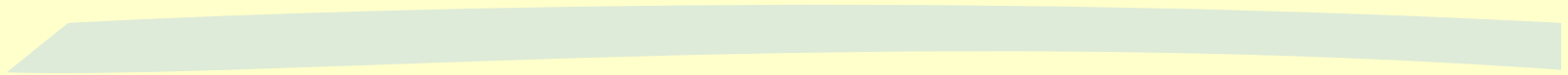


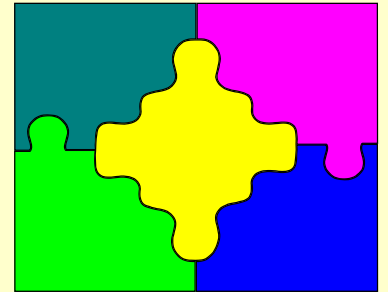
Site Exploration and Characterization; Part I



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)

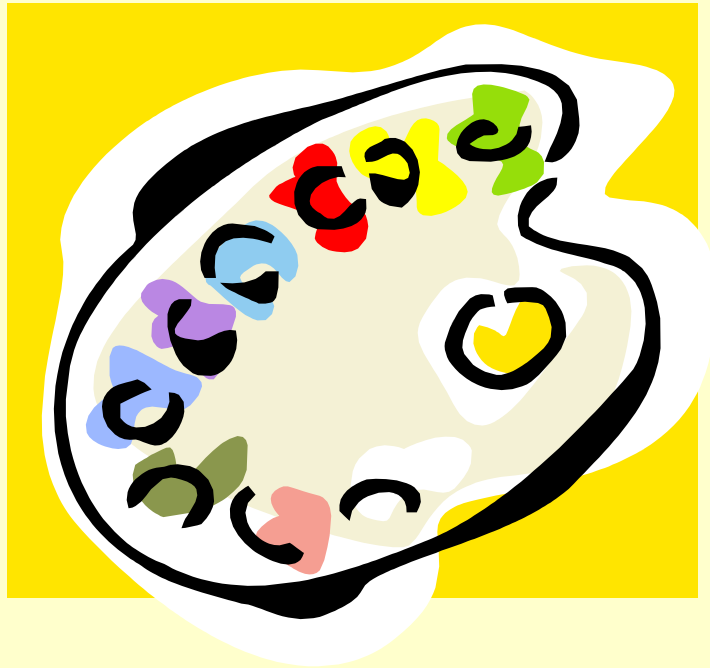
Some Common Objectives

- 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

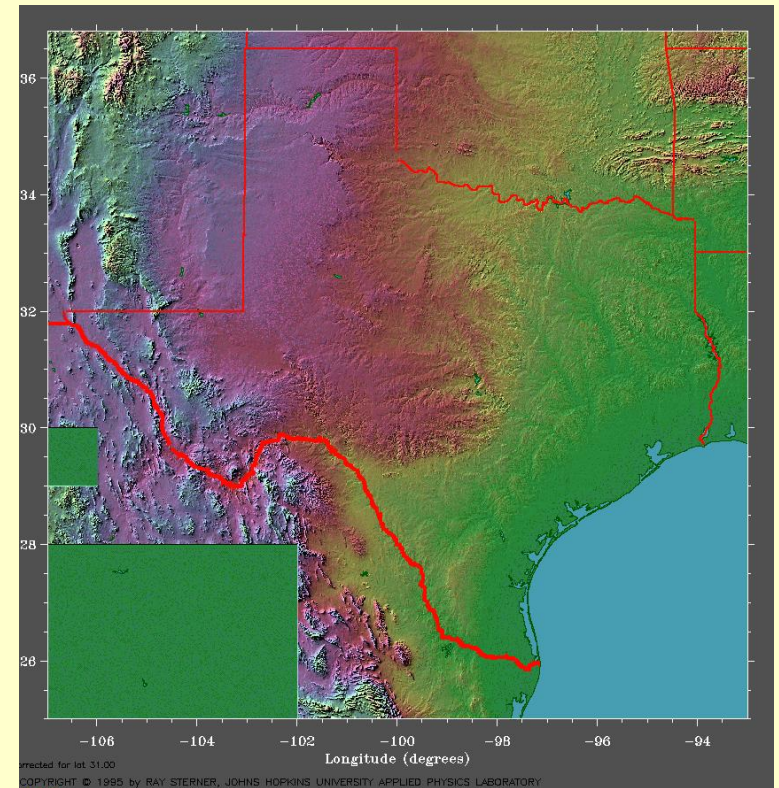
Non-Intrusive Exploration



Site Research

(Published Information)

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



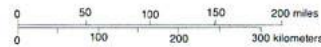
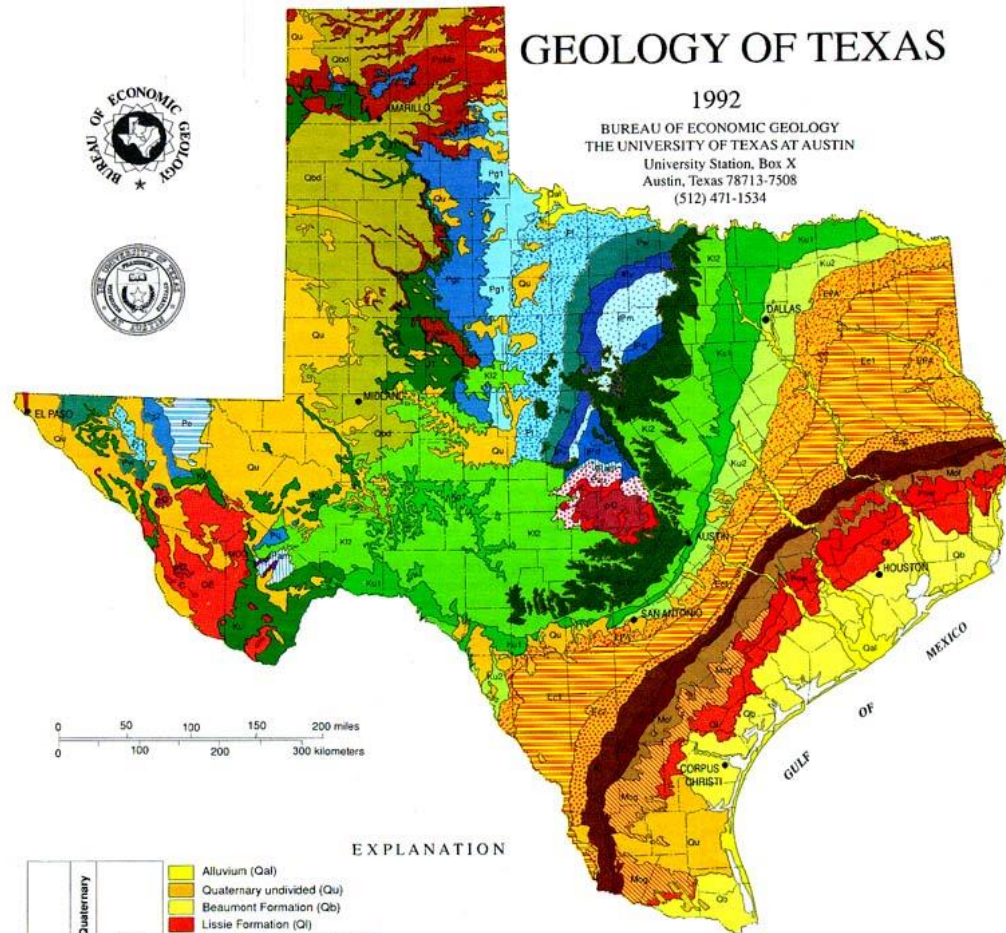
Geologic Maps



GEOLOGY OF TEXAS

1992

BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN
University Station, Box X
Austin, Texas 78713-7508
(512) 471-1534

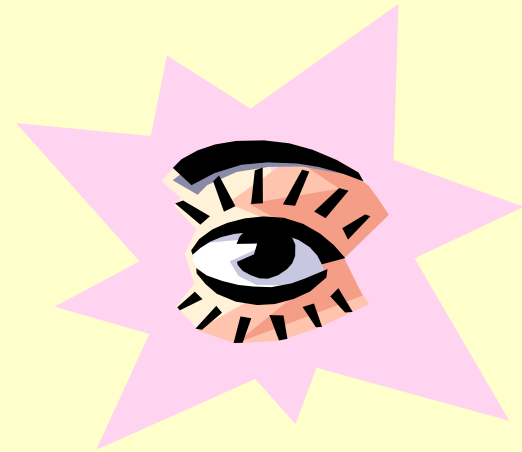


EXPLANATION

CENOZOIC	Time (m.y.)	Unit	Color/Pattern	Description	
					Quaternary
CENOZOIC	Quaternary	Alluvium (Qal)	Yellow	Alluvium (Qal)	
		Quaternary undivided (Qu)	Light yellow	Quaternary undivided (Qu)	
		Beaumont Formation (Qb)	Orange	Beaumont Formation (Qb)	
		Lissie Formation (Ql)	Red	Lissie Formation (Ql)	
	Tertiary	2 m.y.	Blackwater Draw Formation (Qbd)	Dark red	Blackwater Draw Formation (Qbd)
		Pliocene 5 m.y.	Willis Formation (Pow)	Light blue	Willis Formation (Pow)
			Ogallala Formation (PoMo)	Dark blue	Ogallala Formation (PoMo)
		Miocene 24 m.y.	Goliad Formation (Mog)	Light green	Goliad Formation (Mog)
			Fleming and Oakville Formations (Mof)	Dark green	Fleming and Oakville Formations (Mof)
			Catahoula Formation (Oc)	Light purple	Catahoula Formation (Oc)
Oligocene and Eocene undivided (OE) (volcanic rocks and conglomerates in Trans-Pecos Texas)	Dark purple		Oligocene and Eocene undivided (OE) (volcanic rocks and conglomerates in Trans-Pecos Texas)		
Eocene 38 m.y.	Jackson Group (Whitsett, Manning, Wellborn, Caddell, Yazoo, and Moodys Branch Fms.) (Ej)	Dark brown	Jackson Group (Whitsett, Manning, Wellborn, Caddell, Yazoo, and Moodys Branch Fms.) (Ej)		
	58 m.y.	Claiborne Group (Yegua Formation) (Ec2)	Light brown	Claiborne Group (Yegua Formation) (Ec2)	
Paleocene 66 m.y.	Claiborne Group (Cook Mountain, Sparta, Weches, Queen City, and Reklaw) (Ec1)	Dark brown	Claiborne Group (Cook Mountain, Sparta, Weches, Queen City, and Reklaw) (Ec1)		
	58 m.y.	Wilcox and Midway Groups (EPA)	Light brown	Wilcox and Midway Groups (EPA)	
MESOZOIC	Cretaceous 66 m.y.	Navarro and Taylor Groups (Ku2)	Light green	Navarro and Taylor Groups (Ku2)	
		Austin, Eagle Ford, Woodbine, and U. Washita Groups (Ku1)	Dark green	Austin, Eagle Ford, Woodbine, and U. Washita Groups (Ku1)	
	144 m.y.	Fredericksburg and L. Washita Groups (Kl2)	Light green	Fredericksburg and L. Washita Groups (Kl2)	
	144 m.y.	Trinity Group (Kl1)	Dark green	Trinity Group (Kl1)	
	Jurassic 245 m.y.	Cretaceous undivided (Ku)	Light green	Cretaceous undivided (Ku)	
Jurassic 245 m.y.	Jurassic Triassic undivided (JT)	Dark green	Jurassic Triassic undivided (JT)		
PALEOZOIC	Time (m.y.)	Ochoan Series (Po)	Light blue	Ochoan Series (Po)	
		245 m.y.	Guadalupian Series (Whitehorse and Quartermaster Formations) (Pg2)	Dark blue	Guadalupian Series (Whitehorse and Quartermaster Formations) (Pg2)
		245 m.y.	Guadalupian Series (Blaine and San Angelo Formations) (Pg1)	Light blue	Guadalupian Series (Blaine and San Angelo Formations) (Pg1)
		245 m.y.	Leonardian Series (Fl)	Light blue	Leonardian Series (Fl)
		245 m.y.	Wolfcampian Series (Pw)	Dark blue	Wolfcampian Series (Pw)
		286 m.y.	Permian undivided (Pu)	Light blue	Permian undivided (Pu)
		286 m.y.	Virgilian Series (IPv)	Dark blue	Virgilian Series (IPv)
		286 m.y.	Missourian Series (IPm)	Light blue	Missourian Series (IPm)
		286 m.y.	Desmoinesian Series (IPd)	Dark blue	Desmoinesian Series (IPd)
		320 m.y.	Atokan and Morrowan Series (IPam)	Light blue	Atokan and Morrowan Series (IPam)
PALEOZOIC	Time (m.y.)	505 m.y.	Mississippian, Devonian, and Ordovician undivided (MDO)	Dark purple	
		505 m.y.	Cambrian (-C)	Red	
		505 m.y.	Paleozoic undivided (Pau)	Light purple	
Pre-cambrian	Time (m.y.)	1200 m.y.	Precambrian undivided (p-C)	Dark purple	
		2000 m.y.	Precambrian undivided (p-C)	Dark purple	

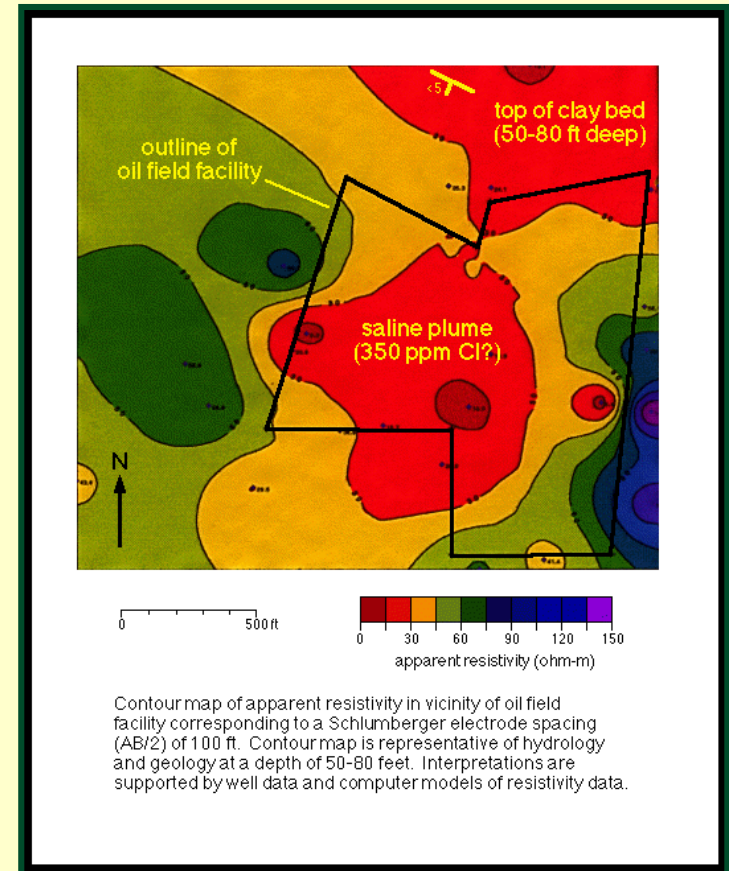
Field Reconnaissance

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



Geophysical Methods

- Electrical Resistivity Surveys
- Geophysical Logging



Example

Non-Intrusive Exploration

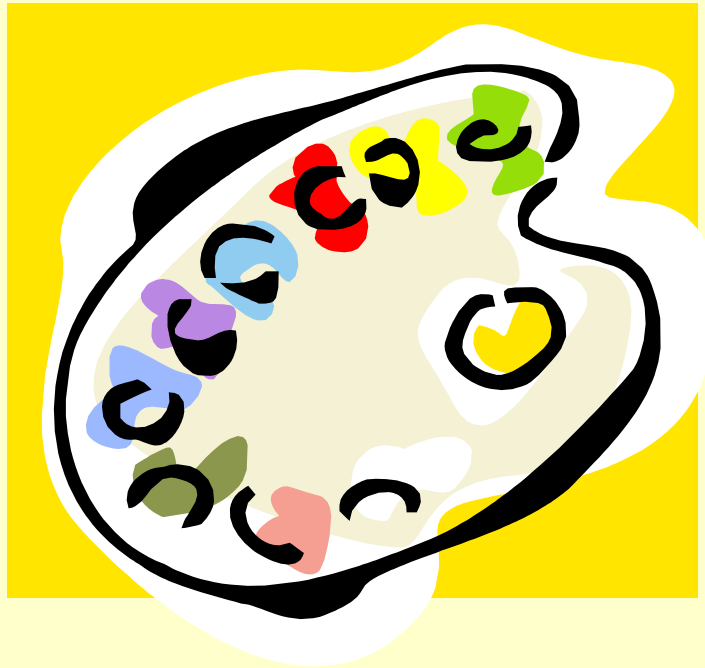


Example

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?

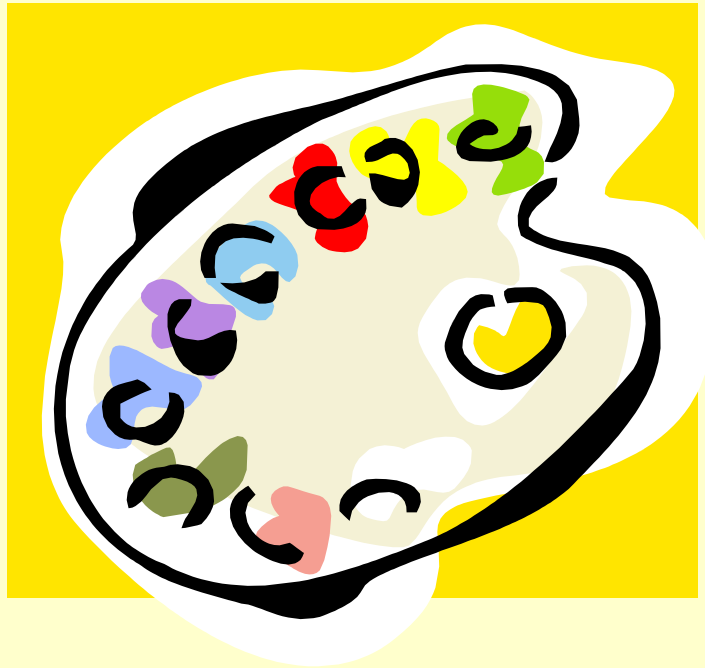
- Rules of Thumb
 - Generally speaking, 50' - 80' is reasonable
 - Local experience is helpful
 - Look at nearby structures if available
 - If no experience or other info available, plan for long first hole, then adjust.

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)**



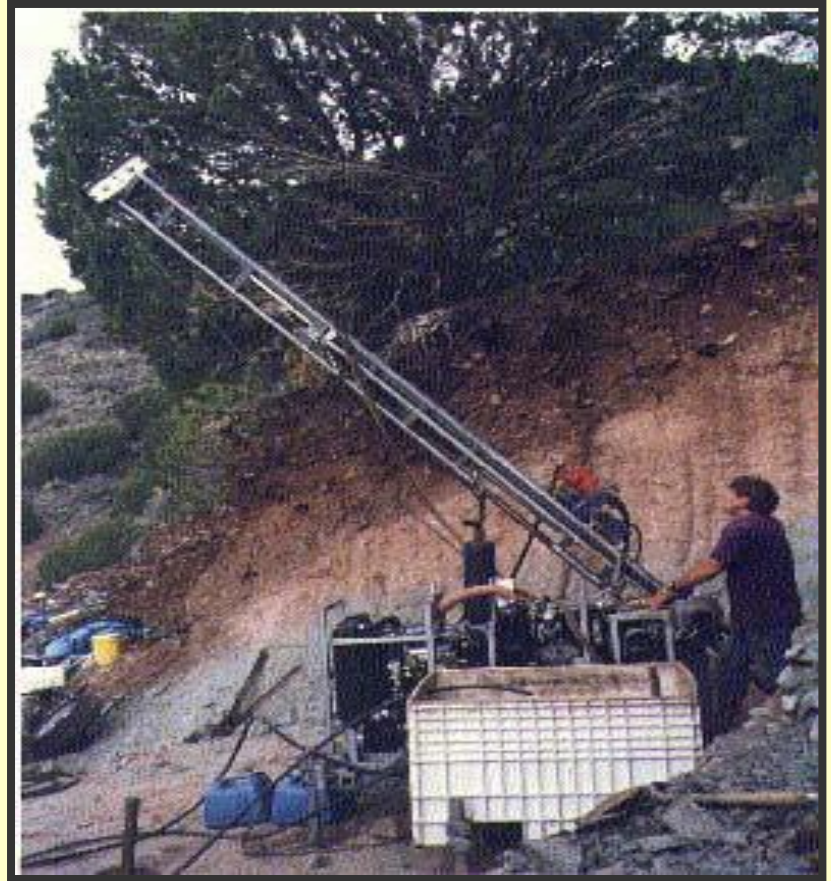
Field Drilling and Sampling

- Air or Mud Rotary Drilling



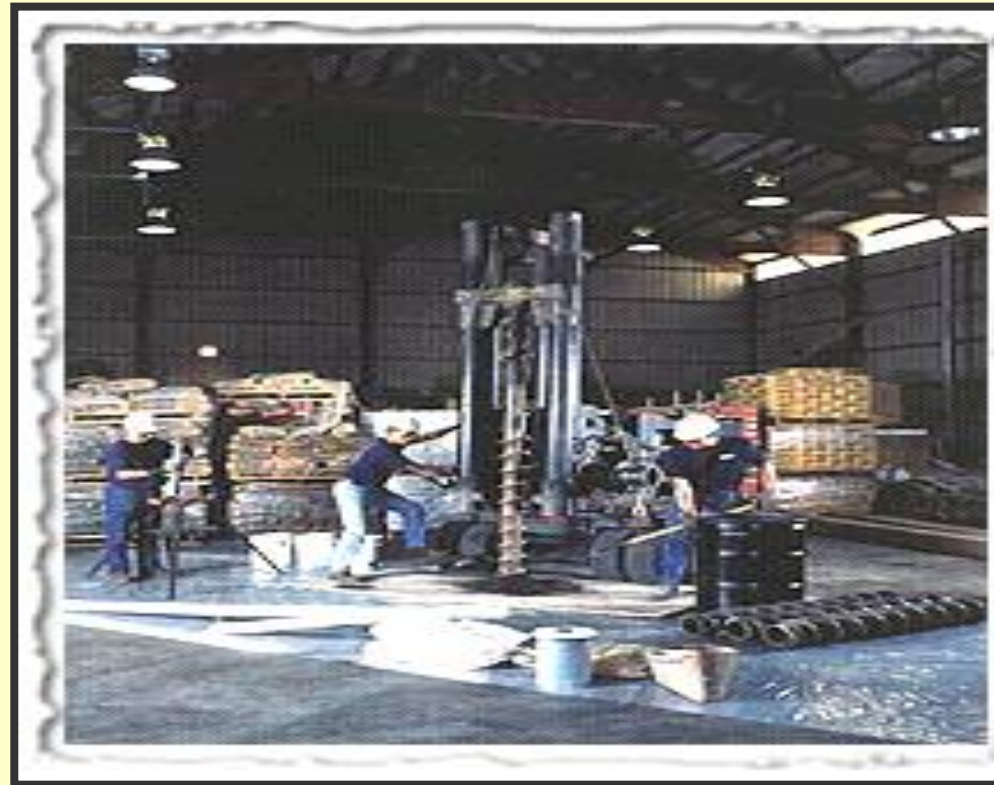
Angle Drilling

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



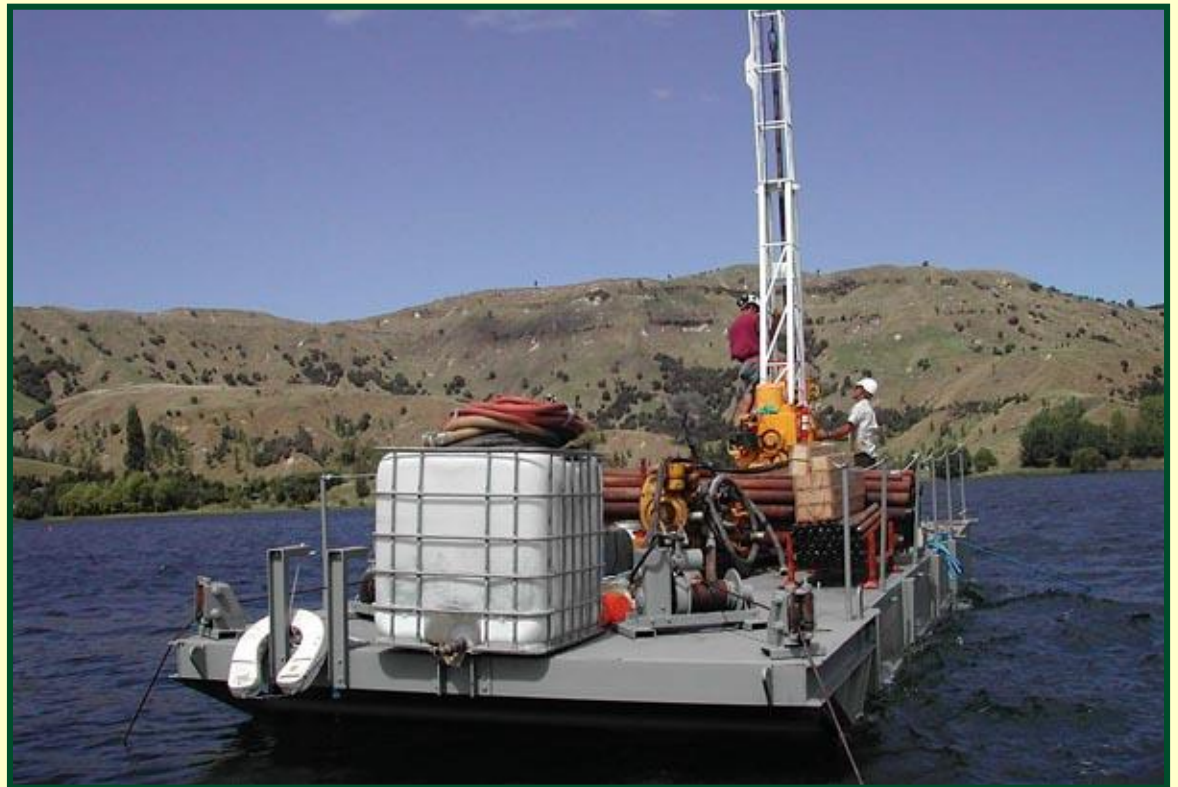
Confined Access/ Interior Drilling

- **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

Drilling vs. Sampling

- Drilling – “Just” a hole... no sample

- *Disturbed* Sampling

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

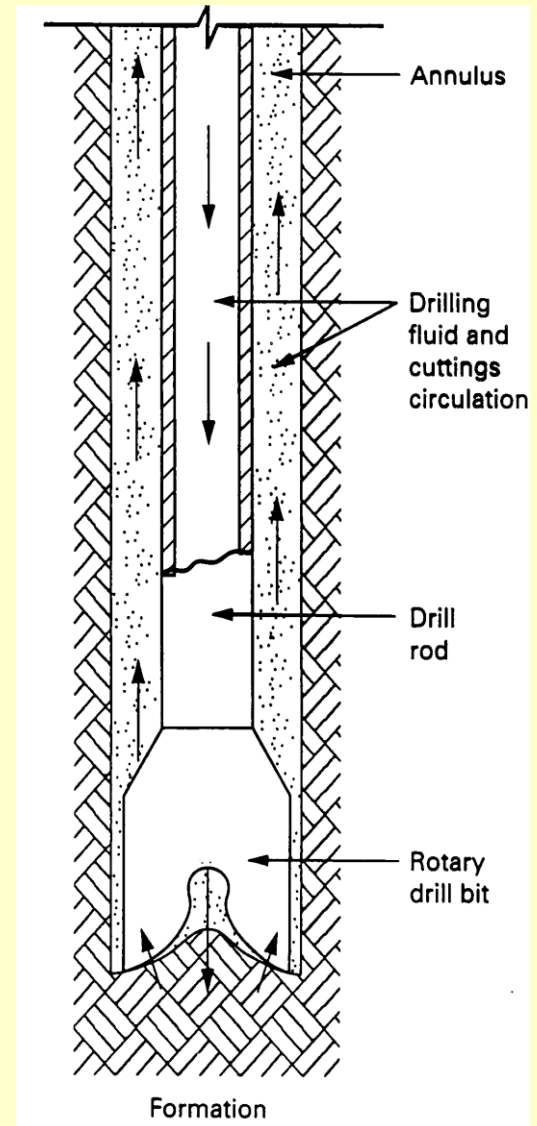
- *Undisturbed* Sampling

- Retrieve a continuous core
- Applicable to both soil and rock



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



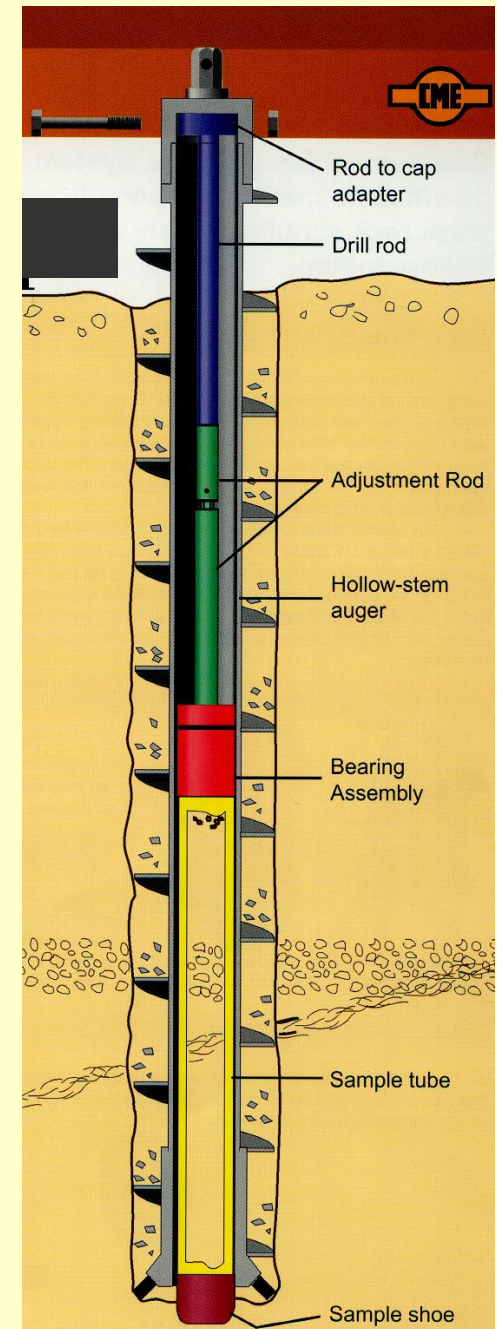
Drilling: Continuous Flight Auger



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

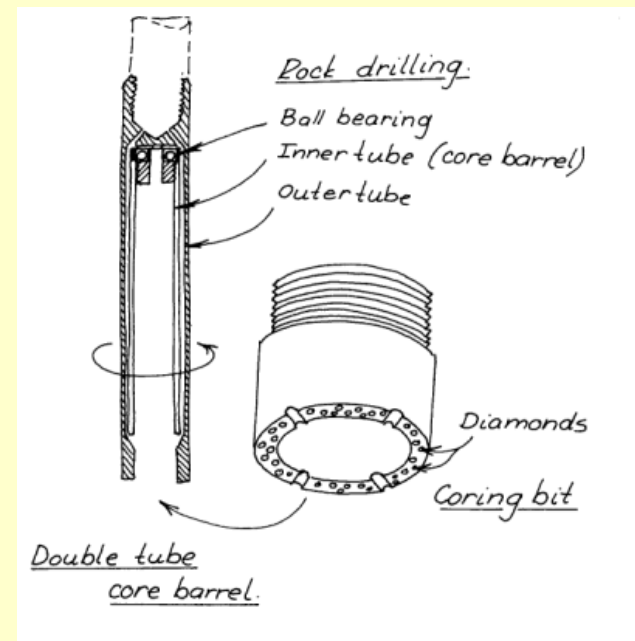
Hollow Stem Auger



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

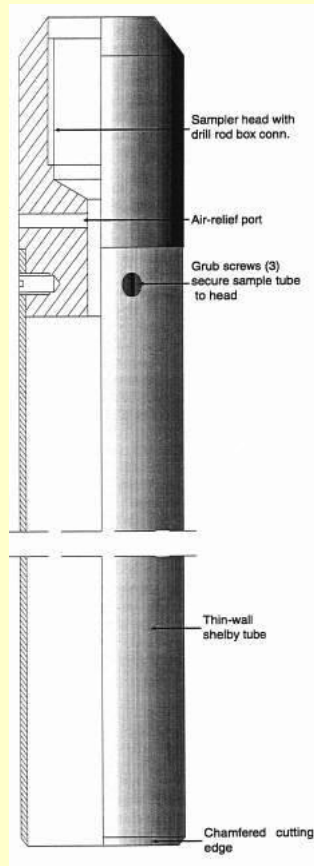
Rock Core Quality

- 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

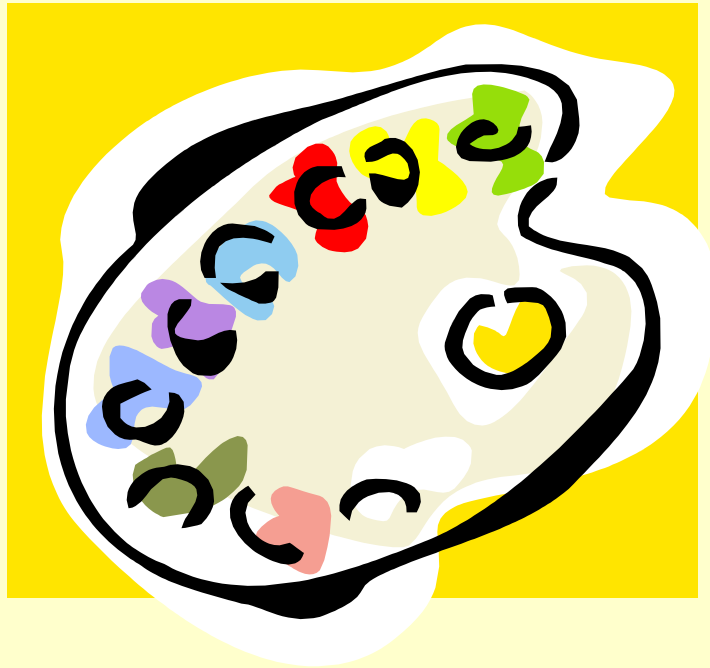
Shelby Tube Sampler



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

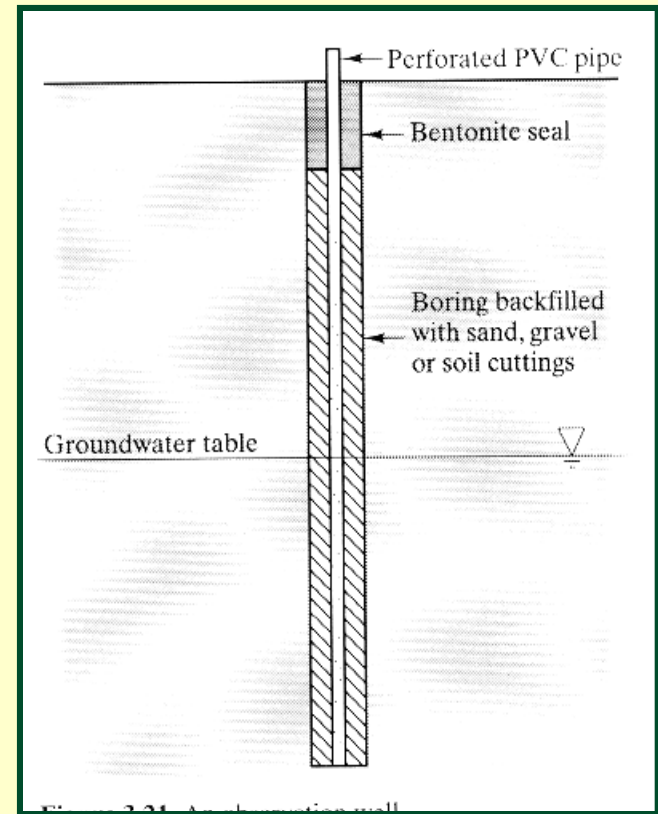


Ground Water



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

