US Army Corps of Engineers
Louisville District

Geotechnical and Dam Safety Section

Mill Creek Deep Tunnel

Geologic Conditions and Potential Impacts on Design/Construction

Kenneth E. Henn III, P.G.

Presented to 2005 Tri-State Infrastructure Systems Conference & Exposition
August 3, 2005

Presentation Outline

- Tunnel Alternative Overview.
- Geological Overview of the Valley.
- Bedrock Findings & Impacts.
- Overburden Findings & Impacts.

The Tunnel Alternative

Mill Creek General Reevaluation Report (GRR) Alternatives

- **Total Relocation**
- **Non-Structural**
- **Non-Structural 2**
- **Non-Structural 3**

Non-Structural

- **Channel Modification**
- **Channel Modification 2**
- **Floodwall & Levee**
- ***Deep Tunnel***
- **Deep Tunnel 2**

Structural

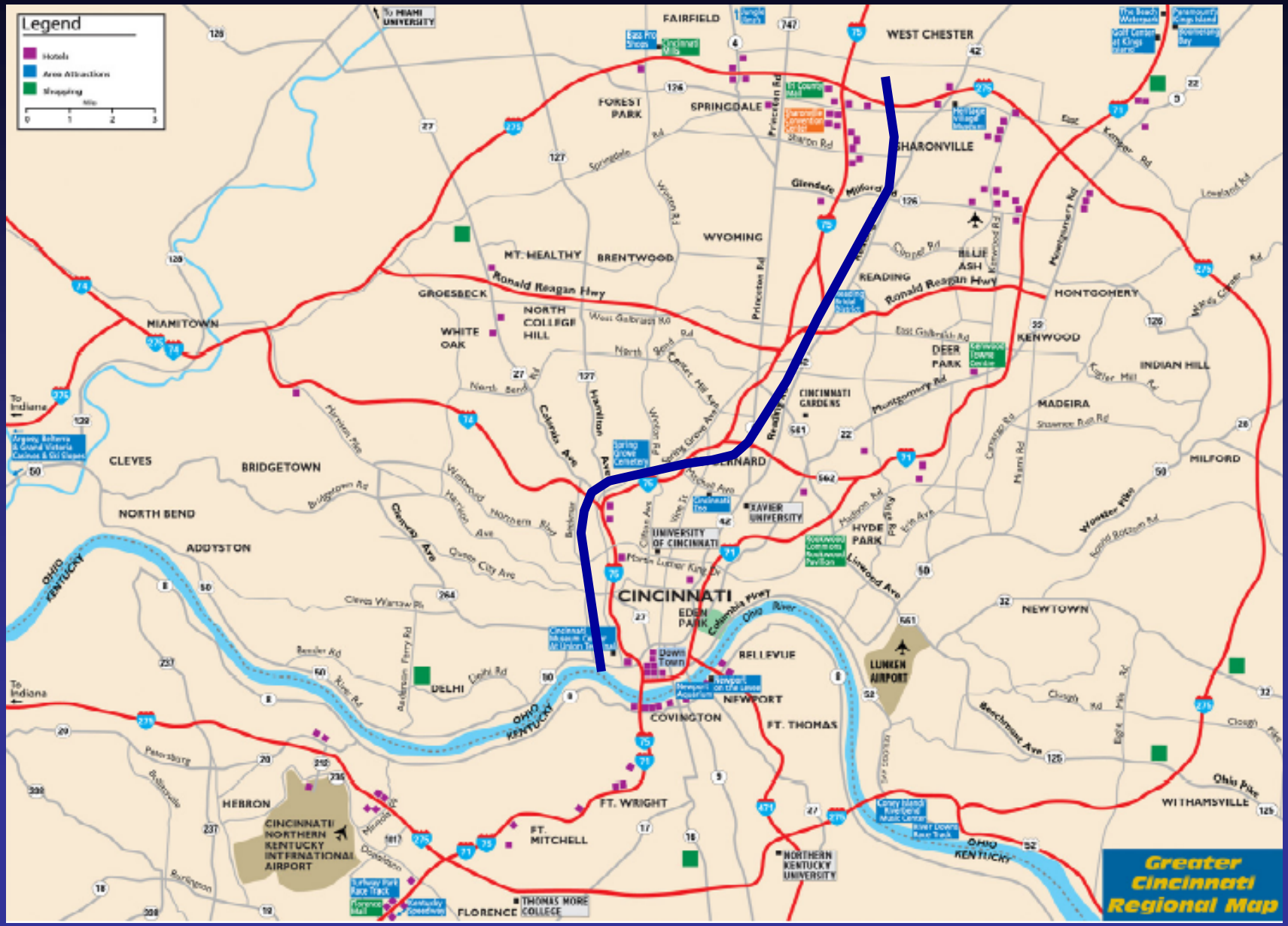
Mill Creek General Reevaluation Report (GRR) Alternatives

- Total Relocation
- Non-Structural
- **Non-Structural 2**
- Non-Structural 3

Non-Structural

- Channel Modification
- **Channel Modification 2**
- Floodwall & Levee
- ***Deep Tunnel***
- Deep Tunnel 2

Structural


Legend
Hotels
Area Attractions
Shopping
0 1 2 3
FAIRFIELD
WEST CHESTER
FOREST PARK
SPRINGDALE
SHARONVILLE
WYOMING
MT. HEALTHY
BRENTWOOD
READING
MONTGOMERY
GROESBECK
NORTH COLLEGE HILL
WHITE OAK
MIAMITOWN
DEER PARK
KENWOOD
INDIAN HILL
CINCINNATI GARDENS
MADEIRA
CLEVES
BRIDGETOWN
NORTH BEND
ADDYSTON
MILFORD
HYDE PARK
CINCINNATI
EDEN PARK
NEWTOWN
BELLEVUE
DELHI
NEWPORT
COVINGTON
FT. THOMAS
LUNKEN AIRPORT
HEBRON
CINCINNATI NORTHERN KENTUCKY INTERNATIONAL AIRPORT
FT. WRIGHT
FT. MITCHELL
NORTHERN KENTUCKY UNIVERSITY
WITHAMSVILLE
FLORENCE
THOMAS MORE COLLEGE
XAVIER UNIVERSITY
UNIVERSITY OF CINCINNATI
Ronald Reagan Hwy
Columbia Pkwy
Ohio River
OHIO KENTUCKY
Greater Cincinnati Regional Map

- Proposed Tunnel Aspects -

Approximately 16 miles long

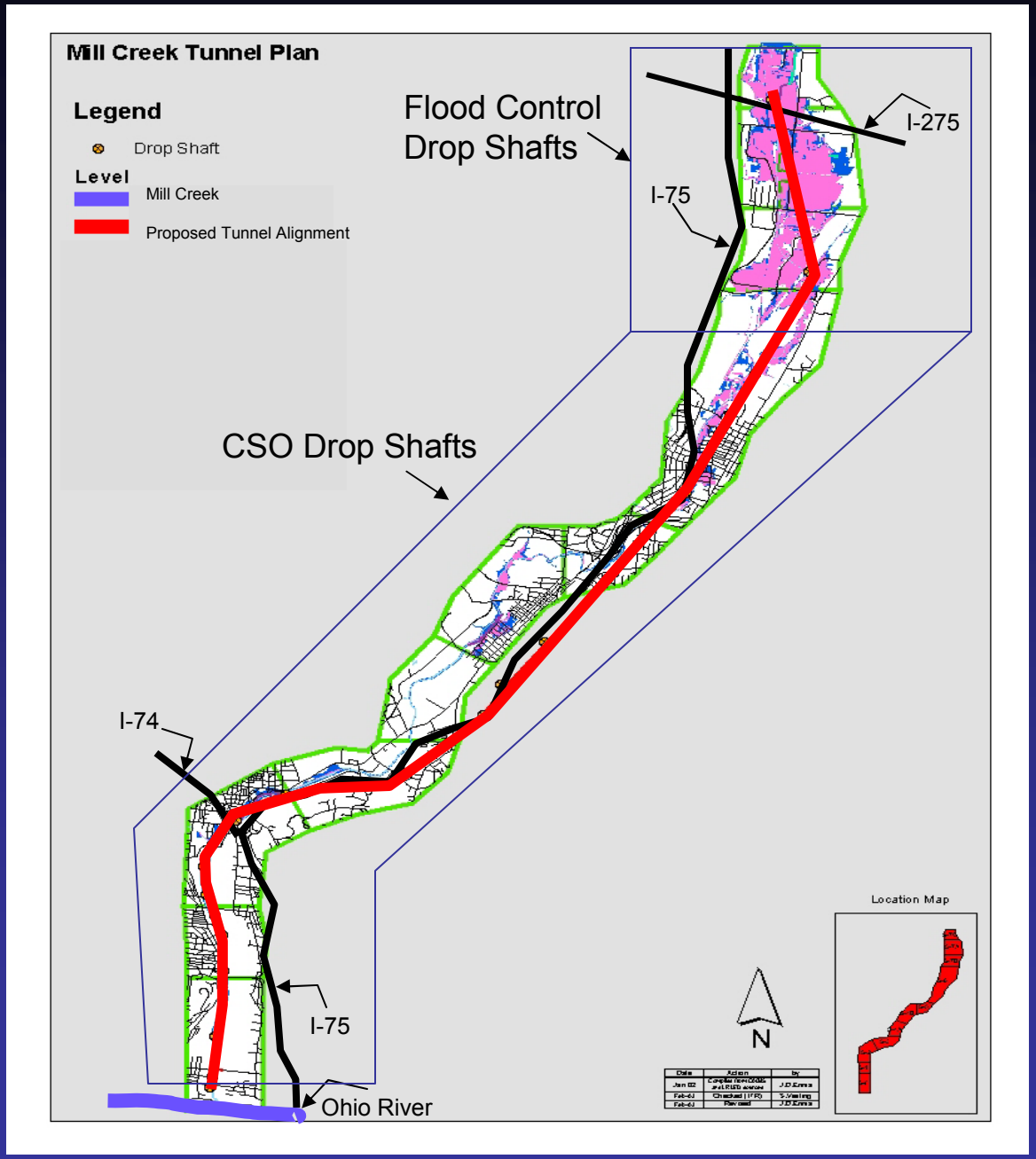
31-foot finished diameter

19 drop shafts, ranging in size from 10-feet to 24-feet in diameter.

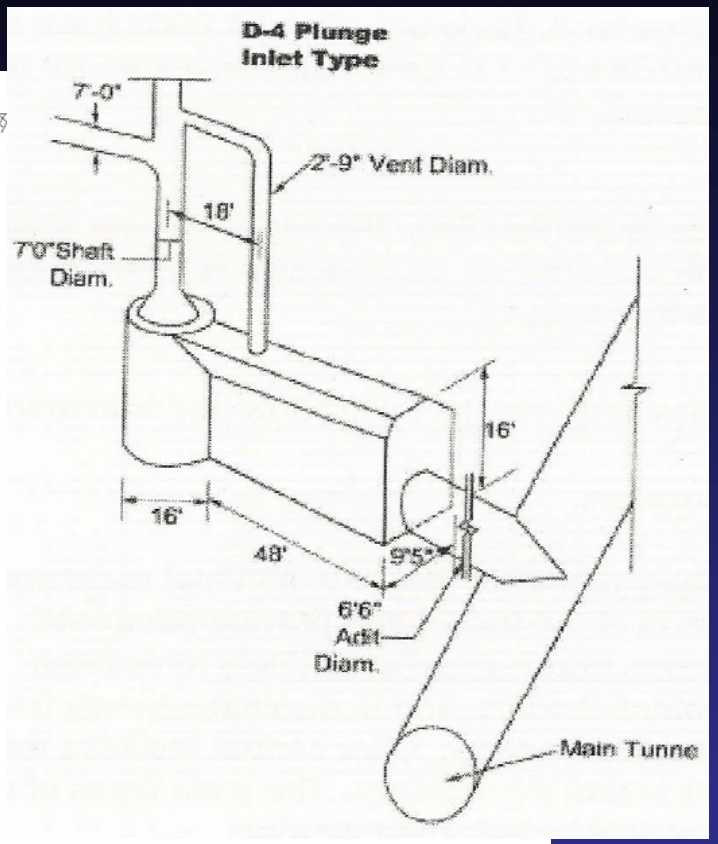
4 mining shafts, ranging in size from 30-feet to 60-feet in diameter.

19 access shafts, with 10-foot diameter

Approximately 67 combined sewer (CSO) runs for a total Of 12 miles of sewer, ranging from 3.5-feet to 10-feet in diameter

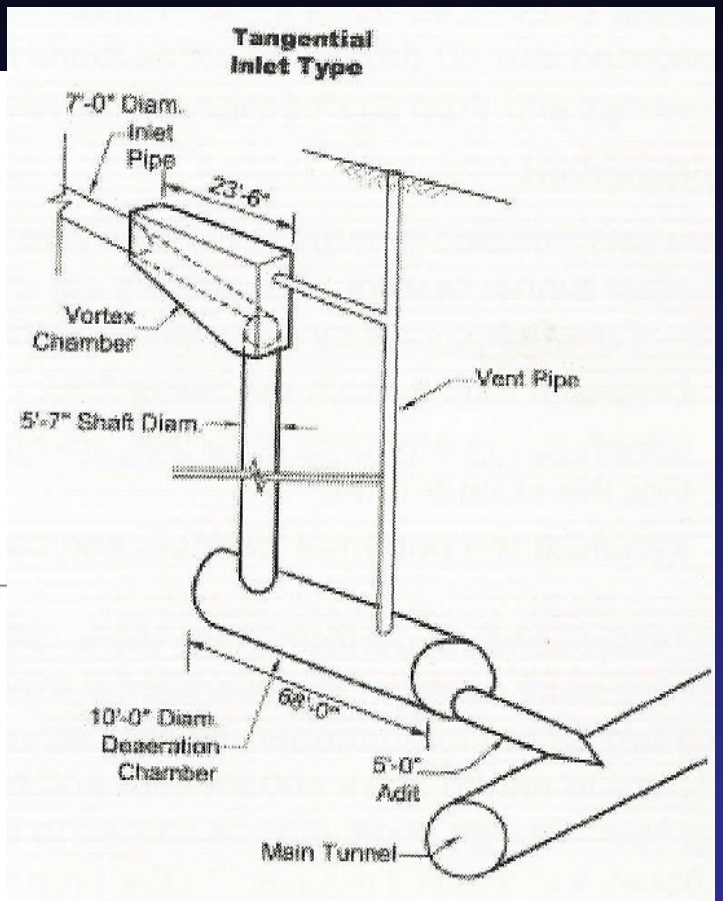


Plunge Shaft



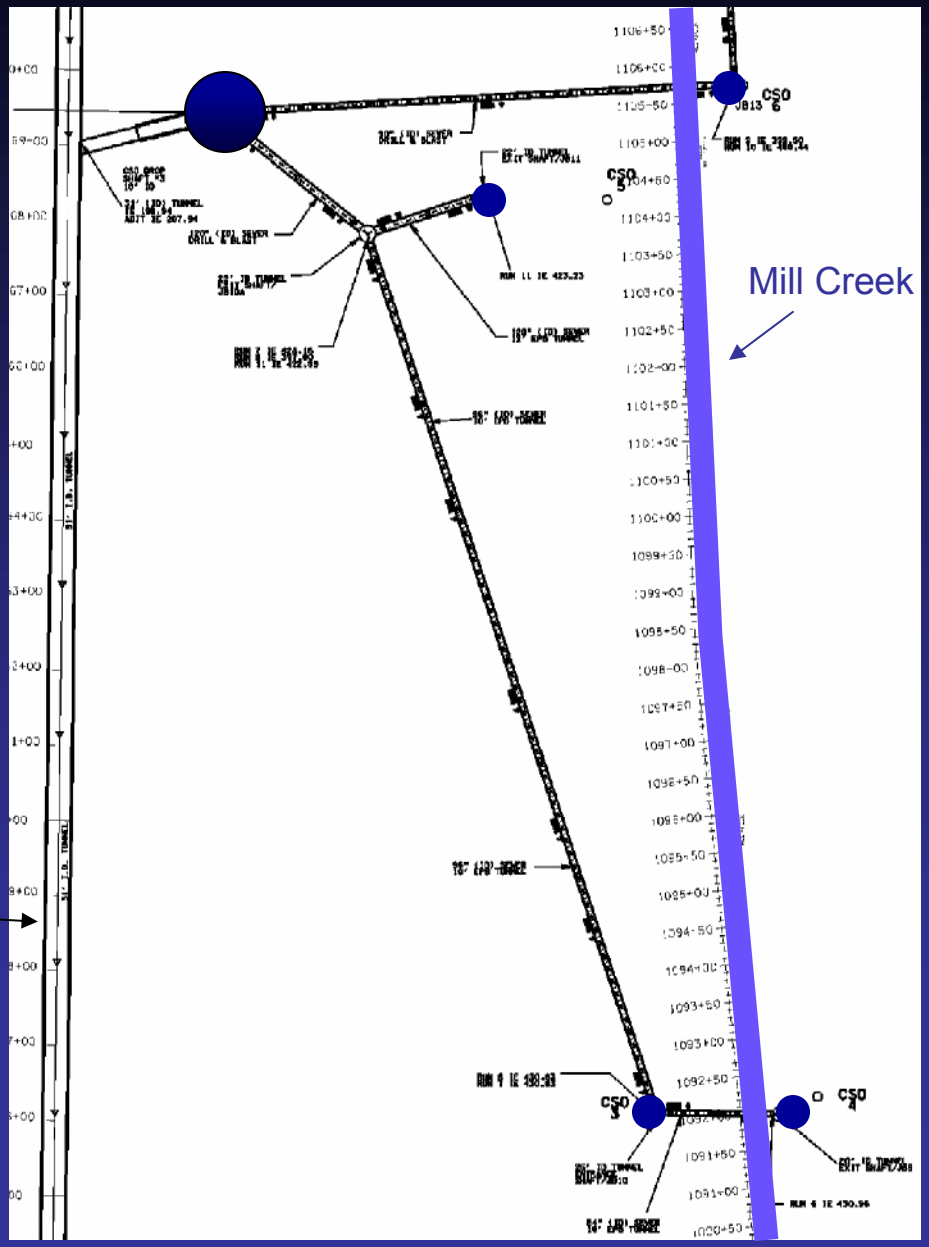
No Scale

Vortex Shaft



No Scale

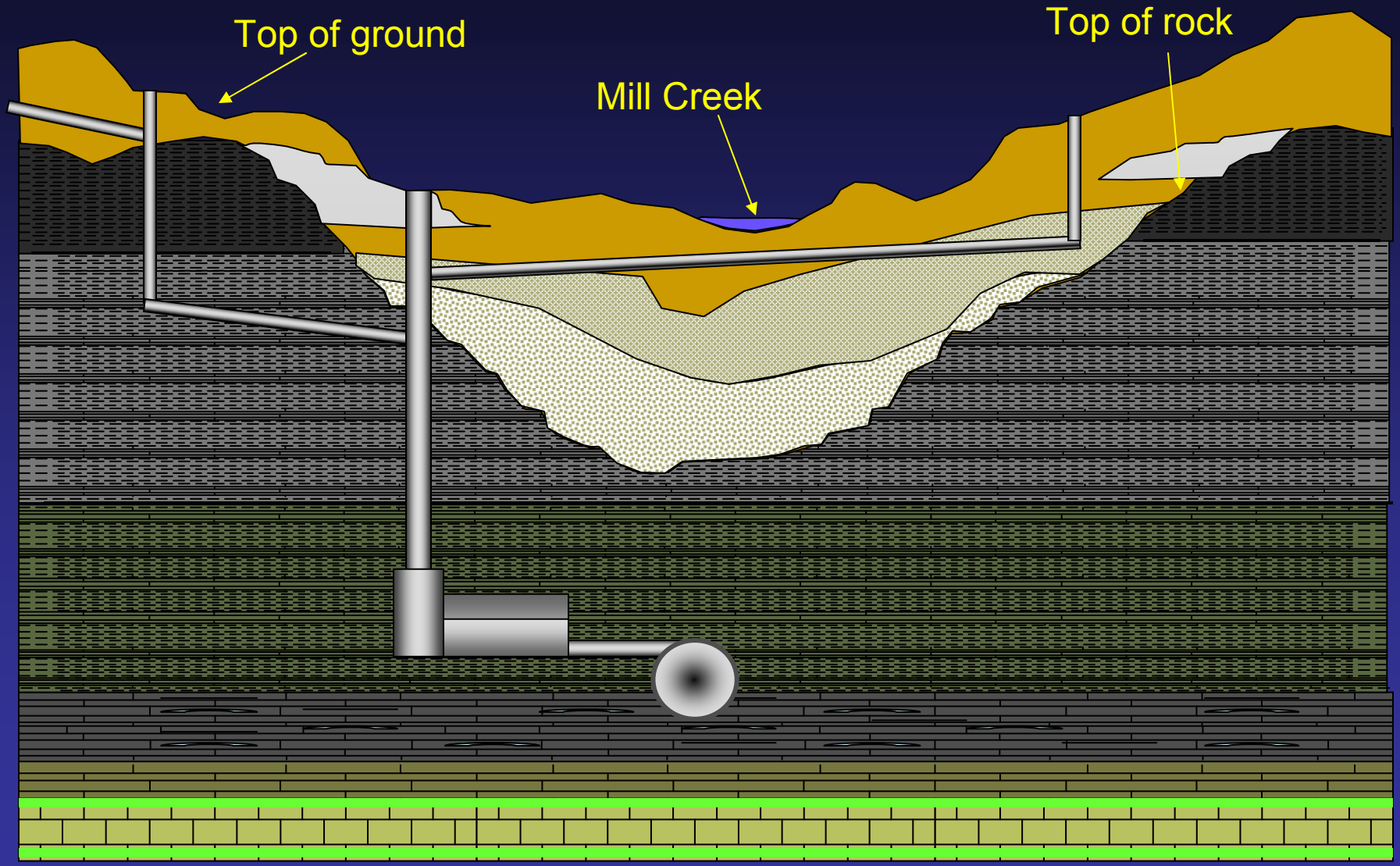
Combined Sewer Outflow (CSO) runs going to Drop Shaft



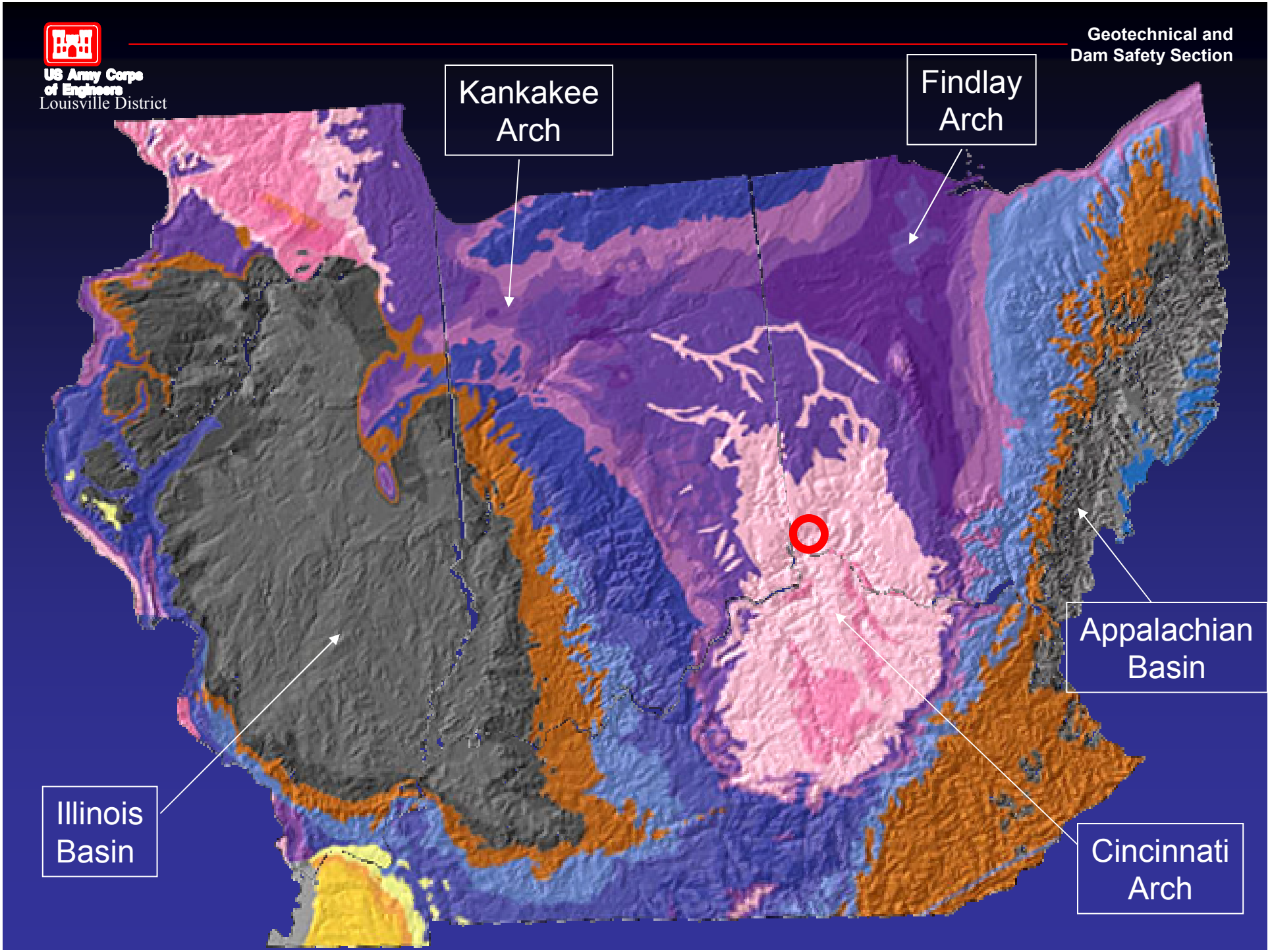
Deep Tunnel

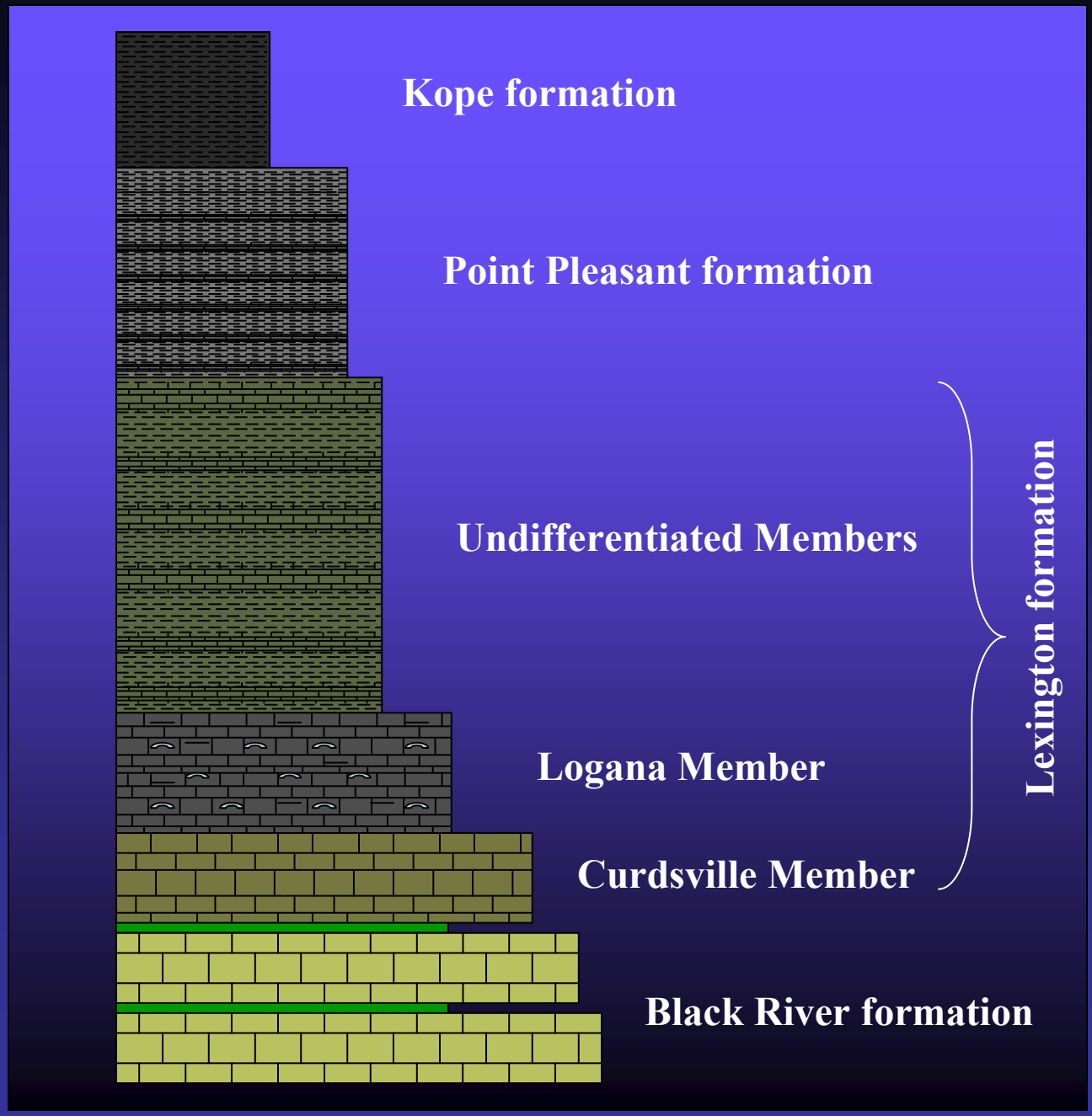
(~300’ below ground surface)

Tunnel Section

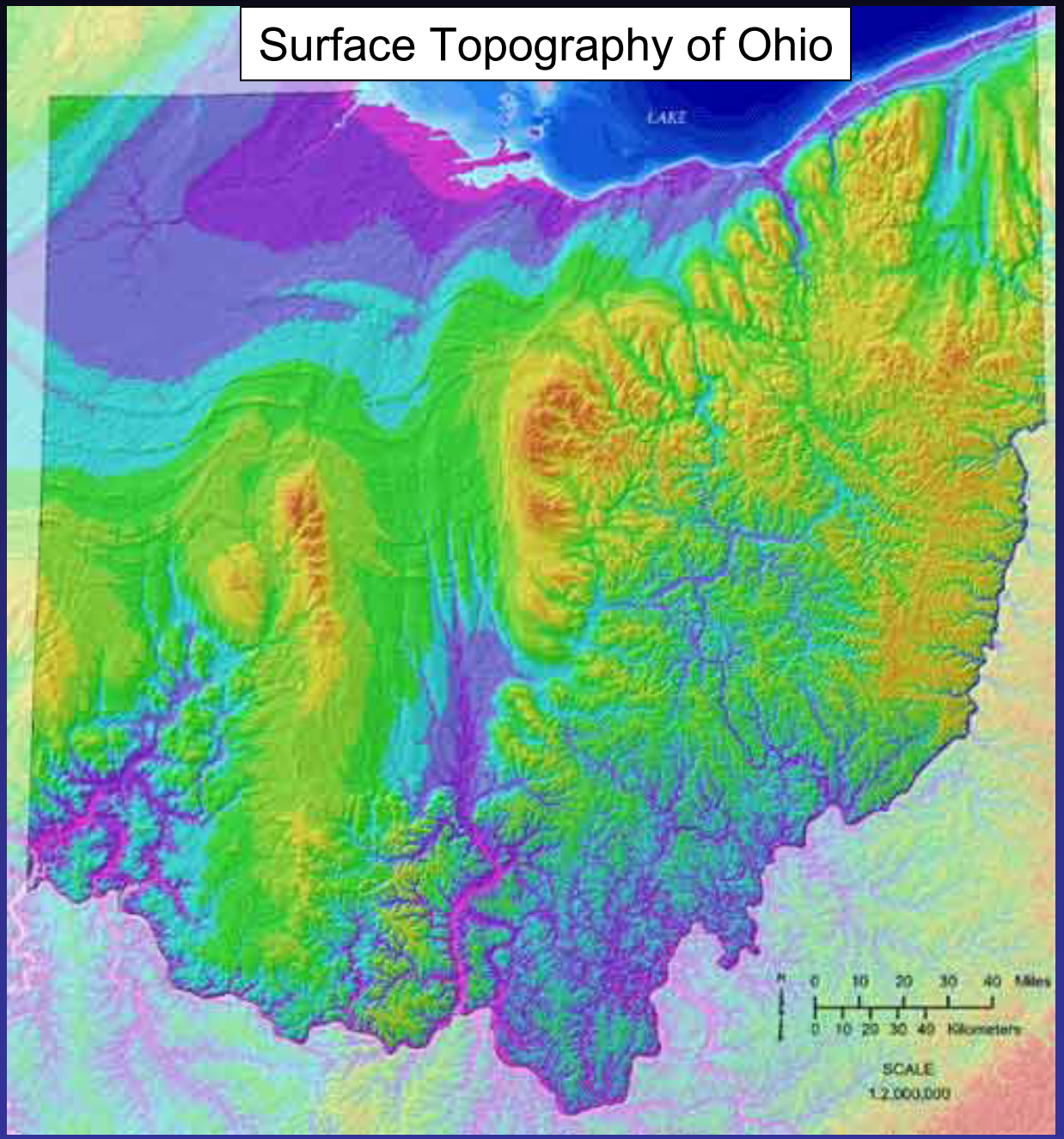


Geologic Overview

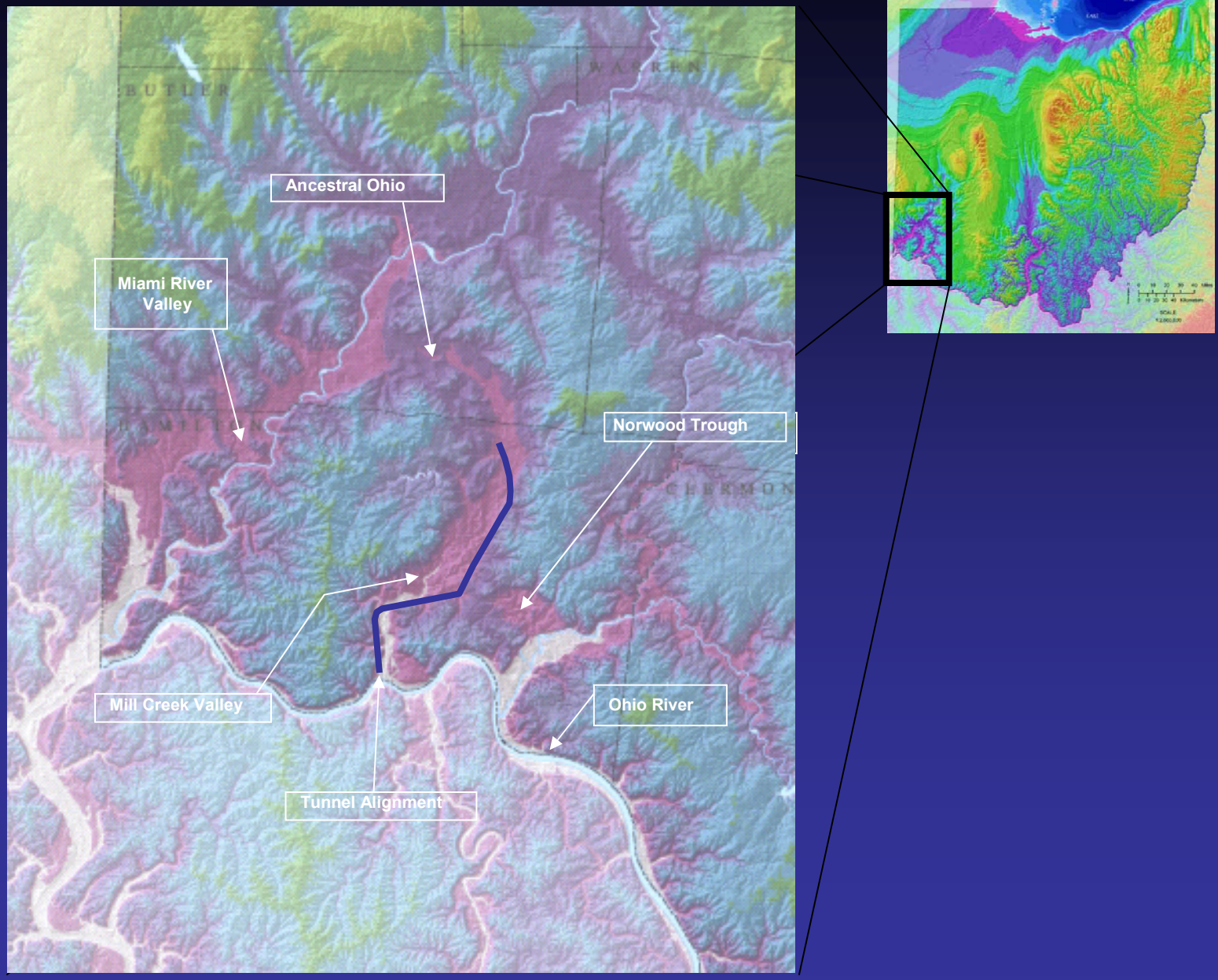

Kankakee Arch
Findlay Arch
Appalachian Basin
Illinois Basin
Cincinnati Arch


Kope formation
Point Pleasant formation
Undifferentiated Members
Logana Member
Curdsville Member
Lexington formation
Black River formation

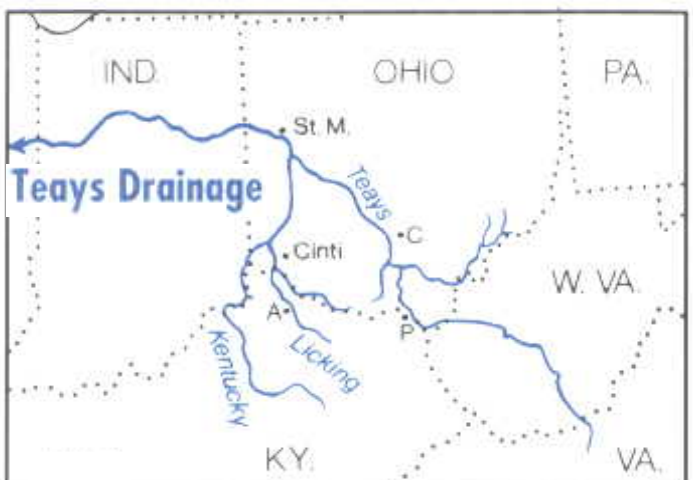
Surface Topography of Ohio

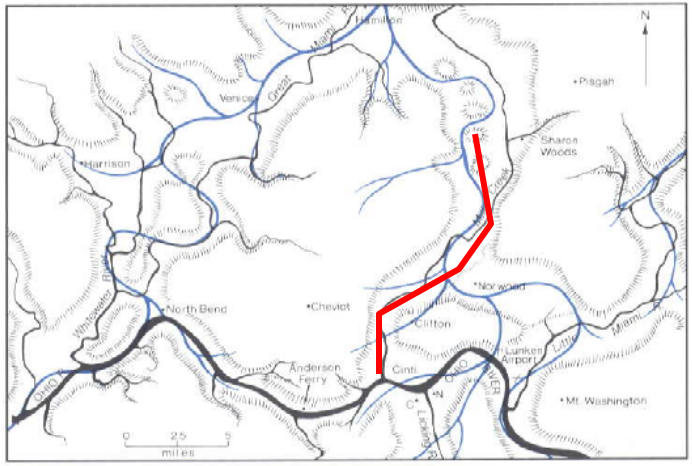


Obtained from the Ohio Geological Survey

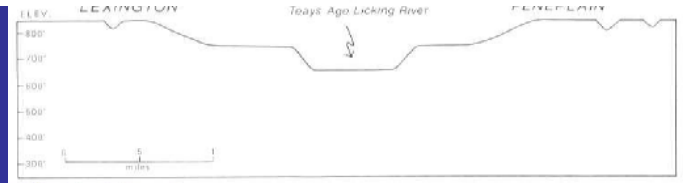

Ancestral Ohio
Miami River Valley
Norwood Trough
Mill Creek Valley
Ohio River
Tunnel Alignment

250,000 YBP



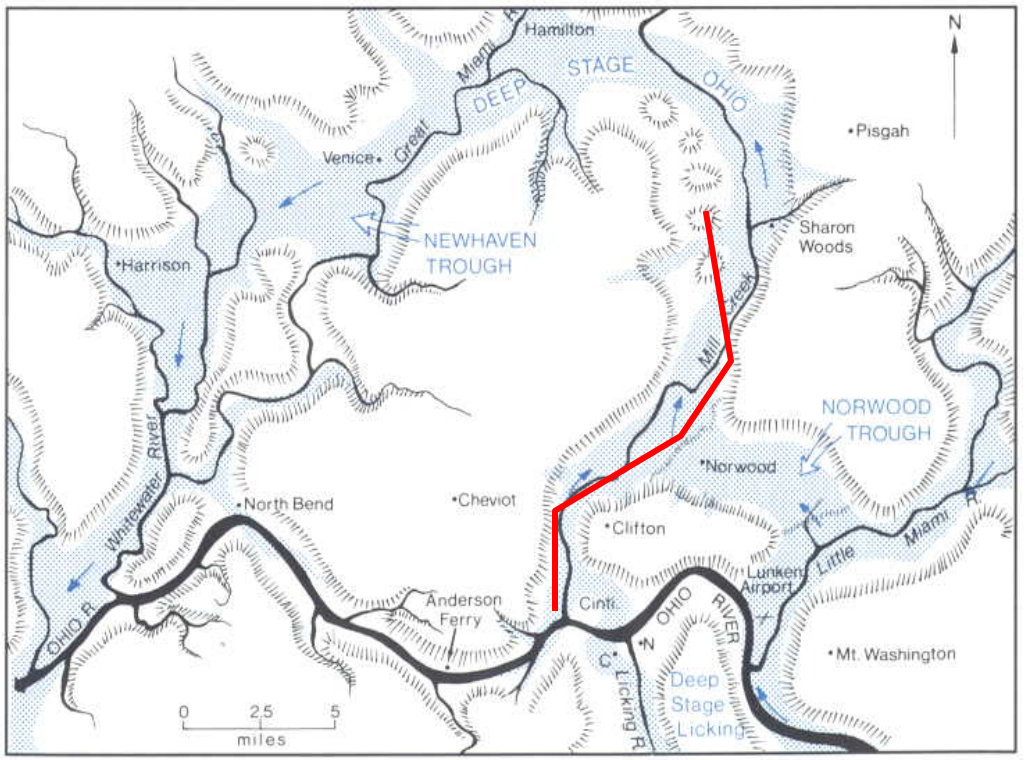


North flowing tributaries to the Teays system in blue. Modern drainage in black. Ohio River nonexistent at that time.

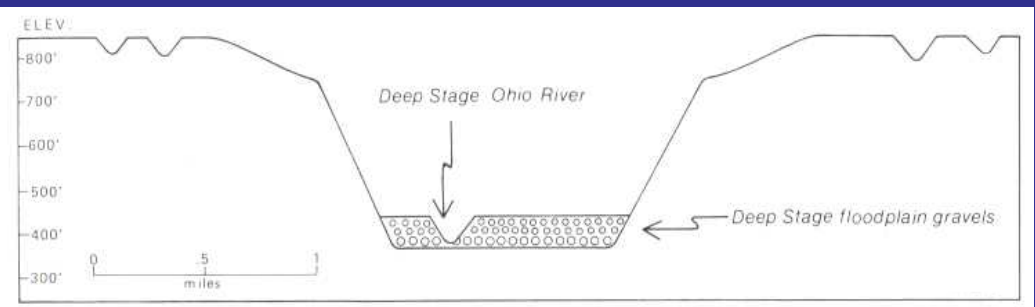


Licking River in Teays Time

Pre-Illinoian (>150,000 YBP)



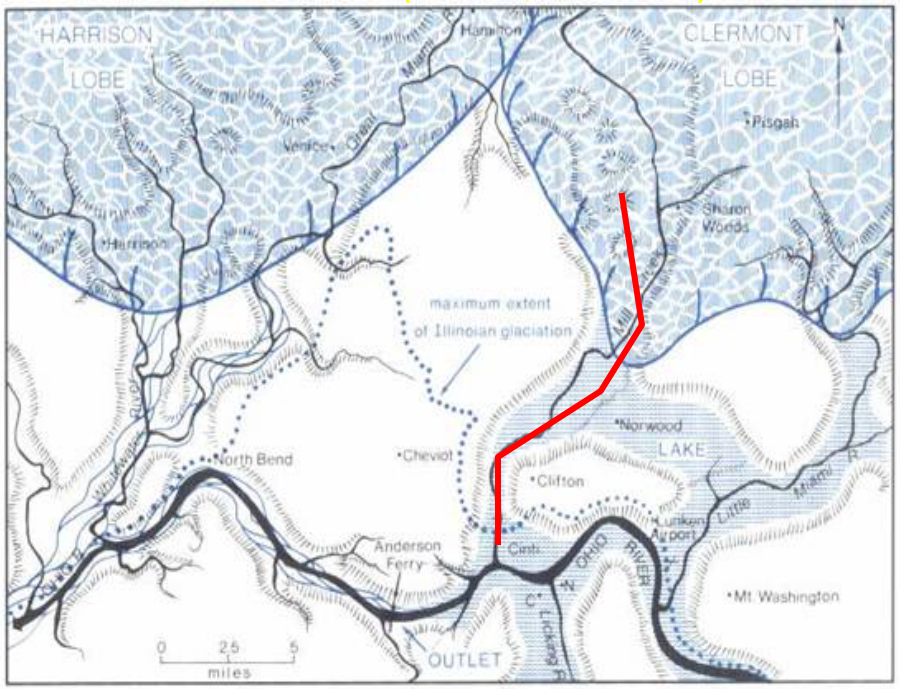
Map of Deep Stage ancestral Ohio shown by arrows.



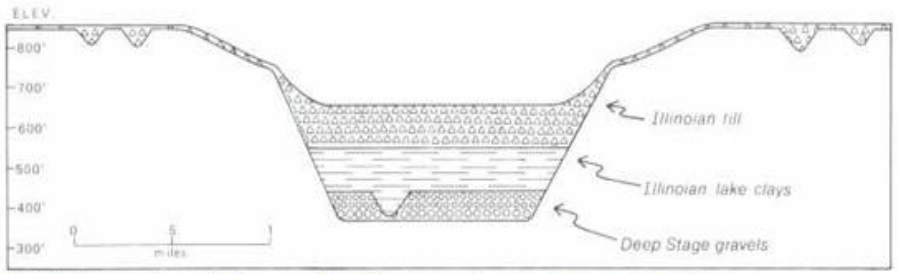
Cross section of Deep Stage Ohio.

from Durrell, 1977

Illinoian (150,000 YBP)

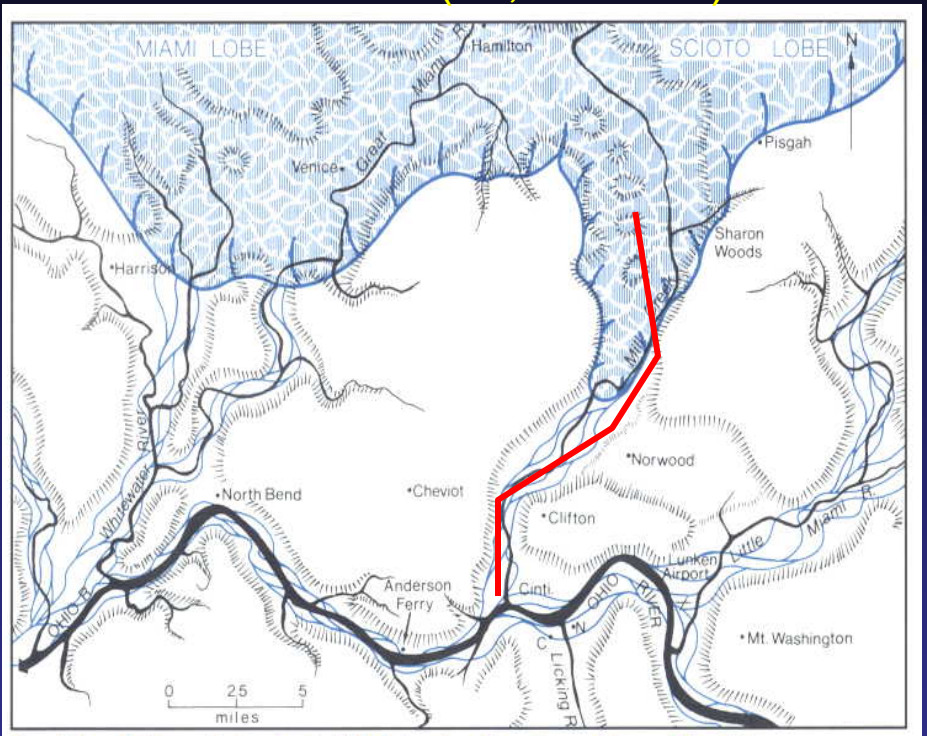


Advance of Illinoian ice ponding north flowing Licking River with the deposition of lake clay followed by over flow of a divide at Anderson Ferry to create present westward course of the Ohio River, south of Cincinnati.

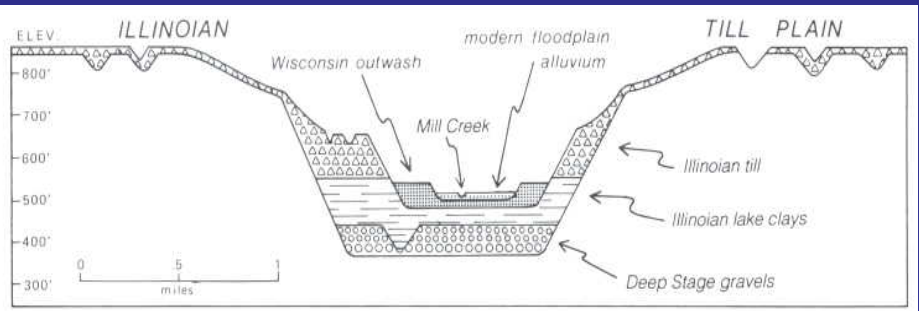


The further southward advance of the Illinoian ice deposited till over the lake clays and on the uplands.

Wisconsin (20,000 YBP)



Two lobes of Wisconsin ice sheet which fed outwash southward toward the Ohio River. Note braided stream pattern.



Cross section of two terraces in Mill Creek Valley well shown in Spring Grove Cemetery.

from Durrell, 1977

Subsurface Investigations

Bedrock Findings and Impacts on Construction Methods

The Foci of the Investigations

Historical and Archive Research: (~1100 historical borings) Included previous borings, research, and investigations by local, state, university, and federal entities.

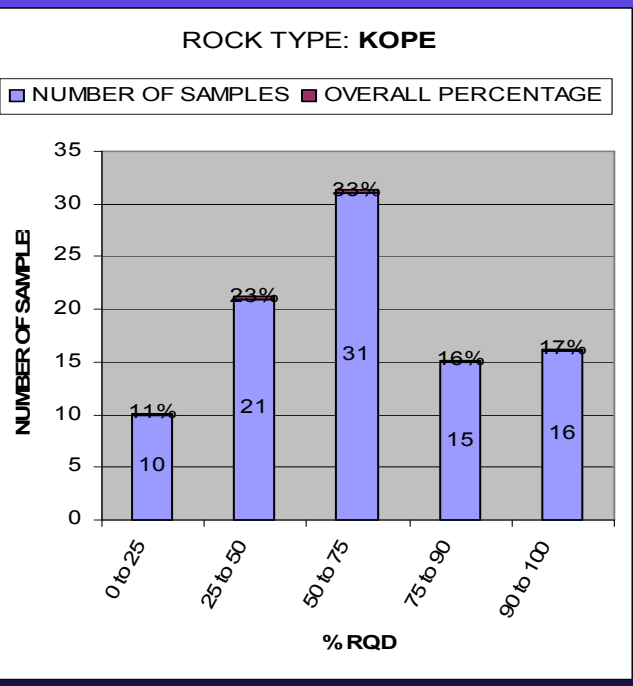
Drilling Round 1: (9 borings) General characterization of the overburden and bedrock formations. Index and physical testing of soils and rock samples.

Drilling Round 2: (13 borings) Specific characterization of bedrock, including borehole geophysics, angle borings, joint orientations, etc.

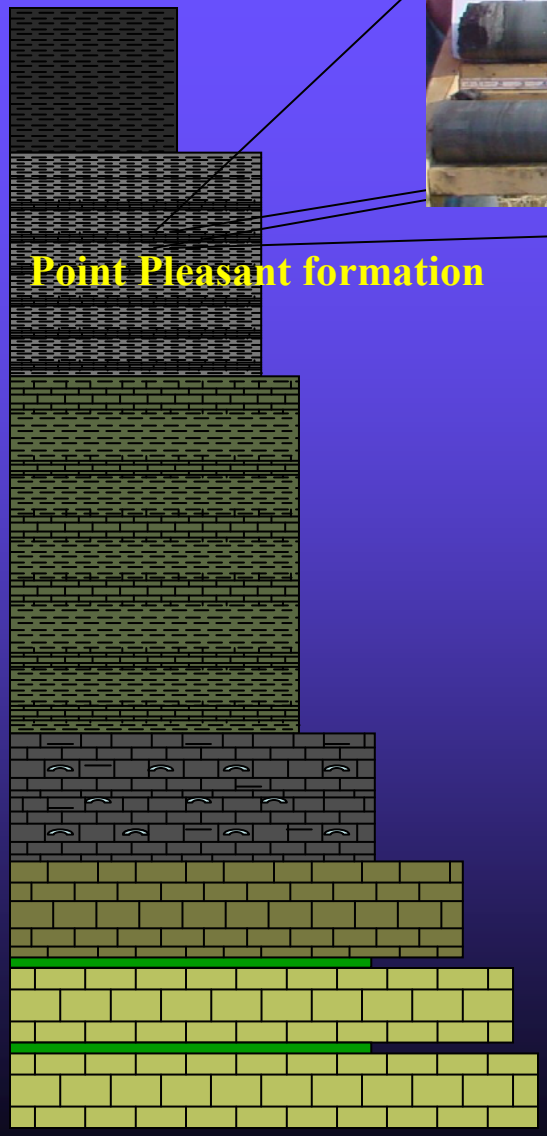
Drilling Round 3: (57 borings) Top of rock verification borings to help define the buried valley geometry.

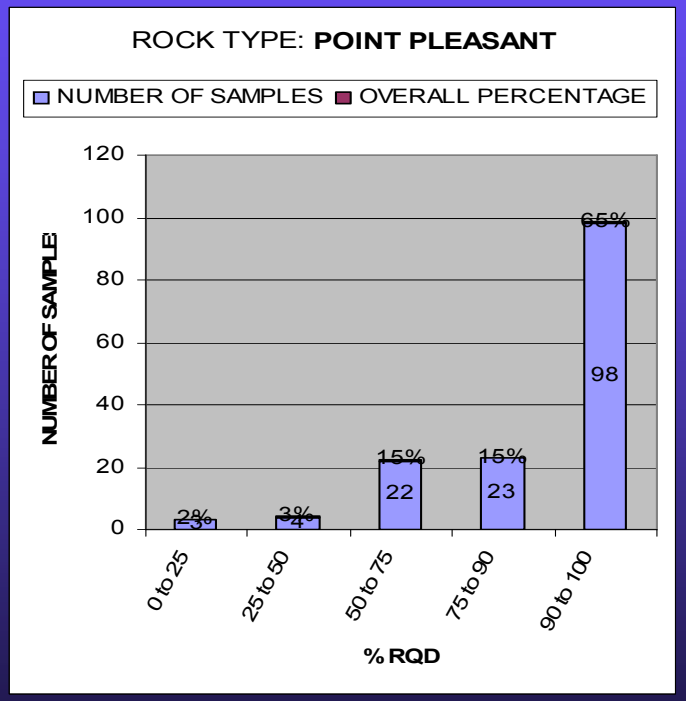
Consultant Involvement: Obtained throughout the investigation process to ensure aspects of tunnel investigations were characterized.

Kope formation

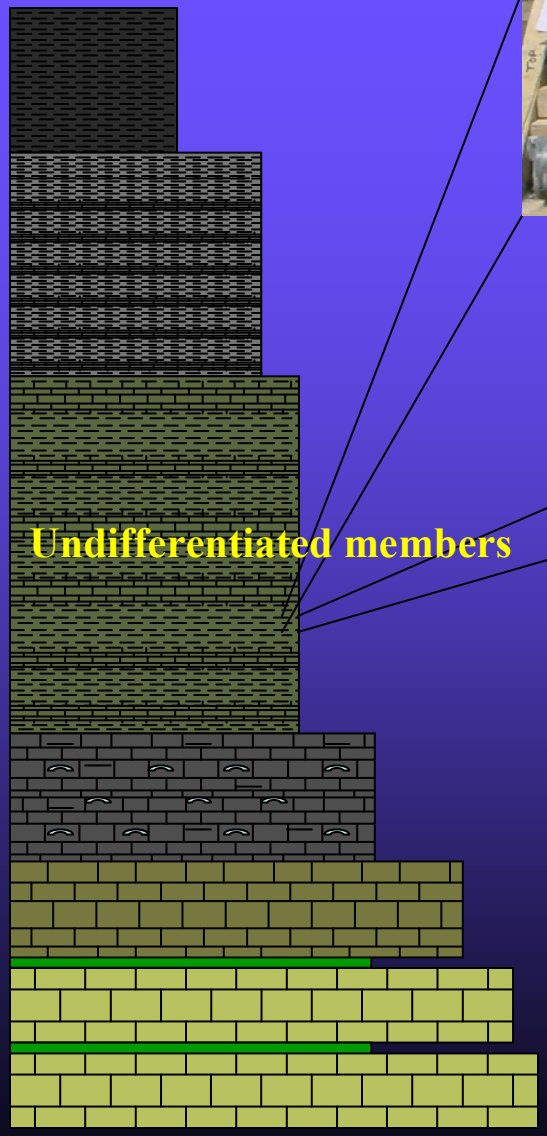


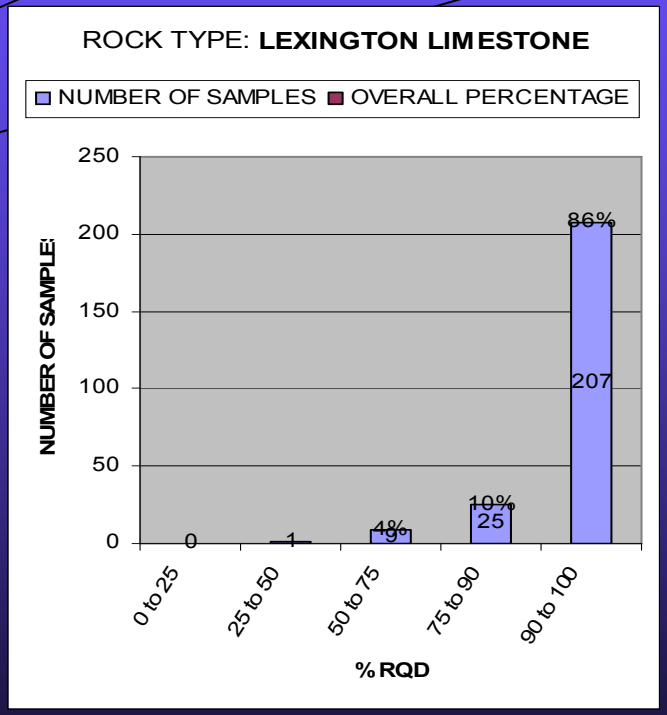
Avg. Compressive Strength: 915 psi



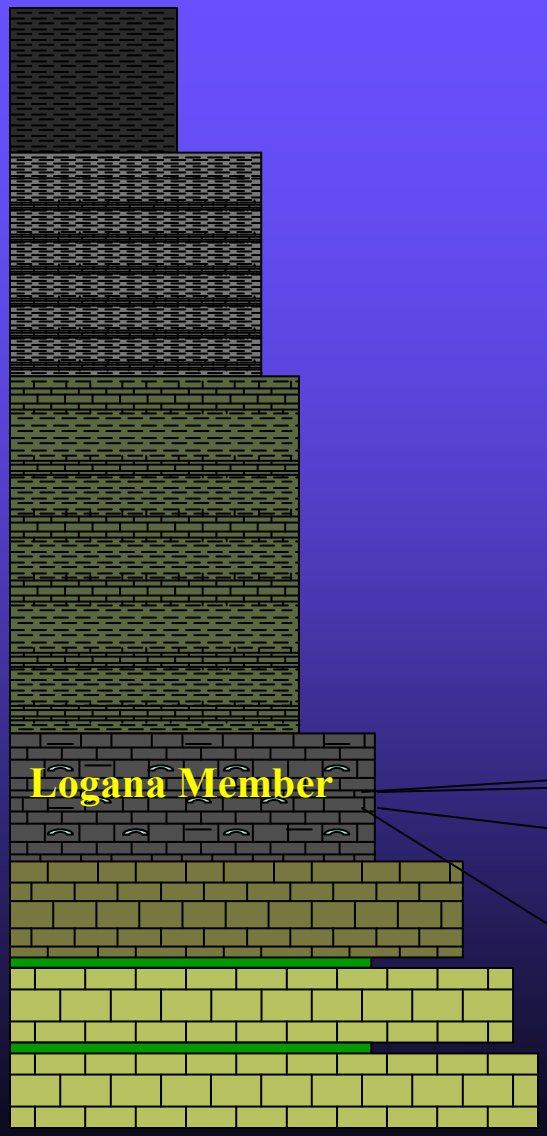


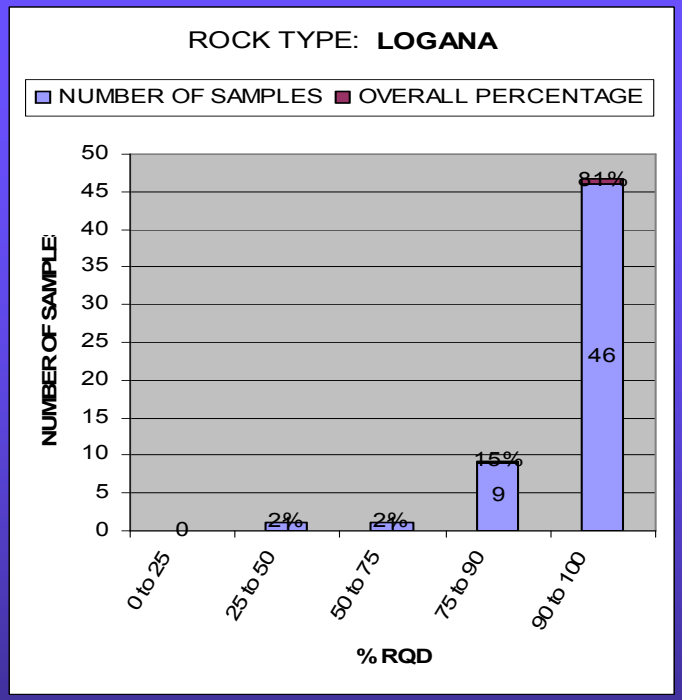
Avg. Compressive Strength: 3057 psi

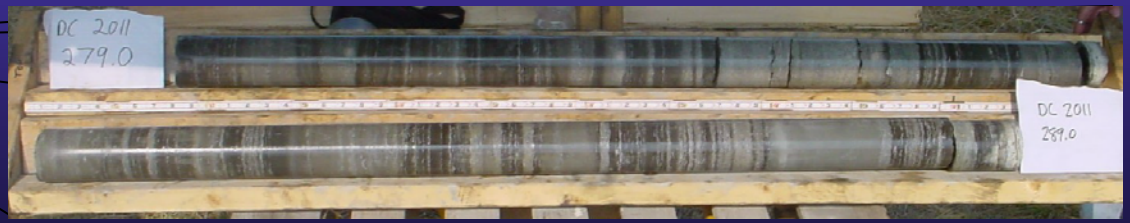




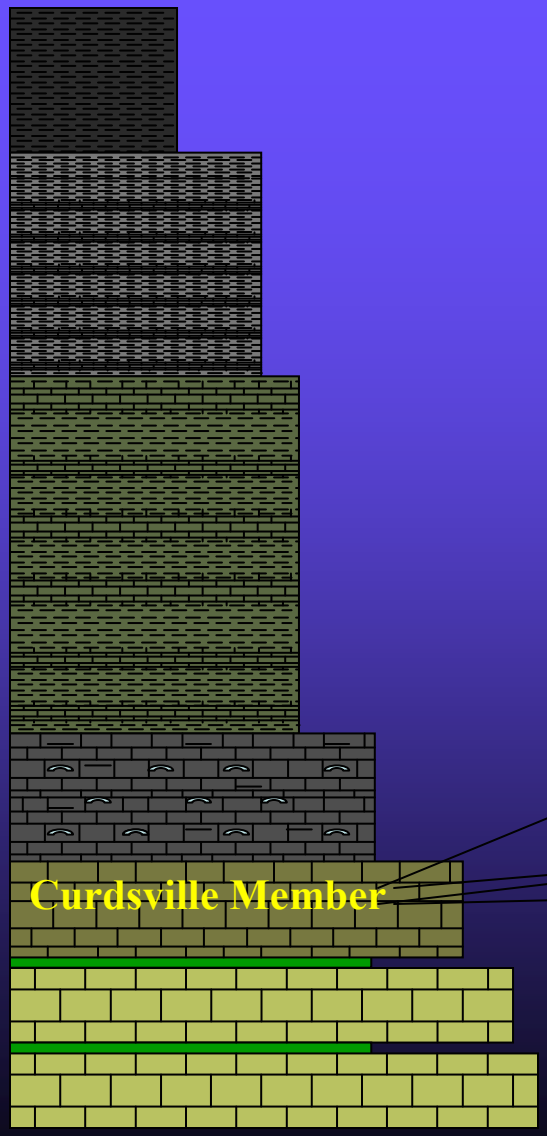
Avg. Compressive Strength: 9281 psi

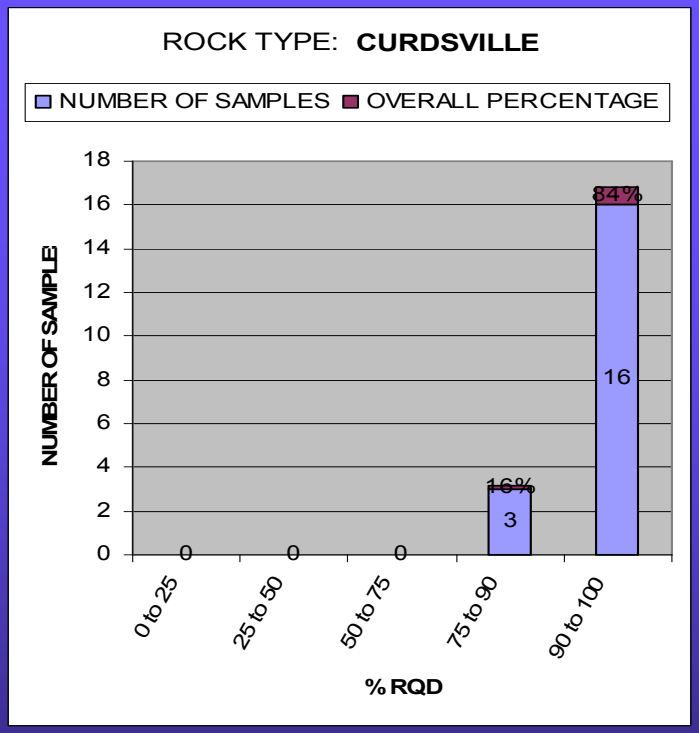




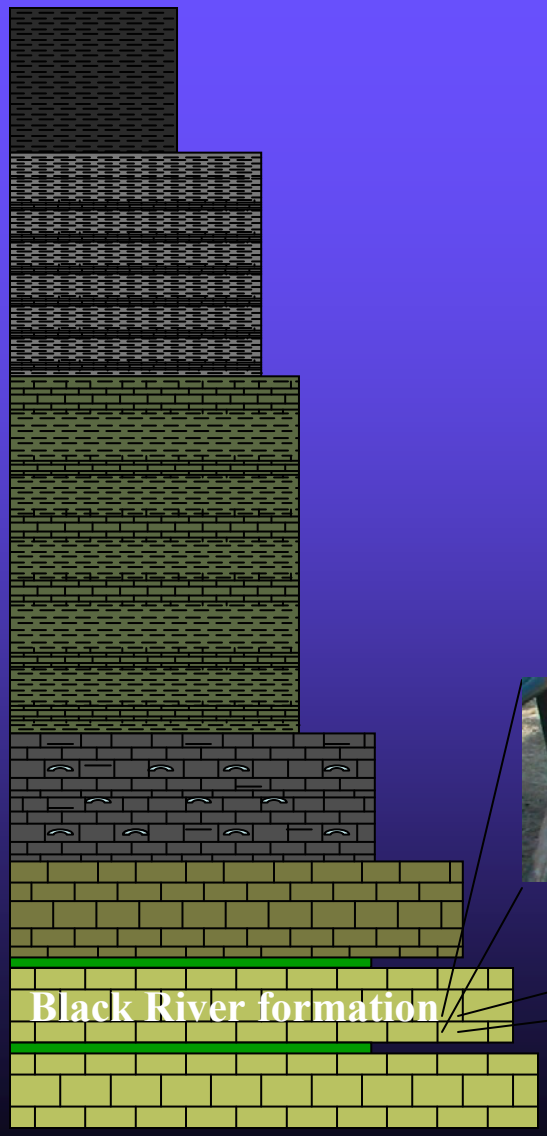


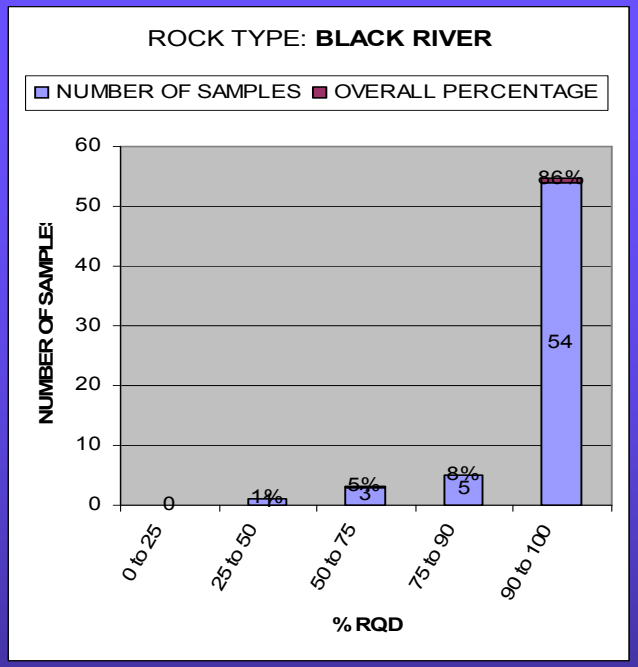
Avg. Compressive Strength: 7821 psi



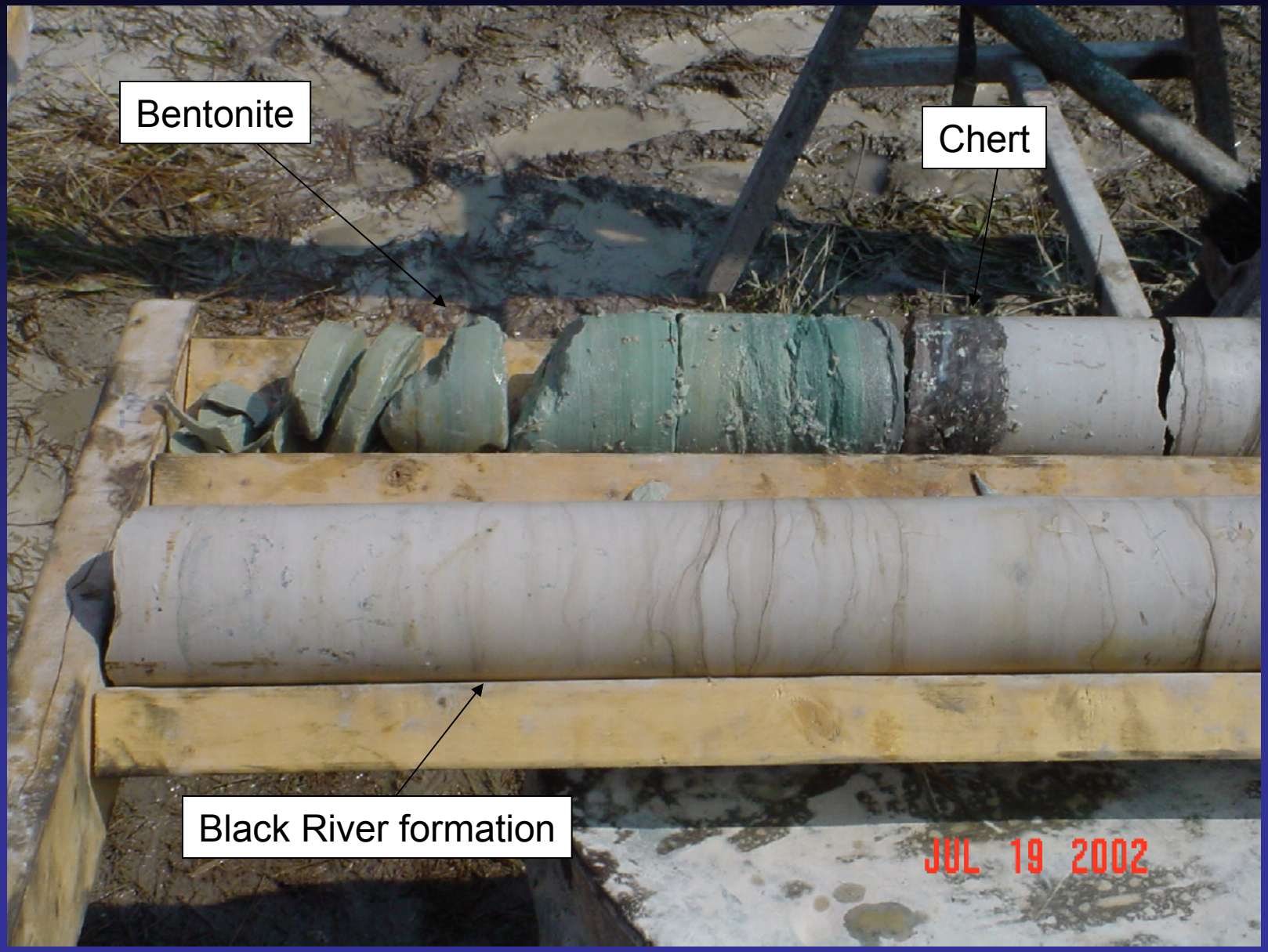


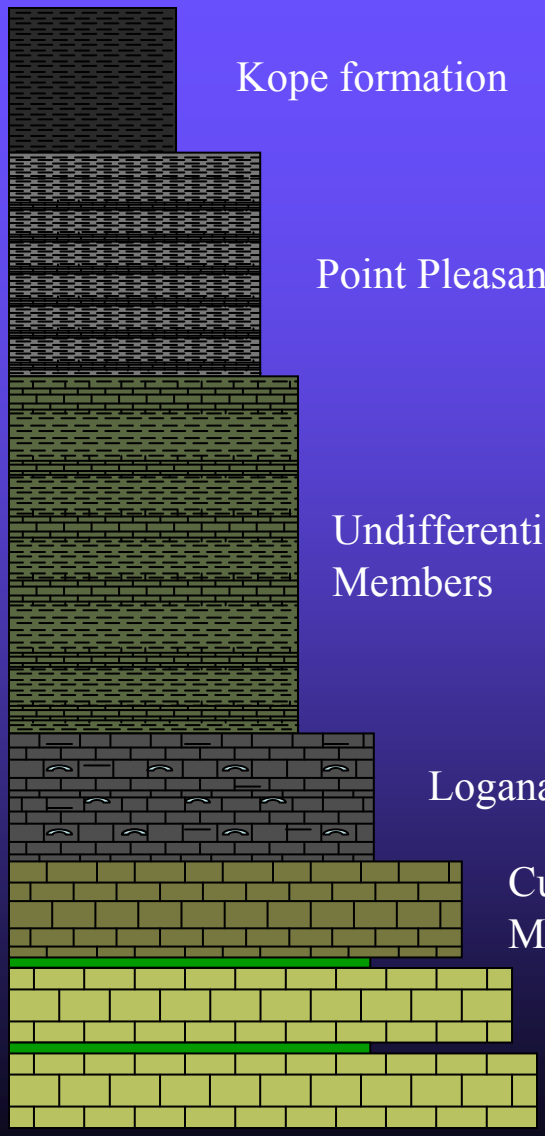
Avg. Compressive Strength: 12,988 psi





Avg. Compressive Strength: 15,719 psi


Bentonite
Chert
Black River formation
JUL 19 2002



Kope formation

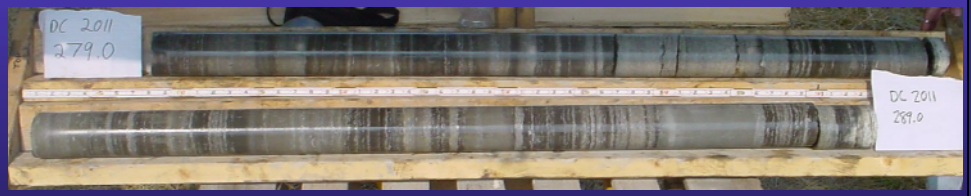
Point Pleasant formation

Undifferentiated Members

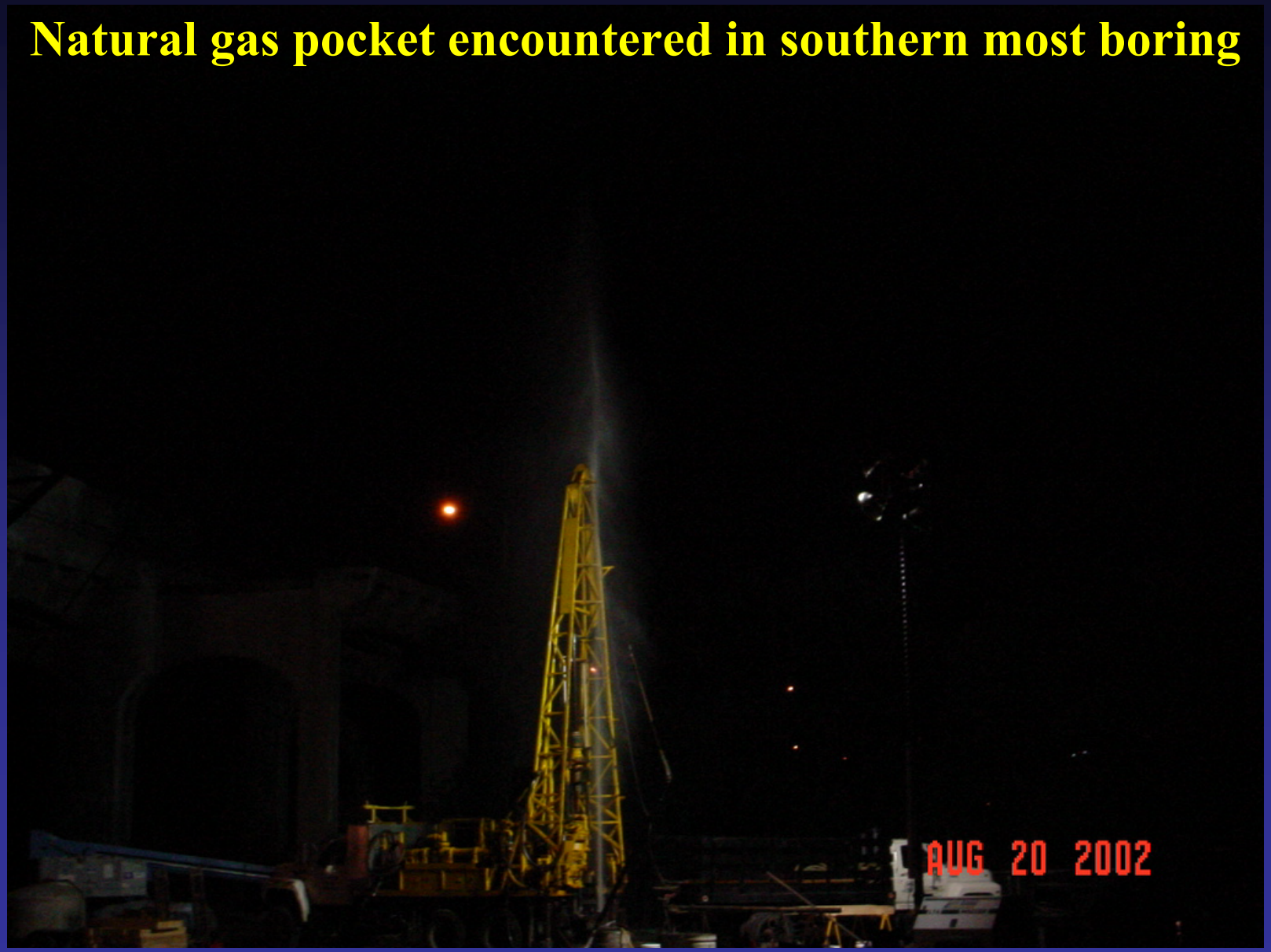
Logana Member

Curdsville Member

Black River formation



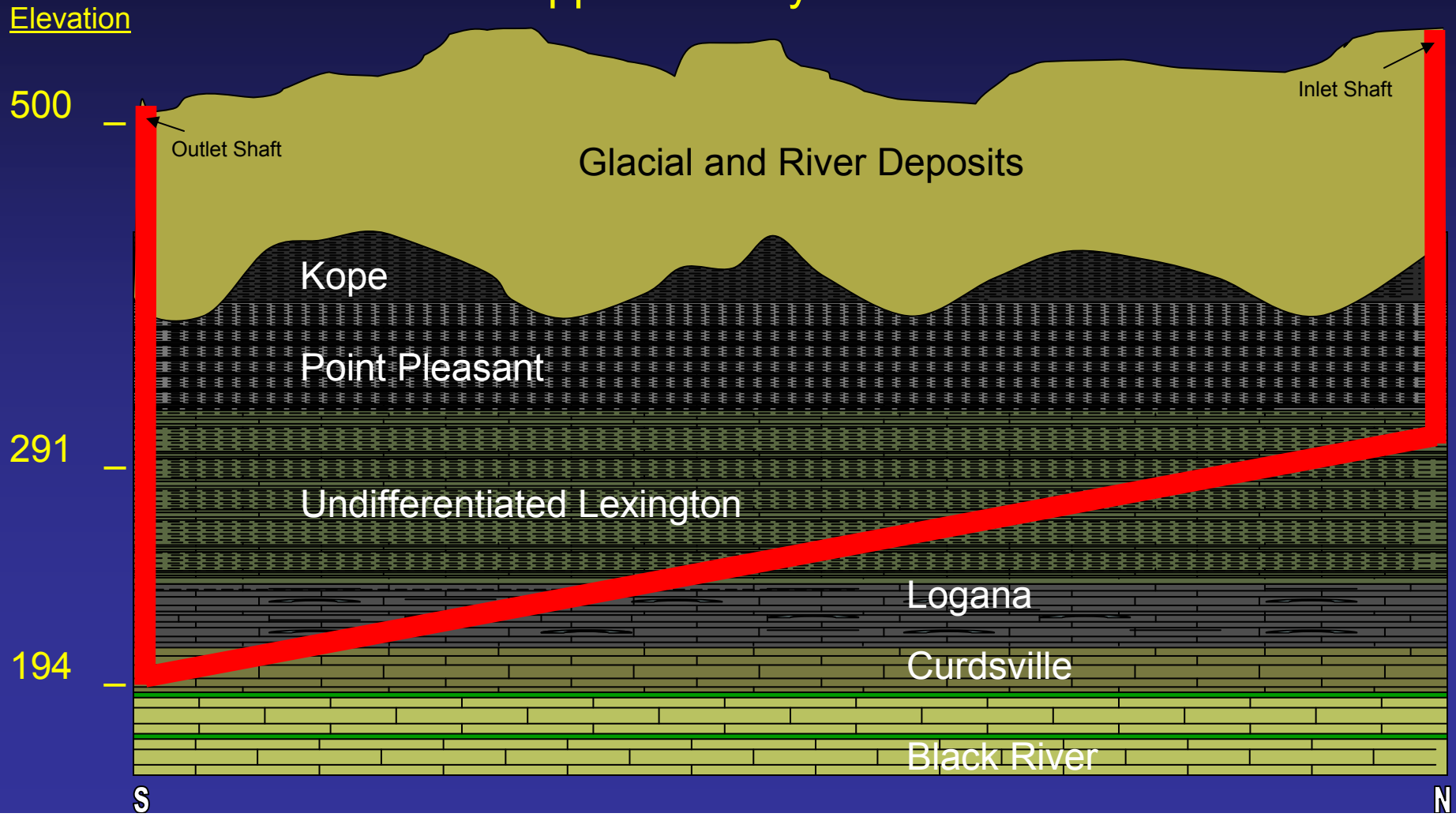
Natural gas pocket encountered in southern most boring



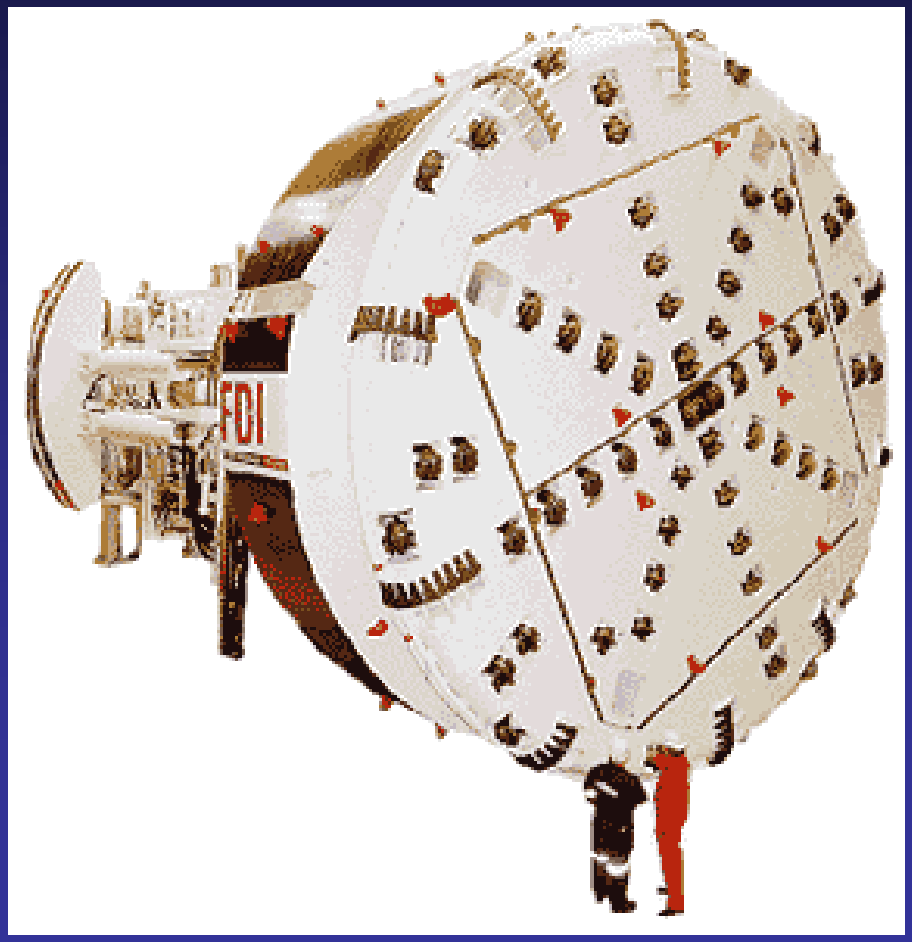
Natural gas pocket encountered in one of northern most borings

TUNNEL PROFILE

34-foot excavated diameter tunnel on a .075% grade
for approximately 16-miles

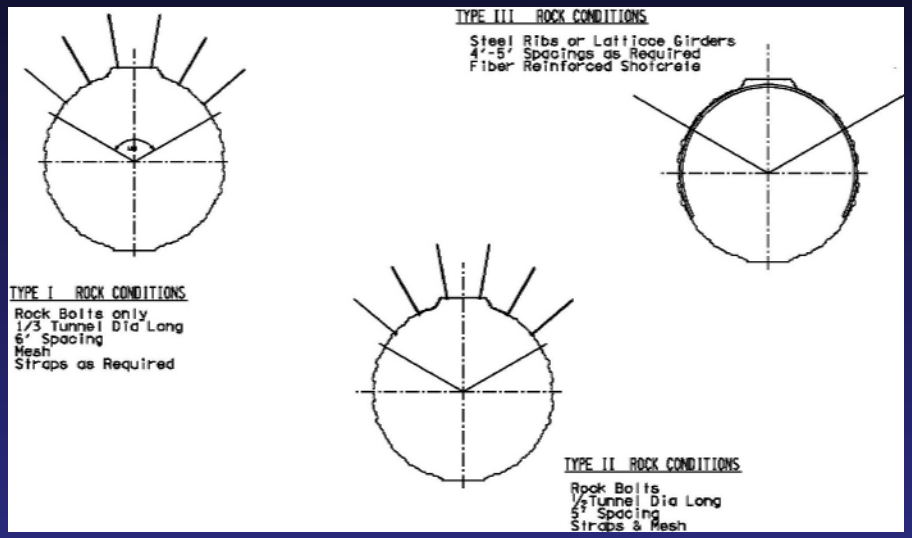


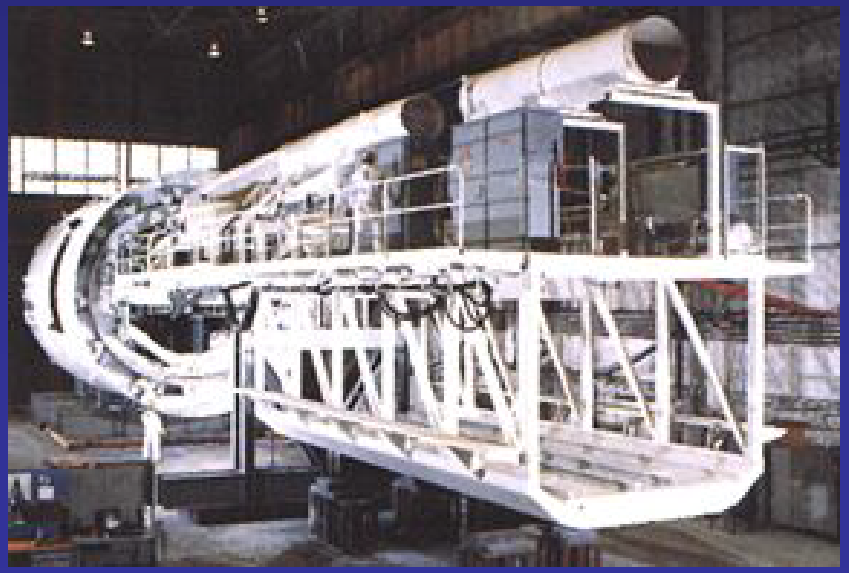
Tunnel Boring Machines



Photos taken from Robbins

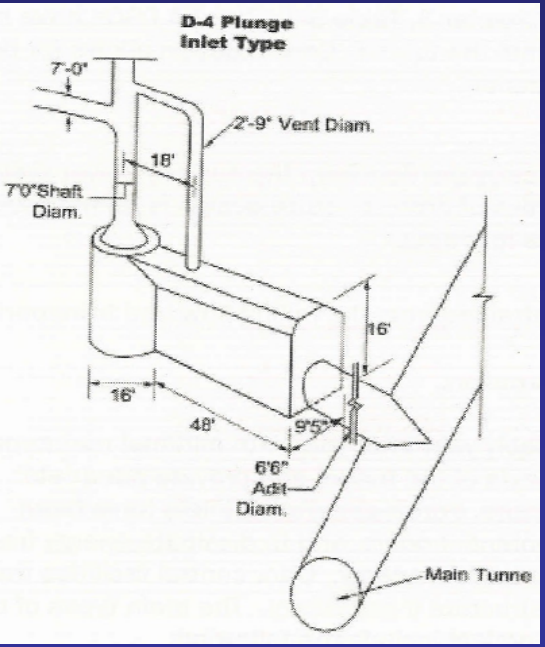
Tunnel Boring Machines

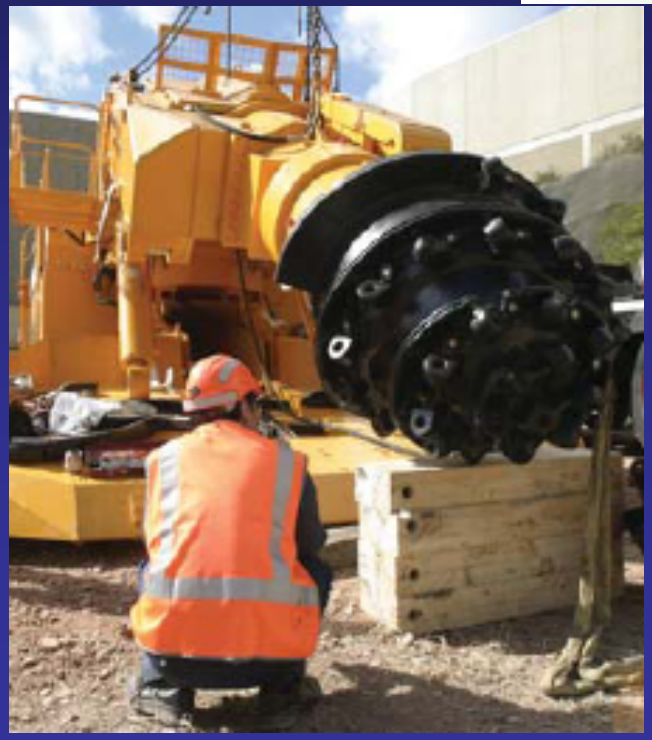




Trailing equipment will consist of rock bolt drill-rigs and possibly instrumentation to sense for high amounts of hydrogen-sulfide and methane, which automatically shuts the TBM down

Road Headers





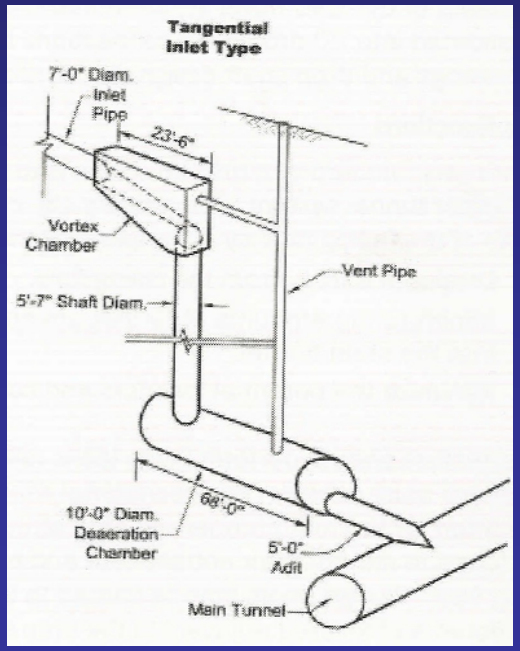
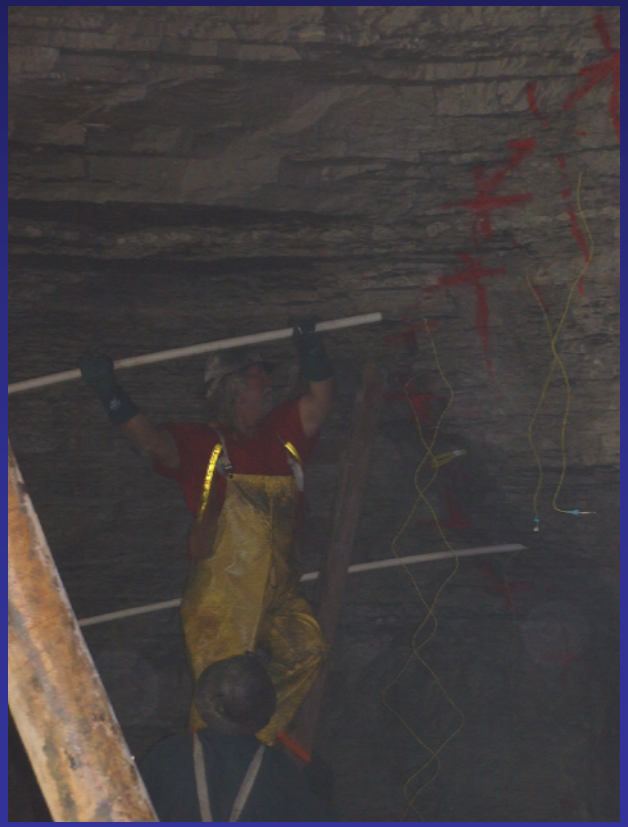


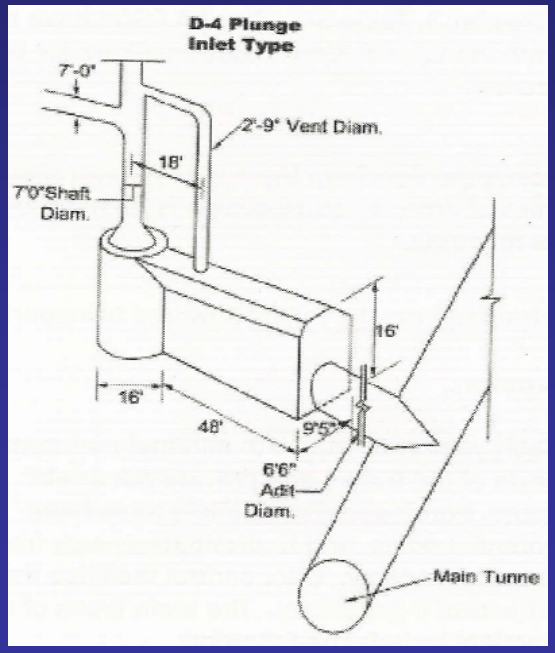
Photo taken from Lane Cove Tunnel Project

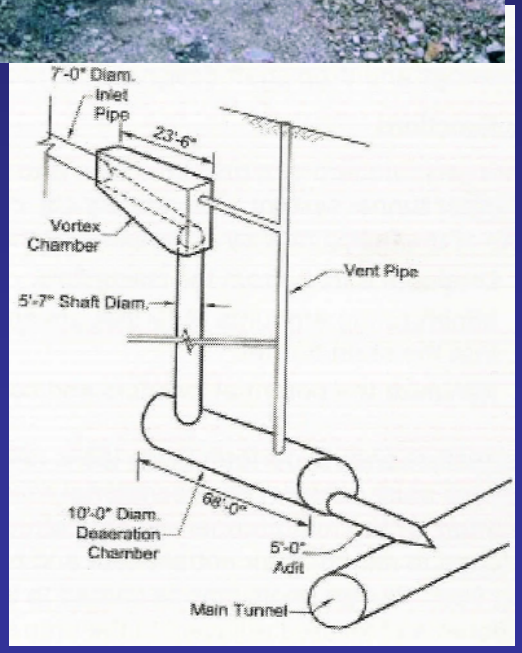
Drill & Blast

Chattahoochee Tunnel

Rescon Mapei





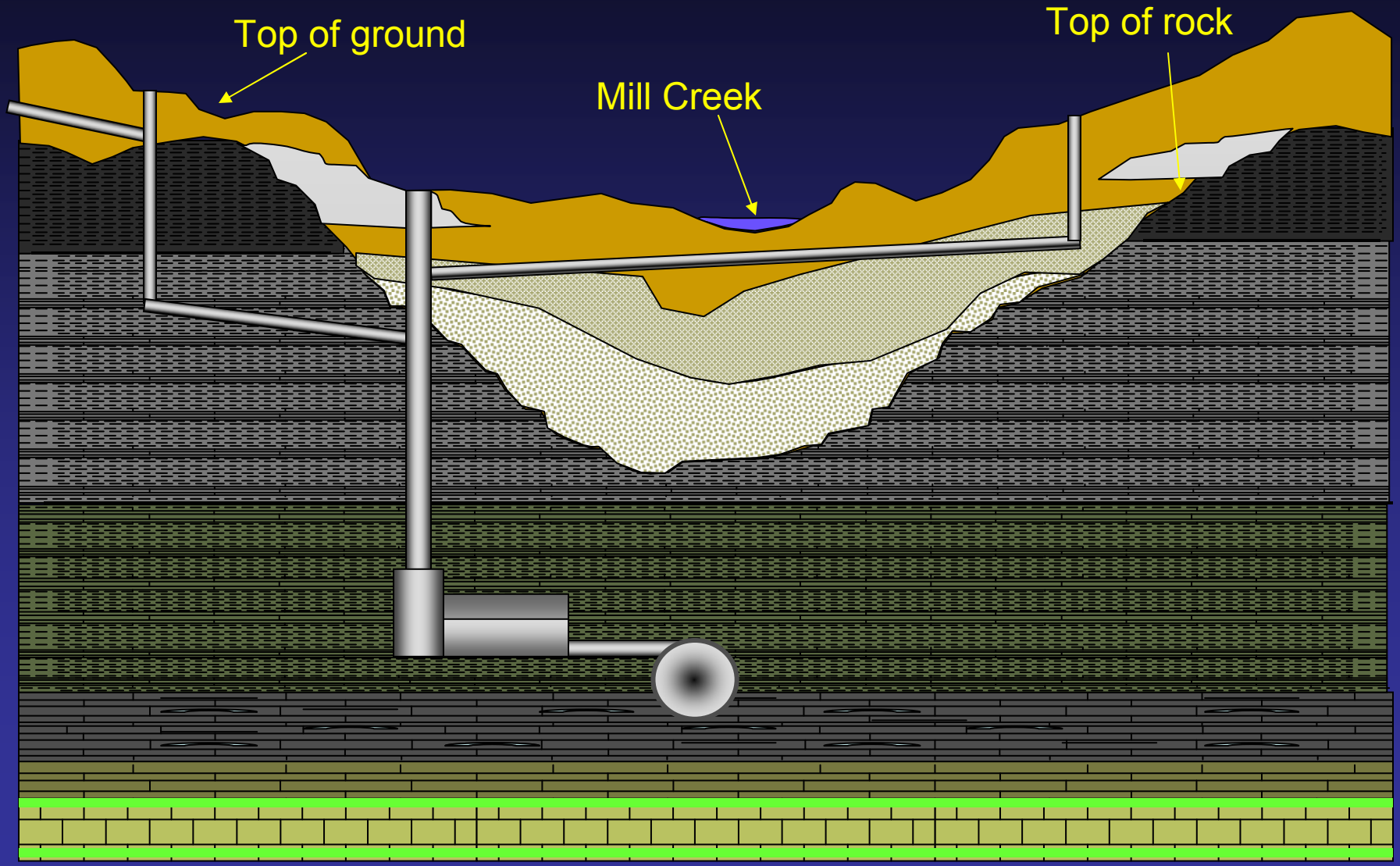


Potential Ground Improvements

- Pre- or post-grouting to help control water inflow, gas inflow, and help to stabilize loose blocks.
- Rock bolts and straps to minimize rock falls.
- Shotcrete to improve excavation stability.
- Minimize drill & blast operations, which can influence rock stability characteristics outside the lines of the excavation.

Overburden Findings and Impacts on Construction Methods

Tunnel Section



Overburden Characterization

Generalization of Subsurface Conditions at Drop Shaft Locations for GRR

Geology
- 1) Estimation of Origin

Geography
- 2) Proximity to Valley Wall
- 3) Proximity to Norwood Trough

Geology (Origin)

- Man-made
  - Artificial fill material (1)
- Riverine
  - Recent alluviums
- Glacial
  - Wisconsin outwash
  - Illinoian glacial till

  Undifferentiated (2)
  - Illinoian lacustrine sediments (3)
  - Pre-Illinoian Deep Stage sands & gravels (4)

Glacial Deposits located at Caldwell Park (eastern wall of Mill Creek valley)

From University of Cincinnati – Geology Department website

Glacial Deposits located at Caldwell Park (eastern wall of Mill Creek valley)

From University of Cincinnati – Geology Department website

Glacial Deposits located at Caldwell Park (eastern wall of Mill Creek valley)

From University of Cincinnati – Geology Department website


Project Number LX2002135
Project Name Mill Creek Deep Tunnel Project
Test ID FMSM 366
Hole Number DC2020
Depth 35.0'-37.0'
Fuller, Mossbarger, Scott and May Engineers, Inc

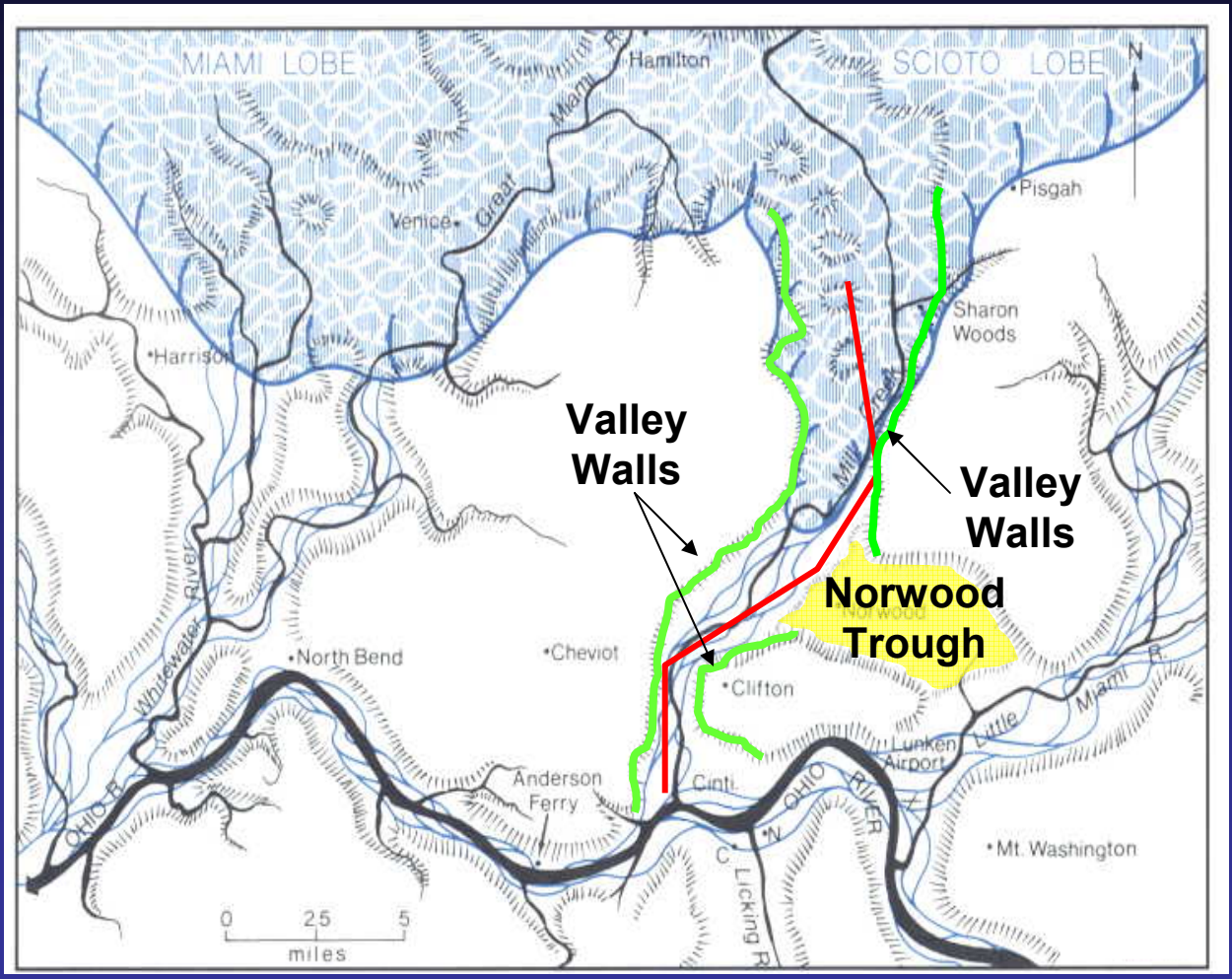
Geography

North of the Norwood Trough
- Valley Wall (1)
- Deep Valley (2)

Confluence of the Norwood Trough with the Mill Creek Valley (3)

South of the Norwood Trough
- Valley Wall (4)
- Deep Valley (5)

Geography

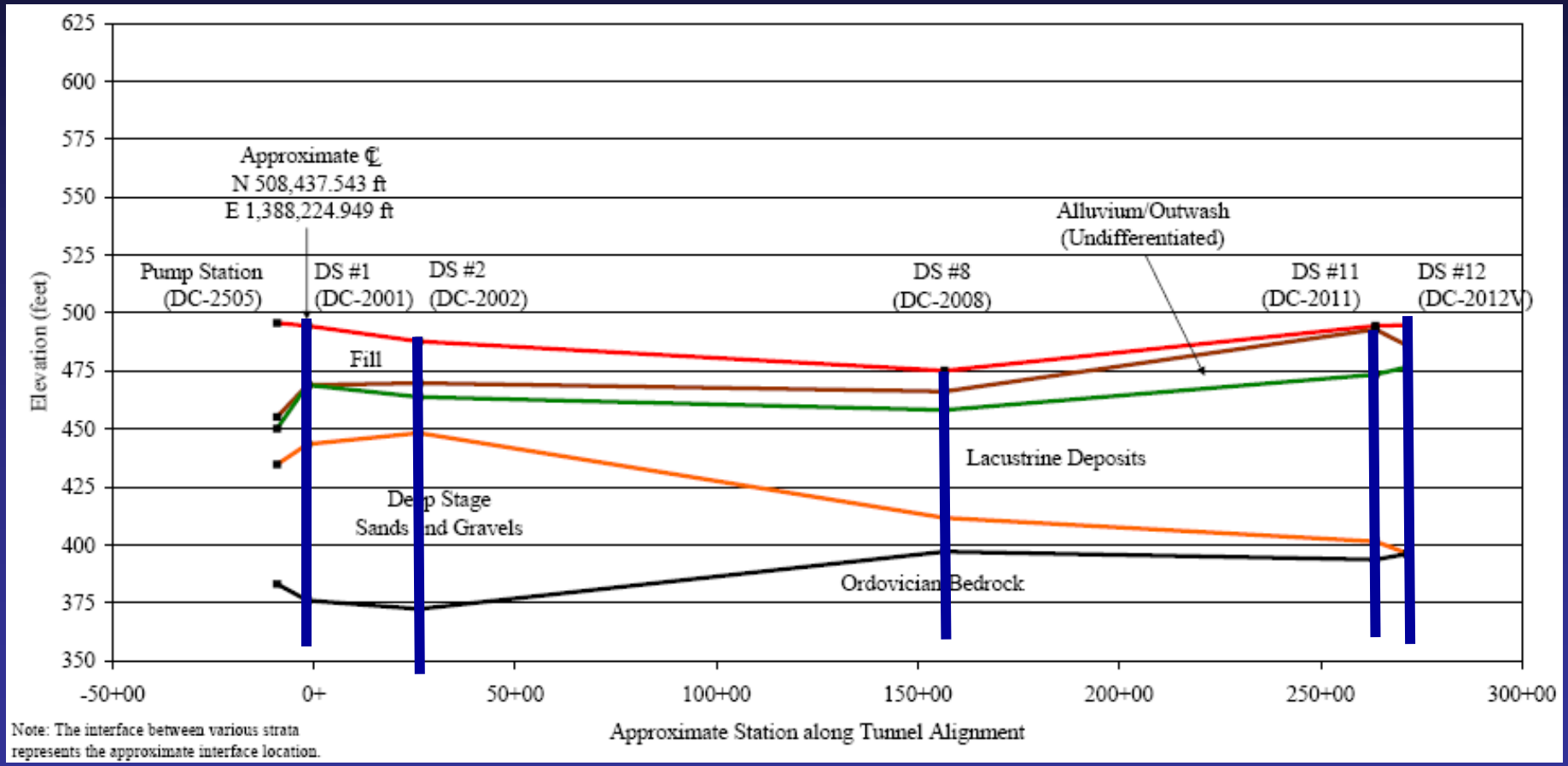


The consistency of the overburden soils was generally stiffer, and the relative density was generally higher, north of the Norwood Trough.

At the confluence of the Norwood Trough with the Mill Creek Valley, deep sand was encountered.

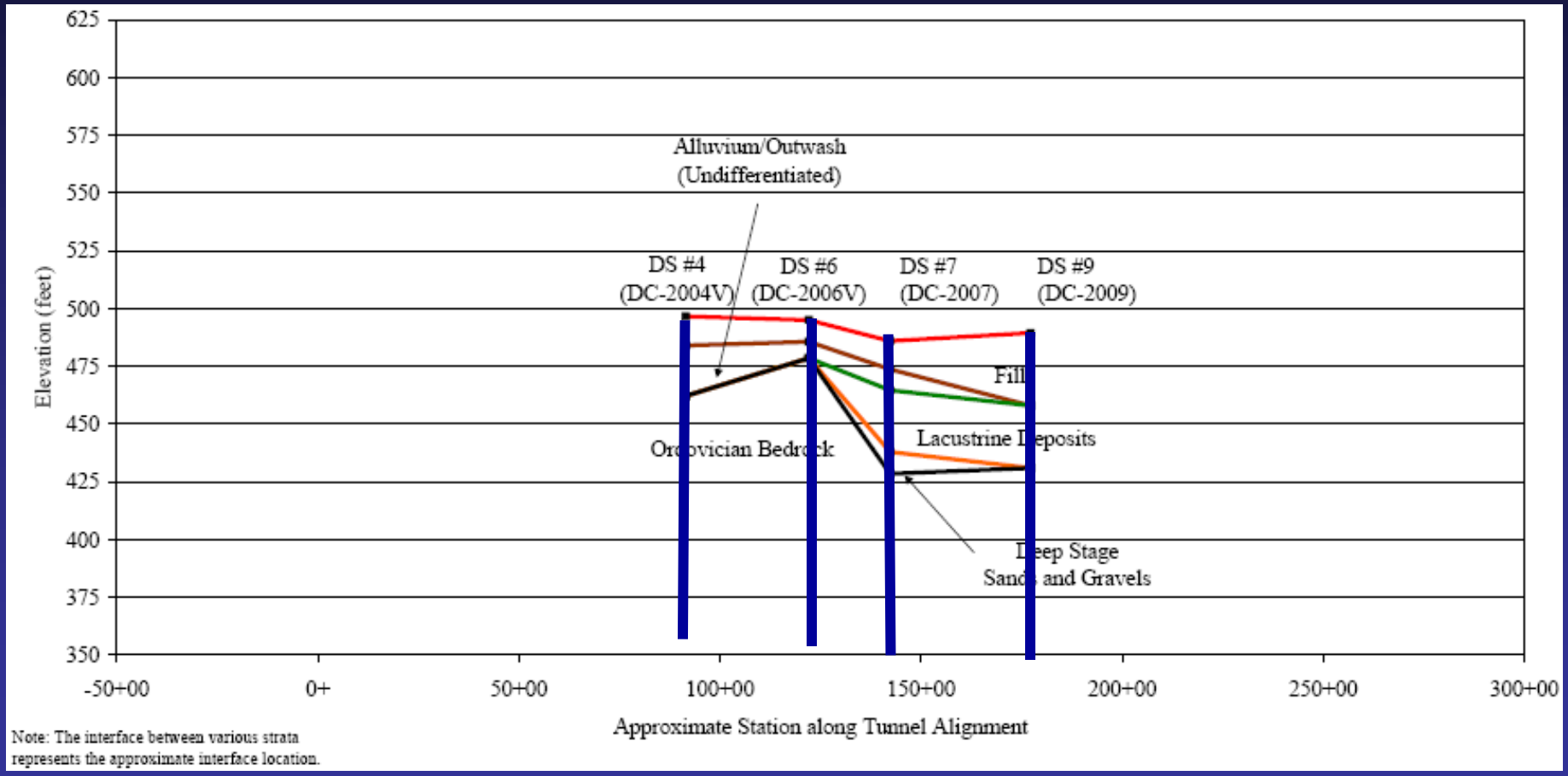
Depth to bedrock decreases near valley walls.

Point-to-Point Profile - Drop Shaft Locations
Deep Valley - South of Norwood Trough



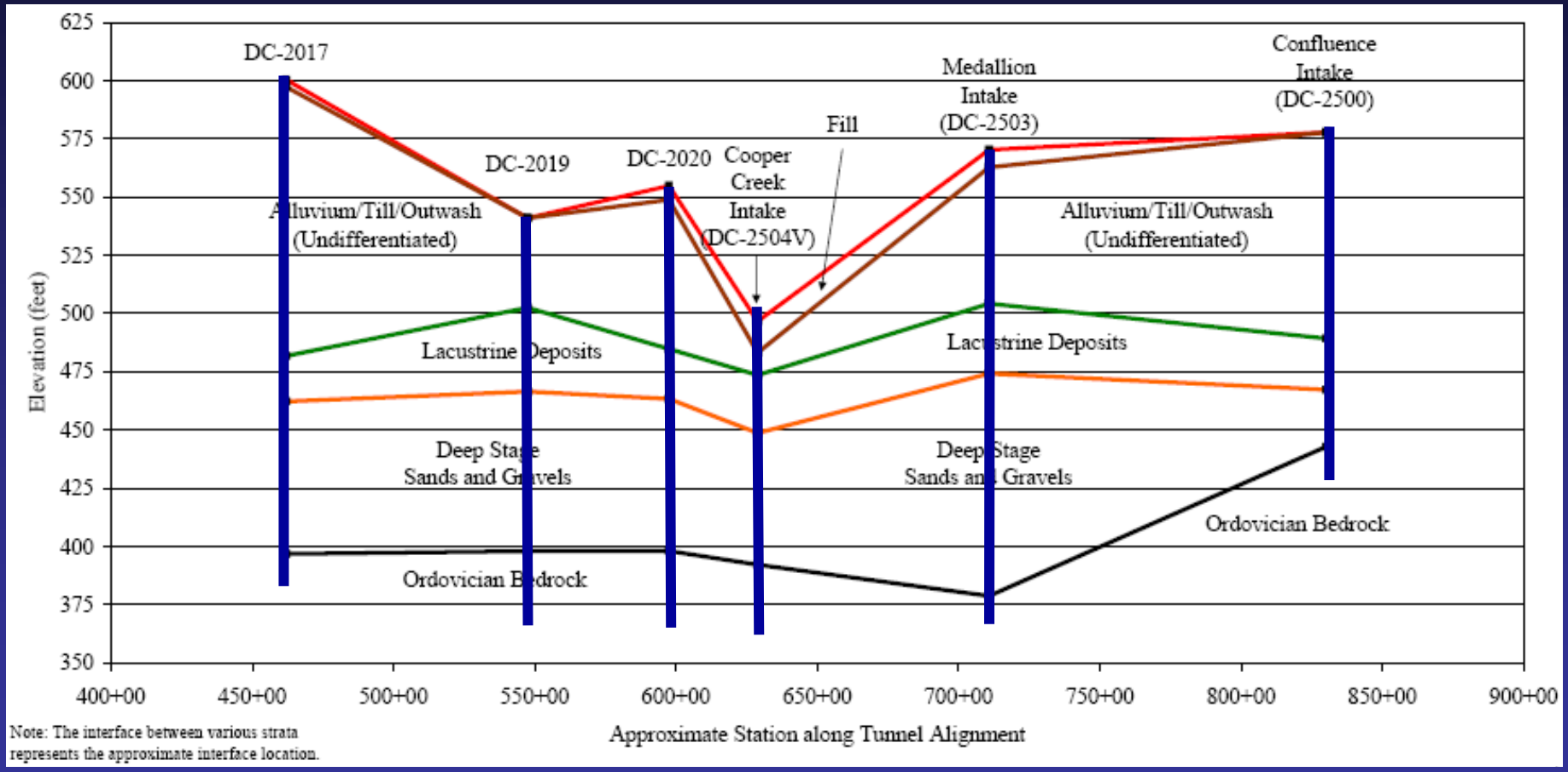
Note: The interface between various strata represents the approximate interface location.

Point-to-Point Profile - Drop Shaft Locations
Valley Wall - South of Norwood Trough



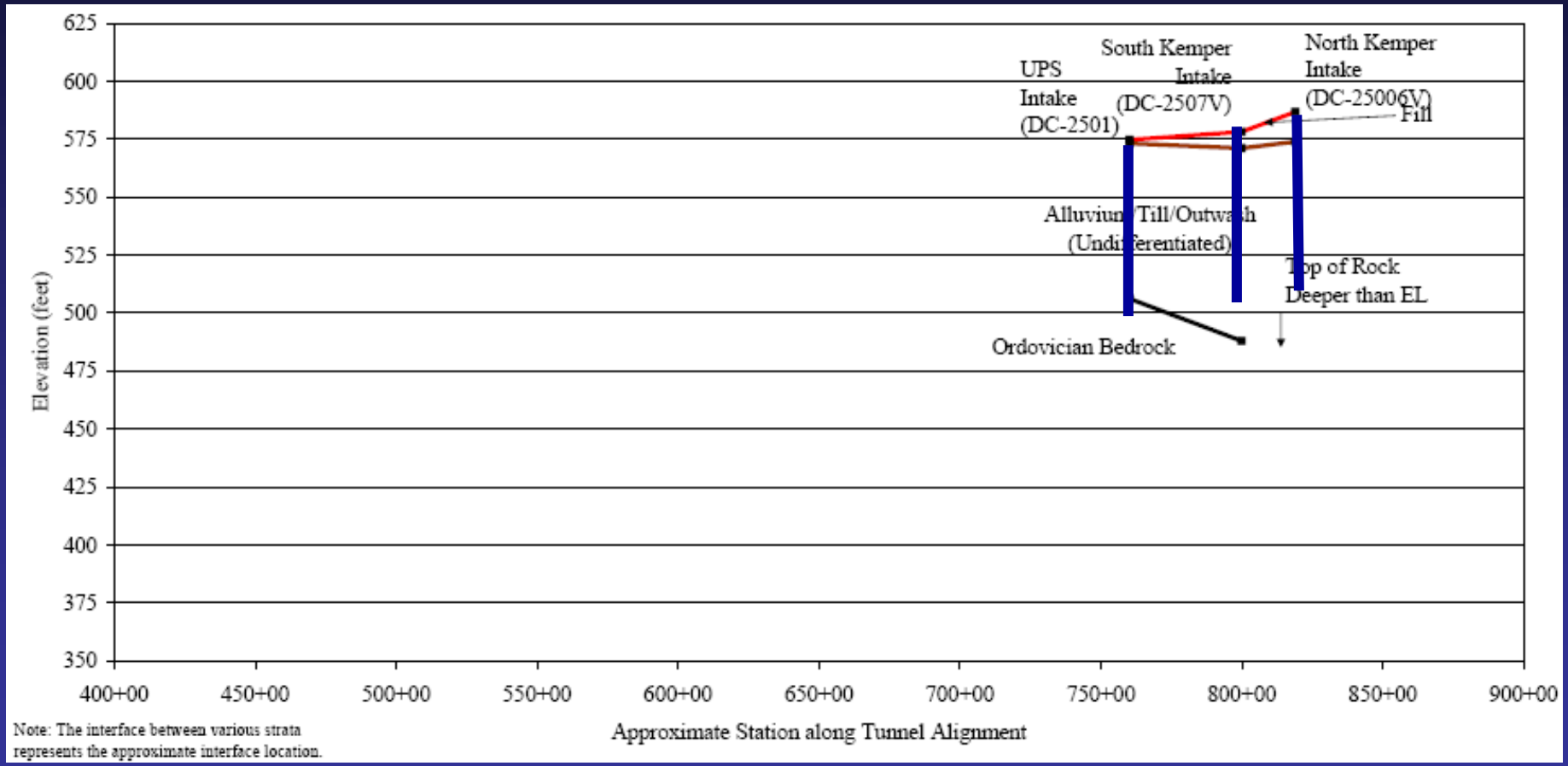
Note: The interface between various strata represents the approximate interface location.

Point-to-Point Profile - Drop Shaft Locations
Deep Valley - North of Norwood Trough



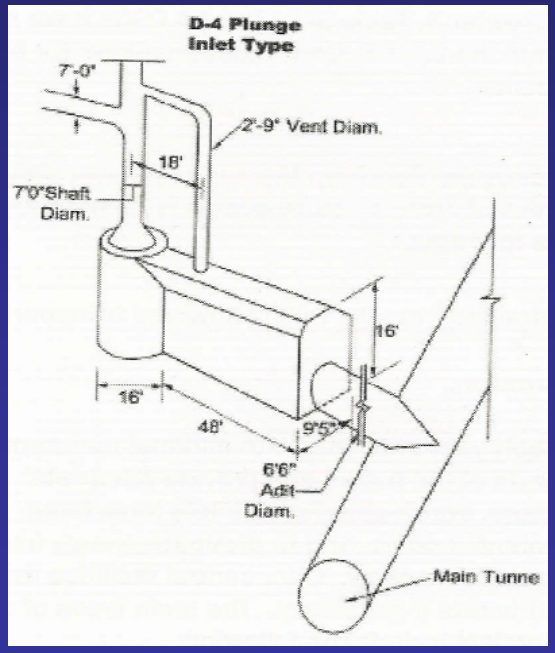
Note: The interface between various strata represents the approximate interface location.

Point-to-Point Profile - Drop Shaft Locations
Valley Wall - North of Norwood Trough

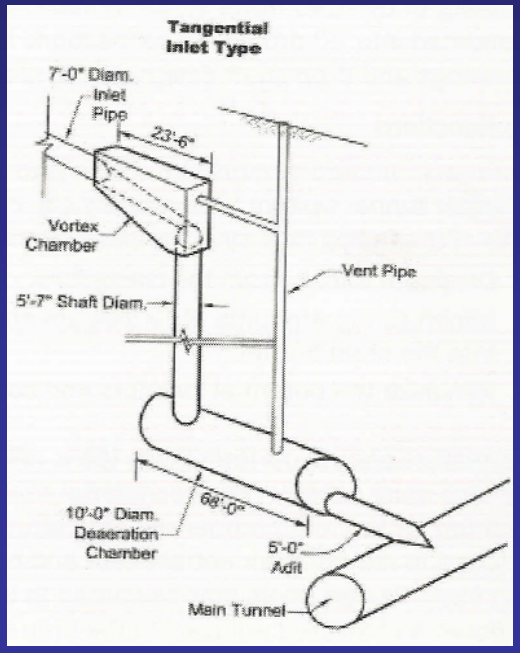


Note: The interface between various strata represents the approximate interface location.

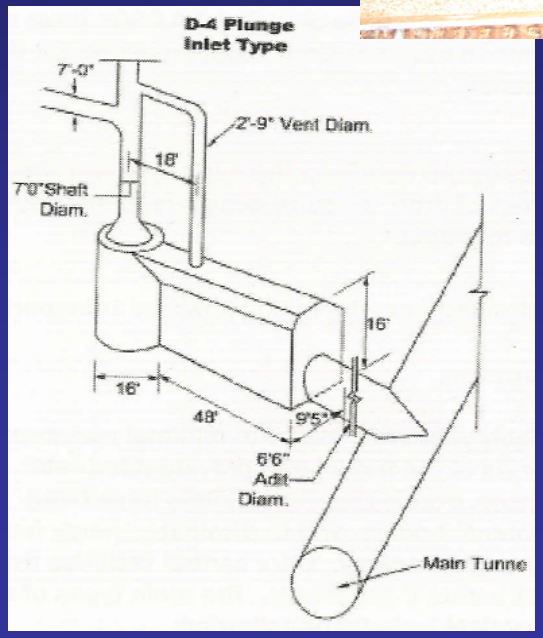
Open Excavations

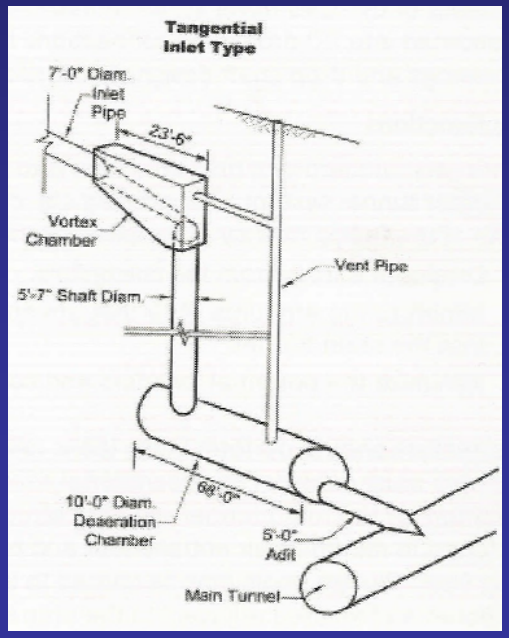


Chattahoochee River Tunnel Project



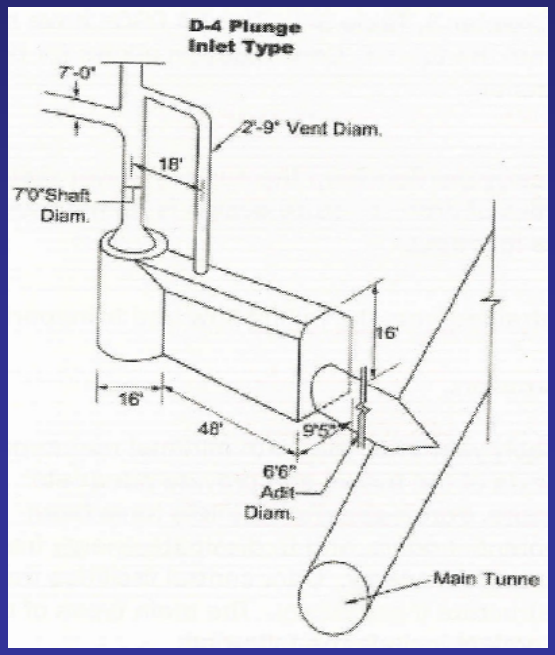
Shaft Excavations

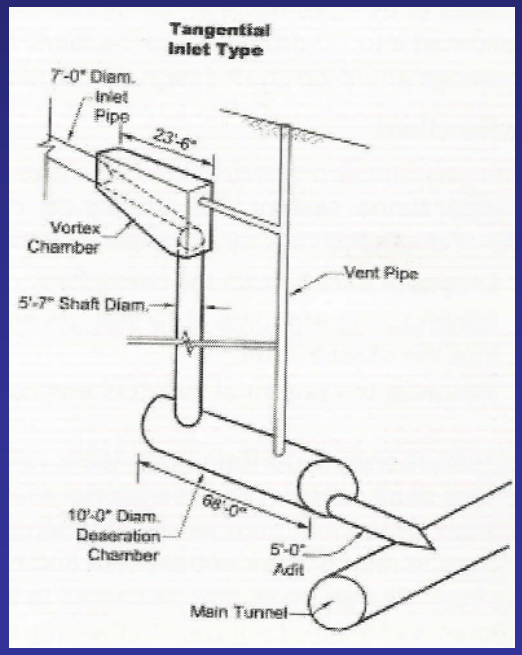




Photos from Dawn Underground Engineering Group

Earth Tunnel Excavations





Traylor Bros.

Potential Ground Improvements

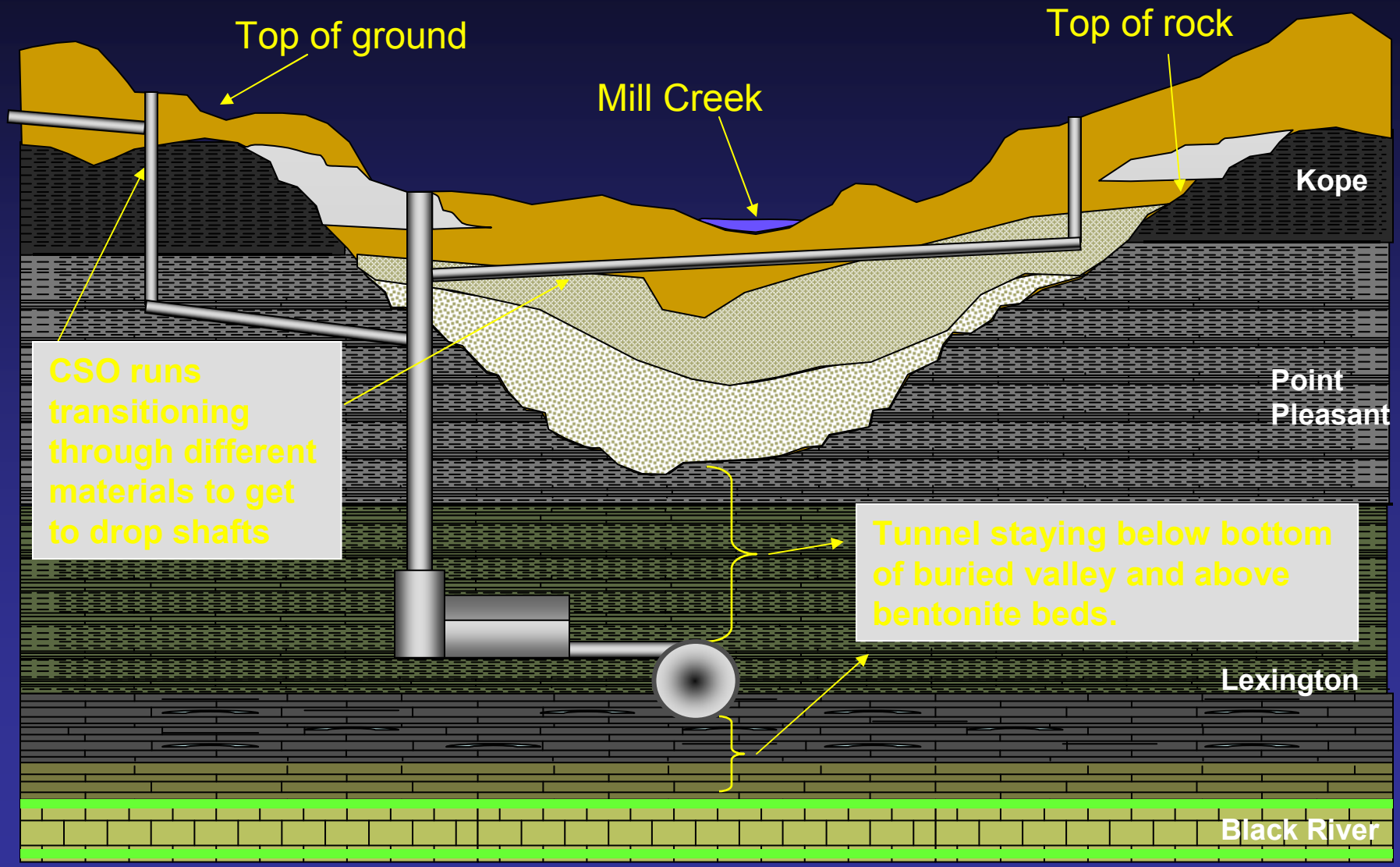
- Pre-stabilization of soils to help control water inflow, help to stabilize loose and squeezing soils, and minimize surface settlement.

- Avoid boulder zones if possible.

US Army Corps of Engineers
Louisville District

Geotechnical and Dam Safety Section

TUNNEL SECTION



Questions ?