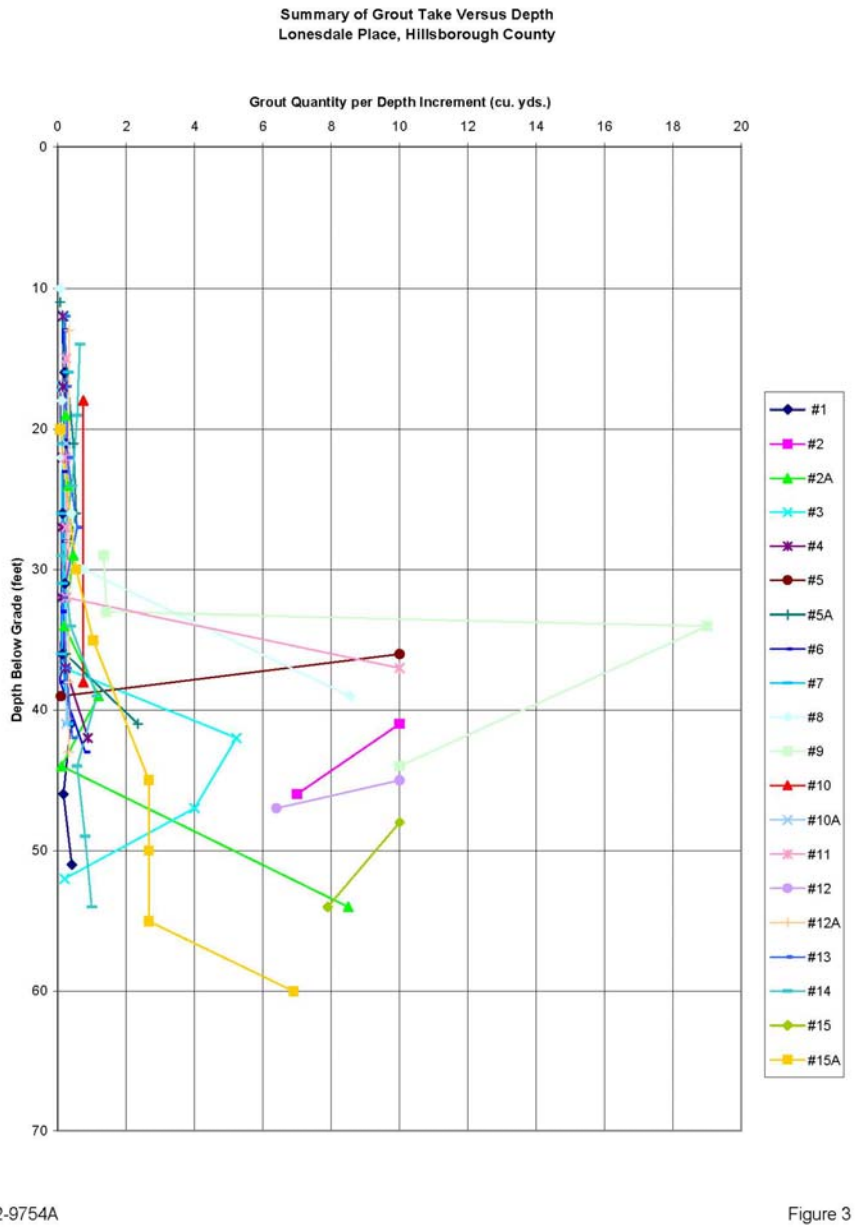

# Geofoam on the Site: Lonesdale Place Sinkhole

# Foam Grout Results – Lonesdale Place



# Estimated Grout Distribution versus Depth below Grade

This shows that the grout is placed mostly above the limestone




02-9754A

Figure 3

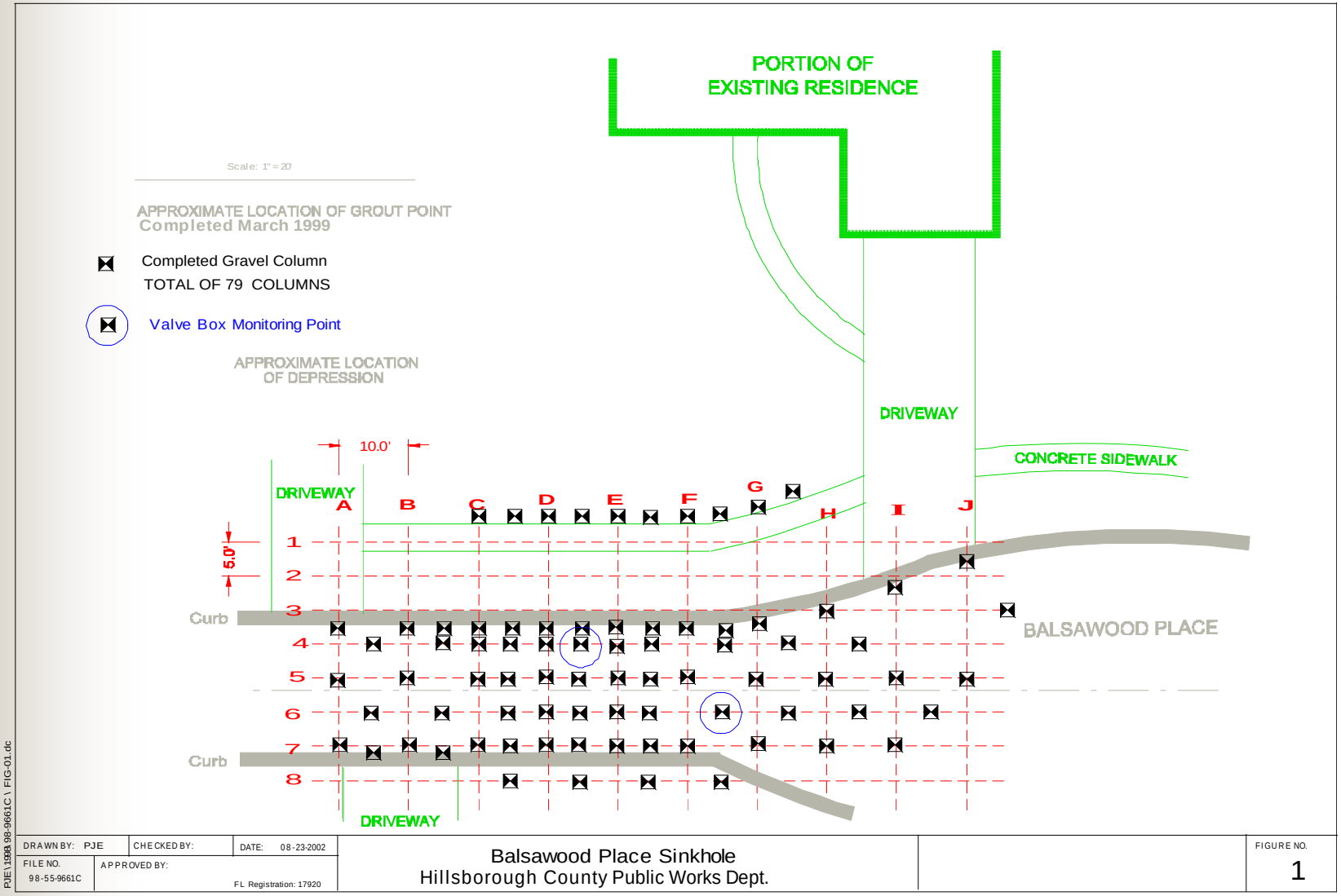
# An Alternative to Grout
# GRAVEL COLUMNS

Although the traditional remediation system for sinkholes is grout injection, usually low mobility grout, sometimes it doesn't work. Also, the costs of grout may be high, and an alternative system might be used.

Balsawood Place was grouted in 1999 with 325 cu. yards in 13 grout points 28 to 44 feet deep. However, the area continued to subside. An alternative system was proposed; CSC Gravel Columns.

# CSV Gravel Columns


# Locations of CSV Gravel Columns



# CSV Gravel Columns:
## Balsawood Place,
## Hillsborough County, FL

1. Used #89 Silica Gravel
2. Limited to about 35 feet below grade with the rig
3. Total cost about ½ the cost of the previous grouting

The project was completed in March, 1999 with no further subsidence

# Another Alternative: Deep Gravel Columns

Deep gravel columns can be installed with three different technologies:

1. Top Feed, Hydraulic Vibratory Methods (Stone Columns)
   a. Experience has shown that this system can trigger sinkholes that may be pre-existing.
   b. The system requires a high rate supply of water.
2. Bottom Feed Dry System: Vibratory Hammer & Top Hopper
   a. The equipment may have mobilization and access problems
   b. The vibration could trigger sinkhole activity (that is good in some cases, bad bad in others.
3. Reverse Auger System
   a. The system uses mobile drilling equipment
   b. There may be access problems due to overhead restrictions.

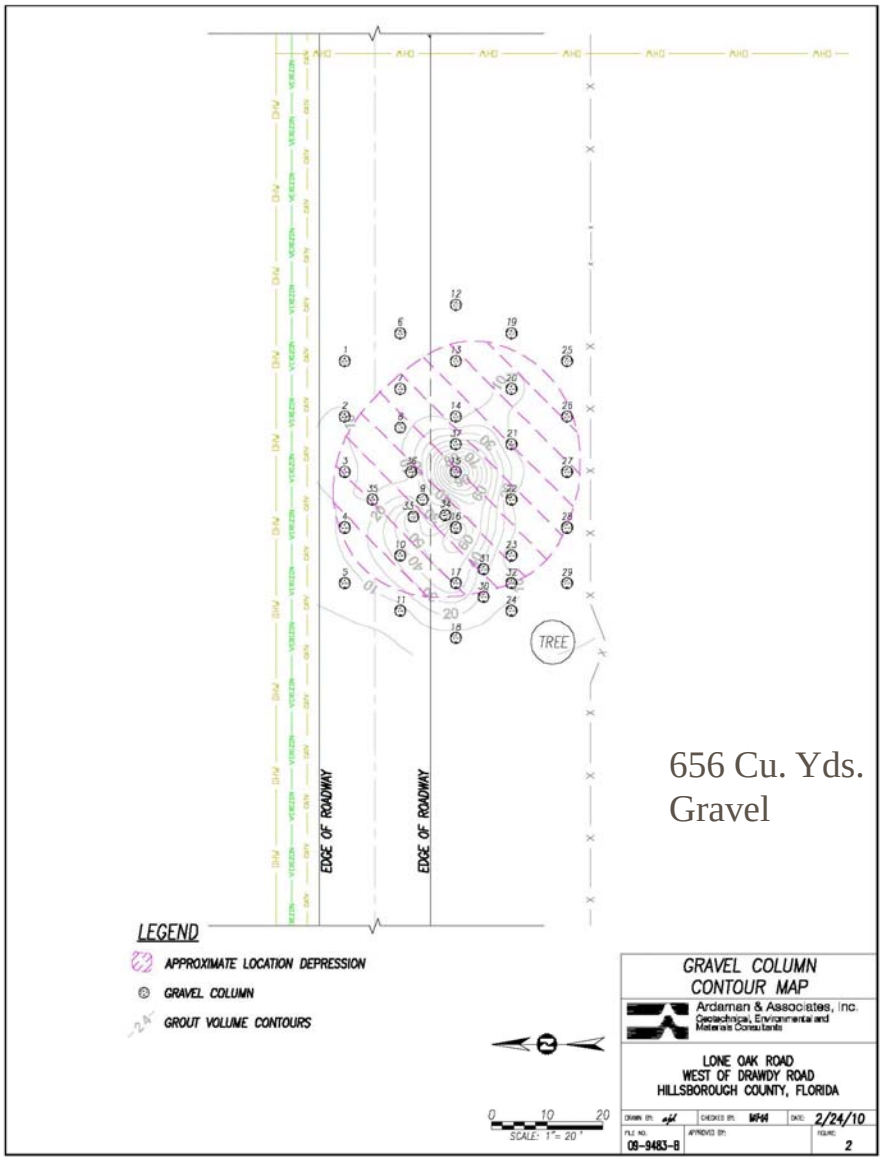
# Typical Stone Columns


# Augured Gravel Columns

# The Sinkhole at Lone Oak 2009/2010

# Placing Gravel Columns

# Gravel Column Results – Lone Oak




656 Cu. Yds. Gravel

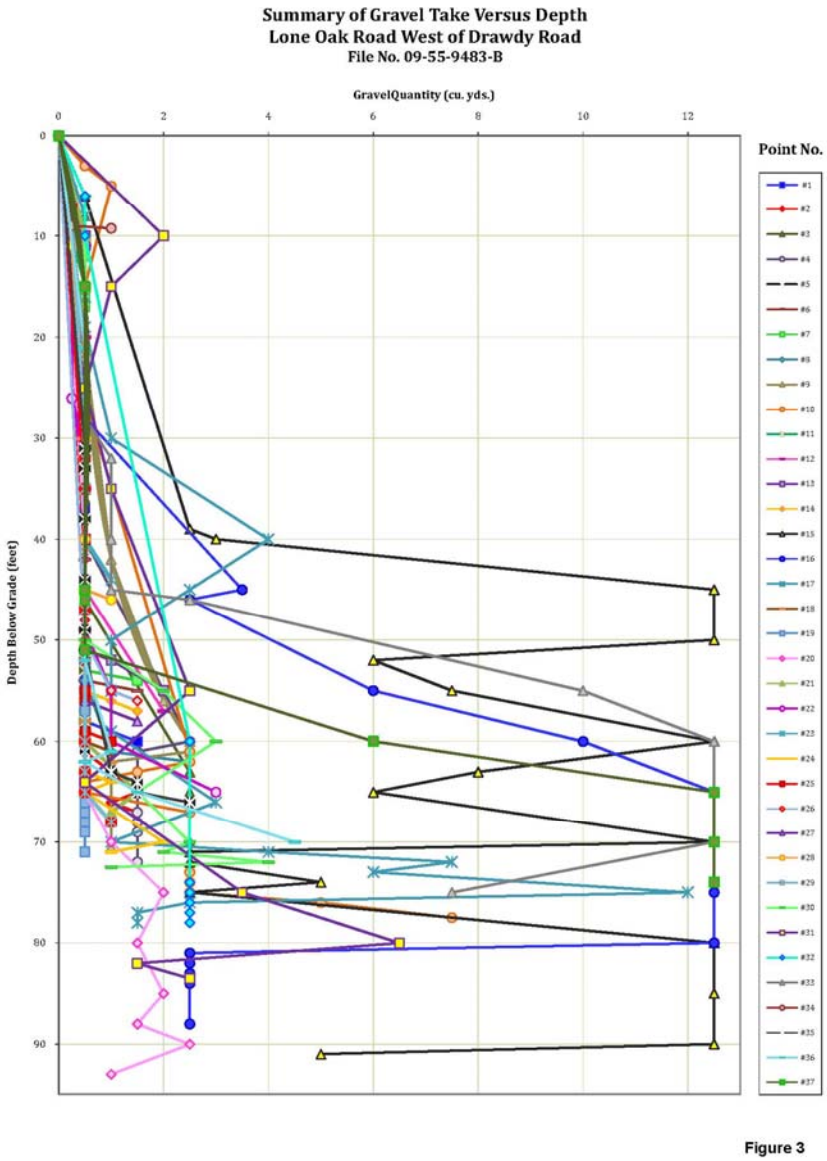



Figure 3

# Sinkholes & Sinkhole Remediation

## Summary

1. The traditional method, grouting:
   a. Good site access
   b. Low site footprint
   c. Grout volume may be difficult to control

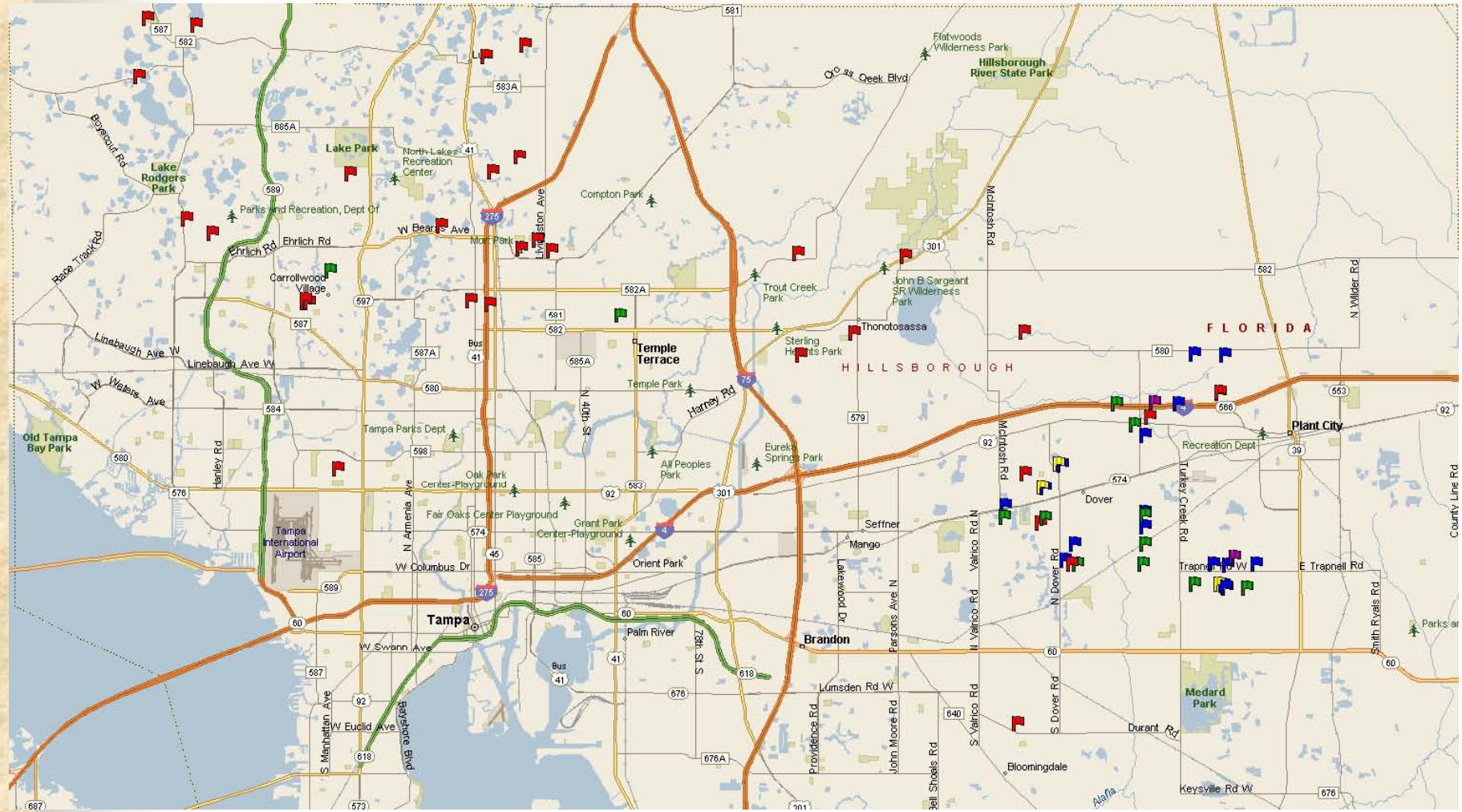
2. Alternative 1: Geofoam Grout
   a. A, b & c above
   b. Lower cost material
   c. Total cost savings to the County

3. Alternative 2: Augered Gravel Columns
   a. Limited site access, especially for overhead powerlines
   b. Low site footprint
   c. Gravel volumes are less than grout, and less likely to cause surface problems such as ground heave
   d. Total Cost Savings to the County where the system can be used.
   e. No effect to adjacent property owners

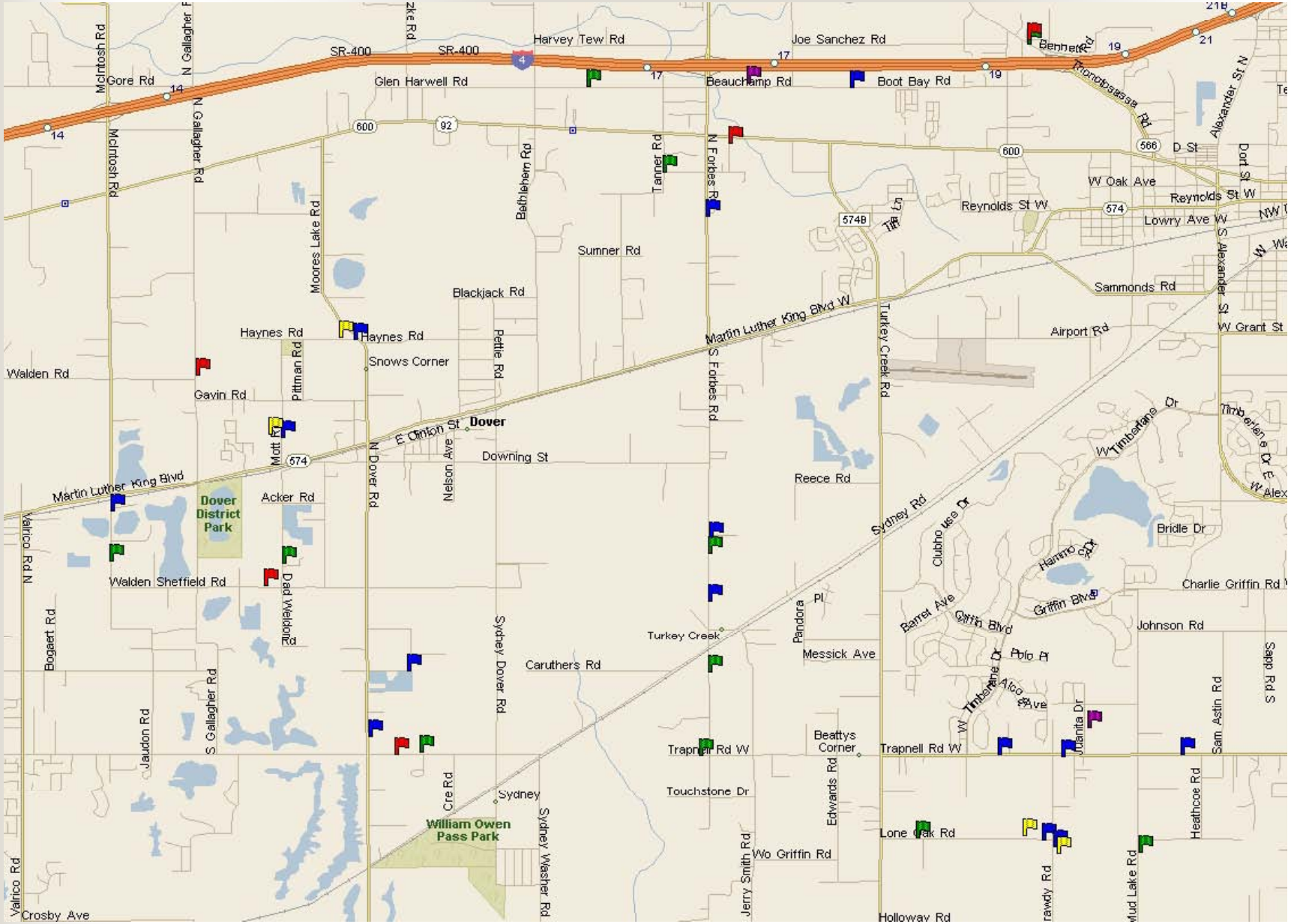
# The Numbers

- 2008
  - 1 Investigation
  - 1 Remediation
- 2009
  - 11 Investigations (9 in Plant City Area after freeze event)
  - 5 Remediations (all grout)
  - 1 Permanent road closure
  - 5 Resurface and monitor
- 2010
  - 37 Investigations (34 in Plant City Area after freeze event)
  - 4 of the 5 2009 monitor sites collapsed
  - 15 Resurface and monitor
  - 20 Remediated (3 gravel only, 2 gravel and grout, 15 grout)
  - 1 Permanent road closure (same road as 2009)
  - 1 Site still closed (railroad issues)

# The Sites


Lake Park
Lake Rodgers Park
North Lakes Recreation Center
Parks and Recreation, Dept Of
Compton Park
Carrollwood Village
Trout Creek Park
John B Sargeant SR Wilderness Park
Thonotosassa
Sterling Heights Park
Temple Terrace
Temple Park
Tampa Parks Dept
Eureka Springs Park
All Peoples Park
Oak Park Center-Playground
Fair Oaks Center Playground
Grant Park Center-Playground
Orient Park
Tampa International Airport
Tampa
Palm River
Brandon
Seffner
Mango
Dover
Plant City
Recreation Dept
Medard Park
Bloomingdale
Lumsden Rd W
Durant Rd
Keysville Rd W
E Trapnell Rd
Old Tampa Bay Park
Flatwoods Wilderness Park
Hillsborough River State Park
FLORIDA
HILLSBOROUGH

# The Sites


SR-400
SR-400
Harvey Tew Rd
Joe Sanchez Rd
Glen Harwell Rd
Beauchamp Rd
Boot Bay Rd
Bennett Rd
Gore Rd
McIntosh Rd
N Gallagher Rd
Moores Lake Rd
Bethlehem Rd
Tanner Rd
N Forbes Rd
Sumner Rd
Blackjack Rd
Haynes Rd
Haynes Rd
Snows Corner
Walden Rd
Gavin Rd
Pittman Rd
Pettie Rd
Martin Luther King Blvd W
Turkey Creek Rd
Airport Rd
Sammonds Rd
W Oak Ave
Reynolds St W
Lowry Ave W
S Alexander St
W Grant St
E Clinton St
Dover
Mott Rd
Downing St
Nelson Ave
N Dover Rd
Martin Luther King Blvd
Dover District Park
Acker Rd
Reece Rd
Sydney Rd
Clubhouse Dr
Bridle Dr
Walden Sheffield Rd
Bell Wethington Rd
Valrico Rd N
Bogaert Rd
Jaudon Rd
S Gallagher Rd
Sydney Dover Rd
Turkey Creek
Pandora Pl
Barret Ave
Griffin Blvd
Charlie Griffin Rd
Johnson Rd
Messick Ave
Caruthers Rd
Trapnell Rd W
Beattys Corner
Edwards Rd
Juanita Dr
Sam Astin Rd
Heathcoe Rd
Touchstone Dr
Cre Rd
Sydney
William Owen Pass Park
Sydney Wagner Rd
Jerry Smith Rd
Wo Griffin Rd
Lone Oak Rd
Valrico Rd
Crosby Ave
Holloway Rd

# Questions?