NORTHERN ARIZONA UNIVERSITY

College of Engineering, Forestry & Natural Sciences

CENE 486C - 100% Final Design Report

Montezuma Castle National Monument Parking Lot Addition & Redesign

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MTE

Table of Abbreviations

ADA: Americans with Disabilities Act
CSP: Corrugated Steel Pipe
FEMA: Federal Emergency Management Agency
FHA: Federal Highway Association
FHAUDM: Federal Highway Association Urban Design Manual
GIS: Geographic Information System
GPS: Global Positioning System
Hr.: Hour
LIDAR: Light Detection and Ranging
Min.: Minute
MCNM: Montezuma Castle National Monument
MTE: Multicultural Technical Engineers
NOAA: National Oceanic and Atmospheric Administration
NPS: National Park Services
RV: Recreational Vehicle
SWPPP: Stormwater Pollution Prevention Plan

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Acknowledgments

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1.0 Project Introduction

Montezuma Castle National Monument is located in central Arizona off the Interstate 17 Highway and is 5 miles north from the City of Camp Verde and is located along Beaver Creek. Figure 1 displays the location of Montezuma Castle National Monument in Arizona. Figure 2 displays the parking lot to be redesigned. The team will closely be working with the National Park Service for this project. Our point of contact, Richard Goepfrich Jr., is the facility manager at Montezuma Castle, has the following concerns about the existing conditions of the visitor parking lot: poor striping and signage, no accessible picnic area for visitors, poor pedestrian facilities, no bus drop off area, and insufficient space for large quantities of buses/RV's and passenger cars. Due to these limitations, the parking lot gets to maximum capacity and visitors are forced to park on the road shoulder during busy visitation days or even turned away from the site. Frequently, buses have to idle at the Cliff Castle Casino approximately 2.7 miles away. With rapid growth rate for the park parking lot is currently insufficient for the needs of the national monument.

Figure 1: Statewide view of Montezuma Castle National Monument in Arizona

Figure 2: Parking Lot to be Redesigned

1.1 Project Objectives

The objectives of this project are to:

- Provide a design for improved parking lot layout through a striping and signage plan.
- Provide a design for a new bus, RV, and overflow parking lot.
- Provide a design for bus drop off zone in the existing parking lot.
- Provide a design for additional sidewalks for pedestrian usage.
- Provide a plan to increase sidewalk usage through improved pedestrian facilities including striping and signage.
- Design a usable and accessible picnic area in the existing center island with an interior sidewalk.
- Verify that proposed changes do not affect the archaeological, ecological, and natural characteristics of the surrounding area through following applicable codes.
- Maintain the existing road alignment that enters/exits the park.
- Determine if a controlled intersection is required for safety of traffic leaving the monument and parking lots.

The intent of this project is to improve the overall accessibility of the Montezuma Castle National Monument parking lot in accordance with the Federal Highway Administration (FHA) design code and applicable ADA regulations. These improvements are: to provide more parking spaces reflective of the traffic flow and projected growth of the site, design a picnic area that will be available for visitors, improve pedestrian facilities within the parking area, and provide better accommodations for large vehicles with a drop off zone and additional parking facilities.

1.2 Project Understanding

The following sections will provide background on Montezuma Castle National Monument, the current conditions of site, and technical aspects for this project.

1.2.1 Site Background

Montezuma Castle is home to some of the most magnificent cliff dwellings made of local clays, wood, and stone created by the Sinagua people. Estimated to be nearly 800 years old, the structure consists of 45 – 50 rooms that are hidden in the side of the cliff walls. A significant amount of artifacts found within the ruins of the once thriving culture and are now on display at the visitor center of the park [1]. Since Montezuma Castle is in a relatively hidden location it quickly became an adventure from reality for many. On December 8, 1906, Montezuma Castle was officially registered as a National Monument under the authority of President Theodore Roosevelt. Since then it has continued to attract visitors and grow as a landmark of the Southwest.

The peak visitation months for the park are March, April, and October which is demonstrated in Figure 3. These months attract visitors for their cool, moderate temperature compared to alternate times of the year. The most popular month for the sight was March at 52,776 visitors in 2016. The lowest three months are December, January, and August, mainly because they offer the harshest of temperatures from both freezing to heat. The least visited in a month was December at 21,874 visitors. These counts include employee, non-recreational and recreation vehicles on top of the passenger car total.

Figure 3: Number of Visitors of Montezuma Castle per Month

1.2.2 Site Description

Montezuma Castle National Monument (MCNM) is a National Monument under National Park Service (federal) jurisdiction. The site is known for the cliff dwellings and is also k for the large

amount of rooms this dwelling has. The site is used for educational and destination visits from local and tourists. The access to the site is on a single two lane road that comes from the east and south into the current parking lot. National Park Services is proposing a new parking lot to the south of the current drive and parking lot. Site improvements for this project will include a new parking lot, picnic area, sidewalks and water mitigation.

The parking lot is currently in the shape of a tear drop and is equipped with 60 regular parking spaces, four ADA parking spaces, and four large spaces available for buses/RV's with a small vegetation area in the center. Being that buses/RV's share the parking lot with passenger cars, it is difficult for large vehicles to safely navigate the tear-dropped shaped bend due to their high turning radii, which poses safety threats to passengers and visitors. Pictures of the existing conditions of the site are shown in *Figure 4.*

Figure 4: Existing Site Features

The surrounding topography of the existing parking lot is steep and leads to Beaver Creek, a nearby stream, flows into the Verde River southwest of the site. All existing runoff from the impervious surfaces of the existing parking lot currently flow into Beaver Creek. To assist in the comprehension of the features on site, an existing site schematic has been prepared and it available in Appendix I. The schematic conveys existing passenger car parking, bus/RV parking, the vegetation area, the existing intersection, and beaver creek which runs adjacent to the site. The site schematic was developed in BlueBeam Revu.

1.2.3 Technical Aspects

The project has several aspects that will require technical expertise. These technical aspects include: surveying, drainage analysis, drafting, and complying with regulations/codes, which the primary areas of focus.

1.2.3.1 Site Survey

A topographic site survey was done using GPS survey equipment this critical because of the precarious location of the site and its unconventional arrangement of natural features. The boundaries of the existing parking lot were found to be steep which was found by the 350 points taken from the survey which explains the unorthodox design. This could potentially cause problems for the new proposed parking lot. It will be important to get precise topographic information to have a clear understanding of the existing conditions.

1.2.3.2 Drainage Analysis

A drainage analysis of the site involved considering the changes in impervious area and determining the effect of storm water flow as a result of the proposed design. The site is a National Monument and therefore site design will be under federal jurisdiction, specifically the Federal Highway Administration. For this site, it could become challenging as there is a nearby water source where drainage will end up unless directed elsewhere. If the governing requirements do not allow storm water to drain to this nearby river, a detention basin may have to be designed to accommodate drainage. There could be potential need for an environmental study evaluating the runoff, which will have to fall outside of the scope of this project.

To assist in the Hydraulics and Hydrology analysis of the site, the team will contact the GIS department in Yavapai County. The team will seek recent LIDAR data in the area which will improve the Hydraulics and Hydrology analysis.

1.2.3.3 Site Plan Design

Design software such as AutoCAD and Civil 3D will be critical to delivering the final set of construction documents for this project. This construction documents will convey the complete Site Plan Design. Ultimately the goal is to produce a set of plans that can effectively show the proposed changes to the site. The team will have to rely heavily on survey and drafting skills to produce an acceptable set of plans. The complete set of plans will include: a cover sheet, a details sheet, a grading/drainage sheet, two improvement sheets, a horizontal control sheet, and a SWPPP Plan. The grading/drainage sheets will convey new surfaces and vertical control along with proposed storm drainage containment. The improvements sheets will convey new striping and signage along with any new curbs, gutters, sidewalks, a drop off zone, pedestrian facilities, and any demolition needed to the existing lot.

1.2.3.4 Governing Regulations and Codes

The site is in an interesting jurisdictional position. Though it lies in Yavapai County, research indicates that the National Monument is on federal land. Therefore, all components of the design will be compliant with federal standards. Specifically, the Federal Highway Administrative codes [2]. In design, it is important to have a set of codes to abide by that give direction to the general development of the site.

1.2.4 Potential Challenges and Limitations

The following section discusses the potential challenges the team will encounter during the project. Firstly, the leading challenge the team will face is coordination of all schedules. The team contains six members, which is 1.5 times the typical capstone team. Coordinating each other's schedules to where all members can meet at one time will present problems. For example, conflicting class schedules and work schedules will make meeting times difficult. Secondly, a prominent potential challenge is travel constraints. Montezuma Castle National Monument is located 53 miles south of Flagstaff. Not all team members have access to a personal vehicle, therefore this will make site visits more difficult. Minor challenges for the group include harsh weather impacts and limiting factors of the department such as building availability, limited computer availability, and other resource availability such as survey equipment.

2.0 Technical Analysis

The following sections will provide insight on all of the technical design work that is required to be completed for this project.

2.1 Field Work

The following subsections will discuss the field work that be performed for preliminary design.

2.1.2 Site Reconnaissance and Analysis

Prior to any design that was chosen the team familiarize themselves with the site and its surrounding features. Multiple site visits were necessary to gain that knowledge. During the site visits, included a site survey and a traffic observation, along with several coordination meetings with the client.

2.1.3 Site Survey

The team conducted a site survey and collected a total of 300 points to make our topographic map. The team reached out to Yavapai County GIS and was able to receive LIDAR data for the entire Montezuma Castle National Monument. The LIDAR was used for all our drafting and analysis.

2.2 Hydrology & Hydraulics Summary

This site currently drains to the south and west and is channeled into Beaver Creek. The hydrology basins are smaller than 200 acres and the existing structures show no sign of lack of efficiency. The proposed drainage will follow the existing drainage patterns.

This project site is located within Zone X of FEMA FIRM Map #04025C2180H effective October 16, 2015. Zone X is described as areas determined to be outside the 0.2% annual chance floodplain. The FEMA map is provided in Appendix A.

The Rational Method was used to determine peak discharge rates for the pre and post-development conditions. Topographic and boundary information was provided by Yavapai County Geographic Information Systems, dated in 2014, were used for analysis. Rainfall data was taken from National Oceanic and Atmospheric Administration (NOAA). Soil information was taken from the NRCS Web Soil Survey website and is proved in Appendix B. The site plan is prepared by Multicultural Technical Engineers and was used to determine the additional impervious areas proposed with the development. Appendix C includes a drainage exhibit which illustrates the drainage patterns and proposed site improvements.

2.2.1 Pre-Development Conditions

2.2.1.1 Procedure of Pre-Development Conditions

The existing runoff is concentrated through two concentration points. Drainage Basin A (DB-A) is located north of the access road and is approximately 5 acres. The Concentration Point A (CP-A) is concentrated through a 15 inch CSP culvert (N/S) that crosses the access road (E/W) and is allowed to naturally run to Beaver Creek to the southwest. This has provided a natural stream to form and deposit water in a low sloped ground where the channel disappears and allows the water to seep into the ground prior to reaching Beaver Creek. Drainage Basin B (DB-B) is located south of the access road and is approximately 8 acres and has a Concentration Point B (CP-B) that sheet flows and natural channels to Beaver Creek to the southwest. There is no definite channel to Beaver Creek but the existing topography shows that the water flows to it. Both of these basins and points were used to determine the pre-development peak flow rates.

There is no evidence that water flows making it from the most upper part of the basin to Beaver Creek. This was determined by extensive topography review and a site walk. There was also no evidence that the existing infrastructure was underperforming or required maintenance.

2.2.1.2 Results of Pre-Development Conditions

DB-A has a net area of 5.51 acres. The Weighted C was calculated by taking the area (4.89 acres) of natural landscape (C = 0.3) and the area (0.62 acres) of impervious area (C = 0.95) and giving a weighted average of 0.373 because there is significantly more natural landscape than impervious area. The flow from DB-A for the 100-year storm is 7.80 CFS. When analyzing CP-A the use of Culvert Master was used. With a flow of 7.80 CFS through a 15 inch corrugated steel pipe (CSP) provides an exit velocity of 13.3 FPS. The velocity exiting the CSP is significant and is considered to be an extreme scour velocity that has the potential of destroying landscapes/ property.

DB-B has a net area of 12.98 acres. The Weighted C was calculated by taking the area (12.73 acres) of natural landscape (C = 0.3) and the area (0.25 acres) of impervious area (C = 0.95) and giving a weighted average of 0.31 because there is significantly more natural landscape than impervious area. The flow from DB-B for the 100-year storm is 5.30 CFS.

2.2.2 Post-Development Conditions

2.2.2.1 Procedure of Post-Development Conditions

The proposed site grading in the post-development condition will not change the size of either drainage basins. DB-A will be unchanged in size and in surface types. DB-B will be unchanged in size but will have an increase in impervious area due to the addition of a parking lot with associated sidewalks. The drainage with not change within the parking lot with the proposed picnic area because the addition of sidewalk is minimal considered the overall size of the drainage basin and will be mitigated through the addition of landscape and proper grading. The overall post-development peak runoff will be increased due to the addition of impervious area with no change in the overall drainage base size.

DB-A is routed under the access road via CSP and will be routed through DB-B with an open channel to Beaver Creek. The open channel will include the runoff from DB-A and DB-B.

The Federal Highway Administration Urban Design Manual does not provide applicable moments when a detention basin is required. If the site was located in a municipality a detention pond would be heavily designed and be required for implementation. Multicultural Technical Engineers recommends an implementation of a Low Impact Development basin or a detention basin. Team will provide a simple and conceptual detention basin that will be required to be heavily analyzed.

As stated above a detention basin will be recommended for implementation. Computer software was used to analyze the pre- and post-condition runoff. A modified rational method was used with a user defined IDF Table provided by NOAA. The software takes the pre-development site and compares it the post-development site once asphalt was added and determines the total volume is needed to be stored.

2.2.3 Results of Post-Development Conditions

DB-A did not change in size or in surface types. The amount of flow through CP-A is 7.80 CFS with 13.3 FPS.

DB-B did not change in size but there was an increase of impervious area by 1.45 acres. Using the Rational Method again the net flow with additional impervious area is increased to 7.00 CFS.

DB-A and DB-B will be drained into a single open channel and deposited through CP-B at Beaver Creek. Flow Master was used to determine the normal depth and velocity of the channel. In Appendix C includes the generated reports for each section of the channel including the culvert. The amount of freeboard through the channel is 1 to 3 feet. The depth is between 0.28 and 0.9 feet. The velocities are between 10.66 to 3.0 FPS. The channel flow was increased from 7.8 CFS to 10.8 CFS as the channel moves southeast to Beaver Creek.

The proposed parking lot will be graded to drain to the open channel. There is locations where water will be graded to drain within proposed green spaces to help alleviate the amount of water to the channel but the channel will be designed to hold the entire amount. The green spaces will include existing vegetation or vegetation the client believes will survive. MTE does not hold responsibility or liability for plant specifications/ locations and types for the area of the green spaces.

A detention basin was determine to have a total storage of 0.184 acre-ft (~8000 ft^3). This storage is approximately 3 large swimming pools. The detention basin will take place to the south of the parking lot and be routed to the proposed channel.

2.3 Traffic Analysis

The following subsections will discuss the traffic analysis involved in this project.

2.3.1 Vehicle Type

A traffic analysis in relation to the types and amount of vehicles visiting Montezuma Castle National Monument was conducted on Saturday, February 3, 2018. The analysis took place between 9AM and 11AM, for a total of two hours during a special event at the site in an attempt to observe a period of activity. The study was conducted at this time because it was concluded as peak visitation for the park. The most common vehicle type was passenger cars. Other vehicle types include: buses, recreational vehicles, and motorcycles. Using the data from the 2-hour period, the business hours of the National Monument (8AM - 5PM), estimates for the number of vehicles parking at the National Monument for a typical business day were calculated. A summary of the raw and calculated data can be found below.

Table 1: Summary of Types and Amount of Vehicles

Vehicle Type	Vehicles in study period	Projected Vehicles in Business Day (8am-5pm)
Passenger Car	85	383
Bus	2	9
Recreational Vehicle	1	5

Motorcycle	1	5

*Values calculated off 2-hour period (9am-11am).

2.3.2 Vehicle Duration

A vehicle duration study was conducted on the same day, Saturday, February 3rd, 2018. The study took place from 9AM - 11AM. The study consisted of observing 60 vehicles from the time they entered the parking lot and ended when they left. Vehicles were identified by their make and model and observed to determine the average length of visit. This data can be used to make conclusions for how many cars would need to be in the parking lot at a given time. This will assist in the determination of the number of parking spots for the new proposed parking lot. Our results conveyed that most visitors were in the park for about 45-60 minutes. To maximize the capacity of the parking lot, 60 minutes will be used for design. The figure below graphically displays the data collected for the general duration vehicles are at the park on a peak day.

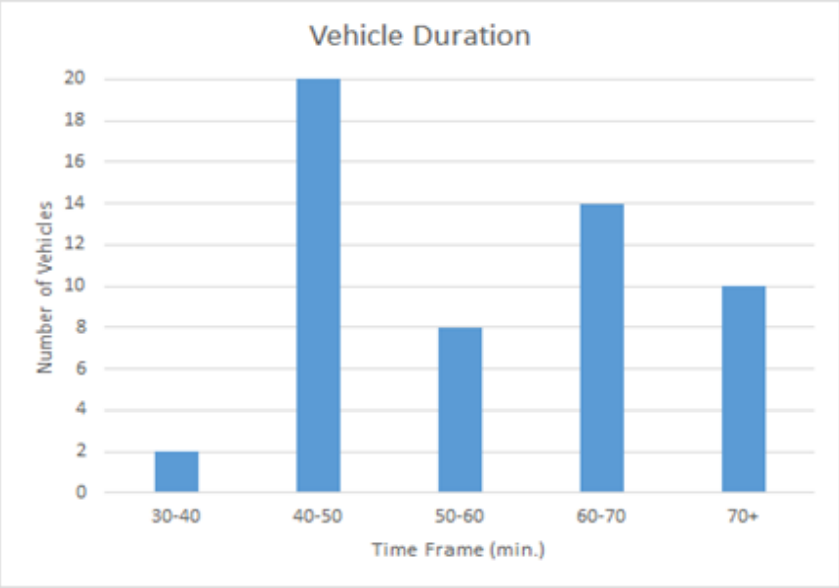

Figure 5: Visitor Travel Duration

2.3.3 Stopping Sight Distance and Turning Movements

The team analyzed the stopping sight distance and turning movements. Stopping sight distance is the sum of two values, the time it takes a driver to see and react to an approaching obstacle, and the time that it takes for the driver to safely stop at the posted speed. The driver should be able to see the full stopping distance required to safely react to their situation. Horizontal curve requirements are mandated by the American Association of State Highways and Transportation

Officials' Policy on Geometric Design of Highways and Streets, which establishes a relationship between speed and the radius of curvature.

The project involves the remodel and redesign of the parking lots that terminate Montezuma Castle Road. Since design is confined to the parking lots, the project limits are not beyond the service road and therefore stopping sight distance was not a consideration for the design of the parking lot. In a full traffic study of the roadway, it should be considered. The figure below shows a horizontal curve at the entrance to the parking lot that could prove to be an example of inadequate stopping sight distance upon further analysis.

Figure 6: Stopping Sight Distance Example

Turning movements also need to be observed to determine appropriate signage at intersections within the project limits. The intersection of the service road (minor) and Montezuma Castle Road (major) is the only intersection within the project limits. With existing signage, the minor approach has a stop sign and the major approach is a through movement. During a site visit one vehicle was observed turning from the minor roadway onto Montezuma Castle Road. Information from the client suggests that the current purpose of the roadway is restricted to employees only and demand is concentrated around employees.

2.3.4 Pedestrian Movements

The team conducted a study regarding the number of pedestrians and usage of the sidewalks at the National Monument. This ran concurrent with the types and number of vehicles visiting the National Monument. During the two-hour period from 9AM to 11AM, observations would determine the number of visitors to the National Monument and whether they were using the sidewalks or walking in the middle of the parking lot.

Table 2 below summarizes the number of visitors within the two-hour study period and their walking patterns. Pedestrians were counted both entering and exiting the park. Using the percentage calculated from vehicle movements (70% entering, 30% existing) the same ratio was applied to determine the total visitors over the duration of the study. Estimates for the number of visitors during a full business day (nine hours) was applied to raw data.

Table 2: Types of Pedestrian Movements and Paths

Pedestrian Movement	Pedestrians in study period*	Projected Pedestrians in Business Day (8am-5pm)
Sidewalk	121	545
Asphalt	303	1364
Total Pedestrians (Total x0.7)	297	1336

*Values calculated off 2-hour period.

Of the pedestrian movements recorded, it was found that 71% of visitors at the national monument are not using the existing sidewalks and walking in the middle of the existing parking lot. This indicates that additional signage and sidewalks should be implemented into the parking lot remodel to make sure visitors are safe while they are in the site. The same concept is applied to the proposed parking lot design.

In relation to table above, there were numerous visitors arriving on buses during the 2-hour study period. The number of people within vehicles is significantly higher for buses than those who travel in passenger cars, RV's, or motorcycles. The number of visitors who arrived on buses is summarized in the table below. Bus visitors were excluded from the total pedestrian count above. Bus visitors will be accommodated with the proposed bus drop off zone.

Table 3: Number of visitors who arrived on buses.

	Pedestrians in study period	Projected Pedestrians in Business Day (8am-5pm)	Projected Pedestrians in Business Day with Safety Factor (1.3)
Bus Visitors	16	72	94

2.3.5 Parking Lot Demand and Expected Growth

The observed pedestrian data (Section 2.4.4) and vehicle type and duration (2.4.1-2) over the two hour time period can be used to make assumptions necessary to determine the required parking lot capacity. Using the total visitors (297) and the total passenger cars (85) the calculated visitors per passenger car is 3.49. 3 visitors/vehicle will be used for design. The projected passenger cars per day is 497 and the design duration is 60 minutes. Based on the "Park Statistics," the visitor traffic at Montezuma Castle is at its highest count [1]. The number of observed visitors do not accurately represent this value.

National Parks and Monuments are a growing attraction in the United States due to a number of different factors. The social media age has provided more exposure to some of the most sacred natural wonders in the country. As people live in an increasingly urban environment, the desire to spend time in a structured outdoor setting continues to increase. The global climate of terrorism is keeping United States visitors traveling within the country and more specifically away from man-made attractions, making a national park and monument vacation an even more appealing prospect. Several of the larger parks have seen a growth of 100% since 1980 [x]. This correlates to a growth rate of approximately 2.5% a year. Assuming the same growth rate for Montezuma Castle, and designing the parking lot for expected 10-year growth, a total growth of 25% will be applied to current visitor counts for the final design capacity.

The tables below show the calculations used to determine the capacity required be the remodel and proposed additional parking lot.

Table 4: Design Calculations by Vehicle Type

	Current Daily	**Daily w/ Growth**	**Peak (Design)**
		Current Daily x 1.25	Daily w/ Growth x 0.2
Passenger Cars	497	621	124
Large Vehicles	18	23	5
Motorcycles	6	8	2

Table 5: Additional Spaces Required

	Passenger Cars	Large Vehicles	Motorcycles
Existing	64	0	0
Needed Spaces	32	4	1

The peak hours for the national monument range from 10AM-1PM which was provided by the client. During these times, an even distribution of 60% of the total visitors of the day (20% of the daily total per hour) and a growth of 25%, the parking lot capacity needs to accommodate a total of 96 passenger cars, 4 large vehicles (buses and RVs), and 1 motorcycles. The existing parking lot holds 64 passenger cars. By taking the difference between what the parking lot must have minus what already exists on site, numbers for the new parking lot were calculated. Therefore, the new proposed parking lot must accommodate an additional 32 passenger car spaces, 4 large vehicle spaces, and 1 motorcycle space. Table 5 below conveys these numbers.

2.4 Site Design Components

The following subsections will discuss the design components of the proposed parking lot along with site signage and the proposed picnic area, drop off zone, and other design components.

2.4.1 Parking Lot Design

The parking lot design was chosen to be user friendly, aesthetic, and low in construction cost. The intent of the design was to optimize efficiency while minimizing costs associated with construction and maintenance. The final design has a footprint with very minimal change in topography, which will also reduce the costs associated with cut and fill of material to the site. This final design can be seen on Improvement Sheet 2 within the complete set of construction documents. The site gradually slopes to the south, which will assist in drainage. Because of this slope, water will have an easier time flowing downward off the parking lot. The parking lot has two proposed landscape areas that will have native plants. This will allow water to infiltrate this area which is beneficial to the surrounding vegetation. Additionally, a detention basin was designed and will be placed just off the lowest elevation point on the parking lot. There are proposed pedestrian facilities from the new lot to the park entrance, such as sidewalks, and crosswalks, as seen on the plans.

2.4.2 Site Layout & Site Signage Plan

To further the design process of the existing and proposed parking lots, a site layout equipped with an adequate signage plan was developed. The construction document containing the Site Layout & Site Signage Plan is located in the construction drawings within Improvement Sheets 1 & 2. Regarding specific elements of the lot, certain design aspects were implemented in order to keep

traffic flowing and avoid congestion. In the existing parking lot, the current bus parking has been converted into a 15-minute maximum loading and unloading zone. This will alleviate traffic build up from busses who will now be required to park in the new proposed lot. The currently roadway to the proposed lot currently restricts all access to the public. This restricted access will be eliminated so that all visitors can utilize the roadway to access the new parking lot.

The new parking facility was designed to be one way only, similar to the existing lot. There are two rows of passenger car parking and two separate areas designated for bus and RV parking only. There is one spot for motorcycle parking only. Visitors of Montezuma Castle National Monument will enter the newly designed lot from the south side and will exit from the north side.

There will be two "Restricted Area" signs that only permit employee access beyond those points so that the road can continue to maintain functionality for its existing purpose. There is an existing stop sign that will serve as sufficient intersection control. Larger vehicles have a much larger turning radii, therefore most of the large vehicles cannot safely navigate the right turn to return back up the main road to exit the property. Therefore, these vehicle types will be restricted from turning right to ensure safety of other vehicles. They will be required to turn left, travel through the existing parking lot, then continue straight to exit the monument.

Some of the existing signs will be kept such as, the speed limit of 15 MPH, and the "No Parking Anytime" signs that are placed on the sides of the main road. There are four existing ADA Spots in the existing lot. Four of the current passenger car parking spots in the existing lot will be converted into additional ADA spots in compliance with FHA Design Codes, resulting in minor restriping of the existing lot and eight total ADA spots at the front entrance.

2.4.3 Sidewalk Placement

Sidewalks will be placed adjacent to the parking spots and along the edge of the road leading to and from the visitor center. Additional sidewalk will need to be placed along the south side of the existing parking lot to the east of the bus drop off zone.

2.4.4 Bus Drop off

Adding the new lot will cause change for bus movement in the site which will convert the existing bus parking zone to be as bus loading zone. Buses will have to go through the existing parking lot then parked in the loading zone to load and unload visitors at the site. After unloading visitors, the buses will go to the proposed parking lot to park. When visitors done with their tours, buses will go through the existing parking lot then parked in bus loading zone to load visitors on. Buses will be forced to go through existing parking lot and will prevent from turning right when they exiting the new unit.

2.4.5 Picnic Area

A preliminary design of the proposed picnic area was developed using Google Sketch-Up. Per client request, the picnic area will replace the existing vegetation area in the existing parking lot. By adding a safe and accessible picnic area, this will in turn attract more visitors to Montezuma Castle. Figures 7 and 8 below display two viewpoints of the Google Sketch-Up draft of the picnic area.

Figure 7: Google Sketch-Up of Proposed Picnic Area looking from the Northwest to the South East of the lot (Front View)

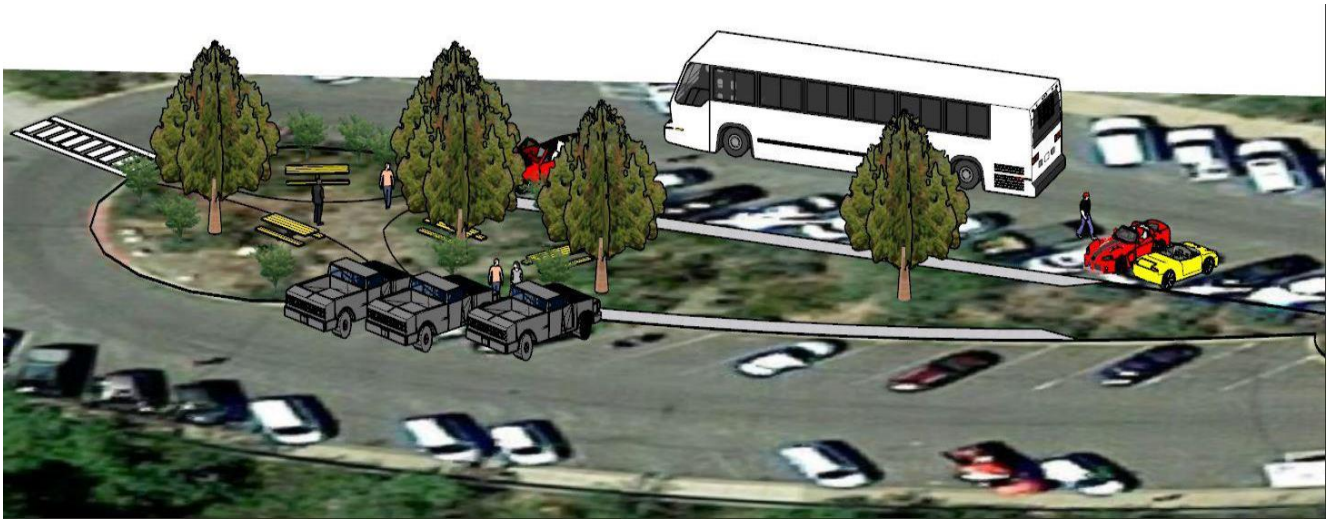

Figure 8: Google Sketch-Up of Proposed Picnic Area from the South end of the lot to the North (Side View)

As seen in the figure above, there are multiple picnic tables for the visitors to use. The four trees shown are indigenous to the property, thus, they will not be removed during the construction process, requested by the client. The proposed picnic area is safely accessible through the

implementation of a high visibility crosswalk near the visitor's center to the middle island. The picnic area is designed to hopefully draw visitors to the center island leads to walk and use the sidewalk to increase pedestrian safety. The sidewalks added to the island leading to the monument will therefore draw visitors to the safety of the sidewalks and away from the center of the drive aisle, which is the current preferred pedestrian route. To preserve the landscape the sidewalk is only along the outside rim of the island and then cuts through the picnic area to the cross walk.

2.5 Cost of Implementation

The cost of construction was calculated with an Engineers Estimate of Probable Cost (EOPC) as demonstrated in Table 5. The cost is calculated by determining a dollar amount per unit and quantifying each unit. The construction portions of the project including demolition, new construction, Drainage, and SWPP are the construction cost giving this portion of the project a total of $1.375 million dollars. The full Engineering Estimate of Probable Cost can be seen in the appendix.

Table 6: Engineering Estimate of Probable Cost

ENGINEERING ESTIMATE OF PROBABLE COST (EOPC)					
KEYNOTE	**TITLE**	**QUANTITY**	**UNIT**	**COST/UNIT**	**TOTAL**
101	Clear and Grub	5135	SY	$35.00	$179,725.00
102	Remove and Dispose Existing Asphalt	550	SY	$30.00	$16,500.00
103	Remove and Dispose Existing Curb and Gutter	20	LF	$55.00	$1,100.00
200	Earthwork (Net Fill)	660	CY	$105.00	$69,300.00
211	Type A Asphalt Pavement (4" AC/ 8" ABC)	4355	SY	$108.95	$474,477.25

212	Type A Concrete Pavement (9" PCC/ 12" ABC)	2300	SF	$65.00	$149,500.00
213	Type A Concrete Sidewalk (6" PCC/ 4" ABC)	2900	SF	$50.00	$145,000.00
214	Type A Curb and Gutter	850	LF	$45.00	$38,250.00
215	Landscaping Per Grading Plan	1450	SF	$20.00	$29,000.00
216	Crosswalk Pavement Markings	250	LF	$18.00	$4,500.00
217	4" White Painted Parking Line Per Detail 3.04	1600	LF	$4.50	$7,200.00
218	Convert Normal Stall to ADA Parking	6	EA	$1,250.00	$7,500.00
220	Install Sidewalk Ramp MAG STD 236-2	1	EA	$2,500.00	$2,500.00
221	Install 4" Thick 1/4" Minus Decomposed Granite	607	SF	$21.00	$12,747.00
222	Motorcycle Parking Spot Per Detail 3.04	1	EA	$3,500.00	$3,500.00
251 - 263	Install and Furnish MUTCD Per Sign SCH.	13	EA	$1,300.00	$16,900.00

501	Channel Cut Into Grade	705	LF	$95.00	$66,975.00
502	18" Corrugated HDPE (Smooth Interior)	60	LF	$200.00	$12,000.00
503	Double Headwall Per MAG STD 501-2	2	EA	$4,500.00	$9,000.00
700	Straw Rolls	602	LF	$6.32	$3,804.64
701	Rock Dams	4.75	CY	$110.00	$522.50
999	Contingency	10%			$125,000.00
Total Construction Costs			$1,375,000.00		

3.0 Summary of Engineering Work

The schedule determined last semester was followed closely throughout the design process this semester. Most of the tasks were completed in the allotted time frame making the total number of hours spent on the project 1006.5 which is a 12.5% increase compared to last semesters estimation of 881 hours. Surveying is the first thing the team started with to get a solid idea of the site. Enough points was collected while surveying the area to create all the necessary maps that the team will use in the new design. Design work was divided into two major parts which are traffic and hydrology. Once enough data was collected from the traffic part the team was able to use the information to design the new parking lot with the appropriate number of vehicle spots. Once the final required number of spots was determined, a design was chosen by the team for a final design. Then we moved into hydrology and hydraulics which determined the size of a channels, culverts and a detention basin. The drafting process was started and quickly moved into construction drawings. A final cost was determined. The client will receive as a final deliverable is a set of construction drawings, reports, and the Engineers' Estimate of Probable Cost.

4.0 Summary of Engineering Costs

The cost of engineering services was calculated by incorporating project staff billing rates and multiplying it by the amount of hours that each positioned worked plus travel fees. The hours of each project member was collected over the course of four months. In that time, the project hours are broken up and disbursed as shown in Table 7 while Table 8 displays the travel fees; the total amount of hours spent on the project was approximately 1,007. In the proposal the amount of hours

proposed was 881 which means the hours now is about a 12.5% increase; due to the hour's increase it caused the engineering services proposal to be increased by 9.5%. Table 7 shows the total cost of engineering services which is $77, 270; combining the travel cost demonstrated in Table 8 the total cost of engineering services is about $1.5 million.

Table 7: Cost of Engineering Services

Staff Hours and Cost								
Task	**Project Engineer**	**Staff Engineer**	**Survey**	**EIT**	**Admin**	**Tech**	**Intern**	**Total**
Site Investigation	4	4	20	8	2	2	8	81
Traffic Analysis	4	4	0	15	5	0	10	33
Hydrology	8	15	4	50	5	9	20	100
Site Plan	8	14	0	24	3	12	13	66
Impacts	8	7	0	20	3	6	11	49
Construction Plans	21	40	0	80	7	70	62.5	197
Deliverables	5	2	3	110	35	7	5	147
Project Coordination	4	5	0	160	53	6	5	208
Hours Total	62	91	27	467	113	112	134.5	**1006.5**
Billing Rate	$120	$100	$90	$80	$65	$60	$50	

Position Total Cost	$7,440	$9,100	$2,430	$37, 360	$7,345	$6, 720	$6,725	**$77,300**

Travel Fee by Mileage	**Cost Rate ($/mi)**	**Approx. Mileage**	**Total**
	$0.65	230	$149.50

5.0 Conclusion

The design provided will ease congestion and provide a safe access for additional motorists and pedestrians. This design meets all needs specified by the client and it is a feasible option with the total cost being about $1.5 million.

6.0 References

[1] “Park Statistics,” *National Park Service: Montezuma Castle*, Feb. 2018. Available: https://www.nps.gov/moca/learn/management/statistics.htm

[2] “Chapter 5: Parking Spaces,” *U.S. Access Board*, March 2018. Online. Available: https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/guide-to-the-ada-standards/chapter-5-parking

[3] https://msc.fema.gov/portal/search?AddressQuery=montezuma%20castle%20national%20monument#searchresultsanchor

[4] Soil Map: https://www.nps.gov/im/sodn/images/soilmapMOCA_1.png?maxwidth=650&autorotate=false

[5] Geology info: https://www.nps.gov/im/sodn/moca.htm

7.0 Appendices