



SLOPE EVALUATION REPORT

QUAIL MESA- VIRGIN, UT

PARCEL ID: V-2-1-26-4421

PROJECT NO.: 4430.2200018.0000

SEPTEMBER 18th, 2022

Prepared for:

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EXECUTIVE SUMMARY

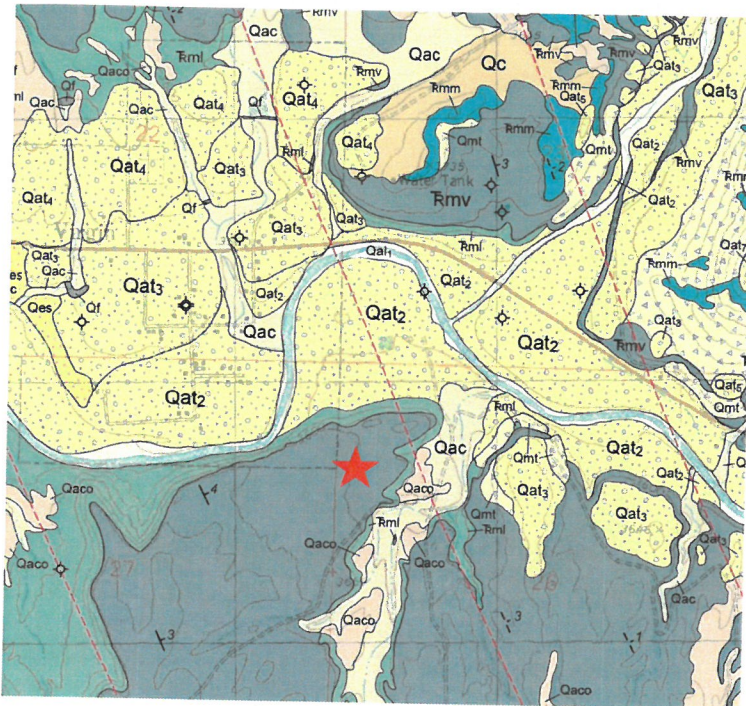
This report presents the results of our slope stability evaluation and field observations for the project site (V-2-1-26-4421), known as Quail Mesa, located in Virgin, UT. The project site consists of an undeveloped lot approximately thirty-five (35) acres in area. It is our understanding that a new development of rental properties of wood-framed construction will be built on site. The general location of the site is shown in the attached Vicinity Map.

The purpose of our services was to provide information and slope stability recommendations relative to the Town of Virgin Municipal Code. In accordance with Chp. 8, Sec. 12 of the Municipal Code, we understand that no slopes greater than 30 degrees shall be developed. UES constructed a Digital Elevation Model (DEM) of the property delineated the area of the property considered to be undevelopable according to the ordinance and recommended building setbacks. We found the developable area of the lot to be no more than approximately 15 acres.

GEOLOGIC CONDITIONS

The project site is located in southwest Utah approximately 1,500 feet north of the Virgin River atop a natural mesa formation. The top of the mesa is approximately 100 ft. above the Virgin River valley to the north at an elevation of 3660 feet. The Town of Virgin is bounded on the west by the Pine Valley Mountains which were formed during a 20-million-year period of volcanic activity. To the west is the Hurricane Fault which defines the western edge of the Colorado Plateau, which encompasses a large area of southeast Utah, southwest Colorado, northeast Arizona and northwest New Mexico. The Colorado Plateau was uplifted between 70 and 30 million years ago due to tectonic activity. The surficial geology of the Virgin consists mainly of Quaternary alluvial deposits from the Virgin River.

The geology of the area is described by the USGS Virgin, Utah 7.5 minute quadrangle, which is shown below in **Figure 1** (Hayden, J.M. and Sable, E.G., 2008). The uppermost portion of the mesa is capped by the Virgin Limestone Member (TRmv- *Grey*) while the slope is comprised of the underlying Lower red member (TRml- *Olive Green*). As noted in Figure 1, the Lower red member is a "slope forming" unit composed of relatively weaker mudstones, siltstones, and sandstones.



Rmv **Virgin Limestone Member (Lower Triassic)** – Three distinct medium-gray to yellowish-brown limestone ledges interbedded with nonresistant, moderate-yellowish-brown, muddy siltstone, pale-reddish-brown sandstone, and light-gray to grayish-orange-pink gypsum; limestone beds are typically 5 to 10 feet (1.5-3 m) thick and contain five-sided crinoid columnals and *Composita* brachiopods; upper contact is drawn at the top of the highest limestone bed; deposited in shallow-marine environment (Dubiel, 1994); 145 feet (44 m) thick south of Hurricane Mesa; generally 100 to 130 feet (30-40 m) thick.

Rmi **Lower red member (Lower Triassic)** – Moderate-reddish-brown siltstone, mudstone, and fine-grained, slope-forming sandstone; locally, the color of the lower part is irregularly altered to yellowish-orange probably due to hydrocarbon migration; generally calcareous and has interbeds and stringers of gypsum; ripple marks and small-scale crossbeds are common in the siltstone; upper contact drawn at the color change from moderate-reddish-brown siltstone of the lower red member to moderate-yellowish-brown, muddy siltstone, typically about 3 feet (1 m) thick, which underlies the base of the first limestone ledge of the Virgin Limestone Member; deposited in tidal-flat environment (Dubiel, 1994); about 250 feet (75 m) thick.

Figure 1: Hayden, J.M. and Sable, E.G., 2008, *Geologic map of the Virgin quadrangle, Washington County, Utah*, Utah Geological Survey, Map 231, 1:24,000. The general location of the project site is marked by the red star.

A field investigation performed by UES found the site geology to be consistent with the description noted by Hayden and Sable (2008). The mesa is capped by an erosion resistant limestone unit with an estimated minimum thickness of 6 to 12 inches. The limestone is fractured by a pair of vertical conjugant joints trending 160° (Southeast) and 220° (Southwest). Vertical joints can be found extensively in the sandstones of the Colorado Plateau and are the result of regional tectonics processes. Additionally, valley side joints were observed near the cliff face. These joints are characterized by their curvilinear nature and presence along valley walls. These joints form due unloading and the loss of lateral confining pressure during valley formation. Both joint systems are shown in Figure 2, which illustrates the joint systems studied within Zion National Park. The underlying formation comprising the mesa slope was found to consist of relatively weak, thinly bedded siltstones, mudstone, and shales.

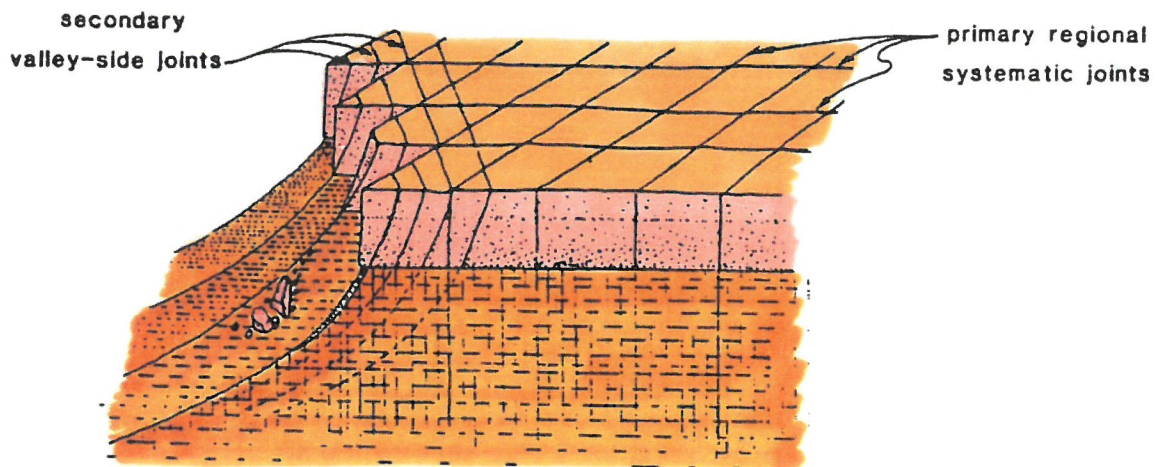


Figure 2: Schematic drawing illustration primary and secondary joint systems found within Zion National Park, UT; taken from an overview of research by J. David Rogers (1982) https://web.mst.edu/rogersda/phd_research/zion_np.htm.

In our opinion, we believe the primary slope forming mechanism at the project site to be due to undercutting of the *Virgin Limestone* by the erosion of the relatively weaker *Lower red member*, as evident in **Photos 3** through **5**. Furthermore, this process is hastened due to the intersection of the conjugant joint sets and valley side joints, which can result in wedge failures as the underlying material erodes, as shown in **Photo 4**.

SLOPE EVALUATION

Based upon our understanding of the Town of Virgin Municipal Code (Chp. 18, Sec. 2), no land designated as “unsuitable” shall be developed. We understand that steep slopes greater than the 30% fall within this classification.

To delineate the area suitable for development based upon these criteria, UES constructed a Digital Elevation Model (DEM) of the parcel using using 0.5m LiDAR elevation data. Slopes greater than 30% were then identified from the DEM and deducted from the developable area of the parcel. In addition, building setbacks from the slope were also subtracted from the developable area. UES evaluated both the minimum building setback in accordance with the 2018 International Building Code (IBC), which we determined to be approximately 33 feet, and a recommended building setback of 50 feet. Due to unregulated nature of the mesa cliff, as well as the presence of the joint systems and potential for wedge failure, we recommend the latter value for occupied buildings developed on the mesa top. Our map of developable area for this property is provided as an attachment to this report. Furthermore, upon request, UES is available to provide GIS data and files of the developable area.

In addition, UES provides the following general recommendations to maintain the stability of the mesa slope:

- Water discharge on the mesa top—including but not limited to septic systems, irrigation, and stormwater—should be avoided.
 - Stormwater drainage should be directed to the streambed to the south which feeds to Cornelius Wash and the Virgin River to the northeast
 - We recommend the use of Xeriscaping to minimize or eliminate the need for irrigation
 - Septic systems should not be placed on the mesa top; placement priority should be given to the wash to the southeast or the bottom of the mesa slope to the north

- Cantilever structures are not recommended without further geotechnical study.

OTHER SERVICES

Upon request, UES may provide GIS data or other files related to the property site and the developable area provided in this report.

UES should be retained to provide a general review of final design plans and specifications in order that grading and foundation recommendations may be interpreted and implemented. In the event that any changes of the proposed project are planned, the conclusions and recommendations contained in this report should be reviewed and the report modified or supplemented as necessary.

The analyses and recommendations in this report are based in part upon data obtained from the field exploration. The nature and extent of variations beyond the locations of the explorations may not become evident until construction. If variations then appear evident, it may be necessary to re-evaluate the recommendations of this report.

CLOSURE

Our professional services were performed using the degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers practicing in this or similar localities. No warranties, either expressed or implied, are intended or made. We prepared this report as an aid in design of the proposed project. This report is not a bidding document. Any contractor reviewing this report must draw his own conclusions regarding site conditions and specific construction techniques to be used on this project.

UNIVERSAL ENGINEERING SCIENCES

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Staff Geologist



Attachments:

- Vicinity Map
- Photographs
- Developable Area Map



The presented layers were obtained from various sources including ESRI, USGS, USDA, CCBD GISMO, CCFCD, GIS User Community among others. The GIS information is presented for reference only. No warranties, either expressed or implied, are intended or made. If you have any questions regarding this information, please contact UES.

Universal Engineering Sciences	PROJECT: Slope Stability Report Quail Mesa Virgin, UT	VICINITY MAP	
	CLIENT: Mr. Jeff Lee- Trees Ranch LLC	PROJECT NO: 4430.2200019	FIGURE NO: 1

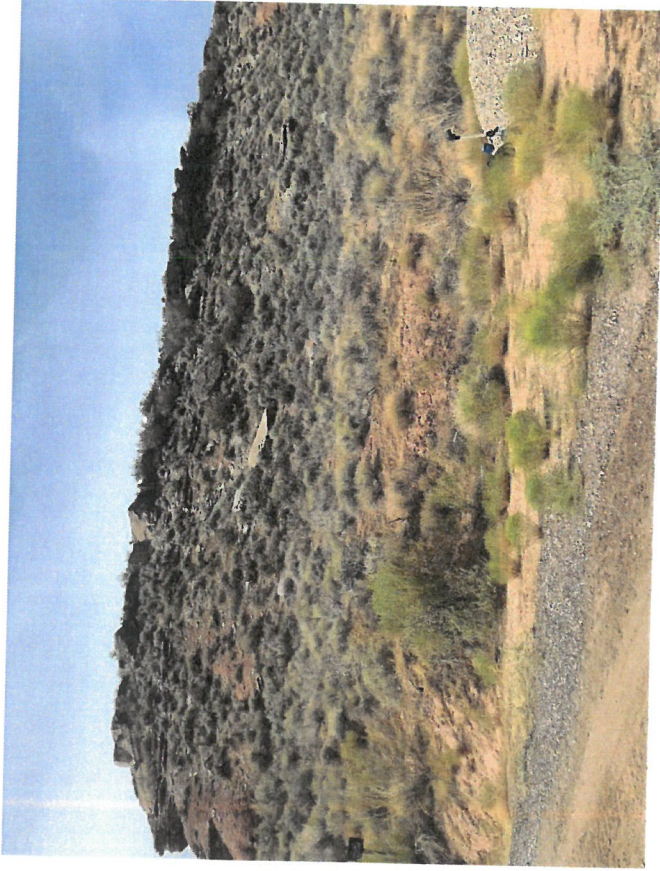


Photo 1: Entrance of Quail Mesa looking to the southwest



Photo 2: View of the mesa from the base of the slope looking southwest

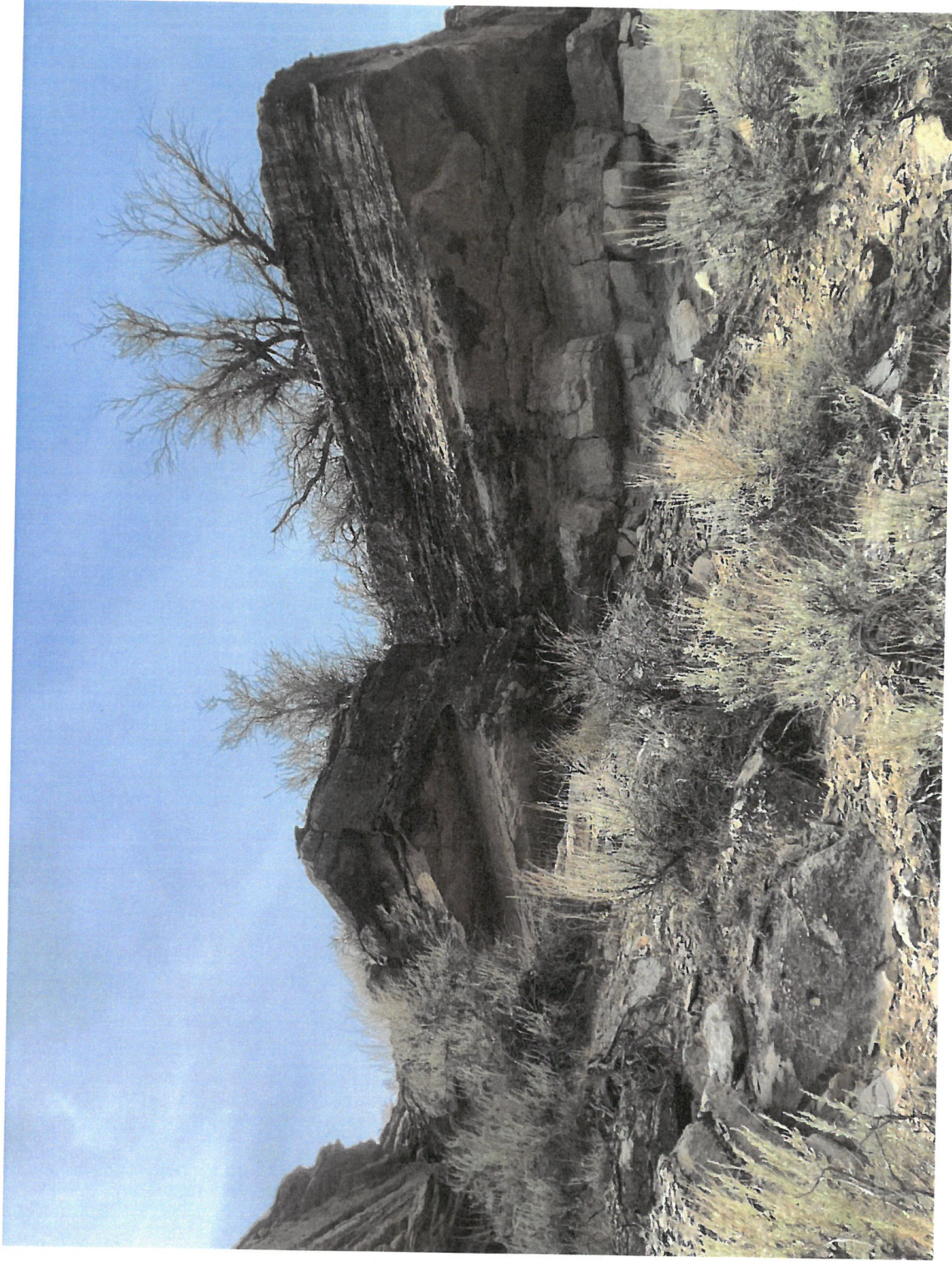


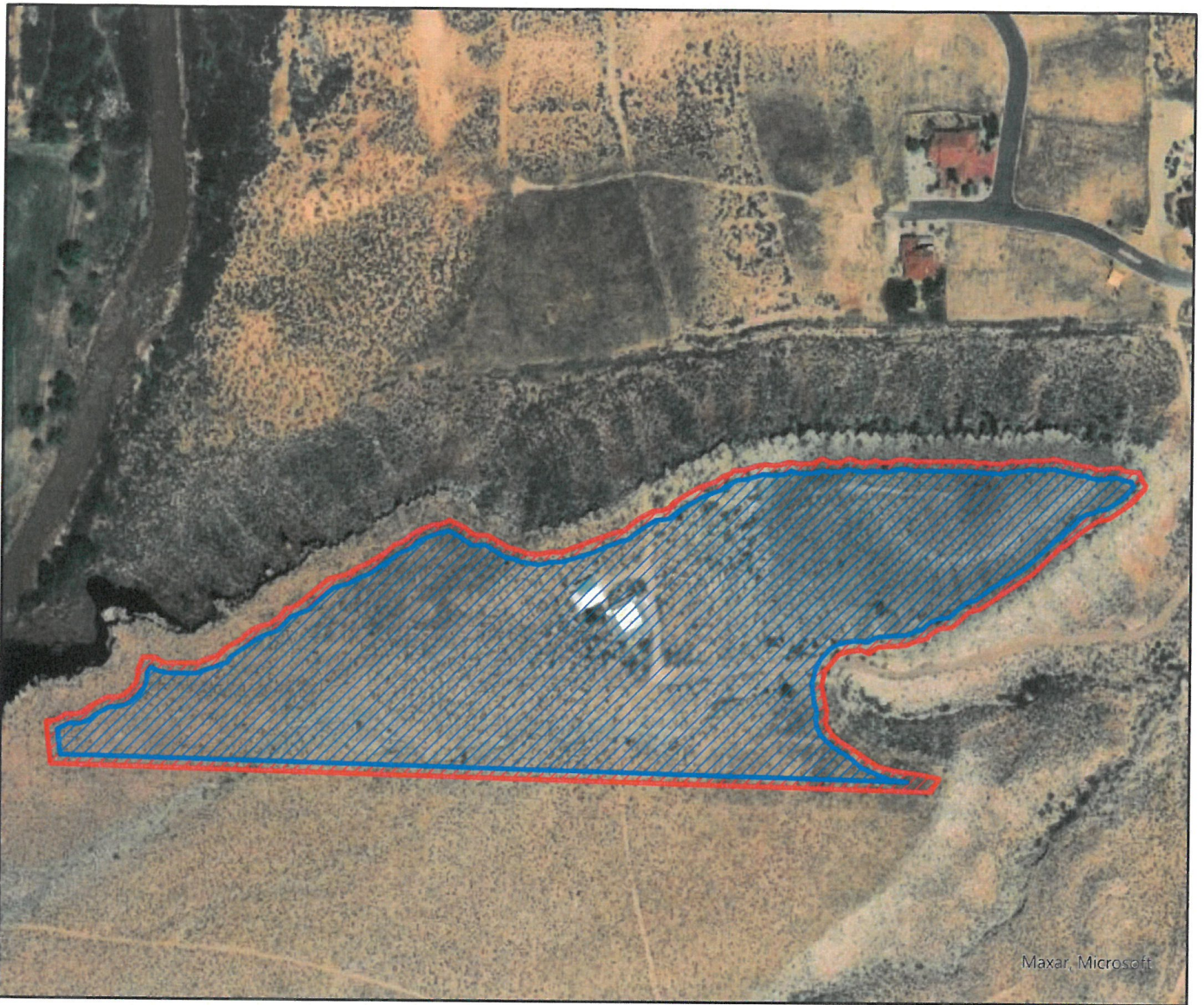
Photo 3: View from near the top of the mesa slope looking up towards the *Virgin Limestone*. Wedge failures are apparent within the interior of the cognate joints.





Photo 4: View from near the top of the mesa slope looking parallel to the cliff face. Apparent valley-side joints can be seen in the *Virgin Limestone*.



Photo 5: Undercutting of the relatively weak formation beneath the *Virgin Limestone*.



Legend

-  50 ft Setback
-  33 ft Setback



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Universal Engineering Sciences	PROJECT:		Quail Mesa Development Area	
	Quail Mesa			
	CLIENT:	Mr. Jeff Lee Tree Ranch LLC	PROJECT NO: 4430.2200019	FIGURE NO: 1