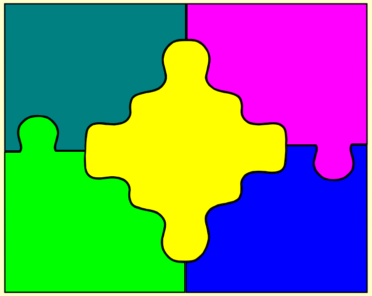
Site Exploration and Characterization; Part I

The Context for Geotechnical Exploration



- What you know….
  - Planned site development
  - Proposed structure information
  - Surface and subsurface data

- What you want to know…
  - Geotechnical Design Recommendations
    - Preliminary
    - Final

What is Site Characterization?

One working definition:

- “The *process* by which a [geo-professional] identifies and describes both the surface and the subsurface materials and conditions at a project site relative to an established design objective.”

Or:

- “A project site so described.”

Why Do It?

"Subsurface material properties cannot be specified; they must be deduced through exploration."

Charles Dowding (1979)

Some Common Objectives

- Identify & describe pertinent surface conditions
- Determine location and thickness of soil and rock strata (subsurface soil profile)
- Determine location of groundwater table
- Recover samples for laboratory testing
- Conduct lab and/or field testing
- Identify special problems and concerns

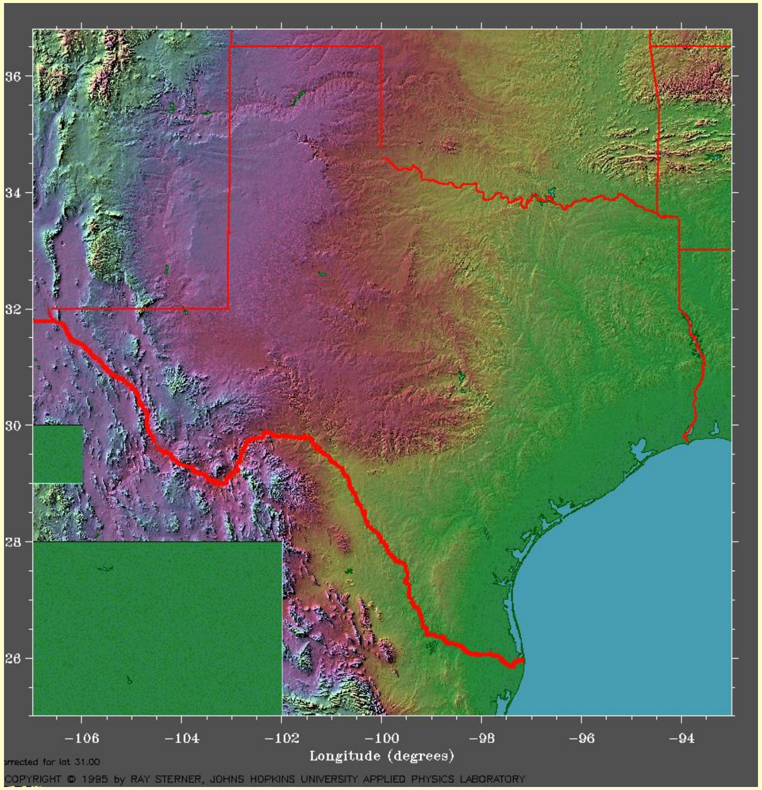
Geotechnical Project Sequence

- Site Research
- Field Reconnaissance
- Field Exploration
- Laboratory Investigations
- Geotechnical Interpretations, Analysis
- Report of Exploration

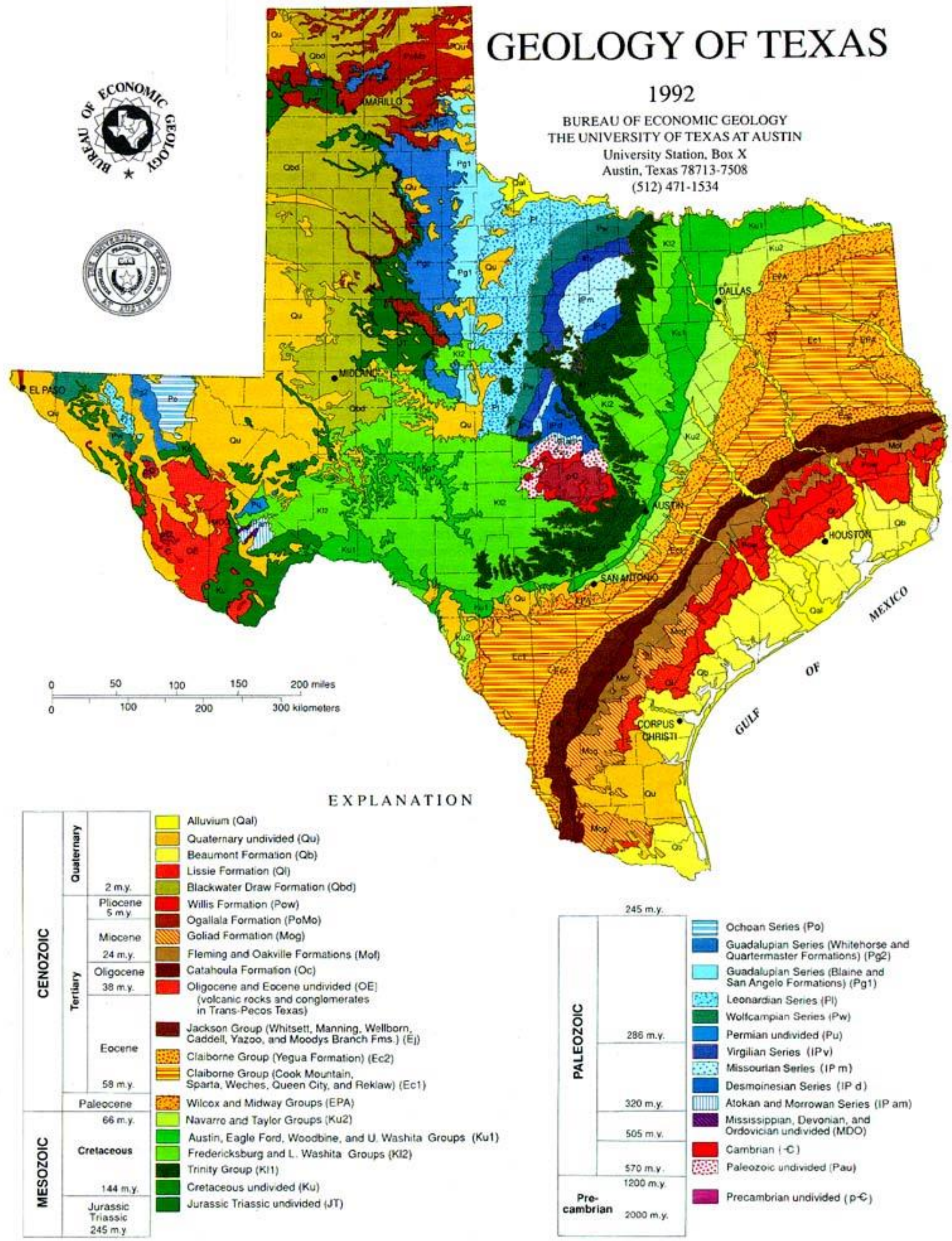
Non-Intrusive Exploration

Site Research
(Published Information)

- Development Plans
- Construction Plans
- Site Location Maps
- Topographic Maps
- Aerial Photographs
- Geologic Maps
- Soil Survey Maps

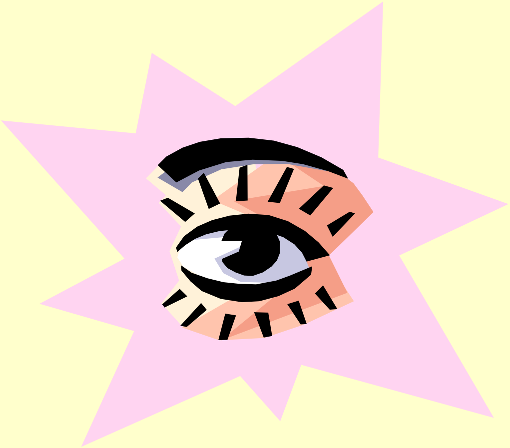


Geologic Maps



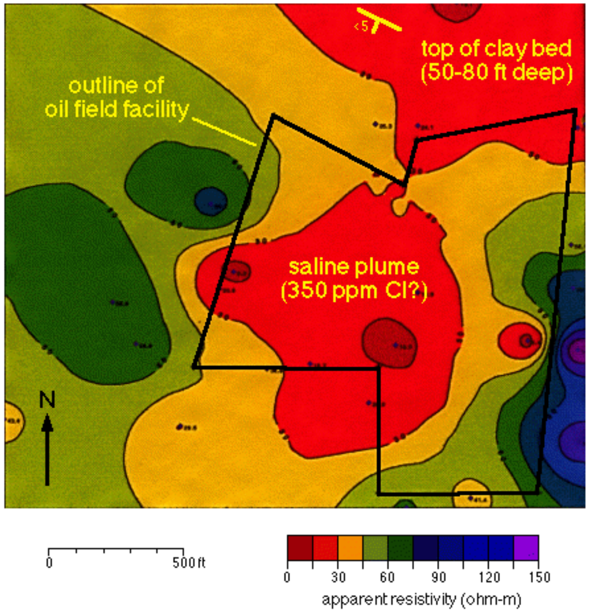
Field Reconnaissance

- Observation of Surface Conditions
  - Accessibility
  - Traffic Control
  - Surface Drainage
  - Geologic Features
  - Vegetation
  - Slopes
  - Water



Geophysical Methods

- Electrical Resistivity Surveys
- Geophysical Logging



Contour map of apparent resistivity in vicinity of oil field facility corresponding to a Schlumberger electrode spacing (AB/2) of 100 ft. Contour map is representative of hydrology and geology at a depth of 50-80 feet. Interpretations are supported by well data and computer models of resistivity data.

Example

Non-Intrusive Exploration

Example

Non-Intrusive Exploration

Intrusive (Field) Exploration

Preliminaries: How Many Borings & How Deep?

"No hard-and-fast rule exists for determining the number of borings or the depth to which borings are to be advanced."

Reference: Braja M. Das, *Principles of Geotechnical Engineering*, 6th Edition

Preliminaries:
How Many Borings?

- Conventional Wisdom :
  - The number (density) of borings will increase:
    - As soil variability increases
    - As the loads increase
    - For more critical/significant structures
- Rules of Thumb :
  - Soft Soils (<10 bpf) - Space 100’ to 200’
  - As soils become harder, spacing may be increased up to 500’

Preliminaries:

How Many Borings?

Structure or Project	Subsurface Variability	Spacing of Borings (ft)
Highway Subgrade	Irregular	100-1000 (200, typical)
	Average	200-2000 (500, typical)
	Uniform	400-4000 (1000, typical)
Multistory Building	Irregular	25-75
	Average	50-150
	Uniform	100-300

Source: Sowers 1979

How Many Borings?

Subsurface Conditions	Structure Footprint Area for Each Exploratory Boring	
	(m^2)	(ft^2)
Poor quality and/or erratic	100–300	1,000–3,000
Average	200–400	2,000–4,000
High quality and uniform	300–1,000	3,000–10,000

How Deep?

Subsurface Conditions	Minimum Depth of Borings (S = number of stories; D = anticipated depth of foundation)	
	(m)	(ft)
Poor	$6\,S^{0.7} + D$	$20\,S^{0.7} + D$
Average	$5\,S^{0.7} + D$	$15\,S^{0.7} + D$
Good	$3\,S^{0.7} + D$	$10\,S^{0.7} + D$

Preliminaries:
How Deep (Bridges)?

- Boring depth is governed by various factors, including:
  - Foundation type
  - Foundation load
  - Lowering of grade line at underpass?
  - Channel relocation, widening, dredging?
  - Scour?

- Rules of Thumb
  - Generally speaking, 50’- 80’ is reasonable
  - Local experience is helpful
  - Look at nearby structures if available
  - If no experience or other info available, plan for long first hole, then adjust.

Preliminaries:
How Deep (Retaining Walls)?

- Boring depth is governed by various factors, including:
  - Wall type (Fill vs. Cut)
  - Lowering of grade line at wall?
  - Scour?
- Rules of Thumb :
  - Fill Walls: Depth = Wall Height +/-
  - Soil Nailed Walls: Depth = Through Nailed Area, plus 10’
  - Drilled Shaft Walls: Depth = Through Exposed Wall Height, plus 150% of Wall Height

Types of Drilling Equipment

Truck-Mounted Drill Rig

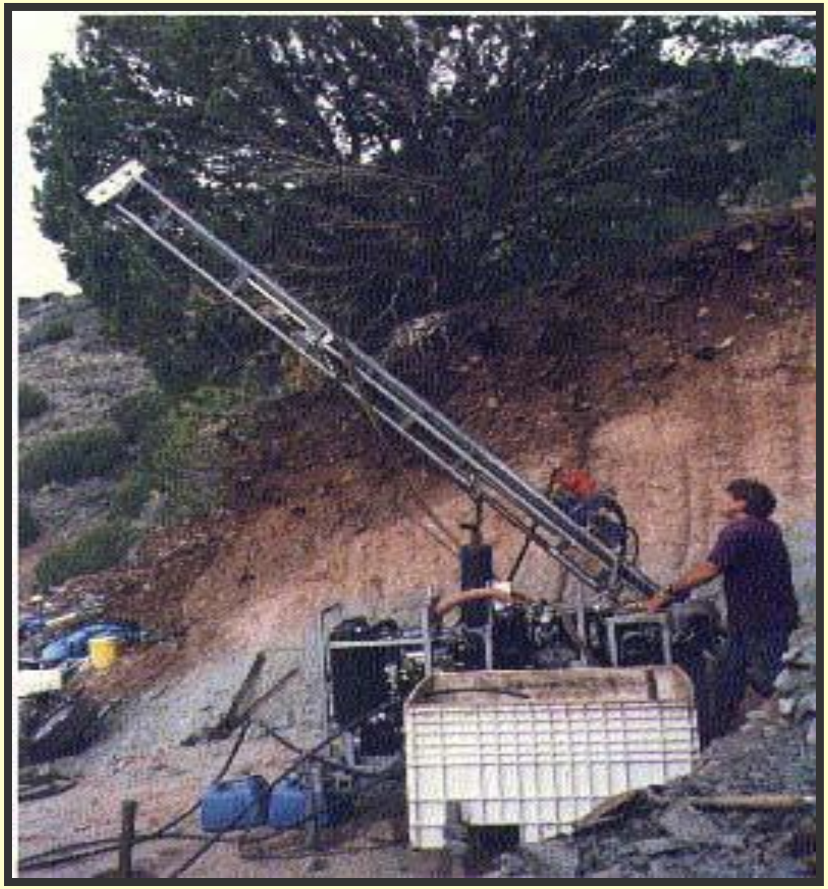
- **Typical Equipment Used for Geotechnical Drilling**
- **Truck Mounted Drill Rig & Support Truck (Water Tank)**

Field Drilling and Sampling

- **Air or Mud Rotary Drilling**

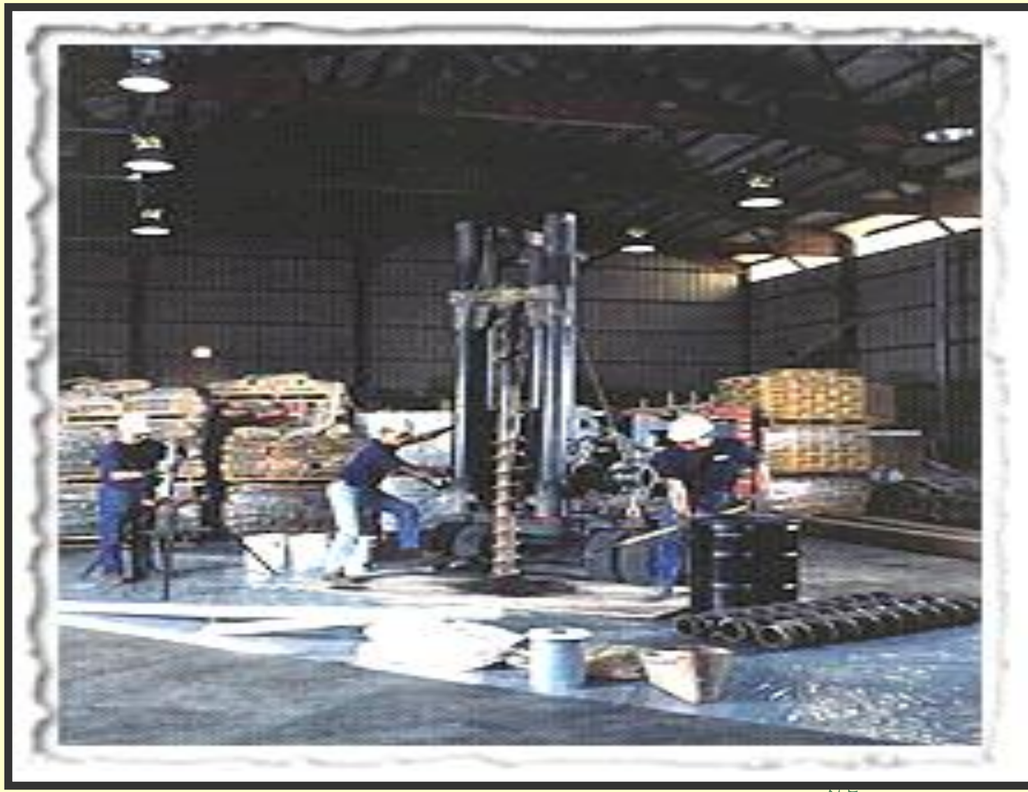
Angle Drilling

- Assess geologic features (dip, strike, joints, etc.)
- Foundation testing for bridge abutments.



Confined Access/ Interior Drilling

- **Limited Access Drill Rigs** are small in size, but have the torque of many full size truck rigs.
- Capability, boring depths, size, etc. vary
- Esp. useful for remedial sampling

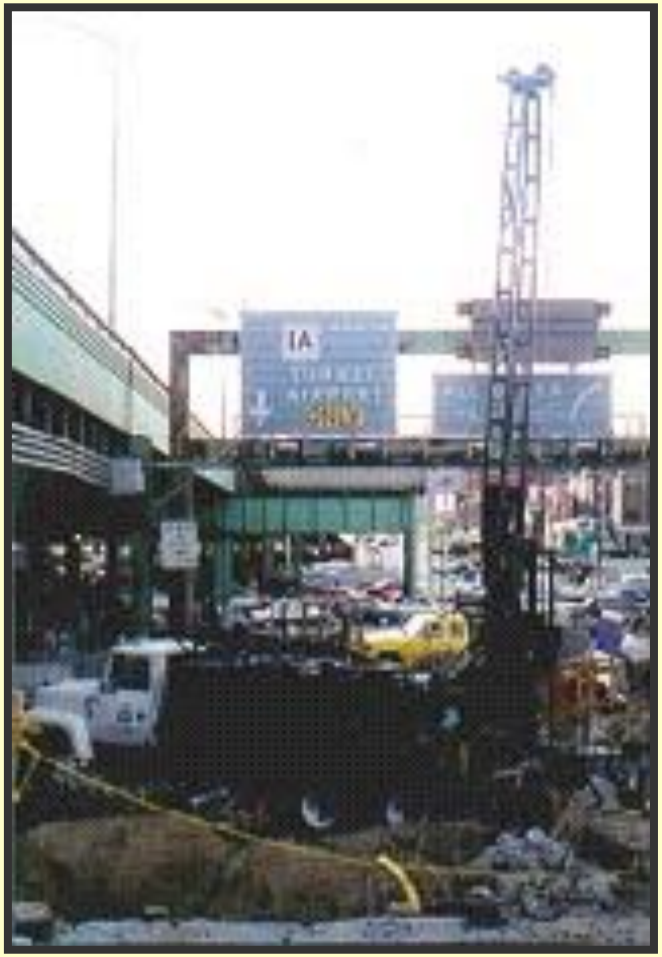


Offshore Drilling/ Barge Rig

- Exploration for abutments, bridges, docks, etc.

Congested Busy Sites

- Reliable underground utility locate is critical
- Traffic control is a must
- Large percentage of effort is in the planning
- Special ordinances/ regulations may apply



Soil & Rock
Drilling & Sampling

Drilling vs. *Sampling*

- Think in terms of a continuum
- Many methods to advance an exploratory shaft
- You get what you pay for

	Drilling ▼						Sampling ▼
Effort	LOW						HIGH
Cost	LOW						HIGH
Time	LOW						HIGH
Data	LOW						HIGH
Quality	LOW						HIGH
Samples	NOTHING	CUTTINGS	CUTTINGS AT DEPTH	CUTTINGS W/ PENETRATION TEST	INTERMITTENT DISTURBED	INTERMITTENT UNDISTURBED	CONTINUOUS/ UNDISTURBED

<u>Drilling</u> vs. *<u>Sampling</u>*

- <u>Drilling</u> – "Just" a hole… no sample
- *Disturbed* <u>Sampling</u>

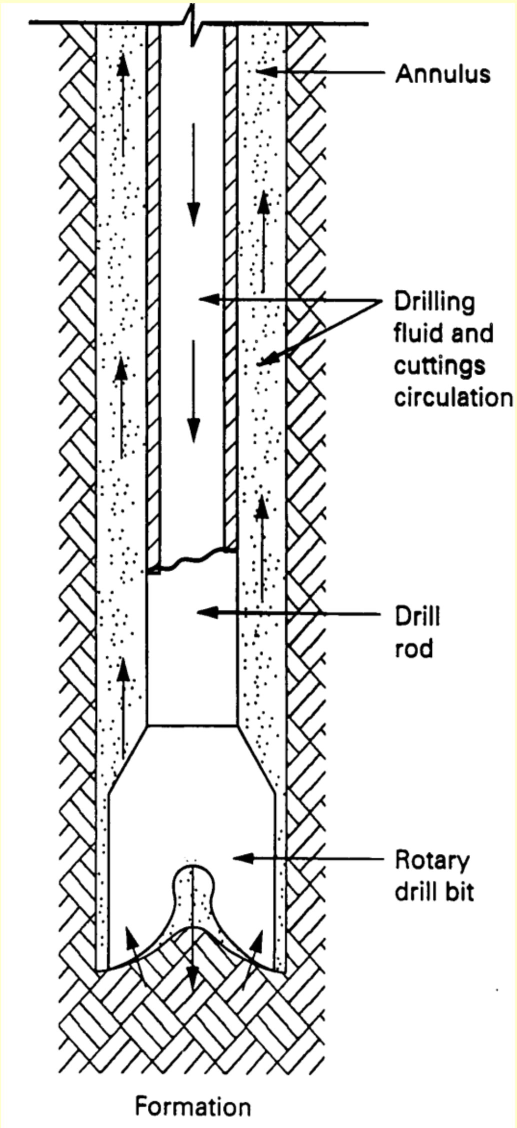
  "…Estimating the nature of the formation from the cuttings is like identifying the cow from the hamburgers." G.F. Sowers

- *Undisturbed* <u>Sampling</u>
  - Retrieve a continuous core
  - Applicable to both <u>soil</u> and <u>rock</u>

Drilling:

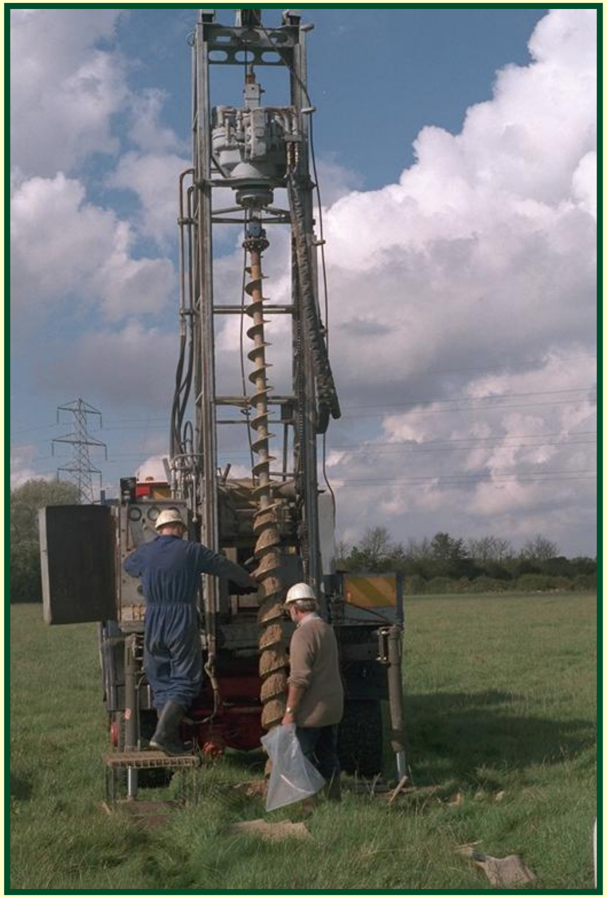
Rotary Bit

- Bit at the end of drill rod rotated and advanced
- Soil/rock cuttings removed by circulating drilling fluid
- Common drilling fluid; bentonite in water with slurry density 68-72pcf
- Air may be used as drilling fluid



Drilling:

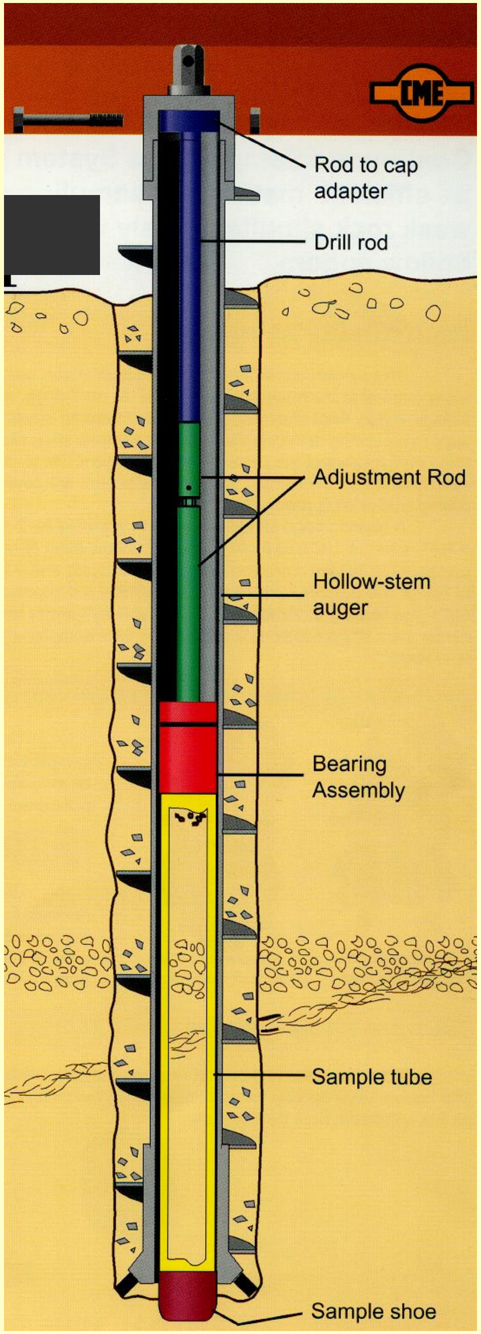
Continuous Flight Auger



Drilling & Sampling

Hollow Stem Auger

- Casing with outer spiral
- Inner rod with plug/or pilot assembly
- For sampling, remove pilot assembly and insert sampler
- Typically 5ft sections, keyed, box & pin connections
- Maximum depth 60-150ft



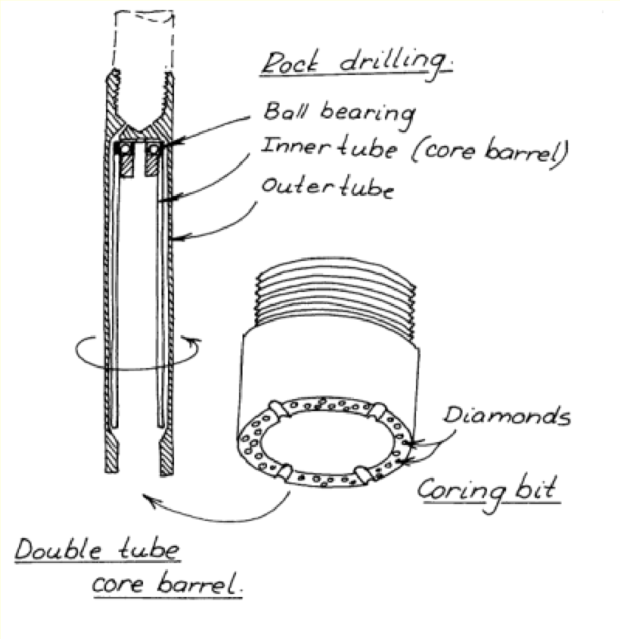
Drilling & Sampling

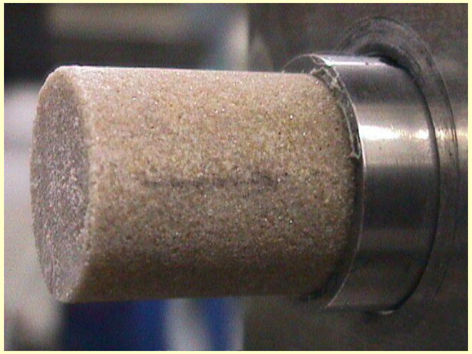
Hollow Stem Auger

Drilling & Sampling

Rock Coring

- Double-tube core barrel is typical
- Diamond or tungsten-carbide tooth bit
- Size of core samples varies (NX, NQ, HQ, etc.)





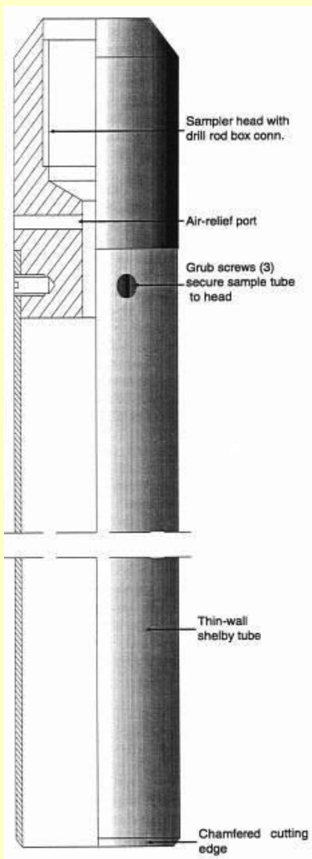
Drilling & Sampling

Rock Core Quality

- Core recovery percentage
- Rock Quality Designation (RQD)
  - Defines the fraction of solid core recovered greater than 4 inches in length
  - Calculated as the ratio of the sum of length of core fragments greater than 4 inches to the total drilled footage per run, expressed as a percentage

Drilling & Sampling

Shelby Tube Sampler

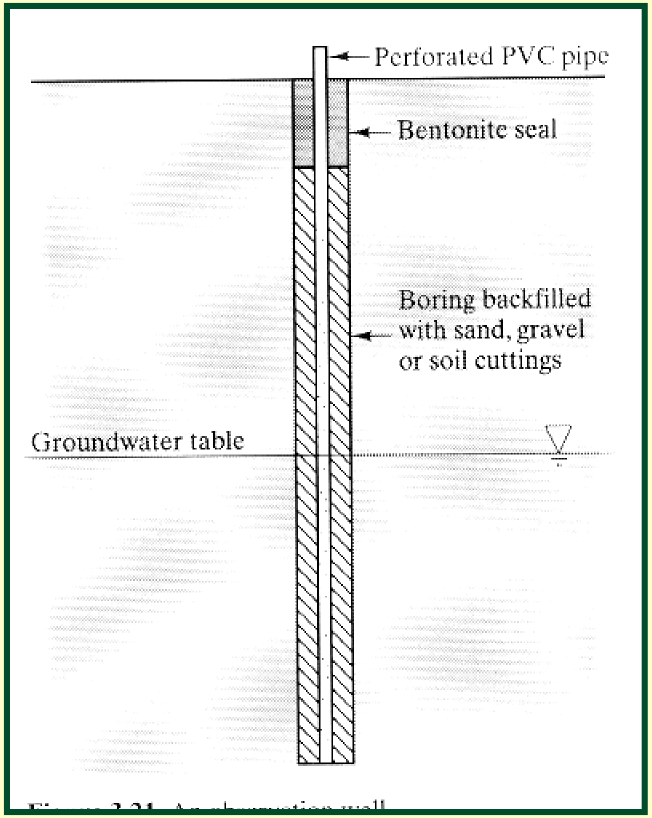


- Suitable for SOIL
- Thin-wall Steel Tubes
- 3.0" OD, 2.875" ID, 30.0" long, 7.2 lbs

Ground Water

Groundwater Monitoring

- Groundwater level must be determined during geotechnical exploration
- Measure at time of drilling and later (24 hrs, 1 week, etc.)
- Can be accomplished by leaving selected soil borings open
- Or, install a piezometer



Ground Water

- Piezometers
- Monitor Wells & Sampling
- Permeability Tests