Ten X Residential Housing Project – Request for Proposal

HYBRID ELECTRICAL SYSTEM

Date:	10/8/2018
Project:	Ten X Residential Housing Project
Location:	Tusayan, AZ
Activity:	HYBRID ELECTRICAL SYSTEM
Bid Due Date:	**Friday, October 19th, 2018 by 5 pm MST**

Project Info

The following specifications are to be used to determine a proposal for the design, procurement, and installation of a complete Microgrid solution for the Ten X Housing Project as shown on attached plot plan. The Project area is located on a 20-acre parcel approximately three miles east of Highway 64 along Forest Road 302 in the Town of Tusayan, Coconino County. There are a total of 52 housing units: 18 @ 800sf each, 23 @ 1,400sf each, and 11 @ 1,900sf each. Potential areas for a fixed system ballasted ground mount are shown on the NE and SE areas of the plot plan. The Water/Wastewater Campus will have a building with South Facing sloped metal roof that could support approximately 30-40kw of the required solar. The building will be extended to provide areas for the Gensets, controls, and electrical gear based on final equipment needs and design.

The following components are to be used to integrate a ballasted ground mounted solar PV array/arrays, an Energy Storage Solution, Prime power gensets, and a monitoring and control system to distribute and maintain power for the off grid community being established.

Base proposal will include Design, engineering, procurement and installation of the HES power solution complete to transformers curb adjacent of lot lines as needed at housing unit locations.
Optional Proposal: Operations and Maintenance cost options available for the system, or various components as required for normal daily operations, and required maintenance intervals.

If you are interested in bidding this Project, please contact James Kelton to receive the necessary invite to Procore in order to download the drawings.

Email: james.kelton@premierbuilders.com
Phone: (520) 293-0300 ext. 139

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HYBRID ENERGY SYSTEM (HES) DESCRIPTION

The Hybrid Energy System (HES) is optimized to provide the lowest levelized cost of energy by minimizing fuel usage and run hours of the prime power generation facility. The HES should be designed with greater than 75% energy penetration from renewables. The HES system must be a scalable, single-branded, and sustained, material solution integrating conventional diesel and / or natural gas-fueled power generation and renewable power with smart energy storage, to provide a reliable, resilient, secure, and cost effective electrical power solution. The HES provider must have Factory authorized and trained service technicians and minimum parts inventory located with 100 miles of HES installation.

The HES needs to include gensets (C18's) as prime power and will integrate solar field approx. 800kW DC of Ballasted Ground Mounted PV System, 700kwac of smart string inverters, 500kw/1001kW-hr battery storage, capable of grid forming/following, interconnect switchgear and a Microgrid Master Controller (MMC). The BID shall include all costs for labor, materials, equipment, etc., and all other items necessary and incidental to construct the HES system Ten X Ranch new development approximately 3.2 miles outside of Tusayan, AZ. Post award documents shall include drawings, Operations & Maintenance Manuals, and other support documents specific to the project. Item includes all foundations, clearing and grubbing, structural, fencing, signage and electrical herein to make a complete usable HES and any other associated items not specifically named but identified on the drawings, RFP or specifications.

PART 1 - ELECTRICAL SYSTEMS

Unless dictated by local codes, standards and conditions, Local Electric Authority, or noted hereinafter, the design, construction and installation of all electrical system equipment, materials, components and devices should conform to the following codes, regulations, standards and recommended practices. Latest edition at time of request for proposals should govern.

ANSI - American National Standards Institute Standards
ASTM - American Society of Testing and Materials
CE – European Conformity
EIA - Electronic Industries Association
EU – European Union
IBC - International Building Code
IEC – International Electrotechnical Commission
IEEE - Institute of Electrical and Electronic Engineers

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IESNA - Illuminating Engineering Society of North America Handbook
NEMA - National Electrical Manufacturer's Association
NESC/IEEE C2 - National Electrical Safety Code
NEC/NFPA 70 - National Electric Code
NFPA - National Fire Protection Association Codes and Standards
UFC - Unified Facilities Criteria
UL - Underwriter's Laboratories

1.1 HYBRID ENERGY SYSTEM (HES)

The requirements of this section encompass the Design and Construction of a HES consisting of 800 kW of Ground Mounted PV, 500kw/1001kW-hr Grid forming battery Storage Module, four diesel genesets, paralleling switchgear, a Microgrid Master Controller (MMC), weather station, ethernet switch box, and necessary communications hardware for remote monitoring and video monitoring.

The HES shall be designed to contribute its fully rated output during optimum weather days. Due to the high penetration level of the PV system, excess energy generated during periods of low power demand, will automatically be stored in a self-contained 500kW Battery Storage System. The batteries within the ESS shall provide sufficient power to guarantee a smooth transient between generator load steps during volatile weather days when the PV system output fluctuates. The operational intent of running this islanded system with diesels gensets, energy storage batteries and PV, is to maximize use of PV energy and reduce diesel fuel usage, while maintaining optimum power reliability, availability and reserves.

1.1.1 PHOTOVOLTAIC (PV) SYSTEM

Provide a complete PV system consisting of, but not limited to PV modules, String inverters, racking, PV String Harnesses, combiner boxes, power panels/switch boards, conductors, conduits, communications wiring, cable trays, station electrical service from generator farm, and other equipment to provide a functioning PV System. Provide the applicable NEMA rating on all equipment.

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1.1.1.1 PV MODULES

The Potential array areas shown on the plot plan should utilize Mono PERC, 72 cell, 365w modules as the basis of design to ensure that the system is sufficiently large enough and makes efficient use of land. Other panels may be used but the design must fit on the fixed site dimensions shown. The PV modules shall be provided with the following minimum requirements:

- Shall have demonstrated a life cycle of at least 25 years.
- Shall have 25 years power warranty with Max degradation of 0.6%/Year or less.
- Shall have delivered -0/+5w positive power tolerance.
- Compatible with advanced 1000V plant architectures.
- Acceptable PV technologies include Mono-PERC Silicon or CdTe Thin Film.
- IEC and Other Standards as applicable to this design.

1.1.1.2 PV STRING HARNESSES

The DC wiring shall be as recommended by the PV manufacturer. A Photovoltaic String Harnesses is a pre-engineered wiring system that is desired but not limited to what is required for this solicitation. If a harness system is not used then all wiring and combiner systems shall be approved by the designer of record to meet the solicitation requirements. A wiring harness system if used shall meet the following minimum requirements:

- Pre-engineered interconnect harnessing to combine common string arrangements
- UL9703 listed or IEC as applicable
- 10 AWG / 1000V rated wire
- MCL or equivalent connectors

1.1.1.3 PV RACKING

The ballasted racking shall hold fixed PV module strings at the proper angle to optimize solar collection at the site location. Racking shall be designed to withstand 120 MPH wind loads. All electrical equipment, include inverters, wire harnesses, AC/DC disconnects or other distribution equipment shall be mounted or installed by means of structural support or elevated pads.

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1.1.1.4 PV STRING INVERTERS

50 kW PV String Inverters shall have transformerless, 480V three-phase output voltage, be UL/IEC listed for up to 1000 V DC maximum system voltage and have a peak efficiency above 98 percent. The inverter shall be equipped with all-pole ground fault protection and integrated AFCI for a safe, reliable solution. Inverter shall offer flexibility with a wide input voltage range suitable for both 600 V DC and 1,000 V DC applications and have two or more independent string inputs to allow for flexible design and a lower installed cost. Inverter shall be housed in a NEMA 3R enclosure and designed for easy mounting. Inverter shall be designed for operating temperatures between -25 °C and +60 °C.

The inverter shall deliver a future-proof solution with full grid management functionality, RS485, Ethernet and built-in Wi-Fi communications, and advanced monitoring. Smart inverter grid support functions include Utility-interactive controls for active and reactive power.

The PV String Inverter shall meet the following minimum requirements:

UL 1741, UL 1998, UL 1699B, IEEE 1547
FCC Part 15 (Class A & B)
UL 1741 SA advanced inverter capabilities
IEC

1.1.1.5 PV SYSTEM DISTRIBUTION

Design and Provide new underground 480V feeders from the PV system distribution system to the new step down transformers designed to serve the distribution of power to all points in the development as shown in attached Plot plan of area.

1.1.2 ENERGY STORAGE SYSTEM (ESS)

The grid stability or ESS Battery storage module shall be a scalable, rapidly deployable energy storage system. Energy storage systems will have the ability to integrate with solar or other renewable sources to provide short duration power when the renewable source is not available or erratic. The energy storage system must also provide temporary backup power to facilities in the event of a brief power outage. The ESS shall:

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- Provide 500kW continuous power output and a minimum nameplate battery capacity of 1001 kW-hr.
- Be packaged as a 30 or 40 Foot ISO Containerized solution, using two 250 kW bidirectional inverter, lithium ion batteries, NOVEC 1230 fire suppression, HVAC, Battery Management System and interior lighting.
- Have 3-Phase, 480V output with Electrically Operated Breaker.
- Lithium-Ion batteries from a Tier 1 Supplier.
- Interact with the power system frequency and voltage to add power when needed to compensate for energy fluctuations in the power system.
- House an Ethernet Switch Box which provides a connection and integration point for the PV inverters, Microgrid Master Controller, and any necessary customer communication.
- Be designed for installation on concrete pad and easily connected with bottom or side entry conduit for power out, shore power and communication.
- Be factory tested.
- Grid Forming and Grid Following.
- Designed for 80% Depth of Discharge (DOD).

Grid Stability or Energy Time-shift Module must be a fully integrated Energy Storage System packaged with Bi-directional Power Inverter(s), Lithium-Ion batteries, Fire suppression, HVAC and ancillary equipment for 480V, 3-Phase output. ESS must be factory tested and factory listed for UL 1741 (SA) and UL 9540. ESS must have fire suppression per NOVEC 1230. ESS must have climate control system to extend battery life. The ESS shall provide the following specific features:

RENEWABLE INTEGRATION

The ESS must be designed to seamlessly integrate with an array of renewable energy systems, gas or diesel reciprocating gensets, utilities, peripheral cluster controllers and Microgrid Master Controller to allow for maximum renewable penetration and full asset control. The system shall have curtailment functionality to control the PV inverters (and communications to them from the microgrid controller) to reduce power output when needed. The grid forming Bi-Directional Power (BDP) inverters shall allow generator sets to be completely switched off to further reduce fuel consumption and operating costs.

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GRID STABILIZATION OR ENERGY TIME-SHIFT MODULE

The grid stabilization or Energy Time-shift module shall protect against typical power problems, including power failure, voltage sags/surges, and under/over voltage conditions.

STANDARD EQUIPMENT

- Bi-directional power inverters
- Energy storage batteries
- Color HMI touchscreen
- Remote communications via Modbus TCP/IP
- HVAC system to maintain 15°C to 27°C (60°F to 80°F) interior temperatures
- Interior AC lighting and convenience receptacles
- NOVEC 1230 Fire suppression system
- Shore Power connection and circuit breaker panel

FEATURED APPLICATIONS

- Renewable smoothing
- Grid firming/grid stabilization
- Facility backup
- Spinning reserve (if designed/needed)

BI-DIRECTIONAL POWER INVERTER

The Bi-Directional Power inverters shall provide the following features:

- Intelligent controls for the charging and discharging of the energy storage equipment.
- Static VAR compensator
- Full four-quadrant output power factor control of VAR/pf
- Automatic anti-islanding
- Parallel-ready to allow multiple modules to be used in parallel to increase total power output
- 50% overload capability for 10 minutes given sufficient battery energy.
- Automatically switching between grid-following and grid-forming modes and must do so within 1ms.
- Capable of switching from full charging to full discharging in < 1 ms.

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ALL PROPOSALS MUST INLCUDE A TIMELINE FOR PROCURMENT OF ALL NECESSARY COMPONENTS. PROPOSALS THAT DO NOT INLCUDE A TIMELINE WILL NOT BE CONSIDERED FOR AWARD.

A. Attachments

1. Drawing Log **(Exhibit "A")**.
2. Geotechnical Engineering Study, *Dated March 27, 2018* **(Exhibit "B")**.
3. Insurance Requirements **(Exhibit "C")**.

EXHIBIT "A"

DRAWING LOG

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Drawing No.	Drawing Title	Rev. No.	Drawing Date
C-101	10X RANCH GRADING PLANS COVER SHEET		8/24/2018
C-102	10X RANCH GRADING PLANS NOTES		8/24/2018
C-103	10X RANCH GRADING PLANS		9/13/2018
C-104	10X RANCH GRADING PLANS		9/13/2018
C-105	10X RANCH GRADING PLANS RECOMMENDED MICRO HOME PRECISE GRADING DETAILS		8/24/2018
C-106	10X RANCH GRADING PLANS BOX CULVERT DETAIL		8/24/2018
C-107	10X RANCH GRADING PLANS SECTIONS		8/24/2018
C-108	10X RANCH GRADING PLANS SECTIONS		8/24/2018
C-109	10X RANCH GRADING PLANS BOX CULVERT DETAILS		8/24/2018
E01	10X RANCH ELECTRICAL COVER SHEET	60%	9/21/2018
E02	10X RANCH REMOTE LIFT STATION PLAN	60%	9/21/2018
E03	10X RANCH WATER PLANT ELECTRICAL SITE PLAN	60%	9/21/2018
E04	10X RANCH WATER PLANT BUILDING POWER PLAN	60%	9/21/2018
E05	10X RANCH WATER PLANT BUILDING LIGHTING PLAN	60%	9/21/2018
E06	10X RANCH WATER PLANT SINGLE LINE DIAGRAM	60%	9/21/2018
E07	10X RANCH WATER PLANT LOAD CALCULATION & SCHEDULES	60%	9/21/2018
E08	10X RANCH ELECTRICAL DETAILS	60%	9/21/2018

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EXHIBIT "B"

GEOTECHNICAL ENGINEERING STUDY

CMT ENGINEERING LABORATORIES

Engineering
Geology
Environmental (ESA I & II)
Organic Chemistry
Materials Testing
Special Inspections

GEOTECHNICAL ENGINEERING STUDY

TEN X RANCH

Forest Road 302
Tusayan, Arizona

Prepared For:

Town of Tusayan
PO Box 709
845 Mustang Drive
Tusayan, Arizona 86023

CMT Project No. 1079
March 27, 2018

CMT ENGINEERING LABORATORIES

March 27, 2018

Mr. Eric Duthie, Town Manager
Town of Tusayan
PO Box 709
845 Mustang Drive
Tusayan, Arizona 86023

Subject: Geotechnical Engineering Study
Ten X Ranch
Forest Road 302
Tusayan, Arizona
CMT Project Number: 1079

Mr. Duthie:

Submitted herewith is the report of our geotechnical engineering study for the subject site. This report contains the results of our findings and an engineering interpretation of the results with respect to the available project characteristics. It also contains recommendations to aid in the design and construction of the earth related phases of this project.

On March 8-9, 2018, CMT Engineering Laboratories (CMT) personnel were on site and performed percolation testing and supervised the drilling of 20 borings extending to depths up to 25 feet below the existing ground surface. Soil samples were obtained during the field operations and subsequently transported to our laboratory for further testing and observation.

Conventional footings may be utilized to support the proposed residential homes, provided the recommendations in this report are followed. A detailed discussion of design and construction criteria is presented in this report. Recommendations for a box culvert, septic tank, and water/wastewater facilities are also included.

We appreciate the opportunity to work with you at this stage of the project. CMT offers a full range of Geotechnical Engineering, Geological, Material Testing, Special Inspection services, and Phase I and II Environmental Site Assessments. With three offices throughout Arizona and four in Northern Utah, our staff is capable of efficiently serving your project needs. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (602) 241-1097.

Sincerely,
CMT Engineering Laboratories

Registered Professional Engineer (Civil) CERTIFICATE NO. 49104 HANK BELLISTON Date Signed 03-27-18 ARIZONA U.S.A. Expires March 31, 2021

Hank Belliston, M.S., P.E.
Arizona Engineering Manager

Reviewed by:

Jeffrey J. Egbert, P.E., LEED A.P., M. ASCE
Senior Geotechnical Engineer

CMT ENGINEERING LABORATORIES

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APPENDIX

1.0 INTRODUCTION

1.1 General

CMT Engineering Laboratories (CMT) was retained to conduct a geotechnical subsurface study for a proposed residential development to be located at the southeast corner of Forest Road 302 and Forest Road 303 in Tusayan, Arizona, as shown in the **Vicinity Map** below.

Vicinity Map

1.2 Objectives, Scope and Authorization

The objectives and scope of our study were planned in discussions between Mr. Matt Cawley, P.E., of WestLand Resources, Inc., Mr. Eric Duthie, Tusayan Town Manager, and Mr. Hank Belliston of CMT Engineering Laboratories (CMT). In general, the objectives of this study were to define and evaluate the subsurface soil and groundwater conditions at the site, and provide appropriate foundation, earthwork, pavement, and seismic recommendations to be utilized in the design and construction of the proposed development.

In accomplishing these objectives, our scope of work has included performing field exploration, which consisted of the drilling/logging/sampling of 21 bore holes, performing laboratory testing on representative samples, and conducting an office program, which consisted of correlating available data, performing engineering analyses, and preparing this summary report. In addition, 5 near-surface percolation tests were performed at

representative locations within the drainage area defined by the Client. This scope of work was authorized by returning a signed copy of our proposal dated February 26, 2018 and executed on February 26, 2018.

1.3 Description of Proposed Construction

We understand that the proposed construction consists of single-family residences which we project will have one or two levels of wood frame construction above grade. We project that wall loads will not exceed 4,000 pounds per linear foot and column loads will not exceed 50,000 pounds. Floor slab loads are anticipated to be relatively light, with an average uniform loading not exceeding 150 pounds per square foot. If the loading conditions are different than we have projected, please notify us so that any appropriate modifications to our conclusions and recommendations contained herein can be made.

In addition to the homes, water and wastewater facilities will also be constructed at the site. This will include a buried septic tank and several above-ground tanks for water and water treatment.

The new local roads within the subdivision will utilize asphalt pavement. One box culvert crossing is expected. Traffic within the subdivision is projected to consist of mostly automobiles and light trucks, a few medium-weight delivery trucks, a weekly garbage truck and tanker truck, and an occasional fire truck.

Site development will require some earthwork in the form of minor cutting and filling. A site grading plan was not available at the time of this report, but we project that maximum cuts and fills may be on the order of 3 to 5 feet. If deeper cuts or fills are planned, CMT should be notified to provide additional recommendations, if needed.

1.4 Executive Summary

The most significant geotechnical aspects regarding site development include the following:

1. Mature native trees exist on some of the site, which will require removal of all roots within structural areas, including building pads and roadways;
2. Rock outcrops and shallow bedrock was encountered during drilling operations - excavation within these areas will require heavy equipment and/or other methods;
3. Groundwater, which was not encountered at depths of our drilling, is not expected to impact construction;
4. Foundations and floor slabs may be constructed on suitable structural/engineered fill which extends to natural soils, or on bedrock, but not a combination of these.

CMT must assess that all topsoil, and any undocumented fill, disturbed, or unsuitable soils have been removed and that suitable soils have been encountered prior to placing site grading fills, footings, slabs, and pavements.

In the following sections, detailed discussions pertaining to the site and subsurface descriptions, geologic/seismic setting, earthwork, foundations, lateral resistance, lateral pressure, floor slabs, and pavements are provided.

2.0 FIELD EXPLORATION

In order to define and evaluate the subsurface soil and groundwater conditions at the site, 20 bore holes were drilled throughout the site to depths of up to 26.5 feet below the existing ground surface. It should be noted that the planned bore hole within the water/wastewater campus was not accessible due to large rocks, outcrops, and trees. Locations of the bore holes are presented on **Figure 1, Site Plan**, included in the Appendix.

Samples of the subsurface soils encountered in the bore holes were collected at varying depths through the hollow stem drill augers. Relatively undisturbed samples of the subsurface soils were collected utilizing a Dames and Moore ring sampler. Disturbed samples were collected utilizing a standard split spoon sampler. The split spoon sampler was driven 18 inches into the soils below the drill augers using a 140 pound hammer free-falling a distance of 30 inches. The number of hammer blows needed for each 6 inch interval was recorded. The sum of the hammer blows for the final 12 inches of penetration is known as a standard penetration test and this 'blow count' was recorded on the bore hole logs. The blow count provides a reasonable approximation of the relative density of granular soils, but only a limited indication of the relative consistency of fine grained soils because the consistency of these soils is significantly influenced by the moisture content. Bulk samples were also collected.

The subsurface soils encountered in the bore holes were logged and described in general accordance with ASTM[1] D-2488. Soil samples were collected as described above, and were classified in the field based upon visual and textural examination. These field classifications were supplemented by subsequent examination and testing of select samples in our laboratory. Logs of the bore holes, including a description of the soil strata encountered, is presented on each individual Bore Hole Log, **Figures 2 through 22**, included in the Appendix. Sampling information and other pertinent data and observations are also included on the logs. In addition, a Key to Symbols defining the terms and symbols used on the logs is provided as **Figure 23** in the Appendix.

3.0 LABORATORY TESTING

3.1 General

Selected samples of the subsurface soils were subjected to various laboratory tests to assess pertinent engineering properties, as follows:

1. Moisture Content, ASTM D-2216, Percent moisture representative of field conditions
2. Atterberg Limits, ASTM D-4318, Plasticity and workability
3. Gradation Analysis, ASTM D-1140/C-117, Grain Size Analysis
4. One Dimension Consolidation, ASTM D-2435, Consolidation properties, moisture sensitivity

[1]American Society for Testing and Materials

3.2 Lab Summary

Laboratory test results are presented on the bore hole logs (**Figures 2 through 22**) and in the following Lab Summary Table:

Lab Summary Table

Bore Hole	Depth (feet)	Soil Class	Sample Type	Moisture Content (%)	Dry Denstiy (pcf)	Gradation			Atterberg Limits			Collapse (-) or Expansion (+)
						Grav	Sand	Fines	LL	PL	PI	
B-1	2.5-4	CL-ML	SPT	9.0		2.0	33.4	64.6	24	18	6	
B-3	0-5	CL	Bulk	10.1		0	32.6	67.4	29	18	11	
B-3	2.5-3.5	CL	Ring	10.6	88.1							-6.8%
B-6	2.5-4	CL-ML	SPT	7.3		3.0	33.9	63.1	24	18	6	
B-7	0-5	CL	Bulk	10.1		0	36.4	63.6	29	17	12	
B-9	0-5	CL	Bulk	10.5		0.7	34.3	65.0	26	17	9	
B-9	2.5-3.5	CL	Ring	6.4	94.6							-1.5%
B-13	0-4	CL	Bulk	8.7		7.7	37.7	54.6	27	16	11	
BC-1	0-5	CL	Bulk	8.0		0	42.7	57.3	28	16	12	
BC-1	5-6	CL	Ring	10.0	95.1							-2.0%
ST-1	10-11.5	GM	SPT	4.0		45.2	35.2	19.6	NV	NP	NP	
P-1	0-5	SC	Bulk	7.7		1.8	51.0	47.2	26	16	10	
P-2	0-5	CL	Bulk	8.9		1.6	44.2	54.2	28	17	11	
P-3	0-1	CL-ML	Bulk	10.0		4.3	33.8	61.9	25	19	6	
P-4	0-5	CL	Bulk	8.9		0	33.1	66.9	27	16	11	
P-5	0-5	CL-ML	Bulk	9.5		0	36	64	24	17	7	

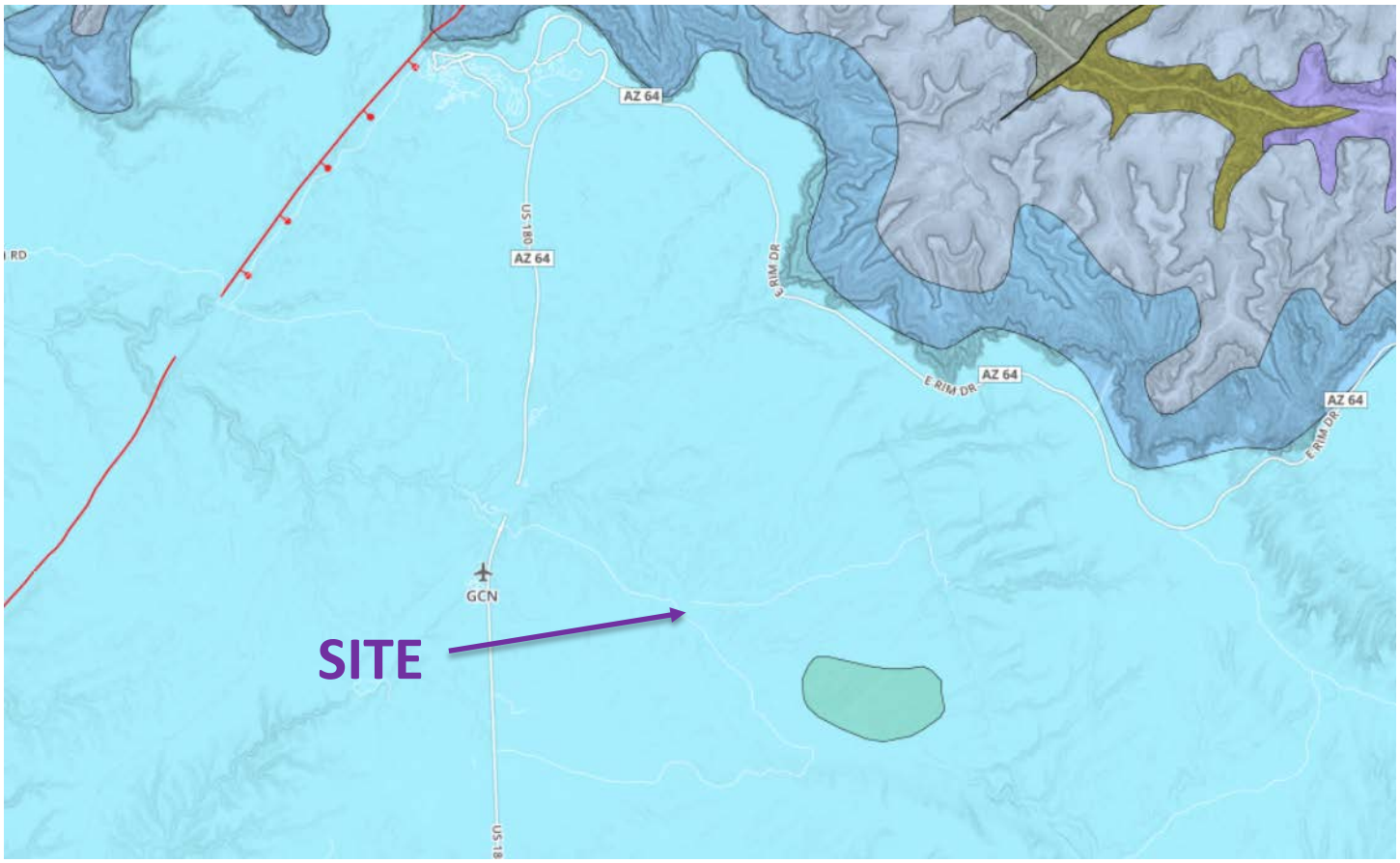
4.0 GEOLOGIC & SEISMIC CONDITIONS

4.1 Geologic Setting

The subject site is located in the central portion of Coconino County in North-central Arizona, approximately 4.3 miles south of the south rim of the Grand Canyon. The site sits at an elevation of between approximately 6,730 and 6,741 feet above sea level. The site is located in an area of somewhat flat to hilly terrain that is part of the Colorado Plateau Physiographic Province.

The geology of the location of the subject site has been mapped and is included on an internet-based interactive geologic map provided by the Arizona Geological Survey[2]. The surficial geology at the location of the subject site and adjacent areas is mapped as "Permian Sedimentary Rocks (270-280 Ma)" (Map Unit P). No fill has been mapped at the location of the site on the geologic map. Unit P is described on the referenced map as "Gray to tan, cherty limestone of Kaibab and Toroweap Formations, and underlying white to tan, fine-grained Coconino Sandstone. Limestone was deposited in a shallow sea, and sandstone was deposited in near-shore dunes and beach settings." Refer to the **Geologic Map** shown on the following page.

2 Arizona Geological Survey Interactive Geologic Map: http://data.azgs.az.gov/geologic-map-of-arizona/#



Geologic Map

4.2 Faulting

No surface fault traces are shown on the referenced geologic map crossing or projecting toward the subject site. The nearest mapped active fault trace is the Bright Angel fault zone, shown as a red line in the geologic map above, located about 7 miles northwest of the site.

4.3 Seismicity

4.3.1 Site Class

Arizona has adopted the International Building Code (IBC) 2015. IBC 2015 determines the seismic hazard for a site based upon 2008 mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points). For site class definitions, IBC 2015 (Section 1613.3.2) refers to Chapter 20, Site Classification Procedure for Seismic Design, of ASCE[3] 7. Given the subsurface soils at the site, including our projection of soils within the upper 100 feet of the soil profile, it is our opinion the site best fits Site Class D – Stiff Soil Profile, which we recommend for seismic structural design.

[3]American Society of Civil Engineers

4.3.2 Ground Motions

The 2008 USGS mapping utilized by the IBC provides values of peak ground, short period and long period accelerations for the Site Class D boundary and the Maximum Considered Earthquake (MCE). This Site Class D boundary represents average bedrock values for the Western United States and must be corrected for local soil conditions. The following table summarizes the peak ground, short period and long period accelerations for the MCE event, and incorporates the appropriate soil correction factor for a Site Class D soil profile at site grid coordinates of 35.9528 degrees north latitude and -112.0859 degrees west longitude:

Spectral Acceleration Value, T	Site Class B Boundary [mapped values] (g)	Site Coefficient	Site Class D [adjusted for site class effects] (g)	Design Values (g)
Peak Ground Acceleration	0.188	F_a = 1.425	0.267	0.178
Short Period Acceleration (0.2 Seconds)	S_S = 0.469	F_a = 1.425	S_{MS} = 0.668	S_{DS} = 0.445
Short Period Acceleration (1.0 Second)	S_1 = 0.131	F_v = 2.276	S_{M1} = 0.298	S_{D1} = 0.199

4.3.3 Liquefaction

Liquefaction is defined as the condition when saturated, loose, sandy soils lose their support capabilities because of excessive pore water pressure which develops during a seismic event. Clayey soils, even if saturated, will generally not liquefy during a major seismic event.

Subsurface soils encountered consisted primarily of Sandy Lean CLAY (CL) and Sandy Silty CLAY (CL-ML) soils. Groundwater was not encountered in any of the bore holes. Based upon these conditions we estimate a low susceptibility to liquefaction at this site for the soils we encountered.

4.4 Other Geologic Hazards

No landslide deposits or features, including lateral spread deposits, are mapped on or adjacent to the site. The site is not located within a currently known or mapped potential debris flow, stream flooding, or rock fall hazard area.

5.0 SITE CONDITIONS

5.1 Surface Conditions

The site is currently vegetated by grasses, some shrubs, and mature forest trees. The site grade slopes slightly downward to the northwest. There are some surface disturbances from prior ranching activities in the form of berms, a drainage tank, and a couple of former structures. There are areas of shallow and surface bedrock

outcrops. A wide wash (now dry) runs from the south toward the north-northwest along the western portion of the site. Based upon aerial photos dating back to 1992 the site appears to have remained relatively unchanged since that time. The site is bordered on the north by NF 303 and hilly forest terrain, on the east by hilly forest terrain, on the south by flat land and NF 302, and on the west by NF 302 and hilly forest terrain (see **Vicinity Map** in **Section 1.1** above).

5.2 Subsurface Soils

At the locations of most of the bore holes we encountered a very thin layer of organic material (topsoil) on the surface. Below the topsoil we encountered primarily natural Sandy Lean CLAY (CL) and Sandy Silty CLAY (CL-ML) soils, extending to the bottom of the bore holes. Some bore holes encountered Clayey SAND (SC), Silty SAND (SM), and Silty GRAVEL with Sand (GM) layers. Auger refusal was encountered in several of the bore holes, ranging from 6 inches to 4 ft below existing grades, while one of the bore holes was advanced to a depth of 26.5 ft. The natural soils were light brown to dark brown in color, damp, with the cohesive soils having soft to hard consistencies, and the granular soils in a loose to very dense states.

For a more descriptive interpretation of subsurface conditions, please refer to the bore hole logs, **Figures 2 through 22**, which graphically represent the subsurface conditions encountered. The lines designating the interface between soil types on the logs generally represent approximate boundaries; in situ, the transition between soil types may be gradual.

5.3 Groundwater

Groundwater was not encountered in any of the bore holes. Groundwater levels in wells in the general vicinity of the site (in and around Tusayan) are more than 400 feet below the local ground surfaces. Groundwater levels can fluctuate as much as 1.5 to 2 feet seasonally. Numerous other factors such as heavy precipitation, irrigation of neighboring land, and other unforeseen factors, may also influence ground water elevations at the site. The detailed evaluation of these and other factors, which may be responsible for ground water fluctuations, is beyond the scope of this study.

5.4 Site Subsurface Variations

Based on the results of the subsurface explorations and our experience, variations in the continuity and nature of subsurface conditions should be anticipated. Due to the heterogeneous characteristics of natural soils, care should be taken in interpolating or extrapolating subsurface conditions between or beyond the exploratory locations.

6.0 SITE PREPARATION AND GRADING

6.1 General

We understand that the existing trees within structural areas of the project will be removed. Removal should include all root systems and loose soils caused by the removal process. All deleterious materials should be

stripped from the site surface prior to commencement of construction activities. This includes loose and disturbed soils, topsoil, vegetation, etc. Based upon the conditions observed in the borings there is a thin layer of topsoil on the surface of the site which we estimated to be less than 6 inches in thickness. When stripping and grubbing, topsoil should be distinguished by the apparent organic content and not solely by color; thus we estimate that topsoil stripping will need to include the upper 4 inches.

The site should be examined by a CMT geotechnical engineer to assess that suitable natural soils have been exposed and any deleterious materials, loose, and/or disturbed soils have been removed, prior to placing site grading fills, footings, slabs, and pavements. Due to the collapse potential of some of the site soils, we recommend that all residential footings be founded upon a minimum of 2 ft of engineered fill, and tank footings on a minimum of 3 ft of engineered fill. We recommend a minimum of 1 ft of engineered fill beneath all street pavement sections.

Fill placed over large areas to raise overall site grades can induce settlements in the underlying natural soils. If more than 5 feet of site grading fill is anticipated over the natural ground surface, we should be notified to assess potential settlements and provide additional recommendations as needed. These recommendations may include placement of the site grading fill far in advance to allow potential settlements to occur prior to construction.

6.2 Temporary Excavations

Groundwater is not anticipated to impact construction activities at this site.

For cohesionless (sandy/gravelly) soils, temporary construction excavations not exceeding 4 feet in depth should be no steeper than one-half horizontal to one vertical (0.5H:1V). For excavations up to 8 feet, side slopes should be no steeper than one horizontal to one vertical (1H:1V). Excavations encountering saturated cohesionless soils will be very difficult to maintain, and will require very flat side slopes and/or shoring, bracing and dewatering.

In cohesive (clayey) soils, temporary construction excavations not exceeding 4 feet in depth may be constructed with near-vertical side slopes. Temporary excavations up to 8 feet deep, may be constructed with side slopes no steeper than one-half horizontal to one vertical (0.5H:1V). Excavations deeper than 8 feet are not anticipated at the site, with the exception of the planned septic tank and some buried utility trenches.

To reduce disturbance of the natural soils during excavation, we recommend that smooth edge buckets/blades be utilized.

All excavations must be inspected periodically by qualified personnel. If any signs of instability or excessive sloughing are noted, immediate remedial action must be initiated. All excavations should be made following OSHA safety guidelines.

6.3 Fill Material

Following are our recommendations for the various fill types we anticipate will be used at this site:

Fill Material Type	Description/Recommended Specification
Structural Fill ≤ 2 ft	Placed below structures, flatwork and pavement (limited to 2 feet in thickness). On-site soils or imported soils, with a maximum particle size of 4 inches, including clay soils not containing excessive amounts of degradable/organic material (see discussion below).
Structural Fill > 2 ft	Placed below structures, flatwork and pavement (more than 2 feet in thickness). Imported well-graded sand/gravel mixture, with maximum particle size of 4 inches, minimum 70% passing 3/4-inch sieve, maximum 30% passing the No. 200 sieve, and maximum Plasticity Index of 15.
Non-Structural Fill	Placed below non-structural areas, such as landscaping. On-site soils or imported soils, with a maximum particle size of 8 inches, including clay soils not containing excessive amounts of degradable/organic material (see discussion below).
Stabilization Fill	Placed to stabilize soft areas prior to placing structural fill and/or site grading fill. Coarse angular gravels and cobbles 1 inch to 8 inches in size. May also use 1.5- to 2.0-inch gravel placed on stabilization fabric, such as Mirafi RS280i or 600X, or equivalent (see **Section 6.6**).

On-site clay soils may be used as structural fill and non-structural fill, but are inherently more difficult to work with in proper moisture conditioning (they are very sensitive to changes in moisture content), requiring very close moisture control during placement and compaction. This will be very difficult, if not impossible, during wet and cold periods of the year. If used, we also recommend that the site grading fill thickness using on-site clay soils not exceed 2 feet below structures, to minimize potential settlements.

All fill material should be approved by a CMT geotechnical engineer prior to placement.

6.4 Fill Placement and Compaction

The various types of compaction equipment available have their limitations as to the maximum lift thickness that can be compacted. For example, hand operated equipment is limited to lifts of about 4 inches and most "trench compactors" have a maximum, consistent compaction depth of about 6 inches. Large rollers, depending on soil and moisture conditions, can achieve compaction at 8 to 12 inches. The full thickness of each lift should be compacted to at least the following percentages of the maximum dry density as determined by ASTM D-698 (or AASHTO[4] T-99) in accordance with the following recommendations:

[4] American Association of State Highway and Transportation Officials

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Conventional Footings: Beneath an area extending at least 3 feet beyond the perimeter of structures, and below flatwork and pavement (structural fill)	0 to 5 5 to 8 8+	95 98 100
Utility trenches within structural areas	-	95
Roadbase and subbase	-	95
Non-structural fill	0 to 5 5 to 8 8+	90 92 95

For best compaction results, we recommend that the moisture content for structural fill/backfill be within 2% of optimum. Field density tests should be performed on each lift as necessary to verify that proper compaction is being achieved.

6.5 Utility Trenches

For the bedding zone around the utility, we recommend utilizing sand bedding fill material that meets current APWA[5] requirements.

All utility trench backfill material below structurally loaded facilities (foundations, floor slabs, flatwork, parking lots/drive areas, etc.) shall be placed at the same density requirements established for structural fill in the previous section.

Most utility companies and local governments are requiring Type A-1a or A-1b (AASHTO Designation) soils (sand/gravel soils with limited fines) be used as backfill over utilities within public rights of way, and the backfill be compacted over the full depth above the bedding zone to at least 95% of the maximum dry density as determined by AASHTO T-99 (ASTM D-698). The natural soils at the site do not meet these requirements.

Where the utility does not underlie structurally loaded facilities and public rights of way, on-site native soils may be utilized as trench backfill above the bedding layer, provided they are properly moisture-conditioned and compacted to the minimum requirements stated above in **Section 6.4**.

6.6 Stabilization

Native clay soils will likely be susceptible to rutting and pumping. The likelihood of disturbance or rutting and/or pumping of the existing native soils is a function of the load applied to the surface, as well as the frequency of the load. Consequently, rutting and pumping can be minimized by avoiding concentrated traffic, minimizing the load applied to the surface by using lighter equipment and/or partial loads, by working in drier times of the year, or by providing a working surface for the equipment. Rubber-tired equipment particularly, because of high pressures, promotes instability in moist/wet, soft soils.

[5] American Public Works Association

If rutting or pumping occurs, traffic should be stopped and the disturbed soils should be removed and replaced with stabilization material. Typically, a minimum of 18 inches of the disturbed soils must be removed to be effective. However, deeper removal is sometimes required.

To stabilize soft subgrade conditions (if encountered), a mixture of course, clean, angular gravels and cobbles and/or 1.5- to 2.0-inch clean gravel should be utilized. Often the amount of gravelly material can be reduced with the use of a geotextile fabric such as Mirafi RS280i or 600X, or equivalent. Its use will also help avoid mixing of the subgrade soils with the gravelly material. After excavating the soft/disturbed soils, the fabric should be spread across the bottom of the excavation and up the sides a minimum of 18 inches. Otherwise, it should be placed in accordance with the manufacturer's recommendation, including proper overlaps. The gravel material can then be placed over the fabric in compacted lifts as described above.

7.0 FOUNDATION RECOMMENDATIONS

The following recommendations have been developed on the basis of the previously described project characteristics, the subsurface conditions observed in the field and the laboratory test data, as well as common geotechnical engineering practice.

7.1 Conventional Foundation Recommendations

Based on our geotechnical engineering analyses, the proposed structures may be supported upon conventional spread and/or continuous wall foundations placed on bedrock, or a minimum of 2 feet of suitable structural fill extending to natural soils or bedrock, but no combination of these. Footings on soil may be designed using a net bearing pressure of 2,000 psf. Footings on bedrock may be designed using a net bearing pressure of 5,000 psf. In no case shall the footings bear on a combination of structural fill and bedrock.

The term "net bearing pressure" refers to the pressure imposed by the portion of the structure located above lowest adjacent final grade, thus the weight of the footing and backfill to lowest adjacent final grade need not be considered. The allowable bearing pressure may be increased by 1/3 for temporary loads such as wind and seismic forces.

We also recommend the following:

1. Exterior footings subject to frost should be placed at least 30 inches below lowest adjacent grade.
2. Interior footings not subject to frost should be placed at least 16 inches below grade.
3. Continuous footing widths should be maintained at a minimum of 16 inches.
4. Spot footings should be a minimum of 24 inches wide.

7.2 Septic Tank

It is our understanding that a large septic tank will be constructed with the bottom of the tank approximately 8 feet below the existing grade. Footings for this tank may be designed using a net bearing pressure of 3,000 psf if in the existing clay soils. If the footings are in the deeper silty gravel soil, or a minimum of 3 feet of engineered fill, a net bearing pressure of 5,000 psf may be used.

7.3 Wastewater Treatment and Water Tanks

It is our understanding that a large water tank and a wastewater treatment tank will be constructed in a portion of the site that is mostly rock outcrops and bedrock. Footings for these tanks may be designed using a net bearing pressure of 5,000 psf if constructed completely on existing bedrock.

7.4 Box Culvert

It is our understanding that a box culvert will be constructed in the western portion of the site beneath the main road into the subdivision, to bridge the wash area. No information was available regarding the depth of the footings for the box culvert, however, based on the terrain, it is not expected to be more than 5 feet below the existing ground surface. Footings for box culvert should rest on a minimum of 2 feet of engineered fill and may be designed using a net bearing pressure of 3,000 psf. Care should be taken to ensure that the sides and bottom of the culvert are protected from erosion and scour. This may be accomplished with concrete wingwalls and aprons, constructed both upstream and downstream. Channel sides should be protected both upstream and downstream of the box culvert with rip rap or other effective erosion protection.

7.5 Installation

Foundations shall not be placed on topsoil with organics, undocumented fill, rubbish, demolition or construction debris, other deleterious materials, frozen soils, or within ponded water.

Deep, large roots may be encountered where trees and larger bushes occupy portions of the site; such large roots should be removed. If unsuitable soils are encountered, they must be completely removed and replaced with properly compacted structural fill. Excavation bottoms should be examined by a qualified geotechnical engineer to confirm that suitable bearing materials soils have been exposed.

All structural fill should meet the requirements for such, and should be placed and compacted in accordance with **Section 6** above. The width of structural replacement fill below footings should be equal to the width of the footing plus 1 foot for each foot of fill thickness. For instance, if the footing width is 2 feet and the structural fill depth beneath the footing is 2 feet, the fill replacement width should be 4 feet, centered beneath the footing.

7.6 Estimated Settlement

Foundations designed and constructed in accordance with our recommendations could experience some settlement, but we anticipate that total settlements of footings founded as recommended above will not exceed 1 inch, with differential settlements on the order of 0.5 inches over a distance of 25 feet. We expect approximately 50% of the total settlement to initially take place during construction.

7.7 Lateral Resistance

Lateral loads imposed upon foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footings and the supporting soils. In determining frictional resistance, a coefficient of 0.30 for natural clay soils, and 0.40 for the natural sand/gravel soils or structural fill, may be utilized for design. Passive resistance provided by properly placed and compacted native soils or structural fill may be considered equivalent to a fluid with a density of 440 pcf. A combination of passive earth resistance and friction may be utilized if the friction component of the total is divided by 1.5.

8.0 CONVENTIONAL FLOOR SLABS

Floor slabs may be established upon a minimum of 2 feet of structural fill extending to suitable native soils (same as for foundations). Under no circumstances shall floor slabs be established directly on any topsoil, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. As with foundations, in no case shall floor slabs bear on a combination of structural fill and bedrock.

In order to facilitate curing of the concrete, we recommend that floor slabs be directly underlain by at least 4 inches of “free-draining” fill, such as “pea” gravel or 3/4-inch to 1-inch minus, clean, gap-graded gravel. This layer may be included in the minimum 2 feet of engineered fill. To help control normal shrinkage and stress cracking, the floor slabs should have the following features:

1. Adequate reinforcement for the anticipated floor loads with the reinforcement continuous through interior floor joints;
2. Frequent crack control joints; and
3. Non-rigid attachment of the slabs to foundation walls and bearing slabs.

9.0 DRAINAGE RECOMMENDATIONS

It is important to the long-term performance of foundations and floor slabs that water not be allowed to collect near the foundation walls and infiltrate into the underlying soils. We recommend the following:

1. All areas around each structure (residences and tanks) should be sloped to provide drainage away from the foundations. We recommend a minimum slope of 4 inches in the first 10 feet away from the structure. This slope should be maintained throughout the lifetime of the structures.

2. All roof drainage should be collected in rain gutters with downspouts designed to discharge at least 10 feet from the foundation walls or well beyond the backfill limits, whichever is greater.

3. Adequate compaction of the foundation backfill should be provided. We suggest a minimum of 90% of the maximum laboratory density as determined by ASTM D-698. Water consolidation methods should not be used under any circumstances.

4. Landscape sprinklers should be aimed away, and kept at least 4 feet, from the foundation walls. The sprinkling systems should be designed with proper drainage and be well-maintained. Over watering should be avoided.

5. Other precautions that may become evident during construction.

10.0 PAVEMENTS

The new local roads within the subdivision will utilize asphalt pavement. One box culvert crossing is expected. Traffic within the subdivision is projected to consist of mostly automobiles and light trucks, a few medium-weight delivery trucks, a weekly garbage truck and tanker truck, and an occasional fire truck.

We anticipate the native clay soils will exhibit poor pavement support characteristics when saturated or nearly saturated. Based on our laboratory testing experience with similar soils, our pavement design is based upon Design Charts 100A and 101A of the 2017 Maricopa County Department of Transportation Pavement Design Manual.

All pavement areas must be prepared as discussed above in **Section 6.1**. Under no circumstances shall pavements be established over topsoil, non-engineered fills (if encountered), loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, bedrock, or within ponded water.

In roadway areas, subsequent to stripping and prior to the placement of pavement materials, a minimum of 1 foot of structural fill should be properly compacted.

Based on the site soils, and Design Chart 101A for local streets, we recommend a pavement section consisting of 2½ inches of AC over 7 inches of ABC. For minor collector streets, we recommend a pavement section consisting of 3 inches of AC over 11 inches of ABC. The following pavement thickness options are provided:

Material	Pavement Section Thickness (inches)	
	Local Streets	Minor Collector Streets
Asphaltic Concrete	**2½**	**3**
Aggregate Base Course	**7**	**11**
Total Thickness	**9½**	**14**

If the pavement will be subjected to construction traffic we should be notified to provide additional recommendations. All asphalt surfaces should be properly graded, so that good drainage off the surface and away from the edge of asphalt should be maintained. For better protection against frost damage, the thicker ABC options should be considered.

Aggregate Base Course (ABC) should conform to Town or County specifications, or to ADOT Class 2 Aggregate Base. Material meeting our specification for structural fill can be used for subbase, as long as the fines content (percent passing No. 200 sieve) does not exceed 15%. ABC and subbase materials should be compacted as recommended above in **Section 6.4**.

11.0 PERCOLATION TESTING

It is our understanding that the existing wide wash area along the western portion of the property is to be used to drain the overflow of the on-site treated water. CMT was requested to perform percolation testing on near-surface soils to determine the soil's capacity for infiltration of this water.

CMT utilized the percolation method as described in Subsection F of R18-9-A310 of the Arizona Administrative Code (AAC). This test method is primarily for septic systems, and was easily implemented in the near-surface soils of the site.

Briefly, the R18-9-A310 method begins with excavating a test hole 12 inches square, 12 inches deep into the soil to be tested. The test hole is then filled with 12 inches of clean water, and timed until either the water is fully drained, or 60 minutes, whichever comes first. If fully drained, this is repeated two more times. If 60 minutes passes, and there is still water in the hole, the water level of the test hole is held above 9 inches for a minimum of 4 hours, after which it is allowed to "rest". Within 16 hours of this pre-soaking, the test hole is cleaned of sloughed material, and filled with clean water to 6 inches. The time it takes for the water level to fall exactly 1 inch is recorded. This is repeated until 3 consecutive tests vary by no more than 10 percent, and the highest of the 3 tests is recorded as the stabilized rate, in minutes/inch.

The results of the percolation testing are tabulated below:

Test Location	Soil Type (USGS)	Stabilized Rate (min/in)
P-1	SC	5.0
P-2	CL	54.0
P-3	CL-ML	46.0
P-4	CL	10.0
P-5	CL	11.0

In addition, bore holes were drilled to depths of up to 15 feet in the vicinity of each of these percolation tests. The bore hole logs for P-1 through P-5 are included in the Appendix as Figures 18 through 22.

12.0 QUALITY CONTROL

We recommend that CMT be retained to as part of a comprehensive quality control testing and observation program. With CMT onsite we can help facilitate implementation of our recommendations and address, in a timely manner, any subsurface conditions encountered which vary from those described in this report. Without such a program CMT cannot be responsible for application of our recommendations to subsurface conditions which may vary from those described herein. This program may include, but not necessarily be limited to, the following:

12.1 Field Observations

Observations should be completed during all phases of construction such as site preparation, foundation excavation, structural fill placement and concrete placement.

12.2 Fill Compaction

Compaction testing by CMT is required for all structural supporting fill materials. Maximum Dry Density (Standard Proctor, ASTM D-698) tests should be requested by the contractor immediately after delivery of any fill materials. The maximum density information should then be used for field density tests on each lift as necessary to ensure that the required compaction is being achieved.

12.3 Excavations

All excavation procedures and processes should be observed by a geotechnical engineer from CMT or his representative. In addition, for the recommendations in this report to be valid, all backfill and structural fill placed in trenches and all pavements should be density tested by CMT. We recommend that freshly mixed concrete be tested by CMT in accordance with ASTM designations.

12.4 Vibration Monitoring

Construction activities, particularly site grading and fill placement, can induce vibrations in existing structures adjacent to the site. Such vibrations can cause damage to adjacent buildings, depending on the building composition and underlying soils. It can be prudent to monitor vibrations from construction activities to maintain records that vibrations did not exceed a pre-defined threshold known to potentially cause damage. CMT can provide this monitoring if desired.

13.0 LIMITATIONS

The recommendations provided herein were developed by evaluating the information obtained from the subsurface explorations and soils encountered therein. The exploration logs reflect the subsurface conditions only at the specific location at the particular time designated on the logs. Soil and ground water conditions may differ from conditions encountered at the actual exploration locations. The nature and extent of any variation in the explorations may not become evident until during the course of construction. If variations do appear, it may become necessary to re-evaluate the recommendations of this report after we have observed the variation.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

We appreciate the opportunity to be of service to you on this project. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (602) 241-1097. To schedule materials testing, please call (602) 241-1097.

APPENDIX

CMT ENGINEERING LABORATORIES	**Ten X Ranch** Forest Road 302, Tusayan, Arizona	**SITE PLAN**	Date:	27-Mar-2018	Figure: 1
			CMT No.:	CMT-1079	

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-1

Boring Type: Hollow-Stem Auger | Total Depth: 11.5' | Date: 3/8/18

Surface Elev. (approx): 6732 | Water Depth: (see Remarks) | Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Silty CLAY damp, soft to firm												
				1	2 3 3	6	9.0		2	33.4	64.6	24	18	6
5				2	1 2 2	4								
10				3	3 2 3	5								
		END AT 11.5'												
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 2

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling

Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-2

Boring Type: Hollow-Stem Auger	Total Depth: 11.5'	Date: 3/8/18
Surface Elev. (approx): 6732	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Silty CLAY damp, soft to firm												
				4	3 1 2	3								
5				5	2 2 3	5								
10				6	3 3 4	7								
		END AT 11.5'												
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 3

CMT ENGINEERING LABORATORIES

Excavated By: D&S Drilling
Logged By: James Curtis
Page: 1 of 1

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-3

Boring Type: Hollow-Stem Auger | Total Depth: 11.5' | Date: 3/8/18

Surface Elev. (approx): 6733 | Water Depth: (see Remarks) | Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Lean CLAY damp, firm to stiff		7			10.1	88.1	0	32.6	67.4	29	18	11
5				8	2 3 3	6								
10				9	4 6 8	14								
		END AT 11.5'												
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 4

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling

Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-4

Boring Type: Hollow-Stem Auger | Total Depth: 11.5' | Date: 3/8/18

Surface Elev. (approx): 6732 | Water Depth: (see Remarks) | Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation: Gravel %	Gradation: Sand %	Gradation: Fines %	Atterberg: LL	Atterberg: PL	Atterberg: PI
0		Brown Sandy Silty CLAY damp, stiff to very stiff												
				10	4 4 6	10								
5				11	5 7 11	18								
10				12	4 7 8	15								
		END AT 11.5'												
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 5

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling

Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-5

Boring Type: Hollow-Stem Auger	Total Depth: 11.5'	Date: 3/8/18
Surface Elev. (approx): 6733	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation: Gravel %	Gradation: Sand %	Gradation: Fines %	Atterberg: LL	Atterberg: PL	Atterberg: PI
0		Brown Sandy Silty CLAY damp, soft to firm												
				13	1 1 2	3								
5				14	2 2 4	6								
10				15	3 3 4	7								
		END AT 11.5'												
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 6

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling
Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-6

Boring Type: Hollow-Stem Auger | Total Depth: 11.5' | Date: 3/8/18

Surface Elev. (approx): 6734 | Water Depth: (see Remarks) | Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Silty CLAY damp, firm to stiff												
				16	3 3 5	8	7.3		3	33.9	63.1	24	18	6
5				17	4 4 5	9								
10				18	2 3 5	8								
		END AT 11.5'												
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 7

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling

Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-7

Boring Type: Hollow-Stem Auger | Total Depth: 11.5' | Date: 3/8/18

Surface Elev. (approx): 6732 | Water Depth: (see Remarks) | Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Lean CLAY damp, stiff to very stiff		19			10.1		0	36.4	63.6	29	17	12
5				20	5 7	9								
10				21	4 8 9	17								
		END AT 11.5'												
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 8

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling

Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-8

Boring Type: Hollow-Stem Auger	Total Depth: 11.5'	Date: 3/8/18
Surface Elev. (approx): 6733	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)		Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
						Total			Gravel %	Sand %	Fines %	LL	PL	PI
0		Brown Sandy Lean CLAY damp, firm to very stiff												
				22		7								
5				23	4 6 9	15								
10				24	5 5 8	13								
		END AT 11.5'												
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 9

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling
Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-9

Boring Type: Hollow-Stem Auger | Total Depth: 11.5' | Date: 3/8/18

Surface Elev. (approx): 6734 | Water Depth: (see Remarks) | Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation: Gravel %	Gradation: Sand %	Gradation: Fines %	Atterberg: LL	Atterberg: PL	Atterberg: PI
0		Brown Sandy Lean CLAY damp, stiff		25			10.5		0.7	34.3	65	26	17	9
5				26	5 9	10		94.6						
		Brown Silty SAND with Gravel damp, very dense												
10				27	17 22 30	52								
		END AT 11.5'												
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 10

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling

Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-10

Boring Type: Hollow-Stem Auger	Total Depth: 11.5'	Date: 3/8/18
Surface Elev. (approx): 6733	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation: Gravel %	Gradation: Sand %	Gradation: Fines %	Atterberg: LL	Atterberg: PL	Atterberg: PI
0		Brown Sandy Lean CLAY damp, stiff to very stiff												
				28		14								
5				29	3 4 7	11								
10				30	8 12 14	26								
		END AT 11.5'												
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 11

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling
Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-11

Boring Type: Hollow-Stem Auger	Total Depth: 0.5'	Date: 3/9/18
Surface Elev. (approx): 6740	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)		Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
						Total			Gravel %	Sand %	Fines %	LL	PL	PI
0		Brown Silty SAND with Gravel												
		END AT 0.5' damp, very dense												
		Auger Refusal Encountered on Bedrock												
5														
10														
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 12

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling
Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-12

Boring Type: Hollow-Stem Auger	Total Depth: 1'	Date: 3/9/18
Surface Elev. (approx): 6734	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N) Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Silty SAND with Gravel damp, very dense											
		END AT 1.0' Auger Refusal Encountered on Bedrock											
5													
10													
15													
20													
25													

Remarks: Groundwater not encountered during drilling.

Figure: 13

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling
Logged By: James Curtis
Page: 1 of 1

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

B-13

Boring Type: Hollow-Stem Auger | Total Depth: 4' | Date: 3/9/18

Surface Elev. (approx): 6740 | Water Depth: (see Remarks) | Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N) Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Lean CLAY damp, hard											
				31	50+	8.7		7.7	37.7	54.6	27	16	11
		END AT 4.0' Auger Refusal Encountered on Bedrock											
5													
10													
15													
20													
25													

Remarks: Groundwater not encountered during drilling.

Figure: 14

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling

Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

BC-1

Boring Type: Hollow-Stem Auger	Total Depth: 16.5'	Date: 3/8/18
Surface Elev. (approx): 6732	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Lean CLAY damp, firm to stiff		32			8.0		0	42.7	57.3	28	16	12
5				33	3 6	7		95.1						
10				34	3 4 5	9								
15				35	4 5 10	15								
		END AT 16.5'												
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 15

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling
Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

ST-1

Boring Type: Hollow-Stem Auger	Total Depth: 26.5'	Date: 3/8/18
Surface Elev. (approx): 6734	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Lean CLAY damp, stiff												
5			■	36	4 4 5	9								
10			■	37	10 13 17	30	4.0		45.2	35.2	19.6	NV	NP	NP
		Brown Silty GRAVEL with Sand damp, medium dense to loose												
15			■	38	12 8 16	24								
20			■	39	5 6 9	15								
25			■	40	3 4 5	9								
		END AT 26.5'												

Remarks: Groundwater not encountered during drilling.

Figure: 16

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling
Logged By: James Curtis

Ten X Ranch

Bore Hole Log

WW-1

Forest Rd 302, Tusayan

Boring Type: Hollow-Stem Auger	Total Depth: 1'	Date: 3/9/18
Surface Elev. (approx): 6741	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N) Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Location not accessable due to large rocks at ground surface. It is assumed that shallow refusal would be encountered, similar to boreholes B-11 and B-12.											
5													
10													
15													
20													
25													

Remarks: Location not drilled due to rough terrain

Figure: 17

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling
Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

P-1

Boring Type: Hollow-Stem Auger	Total Depth: 9'	Date: 3/8/18
Surface Elev. (approx): 6734	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Clayey SAND damp, medium dense to very dense		1			7.7		1.8	51	47.2	26	16	10
5				2	5 8 7	15								
		Brown Silty GRAVEL with Sand												
		AUGER REFUSAL AT 9.0'												
10														
15														
20														
25														

Remarks: Groundwater not encountered during drilling.

Auger refusal encountered at 9' on bedrock

Figure: 18

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling

Logged By: James Curtis

Ten X Ranch

Bore Hole Log

P-2

Forest Rd 302, Tusayan

Boring Type: Hollow-Stem Auger | Total Depth: 16.5' | Date: 3/8/18

Surface Elev. (approx): 6730 | Water Depth: (see Remarks) | Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Lean CLAY damp, soft		3			8.9		1.6	44.2	54.2	28	17	11
5				4	2 2 2	4								
		Dark Brown below 6.5'												
10				5	1 2 1	3								
		Light Brown Clayey SAND with Gravel damp, very dense												
15				6	15 28 34	62								
		END AT 16.5'												
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 19

CMT ENGINEERING LABORATORIES

Excavated By: D&S Drilling

Logged By: James Curtis

Ten X Ranch

Bore Hole Log

P-3

Forest Rd 302, Tusayan

Boring Type: Hollow-Stem Auger	Total Depth: 1'	Date: 3/8/18
Surface Elev. (approx): 6732	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N) Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Silty CLAY damp, hard		7		10		4.3	33.8	61.9	25	19	6
		AUGER REFUSAL AT 1.0'											
5													
10													
15													
20													
25													

Remarks: Groundwater not encountered during drilling.
Auger refusal encountered at 1' on bedrock

Figure: 20

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling
Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

P-4

Boring Type: Hollow-Stem Auger	Total Depth: 16.5'	Date: 3/8/18
Surface Elev. (approx): 6732	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Lean CLAY damp, soft to stiff		8			8.9		0	33.1	66.9	27	16	11
5				9	1 2 1	3								
10				10	3 5 7	12								
15				11	6 7 7	14								
		END AT 16.5'												
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 21

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling
Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Bore Hole Log

P-5

Boring Type: Hollow-Stem Auger	Total Depth: 16.5'	Date: 3/8/18
Surface Elev. (approx): 6733	Water Depth: (see Remarks)	Job #: 1079

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Brown Sandy Lean CLAY damp, stiff		12			9.5		0	36	64	24	17	7
5				13	4 4 6	10								
10				14	7 6 9	15								
15				15	4 5 8	13								
		END AT 16.5'												
20														
25														

Remarks: Groundwater not encountered during drilling.

Figure: 22

CMT ENGINEERING LABORATORIES

Drilled By: D&S Drilling
Logged By: James Curtis

Ten X Ranch

Forest Rd 302, Tusayan

Key to Symbols

Date: 3/8/18

Job #: 1079

① Depth (ft)	GRAPHIC LOG	③ Soil Description	④ Sample Type	⑤ Sample #	⑥ Blows(N)	⑦ Total	⑧ Moisture (%)	⑨ Dry Density(pcf)	⑩ Gradation			Atterberg		
									Gravel %	Sand %	Fines %	LL	PL	PI

COLUMN DESCRIPTIONS

Depth (ft.): Depth (feet) below the ground surface (including groundwater depth - see water symbol below).

Graphic Log: Graphic depicting type of soil encountered (see below).

Soil Description: Description of soils encountered, including Unified Soil Classification Symbol (see below).

Sample Type: Type of soil sample collected at depth interval shown; sampler symbols are explained below-right.

Sample #: Consecutive numbering of soil samples collected during field exploration.

Blows: Number of blows to advance sampler in 6" increments, using a 140-lb hammer with 30" drop.

Total Blows: Number of blows to advance sampler the 2nd and 3rd 6" increments.

Moisture (%): Water content of soil sample measured in laboratory (percentage of dry weight of sample).

Dry Density (pcf): The dry density of a soil measured in laboratory (pounds per cubic foot).

Gradation: Percentages of Gravel, Sand and Fines (Silt/Clay), obtained from lab test results of soil passing the No. 4 and No. 200 sieves.

Atterberg: Individual descriptions of Atterberg Tests are as follows:

LL = Liquid Limit (%): Water content at which a soil changes from plastic to liquid behavior.

PL = Plastic Limit (%): Water content at which a soil changes from liquid to plastic behavior.

PI = Plasticity Index (%): Range of water content at which a soil exhibits plastic properties (= Liquid Limit - Plastic Limit).

STRATIFICATION	
Description	**Thickness**
Seam	Up to ½ inch
Lense	Up to 12 inches
Layer	Greater than 12 in.
Occasional	1 or less per foot
Frequent	More than 1 per foot

MODIFIERS
Trace
<5%
Some
5-12%
With
> 12%

MOISTURE CONTENT
Dry: Absence of moisture, dusty, dry to the touch.
Moist: Damp / moist to the touch, but no visible water.
Saturated: Visible water, usually soil below groundwater.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS SYMBOLS	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 sieve size.	**GRAVELS** The coarse fraction retained on No. 4 sieve.	**CLEAN GRAVELS** (< 5% fines)	GW	Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
			GP	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
		GRAVELS WITH FINES (≥ 12% fines)	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS The coarse fraction passing through No. 4 sieve.	**CLEAN SANDS** (< 5% fines)	SW	Well-Graded Sands, Gravelly Sands, Little or No Fines
			SP	Poorly-Graded Sands, Gravelly Sands, Little or No Fines
		SANDS WITH FINES (≥ 12% fines)	SM	Silty Sands, Sand-Silt Mixtures
			SC	Clayey Sands, Sand-Clay Mixtures
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 sieve size.	**SILTS AND CLAYS** Liquid Limit less than 50%		ML	Inorganic Silts and Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with
			CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean
			OL	Organic Silts and Organic Silty Clays o f Low Plasticity
	SILTS AND CLAYS Liquid Limit greater than 50%		MH	Inorganic Silts, Micacious or Diatomacious Fine Sand or Silty Soils
			CH	Inorganic Clays of High Plasticity, Fat Clays
			OH	Organic Silts and Organic Clays of Medium to High Plasticity
HIGHLY ORGANIC SOILS			PT	Peat, Humus, Swamp Soils with High Organic Contents

Note: Dual Symbols are used to indicate borderline soil classifications (i.e. GP-GM, SC-SM, etc.).

SAMPLER SYMBOLS

- Block Sample
- Bulk/Bag Sample
- Modified California Sampler
- 3.5" OD, 2.42" ID D&M Sampler
- Rock Core
- Standard Penetration Split Spoon Sampler
- Thin Wall (Shelby Tube)

WATER SYMBOL

- Encountered Water Level
- Measured Water Level

(see Remarks on Logs)

1. The results of laboratory tests on the samples collected are shown on the logs at the respective sample depths.
2. The subsurface conditions represented on the logs are for the locations specified. Caution should be exercised if interpolating between or extrapolating beyond the exploration locations.
3. The information presented on each log is subject to the limitations, conclusions, and recommendations presented in this report.

CMT ENGINEERING LABORATORIES

Figure: 23

Ten X Residential Housing Project – Request for Proposal

HYBRID ELECTRICAL SYSTEM

EXHIBIT "C"

INSURANCE REQUIREMENTS

INSURANCE REQUIREMENTS

	Required Coverage	Required Policy Provisions, if any
Workers' Compensation and Employer's Liability Insurance	Subcontractor shall maintain workers' compensation insurance and such other forms of insurance which Subcontractor is required to maintain in order to comply with statutory limits under workers' compensation laws of any applicable jurisdiction in the United States (and any other location in which the Work is to be performed) including USL&H coverage (if any exposure exists), where applicable, and employer's liability (including occupational disease) coverage with limits of One Million Dollars ($1,000,000) per accident, One Million Dollars ($1,000,000) for disease, and One Million Dollars ($1,000,000) for each employee, which shall cover all of Subcontractor's employees, whether full-time, leased, temporary or casual, who are engaged in the Work.	- To provide that the insurer shall waive for the benefit of Contractor and Owner where permitted by law, all rights of subrogation against Contractor, Owner, their respective subsidiaries and Affiliates, co-venturers, or their directors, officers, members, managers, as well as their respective employees and/or agents of each.
Commercial General Liability Insurance	Subcontractor shall maintain commercial general liability insurance written on an occurrence basis in limits of One Million Dollars ($1,000,000) per occurrence and Two Million Dollars ($2,000,000) annual aggregate. Such insurance shall include coverage for products/completed operations, broad form/blanket contractual liability for written contracts, broad form property damage and personal injury liability, mobile equipment liability, premises/operations explosion, independent contractor liability, and collapse, and underground hazards coverage and hostile fire liability.	- To provide that the insurance shall waive any and all right of subrogation or recovery which the insurer may have or acquire against Contractor, Owner, their respective subsidiaries and Affiliates, co-venturers, or their directors, officers, members, managers, as well as the employees and/or agents of each. - To provide a severability of interest and cross liability clause. - That the insurance shall be primary and not excess to or contributing with any insurance or self-insurance maintained by Contractor. - To identify Contractor, Owner, their respective subsidiaries and Affiliates, co-venturers, and their directors, officers, members, managers, as well as the employees and/or agents of each, and any Financing Parties as additional insureds for their legal liability arising out of the operations of Contractor. This additional insured status shall apply regardless of the enforceability of the indemnity provisions in the Agreement. - With respect to coverage for completed operations under the general liability insurance, to be in place throughout the performance of the Work and either during all applicable warranty period(s) or for three (3) years after Final Completion of the Work, whichever is later.

Automobile Liability Insurance	Subcontractor shall maintain automobile liability insurance (including coverage for owned, non-owned, and hired automobiles) covering vehicles used by Subcontractor in connection with the Work in an amount of One Million Dollars ($1,000,000) combined single limit per occurrence for bodily injury and property damage. Subcontractor's automobile liability insurance coverage shall contain appropriate no-fault insurance provisions or other endorsements in accordance with Applicable Laws.	- To provide that the insurance shall waive any and all right of subrogation or recovery which the insurer may have or acquire against Contractor, Owner, their respective subsidiaries and Affiliates, co-venturers, or their directors, officers, members, managers, as well as the employees and/or agents of each. - To provide a severability of interest and cross liability clause. - That the insurance shall be primary and not excess to or contributing with any insurance or self-insurance maintained by Contractor. - To identify Contractor, Owner, their respective subsidiaries and Affiliates, co-venturers, and their directors, officers, members, managers, as well as the employees and/or agents of each, and any Financing Parties as additional insureds for their legal liability arising out of the operations of Contractor. This additional insured status shall apply regardless of the enforceability of the indemnity provisions in the Agreement.

Umbrella or Excess Liability Insurance	Subcontractor shall maintain umbrella/excess insurance on an occurrence basis covering claims in excess of the underlying insurance described in this Exhibit (exclusive of Workers' Compensation and Professional Liability Insurance), in the amount of Five Million Dollars ($5,000,000) per occurrence, and on a following-form basis.	- To provide that the insurance shall waive any and all right of subrogation or recovery which the insurer may have or acquire against Contractor, Owner, their respective subsidiaries and Affiliates, co-venturers, or their directors, officers, members, managers, as well as the employees and/or agents of each. - To provide a severability of interest and cross liability clause. - That the insurance shall be primary and not excess to or contributing with any insurance or self-insurance maintained by Contractor. - To identify Contractor, Owner, their respective subsidiaries and Affiliates, co-venturers, and their directors, officers, members, managers, as well as the employees and/or agents of each, and Financing Parties as additional insureds for their legal liability arising out of the operations of Contractor. This additional insured status shall apply regardless of the enforceability of the indemnity provisions in the Agreement. - To be in place throughout the performance of the Work and either during all applicable warranty period(s) or for three (3) years after Final Completion of the Work, whichever is later.
Sub-subcontractors Equipment, Tools Supplies and Materials	All other supplies, materials, consumables, tools, and equipment required for the Work (a) belonging to Subcontractor or to any of its Sub-subcontractors, whether owned, rented, leased or hired or (b) used by or on behalf of Subcontractor or any of its Sub-subcontractors for its performance hereunder, shall be brought to and kept at the Site at the sole cost, risk and expense of Subcontractor or such Sub-subcontractor, and Contractor shall not be liable for loss or damage thereto. Should such property be insured, said insurers shall waive rights of subrogation against Contractor, and any insurance premium costs for such insurance shall not be passed along to Contractor.	- That the insurance shall be primary and not excess to or contributing with any insurance or self-insurance maintained by Contractor. - To provide a severability of interest and cross liability clause.

Professional Liability Insurance	Subcontractor shall maintain professional liability insurance (errors and omissions) in connection with the Work (including all design and engineering activities) in an amount of Two Million Dollars ($2,000,000)	- To be in place throughout the performance of the Work and either during all applicable warranty period(s) or for three (3) years after final completion of the Work, whichever is later.
Deductibles on all Subcontractor's insurances in excess of Fifty Thousand Dollars ($50,000) shall be subject to Contractor approval (not to be unreasonably withheld or delayed).		