

An Innovative Approach to Characterizing, Permitting, and Constructing Landfills in Karst Geologic Settings

Robert C. Bachus, Ph.D., P.E., Geosyntec Consultants

Richard B. Tedder, P.E., Florida Department of Environmental Protection

Session 3: Geohazards and Infrastructure
Geohazards Impacting Transportation in Appalachia
Chattanooga, TN
3 August 2011

Innovative....

- Presentation Topic
 - An Innovative Approach to Characterizing, Permitting, and Constructing Landfills in Karst Geologic Settings
 - *Innovation* relates to a rather unique collaboration between an environmental regulator and the regulated community
- Innovative Presentation
 - Infrastructure *du jour* is the municipal solid waste landfill
 - I want to set the stage using a rather long introduction and then ask you for your opinion, insight, and recommendations
 - *Innovation* relates to the fact that I have never done this type of thing before

Problem Statement and Objectives

- Federal regulations exist to govern the siting and design for modern landfills
- Landfills have to be constructed on “stable” ground
- Karst (and other geohazards) present significant challenges:
 - Engineering design (stability)
 - Hydrogeology (monitorability)
 - Construction (soil/rock condition, voids, variability)

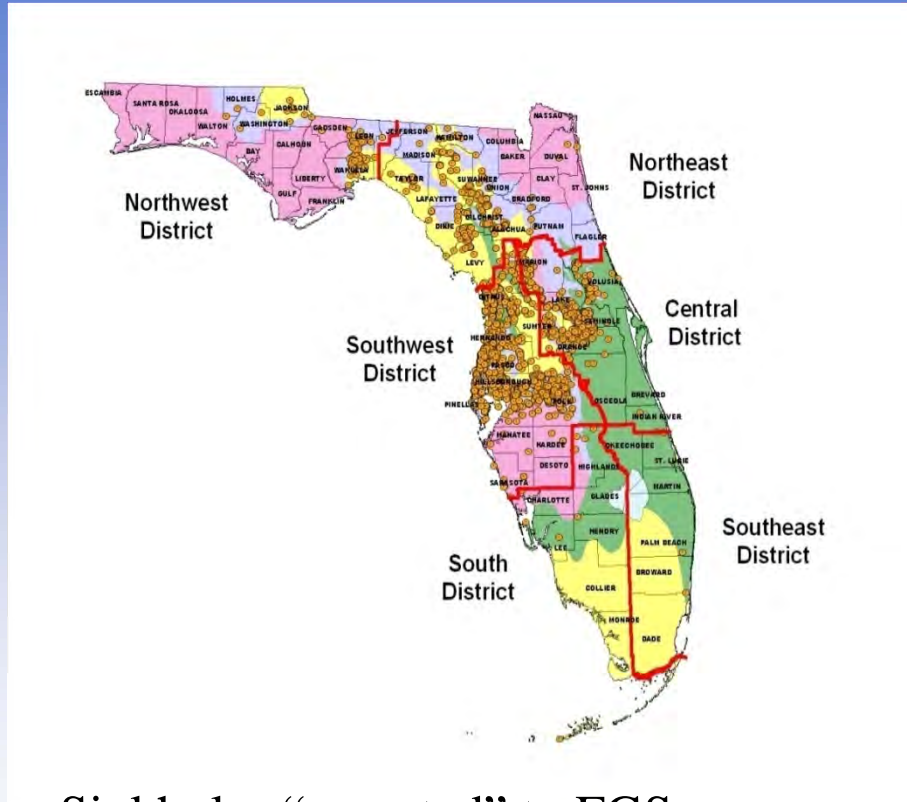
Problem Statement and Objectives

- All parties need objective criteria to address siting, design, monitorability, operations
- Florida Department of Environmental Protection (FDEP) needs to address issues when considering permitting in karst across the State
- Convened a Technical Advisory Group (TAG) and solicited public participation to help develop objective guidelines.

Why TAG?

- Recent Class I Landfill permitting projects in karst areas in Florida raised questions about potential risks to ground water if sinkholes formed and damaged the liner systems.
- While the actual risks to ground water are unclear, the potential risks have created great difficulty for the Department and for applicants when trying to process permit applications for solid waste disposal facilities in Florida
- Need objective expertise to assist the Agency

Florida Geological Survey (FGS) Subsidence Incidence Reports



Sinkholes “reported” to FGS
but not necessarily “verified.”

- Distribution in DEP’s Six Districts:
 - SWD: 1,403 (60%)
 - CD: 586 (25%)
 - NED: 246 (10.5%)
 - NWD: 99 (4.2%)
 - SD: 9 (0.4%)
 - SED: 4 (0.2%)
- Total = 2,347 (as of 03-16-09)

Goals of the TAG

- Guidance is needed to:
 - Help the Department decide how to evaluate and issue these solid waste disposal permits; and,
 - Help applicants know what information should be submitted when seeking them.
- When developing the guidance, we need to:
 - Balance proposed “costs” with the “risks of failure;”
 - Use both “good science” and “reasonable judgment” when making recommendations; and,
 - Set aside personal interests, if any, and focus on what is really “good” for Florida.

Why Geohazards Conference

- The FDEP approach focuses on technical issues regarding the investigation, characterization, design, and construction of engineered facilities in karst geologic settings.
 - Technical issues impact all engineered facilities, not just those constructed for environmental applications.
 - Approach developed by FDEP may benefit other agencies, owners, and consultants.
- The conference participants at this conference may have specific experiences and recommendations that will ultimately be beneficial to the FDEP.
 - Actively engage the participants
 - Solicit input based on their experience and expertise.

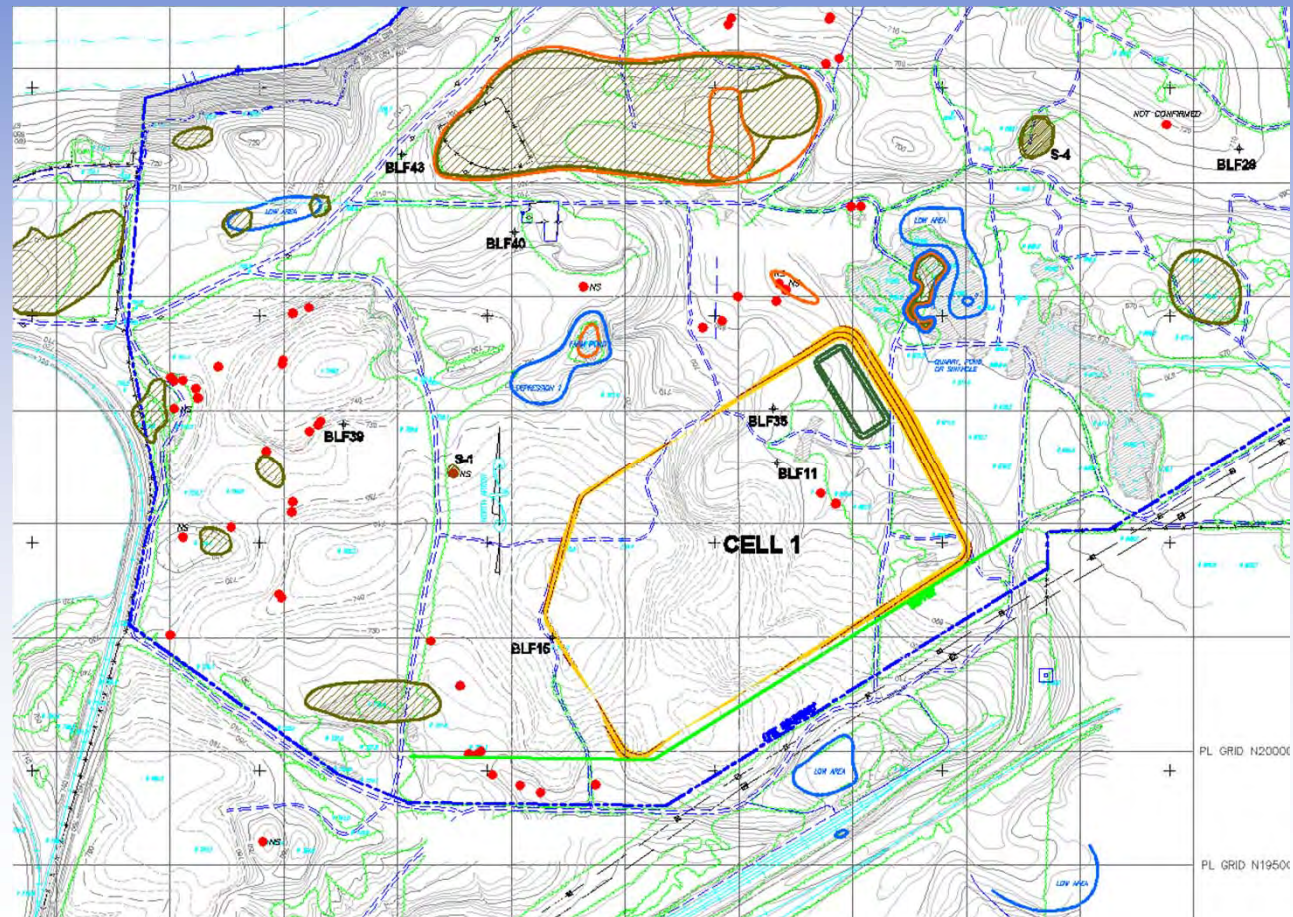
-

Geohazards...plus

- Since you are all here today, we share a common bond of.... geohazards
- What are your backgrounds?
 - karst ...or other geohazard?
 - landfill expertise and/or regulatory knowledge?
 - permittee or permitter?
 - engineer, geologist, hydrogeologist, scientist?
 - exhibitor/vendor (tools of the trade expertise)

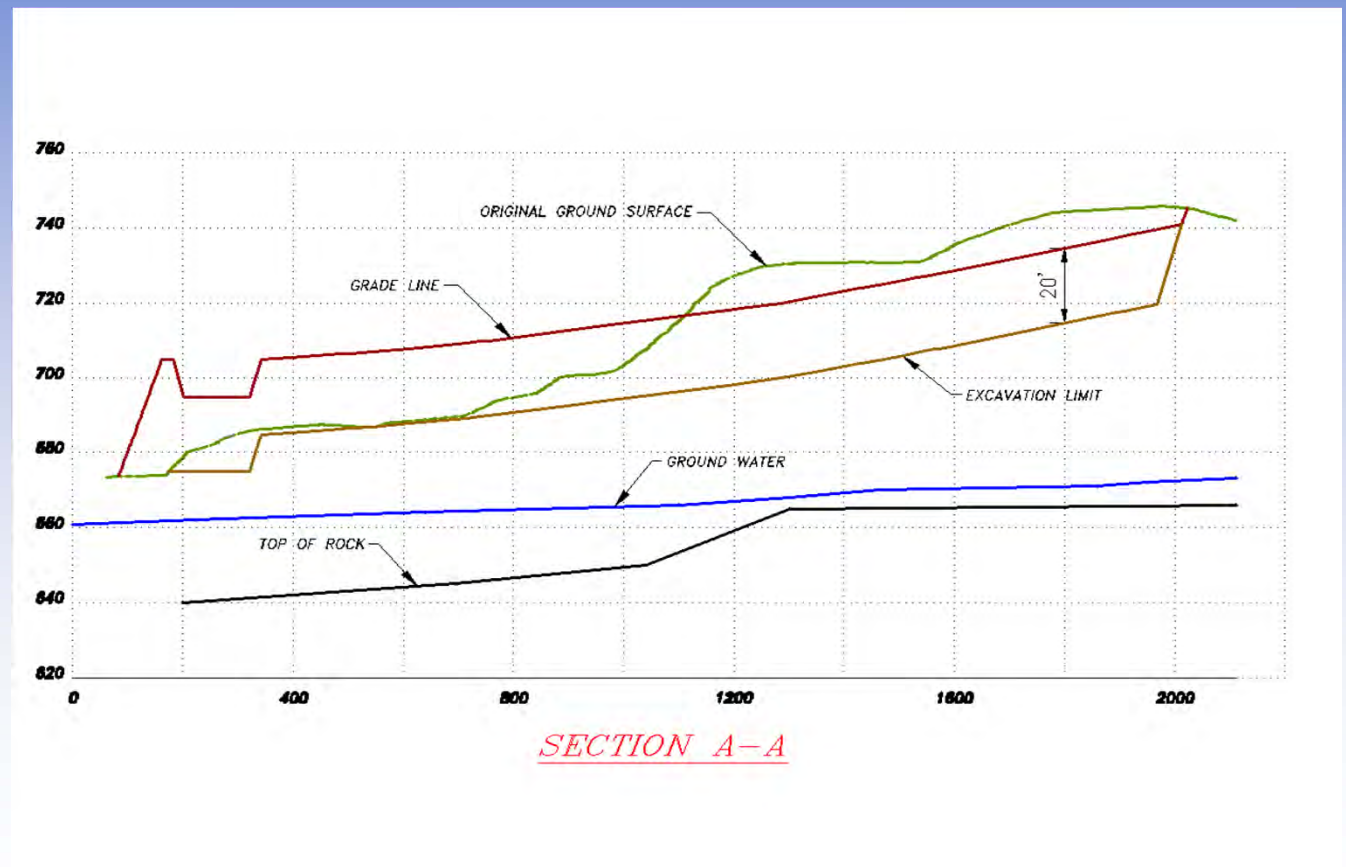
What is the End-Product ?

Plan layout of
landfill cell



What is the End-Product?

Cross-section
through landfill
cell



What is the End-Product?

Excavate to
design grades



What is the End-Product?

Cut existing soil, remove undesirable materials, and/or fill to achieve design grades



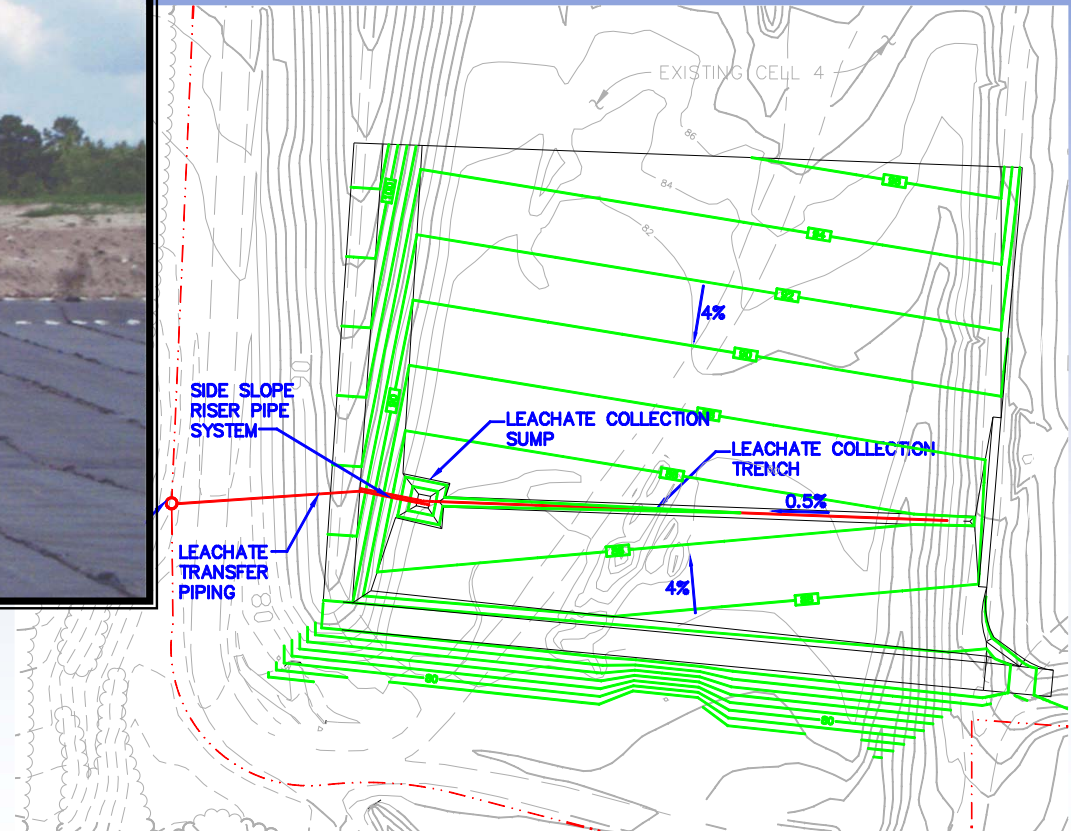
Cutter-Pinnacle Conditions

Soil between pinnacles subjected to differential compression due to subsequent loading



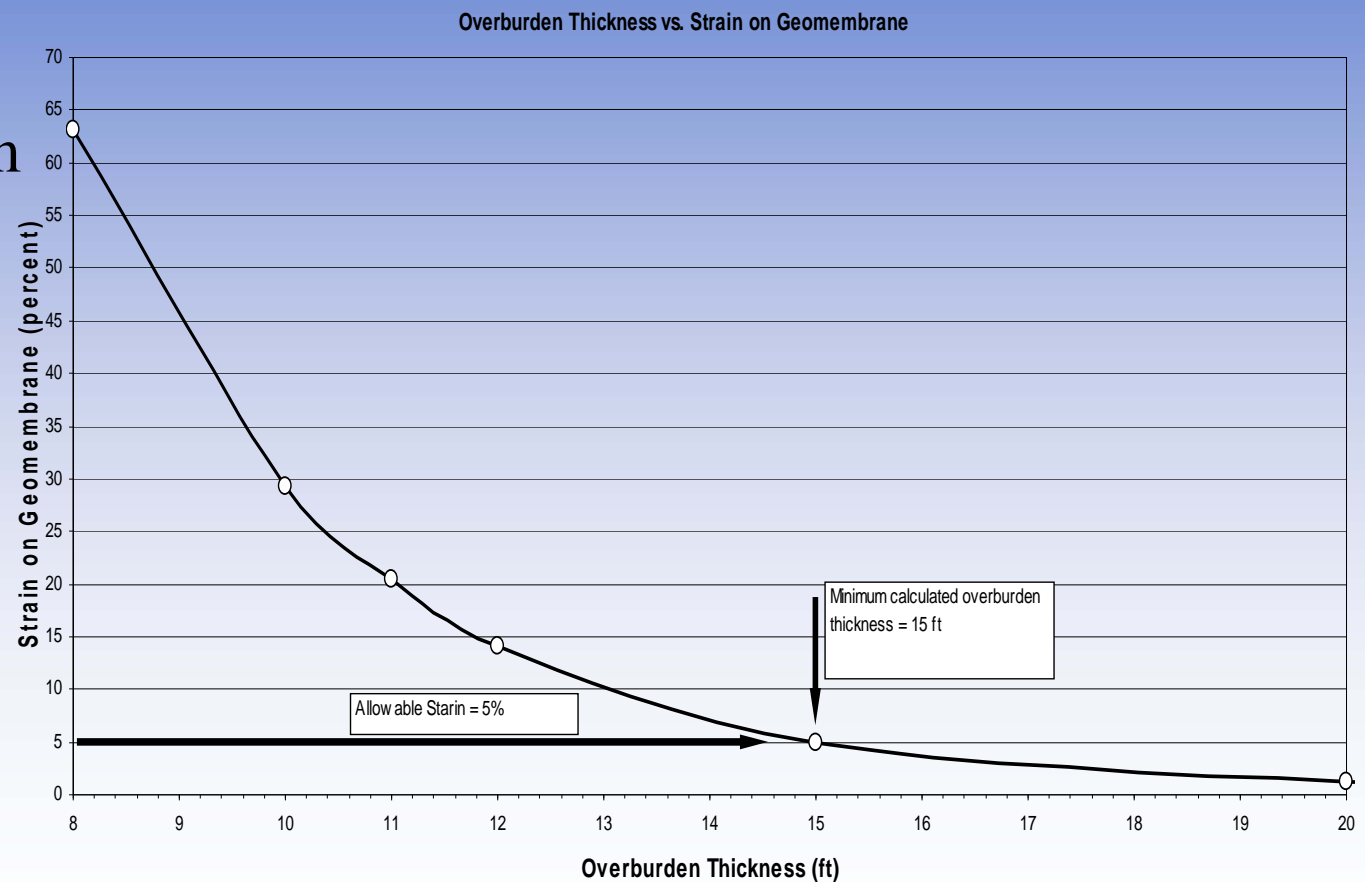
What is the End-Product

Cell Grading to Facilitate Leachate Collection



What is the End-Product

In karst, again use analysis to calculate minimum thickness of soil over “design” karst feature



How Big Is This Problem

(Slide from First TAG Meeting on 5 May 2010)

- Hard to say. Fortunately, to date, in Florida there are no known sinkholes that have formed under solid waste disposal facilities.
- However, the “perception” of a potential problem has made processing permit applications very difficult.



Winter Park, Florida sinkhole in 1981
(~320 ft. wide, ~90 ft. deep)

Southeast Landfill

- Initial Collapse
- 14 Dec 2010

- First TAG
- 5 May 2010

- 129 ft wide
- 60 ft deep
- Vertical sides



Southeast Landfill Hillsborough County, FL

- 162 acres
- Constructed over phosphate clay slimes at 15 -18 ft thick
- 50 ft of waste
- Built over Hawthorne Formation over Floridan Aquifer



Rules from Chapter 62-701, F.A.C.

- Rule 62-701.300(2)(a), F.A.C. (prohibition for all solid waste disposal facilities)
 - (2) Siting. Unless authorized by a Department permit or site certification in effect on May 27, 2001, or unless specifically authorized by another Department rule or a Department license or site certification based upon site-specific geological, design, or operational features, no person shall store or dispose of solid waste:
 - (a) In an area where geological formations or other subsurface features will not provide support for the solid waste;

Rules from Chapter 62-701, F.A.C.

- Rule 62-701.340(3)(a), F.A.C. (location requirement for landfills)
 - (3) Location requirements.
 - (a) The site shall provide structural support for the facility including total wastes to be disposed of and structures to be built on the site.
- Rule 62-701.400(3)(a)2, F.A.C. (design requirement for landfills)
 - (a) Liners shall be:
 2. Installed upon a base and in a geologic setting capable of providing structural support to prevent overstressing of the liner due to settlements and applied stresses;

Rules from Chapter 62-701, F.A.C.

- Rule 62-701.410(2)(b), F.A.C. (geotechnical requirements for landfills and C&D debris disposal facilities)
 - (2) Geotechnical site investigation...Prior to any construction on the landfill site, the engineer shall define the engineering properties of the site that are necessary for the design, construction, and support of the landfill and all installations of the facility and shall:
 - (b) Explore and address the presence of muck, previously filled areas, soft ground, lineaments, and sinkholes;

The Permitting Test: Reasonable Assurance

- In order to issue a DEP permit the applicant must provide “reasonable assurance” that the proposed project and the applicant will comply with the Department’s rules.
- Rule 62-701.200(94), F.A.C.

“Reasonable assurance” means the existence of a substantial likelihood, although not an absolute guarantee, that the proposed activity and applicant will comply with agency rules, laws, orders and permit conditions. It does not mean proof that a facility will not fail.
- NOTE: The permitting test is “reasonable assurance” not “absolute assurance.”

Purpose and Scope of Work for the TAG

- Develop objective guidance for:
 1. Using physical and geophysical techniques for characterizing sinkhole potential of a site;
 2. Determining if potential sinkhole risks for a site are low, moderate or high;
 3. Deciding when a site cannot be used or can be used if properly stabilized;
 4. Selecting appropriate site stabilization procedures (and confirming that they achieved function)
 5. Monitoring a disposal facility for sinkhole formation.

Purpose and Scope of Work for the TAG

Three primary tasks:

1. Site Characterization – What is the right way to determine the sinkhole potential of a site?
2. Site Stabilization – If a site has problems but can be “fixed” what is the right way to do it and how do you know you succeeded?
3. Disposal Facility Monitoring – Should we add special techniques for sinkhole monitoring?

Landfill Sinkhole TAG website address:

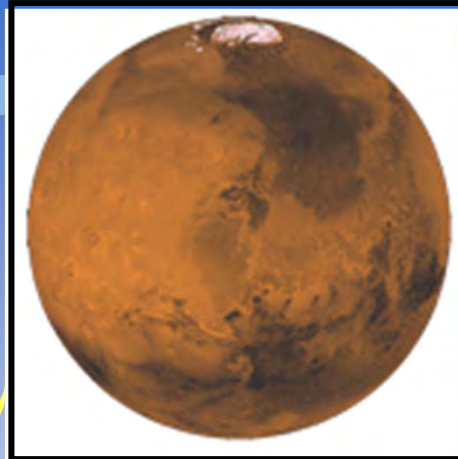
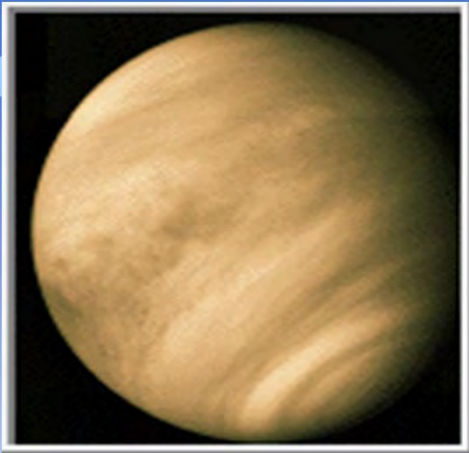
http://www.dep.state.fl.us/waste/categories/solid_waste/pages/TAG.htm

Geohazard Participation

1. Are you aware of other forums similar to the TAG where results are in public domain?
2. Are there specific certain (gray) conditions that are non-starters?
3. Are certain investigation techniques de facto required
4. Do we define criterion for criticality by "holes per acre"
5. Can one develop objective exceptions?
6. Should we avoid the "E " word or embrace it?

Pitfalls of this Forum

Engineers are from Mars.... Hydrogeologists are from Venus



VENUS

MARS

(after Bachus, 2005)





Summer, 2003



Engineer
(Mars)

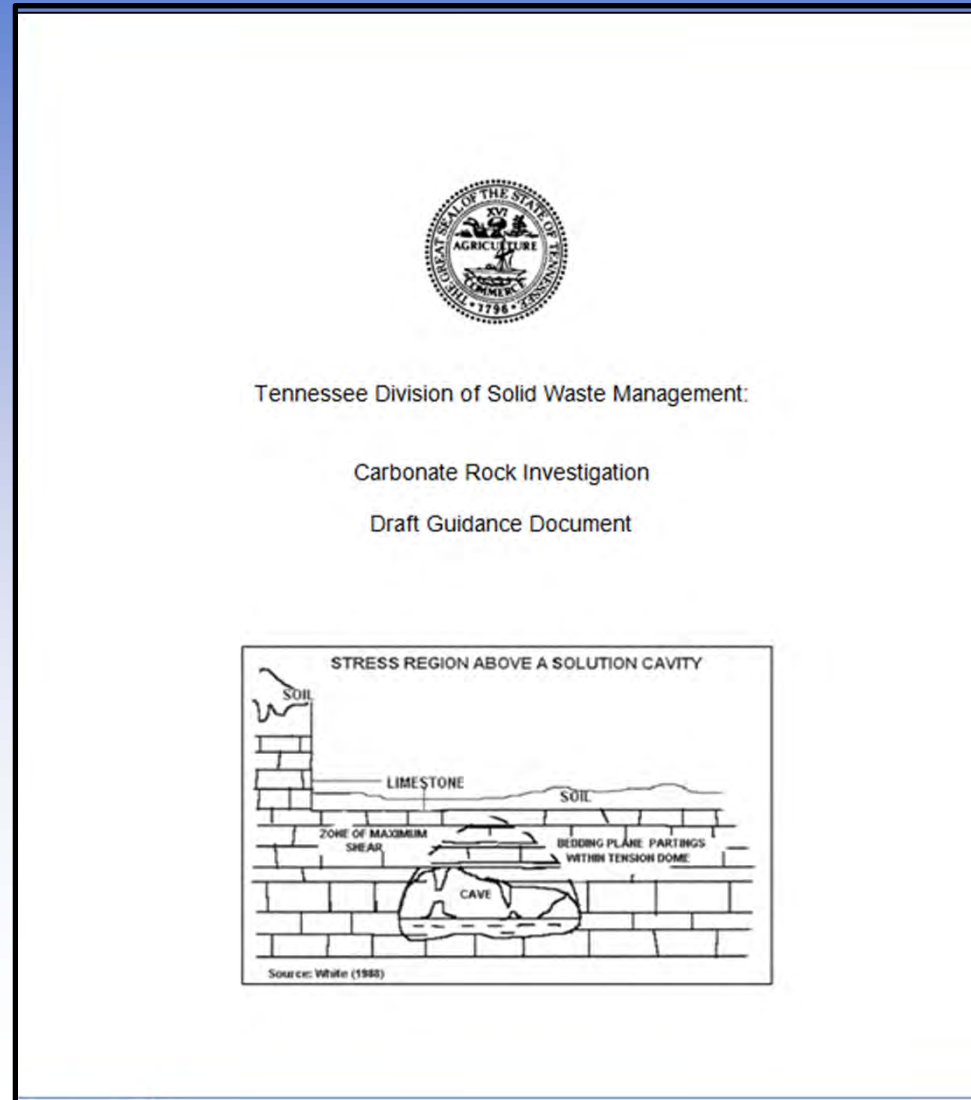
Hydrogeologist
(Venus)

Summer, 2003)

1. Other Public Domain Forum/Guidance

- TDEC Draft Guidance Document (July 1993)

- Needs objective criterion and even more guidance



1. Other Public Domain Forum/Guidance

- Identification – Use incremental approach of office reconnaissance, visual assessment, proof rolling and confirmatory drilling to assess conditions at site
 - How many holes?
 - Objective guidance needed
- Assessment of Site Conditions – Use numerical analysis to confirm stability
 - In TN, GA, and AR, this often means specific void size and confirmatory soil thickness
 - Objective guidance needed
- Remedial Actions - Evaluate range of potential rehabilitation measures to include over-excavation, grouting, reinforcement, and reverse filter
 - If you originally knew it was there, would you permit
 - Guidance needed apriori

(after House, 2011)

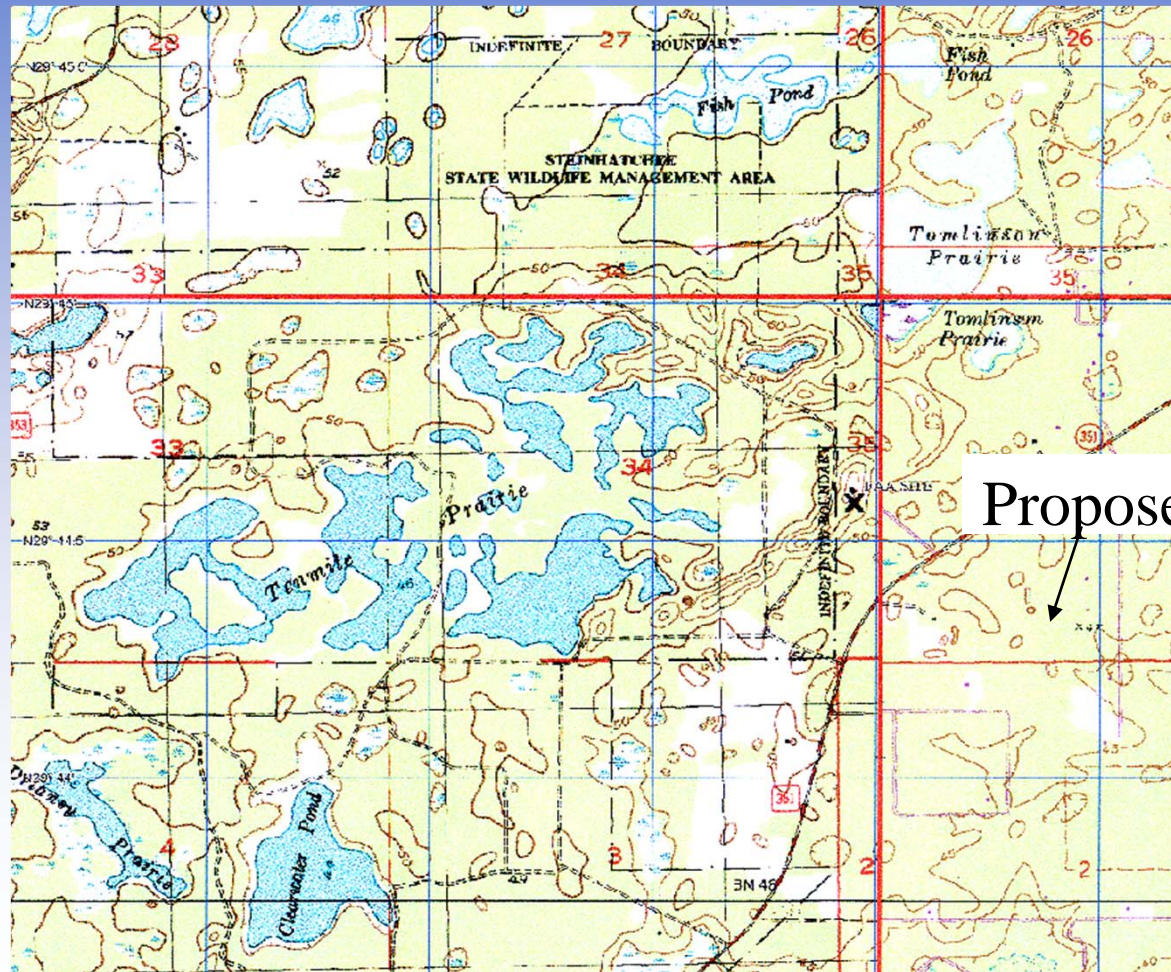
2. Conditions that are Non-starters?

- Southeast Landfill
- “If I knew then what I know now’ is really not an appropriate model



2. Conditions that are Non-starters?

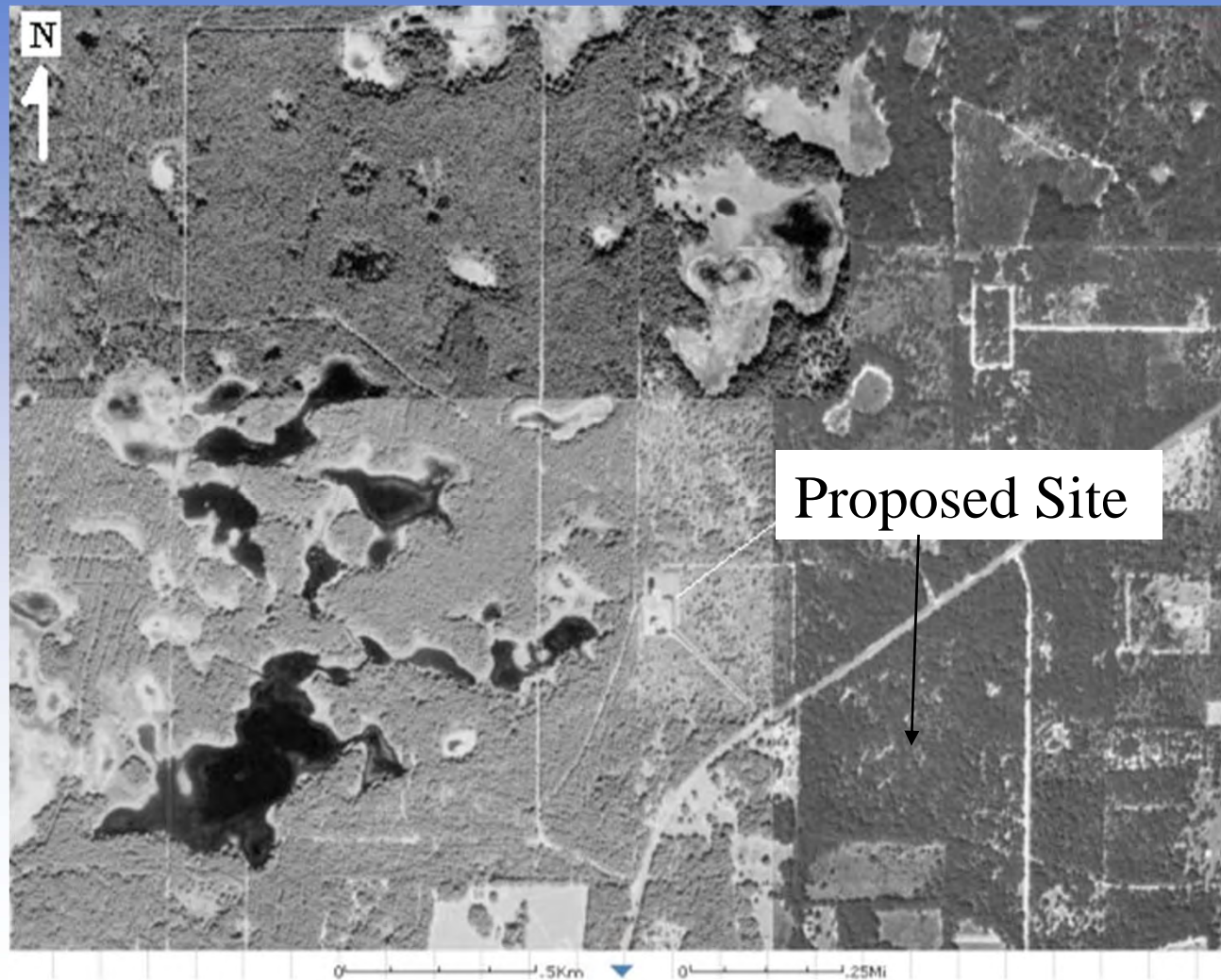
- USGS Topo



Proposed Site

2. Conditions that are Non-starters?

- Satellite Imagery



3. Define Minimum Exploration Guidelines

- Drilling
- CPTu
- Geophysics



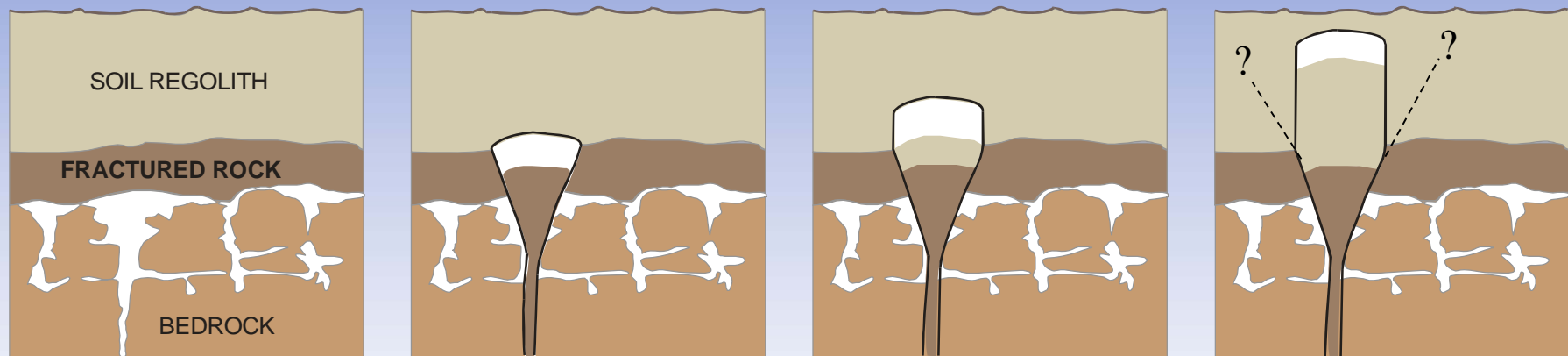
4. Define *** per Acre Criterion

- Holes
- Voids
- RQD/RMR



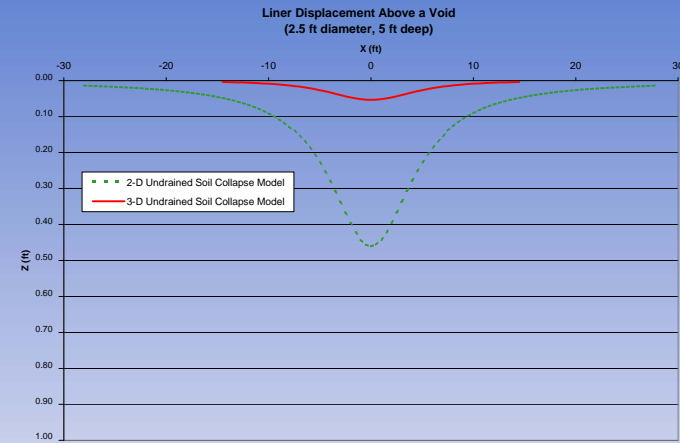
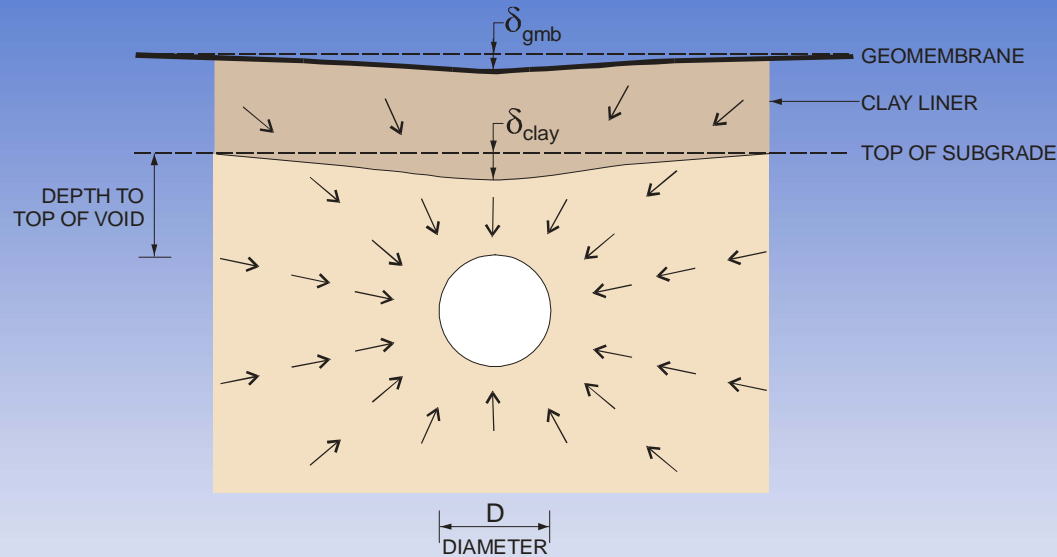
5. Objective Exceptions

Importance of Conceptual Site Characterization Model

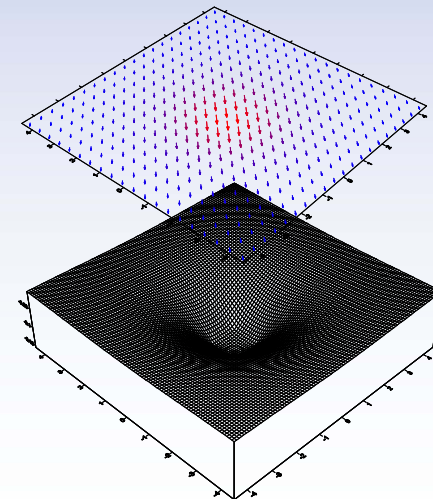


In author's opinion, this is likely the most difficult and contentious issue facing the decision process

6a. Avoid the "E" Word



3-D View of Ground Displacement Field for the Undrained Soil Collapse Model

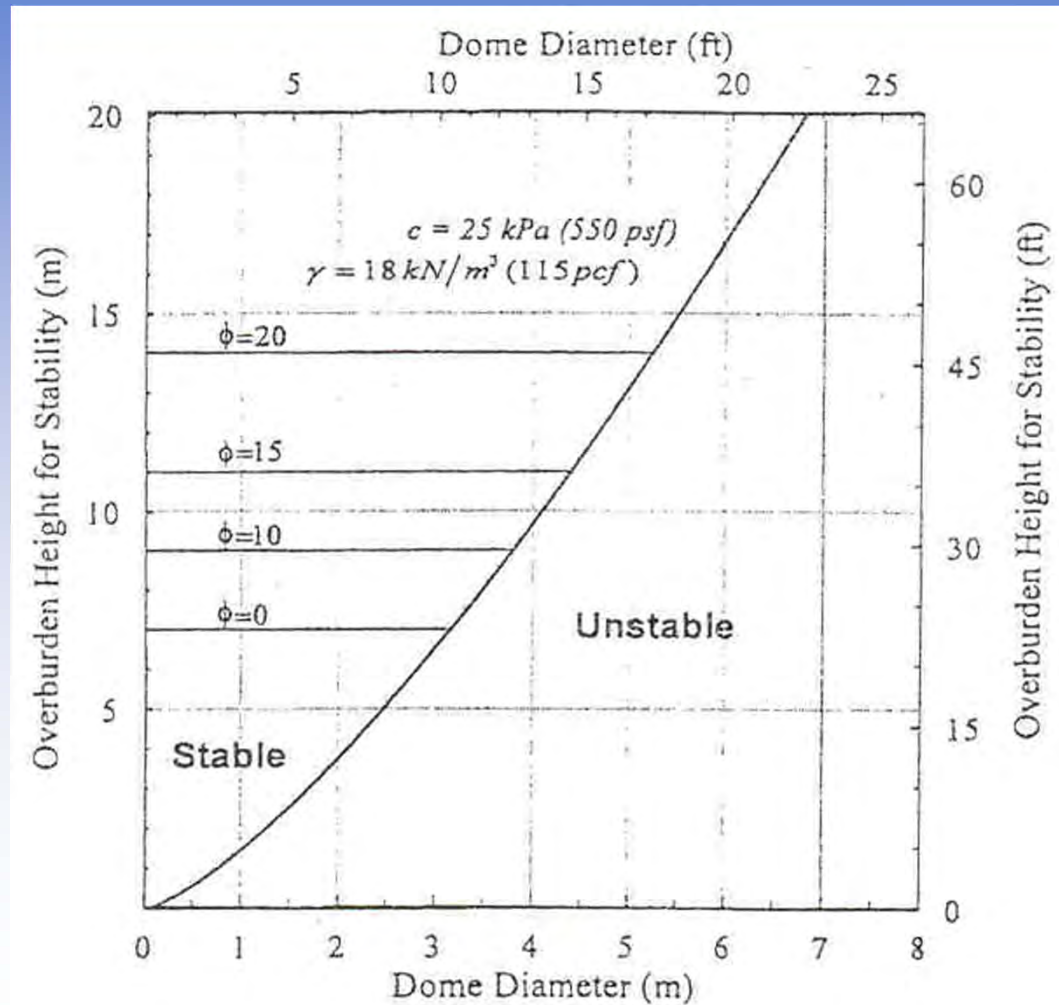


$$S_{z_{total}} = 2 \cdot S_{z_1} = 2 \cdot \frac{\left(\sqrt{x^2 + y^2 + z^2 - 2zh + h^2} - \left((x^2 + y^2 + z^2 - 2zh + h^2)^{3/2} - r^3 \right)^{1/3} \right) (z - h)}{\sqrt{x^2 + y^2 + z^2 - 2zh + h^2}}$$

(after Geosyntec using Sagaseta, 1987)

6a. Avoid the "E" Word

Analysis results used to assess stable and unstable conditions



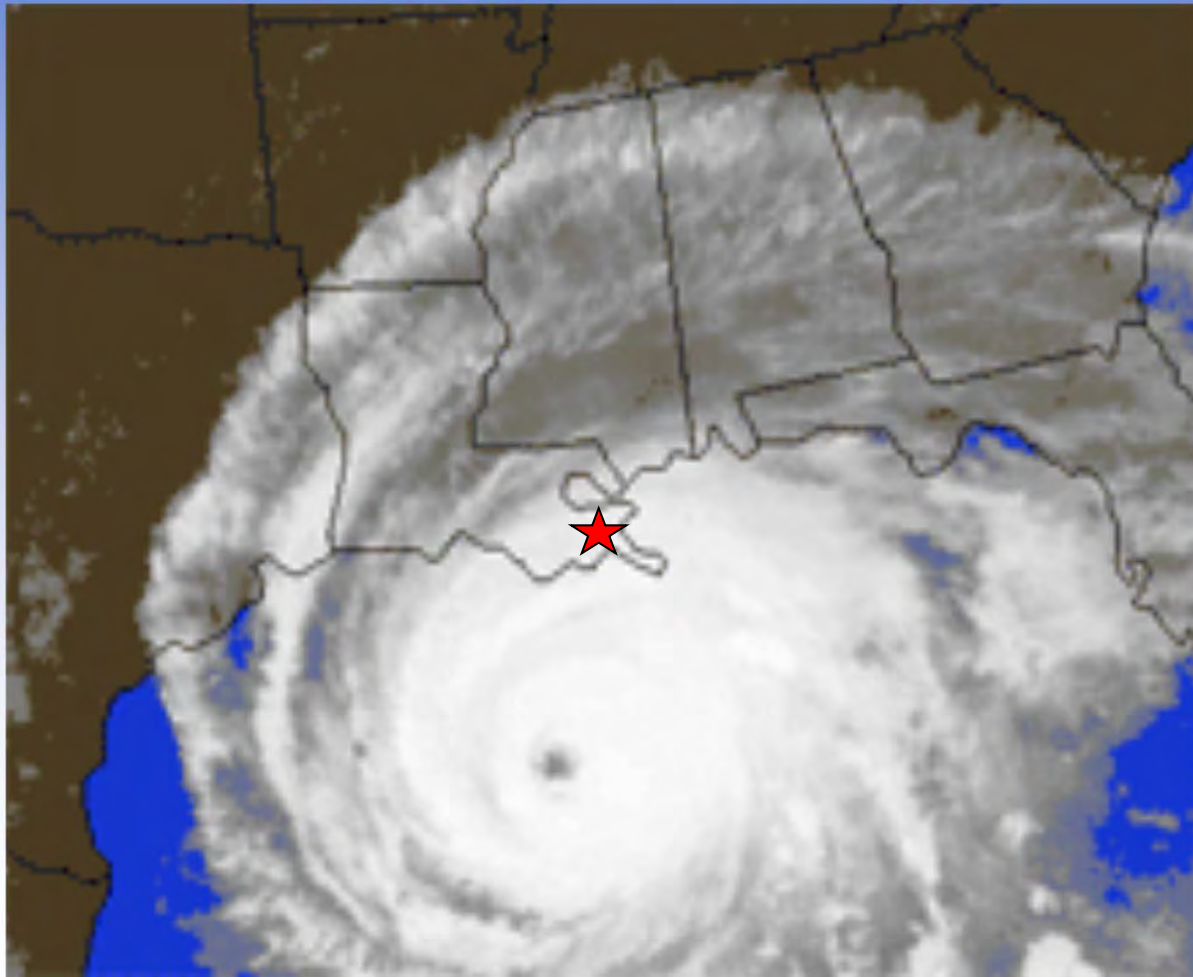
(after Drumm and Yang, 2005)

6b. Embrace the “E” Word

Assessment of “Worst-Case”

- Worst-case condition sounds good, in that it considers an extreme event
- If safe in “extreme event”, then there will likely be “no surprises” during operation and will be safe for the life of project
- Desirable from several perspectives
 - public safety
 - professional liability
 - client relationship
- What should we consider as “design” and/or “worst-case” condition
- Balance risk and cost/benefit

6b. Embrace the "E" Word (Extreme Event Engineering)



Hurricane Katrina
(Category 4)
Immediately Preceded
Hurricane Rita
(Category 4) in
September, 2005

*Levees in
New Orleans
Were Designed for a
Category 3 Hurricane*

Geohazard Participation

1. Are you aware of other forums similar to the TAG where results are in public domain?
2. Are there specific certain (gray) conditions that are non-starters?
3. Are certain investigation techniques de facto required
4. Do we define criterion for criticality by "holes per acre"
5. Can one develop objective exceptions?
6. Should we avoid the "E " word or embrace it?

An Innovative Approach to Characterizing, Permitting, and Constructing Landfills in Karst Geologic Settings

THANK YOU
for the invitation and your participation