STABILITY ANALYSIS NEAR KANSAS CITY, MO

- Historic single-level limestone operation
- Scope of Work:
 - / Determine the stability of the general area
 - / Identify alternatives for a remediation plan to allow for construction of commercial structures on site

Background Information:

- / Located in Midwest United States
- / Not actively mined since the 1970's
- Previous post-mining land use for cold storage
- / No available access to the underground workings





INITIAL INVESTIGATION

Reviewed Data:

/ Historical data

- » Survey and mine maps
- » Geological cross sections
- Supporting studies (same geological zones)
- / Had to adjust historic maps to match the most up to date data

Concerns:

- / Accuracy of the historic maps
 - » Extents
 - » Mined areas
 - » Roof falls / collapsed zones
- Extents of collapsed zones
- **Overall geotechnical stability of the area**



PROJECT OVERVIEW

Develop a Site Investigation Plan

- / Drill holes to remotely access the workings
- / Remotely scan, map, and geolocate underground workings
- / Investigate the extents of the mine
 - » Unknown center area
 - » North and Northwest extents
- Adjust historic mine maps to match collected scan data
- Collect geotechnical information to be used in stability analysis
 - » Extent of roof collapse



SITE INVESTIGATION

Remote Scan and Mine Map Correction

- / Drilled 13 Holes
- / Surveyed 15 Holes
- / Geolocate and update maps with scans
 - » Plan view
 - » Elevation adjustment







SITE INVESTIGATION: MAP CORRECTION NOI





SITE INVESTIGATION

Review of Mine Extents and Collapse:

- / Confirm drill logs
- / Photos of geological, hole, and working conditions
 - » Identify roof support and utilities underground
- Mapping information geotechnical analysis
 - Approximate depth of geological inconsistencies
 - » Pillar dimensions and integrity
 - » Roof conditions
 - Stable and collapsed areas

Surface Investigation

» Sinkholes



DATA ANALYSIS

- Review of Mine Extents and Collapse:
 - / Collapse extent determined using BF and size of historic workings
 - / Volumetric analysis separated into 4 horizons



DATA ANALYSIS

Roof Collapse Review:

- / Reviewed all holes with caving above designed roof height
 - » 8 of 15 holes investigated
- / Estimated Bulking Factor (BF)
 - » Range of cave height using an assumed floor elevation based on scan data
- Collapse potential calculated based on remaining void and a conservative BF of 1.3
- / Sinkhole is an outlier most likely related to local geology

	No. of Cases	Мах	Min	Average
Cave Height Above Roof (ft)	8	29 - 36	3 - 9	20 - 22
Cave Distance Into Winterset (ft)	5	23	3	14
Cave to Top of Winterset	1	CH3, 75-ft Unsupported Span		
Cave Above Winterset	1	Sinkho	ole, Cave to Sur	face
BulkingFactor	8	1.52 – 1.93	1.18 – 1.25	1.45 – 1.57



DATA ANALYSIS

Roof Collapse Review Example:



RECOMMENDATIONS

Reclamation Requirements and Limitations

70 ft cover requirement

Anything less will need to be excavated and back filled
70 ft to 80 ft will require grout columns





RECOMMENDATIONS

- Recommended Approach for Site Development
 - Prepare site for commercial construction
 - / Shallow cover extraction with grout columns
 - / Backfill with material on-site
 - » Regrade and put in roads as needed
 - / Work possible year-round with consideration of the effects of wet and cold weather
 - / Provided estimated cost summary

Extraction Area Volumetric Analysis					
		Volume	Avg. Thickness		
Horizon	Strata	(CY)	(ft)		
Overburden	Shale/Limestone	38,000	21		
	Winterset Limestone	43,800	23		
	Galesburg Shale	10,700	6		
	Bethany Falls	7,200	4		
	Sub-Total	99, 700	53		
Remaining Pillars	Bethany Falls	1,800	12		
Extraction Total		101,500	65		

