

Managing a Project With Karst Geology



Chester County Engineers – Fall Conference 2021

Patrick McNamara, P.E.

John T. Pusey, Jr.



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Managing a Project With Karst Geology

- What is Karst Geology and Where is it Found?
- Planning for Development in Karst
- Remediation of Sinkholes
- Minimizing Impacts



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What is Karst Geology?

Karst is the type of landscape that forms where the underlying Dolomite and Limestone bedrock characterized by:

- Highly Irregular Rock Surface (Pinnacles)
- Depressions in the ground surface (Closed Depressions)
- Sinkholes
- Ghost Lakes
- Disappearing Streams
- Caves



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What is Karst Geology?



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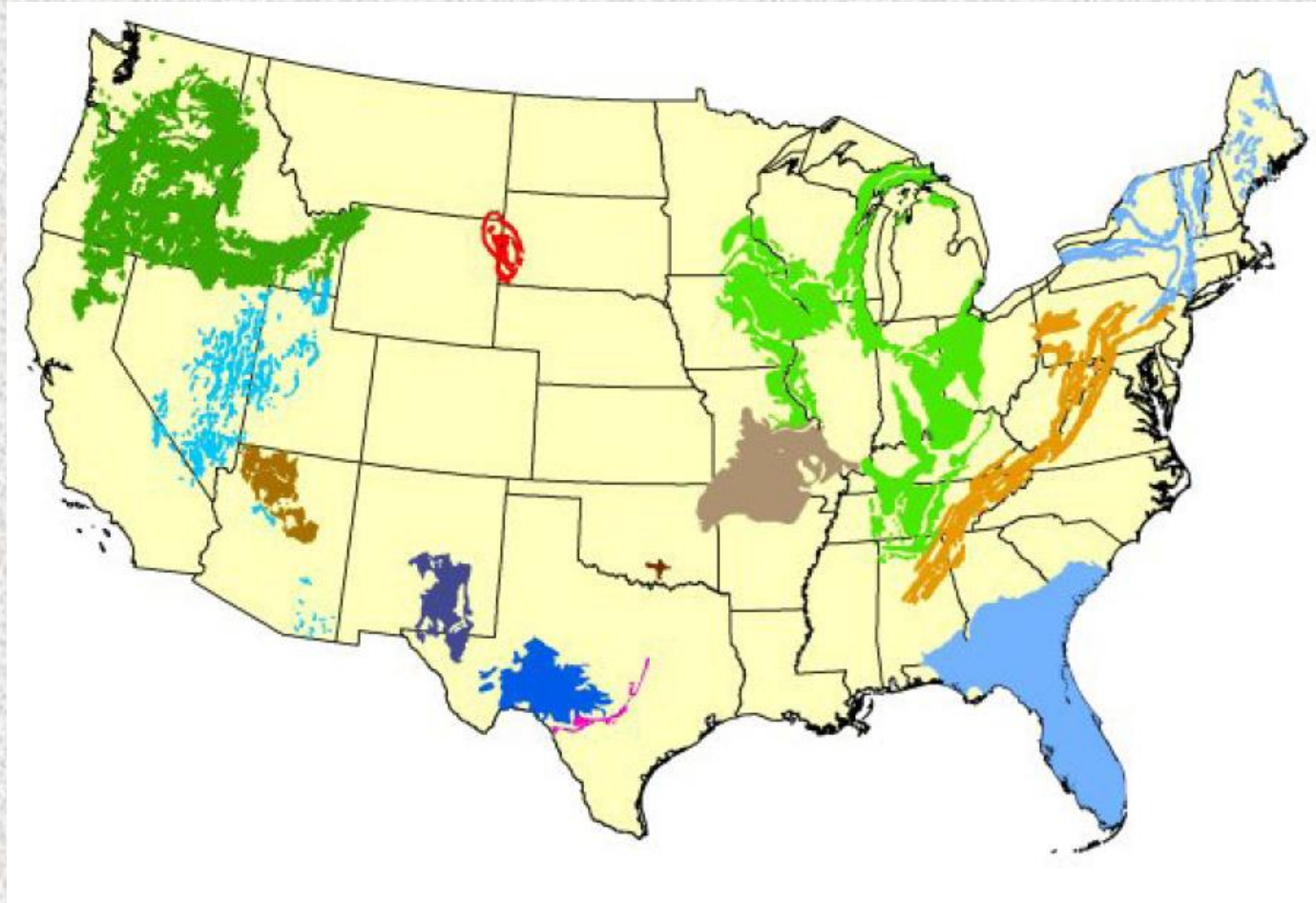
What is Karst Geology?



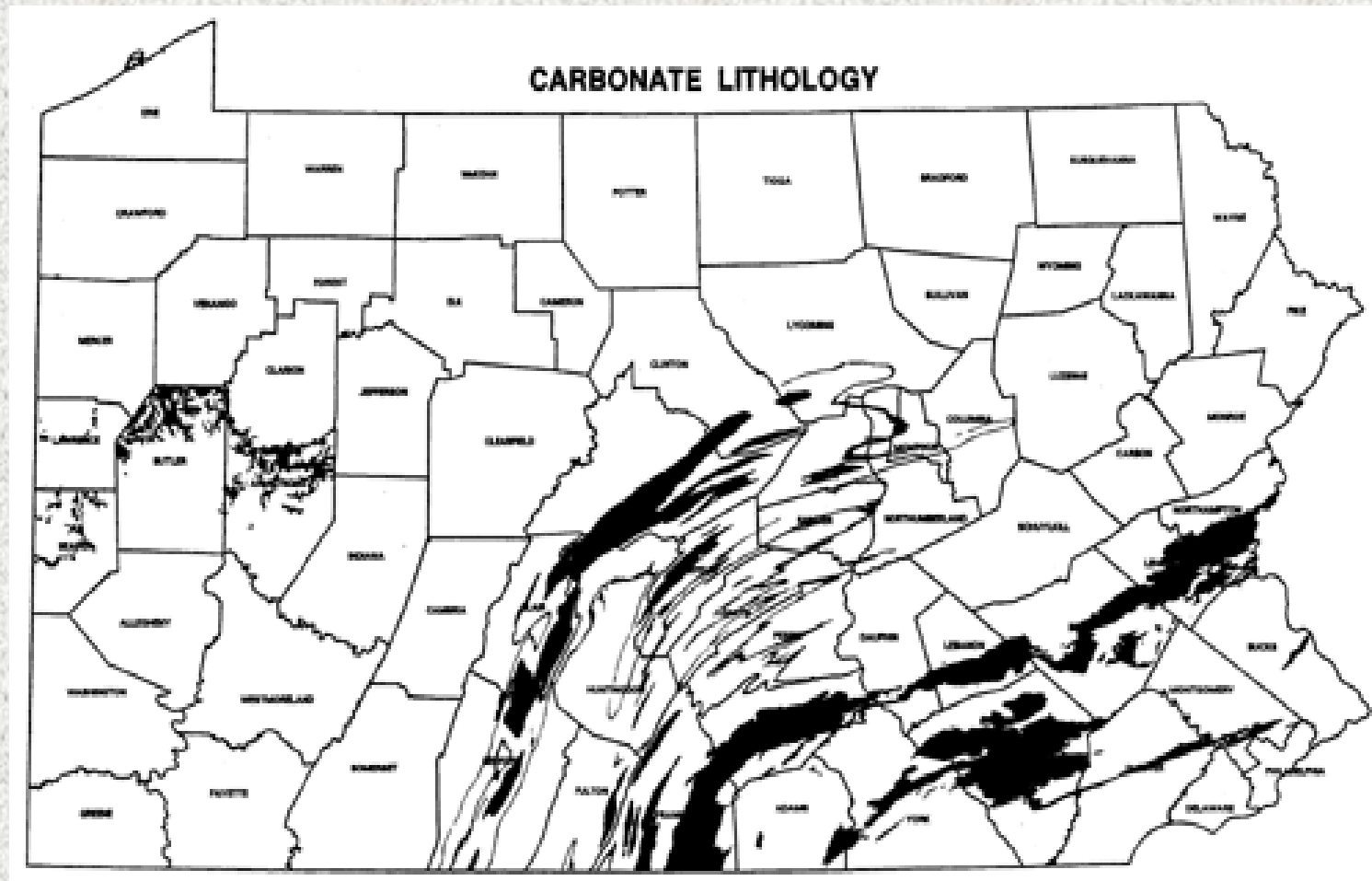
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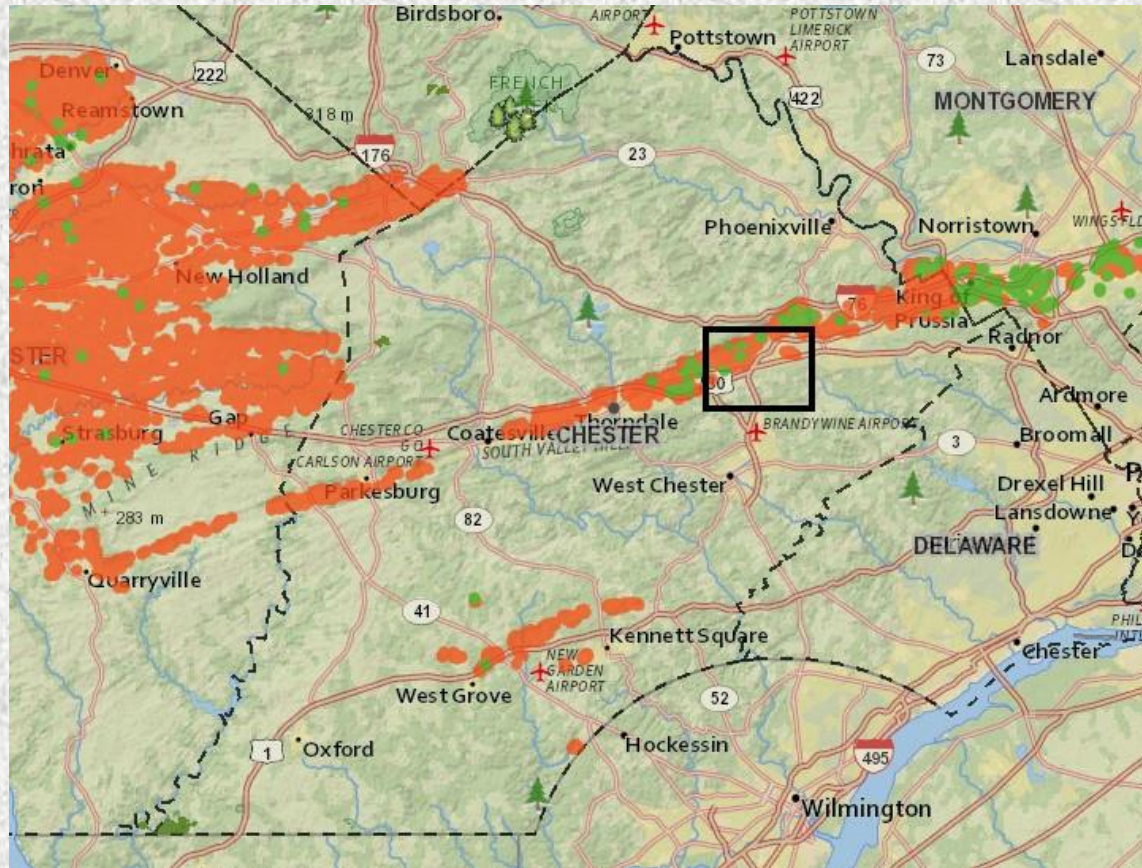
Map of Karst Formations in the United States



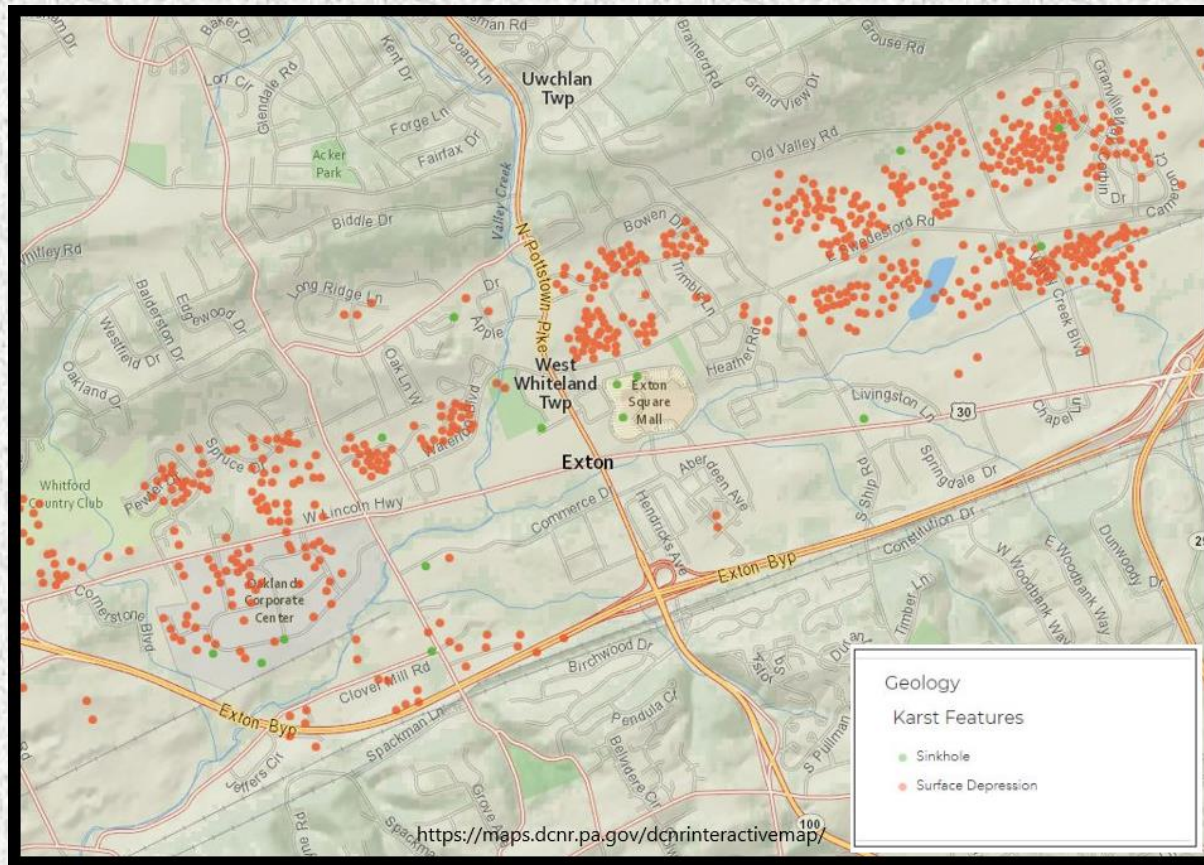
Carbonate Bedrock Map of PA



Chester County Karst Map



Chester County Karst Map Features



Planning in Karst



**REPORT OF CARBONATE ASSESSMENT
FOR KARST RELATED FEATURES**

PROPOSED RESIDENTIAL COMMUNITY

Planning in Karst - Carbonate Assessment

- Site Reconnaissance
- Geology
- Soils
- Carbonate Features (Fracture Trace Analysis)
- Control Measures
 - Minimizing Risk Techniques
 - Remediation Techniques

Investigation Techniques

- Geophysical Investigations
 - MASW
 - Microgravity
 - Electrical Resistivity
- Subsurface Investigations
 - Test Borings
 - Test Pits
 - CPT

Examples:

Site #1 - Sinkhole Activity at Creek

Disappearing Stream
condition(s) and multiple
sinkholes adjacent to creek in
commercial property



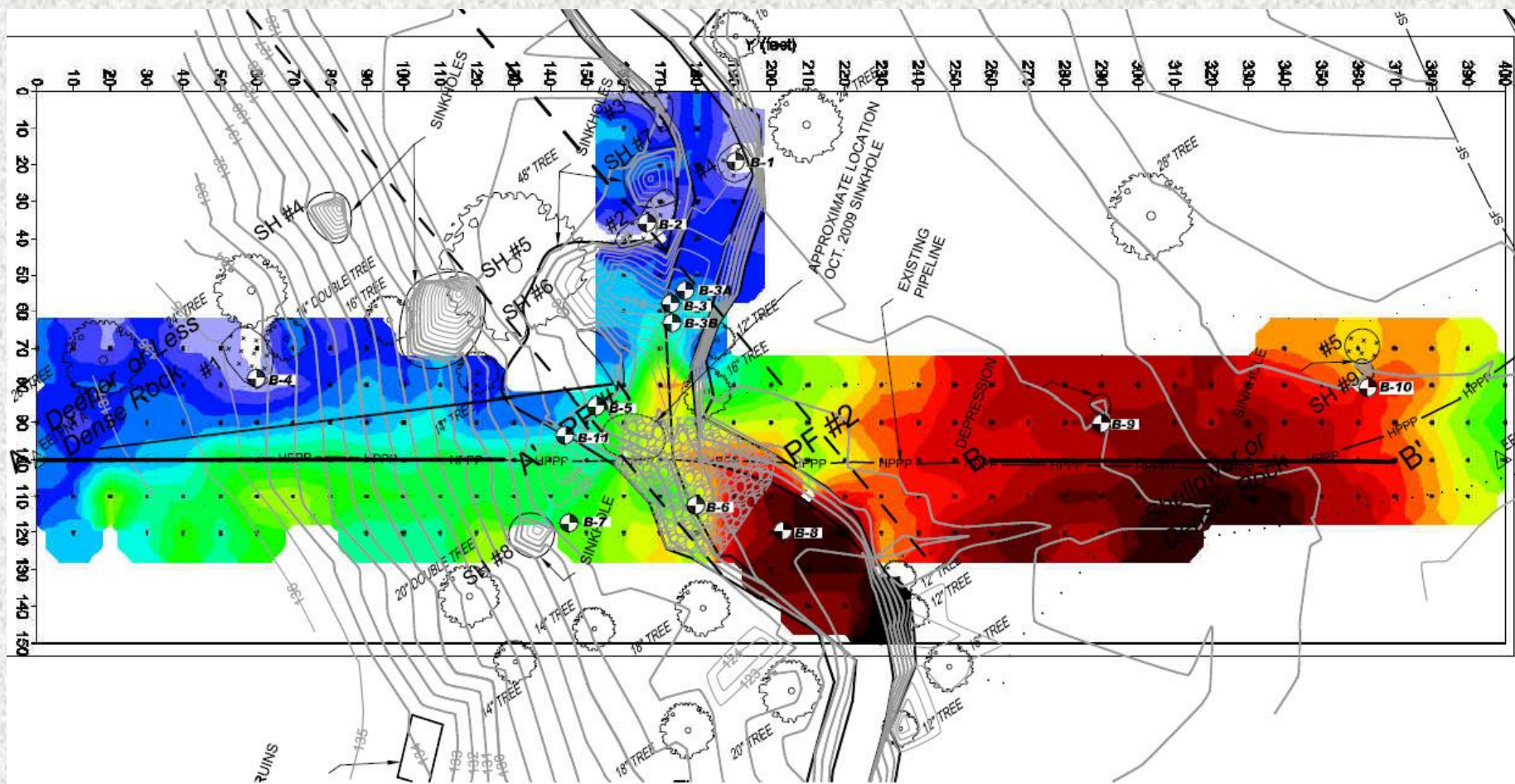
Large sinkhole causing disappearing stream



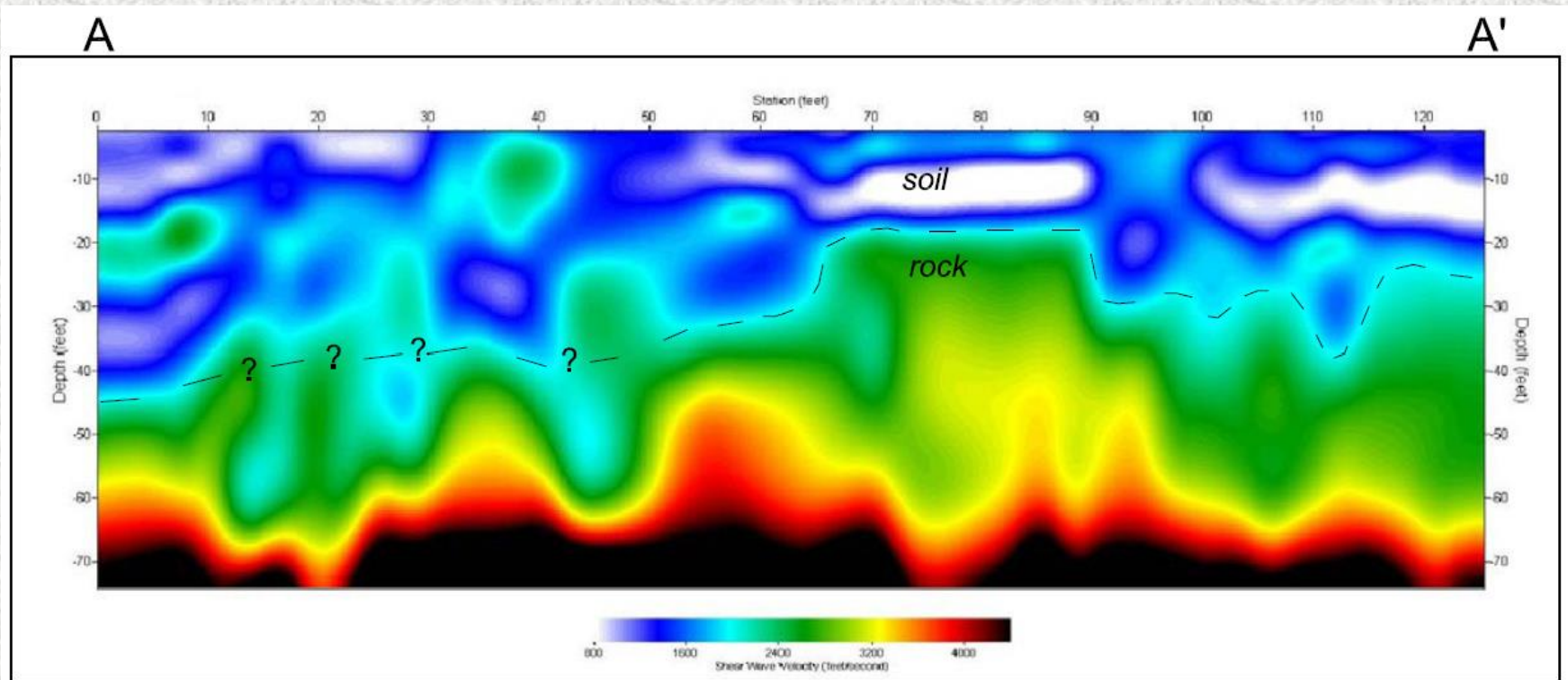
Initial Investigation Methods Performed

- Perform Microgravity Investigation in Stream Channel
- Provides broad interpretation of subsurface conditions in study area
- After Microgravity, performed Multi-Channel Analysis of Surface Waves (MASW) & Two Dimensional Electrical Resistivity Investigation (2D ERI)
- Profiles subsurface profile below survey line

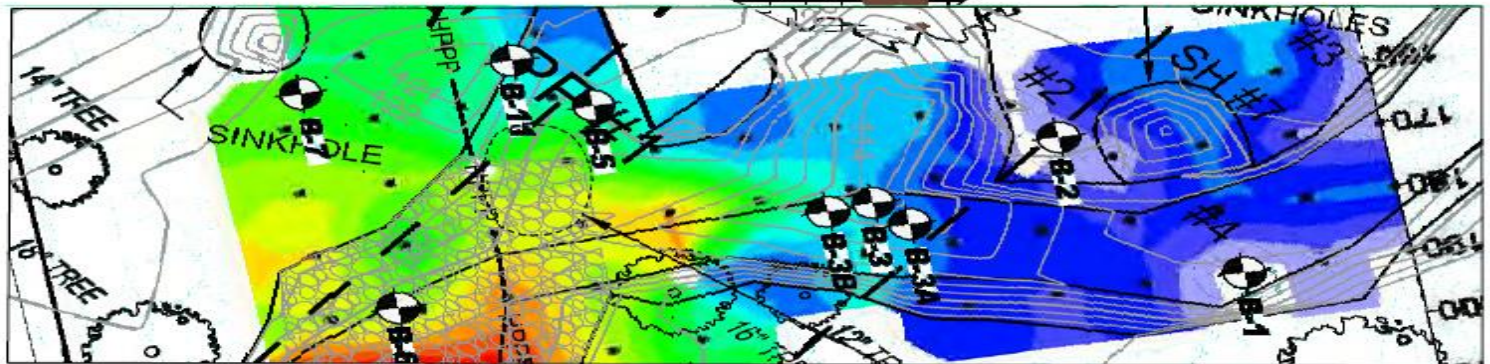
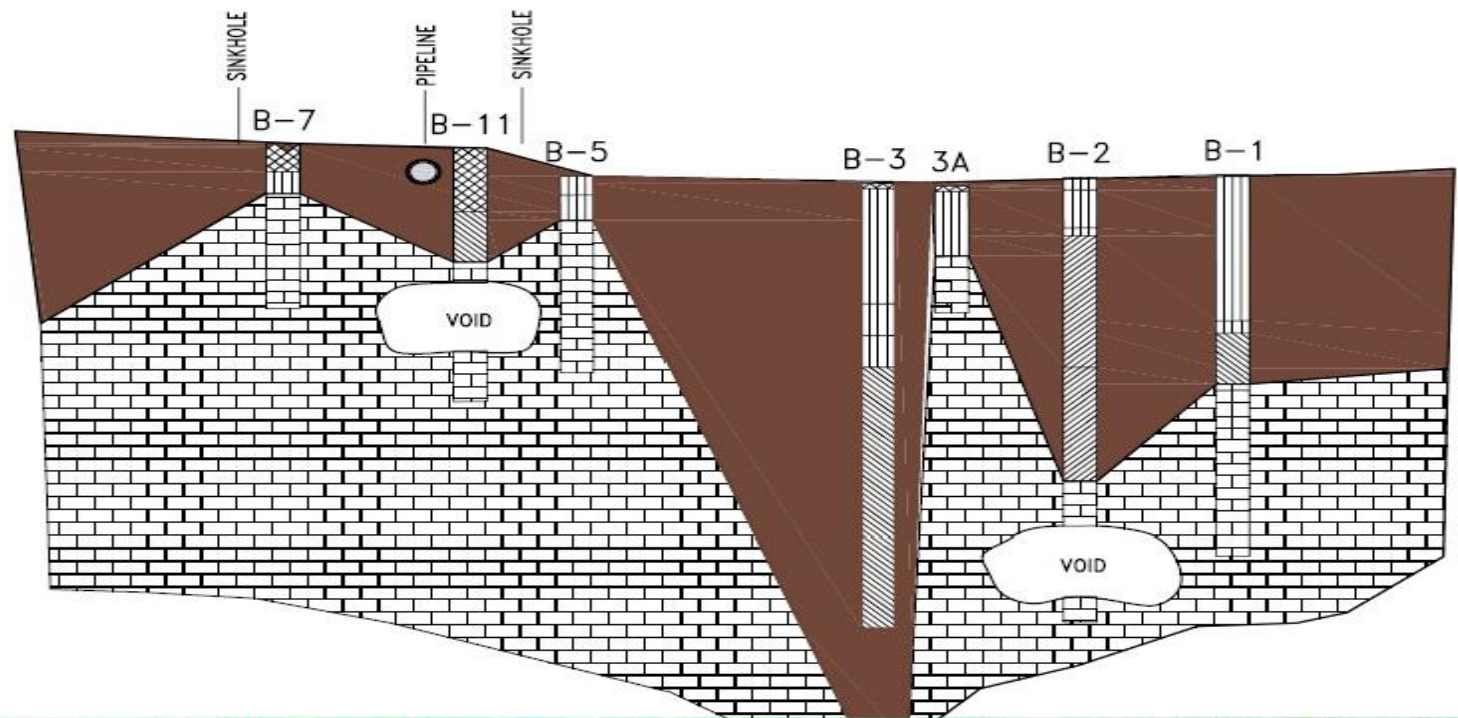
Microgravity Plan



MASW Profile



Test Borings Performed to Verify Geophysical

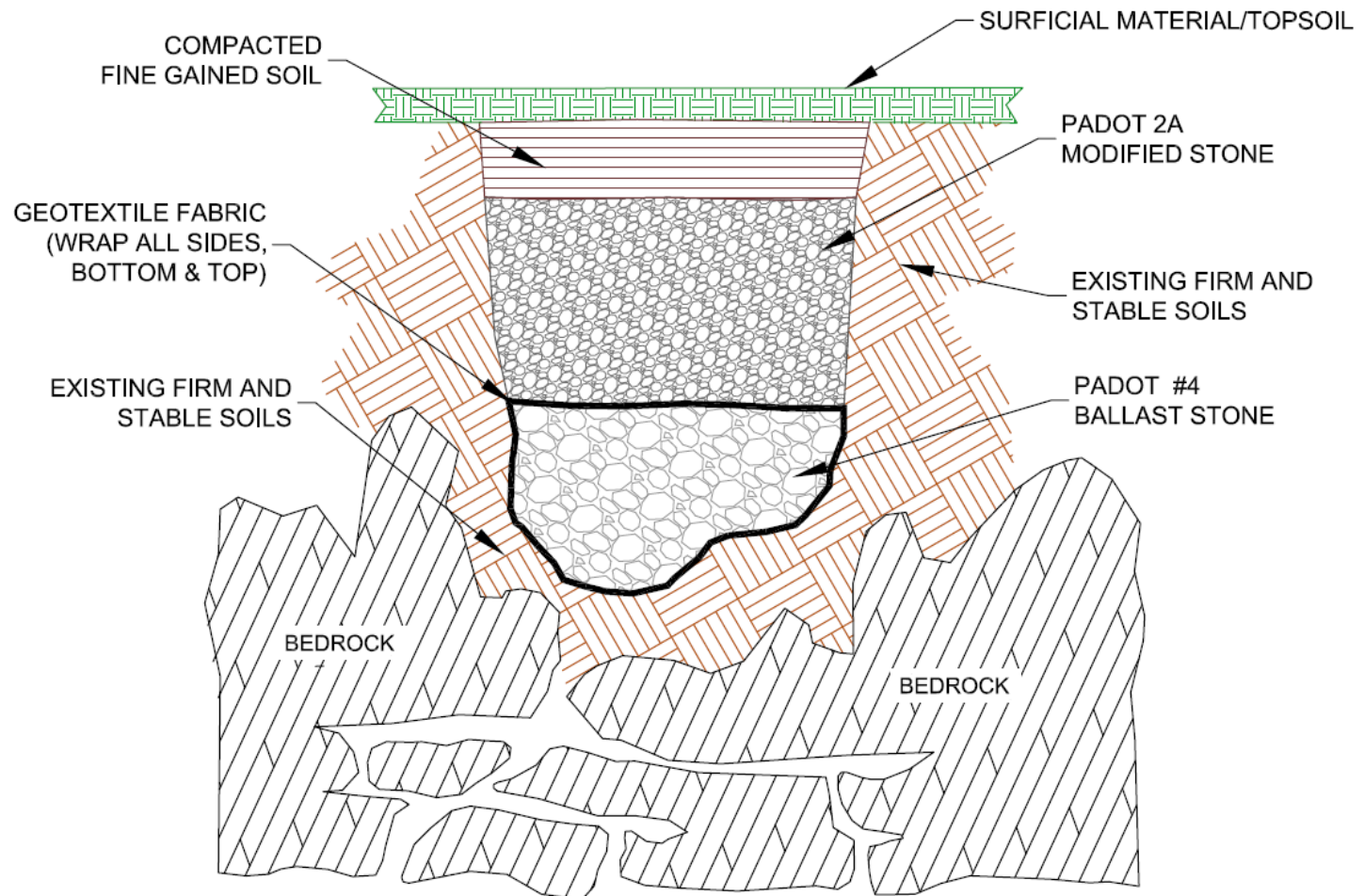


Sinkhole Stabilization

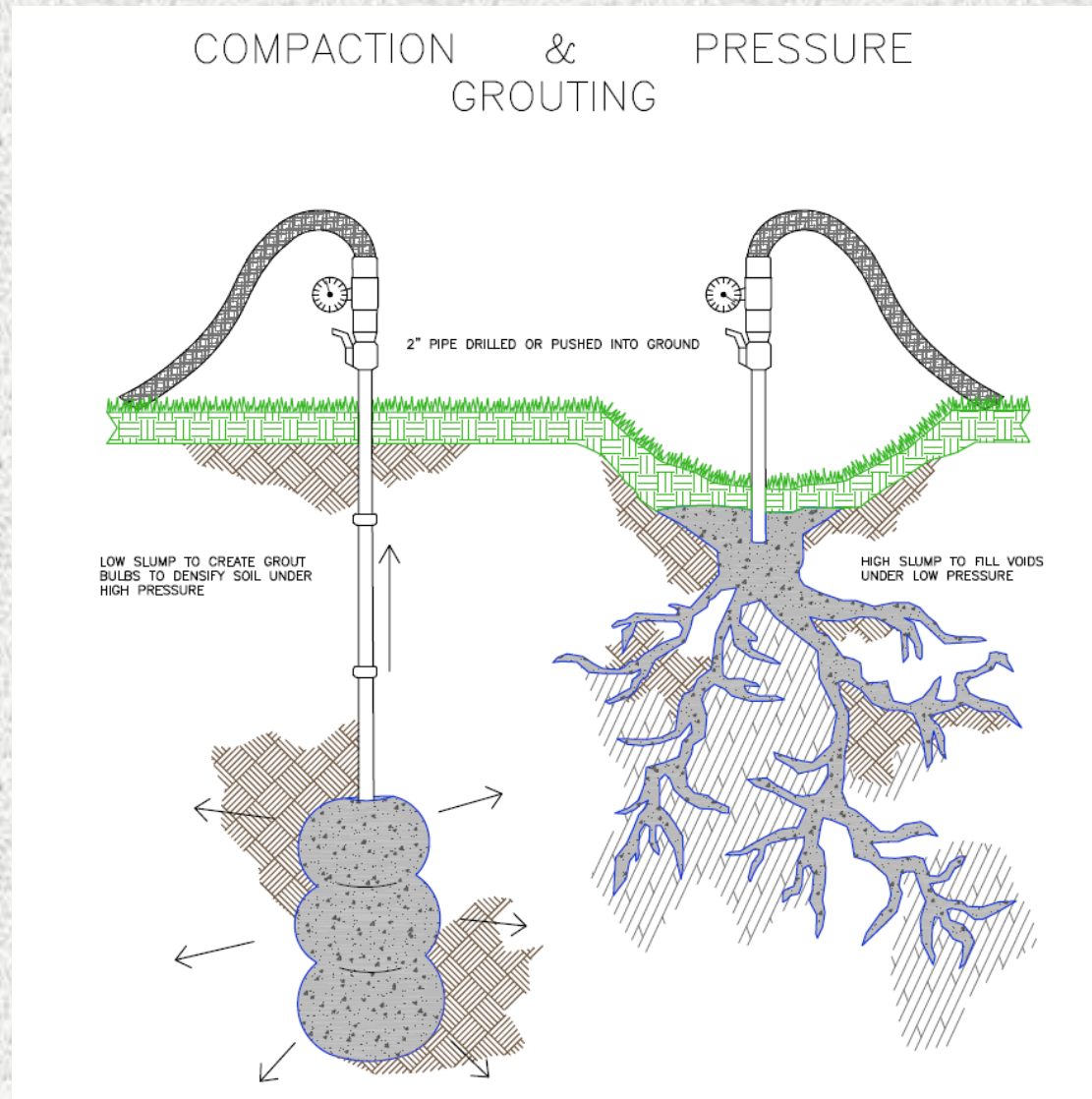


Stabilization Techniques

CONCEPTUAL DIAGRAM OF "INVERTED CONE" REPAIR



Stabilization Techniques



High School
Varsity
Baseball Field
– Left Field
Sinkhole –

March 2021



Remediation: Inverted Filter Method: Excavation and Replacement Technique Recommended by Earth Engineering Inc.

Excavation of sinkhole conducted with large track-hoe to remove the excessively soft/loose soils from sinkhole.

Excavation was conducted to the bedrock surface on northwestern side of excavation.

Dense soils were encountered in remainder of excavation.

Overall approximate dimensions of the excavation were 22' x 17' x 12' to 14' (length x width x depth).



Placement and Compaction of Shot Rock Layer

Compaction was performed to densify the layer of shot rock placed.



Lining excavation with geotextile fabric and backfilling with PADOT 2A aggregate

The remaining sides and base of excavation were lined with a woven geotextile fabric and backfilled with 12" thick lifts of PADOT 2A aggregate. Each lift was compacted with the Rammex trench roller.

3 feet of aggregate was placed and compacted in the sinkhole excavation.



Backfill and compaction with excavated soil

The remainder of excavation was backfilled with the excavated soils in multiple 12" lifts to the soil subgrade elevation.

Each lift was compacted with a combination of the Rammex trench roller and a Jumping Jack Tamper.

The Jumping Jack tamper was performed around the perimeter of the excavation to seal the edges of each lift.

During visual inspection, each lift was observed to be firm, stable and well compacted.



Contractor placing subbase stone

The contractor replaced the PADOT 2B subbase stone layer to match the surrounding stone layer.

The surficial screenings layer will be placed on 4/2/2021



Site #2 – Sinkhole in Large Culvert

- Culvert measures approx 30' wide by 15' in height by 1500 feet in length
- Required a Natural Stream bottom throughout structure
- Several Pipe Penetration Locations Inside causing scour and poor grading



First Sinkhole - March



Excavation and Replacement method utilized to stabilize sinkhole



2nd Sinkhole – November

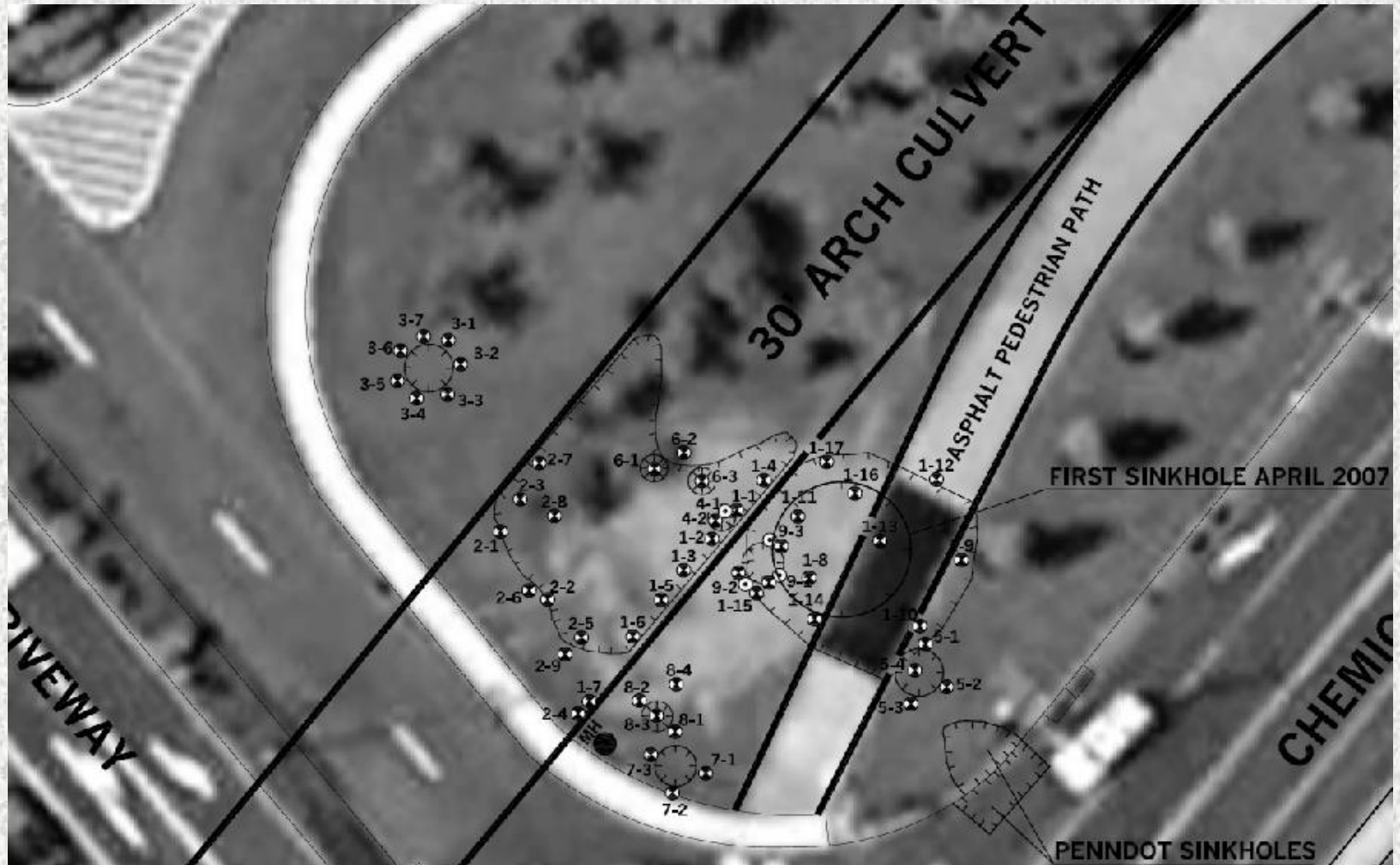


Sinkhole Re-Emerges – two years later

- Very large Sinkhole discovered inside culvert
- A portion of the culvert foundations undermined by sinkhole activity
- Open void backfilled with grout to protect foundations



Sinkhole/ Grouting Location Plan



Site #3 – Sinkhole Below Underground Detention Basin – Initially 16' in diameter by 15' in depth



Large Rain Event caused sinkhole to expand to 40' in diameter by 15' in depth



- Leaking connection between connecting pipes suspected as cause of sinkhole
- During the excavation process, a section of pipe was vertical in sinkhole



Grouting conducted in a grid pattern in open excavation



- Grouting also conducted outside of excavation to minimize potential growth
- A combination of Permeation grouting and low mobility grouting used to effectively stabilize sinkhole
- This method proved to fill in voids and fractures in the bedrock and overburden soils



Case History – Sinkholes in Stormwater Basin





Limited Excavation Performed to further expose the bedrock

Overall Sinkhole measured 35 feet in diameter by 30 feet in depth.

“Liner” only installed at bottom
of basin and not up sides



Flowable fill placed to slightly
above the top of rock surface



New sinkhole forms after overflow structure installed



Excavation
method used
to stabilize
new
sinkhole



New liner
installed on
basin
embankment



Liner
installed by
qualified
contractor.
Seams of new
liner properly
welded





3rd sinkhole forms a few
months later...

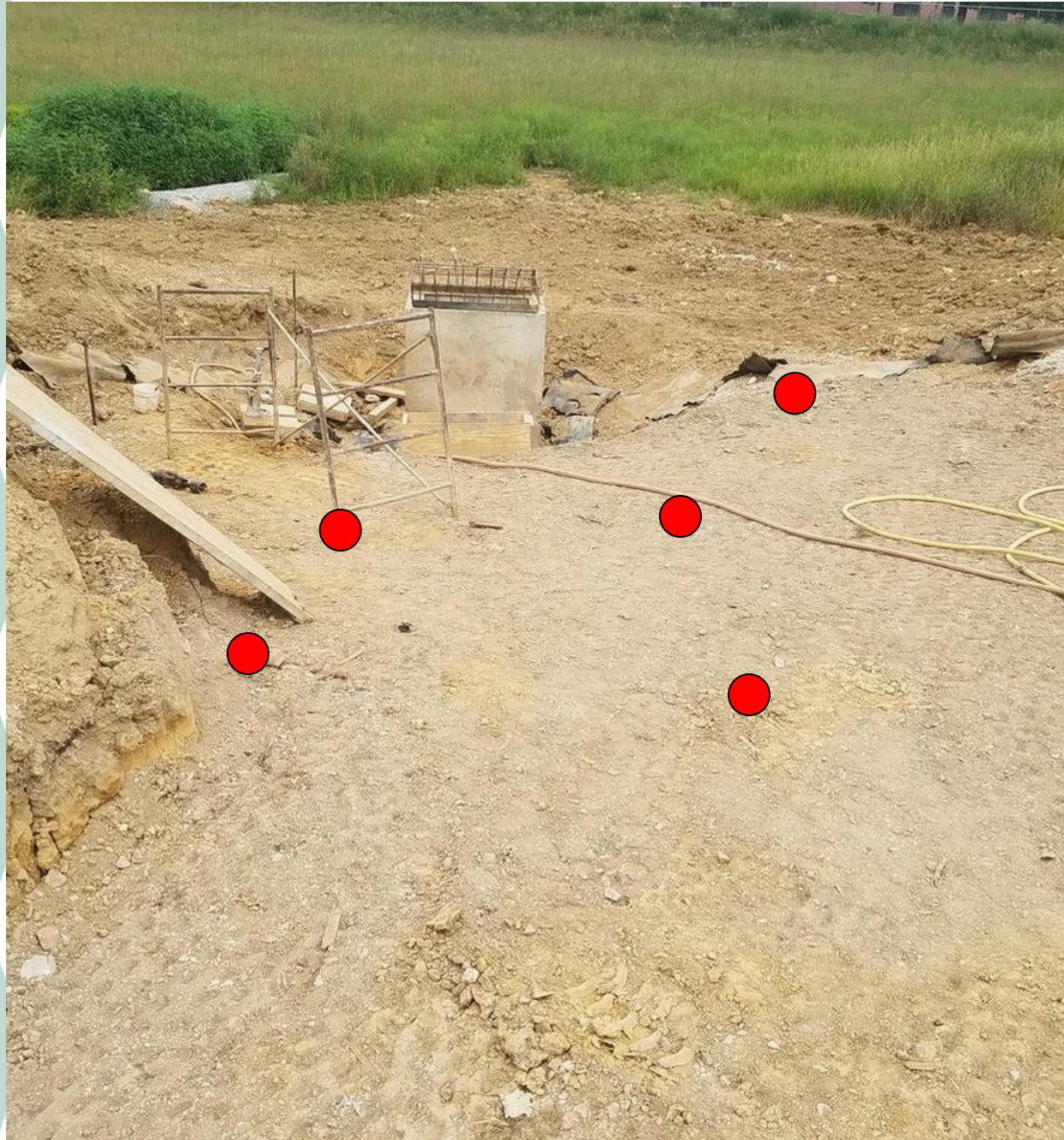


And grows..



Fourth
sinkhole
forms
along new
pipe run

Pressure
Grouting
performed to
stabilize
sinkhole and
reduce future
risk





High
mobility
grout
injected
under
pressure to
seal voids at
soil/bedrock
interface

Batton strips
used to create
watertight
seal between
overflow and
liner





Anchor
trench
installed at
top of
slope



No new
sinkholes
following
completion

Control Measures

Minimizing Risk Techniques

- Keep Excavation to a Minimum
- Design Watertight Seals for all Water Bearing Utilities (Stormwater, Roof Drains..)
- Utilize Open Basins/Rain Gardens
- Impermeable Liners in Basins and Swales
- Avoid Blasting for Rock Excavation
- Seal Joints between Paving and Curbing
- Install Clay “Plugs” in Underground Utility Trenches

THANK YOU !



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Engineering Catastrophies

https://drive.google.com/file/d/11KH_7GAG7bQd1pVtyYBWSa5JT99D3agr/view