EXPERT REPORT
Timothy Hill, P.G.

Hydrogeology Evaluation
Cross Hollow Quarry
1425 Old Wire Road
Benton County, Arkansas

Prepared for:
Anchor Stone Company
4124 S. Rockford Avenue, Suite 201
Tulsa, Oklahoma 74105

Expert Report Prepared by
Timothy Hill, P.G.

ATOKA, Inc.

544 Mid America Blvd, Hot Springs, AR 71913
800-305-2392 501-623-1121 Fax 501-623-2769
aaronb@atokainc.com

Professional Engineering & Environmental Consulting Services

Report Dated: November 18, 2019
ATOKA Project # 19-293

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1.0 INTRODUCTION AND REPORT OBJECTIVES

1.1 Introduction

My name is Timothy Hill and I reside at 217 Scenic Drive, Hot Springs, AR 71913. I am a Senior Hydrogeologist and Director of Environmental Services for ATOKA, Inc. (ATOKA). I am a licensed Professional Geologist (P.G.) in Kansas, Arkansas, Kentucky, Indiana, Texas, and Tennessee. My resume and work experience (**Appendix A**) and the Standard Fee Schedule for ATOKA, Inc. (**Appendix B**) are attached to this report. In preparing this report, I relied on tasks completed by employees of ATOKA under my supervision. Whenever I use the term ATOKA, I am including my work and that of employees directly under my supervision.

I received a Bachelor's of Science degree in Geology in 1979, from Edinboro University of Pennsylvania. I have extensive experience in implementing successful environmental programs, hydrogeological investigations, mineral extraction, mine permitting, acid mine drainage, due diligence, mergers and acquisitions, NEPA, environmental compliance, prevention, corrective action, and closures for mining, aviation, automotive, agrochemical, chemicals, petrochemicals, refining and energy industries. I have conducted hydrogeologic investigations for landfills, waste ponds, manufacturing operations, pipelines, limestone and coal mining, remedial actions (RIFS/CAPs, RFIs, State clean up), water supply, and hydrology assessments. Conducted investigations in various hydrogeological settings for fill, deltaic sediment, glacial, igneous, metamorphic, and sedimentary deposits (including Karst).

This report provides my analysis and review of documents, site visits, and my conclusions derived thereof. In the report to follow, when the term ATOKA is used, it refers to my work and any discussions or other assistance I may have had with other employees of ATOKA, Inc. (ATOKA) or during the evaluation of documents and the derivation of my opinions.

I was requested to review the current conditions and assess impacts to the local hydrogeology in the vicinity of the proposed Cross Hollow Quarry (Site) due to future quarry activities.

1.2 Report Objectives

The primary objectives of this Expert Report are to determine:

1. The potential impacts of the proposed limestone activities on the local domestic wells; and

2. The potential impacts of the proposed limestone quarrying on the major aquifers, hydrology, environmental conditions, and karst development.

This report may be further supplemented if additional information is received or developed from any other sources and made available. In the case of a supplement to this report the objectives, conclusions, and/or recommendations may also be modified accordingly.

2.0 DOCUMENTS EVALUATION AND BACKGROUND

2.1 Document Evaluations

ATOKA was asked by Anchor Stone's Engineering Consultant to review documents pertinent to this case, including, but not limited to:

- Joshua D. Elson, R.G., P. Benjamin Luetkemeyer, PhD., R.G., and Michael Homan, P.E., 2019. Geophysical and Drilling Services - Karst Evaluation Report for Cross Hollow Quarry at 1425 Old Wire Road Benton County, Arkansas. *Terracon Consultants, Inc., Project No. 04195028.1.*

2.2 Documents Generated by ATOKA

ATOKA has been able to identify and review documents readily available, including, but not limited to:

- Aerial imagery through Google Earth and the United States Geological Survey (USGS) Earth Explorer;

- Ernest E. Glick, 1970. Geologic Work Sheet – Rogers, Arkansas, Scale 1:24,000 Quadrangle, *Arkansas Geological Survey;*

- United States Geological Survey, 1958 (Photo Revised 1976)., Topographic Map, - Rogers Arkansas, Scale 1:24,000 Quadrangle, *United States Geological Survey, Denver Colorado, 80225 and Arkansas Geological Commission, Little Rock, Arkansas 72204;*

- Domestic Water Wells in the Vicinity of the Proposed Cross Hollow Quarry, Website awwcc.publishpath.com/construction Reports, *Water well Construction Commission of Arkansas;*

- Phillip R. Shelby, 1986. Depositional History of the St. Joe and Boone Formations in Northern Arkansas, *Journal of the Arkansas Academy of Science, Volume 40, Article 22;*

- John Murdoch, Carrol Bitting, and John Van Brahana, 2016. Characterization of the Karst Hydrogeology of the Boone Formation in the Big Creek Valley, *Environmental Earth Science (2016) 75:1160, DOI 10.1007/s12665-016-5981-y; and*

- Jon C. Dowell, Camille M. Hutchinson, and Stephen K. Boss, 2005. Bedrock Geology of the Rogers Quadrangle, Benton County, Arkansas, *Journal of the Arkansas Academy of Science, Volume 59, Article 9.*

A list of the documents identified and reviewed by ATOKA regarding the evaluation of the area geology, soils, and hydrology is also provided in **Appendix C**. Some of the documents in **Appendix C** have been cited in this report; others in the appendix were reviewed by ATOKA but not cited. These and all other references reviewed are provided in **Appendix C**.

Additional revisions may be necessary if any additional documents are acquired and are reviewed by ATOKA following the completion and submission of this report.

3.0 SITE LOCATION, GEOLOGY, SOILS, AND HYDROLOGY

3.1 Site Location

The location of the proposed Limestone Quarry (Site) is in the southwest quarter of the northwest quarter and southeast quarter and southwest quarter of the northeast quarter of Section 31, Township 19 North, and Range 29 West of Benton County, Arkansas. The Site is approximately 48.60 acres, and is located 2.8 miles northeast of the city of Lowell, Arkansas. The Site latitude and longitude coordinates are coordinates 36.27194 and -94.10609, respectively. A Site Location and Vicinity Map is provided as Figure - 1.

3.2 Geology

The subject site lies on the south flank of the Ozark Dome (Dowell, 2005). Benton County occupies a portion of the Springfield Plateau formed along the southern portion of the Ozark Dome. This erosional plateau is defined by the top of the Boone Formation (Lower Mississippian Limestone and Chert), which is a maturely dissected, dendritic drainage system dominated by the White River. This river system is impounded by the Beaver Dam to form Beaver Lake. The southern portion of Beaver Lake is located approximately 1.7 miles east of the Site.

The rock outcrops at the surface are sedimentary and range from Upper Devonian to Lower Mississippian. The Geologic Work Sheet of the Rogers, Arkansas Quadrangle (Glick, 1970) indicates that the surface geology of the site is Lower Mississippian limestone and Chert of the Boone (Osagean Series) and St. Joe (Kinderhookean Series) Formations. Underlying the Boone and St. Joe Formations is a black pyritic shale (Devonian age Chattanooga Shale).

A Fault has been identified just north of the site with displacement ranging from 1 - 10 meters (Jon Dowell, 2005) trending SW-NE along the Monte Ne drainage to Beaver Lake. The fault is a Normal Fault with the upside displacement north of the fault line, and the downside displacement south of the fault line. The fault location is depicted on Figure – 1.

Terracon Consultants, Inc. (Terracon) conducted geophysical and drilling explorations services within the proposed five stage quarrying areas (Elson, 2019). The exploration services consisted of Electrical Resistivity Imaging (ERI), Multi-Channel Analysis of Surface Wave (MASW), and soil sample/rock core borings. The purpose was to characterized the site subsurface conditions and identify potential karst features that may impact quarry operations. The Report is presented in Appendix D, and the Terracon findings are summarized below:

- Drilling exploration consisted of five borings (B-1 – B-5);
- Overburden is a clay gravel to depths of 30 feet (Overburden);
- Limestone drilling to depths of 80 feet in borings 1 and 2, and 60 feet (B-5);
- The limestone bedrock surfaces are pinnacle/cutter erosional shapes buried under the overburden;

- The overburden was logged by Terracon as a reddish brown clayey gravel (ATOKA, however, has logged exposed high walls in the proposed limestone mining areas as stratified gray sandstone interbedded with reddish brown saprolite, highly weathered shale. The stratified over- burden is shown on Figure – 2);
- No significant karst development was discovered by Terracon (ATOKA confirmed this from examining several limestone outcrops on Site and adjacent areas); and
- No free water inflow to the borings was observed by Terracon.

ATOKA obtained additional geologic information from geologic field mapping, logging rock cuttings, and observing hydrogeological conditions in MW-1 (Well Log in **Appendix D)**. Additional data was collected from springs in an unnamed tributary that drains to the Monte Ne Branch of Beaver Lake. Location of MW – 1, spring, and exploratory boring B-5 is shown on Figure - 3. The subsurface Geology at the site and vicinity is shown on Figure - 4 (Geologic Cross Section A-A'). The location of the Geologic Cross Section is depicted on Figure – 3.

The surface elevation and latitude and longitude coordinates for MW-1 and the spring were approximated by using Google Earth, and exploratory boring B-5 surface elevation was obtained from Google Earth and the coordinates were from the Terracon Report (Elson, 2019). The surface elevations and coordinates are present below:

- MW -1: Surface Elevation – 1333 ft above mean sea level (MSL)
  Coordinates - Latitude 36.27194; Longitude -94.10609
- Spring: Surface Elevation – 1227 ft MSL
  Coordinates - Latitude 36.27697; Longitude -94.11419
- Boring B-5: Surface Elevation – 1262 ft MSL
  Coordinates - Latitude 36.2762; Longitude -94.1101

3.3 Soil Survey

The U.S. Department of Agriculture, Soil Conservation Service Soil Surveys, and the United States Department of Agriculture, Natural Resources Conservation Service (NRCS) on-line database https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm were used to provide information on the soils at the Anchor Stone property. The soils indicated to be present on or near the Anchor Stone site for the proposed quarry are the:

- Elsa soils (Eg), 0 to 3 percent slopes, extremely gravelly silt loam, occasionally and frequently flooded, hydric, classified as not prime farmland;

- Nixa very gravelly silt loam (NfC), 3 to 8 percent slopes, not hydric, classified as not prime farmland;

- Noark very gravelly silt loam (NoF), 20 to 40 percent slopes, not hydric, classified as not prime farmland;

See **Appendix E** for the detailed summary of the soils and the soil maps as a part of the full NRCS Soil Reports. The Noark soils comprise approximately 64.3 percent of the soils on the map, with the remaining 30.7 percent the Nixa soils and 5 percent Elsa soils. The Noark and Nixa soils cover the higher elevation mapped areas, with the Elsa soils located along streams in the north of the mapped area. None of the soils in the mapped area are classified as prime farmland. Hydric soils are only located in the areas with Elsa soils.

3.4 Hydrogeology

Groundwater in the area is recharged principally from local precipitation, and underflow from adjacent regional aquifers. Groundwater discharge is mainly by seepage into streams and transpiration by plants. Domestic and stock water supplies are obtained from wells.

Groundwater at the site occurs near the base of the Boone and St Joe Limestones. Groundwater discharge to the surface as springs was identified in an unnamed tributary on Site (Figure - 4). Groundwater was also detected during drilling MW – 1. Two small fracture zones (based on drilling penetration rates) were encountered at 80 ft (flowing at 0.5 gpm) and 105 ft (flowing at 4.5 gpm). Groundwater flow is confined to these fracture zones, and are under hydrostatic pressure conditions (confined conditions).

The potentiometric head for these two fractures zones was measured in MW -1 at 37 ft (1296 ft MSL). Although the potentiometric head is shown in the proposed Quarry area (Figure – 4), groundwater flow is confined to the fracture zones, and the hydrostatic pressure rises to the potentiometric head level in wells. Thus groundwater flow does not occur above or below the two small fracture zones at the Site.

Note no groundwater was detected above 80 ft (1253 ft MSL) in MW-1, which was also confirmed by dry tributaries at this elevation on Site. Groundwater discharging to the surface was observed around the Site vicinity along the Monte Ne drainage to Beaver Lake. The spring elevation on Site correlates to the fracture zone in MW -1 at a depth of 105 ft (1228 MSL).

3.5 Local Water Wells

The State of Arkansas water well database operated by the Arkansas Water Well Construction Commission was accessed to obtain data and locations of 12 water wells located in the vicinity of the proposed quarry location. The Water Well Records for these wells are included in Appendix F and a summary table of well locations, depths, static water levels, construction type, producing zones and yield are included in Table 1. Seven of the wells are listed as completed in limestone, one in shale and four have unknown completion zones. The wells range in depth from 126 to 1,032 feet below ground surface, with static water levels ranging from 46 to 290 feet below ground surface. The well locations are shown on Figure – 5.

The well yields range from a few gallons per minute (gpm) to 480 gpm. No public water supply wells are located in the vicinity of the mine area. Based on domestic well elevations, the domestic wells encounter groundwater in deeper fracture zones than the two fractures zones identified in the on- site well MW-1.

4.0 FINDINGS: POTENTIAL LIMESTONE QUARRY IMPACTS TO GROUNDWATER AND SURFACE WATER

4.1 Quarry Impacts to Onsite Groundwater and Surface Water

The proposed Quarry is not expected to impact onsite surface water and groundwater conditions. The proposed Quarry operations plan is to extract limestone to a maximum depth of 80 ft, and will not encounter any major aquifers or groundwater flow zones in the Site vicinity. The proposed Quarry will be located on the highland areas of the Site, and engineered erosion and sedimentation structures will minimize any impacts to onsite surface drainage areas.

4.2 Quarry Impacts to Offsite Groundwater and Surface Water

The proposed Quarry is not expected to impact offsite surface water and groundwater conditions. Since the Quarry will extract limestone only to a depth of 80 ft and the local domestic wells obtain groundwater from lower elevation fracture zones, the quarry operations is not expected to impact the flow to the domestic wells.

The proposed Quarry will be located on the highland areas of the Site, and engineered erosion and sedimentation structures will minimize any impacts to offsite surface drainage areas. Surface water discharge from the Quarry will be through controlled engineer erosion and sedimentation structures. Therefore, the Quarry is unlikely to impact invertebrate ecology and organisms due to turbulent discharge flows, fluctuations in water temperature, or the mobilization of streambed sediments. Thus, the Quarry will not impact vertebrate ecology and habitats by reducing the source of food availability to vertebrates.

4.3 Potential Quarry Impacts to Karst Development

Karst is a type of topography that is formed over limestone by dissolving or solution, and that is characterized by closed depressions or sinkholes, caves, and underground drainage. Karst development in limestone can occur when carbon dioxide in air and soil combines with water to form weak carbonic acid. Water containing carbonic acid (HCO_3^-) can slowly dissolve limestone, especially along fractures. As fractures enlarge, they can become caves, and collapse of cave roofs causes sinkholes.

Karst solution in limestone is essentially the hydrolysis of calcium carbonate ($CaCO_3$). A Solution of calcite in groundwater made acid by dissolved CO_2 is represented by the following reaction (Bloom, 1978):

$$CaCO_3 + H_2O + CO_2 = Ca^{+2} + 2HCO_3^-$$

There are no known developed Karst areas located on or in the vicinity of the proposed Quarry. Because the Quarry is not is not expected to encounter groundwater inflow, limestone solution and Karst development is unlikely to occur at the Site.

5.0 CONCLUSIONS OF MR. HILL, P.G.

The following conclusions are made from the reviews and evaluations undertaken for the Hydrogeology Evaluation for the Cross Hollow Quarry case:

- The Hydrogeology Evaluation assessed the Boone and St. Joe Formations, and the Chattanooga Shale to a depth of 300 ft;
- The Quarry deposits at the Site include the Boone and St. Joe. Formations;
- The proposed Quarry will extract the Boone/St. Joe and limestone to depth of 80 ft;
- The Terracon Geophysical and Exploration Drilling Findings:
    - Drilling exploration consisted of five borings (B-1 – B-5);
    - Overburden is a clay gravel to depths of 30 feet (Overburden);
    - Limestone drilling to depths of 80 feet in borings 1 and 2, and 60 feet (B-5);
    - The limestone bedrock surfaces are pinnacle/cutter erosional shapes buried under the overburden;
    - The overburden was logged by Terracon as a reddish brown clayey gravel. ATOKA, however, has logged exposed high walls in the proposed limestone mining areas as stratified gray sandstone interbedded with reddish brown saprolite (highly weathered shale);
    - No significant karst development was discovered by Terracon (ATOKA confirmed this from examining several limestone outcrops on Site and adjacent areas); and
    - No free water inflow to the borings was observed by Terracon.
- A Normal Fault has been identified just north of the site with displacement ranging from 1 - 10 meters (Jon Dowell, 2005) trending SW-NE along the Monte Ne drainage to Beaver Lake;
- Groundwater was also detected during drilling MW – 1, and two small fracture zones (based on drilling penetration rates) were encountered at 80 ft (flowing at 0.5 gpm) and 105 ft (flowing at 4.5 gpm);
- Groundwater flow is confined to these fracture zones, and are under hydrostatic pressure conditions (confined conditions), thus groundwater flow does not occur above or below the two small fracture zones at the Site;
- The potentiometric head for these two fractures zones was measured in MW -1 at 37 ft (1296 ft MSL);
- Note no groundwater was detected above 80 ft (Proposed Quarry Area shown Figure - 4) in MW-1, which was also confirmed by dry tributaries at this elevation on Site;
- The spring elevation on Site correlates to the fracture zone in MW -1 at a depth of 105 ft (1228 MSL);
- Groundwater discharging to the surface was observed around the Site vicinity along the Monte Ne drainage to Beaver Lake;

- No public water supply wells are located in the vicinity of the mine area;
- Based on domestic well elevations near the Site, groundwater was encountered in deeper fracture zones than the two fractures zones identified in the on-site well MW-1;
- Since the Quarry will extract limestone only to a depth of 80 ft and the local domestic wells obtain groundwater from lower elevation fracture zones, the quarry operations is not expected to impact the groundwater flow to domestic wells;
- The proposed Quarry operations will not encounter any major aquifers or groundwater flow zones in the Site vicinity.
- Since surface discharge from the Quarry will be through controlled engineer erosion and sedimentation structures, the Quarry should not cause harm to invertebrate or vertebrate ecology and organisms due to turbulent discharge flows, fluctuations in water temperature, and the mobilization of streamed sediments;
- Limestone Quarry will not increase limestone solution, and thus increase Karst development at the Site.

6.0 OPINIONS OF MR. HILL, P.G.

The following are the opinions of the Hydrogeologist:

- The proposed limestone quarry at the Site will not negatively impact the hydrogeology, groundwater flow to domestic wells, environmental conditions, wildlife habitats, and Karst development at the Site; and
- It is my opinion, a limestone quarry is suitable for the Site.

7.0 RECOMMENDATIONS OF MR. HILL, P.G.

- The Hydrogeologist has no recommendations for the Limestone Quarry and its operations.

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FIGURES

Figure – 1 Proposed Limestone Quarry Location and a Normal Fault Location

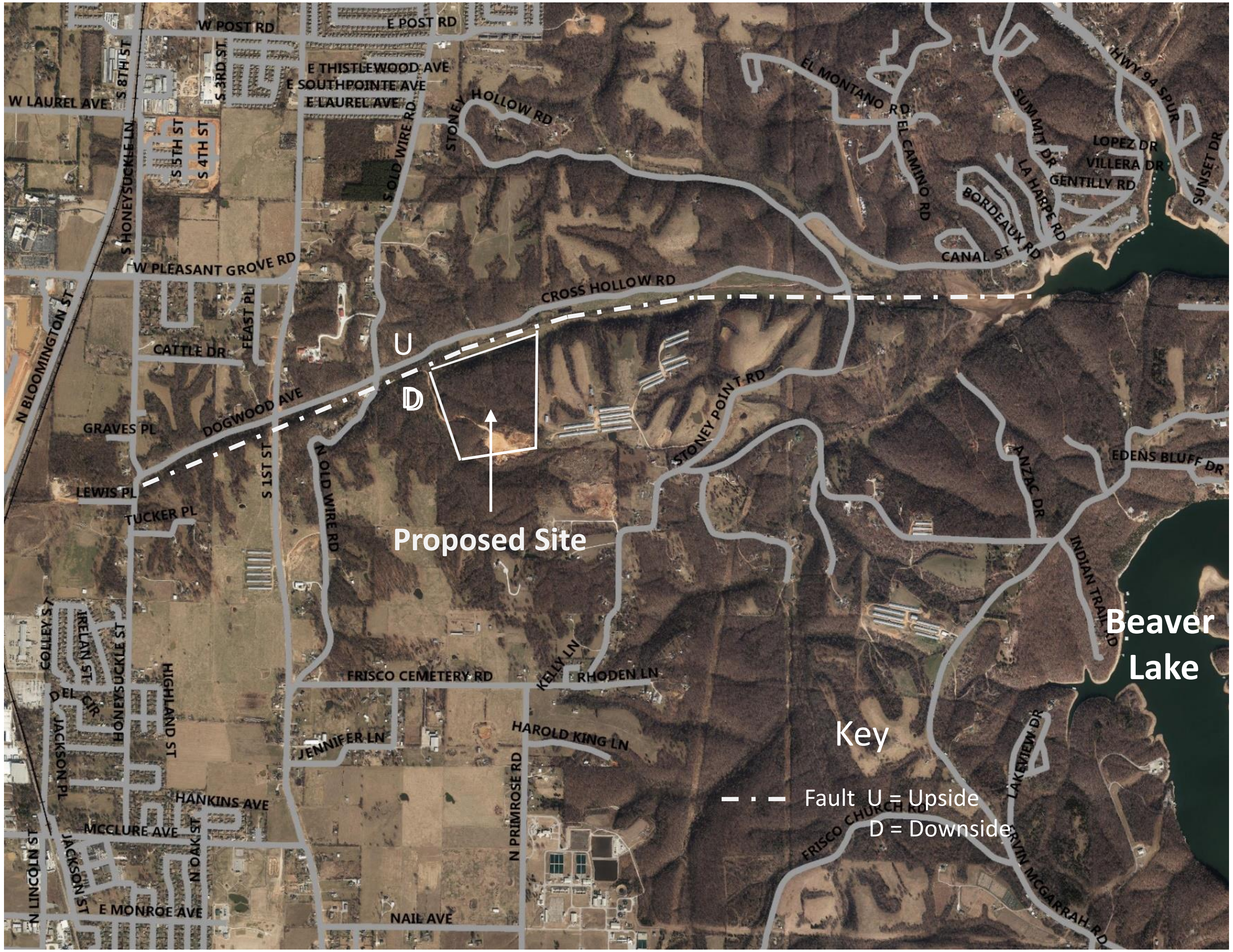


Figure – 2 Stratified Overburden

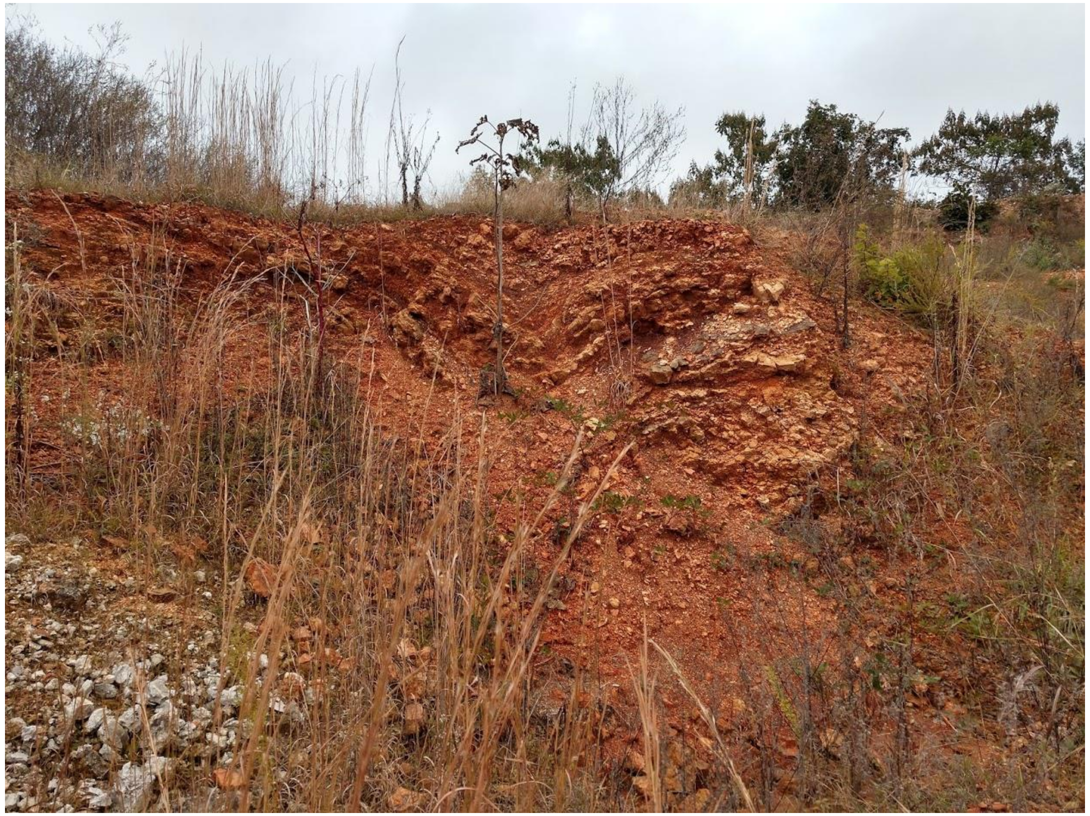


Figure 3 - Location of Cross Section A-A’

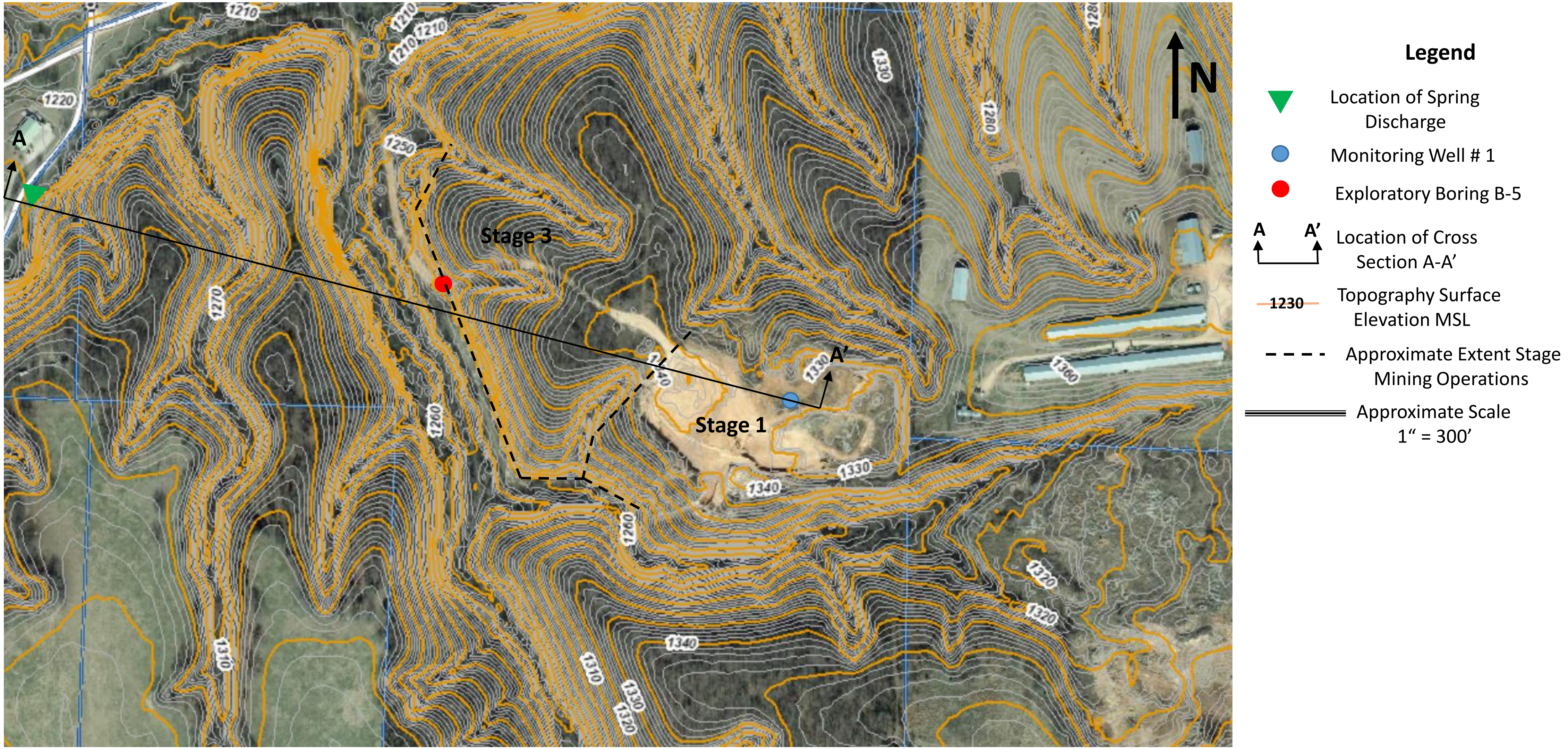


Figure 4 – Geologic Cross Section A-A'
It's Location is Shown on Figure 3

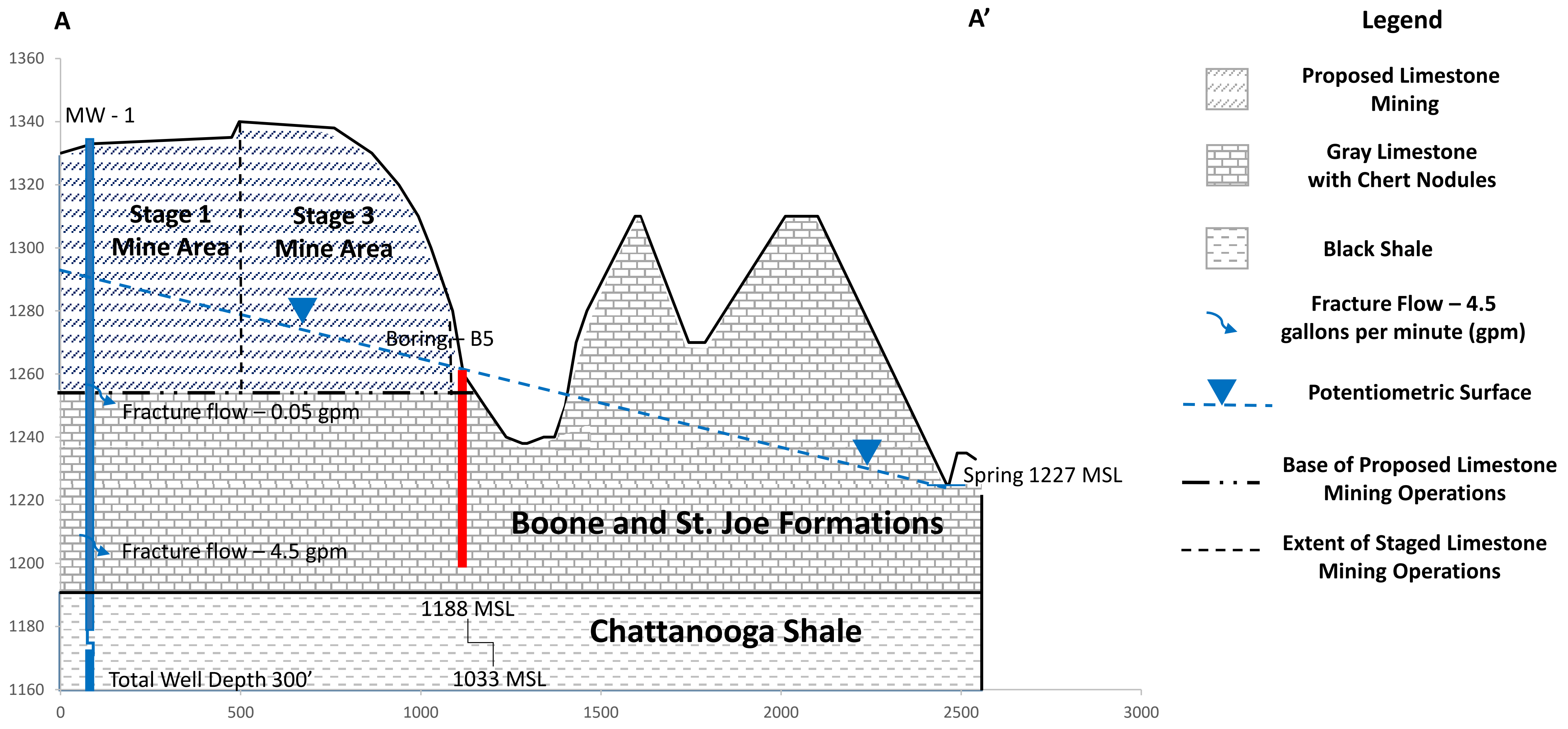
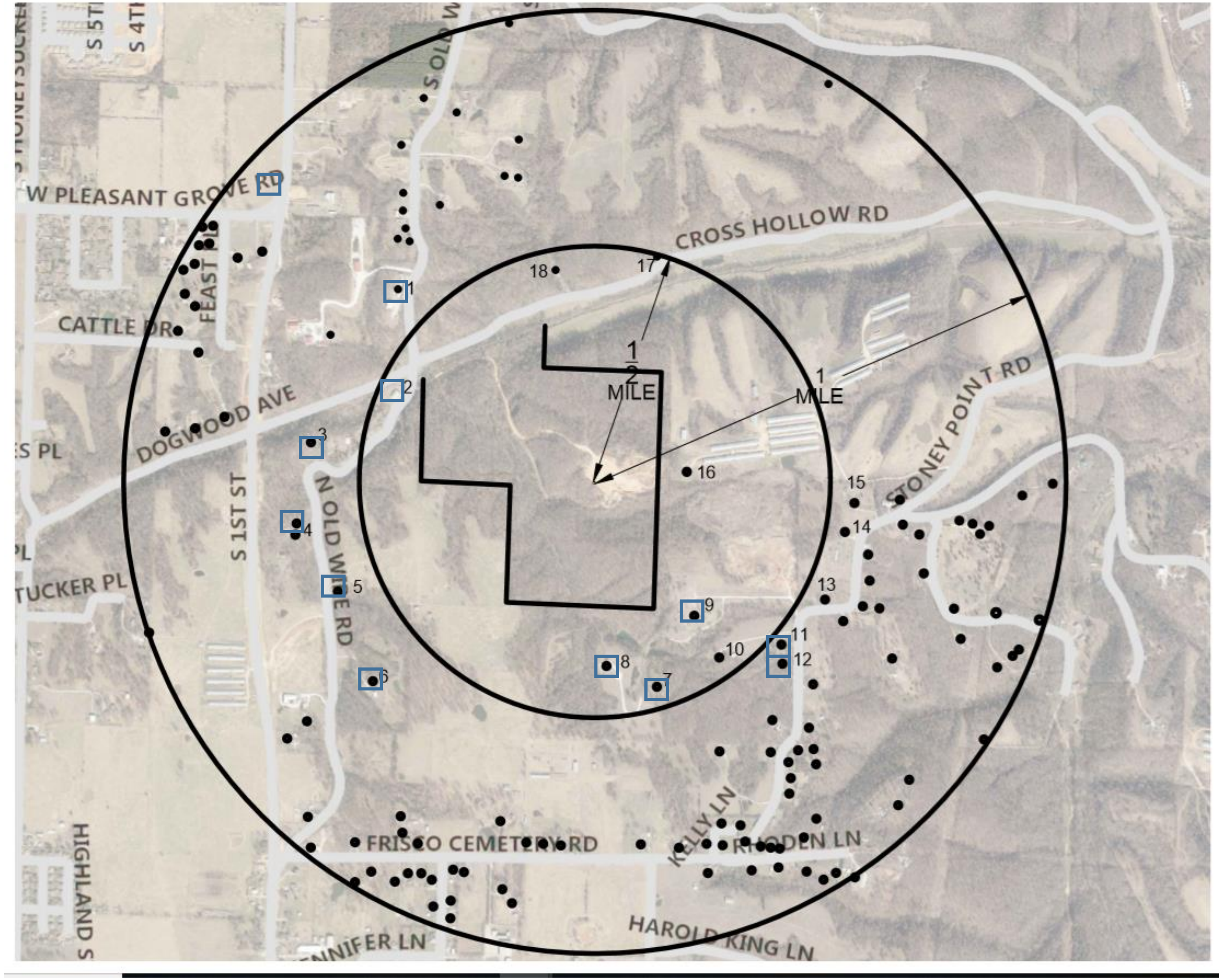


Figure – 5 Selected Domestic Water Well Records



TABLES

Table - 1
Selected Domestic Well Records

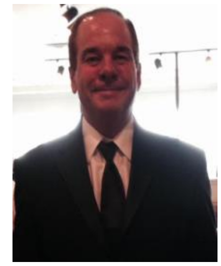
Well No.[1]	Latitude	Longitude	Depth	Water Level (ft below ground surface)	Construction[2]	Bedrock Producing Zone	Yield (gallons)
1	36°16′03″	94°06′04″	300	65	U	Shale	0
2	36°16′06″	94°06′05″	200	60	U	Limestone	480 minute
3	36°16′08″	94°06′19″	250	100	U	Limestone	2
4	36°16′30″	94°06′35″	600	100	U		15
5	36°16′36″	94°06′52″	659	250	U	Limestone	22 minute
6	36°16′08″	94°06′19″	250	100	U	Limestone	2
7	36°16′52″	94°06′42″	126	46	U	Limestone	30 minute
8	36°16′37″	94°07′13″	700	248	U	Limestone	78 hour
9	36°16′37″	94°07′13″	1032	269	U	Limestone	155 minute
10	36°16′49″	94°06′59″	635	140	C		6
11	36°16′55″	94°07′04″	180				0
12	36°16′60″	94°07′01″	650	290			4

[1] Well Locations are Shown on Figure - 5

[2] U=Uncased well, C= Cased Well

APPENDIX A
RESUME

Timothy J Hill, P.G.



EDUCATION:

Edinboro University, Bachelor of Science Geological Sciences, 1979

PROFESSIONAL REGISTRATIONS & MEMBERSHIPS:

Licensed Professional Geologist: Arkansas, Texas, Indiana, Tennessee, Kentucky, and Kansas
40-Hour, 24-Hour, and 8-hr HAZWOPER certifications
RCRA and DOT Certifications
Groundwater Pollution and Hydrology – Princeton University
Project Management Training – Civil and Environmental Consultants, Inc.
Petroleum Refining and Processing - Colorado School of Mines
Certified Storm Water Site Inspector – City of Hot Springs, AR
Hazardous Waste Contractor/Consultant License - Arkansas
Certificate of Extreme Achievement - Leadership Consulting Services, Inc.
How to Supervise People - Fred Pryor Seminars

LITIGATION AND ENFORCEMENT EXPERIENCE

- Litigation Support for Expert Witness Report, US Federal Court, Southern Indiana District, for chlorinated solvent releases in karst bedrock. (Required geotechnical analysis of fill material)
- Litigation Support for Expert Witness Opinion, US Court of Federal Claims, for alleged impacts to private property by the United States. (Required geotechnical analysis of fill material)
- Litigation Support for Expert Witness Opinion, Arkansas 6th Circuit Court, for alleged home flooding. (Required geotechnical analysis of fill material)
- Expert Witness Opinion, Pennsylvania Commonwealth Fifth District Court, for a Limestone Mine Reserves Assessment.
- Expert Witness Opinion, Mediation/Alternative Dispute Resolution, Indianapolis Indiana, for an Offsite Chlorinated Solvent releases and impacts to a commercial real estate transaction. (Required geotechnical analysis of fill material)
- Expert Witness Opinion, Mediation/Alternative Dispute resolution, Indianapolis Indiana, for Insurance Cost Recovery of Chlorinated Solvent Releases by a Cleaning Services Facility. (Required geotechnical analysis of fill material)
- Litigation Support for Expert Witness Opinion, US Federal Court, District of Delaware, for Insurance Cost Recovery of Chemical Releases at multiple chemical Facilities.
- Absolved a Hazardous Waste Management Enforcement Action, Indiana Department of Environmental Management Cease and Desist Order, for an Automotive Wheel Manufacture.
- Absolved a Wastewater Treatment Enforcement Action, Arkansas Department of Environmental Quality Consent Administrative Order, for a Precision Machine Tool and Die Manufacturing.
- Absolved 45 Hazardous Waste Violations, Oklahoma Department of Environmental Quality Administrative Consent Order, for a Fuels Refinery.
- Absolved seven (7) Notices of Enforcement, Texas Commission on Environmental Quality, for air emissions from a Petrochemical Manufacturing.

PROFESSIONAL EXPERIENCE:

An Environmental Leader with distinguished National and International (Canada, Mexico, China, Germany, Belgium, UK, Hungary, and Italy) corporate, divisional, facility, and consulting assignments; providing leadership direction to corporate and facility managers, environmental staff, coordinators, and contractors in implementing cost effective environmental programs for hydrogeological Investigations, due diligence, mergers and acquisitions, NEPA, environmental compliance, prevention, corrective action, and closures for lumber and wood products, aviation, automotive, agrochemical, chemicals, petrochemicals, mining, refining and energy industries. Conducted chemical(s) analysis of volatile organic compounds (VOCs), semi-VOCs, and metals for over 800 assessment/remediation projects for state cleanups programs, RCRA CA, Superfund, UST, and emergency response actions. Designed and managed over 75 groundwater and surface water treatment facilities for remediation projects. Over 12 years of multi-site(s) experience and demonstrated competencies for developing business programs, corporate strategies and policies, influencing new regulations, negotiating agency consent orders, implementing EHS stewardship initiatives, minimizing risks, supporting community outreach initiatives, managing corporate leadership expectations, and meeting and exceeding goals and corporate metrics.

PROFILE OF PROFESSIONAL EXPERIENCE:

- Managed several hundred environmental projects ranging in cost from $5,000 to $60,000,000. These projects include remediation, hydrogeologic investigations, environmental compliance implementation for new facilities, capital projects for manufacturing, NEPA activities, Brownfield redevelopment, multi-facility acquisitions and divestitures, and mineral resource assessments.
- Successfully developed and managed environmental systems and compliance for solid and hazardous waste management (RCRA storage, treatment, and disposal facilities [interim and Part B Permits]), federal and state pollution discharge elimination systems (NPDES), Storm Water Pollution and Prevention Plans, Spill Prevention Control and Countermeasure(s) Plans, Emergency Response, CAA permitting requirements (Title V, obtainment and nonattainment NSR, FESOP, MSOP, PBR, SSOA, etc.), Public Water Supplies, Environmental Reporting (emission events, spills and releases, HRVOC, NOX, Engines, RCRA waste summaries, BWON TAB, SARA TRI and Tier II, DMRs, Title V Deviations, various NESHAPs [MACT]), and environmental monitoring (air, waste, and water).
- Developed permitting strategies and negotiated permit requirements for RCRA Part B TSD, CAA (Title V, NSR, PBR, FESOP, MSOP, etc.), NPDES wastewater, and Public and Industrial Water Supply. Developed and prepared SPCC and SWPP Plans.
- Successfully obtained 41 affirmative defenses, and rescinded seven notices of enforcement and two notices of violation actions for upset emission events in the past four years. Negotiated consent order requirements for emission and release events, and activities under 3008(h), 3004(u), 3007, Section 114, and CERCLA Administrative Consent Orders. Regulatory advocacy for Primary Sludge, TC, 2nd/3rd LDRs, CAMU, UST, and several state clean up rules.
- NEPA EAs, wetlands, streams, endangered species, and cultural resources determination, assessment, mitigation, permitting, and construction for surface impoundments pipelines, landfills, mining, and remediation sites.
- Conducted hydrogeological investigations for landfills, waste ponds, manufacturing operations, pipelines, limestone and coal mining, remedial actions (RIFS/CAPs, RFIs, State clean up), water supply, and hydrology assessments. Conducted investigations in various hydrogeological settings for fill, deltaic sediments, glacial, igneous, metamorphic, and sedimentary deposits (including Karst).
- Successful in negotiating, remediating, and closing industrial sites, landfills, and waste ponds (regulated by UST, CERCLA, RCRA CA, consent orders, and state cleanup programs) that have had historical petroleum, chemical, and metal releases to soil, groundwater, and surface water in 27 states and nine (9) US EPA Regions. Significantly reduced remediation costs through risk exposure assessments,

engineering controls, institutional controls, Brownfield redevelopment grants, expert testimony, and insurance cost recovery.

- Conducted due diligence and financial reserve assessments for corporate acquisitions throughout the United States, Germany, Belgium, Italy, Hungary, UK, Canada, Mexico, and China (reduced corporate financial reserves by $2.0 million). Conducted over 200 Phase I/Phase II environmental site assessments and compliance audits for mergers, acquisitions, and divestitures of chemical, steel, and automotive manufacturing plants; pipelines; and for commercial developers, lenders and attorneys.
- Conducted coal, limestone, and clay exploration projects in the Dunckard Basin (OH, PA, & WV) mining districts. Managed drilling operations, performed geologic analysis on rock cores, field mapping, stratigraphic correlation, structure contouring, and depositional modeling for coal and mineral stone continuity, coal quality, and minable coal reserve analysis. Performed economic analysis for strip and deep mine operations. Conducted hydrogeologic investigations for acid mine drainage (AMD) from strip and deep mine operations. Performed surface water and groundwater monitoring, fracture trace analysis, AMD source characterization, and AMD plume delineation and attenuation. Conducted pump, Slug, and tracer tests to evaluate aquifer hydraulic conductivities, gradients, and flow rates effect on AMD plume attenuation and AMID surface water loadings. Prepared acid mine drainage permits for bituminous coal mine operations. Established baseline surface water and groundwater quality, conducted hydrogeologic analysis of affected aquifers, designed E&S controls, designed mine haulage systems, and prepared permit applications.
- Conducted investigations, assessments, and prepared expert testimony reports for US Federal Courts resulting in client's favorable settlements. Technical support for environmental insurance cost recovery resulting in client's favorable insurance settlements. Reducing energy use, recycling waste into products, and conserving water resources.

REPRESENTATIVE WORK EXPERIENCE:

2016 – Present ATOKA, Inc.: Vice President and Director of Environmental Services
2011 – 2016 Chevron Phillips Chemical Company LP: Environmental Superintendent; Ethylene Manufacturing and Bulk Terminals. I provided specific direction to a team of environmental engineers, scientists, and technicians.

Prior Work Experience

4/2009 – 9/2011 Partners Environmental Consulting, Inc.: Director of Indiana Operations; Consulting
2/2007 – 3/2009 Civil and Environmental Consultants, Inc.: Principle EHS Department; Consulting
11/2001 – 2/2007 August Mack Environmental, Inc.: Technical Manager; Consulting
5/1996 - 11/2001 Hill/Liebert, Inc.: President and Owner; Environmental Services
11/1993 - 5/1996 ATEC and Associates, Inc.: Associate Vice President; Consulting
8/1987 – 11/1993 DuPont/Conoco: Environmental Program Manager/Sr. Supervising Engineer; Chemicals/Refining

SELECTED ENVIRONMENTAL PROJECT SUMMARIES:

Through strong leadership, effective project management, and sound fiscal management, has been successful in negotiating, remediating, and closing industrial sites that have had historical petroleum, chemicals, and metals releases in 27 states and nine (9) US Environmental Protection Agency (EPA) Regions. Significantly reduced remediation costs through risk exposure assessments, engineering controls, and institutional controls. In recent years, He has used his collective technical remediation skills and business experience to address Fortune 500 companies' non-performing assets by creating economic value and generating funds from external resources for environmental remediation and Brownfield redevelopment activities.

Specializes in soil and groundwater remediation and environmental regulatory programs at commercial, industrial and hazardous waste sites. Has extensive experience with state clean-ups, due diligence, Resource Conservation and Recovery Act (RCRA) Corrective Action (CA) sites, landfills, superfund (CERCLA) sites, cost recovery, expert testimony; and negotiating and coordinating with local, state, and federal regulatory agencies throughout the United States and abroad. The following list of project descriptions summarizes the environmental experience for audits/due diligence, hazardous waste management, underground/aboveground storage tanks/ hydrogeology and remediation, landfills, Air, and miscellaneous projects:

MANUFACTURING AIR AND ENVIRONMENTAL COMPLIANCE

Managed Title V/NSR/PBR permits, PSM, HRVOC, EMACT, Boiler MACT, REG 117 (NOX and engines), HON, MON, EI, GHG, TRI (Form R), Tier II, LDAR, MSS, DMR, SWPPP, RMP, GRI, DOT, SPCC, OSPRA, NORM, BWON, RCRA, NPDES, PWS (three water supply permits), TRRP, EPA Flares and EMACT Section 114 Requests, due diligence for acquisitions, and air/waste/wastewater permitting and environmental compliance for ethylene manufacturing; and implemented plans for new polyethylene units. Conducted Emergency Response drills, EHSSC audits, incident investigations, and MOCs, for ethylene manufacturing operations. Recent accomplishments:

- Successfully led the environmental department turnaround from the company's trailing program in environmental compliance systems to a leading program that the Company shared with its other facilities.
- Served as the regulatory liaison for TRRC and Coast Guard drills.
- Developed a new Hazardous Chemicals Approval Program for the facility.
- Completed marine toxicity assessments (Toxicity Reduction Evaluations) to meet EPA NPDES water and wastewater discharge requirements.
- Successfully managed the environmental department requirements of over 1,000 annual tasks and activities for twenty-five major regulatory programs.
- Reduced environmental waste management cost by $200,000/year thru recycling activities.
- Reduced environmental department's operating budgets by 39%, while experiencing a 25% increase in environmental compliance requirements.
- By conducting appropriate inquiry audits, discovered over 250 compliance gaps which were addressed thru Title V reporting and permitting, and reduced annual Title V deviations by 40% over a four year period.
- Developed environmental program systems that resulted in a 93% improvement in the TCEQ compliance score (from 49 to 3.4) for the facility.
- Successfully endured ten US EPA, TCEQ and TRRC audits, and four (4) third party audits for air/waste/water resulting in no findings.
- Improved environmental department's performance by creating a highly charged and collaborative environment for the staff thru implementing the next generation environmental compliance systems, which increased quality and improved workflow efficiency.
- Successfully supported the permitting and development of the compliance implementation for two new polyethylene units.
- Successfully obtained 41 affirmative defenses, and rescinded seven notices of enforcement and two notices of violation actions for upset emission events.
- Maintained company assets thru successfully managing historic soils and groundwater contamination from multiple historic sources under TRRP, and negotiating a cost effective plan to a successful closure.

The Environmental Department was awarded the Texas Chemical Counsel's prestigious award Caring for Texas "Sustained Excellence" for four consecutive years.

AUDITS/DUE DILIGENCE

- Conducted due diligence activities, environmental; compliance audits, and financial reserve assessments for corporate acquisitions throughout the United States, and in Europe, Canada, Mexico, and China (reduced *financial reserv*es by $2.0 million).
- Conducted over 200 Phase I/Phase II environmental site assessments and compliance audits for chemical, steel, and automotive manufacturing plants and for commercial developers, lenders and
- Conducted environmental audits for steel, automotive, and chemical manufacturing plants. Audits identified non-compliance issues for air, water waste, and soil and ground water contamination. The results of the audits were used to develop environmental programs to address the issues identified during the audits.
- Conducted multi-media environmental audits at Lube oil manufacturing and drum reconditioner sites.

HAZARDOUS WASTE MANAGEMENT

- Developed over 100 solid and hazardous waste management and recycling programs for steel, chemicals, pharmaceuticals, energy, and automotive manufacturing.
- Developed an innovative metal recycling solution to finance a steel plant Brownfield Redevelopment that offset $60 million in remediation costs with $287 million in revenue by recycling ferromanganese from steel slag.
- Developed a waste minimization program for a fuels refinery site. The program addressed listed and characteristic hazardous wastes. The waste minimization program reduced hazardous waste generated at the plant by 34,000 tons (36%) over a two-year period.
- Developed a "cradle to grave" waste management program for a fuels refinery site. The program also reduced waste management manpower requirements, thus saving the plant over $100,000 in annual operating costs. The waste management program successfully passed several EPA and state RCRA audits.
- Developed an innovative solvent reuse program that reduced hazardous waste generation up to 90% for the Cabinet industry.

UNDERGROUND/ABOVEGROUND STORAGE TANKS

Conducted environmental site assessments for major oil companies. Evaluated retail service stations environmental liability for acquisitions and divestitures. Served as principal investigator for product releases from petroleum and chemical USTs. Conducted hydrogeologic investigations, aquifer hydraulic testing, contaminant plume attenuation analysis, and groundwater flow net analysis. Managed petroleum and chemical tank removal, decontamination, and demolition. Conducted in-situ and ex-situ soil remediation using chemical oxidation, vapor phase extraction, bioremediation, neutralization, and stabilization technologies. Designed and constructed groundwater remediation systems using chemical oxidation, containment, in-situ bioremediation, and ex-situ carbon filtration technologies.

HYDROGEOLOGY

- Prepared and instructed a corporate groundwater course for a Fortune 10 Chemical Corporation. This course was specifically designed to provide remediation and hydrogeology training to international plant engineers, environmental managers, and business managers.
- Negotiated a Corrective Measures Implementation (CMI) under a State Consent Order. Prepared detailed designs and construction bid documents, and managed the construction of a groundwater/leachate collection and treatment system for a chemical manufacturing plant hazardous

waste landfill. The system captures volatile organic compounds (VOCs) contaminated groundwater and leachate, and conveys the waste stream to the plant waste water system for treatment.

- Designed and implemented multi-aquifer groundwater monitoring systems for commercial RCRA hazardous waste landfills. These landfills received stabilized pickle liquoring waste streams. Groundwater monitoring systems were designed for monitoring sedimentary bedrock and mine spoil aquifers and water bearing zones at two large landfill sites. The groundwater monitoring systems were designed and constructed to meet RCRA Part B permitting requirements.
- Served as principal investigator for hydrogeologic investigations of acid mine drainage (AMD) from strip mine and deep mine operations. Performed surface water and groundwater monitoring, fracture trace analysis, AMD source characterization, and AMD plume delineation and attenuation. Conducted pump tests, in-situ hydraulic conductivity tests, and tracer tests to evaluate aquifer(s) hydraulic conductivities, gradients, and flow rates effect on AMD plume attenuation and AMID surface water loadings.
- Developed and managed a site-wide groundwater remediation program for a fuels refining plant, which included a 2.5 mile offsite hydrocarbon plume.
- Managed ground water modeling efforts at a Refinery Plant-wide dissolved and free phase capture zone determination. Based on the hydrogeologic analysis, identified critical boundary condition adjustments and additional monitoring requirements needed to improve the accuracy of a three-dimensional model. These adjustments were used to recalibrate the model for determining how to successfully pump a surficial aquifer in order to fully capture dissolved and free phase plumes.
- Designed a seven aquifer-monitoring network in sedimentary bedrock and valley fill deposits. The site was located in a highly dissected area with elevation relief of over 2000 feet. A hydrogeologic investigation consisted of drilling three exploratory borings via continuous wire line coring, bore hole geophysical logging, and drilling, installing and sampling 45 monitoring wells. Some wells required telescoping through five aquifers and drilling to a depth of 450 feet. The results were used to address releases from RCRA Solid Waste Management Units (SWMUs). The results were also used to determine that one SWMU, a pond containing waste from chemical manufacturing, recharge four of the seven aquifers at the site. The hydrogeologic analysis and monitoring network significantly reduce RCRA Corrective Action remediation costs.
- Conducted a groundwater statistical analysis of 40 CFR 265 indicator parameters for a RCRA surface impoundment at a chemical manufacturing facility. The initial results, by another contractor, indicated that contaminants had a release from the surface impoundment. A second statistical study indicated that the statistical exceedance resulted from the initial analysis and did not indicate a release from the surface impoundment. The state agency agreed with the second analysis, and eliminated a costly hydrogeologic investigation and remediation.
- Served as principal investigator for a hydrogeologic assessment of chlorinated hydrocarbon releases from a RCRA surface impoundment at a chemical manufacturing plant. The investigation included a work plan, drilling and sampling monitoring wells, aquifer hydraulic testing, groundwater modeling, and plume attenuation analysis. Based on the results, a ground water remediation system was designed and RCRA compliance point monitoring was negotiated with EPA.
- Conducted a bedrock fracture trace study at a Department of Energy (DOE) testing laboratory for a Pre-RCRA Investigation (RI) analysis. The results identified secondary zones of permeability for potential contaminant migration in aquifers and aquitards underlying the site. The results were used to develop the RI Work Plan.
- Served as principal investigator and conducted a Hydrogeologic Landfill Siting Study for a major steel manufacturer. The results of the study indicated that a hazardous waste landfill could be safely

constructed into the local environment. The landfill will be used for stabilized waste removed from closed SWMUs.

- Served as principal investigator for a hydrogeologic assessment of chlorinated hydrocarbon releases from a RCRA surface impoundment at a chemical manufacturing plant. The investigation included a work plan, drilling and sampling monitoring wells, aquifer hydraulic testing, groundwater modeling, and plume attenuation analysis. Based on the results, a ground water remediation system was designed and RCRA compliance point monitoring was negotiated with EPA.
- A production well rehabilitation program was implemented for eight production wells to meet a chemical manufacturing plant 3000 gallons/minute production requirement. The results showed an increased yield of 50%. The rehabilitation program saved the facility $250,000 in drilling new production wells.
- Developed a potable water supply for a community of 15,000 people from groundwater resources. A new water supply system was required to replace an existing system that had insufficient capacity and quality due to local coal mining and low seasonal recharge. A groundwater exploration project was designed and implemented. Tasks include a fracture trace analysis, hydrogeologic analysis, field mapping, test well sitting, design, and construction. A test well was constructed into a sandstone aquifer that had a specific capacity of two gallons/minute/ft. A production well was designed and constructed at the site. The production well yield exceeded the state water supply requirement of 20,000 gallons/hour.
- Served as a principal investigator for a National Priority List (NPL) Superfund Site located in the Pennsylvania anthracite-mining district. Prepared Remedial Investigation (RI) and site operation work plans for investigating chemicals disposed in a closed mine shaft. The site consisted of 80 ft. of mine tailings overlying vertical dipping slate, coal, and sandstone. Deep mining and a low angle thrust fault were located within 50 feet of the mineshaft. The RI included drilling overburden and bedrock wells into a multi-aquifer regime, test pits, pump and slug tests, groundwater and surface water sampling and analysis, and hydrogeologic analysis of aquifer(s) characteristics and hydraulic interconnection with mine pool and surface water reservoirs. The results determined that VOCs, semi-VOCs, and heavy metal plumes had contaminated underlying aquifers, a mine pool, and a public reservoir located 1.5 miles down gradient of the site.
- Served as the principal investigator for a NPL Superfund Site that operated as a drum disposal facility. The project consisted of a RI work plan, site operations plan, drum removal, multi-aquifer monitoring, sampling and analysis, pump tests, test pits, and a final report. The analysis identified contaminants migrating from the site into underlying the Pleistocene Aquifer and Upper and Lower Cretaceous Aquifers. Flow net analysis and aquifer hydraulic characteristics were used to determine VOCs and semi-VOCs plume attenuation and surface water contaminant loading. The analysis also showed that the plumes would attenuate to a municipal well field four miles away.
- Conducted a 30-day pump test in 400 ft. basalt capped by 50 ft. of glacial drift for a NPL Superfund Site. The pump test consisted of pumping a municipal well at 385 gallons/minute and monitoring over 40 observation wells constructed in the glacial drift and the basalt. The results were used to determine aquifer characteristics such as hydraulic conductivity, storage, transmissivity, and leakance coefficients. The analysis was used for groundwater modeling and VOC plume attenuation from the superfund site.
- Served as a principal investigator for *a* NPL Superfund Site that operated as a municipal landfill and received liquid and solid hazardous waste. The landfill was constructed into Pleistocene Stream Channel Deposits, which overlay Cretaceous Deltaic Sediments. The project included a RI work plan, site operations plan, and multi-aquifer monitoring, sampling and analysis, and report preparation. Seven-day pump test and slug tests were performed to determine aquifer(s) hydraulic characteristics. Based on the

results, it was determined that VOCs and semi-VOCs plumes have contaminated the Pleistocene Aquifer and the upper and lower hydrologic aquifers in the Cretaceous sediments. The results were also used for modeling plume(s) attenuation potential into municipal well field capture zones. The modeling showed that the plumes would have a negative impact on public water supply for two major metropolitan areas.

- Served as a principal investigator for a NPL Superfund Site at an abandoned wood preservative facility. Tasks included a RI work plan, site operations plan, test pit investigation, soil gas survey, and a hydrogeologic investigation of glacial outwash and bedrock aquifers. The results determined that a semi-VOCs plume had contaminated the shallow glacial outwash aquifer and had attenuated to a surface water stream used for recreation.
- Prepared a RI work plan for investigating a pentachlorophenol (PCP) NPL Super-fund Site. A wood preserving facility, injecting spent PCP via an on-site well, contaminated a shallow aquifer in weathered schist bedrock. A PCP plume had migrated to a storm sewer and surfaced into a stream, which was located in adjacent residential. EPA approved the work plan and a subcontractor carried out the Remedial Investigation/ Feasibility Study (RI/FS).
- Served as a project manager for a NPL superfund site at a chemical manufacturing facility. The chemical company sold a pigment manufacturing site and retained sole liability of the superfund enforcement action. The results of the RI determined that inorganic and organic plumes had migrated from two on-site landfills and other sources from the chemical manufacturing operations. The RI program also consisted of the "state of the art" waste management that received praise from EPA Region III. The Feasibility Study (FS) resulted in a remediation program that mitigated the leachate from on-site landfills and fugitive contaminant releases from current manufacturing operations.
- Served as a technical advisor to a fortune 10 chemical manufacturing companies for a NPL solvent recycling facility. Tasks include reviewing both EPA and the Principal Responsible Parties (PRP) contractors proposed remediation systems for the final record of decision (ROD). The results of the technical advisory efforts helped negotiate a more comprehensive and cost affective remedy to a three-acre site consisting of a solvent landfill, surface impoundment, and contaminated soils and
- Served as a major chemical company technical committee representative for NPL superfund site in Mobile, Alabama. Provided an alternative remedial design and costing and successfully negotiated the requirements with the Alabama Department of Environmental Management, thus resulting in a cost savings of $1.4 million in remediation costs.
- Served as a major chemical company technical committee representative for NPL superfund site in Newark, New Jersey. Provided technical oversight and coordination of the RI/FS with consultants and EPA Region 2. Successfully negotiated an innovative stabilization remedial approach to heavy metals underlying an active pigment chemical manufacturing plant.

REMEDIATION, CERCLA, RCRA CORRECTIVE ACTION, AND CLOSURES

- Managed wetland assessments, storm water pollution prevention plans (SWPPPs), spill prevention control and counter measure (SPCC) plans, Clean Water Act (CWA) permitting; and endangered species assessments, stream relocations, and hydrogeologic assessments for superfund remediation projects.
- Successfully authored a $400,000 Community wide Assessment Grant (Columbia City, Indiana) for a Brownfield Redevelopment.
- Developed a revised remediation and closure plan for chlorinated hydrocarbon releases in soil and groundwater underlying a shopping mall resulting in a 50% ($750,000) reduction in site closure costs.

- Successfully closed an underground storage tanks (USTs) remediation by renegotiating the closure plan using a risk exposure assessment, thus resulting in the elimination of a very costly, state directed investigation.
- Project Director of a $2.8 million Clean Ohio Brownfield Redevelopment Grant to address historic metal, petroleum and chlorinated hydrocarbon releases in soil and groundwater. Managed budgets for installation of multiple remediation technologies, established a detailed three year project schedule for project tasks and activities, maintained monthly reports to the Clean Ohio project manager, and managed multiple consultants and contractors.
- Provided consulting services for the development of a $1 billion Strategic Remediation Program for a "Fortune 10" chemical manufacturing company.
- Developed a soils utilization program for a fuels refinery plant. The program consisted of an innovative field sampling and analytical technique for identifying contaminated soil, hazardous waste soil, and non-contaminated soil. Remediation technologies included bioremediation and vapor phase extraction for organic contaminated soils and stabilization for soil contaminated with metals. The soils program treated the contaminated soil for reuse in the plant. This program was designed to treat in excess of 50,000 Tons of soil per year, and save the plant over $2 million per year in annual operating costs.
- Designed and implemented in-situ remediation of acid mine drainage from surface and deep mine operations. Designed, constructed, and monitored injection systems in multi-aquifer regimes. Developed injection rates of in-situ bacteria reducing agents and neutralizing materials for acid mine drainage (AMD) remediation. Designed and constructed groundwater containment systems to control AMD migration from mine site operations.
- Served as a project manager for a New Jersey Environmental Clean-up and Recovery Act (ECRA) site at a chemical manufacturing facility. The Chemical Company retained ECRA responsibility after they sold a pigment manufacturing plant. The facility was over 60 years old and was built over the years by the land filling of organic and inorganic pigment wastes into wetland areas. The RI/FS results determined that a majority of the plant site would require waste stabilization by in-situ and ex-situ techniques. A groundwater remediation system was designed and installed.
- Designed and developed an in-situ chemical oxidation technology that is used for soil, waste and groundwater remediation. This technology has been used to remediate and to obtain closure in twelve (12) states.
- Used a proprietary owned in-situ chemical oxidation to addressed petroleum releases from a former UST resulting in site closure within four months, which had 11 unsuccessful remediation attempts during the previous 22 years.
- Developed a RCRA Corrective Action (CA) program for a chemical manufacturing facility. The facility received a RCRA 3008 (h) order to address Solid Waste Management Units (SWMU) s that contributed to a release of chlorinated solvents to groundwater that has migrated off site. The RCRA CA program consisted of remediating five SWMUs and conducting a hydrogeologic assessment of two aquifers in glacial outwash and a bedrock aquifer in pegmatitic gneiss. Dense Non-Aqueous Phase Liquids (DNAPL) plumes were detected in each of the three underlying aquifers. A groundwater extraction/containment system was designed to capture the three plumes and to protect off site public groundwater supply and adjacent surface water streams.
- Prepared a Part B Permit for steel manufacturer. The permit included hazardous waste tanks, surface impoundments, an on-site landfill and SWMUs under 3004 (u). The permit also included waste management unit designs, systems and operations, and installing a ground water monitoring system for the RCRA waste management units.

- At a fuels refinery, conducted a RCRA Corrective Measures Study (CMS), which identified a saving of over $70 million by applying in-situ bioremediation technologies and the Corrective Action Management Unit (CAMU) Rule. The CAMU rule provided remediation savings by eliminating costly hazardous waste management procedures for listed and characteristic hazardous wastes.
- Eradicated six API oil water separators from a fuels refinery RCRA permit. A position paper was submitted to the EPA that performed an engineering analysis of the six traps. The results were used to convince state and federal agencies that the American Petroleum Institute oil water separators met the RCRA exempted wastewater treatment definition. By removing these units from the RCRA permit, a savings of $1.5 million in RCRA closures and approximately $20 million in sewer up grades was realized for the plant.
- Performed RCRA CA remediation at a chemical manufacturing site. The plant required expansion of operations over an existing SWMU. A subsurface investigation determined that the SWMU released contaminants above risk based action levels and required remediation. The waste and soils was removed, treated, and disposed. A groundwater dewatering system was installed to lower the water table 10 ft. so that remediation and plant expansion could be carried out.
- Provided consulting services to a chemical manufacturing operation for addressing the plant RCRA Corrective Action Program. Saved the plant over $2 million in RCRA Facility Investigation (RFI) costs by using existing investigation data to meet the RCRA Corrective Action requirements.
- Performed a Structural Integrity Analysis for a major chemical manufacturer. The results were used to prove that seven wastewater sumps meet the 40 CFR 260.10 definitions of RCRA exempted wastewater treatment tanks. The results of the Structural Integrity Analysis saved the plant over $I million in RCRA permitting and closure costs.
- Served as principal reviewer of a RCRA Facility Investigation (RFI) for a chemical manufacturing plant. The results of the review indicated that the 3004 (u) permits conditions were met, and absolved the plant from alleged civil penalties for non-compliance of the RCRA Permit.
- Prepared RFI Work Plan, Interim Measures Work Plan, and Pre-Investigation Corrective Measures Report under RCRA 3008(h) Consent Order. The RFI Work Plan was approved by the state agency.
- Developed a RCRA Corrective Action program for 27 Solid Waste Management Units (SWMU) at a fuels refinery plant. An innovative approach used risk-based analysis of waste characteristics and eliminated 8 SWMUs from the first phase of the RCRA Facility Investigation (RFI).
- A fuels refinery plant RCRA permit required a closed RCRA landfill to undergo groundwater remediation due to an assessment, which determined a release of phenolic caustic. A groundwater modeling effort was used to convince state and federal agencies that the plant wide groundwater remediation system had contained the phenolic caustic plume with in its area of influence. This effort saved the plant $2.5 Million in RCRA post closure remediation and monitoring costs.
- Prepared and negotiated a RCRA Part B and Hazardous and Solid Waste Amendments (HSWA) terms and conditions for a chemical manufacturing facility. In addition, closure and post closure plans under 40 CFR 265 requirements were prepared for three RCRA surface impoundments. Post closure included groundwater remediation and post closure compliance monitoring. The HSWA permit consisted of a new cost effective approach to the RCRA Facility Investigation. A risk-based approach was used to determine which SWMUs could be eliminated from future assessment and remediation.
- Prepared specifications for a $40 million decommissioning of a Toluene Diisocyanite Plant. Specifications included: waste segregation, classification, testing and disposal; equipment demolition; chemical management; and environmental remediation.

- Provided consulting services for the closure of 53 RCRA surface impoundments to a "Fortune 10" chemical manufacturing company.
- Performed clean closure certification of a surface impoundment and a waste toluene diisocyanite storage facility for a major chemical manufacturer. Services included verification sampling and independent engineering certification.
- A fuels refinery RCRA permit required 6 RCRA surface ponds to be closed and waste removed (F037 and D018), treated, and disposed by May 1995. A closure in place plan was prepared and approved, which would cost $56.5MM. A Revised RCRA Closure Plan was prepared and successfully negotiated with the state and EPA Region 6 for the six impoundments. Twenty three million dollars in savings was realized by using a clean closure plan with six negotiated variances, which include a risk based approach and the application of the Skinner Rule. The closure strategy also allowed for the removal of waste prior to the land disposal restriction deadline of June 1994, and thus saved 11 Million in additional hazardous waste treatment costs.
- A fuels refinery plant was under RCRA closure activities for a D002 surface impoundment. During the closure assessment, a historic process water pond was discovered which lied beneath the RCRA surface impoundment. Both state and federal agencies approved a permit modification for a new closure plan for both RCRA units. A CAMU approach was negotiated which deferred $7 million in RCRA closure costs and eliminated $1 million in post closure monitoring. The CAMU approach also saved additional remediation costs by eliminating hazardous waste management standards that would apply to RCRA closure operations.
- Served as a project manager for RCRA closure of a surface impoundment containing "welding rod" wastes. As a result of the facility operation a chlorinated solvent plume was detected migrating towards an off-site water supply well. Tasks included a 40 CFR 264 RCRA Closure Plan, waste removal, and groundwater remediation of an Ohio River Terrace Deposit Aquifer. The remediation plan included a 700-gpm capture zone and carbon filtration for a groundwater treatment system.
- Designed and cost estimated a superfund remedy for coal tar waste contained in a three (3) mile river channel resulting in the final Record of Decision (ROD).
- Served as a major chemical company technical committee representative for a superfund site, and successfully negotiated an alternative remedial design and costing requirements with state and USEPA resulting in a savings of $1.4 million in remediation costs.

LANDFILLS

- Prepared the Final Closure Plan for an Industrial Ash Landfill at a major chemical manufacturing plant. The project included the amendment of previous closure plans, the development of the final bid documents, health and safety plans, a Construction Quality Assurance Plan, and construction of a final cap. Closure certification was prepared and executed.
- Served as principal investigator and conducted a Hydrogeologic Landfill Siting Study for a major steel manufacturer. The results of the study indicated that a hazardous waste landfill could be safely constructed into the local environment. The landfill was used for stabilized waste removed from closed SWMUs.
- Managed the preparation of detailed designs and solid waste permits for an on-site industrial waste landfill. The landfill was designed to extend existing landfill for an additional 30 years of operations. Due to state and federal Subtitle D regulations and the local geologic environment, unique E&S control structures and leachate collection systems were specifically designed for each disposal cell.

- Conducted RCRA Landfill audits for major chemical and petroleum companies. Audited waste management, operations, landfill design, and monitoring systems.
- Prepared RCRA Part B Permits and Permit Modifications for commercial RCRA hazardous waste landfills.

MISCELLANEOUS

- Assigned to the Chemical Manufacturing Association RCRA ad hoc group for UST (40 CFR 280) regulatory negotiation. Successfully negotiated 45 paragraphs of regulatory language, which was incorporated into the final 40 CFR 280 regulations.
- Assisted a refinery fuels site negotiate an Oklahoma House Bill, which will incorporated a RCRA financial assurance test and guarantee for the plant's solid waste landfill. The bill was successfully amended through the Senate Natural Resources Committee. As a result, the new bill will reduce plants annual operating cost by $65,000.
- Conducted coal exploration projects in Ohio, Pennsylvania, and West Virginia mining districts. Managed drilling operations and performed geologic analysis on rock and coal cores, field mapping, stratigraphic correlation, structure contouring, and depositional modeling for coal continuity, coal quality, and minable coal reserve calculations. Performed economic analysis for strip and deep mine operations.
- Prepared acid mine drainage permits for bituminous coal mine operations. Established baseline surface water and groundwater quality, conducted a hydrogeologic analysis of potential affected aquifers, designed erosion and sedimentation controls, designed mine haulage systems, and prepared permit applications.
- Manage permitting activities for a new cogeneration plant for a fuels refinery, and prepared multisite environmental permitting for coal and fuel fired energy plants for a major chemical company.
- Prepared expert witness report for US Federal Court for solvent releases in karst bedrock, resulting in the client's judgment settlement award of $2.8 million.
- Prepared expert witness assessment for a limestone mine mineral reserved analysis.
- Technical support for environmental insurance cost recovery of solvent releases in groundwater resulting in a $1 million insurance settlement.

APPENDIX B
ATOKA STANDARD FEE SCHEDULE

ATOKA, Inc.

STANDARD FEE SCHEDULE

(EFFECTIVE January 1, 2016)

For Professional Engineering & Environmental Consulting Services, the compensation to ATOKA, Inc. will be the sum of all of the items utilized and at rates as set forth below:

A. PERSONNEL RATES — **HOURLY RATE**

PERSONNEL RATES	HOURLY RATE
SENIOR PRINCIPAL	$175.00
SENIOR PROJECT MANAGER	$165.00
SENIOR ENGINEER	$155.00
PROJECT ENGINEER	$135.00
STAFF ENGINEER	$120.00
ENGINEERING INTERN	$100.00
ENGINEERING TECH 2	$80.00
ENGINEERING TECH 1	$70.00
CAD DRAFTER	$ 65.00
SENIOR GEOLOGIST/HYDROGEOLOGIST	$165.00
PROJECT GEOLOGIST/HYDROGEOLOGIST	$135.00
STAFF GEOLOGIST/HYDROGEOLOGIST	$100.00
SENIOR HYDROLOGIST	$165.00
PROJECT HYDROLOGIST	$135.00
WETLANDS SPECIALIST	$120.00
SENIOR MICROBIOLOGIST	$135.00
PROJECT MICROBIOLOGIST	$120.00
STAFF MICROBIOLOGIST	$100.00
INDOOR AIR QUALITY CONSULTANT	$135.00
CHEMIST	$100.00
ASBESTOS MANAGER/INSPECTOR	$110.00
ASBESTOS AIR MONITORING TECHNICIAN	$90.00
ASBESTOS PLANNER	$120.00
CERTIFIED INDUSTRIAL HYGIENIST	$150.00
INDUSTRIAL HYDIENIST	$135.00
LABORATORY SPECIALIST	$ 85.00
LABORATORY TECHNICIAN	$ 65.00
FIELD TECHNICIAN	$ 70.00
TWO-MAN LAND SURVEY CREW	$ 175.00
SECRETARIAL	$ 45.00

NOTES:

1. Increase hourly rates by 1.5 for Saturday, Sunday and Holidays.
2. Field Services provided after 6:00 p.m. and prior to 6:00 a.m. subject to surcharge rates.
3. Deposition or Court Testimony at 1.5 multiplied times regular rate (minimum of $175.00/hour).

B. EXPENSES AND SUPPLIES:

1. Vehicle charge (Local Area, within 25 miles of office) ....$ 75.00/day

2. Vehicle charge (Local Area, within 25 miles of office, less than 4 hours).............$50.00/day

3. Vehicle charge (Outside Local Area)... $ 0.60/mile

4. Per Diem, Lodging and Meals..Minimum of $ 150/day

5. Miscellaneous charges, including analytical laboratory tests, shipping charges, rental equipment, outside labor, public transportation, materials or other contracted services.…………………………………………………………………………………………… cost + 20%

6. Photo Copying (Page Size).. $0.10/page

C. LABORATORY RATE SCHEDULE:

ATOKA, Inc. Laboratory charges (Asbestos, Mold, Treatability, etc.) are published as separate fee schedules. These schedules will be provided upon request.

APPENDIX C
DOCUMENTS REVIEWED

DOCUMENTS REVIEWED

Document Evaluations

ATOKA was asked by Anchor Stone's Engineering Consultant to review documents pertinent to this case, including, but not limited to:

- Joshua D. Elson, R.G., P. Benjamin Luetkemeyer, PhD., R.G., and Michael HomanP.E., 2019. Geophysical and Drilling Services - Karst Evaluation Report for Cross Hollow Quarry at 1425 Old Wire Road Benton County, Arkansas. *Terracon Consultants, Inc., Project No. 04195028.1.*

Documents Generated by ATOKA

ATOKA has been able to identify and review documents readily available, including, but not limited to:

- Aerial imagery through Google Earth and the United States Geological Survey (USGS) Earth Explorer;

- Ernest E. Glick, 1970. Geologic Work Sheet – Rogers, Arkansas, Scale 1:24,000 Quadrangle, *Arkansas Geological Survey;*

- United States Geological Survey, 1958 (Photo Revised 1976)., Topographic Map, - Rogers Arkansas, Scale 1:24,000 Quadrangle, *United States Geological Survey, Denver Colorado, 80225 and Arkansas Geological Commission, Little Rock, Arkansas 72204;*

- Domestic Water Wells in the Vicinity of the Proposed Cross Hollow Quarry, Website awwcc.publishpath.com/construction Reports, *Water well Construction Commission of Arkansas;*

- Phillip R. Shelby, 1986. Depositional History of the St. Joe and Boone Formations in Northern Arkansas, *Journal of the Arkansas Academy of Science, Volume 40, Article 22;*

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APPENDIX D
TERRACON GEOPHYSICAL AND DRILLING EXPLORATION REPORT
AND
MW - 1 WELL LOG

June 18, 2019

Anchor Stone Company
4124 S. Rockford Avenue, Suite 201
Tulsa, Oklahoma 74105

Attn: Mr. Tom Snyder
President

Re: Geophysical and Drilling Exploration Services
Karst Evaluation
Cross Hollow Quarry
1425 Old Wire Road
Benton County, Arkansas
Terracon Project No. 04195028.1

Dear Mr. Snyder:

This letter provides an evaluation of exploration services performed at the above referenced property. Exploration services consisted of Electrical Resistivity Imaging (ERI), Multi-Channel Analysis of Surface Wave (MASW) and soil sample/rock core borings. This study was performed in general accordance with Terracon Proposal No. P04195028 dated, January 31, 2019 and Terracon Supplemental Change Order No. P04195028.1. This study presents the results of a subsurface investigation as a part of a due diligent effort to characterize subsurface conditions and identify potential karst features at the above referenced property.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.
Arkansas Cert.of Authorization #223, Expires 12/31/2019

Joshua D. Elson, R.G. (MO)
Senior Staff Geologist

Michael H. Homan, P.E.
Office Manager/Principal
Arkansas No. 7052

P. Benjamin Luetkemeyer, PhD, R.G. (MO)
Senior Geophysicist

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INTRODUCTION

This report presents the results of our geophysical and drilling exploration services within the Stage 1 through Stage 5 areas (48.60 acres) of the proposed quarry development at Cross Hollow Quarry in Benton County, Arkansas.

The purpose of the geophysical exploration was to characterize the site subsurface conditions and identify potential karst features that may impact future quarry operations. Document research and site reconnaissance was performed prior to mobilizing exploration crews. Results of document research and site reconnaissance are discussed in Terracon letter report 04195028, dated March 27, 2019.

The exploration services for this project included eight (8) electrical resistivity imaging (ERI) lines, one (1) Multi-Channel Analysis of Surface Wave (MASW) line and the advancement of five (5) borings to depths ranging from 36½ to 80 feet.

An **Exploration Site Plan** with the ERI test locations, MASW test locations, boring locations, **Resistivity Profiles** that include cross-sections of ERI results, **MASW Profiles** that include cross-sections of MASW results and **Boring Logs** that include the results of the laboratory testing and soil/rock classifications are provided in the **Attachments**.

SUBSRUFACE CONDITIONS

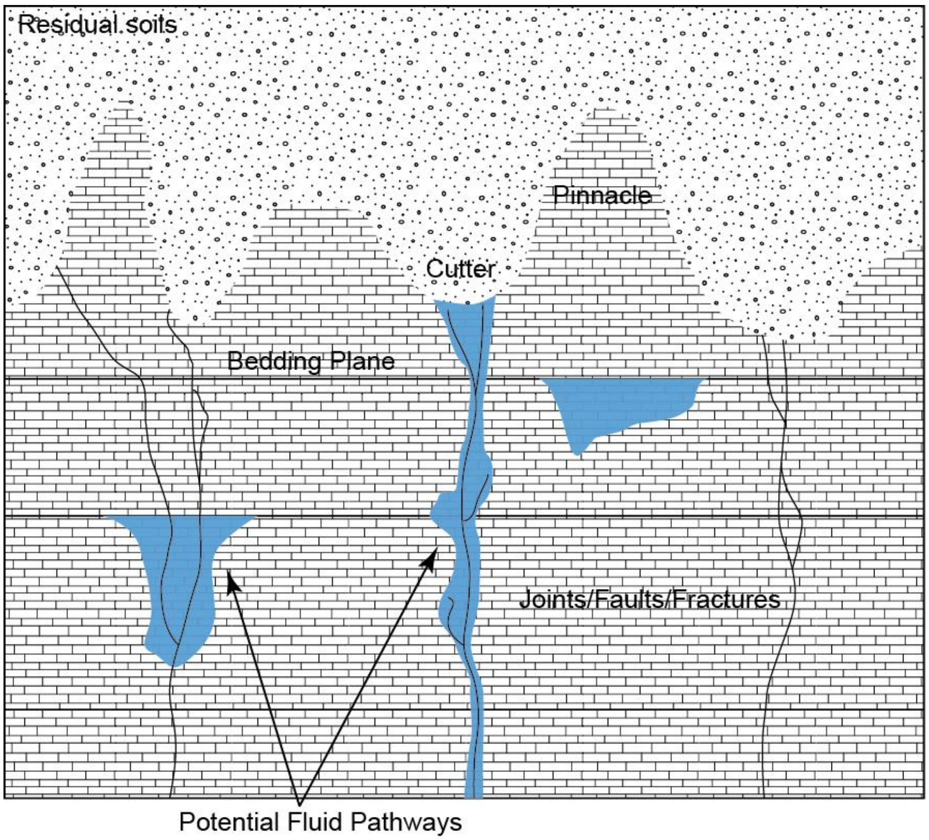
Site Geology

The project site is underlain by the Boone Formation which is Mississippian Age Osagean Series (Mo) and the St. Joe Formation which is Mississippian Age Kinderhookean Series (Mk). The characteristics of the units are provided in the table below.

Formation	Description
Boone Formation (Mo)	Gray massive limestone
St. Joe Formation (Mk)	Silty limestones and shale formations

Limestone is a relatively soluble carbonate bedrock and can be dissolved by acidic natural waters (e.g. precipitation, groundwater). Precipitation can become acidic as it falls through the atmosphere and carbon dioxide (CO_2) concentrations increase. These waters often become more acidic as they soak into the ground and dissolve CO_2 from the soil. Landscapes where bedrock is sculpted by dissolution processes due to acidic natural waters is referred to as karst terrain. Sinkholes, caves, and “cutter-and-pinnacle” formations can form in karst terrain.

Cutter-and-pinnacle formations are formed as natural water (e.g. precipitation and groundwater) dissolves bedrock along natural planar features, such as bedding planes, joints, or fractures. The process can widen joints in the bedrock and create "cutters", which are generally filled with soil or gouge (a clay-like material produced as dolomite/limestone weathers). The bedrock that remains between cutters can be reduced to relatively narrow ridges of rock called "pinnacles". A profile through a typical cutter-and-pinnacle formation including potential fluid flow conduits is illustrated in the figure below.



GEOPHYSICAL EXPLORATION

Electrical Resistivity Imaging (ERI)

Terracon used an Electrical Resistivity Imaging (ERI) system consisting of an Advanced Geosciences Inc. (AGI) SuperSting R8 control unit. Data was acquired using a dipole-dipole and strong gradient array configuration to complete the survey. This method uses potential and current electrodes that function independently of one another to measure the potential field. A transmitting current dipole is followed by a series of potential dipoles which measure the resulting voltage gradient at each station. As the transmitting dipole is advanced along the electrodes, the resulting gradient measurements were collected as a 2D section below the survey array. After field collection, the resistivity data was processed using EarthImager 2D (engineered by AGI), an inversion and modeling software package. During post-processing, the field-derived data was numerically inverted to generate 2-D model sections of resistivity in the x-z plane, where x and z represent the horizontal and vertical directions, respectively. The 2D inversions generate the resistivity graphs in the direction of the resistivity line layout. Changes in the earth resistivity may indicate changes in the physical properties of the subsurface materials including changes in lithology (e.g. soil-rock interface), degree of saturation, and amount of fracturing.

Eight (8) ERI survey lines were performed at the locations indicated on the **Exploration Site Plan**. The line lengths and electrode spacings were varied to accommodate the amount of space available to perform the tests. A summary of the field setup for each test is provided in the table below.

ERI Survey Line	Approximate Orientation	Array Length (feet)	Number of Electrodes	Spacing (feet)
1	West to East	664	84	8
2	Northwest to Southeast	415	84	5
3	Southwest to Northeast	390	79	5
4	Northwest to Southeast	664	84	8
5	South to North	504	84	6
6	Northwest to Southeast	415	84	5
7	Southeast to Northwest	581	84	7
8	Northwest to Southeast	415	84	5

Multi-Channel Analysis of Surface Wave (MASW)

Terracon performed a Multi-Channel Analysis of Surface Wave (MASW) seismic survey along one (1) line near and parallel to ERI Line 7 as shown on the **Exploration Site Plan**. The seismic survey utilized a Geometrics Geode seismograph and a mobile linear array of twenty-four, 4.5 Hz geophones (called a landstreamer) to collect the MASW data. The geophones measure ground surface displacement caused by the passage of elastic wave energy generated by a seismic source. The seismic sources consisted of a 10-lb sledgehammer which required striking a steel ground plate from some height. A seismic source was generated, and data was collected in 5-foot increments along each seismic line.

Geophysical Findings

The cross-sectional images generated from the ERI testing are provided in the **ATTACHMENTS** in Figures 2 through 4. The color-coded images are best-fit models of the data and represent the apparent electrical resistivity of the subsurface at the test location. Relatively high resistivity values (red, orange, and yellow) are consistent with the resistivity characteristics of competent bedrock (i.e. slightly fractured and weathered), or air-filled voids. Relatively lower resistivity values (green, blue, and purple) are consistent with the resistivity characteristics of soils consisting of clay, sand, and gravel or highly fractured bedrock. The orientation of the test line relative to that of fluid-filled fractures and the saturation of the subsurface materials at the time of the tests greatly influence the measured apparent resistivity results. Thus, our results represent a "snapshot" of the material response at the time of our exploration.

The transitions from soil to bedrock and areas of potential karst features are outlined on the **Resistivity Profiles**. Our interpretation is based on observations of the materials encountered in the borings, our experience with the local geology, and with the ERI method.

High "contact resistance" between the electrode and surrounding materials can introduce noise into the data set. Placing an electrode directly into the gravelly soils and exposed bedrock present at the site can lead to high contact resistance. These conditions were prevalent along Lines 1, 2, 3, 4 and 7. Terracon drilled holes at each electrode location using a hammer drill and filled the holes with a bentonite slurry prior to performing each test at the referenced locations to minimize the contact resistance. The contact resistance was high for electrodes 1 through 40 for Line 7 despite our best efforts. The resulting model is characterized by a very low resistivity anomaly noted on ERI Line 7 in Figure 4. We present the results of Line 7 in this report as a qualitative subset of the entire data set collected as a part of this exploration. The results of additional exploration at this test location are presented in the section titled **Correlation Between MASW and Geotechnical Boring**.

Correlation Between ERI and Geotechnical Borings

We explored a limited number of the observed resistivity anomalies with soil/rock borings to differentiate between fracture zones, weathered rock, voids, highly resistive bedrock, wet soils, and possible water filled voids. Based on the results of exploratory borings, conditions identified at each of the selected anomalies were then used to help characterize the remaining anomalies identified throughout the site. Four (4) borings were advanced to depths from 36½ to 80 feet. A summary of the materials encountered in the borings and qualitative indicators of the measured apparent resistivity are provided in the table below.

Boring B-1 (Line 1)				
Stratum	**Approximate Depth to Bottom of Stratum (feet)**	**Material Description**	**Consistency/ Density/ RQD**	**Apparent Resistivity (Color and Relative Resistivity)**
1	11.8	Clayey gravel and Fat clay (CH) with varying amounts of gravel	Stiff Medium dense	Light blue to green: low
2	50	Limestone	Good to excellent	Orange to red: medium to high
3	60	Limestone	Fair	Green to dark green: low
4	80	Limestone	Fair to good	Green: low to medium
Boring B-2 (Line 4)				
Stratum	**Approximate Depth to Bottom of Stratum (feet)**	**Material Description**	**Consistency/ Density/ RQD**	**Apparent Resistivity (Color and Relative Resistivity)**
1	46	Clayey gravel and Fat clay (CH) with varying amounts of gravel	Very stiff Medium dense	Dark blue: low
2	80	Limestone	Very poor to excellent	Green to red: medium to high
Boring B-3 (Line 5)				
Stratum	**Approximate Depth to Bottom of Stratum (feet)**	**Material Description**	**Consistency/ Density/ RQD**	**Apparent Resistivity (Color and Relative Resistivity)**
1	42	Clayey gravel and Fat clay (CH) with varying amounts of gravel	Very stiff Medium dense	Dark blue to blue-green: low to medium
2	42.5	Limestone	Limestone not sampled	Green: medium

Boring B-4 (Line 6)				
Stratum	**Approximate Depth to Bottom of Stratum (feet)**	**Material Description**	**Consistency/ Density/ RQD**	**Apparent Resistivity (Color and Relative Resistivity)**
1	36	Clayey gravel and Fat clay (CH) with varying amounts of gravel	Very stiff to hard Medium dense	Dark blue to blue-green: low to medium
2	36.5	Limestone	Limestone not sampled	Green: medium

Correlation Between MASW and Geotechnical Boring

The 2D cross-section model generated from the MASW testing is provided in the **ATTACHMENTS** in Figure 5. The color-coded image is the best-fit model of the data and represents the apparent shear wave velocity of the subsurface at the test location. Shear wave velocities for the entirety of the profile are greater than 2,000 ft./sec. These shear wave velocities are consistent with the presence of bedrock at or within a couple feet of the surface. Rock was observed at the ground surface and in Boring B-5. No significant anomalies were observed in the MASW profile. In addition, one (1) boring was advanced to a depth of approximately 60 feet. A summary of the materials encountered in the borings and qualitative indicators of the measured apparent resistivity are provided in the table below.

Boring B-5 (MASW Line 1)				
Stratum	**Approximate Depth to Bottom of Stratum (feet)**	**Material Description**	**Consistency/ Density/ RQD**	**Apparent Shear Wave Velocity (Color and Relative Velocity)**
1	3	Clayey gravel and Fat clay (CH) with varying amounts of gravel	Stiff Medium dense	Not detectable
2	60	Limestone	Good to excellent	Blue to Bluish Green: High Velocity

We believe the MASW results more accurately characterize the subsurface materials at the location tested than the results obtained for ERI Line 7. Our interpretation is based on observations of the materials encountered on the ground surface, in the boring, our experience with the local geology, and with the MASW method.

Interpretations

Boring B-1 encountered the transition from clayey gravel and gravelly fat clay overlying limestone bedrock at a depth of about 11.8 feet consistent with the sharp transition from relatively low to higher apparent resistivity values (blue to green to red). Additionally, Boring B-2 encountered the transition from clayey gravel and gravelly fat clay overlying limestone bedrock at a depth of about 46 feet consistent with the sharp transition from relatively low to higher apparent resistivity values (blue to green to red). The transition from clay and gravelly clay to bedrock observed in Borings B-3 and B-4 were also associated with changes in the apparent resistivity from relatively low to medium or high values.

The location along ERI Line 1 with a low resistivity anomaly from 275 to 350 feet (horizontal scale), at depths from about 55 to 85 feet, was selected for further investigation. Based on the observation of the materials encountered in Boring B-1, the RQD changes from good/excellent to fair between depth of 50 to 60 feet and then to fair/good from 60 to 80 feet. The transition from relatively high to low resistivity is consistent with the variation in RQD (i.e. an increase in fracture density and the presence of clay seams).

In general, we interpret the low to medium apparent resistivity values to be consistent with the characteristics associated with overburden soils, fractured bedrock, clay seams or potential karst features. Areas of high resistivity are interpreted as very competent bedrock or potential air-filled cavities. While it is possible that an air-filled cavity exists, the one area of high resistivity identified in our model and sampled in our boring was consistent with the presence of competent bedrock. Our interpretations of the resistivity models are indicated on the **Resistivity Profiles**.

ERI Line 7 was located adjacent to a mapped losing stream. The 2D pseudo-inversion model for ERI Line 7 contained a low resistivity anomaly; however, data quality was poor due to the high contact resistance between the electrodes and the surrounding materials during data acquisition. The area containing the apparent low resistivity feature was further investigated using the MASW method and by advancing an exploration boring to a depth of approximately 60 feet. MASW Line 1 was aligned in close proximity to ERI Line 7. Shear wave velocities greater than 2,000 ft/sec. were measured along the portions of the cross-section containing the low resistivity anomaly in ERI Line 7. The observed shear wave velocities are consistent with the presence of relatively competent bedrock at or near the surface to depths greater than 150 feet.

Boring B-5 was located at about 355 feet on ERI Line 7 and at about 270 feet on MASW Line 1 and was advanced to a depth of approximately 60 feet. This location was selected to further investigate the low resistivity anomaly identified on ERI Line 7. The boring encountered limestone bedrock from 3 feet below site grade to the boring termination depth. No voids or clay seams were observed in the rock core.

Geophysical Limitations

All geophysical testing methods rely on instrument signals to indicate physical conditions in the field. Signal information can be affected by on-site conditions beyond the control of the operator, such as, but not limited to, cultural features, standing water, high subsurface moisture content, and other buried objects. Interpretation of those signals is based on a combination of known factors combined with the experience of the operator and geophysical scientist evaluating the results. The provided depth measurements are estimations based on an estimation of the electrical properties of the subsurface material.

SUBSURFACE EXPORATION AND TESTING

Field Exploration

Geophysical findings were confirmed by drilling a total of five (5) soil sample/rock core borings at locations selected in the field upon review of preliminary ERI and MASW data analysis.

Boring Layout and Elevations: The boring locations were selected, and layout was performed by Terracon after review of preliminary ERI testing results. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±30 feet). Approximate elevations were obtained by interpolation from a site plans provided by Sand Creek and are rounded to the nearest ½-foot. If more precise boring locations and elevations are desired, we recommend the borings be surveyed.

Subsurface Exploration Procedures: The borings were advanced with an ATV-mounted rotary drill rig using continuous flight, solid-stem augers. Samples were obtained in the borings as noted on the boring logs. The split-barrel sampling procedure was performed using a standard 2-inch outer diameter, split-barrel sampling spoon that was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration was recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at their respective test depths. Water levels were observed and recorded during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

A CME automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency (88 percent for Rig #726) is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT N-value. The effect of this efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

Auger refusal materials were explored with rock coring procedures. An NQ2 rock core barrel was utilized to perform the rock core at Borings B-1, B-2 and B-5. Water was used as a drilling fluid for cooling the rock bit and the spent water was discharged on site. Due to the use of water for rock coring, groundwater observations were not performed after the start of rock coring and through the completion of the boring. Photographs of rock core are presented in **ATTACHMENTS**.

The sampling depths, penetration distances, and other sampling information were recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Terracon geologist. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

Classification of the soil samples was performed in general accordance with the Unified Soil Classification System (USCS) based on the material's texture and plasticity. The project engineer reviewed the field data and assigned laboratory tests to better understand the engineering properties of the various soil strata.

- Water (Moisture) Content of Soil and Rock by Mass

Boring log rock classification was determined using the Description of Rock Properties included in the attached General Notes and locally accepted practices for engineering purposes. Petrographic analysis may reveal other rock types. Rock core samples typically provide an improved specimen for this classification.

CONCLUSION

The boring data and surface observations (bedrock outcrop) have been correlated with the ERI and MASW cross sections. The geophysical survey results indicate the top of bedrock is pinnacled in areas tested and, in some areas, deep cutters may be present as seen in ERI Lines 4 and 8. In undisturbed areas on ridge tops, the average depth to the top of bedrock is approximately 30 feet below ground surface.

In areas disturbed by previous overburden mining activity the average top of bedrock rock depths was at or within 10 feet of the ground surface. Pinnacle and cutter areas exist where top of bedrock depths could be greater than 30 feet.

Low resistivity anomaly locations consistent with karst features were identified in the ERI models. Based upon observations from our borings, the characteristics of these anomalies appear to be consistent with the presence of clay-filled seams and fractured/vuggy zones of limestone bedrock.

The data quality for ERI Line 7 was poor and the low resistivity bedrock anomaly identified in ERI Line 7 is near the infiltration zone of the losing stream located west of ERI Line 7. This area was further investigated utilizing a seismic survey via the MASW method.

MASW Line 1 was located within very close proximity to the location of ERI Line 7. No low velocity anomalies that would indicate potential karst features consistent with the low resistivity modelled in ERI Line 7 were observed in the 2D shear wave model. Shear wave velocities of over 2,000 ft./sec. were observed in MASW Line 1 to depths up to 150 feet below ground surface consistent with the presence of shallow bedrock extending to the depths explored. These conditions were confirmed in boring B-5 were competent limestone was encountered at 3 feet below ground surface and extended the full depth of the boring where it was terminated at 60 feet below ground surface. A few fractures were observed in rock core samples; however, no voids or clay seams were encountered.

LIMITATIONS

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geophysical and geological practices. No warranties, express or implied, are intended or made. The findings presented in this report are based upon the data obtained from the geophysical surveys, exploratory borings and from other information discussed in this report. This report does not reflect variations that may occur in areas not tested or inaccessible to the geophysical equipment, across the site, or due to the modifying effects of construction or weather.

It should be noted that the geophysical testing processes rely on instrument signals to indicate physical conditions in the field. Signal information can be affected by on-site conditions beyond the control of the operator, such as, but not limited to, cultural features, soil types, soil moisture, and/or groundwater table depth. Interpretation of those signals is based on a combination of known factors combined with the experience of the operator and the geophysical scientist evaluating the results.

The nature of karst activity typical in the Ozarks region is generally unpredictable. Findings, conclusions, and recommendations resulting from these services are based upon information derived from the on-site activities and other services performed under this scope of work; such information is subject to change over time. Certain indicators of the presence of subsurface conditions that are inaccessible, unobservable, non-detectable, or not present during these services. We cannot represent that the site contains no karst hazards other than latent conditions beyond those identified during this investigation. The data, interpretations, findings, and our recommendations are based solely upon data obtained at the time and within the scope of these services.

The analysis presented in this report are based upon the data obtained from the geophysical surveys and from other information discussed in this report. This report does not reflect variations that may occur in areas inaccessible to the geophysical equipment, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after further mining activities.