# OLD TOWN FRAME COMPANY SITE REDESIGN

Submitted by Mitchell Tulk, Matt Rollins, Ryan Wolff, Saud al Saadoon

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# Contents

# 1.0 Acknowledgements

The engineering team would like to acknowledge with much appreciation the crucial role of the staff who assisted in the success of this design project including: Mark Lamer-Northern Arizona University, Gary Miller-City of Flagstaff, Adam Bringhurst-Northern Arizona University, and Dr. Wilbert Odem-Northern Arizona University. Each member of the team appreciates the guidance given by each supervisor listed above. Acknowledgement of appreciation is also owed to members of the city of Cottonwood recorder's office for their assistance in gathering necessary property documents and engineering design codes as well as Western Technologies for donating lab time.

# 2.0 Project Information

## 2.1 Project Location

The client for this project is Trevor Gottschalk, the owner of Old Town Frame Company. The property is located in Cottonwood at 107 S. Candy Ln, parcel number 406-33-001C. Figure 1 displays the location of the site.

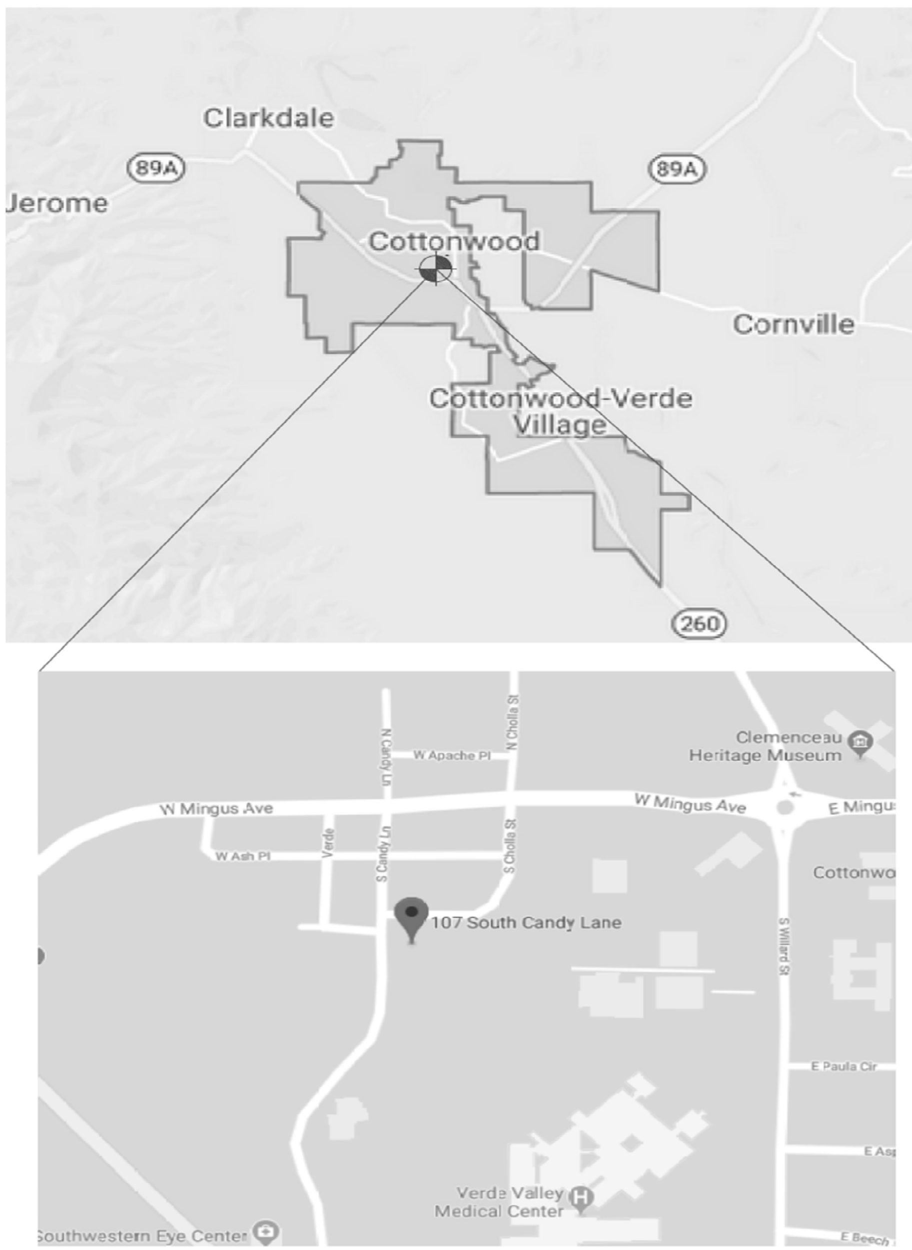



*Figure 1. Site Map*

## 2.2 Existing Site Conditions

Prior to requesting this project, the client was unaware of the property boundaries. As a result, it was unknown whether the one-hundred-year-old retaining wall in the northeast corner of the lot was on the client's property. After completion of the site survey, it was determined that the retaining wall is on the property. Figure 2 below displays the exiting retaining wall.

*Figure 2. Existing Retaining Wall*

The current condition of the site is unpaved on the northern half which currently creates runoff during heavy rains. The runoff flows into the adjacent parking lot. The adjacent parking lot property owner wants this to stop. Following the first site visit in October 2018, the engineering team confirmed these preexisting conditions, and noted extreme soil erosion taking place on the eastern edge of the property. Figure 3 displays the erosion occurring on the site.

*Figure 3. Erosion Occurring on Site*

During the initial meeting with Mr. Gottschalk it was determined that the primary goal of this redesign is to determine official boundaries. Then the engineering team developed a site plan which provides more efficient use of the area and reduces runoff. This will also allow for possible future paving of the site in order to host a local farmer's market.

The design was primarily focused on the parking lot of the site seen in figure 4 below. The client would like to extend the current limited parking (4 spaces) into more of a "traditional" parking lot. The lot is also almost entirely dirt; the unpaved parking areas tend to experience both ponding and soil erosion. The client has requested that the dirt lot be redesigned to better drain during rainfall and that the team make recommendations to the retaining wall. A full set of construction plans has been provided for the site redesign.

*Figure 4. Existing Parking on Site*

The primary goal of the redesign was to increase parking capacity and to reduce runoff to adjacent properties during heavy rain. Table 1 below shows a list of the necessary codes used for compliance with accessibility standards. To determine the number of parking stalls required for the site, this was dependent on both the parcel's zoning and Cottonwood development standards. To also meet federal ADA compliance for parking stall requirements, the International Building Code (IBC) was referenced alongside the City of Cottonwood's development design standards [1].

*Table 1. Engineering Design Codes Used*

| | | |
|---|---|---|
| City of Cottonwood Engineering Design Standards Manual | Grading Design Standards | A2.1.3 |
| City of Cottonwood Engineering Design Standards Manual | Retaining Walls | A2.9.1-3 |
| City of Cottonwood Engineering Design Standards Manual | Drainage Design Standards | A3.1.3 |
| City of Cottonwood Engineering Design Standards Manual | Drainage Construction Plans | A3.2.5 |
| City of Cottonwood Engineering Design Standards Manual | FEMA Designated Flood Hazard Areas | A3.2.6 |
| City of Cottonwood Engineering Design Standards Manual | Hydrology | A3.3 |
| City of Cottonwood Engineering Design Standards Manual | Stormwater Detention | A3.8 |
| City of Cottonwood Engineering Design Standards Manual | Erosion Control | A3.9 |
| City of Cottonwood Engineering Design Standards Manual | Easements and Dedications | A7.5 |
| City of Cottonwood Engineering Design Standards Manual | Pavement Cross Sections | A7.8 |
| City of Cottonwood Engineering Design Standards Manual | On-Street Parking | A7.13 |
| City of Cottonwood Engineering Design Standards Manual | Pavement Cuts | A8.12 |
| City of Cottonwood Engineering Design Standards Manual | Boundary Survey Standards | A9.2.1 |
| International Building Code | Accessibility Parking | Section 1106 |
| International Building Code | Accessibility Other Features | Section 1109 |
| International Building Code | Accessibility Signage | Section 1111 |

## 2.3 Project Constraints and Limitations and Exclusions

The constraints for this land development project were primarily based on economic impacts. Schedule, cost, and scope also contributed to limitations as well as exclusions.

Environmental impacts, primarily soil erosion, were noted on the eastern boundary. Because of the magnitude of a complete drainage design, the drainage requirements serve as a limitation. To account for this the engineering team has completed accurate drainage calculations and identified the plausible location for a detention basin and outlet. This is limited because it is mandated that any drainage design does not change the historical drainage patterns onto a neighboring property.

Due to the complexity and lack of time, a full redesign of the retaining wall was excluded from the scope. During due diligence and land surveying, the team determined the retaining wall was on the client's property. The team also determined the retaining wall is over 100 years old and therefore a historical site according to City of Cottonwood. The property owner cannot touch the retaining wall as it belongs to the city.

Due to complexity and lack of time, a full pavement design was also excluded from the scope. The team provided a parking lot design as well as recommended details from City of Flagstaff and City of Cottonwood Code.

Another constraint was compliance with accessibility standards. To comply, the design was done in accordance with county design guidelines. These guidelines are based on federal ADA requirements which require facilities to be accessible to all persons regardless of mental or physical disabilities. These regulations were applied in the redesign of the parking lot (ramps and handicap spots).

### 2.4 Stakeholders

Known stakeholders for this project include the client, Trevor Gottschalk, and the professional engineer hired by the client, Mark Lamer. The project site is privately owned and surrounded by other private property. Since the retaining wall is considered a historical site, being over one-hundred years old, the state of Arizona also acts a stakeholder. Another is City of Cottonwood since their engineering drainage design manual was followed for this design. The city also serves as a stakeholder because they oversee permitting and inspecting for both grading and drainage improvements to properties.

The goal of the project was to reduce the impact of current drainage patterns to nearby property owners. This makes the church to the east, which is most affected, and other neighboring properties to the parcel a stakeholder for this project. It was one of the team's priorities to have no negative impact involving drainage patterns on nearby property. Since another stakeholder to be considered is the location population, the updated parking lot is not expected to increase traffic; it is simply expected to better accommodate current traffic volumes.

### 2.5 Major Objectives

The major objective for this project was to redesign the parking lot of the site. The milestones were the due diligence, the site investigation, the geotechnical analysis, the drainage analysis, the site topography map, and the parking lot design.

# 3.0 Technical Sections

## 3.1 Task 1: Due diligence

The goal of due diligence was to locate government records which were used to determine the project site's existing boundaries based on data gathered during land survey. This was completed in January 2019.

### 3.1.1: Site Due Diligence

The located government documents from the county recorder were used to establish the known boundaries for parcel 406-33-001C. These documents included historic land surveys completed for the project site by previous owners and surveys completed by surrounding property owners. This information was located using the county recorder's search tool for parcels located in section 33, township 16N, and region 03E.

First, the engineering team used the county's interactive GIS mapping software to determine surrounding property's parcel numbers. The engineering team was able to locate the survey for the site design. The primary document used is shown in the Appendix. It is a land survey completed by Cornerstone Surveying and Engineering, Inc. for the benefit of Coe and Van Loo Consultants, Inc. who were the owners of the adjacent property prior to its development. At the time, Candy Lane, LLC owned the project site and its property corners are noted in this survey. It should be noted that this land survey is not in any way project specific. Because no other professional survey of the area was completed of the project site, this was used as a reference to help identify property boundary during the land survey.

### 3.1.2: Existing Conditions Map

The goal of creating an existing condition map in the construction plan is to professionally represent the current site prior to any redesign. This provides the client and engineering team with a better understanding of the geometry of the site, as well as other features found during investigation and survey below. This includes property corners, retaining wall location, existing pad location, and parking lot locations.

## 3.2 Task 2: Site Investigation

The goal of the site investigation was to gather physical data of the property for later use in the design process. This included soil sampling for geotechnical testing, land survey for topographic mapping and site planning, and a lot sketch for a general understanding of the property. This was completed across two site visits in February 2019.

Task 3.2.1: Lot sketch

The goal of the lot sketch was to gather a general understanding of the project site's existing geometry. The sketch was completed on February 3, 2019, by Matt Rollins. This was used to develop a plan for the land survey completed on the second visit. The plan for the land survey of the site was as follows: stake property line, stake concrete building pad perimeter, stake building frame perimeter, stake external points such as tress and roadway, stake both wall boundaries, and stake the central gravel are to determine drainage slope.

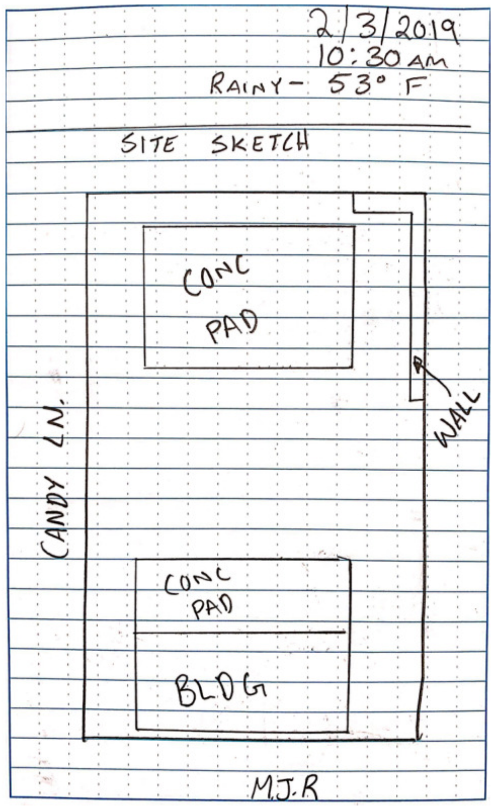



*Figure 3. Site Sketch*

### 3.2.2: Field Investigation

The goal of the field investigation, which took place on February 2, 2019, was to identify other project challenges and collect soil samples. Challenges noted during the investigation included a sealed well near center of property which appears to cause drainage flow problems (figure 5), a crack concrete slab on the northern line with unknown corners (figure 6), and an aged fence which made staking the official property line difficult.

*Figure 4. Sealed Well*

*Figure 5. Existing Concrete Pad*

3.2.3: Land Survey

The goal of the land survey was to create a topography map with a site layout projection in AutoCAD. The created topography map along with the document of a past survey of the site was used to determine property boundaries. The survey was done using GPS technology through the 'SurveyPro GNSS Software'. As noted, the survey took place on February 8, 2019 starting at 1:26 PM and concluding at 4:18 PM. The weather was noted as a sunny 51 degrees Fahrenheit with a pressure of 29.83 inHg. In total, 148 points were taken throughout the property. All raw data collected for land survey is attached in appendix.

### 3.2.4: Soil Sampling

The goal of soil sampling was to gather a diverse collection of soil from the site to be used for geotechnical testing. Initial visual observations of the soil are shown in figure 7 below. The soil appeared to be homogenous throughout the site. Samples were taken at the center of the property, northern line by the retaining wall, and at the southern line by the building pad.

*Figure 6. Existing Soil on Site*

## 3.3 Task 3: Geotechnical Analysis

ASTM standards were used to test the surface soil sample for moisture content, plasticity index and sieve analysis. This was used to classify the soil based on AASHTO and USCS standards. Once classified, the engineering team was able to provide soil data for future pavement design. The Proctor Test was eliminated from this task because it was only necessary if the sieve analysis produced results of more than 90% of the soil passing through the #200 sieve. All information for this section is presented in a geotechnical report attached in appendix A-2.

Table 5: Summary of Results

| Sample | South | Middle | Wall |
|---|---|---|---|
| Moisture Content | 13% | 13.1% | 24.6% |
| Passing No. 200 Sieve | 23.6% | 32% | 39.9% |
| Liquid Limit | 27 | 28 | 48 |
| Plastic Limit | 20 | 17 | 18 |
| Plasticity Index | 7 | 11 | 30 |
| **Soil Classification** | Sandy Clay | Gravely Clay | Fatty Clay |

### Task 3.3.1: Moisture Content Testing (ASTM DD2216-10)

The goal of moisture content testing was to use ASTM methods to determine the amount of water in the soil. This data was used to calculate the unit weight. The moisture content of the southern end of the sight and middle of the sight were both 13%. The moisture content near the retaining wall was 24%. A summary of results is shown in the appendix.

### 3.3.2: Atterberg Limits Testing (ASTM D4318)

The goal of Atterberg limits testing was to use ASTM methods to determine the plasticity and liquidity of the soil. The data produced from both limits was used to calculate the ultimate strength of the soil. This will also be used for any future pavement design done by the client. The plasticity index for each sample is:  A summary of results is shown in the appendix.

### 3.3.3: Sieve Analysis (ASTM D6913)

The goal of a sieve analysis was to use ASTM methods to classify the soil via AASHTO and USCS organizations. The sieve analysis test provided data regarding the particle sizes of the soil. This was then used to determine the soil type for each sample area taken. This test confirmed the south and middle of the site is comprised of homogenous soil. The retaining wall appears to be different. The soil types for each sample were found to be: sandy clay at the south, gravely clay at the middle, and fatty clay at the wall.

### 3.3.4 Pavement Section Recommendation

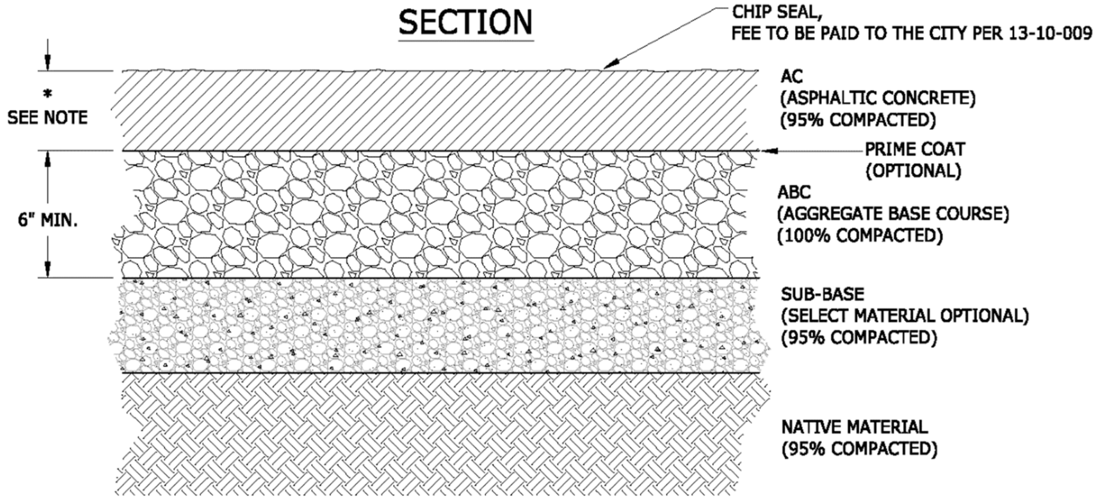
Using geotechnical test results, the team determined a pavement recommendation. After research it was found that no typical cross sections for parking lots are provided in either Yavapai County or Cottonwood design manuals. So, the team used a pavement section recommended in the City of Flagstaff of Engineering Design Standards. The soil classification, plastic limit, and moisture content were used in determining its compliance. Comparing both Cottonwood and Flagstaff design manuals, it was determined that pavement requirements are equal so the cross section from Flagstaff code will be used as a reference to the Cottonwood details.

The table below shows the teams results from the pavement analysis. A full analysis can be found in the attached geotechnical report.

| Pavement Sections | | | | | |
|---|---|---|---|---|---|
| Area of Placement | Flexible (AC Pavement) | | | Rigid (PCC Pavement) * | |
| | Thickness | | Daily 18-kip ESALs | Thickness | Daily 18-kip ESALs |
| | AC (0.39) | ABC (0.12) | | PCCP | |
| Auto Parking | 2.5” | 4.0” | 20 | 5.0” | 10 |
| Main Drivers, Truck Traffic & Fire Lanes | 2.5” | 4.0” | 90 | 6.0” | 20 |
| | 2.5” | 4.0” | 180 | 7.0” | 50 |
| | 2.5” | 4.0” | 300 | 8.0” | 100 |

*does not apply to this site, use flexible pavement

The attached figure below depicts this recommended section.  The minimum off-street parking pavement thickness is noted in the details if two and a half inches of asphaltic concrete. The team used section 8.12 in the Cottonwood engineering design standards [2]. The soil classification, plastic limit, and moisture content were crucial in helping the engineering team determine its compliance. The team recommends a flexible pavement design as it will be a “low-volume” road [1].




* THE MINIMUM DEPTH OF THE AC VARIES, DEPENDING ON THE TYPE OF ROADWAY. THE TYPICAL MINIMUM PAVEMENT DEPTHS ARE AS FOLLOWS, OR MATCH EXISTING, WHICHEVER IS GREATER.

ARTERIALS = 5"
COLLECTORS = 4"
LOCALS & ALLEYS = 3"

OFF-STREET PARKING MINIMUM DEPTH OF AC IS 2 1/2"
PARKING LOTS MAY BE PAVED WITH 4" PORTLAND CEMENT CONCRETE UPON COMPACTED SUBGRADE.

**ALTERNATIVE SECTIONS:**

1. FOR PARKING LOTS, ALTERNATIVE SECTIONS OF PAVEMENT WILL BE CONSIDERED (i.e. PAVERS, POROUS ASPHALT AND CONCRETE, GRASS CRETE, GRAVEL PAVE, ETC.)

**NOTES:**

1. ALTERNATIVE SECTIONS SHALL BE LIMITED TO THE PARKING AREAS AND DRIVE AISLES THAT DO NOT SERVE AS FIRE ACCESS AISLES.
2. THE PROFESSIONAL ENGINEER MAY RECOMMEND PAVEMENT STRUCTURAL SECTION THAT ARE EQUIVALENT TO THE MINIMUM SECTIONS ABOVE.

NTS

| City of Flagstaff ENGINEERING DETAIL | PAVEMENT STRUCTURAL SECTIONS for STREETS & OFF-STREET PARKING LOTS | | |
|---|---|---|---|
| | DETAIL NO. 10-09-010 | REVISION DATE: 11/22/16 | 1/1 |

*Figure 7. Pavement Section Recommendation* [3].

## 3.4 Task 4: Site Topographic Mapping

The goal of creating a site topographic mapping was to process data collected during survey in a computer-aided drafting format. This was then used to determine site elevations which were necessary for designing the proposed site plan.

### Task 3.4.1: Data Processing

The purpose of data processing is to develop s site-specific topography map. The data collected during survey was uploaded to a computer as a spreadsheet file. Once in spreadsheet form each of the 148 points taken were reviewed to confirm the grouping of data was correct.

### Task 3.4.2: Existing Conditions Map

Once the data was processed it was uploaded to the three-dimensional computer aided-drafting software, Civil3D. The goal of developing a topography map was to professionally present the existing conditions for the site and label the property corners found during due diligence. Once labelled, the property boundaries were officially determined. The topography map was used to create a site plan, determine if the retaining wall was on the property, and aide in drainage design recommendations. Figure 9 below shows the existing conditions map which presents all the information discussed above. The goal of this figure is to present the current project site which can be used for designing the site plan.

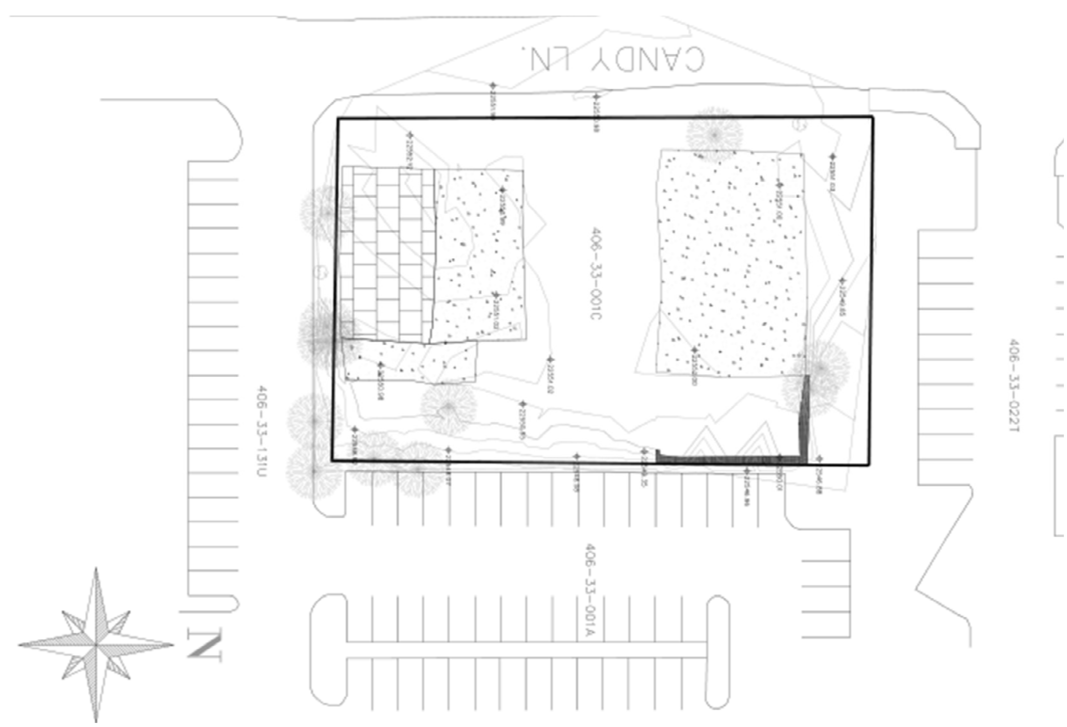



*Figure 8. Existing Mapping*

## 3.5 Task 5: Site Plan

The proposed site plan serves as the main milestone for this project. The proposed site plan serves as an erosion control plan, grading plan, and drainage plan combined into one document. The erosion control aspects are also shown as details in the construction documents which were gathered from county construction standards. The purpose of these is to define possible mitigation methods which will be used during construction to prevent soil erosion onto other properties and temporarily control drainage prior to completion.

The purpose of the grading and drainage plans is to recommend land elevation adjustments to improve the site's drainage during periods of high flow. The designs are based on the completed drainage calculations. These values are shown on the plan. To accommodate the drainage design, a low-impact development basin has been proposed for the site. This is because a LID basin is useful in reducing drainage flow rate while also controlling the runoff.

The figure below is an image from ADOT that shows the effects of an LID basin on a developed site. The LID basin will hold enough water (per dimensions on design sheets) to negate the increased flow due to the increase in impervious area.

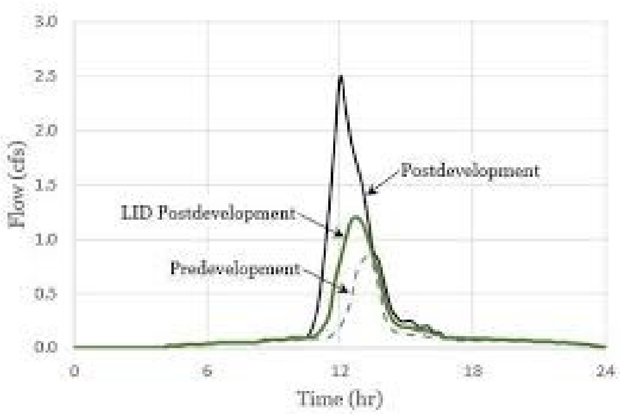



*Figure 10. LID Basin Example*

Shown in the drainage calculations below is precipitation depth and intensity values for each time of concentration per NOAA Atlas database. Also shown below is the City of Cottonwood rainfall data. Below is flood hazard data from the USGS database. As shown on the map, the project site is considered an area of minimal flood hazard. Using the known physical properties of the project site, the necessary time of concentration value was determined. The calculations for this are shown in the table. The n value used is described as "low intensity developed space." The n value gives a Tc value of less than 5 which influenced the results of table 8. Lastly, the necessary precipitation depth and intensity were found using the time of concentration calculated and this data was applied to completing the drainage flowrate calculations shown in the table below.

**TABLE 3-1: RAINFALL DATA FOR CITY OF COTTONWOOD**

| DURATION | STORM FREQUENCY (YEARS) RAINFALL DEPTH (INCHES) / INTENSITY (INCHES/HOUR) | | | | | |
|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 50 | 100 |
| 5-min | 0.27 | 0.37 | 0.45 | 0.57 | 0.67 | 0.77 |
| | 3.29 | 4.46 | 5.44 | 6.83 | 8.00 | 9.26 |
| 10-min | 0.42 | 0.57 | 0.69 | 0.87 | 1.02 | 1.18 |
| | 2.50 | 3.40 | 4.13 | 5.20 | 6.12 | 7.08 |
| 15-min | 0.52 | 0.70 | 0.86 | 1.08 | 1.26 | 1.46 |
| | 2.07 | 2.81 | 3.42 | 4.32 | 5.04 | 5.84 |
| 30-min | 0.70 | 0.95 | 1.15 | 1.45 | 1.69 | 1.96 |
| | 1.39 | 1.89 | 2.30 | 2.90 | 3.38 | 3.92 |
| 60-min | 0.86 | 1.17 | 1.43 | 1.79 | 2.10 | 2.43 |
| | 0.86 | 1.17 | 1.43 | 1.79 | 2.10 | 2.43 |
| 2-hour | 0.99 | 1.31 | 1.58 | 1.97 | 2.30 | 2.66 |
| | 0.49 | 0.66 | 0.79 | 0.99 | 1.15 | 1.33 |
| 3-hour | 1.06 | 1.37 | 1.64 | 2.02 | 2.34 | 2.69 |
| | 0.35 | 0.46 | 0.55 | 0.67 | 0.78 | 0.90 |
| 6-hour | 1.26 | 1.57 | 1.85 | 2.24 | 2.56 | 2.91 |
| | 0.21 | 0.26 | 0.31 | 0.37 | 0.43 | 0.49 |
| 12-hour | 1.49 | 1.83 | 2.11 | 2.48 | 2.78 | 3.09 |
| | 0.12 | 0.15 | 0.18 | 0.21 | 0.23 | 0.26 |
| 24-hour | 1.77 | 2.22 | 2.58 | 3.06 | 3.44 | 3.83 |
| | 0.07 | 0.09 | 0.11 | 0.13 | 0.14 | 0.16 |

*Table 2. Time of Concentration calculations.*

| Flow Time of Concentration | | | | |
|---|---|---|---|---|
| n | L (ft) | s (ft/ft) | Tc (hr) | Tc(min) |
| 0.0678 | 186.8617 | 0.05 | 0.011386 | 0.68316 |

*Table 3. Drainage flowrate calculations.*

| Drainage Flowrate Calculations | | | | | |
|---|---|---|---|---|---|
| **Storm** | **Cf** | **C** | **i (in/hr)** | **A (acres)** | **Q (cfs)** |
| 2-year | 1.2 | 0.95 | 3.29 | 0.520166 | **1.950934** |
| 5-year | 1.2 | 0.95 | 4.46 | 0.520166 | **2.644731** |
| 10-year | 1.2 | 0.95 | 5.42 | 0.520166 | **3.214** |
| 25-year | 1.2 | 0.95 | 6.83 | 0.520166 | **4.050115** |
| 50-year | 1.2 | 0.95 | 7.98 | 0.520166 | **4.732052** |
| 100-year | 1.2 | 0.95 | 9.25 | 0.520166 | **5.485148** |

### 3.6 Final Design Recommendations

The social impact of the design is minimal but positive. The site is in a remote part of a small town in northern Arizona. A popular church lies adjacent to the property and deals with the majority of drainage issues during rainstorms. The redesign will better accommodate the church's social gathering.

The economic benefit will be immediate for the client. There will be more room for customers to park and therefore can only increase business.

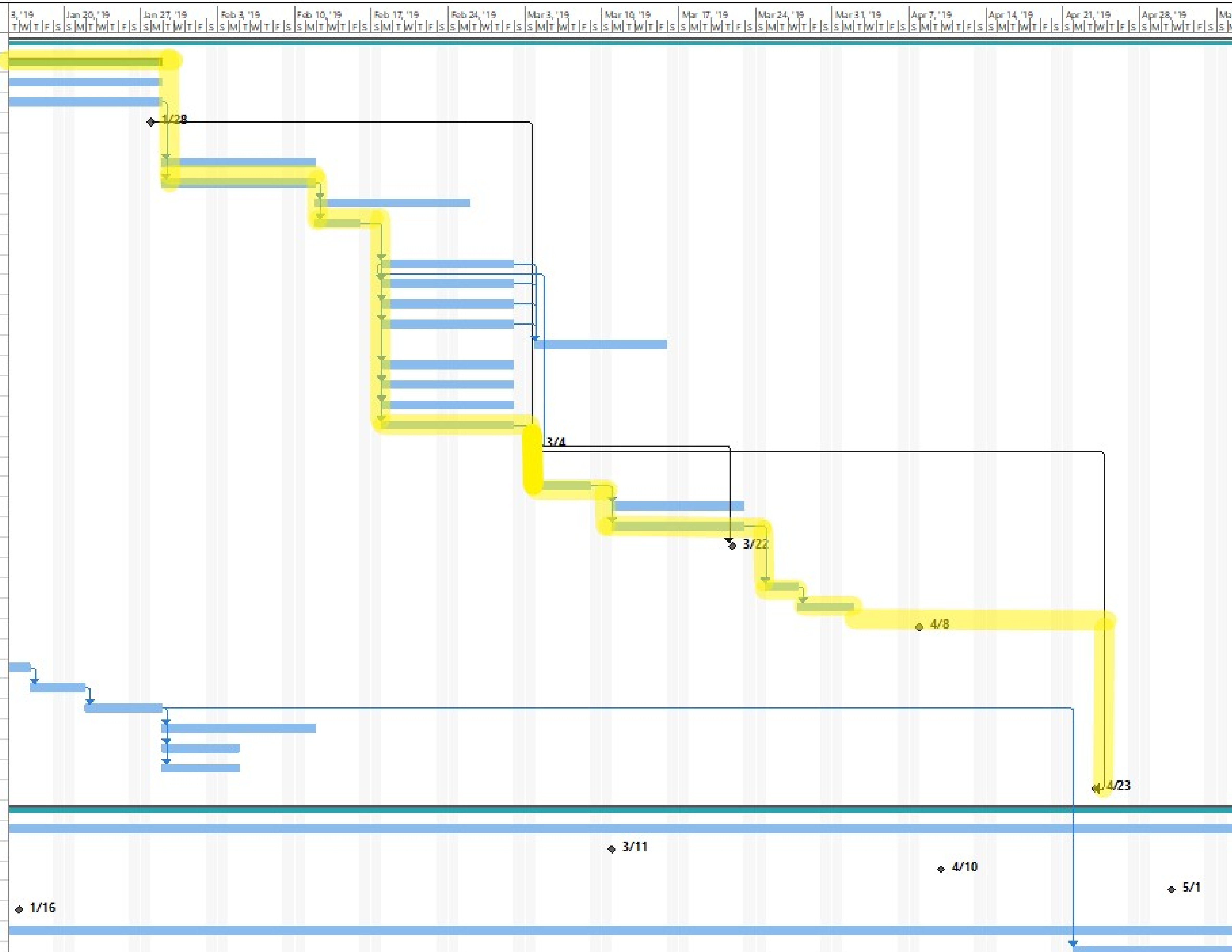
The environmental impact of the proposed site plan will be positive. The survey of the site has been completed and uploaded to Civil 3D. All geotechnical testing items have been completed and developed into a professional lab report for presenting its necessary data. An existing conditions map has been completed using the survey data. The development of a proposed site plan has been completed using survey data. Lastly, construction plans have been developed to present all items of the final design for this project and serve as the engineer's recommendations for any future land development of the site.

# 4.0 Summary of Engineering Work

The engineering team has completed all tasks leading up to the final design for this project. The team is on schedule according to the schedule presented in the figures below. In regard to the scope of the project, a change was made in the type of equipment to be used for the field survey. The team decided to conduct a GPS survey instead of using a total station. This decision was made to save time, and to obtain a more accurate survey with less human error involved. Figure 8 below shows the original schedule the team presented in the proposal, while figure 9 below shows the modified schedule at this point in the project. The purpose of changing the scope items defined in the proposal is that once the design process began certain changes had to be made in order to overcome all challenges presented. The scope has changed from the proposal by combining all plan items in to one general site plan and one general existing conditions map. The engineering team also adjusted the geotechnical tests completed for this project so that only tests which provided necessary values for design were completed.

3.0 Old Town Frame Company - Land Development Schedule

| ID | Task Name | Duration |
|---|---|---|
| 1 | **Old Town Frame Company - Land Development** | **81 days** |
| 2 | **Task 1: Due Diligence** | **10 days** |
| 3 | Task 1.1: Existing Mapping | 10 days |
| 4 | Task 1.2: Site Due Diligence | 10 days |
| 5 | Task 1.1: Existing Mapping | 0 days |
| 6 | **Task 2: Site Investigation** | **20 days** |
| 7 | Task 2.1: Lot Sketch | 10 days |
| 8 | Task 2.2: Field Investigation | 10 days |
| 9 | Task 2.3: Land Survey | 10 days |
| 10 | Task 2.4: Soil Sampling | 4 days |
| 11 | **Task 3: Geotechnical Analysis** | **20 days** |
| 12 | Task 3.1: Moisture Content | 10 days |
| 13 | Task 3.1.1: Plastic Limit (ASTM D4318) | 10 days |
| 14 | Task 3.1.2: Water Content (ASTM D2216) | 10 days |
| 15 | Task 3.2: Perform Sieve Analysis | 10 days |
| 16 | Task 3.2.1: AASHTO/USCS Soil Classification | 10 days |
| 17 | Task 3.3: Perform Hydrometer Test - Tentative | 10 days |
| 18 | Task 3.4: Perform Consolidated Udrained Test | 10 days |
| 19 | Task 3.5: Perform Direct Shear Test | 10 days |
| 20 | Task 3.6: Perform Triaxial Compression Test | 10 days |
| 21 | Task 3.7: Lab Testing Report | 0 days |
| 22 | **Task 4: Site Topography Map** | **15 days** |
| 23 | Task 4.1: Data Processing | 5 days |
| 24 | Task 4.2: Topographic Map | 10 days |
| 25 | Task 4.3: Aerial Map | 10 days |
| 26 | Task 4.2: Topographic Map | 0 days |
| 27 | **Task 5: Parking Lot Design** | **10 days** |
| 28 | Task 5.1: Existing Drainage | 3 days |
| 29 | Task 5.2: Parking Layout | 3 days |
| 30 | Task 5.3: Proposed Drainage Plan | 0 days |
| 31 | **Task 6: Create Construction Plans** | **71 days** |
| 32 | Task 6.1: Create Border | 2 days |
| 33 | Task 6.2: Cover | 3 days |
| 34 | Task 6.3: Notes/Details | 5 days |
| 35 | Task 6.4: Site Layout | 10 days |
| 36 | Task 6.5: Plan and Profile | 5 days |
| 37 | Task 6.6: Cross Sections | 5 days |
| 38 | Task 6: Create Construction Plans | 0 days |
| 39 | **Task 7: Project Management** | **81 days** |
| 40 | Task 7.1: Meeting | 80 days |
| 41 | Task 7.2.1: 30% Submittal | 0 days |
| 42 | Task 7.2.2: 60% Submittal | 0 days |
| 43 | Task 7.2.3: Final Report | 0 days |
| 44 | Task 7.2.4: Website | 0 days |
| 45 | Task 7.3: Travel reports | 80 days |
| 46 | Task 7.4: Engineers Opinion of Probably Cost | 11 days |

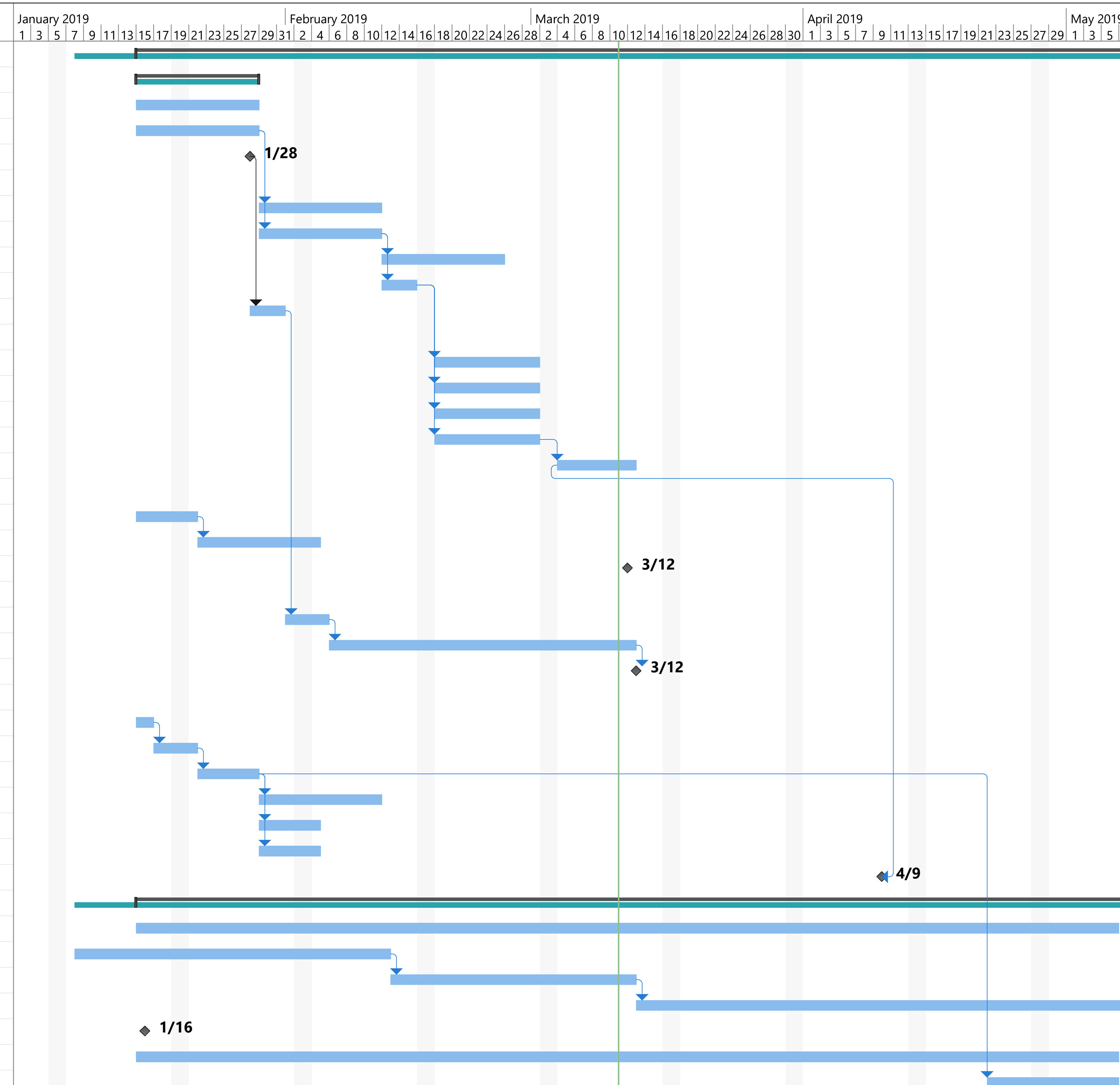



Project Schedule
November 6, 2018

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task | Summary | Inactive Milestone | Duration-only | Start-only | External Milestone | Manual Progress |
| Split | Project Summary | Inactive Summary | Manual Summary Rollup | Finish-only | Deadline | |
| Milestone | Inactive Task | Manual Task | Manual Summary | External Tasks | Progress | |

3.0 Old Town Frame Company - Land Development Schedule

| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **Old Town Frame Company - Land Development** | **81 days** | **Tue 1/15/19** | **Tue 5/7/19** |
| 2 | **Task 1: Due Diligence** | **10 days** | **Tue 1/15/19** | **Mon 1/28/19** |
| 3 | Task 1.1: Existing Mapping | 10 days | Tue 1/15/19 | Mon 1/28/19 |
| 4 | Task 1.2: Site Due Diligence | 10 days | Tue 1/15/19 | Mon 1/28/19 |
| 5 | Task 1.1: Existing Mapping | 0 days | Mon 1/28/19 | Mon 1/28/19 |
| 6 | **Task 2: Site Investigation** | **21 days** | **Mon 1/28/19** | **Mon 2/25/19** |
| 7 | Task 2.1: Lot Sketch | 10 days | Tue 1/29/19 | Mon 2/11/19 |
| 8 | Task 2.2: Field Investigation | 10 days | Tue 1/29/19 | Mon 2/11/19 |
| 9 | Task 2.3: Land Survey | 10 days | Tue 2/12/19 | Mon 2/25/19 |
| 10 | Task 2.4: Soil Sampling | 4 days | Tue 2/12/19 | Fri 2/15/19 |
| 11 | Task 2.5 Existing Conditions | 4 days | Mon 1/28/19 | Thu 1/31/19 |
| 12 | **Task 3: Geotechnical Analysis** | **17 days** | **Mon 2/18/19** | **Tue 3/12/19** |
| 13 | Task 3.1: Moisture Content | 10 days | Mon 2/18/19 | Fri 3/1/19 |
| 14 | Task 3.1.1: Atterberg Limit | 10 days | Mon 2/18/19 | Fri 3/1/19 |
| 15 | Task 3.2: Perform Sieve Analysis | 10 days | Mon 2/18/19 | Fri 3/1/19 |
| 16 | Task 3.2.1: AASHTO/USCS Soil Classification | 10 days | Mon 2/18/19 | Fri 3/1/19 |
| 17 | Task 3.7: Lab Testing Report | 7 days | Mon 3/4/19 | Tue 3/12/19 |
| 18 | **Task 4: Site Topography Map** | **40 days** | **Tue 1/15/19** | **Tue 3/12/19** |
| 19 | Task 4.1: Data Processing | 5 days | Tue 1/15/19 | Mon 1/21/19 |
| 20 | Task 4.2: Topographic Map | 10 days | Tue 1/22/19 | Mon 2/4/19 |
| 21 | Task 4.2: Topographic Map | 0 days | Tue 3/12/19 | Tue 3/12/19 |
| 22 | **Task 5: Parking Lot Design** | **28 days** | **Fri 2/1/19** | **Tue 3/12/19** |
| 23 | Task 5.1: Existing Drainage | 3 days | Fri 2/1/19 | Tue 2/5/19 |
| 24 | Task 5.2: Parking Layout | 25 days | Wed 2/6/19 | Tue 3/12/19 |
| 25 | Task 5.3: Proposed Drainage Plan | 0 days | Tue 3/12/19 | Tue 3/12/19 |
| 26 | **Task 6: Create Construction Plans** | **61 days** | **Tue 1/15/19** | **Tue 4/9/19** |
| 27 | Task 6.1: Create Border | 2 days | Tue 1/15/19 | Wed 1/16/19 |
| 28 | Task 6.2: Cover | 3 days | Thu 1/17/19 | Mon 1/21/19 |
| 29 | Task 6.3: Notes/Details | 5 days | Tue 1/22/19 | Mon 1/28/19 |
| 30 | Task 6.4: Site Layout | 10 days | Tue 1/29/19 | Mon 2/11/19 |
| 31 | Task 6.5: Plan and Profile | 5 days | Tue 1/29/19 | Mon 2/4/19 |
| 32 | Task 6.6: Cross Sections | 5 days | Tue 1/29/19 | Mon 2/4/19 |
| 33 | Task 6: Final Construction Plans | 0 days | Tue 4/9/19 | Tue 4/9/19 |
| 34 | **Task 7: Project Management** | **81 days** | **Tue 1/15/19** | **Tue 5/7/19** |
| 35 | Task 7.1: Meeting | 80 days | Tue 1/15/19 | Mon 5/6/19 |
| 36 | Task 7.2.1: 30% Submittal | 26 days | Tue 1/8/19 | Tue 2/12/19 |
| 37 | Task 7.2.2: 60% Submittal | 20 days | Wed 2/13/19 | Tue 3/12/19 |
| 38 | Task 7.2.3: Final Report | 40 days | Wed 3/13/19 | Tue 5/7/19 |
| 39 | Task 7.2.4: Website | 0 days | Wed 1/16/19 | Wed 1/16/19 |
| 40 | Task 7.3: Travel reports | 80 days | Tue 1/15/19 | Mon 5/6/19 |
| 41 | Task 7.4: Engineers Opinion of Probably Cost | 11 days | Mon 4/22/19 | Mon 5/6/19 |




Project Schedule
November 6, 2018

| | | | | |
|---|---|---|---|---|
| Task | Project Summary | Manual Task | Start-only | Deadline |
| Split | Inactive Task | Duration-only | Finish-only | Progress |
| Milestone | Inactive Milestone | Manual Summary Rollup | External Tasks | Manual Progress |
| Summary | Inactive Summary | Manual Summary | External Milestone | |

# 5.0 Summary of Engineering Costs

Table 9 below shows the staffing section for this project. No changes have been made to the staffing positions.

*Table 4. Staffing Positions*

| Classification | Code |
|---|---|
| Senior Engineer | SENG |
| Engineer | ENG |
| Lab Tech | LTECH |
| Intern | INT |

Table 10 below shows the cost of engineering services for the project.

*Table 5. Current Cost of Project*

| Personnel | Classification | Hours | Rate $/hr | Cost |
|---|---|---|---|---|
| | SENG | 107 | $145.00 | $15,515.00 |
| | ENG | 136 | $90.00 | $12,240.00 |
| | LAB | 105 | $80.00 | $8,400.00 |
| | INT | 144 | $45.00 | $6,480.00 |
| | Subtotal | | | $42,635.00 |
| | | | | |
| 2.0 Travel | Distance (miles) | Meetings | Rate $/mile | Cost |
| | 120 | 2 | $0.54 | $129.60 |
| 3.0 Supplies | | Hours | Rate $/hr | Cost |
| Survey Equipment | | 5 | $50.00 | $250.00 |
| **4.0 TOTAL** | | | | **$43,014.60** |
| | | | Projected Total | $88,028.31 |

Table 11 below shows the engineering staffing hours for each task, for each position. The final column displays the projected hours for each task before the project began. The current total hours are approximately 80% of the projected hours. The team has saved significant time in the site investigation and the geotechnical analysis, this was due to changes in the scope once the project began.

*Table 6. Staffing Hours*

| Tasks | SENG | ENG | LTECH | INT | Total Hours | Total Hours Expected |
|---|---|---|---|---|---|---|
| **Task 1: Due Diligence** | 4 | 8 | 0 | 9 | 21 | 44 |
| Task 1.1: Existing Mapping | 2 | 4 | 0 | 4 | 10 | 23 |
| Task 1.2: Site Due Diligence | 2 | 4 | 0 | 5 | 11 | 21 |
| **Task 2: Site Investigation** | 10 | 10 | 10 | 22 | 52 | 116 |
| Task 2.1: Lot Sketch | 1 | 1 | 1 | 1 | 4 | 12 |
| Task 2.2: Field Investigation | 2 | 2 | 2 | 8 | 14 | 12 |
| Task 2.3: Land Survey | 5 | 5 | 5 | 5 | 20 | 80 |
| Task 2.4: Soil Sampling | 2 | 2 | 2 | 8 | 14 | 12 |
| **Task 3: Geotechnical Analysis** | 5 | 7 | 17 | 7 | 36 | 142 |
| Task 3.1: Moisture Content (ASTM D2216-10) | 1 | 1 | 3 | 1 | 6 | 13 |
| Task 3.2: Plastic Limit Testing (ASTM D4318) | 1 | 1 | 3 | 1 | 6 | 13 |
| Task 3.3: Sieve Analysis (ASTM D6913) | 1 | 1 | 3 | 1 | 6 | 13 |
| Task 3.4: Lab Testing Report | 2 | 4 | 8 | 4 | 18 | 13 |
| **Task 4: Site Topo Map** | 4 | 10 | 2 | 8 | 24 | 32 |
| Task 4.1: Data Processing | 1 | 3 | 0 | 2 | 6 | 11 |
| Task 4.2: Topographic Map | 2 | 4 | 0 | 4 | 10 | 11 |
| Task 4.3: Aerial Map | 1 | 3 | 2 | 2 | 8 | 10 |
| **2.5 Task 5: Parking Lot Design** | 7 | 20 | 4 | 18 | 49 | 59 |
| Task 5.1: Existing Drainage | 3 | 6 | 2 | 6 | 17 | 21 |
| Task 5.2: Parking Layout | 2 | 8 | 1 | 6 | 17 | 19 |
| Task 5.3: Proposed Drainage Plan | 2 | 6 | 1 | 6 | 15 | 19 |
| **Task 6: Create Construction Plans** | 7 | 13 | 3 | 23 | 46 | 92 |
| Task 6.1: Create Border | 0 | 1 | 1 | 2 | 4 | 9 |
| Task 6.2: Cover | 1 | 2 | 0 | 3 | 6 | 9 |
| Task 6.3: Notes/Details | 1 | 2 | 0 | 3 | 6 | 13 |
| Task 6.4: Site Layout | 5 | 8 | 2 | 15 | 30 | 24 |
| **Task 7: Project Management** | 55 | 59 | 50 | 58 | 88 | 88 |
| 7.1: Meetings | | | | | | |
| 7.1.1 Technical Advisor | 8 | 8 | 8 | 8 | 32 | 20 |
| 7.1.2 Client | 1 | 1 | 1 | 1 | 4 | 20 |
| 7.1.3 Grading Instructor | 8 | 8 | 8 | 8 | 32 | 40 |
| 7.1.4 Lab Coordination | 5 | 5 | 5 | 5 | 20 | 8 |
| Task 7.2: Deliverables | | | | | 134 | 166 |
| 7.2.1 30% Submittal | 8 | 8 | 8 | 8 | 32 | 40 |
| 7.2.2 60% Submittal | 10 | 10 | 10 | 10 | 40 | 32 |
| 7.2.3 Final Report | 6 | 6 | 6 | 6 | 24 | 32 |
| 7.2.4 Website | 2 | 3 | 2 | 8 | 15 | 32 |
| Task 7.3: Travel Reports | 1 | 1 | 1 | 1 | 4 | 5 |
| Task 7.4: Engineers Opinion of Probable Cost | 6 | 9 | 1 | 3 | 19 | 25 |
| **Total Hours** | 180 | 246 | 172 | 281 | 450 | 739 |

# 6.0 Conclusion

The team has recommended the following:

- Remove the northern concrete pad
- Install LID basin on eastern edge of site
- Install parking lot per design sheets

# 7.0 References

## References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[3] P. Gary Miller, Writer, [Performance]. City of Flagstaff; Development Engineer, 2019.

[4] N. W. Service, "Hydrometeorological Design Studies Center: Precipitation Frequency Data Server (PFDS)," NOAA's National Weather Service, 2019. [Online]. Available: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html. [Accessed 11 March 2019].

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[6] U. S. C. System, "Soil Classification Chart".

[7] A. A. o. S. H. a. T. Officials, "Soil Classification Chart".

[8] C. o. Flagstaff, "Low Impact Development," City of Flagstafff Utilities Division, Flagstaff, 2019.

[9] C. o. Flagstaff, "Guidance for Erosion Control Plan - ECP," Flagstaff, 2019.

[10] R. J. Houghtalen, A. O. Akan and N. H. C. Hwang, Fundamentals of Hydraulic Engineering Systems Fifth Edition, Pearson Education, 2017.

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# 8.0 Appendix

Raw Survey Data:

| | | | | |
|---|---|---|---|---|
| 1 | 190655.643 | 212960.233 | 22550.479 | Cogo |
| 2 | 190655.643 | 212960.233 | 22550.479 | 1 |
| 138 | 190653.124 | 212962.122 | 22551.191 | Autonomous Setup |
| 139 | 190655.978 | 212959.888 | 22550.456 | fnc |
| 140 | 190683.873 | 212901.818 | 22549.04 | fnc |
| 141 | 190672.569 | 212901.345 | 22549.089 | fnc |
| 142 | 190667.869 | 212900.909 | 22550.48 | fnc |
| 143 | 190668.14 | 212901.376 | 22549.624 | CONC |
| 144 | 190666.695 | 212902.695 | 22550.5 | CONC |
| 145 | 190655.062 | 212900.881 | 22550.818 | CONC |
| 146 | 190655.952 | 212906.35 | 22551.438 | CONC |
| 147 | 190655.253 | 212906.687 | 22551.382 | CONC |
| 148 | 190668.102 | 212906.516 | 22550.139 | CONC |
| 149 | 190671.383 | 212905.982 | 22550.785 | CONC |
| 150 | 190679.753 | 212907.344 | 22550.329 | CONC |
| 151 | 190685.878 | 212908.554 | 22549.407 | CONC |
| 152 | 190680.589 | 212922.499 | 22550.093 | CONC |
| 153 | 190668.13 | 212923.298 | 22550.654 | CONC |
| 154 | 190667.921 | 212923.368 | 22550.854 | CONC |
| 155 | 190655.418 | 212930.493 | 22550.867 | CONC |
| 156 | 190658.333 | 212931.817 | 22551.26 | CONC |
| 157 | 190669.682 | 212932.145 | 22551.011 | CONC |
| 158 | 190677.435 | 212932.362 | 22550.289 | CONC |
| 159 | 190680.008 | 212931.016 | 22550.063 | CONC |
| 160 | 190677.676 | 212937.229 | 22549.866 | TR |
| 161 | 190683.326 | 212941.019 | 22549.928 | |
| 162 | 190668.744 | 212944.764 | 22551.208 | CONC |
| 163 | 190663.551 | 212946.612 | 22550.63 | CONC |
| 164 | 190654.397 | 212947.442 | 22551.05 | CONC |
| 165 | 190648.425 | 212931.702 | 22550.361 | CONC |
| 166 | 190620.552 | 212932.795 | 22552.749 | CONC |
| 167 | 190597.894 | 212932.183 | 22553.671 | CONC |
| 168 | 190594.689 | 212946.838 | 22551.246 | CONC |
| 169 | 190594.934 | 212963.56 | 22551.036 | CONC |
| 170 | 190625.039 | 212963.525 | 22551.016 | CONC |
| 171 | 190587.617 | 213011.625 | 22551.812 | CONC |
| 172 | 190587.809 | 213035.25 | 22551.805 | CONC |
| 173 | 190589.119 | 213061.152 | 22551.932 | CONC |
| 174 | 190638.41 | 213062.516 | 22551.962 | CONC |
| 175 | 190666.647 | 213061.774 | 22552.173 | CONC |
| 176 | 190667.311 | 213035.538 | 22551.94 | CONC |
| 177 | 190665.425 | 213009.63 | 22552.443 | CONC |

| | | | | |
|---|---|---|---|---|
| 178 | 190634.116 | 213011.679 | 22551.99 | CONC |
| 179 | 190649.021 | 213009.006 | 22552.092 | well |
| 180 | 190686.034 | 212951.788 | 22549.833 | fnc |
| 181 | 190685.806 | 212953.893 | 22549.764 | fnc |
| 182 | 190686.235 | 212962.44 | 22549.918 | fnc |
| 183 | 190686.016 | 212965.604 | 22550.787 | fnc |
| 184 | 190686.654 | 213000.184 | 22550.993 | fnc |
| 185 | 190690.149 | 213006.128 | 22550.711 | fnc |
| 186 | 190692.451 | 213009.589 | 22550.025 | fnc |
| 187 | 190692.727 | 213010.863 | 22550.613 | fnc |
| 188 | 190694.402 | 213010.851 | 22550.708 | fnc |
| 189 | 190695.107 | 213018.618 | 22550.117 | fnc |
| 190 | 190694.832 | 213036.06 | 22550.497 | fnc |
| 191 | 190694.703 | 213054.514 | 22550.654 | fnc |
| 192 | 190694.662 | 213060.048 | 22550.306 | fnc |
| 193 | 190683.202 | 213059.459 | 22550.562 | fnc |
| 194 | 190670.148 | 213059.209 | 22552.157 | fnc |
| 195 | 190590.718 | 213059.831 | 22550.627 | pole |
| 196 | 190696.154 | 213066.5 | 22546.901 | pole |
| 197 | 190677.097 | 213063.135 | 22547.022 | wall |
| 198 | 190671.384 | 213063.489 | 22547.448 | TR |
| 199 | 190664.103 | 213067.502 | 22547.337 | TR |
| 200 | 190620.065 | 213086.53 | 22548.92 | transformer |
| 201 | 190620.596 | 213086.091 | 22549.088 | transformer |
| 202 | 190576.583 | 213084.322 | 22550.255 | stake |
| 203 | 190573.037 | 213084.271 | 22550.534 | sw |
| 204 | 190573.761 | 213084.347 | 22550.626 | sw |
| 205 | 190566.857 | 213084.066 | 22550.534 | road |
| 206 | 190566.031 | 213075.416 | 22550.711 | road |
| 207 | 190564.926 | 213054.541 | 22551.266 | road |
| 208 | 190564.456 | 213030.153 | 22551.368 | road |
| 209 | 190567.489 | 212984.885 | 22550.9 | road |
| 210 | 190534.136 | 212995.655 | 22552.592 | water |
| 211 | 190533.38 | 212994.571 | 22552.819 | water |
| 212 | 190533.268 | 212993.551 | 22552.832 | road |
| 213 | 190576.417 | 212948.596 | 22551.744 | water |
| 214 | 190592.056 | 212948.805 | 22551.233 | water |
| 215 | 190568.431 | 212909.001 | 22551.738 | road |
| 216 | 190569.021 | 212904.094 | 22551.404 | road |
| 217 | 190584.825 | 212899.979 | 22551.293 | sign |
| 218 | 190585.697 | 212900.827 | 22551.939 | sign |
| 219 | 190592.693 | 212899.328 | 22551.27 | sign |
| 220 | 190587.796 | 212897.948 | 22551.181 | sign |
| 221 | 190580.109 | 212897.763 | 22551.316 | electric |
| 222 | 190593.417 | 212900.181 | 22551.139 | building |
| 223 | 190625.584 | 212899.114 | 22550.079 | building |

| | | | | |
|---|---|---|---|---|
| 224 | 190653.509 | 212899.754 | 22546.907 | building |
| 225 | 190697.352 | 213009.8 | 22547.427 | wall |
| 226 | 190697.961 | 213023.961 | 22546.659 | wall |
| 227 | 190697.316 | 213043.954 | 22546.531 | wall |
| 228 | 190697.642 | 213062.541 | 22546.701 | wall |
| 229 | 190706.915 | 213075.858 | 22546.163 | transformer |
| 230 | 190701.006 | 213056.043 | 22546.389 | curb |
| 231 | 190700.407 | 213044.988 | 22546.724 | curb |
| 232 | 190700.521 | 213028.456 | 22546.492 | curb |
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| 234 | 190699.53 | 212997.174 | 22546.929 | curb |
| 235 | 190696.962 | 212997.598 | 22547.486 | curb |
| 236 | 190694.025 | 212986.574 | 22548.267 | curb |
| 237 | 190694.851 | 212987.164 | 22548.094 | curb |
| 238 | 190698.946 | 212975.793 | 22547.014 | curb |
| 239 | 190694.661 | 212974.739 | 22548.271 | curb |
| 240 | 190694.691 | 212964.35 | 22547.907 | curb |
| 241 | 190699.154 | 212964.005 | 22546.9 | curb |
| 242 | 190697.225 | 212947.303 | 22546.72 | curb |
| 243 | 190692.642 | 212944.572 | 22548.304 | curb |
| 244 | 190697.586 | 212936.097 | 22547.133 | curb |
| 245 | 190699.97 | 212920.567 | 22546.829 | curb |
| 246 | 190699.402 | 212926.54 | 22546.205 | TR |
| 247 | 190695.637 | 212911.212 | 22546.944 | TR |
| 248 | 190700.152 | 212890.311 | 22546.833 | TR |
| 249 | 190682.637 | 212890.637 | 22547.302 | TR |
| 250 | 190664.736 | 212890.887 | 22548.003 | curb |
| 251 | 190656.724 | 212890.904 | 22548.344 | bush |
| 252 | 190654.864 | 212894.282 | 22548.436 | TR |
| 253 | 190654.105 | 212897.677 | 22546.438 | TR |
| 254 | 190649.409 | 212894.834 | 22546.179 | TR |
| 255 | 190638.8 | 212891.818 | 22548.931 | curb |
| 256 | 190630.576 | 212892.498 | 22549.115 | bush |
| 257 | 190615.157 | 212891.266 | 22549.627 | curb |
| 258 | 190609.897 | 212895.188 | 22550.873 | TR |
| 259 | 190603.063 | 212896.531 | 22551.29 | bush |
| 260 | 190583.766 | 212901.216 | 22551.152 | |
| 261 | 190583.712 | 212901.277 | 22551.175 | |
| 262 | 190581.911 | 212963.285 | 22551.459 | |
| 263 | 190582.285 | 212989.608 | 22551.819 | |
| 264 | 190582.156 | 213013.113 | 22551.553 | |
| 265 | 190582.579 | 213030.133 | 22551.916 | TR |
| 266 | 190578.699 | 213059.881 | 22551.335 | bush |
| 267 | 190586.597 | 212992.755 | 22551.743 | bush |
| 268 | 190607.838 | 212993.946 | 22551.508 | |
| 269 | 190626.723 | 212995.109 | 22551.304 | |

| | | | | |
|---|---|---|---|---|
| 270 | 190643.895 | 212995.867 | 22551.216 | |
| 271 | 190665.673 | 212995.612 | 22551.603 | |
| 272 | 190678.837 | 212995.321 | 22551.512 | |
| 273 | 190678.561 | 213008.785 | 22551.137 | |
| 274 | 190679.272 | 213028.505 | 22551.17 | |
| 275 | 190680.083 | 213048.835 | 22550.592 | |
| 276 | 190676.396 | 212972.235 | 22551.276 | |
| 277 | 190659.221 | 212972.952 | 22550.997 | |
| 278 | 190636.713 | 212974.66 | 22551.128 | |
| 279 | 190615.532 | 212974.674 | 22551.029 | |
| 280 | 190594.639 | 212974.66 | 22551.403 | |
| 281 | 190596.269 | 212995.118 | 22551.107 | light |
| 282 | 190601.027 | 213009.75 | 22551.438 | control box |
| 283 | 190634.378 | 213036.837 | 22551.888 | CONC |
| 284 | 190668.601 | 213057.794 | 22551.717 | light |
| 285 | 190667.49 | 213036.419 | 22551.304 | |
| 286 | 190666.839 | 213009.989 | 22551.787 | |
| 287 | 190643.055 | 213011.272 | 22551.996 | |
| 288 | 190622.447 | 213011.496 | 22551.872 | |
| 289 | 190587.431 | 213011.492 | 22551.759 | |
| 290 | 190590.833 | 212940.494 | 22551.056 | |
| 291 | 190594.505 | 212940.444 | 22550.944 | |
| 292 | 190594.638 | 212953.063 | 22550.724 | |
| 293 | 190595.064 | 212962.79 | 22550.724 | |
| 294 | 190608.579 | 212962.963 | 22550.927 | |
| 295 | 190627.686 | 212962.924 | 22550.888 | |
| 296 | 190641.152 | 212961.967 | 22550.718 | |
| 297 | 190654.117 | 212964.341 | 22550.643 | |

# Geotechnical Report

## Done: March 2, 2019 Samples

Sample 1: Collected at the northeastern corner of the property closest to the retaining wall.
Sample 2: Collected at center of property near sealed well.
Sample2: Collected at southwestern corner of the property closest to the building pad.

### Tests Completed

Moisture Content ASTM DD2216-10
Plastic Limit ASTM D4318
Sieve Analysis ASTM D6913

## Moisture Content

Materials [1]

- 6 moisture cans (2 for each sample bag)
- 3 soil sample bags
- Evaporating dish
- Electronic scale
- Oven (T=105 F)
- China marker
- Tongs
- Oven gloves

Procedure [1]

Six moisture cans were weighed on the electronic scales to determine the weights of each can (W_c). Using the evaporating dish, two samples were collected from each bag and to each can. This was weighed to determine the initial sample weights including the moisture can (W_1). Each can was labeled using the china marker. Each can was then placed in an oven at 105 degrees for 16 hours. After this, the dried sample weight including the can (W_2) was found using the scale. Table 1 below documents this data.

Table 1: Data collected during moisture content testing for each sample [1].

| | South | Middle | Wall |
|---|---|---|---|
| Wet weight, AA | 379.2 | 289.5 | 250 |
| Dry weight, BB | 335.6 | 255.9 | 200.7 |
| Moisture Content (AA-BB)/BB * 100 | 43.6 | 33.9 | 24.6 |

Equation 1 below shows the calculation used to find the moisture content for each sample.

$$w = (W_1 - W_2)/(W_2 - W_c)*100\%$$

The moisture content is the weight of water in the sample expressed as a parentage of the dry weight of the sample.

## Sieve Analysis

Materials [1]

- Oven dried soil samples
- No. 4, 10, 20, 40, 60, 140, 200 sieves
- Sieve pan
- Mechanical shaker
- Electronic scale

Procedure [1]

Continuing from above, each oven dried sample size was approximately 500g. Used a rubber tipped pestle and mortar to break down clumps in the soil. Weighed each of the three samples ($W_i$) one for each sample bag. Cleaned each sieve and inspect the sieves prior to use to verify there were no unnecessary holes. Then obtained the weight of each sieve and the pan. Stacked the sieves in order from the Pan (on the bottom), #200, #140... to #4 (on the top). Poured the soil sample in the top sieve and covered it with a lid. Placed the nest of sieves in the mechanical shakers and turned on the shaker for 11 minutes. Weigh each separate sieve and the pan with the sample retained. Table 2 below documents this data.

Table 2: Data collected during sieve analysis.

| Sieve No. | Weight Retained | | | % Retained | | | % Pass Accumulative | | |
|---|---|---|---|---|---|---|---|---|---|
| | South | Middle | Wall | South | Middle | Wall | South | Middle | Wall |
| 1 ¼ in | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 100 |
| 1 in | 56 | 48 | 70 | 3.4 | 2.6 | 4.3 | 97 | 97.4 | 95.7 |
| 3/4 in | 120 | 82 | 112 | 7.2 | 4.4 | 6.9 | 90 | 93 | 88.8 |
| ½ in | 58 | 213 | 51 | 3.5 | 11.5 | 3.2 | 86 | 81.5 | 85.6 |
| 3/8 in | 136 | 166 | 75 | 8.2 | 8.9 | 4.6 | 78 | 72.6 | 81 |
| No. 3 | 45 | 216 | 57 | 2.7 | 11.6 | 3.5 | 75 | 70 | 76.5 |
| No. 4 | 45 | 131 | 25 | 2.7 | 7.1 | 1.5 | 72 | 62.9 | 75 |
| No. 8 | 14 | 12 | 12 | 1.8 | 1.5 | 2.2 | 70 | 61.4 | 72.8 |
| No. 10 | 50 | 46 | 14 | 6.4 | 5.9 | 2.6 | 64 | 55.5 | 70.2 |
| No. 15 | 45 | 49 | 29 | 5.7 | 6.2 | 5.3 | 58 | 49.3 | 64.9 |
| No. 30 | 22 | 23 | 18 | 2.8 | 2.9 | 3.3 | 55 | 46.4 | 61.6 |
| No. 40 | 20 | 19 | 17 | 2.5 | 2.4 | 3.1 | 53 | 44 | 58.5 |
| No. 50 | 57 | 39 | 51 | 7.2 | 5 | 9.3 | 46 | 39 | 49.2 |
| No. 100 | 5 | 39 | 38 | 0.6 | 5 | 6.9 | 45 | 34 | 42.3 |
| No. 200 | 73 | 16 | 13 | 9.3 | 2 | 2.4 | 23.6 | 32 | 39.9 |

Equation 2: Calculation for percent of mass retained.

$$R_n = W_n/W_t * 100\%$$

$W_n$ = mass of individual sieve

$W_t$ = total mass of sample

Equation 3: Percent finer.

100 - sum($R_n$)

Equation 4: Coefficient of uniformity.

$$C_u = D60/D10$$

D60 = diameter at which 60% of the particles are finer

D10 = diameter at which 10% of the particles are finer

The diameter at which a certain percentage of particles are finer is where the curve intersects the line for the associated percent finer on the size distribution chart above.

With respect to the gradation of the soil, different terms such as well graded, poorly graded, densely graded, uniformly graded, and gap-graded, are often used to describe how densely or loosely the particles fit together. Soils and aggregate with a particular gradation may or may not be well suited for a particular application. Therefore, understanding the grading characteristics of a particular soil was important to determine if the material will be acceptable for use on this project for applications such as withstanding added pavement or drainage control devices. In order to classify each soil sample the Atterberg limit had to be found for each as well.

# Atterberg Limits

Materials [1]
- No. 40 sieve
- 3 moisture cans
- 2 evaporating dishes
- Casagrande device
- Spatula
- Grooving tool
- Water container
- Proctor compaction:
- Standard proctor hammer
- Modified proctor hammer
- 4 inch mold

Plastic Limit Procedure [1]
- 6 moisture cans
- Large capacity balance (kg)
- Small capacity balance (kg)
- No. 4 sieve
- Straight edge
- Spatula
- Large mixing pan
- Large spoon
- Graduated cylinder
- Sample extraction device

Table 3: Sieve data collected for Atterberg Limit Testing.

| | | South | Middle | Wall |
|---|---|---|---|---|
| Pass No. 4 | Wet | 1357 | 1131.8 | 1553 |
| | Dry | 1201 | 1000.7 | 1252.4 |
| Wet weight before wash | | 640.5 | 558 | 522 |
| Dry weight before wash | | 566.8 | 493.4 | 418.9 |
| Weight after wash | | 403 | 311 | 217 |
| Total Dry | | 1661 | 1856.1 | 1617.4 |

Table 4: Plasticity Index Table.

| **Liquid Limit** | South | Middle | Wall |
|---|---|---|---|
| Liquid Limit – Taps | 24 | 23 | 25 |
| Container Identification | A3 | YU | X1 |
| Wet weight + container | 26.61 | 21.11 | 21.2 |
| Dry weight + container | 24.2 | 19.24 | 18.45 |
| Weight of water | 2.41 | 1.87 | 2.75 |
| Weight of container | 15.20 | 12.72 | 12.75 |
| Weight of dry soil | 9 | 6.52 | 5.7 |
| Water content | 26.8 | 28.7 | 48 |
| Liquid limit at 25 taps | 27 | 28 | 48 |
| **Plastic Limit** | | | |
| Container Identification | X1 | F4 | A3 |
| Wet weight + container | 20.72 | 20.99 | 22.95 |
| Dry weight + container | 19.37 | 19.83 | 12.78 |
| Weight of water | 1.35 | 1.16 | 1.17 |
| Weight of container | 12.72 | 13.03 | 15.19 |
| Weight of dry soil | 6.62 | 6.80 | 6.59 |
| Plastic Limit | 20.4 | 17.1 | 17.8 |
| Average plastic limit | 20 | 17 | 18 |
| **Plasticity Index** | 7 | 11 | 30 |

Obtained a soil sample of approximately 250 grams finer than the #40 sieve. Labeled and weighed each moisture can. Split each sample into 2 evaporating dishes. Slowly added water to each of the samples until the sample was stiff and had a putty-like consistency. Rolled 3 ellipsoidal-shaped soil masses of approximately ½ inch in diameter. Took one of the soil masses and roll it on the etched side of a glass plate into a cylindrical thread. This rolling motions was completed with the palm of a hand. The soil was at its plastic limit when it broke at a diameter of 1/8th of an inch. So the goal of this process was to create a thread that starts to break and form cracks when it was exactly 1/8th of an inch. Then, using the moisture content procedures from above, the content for each sample was determined. Plastic limit for each sample is shown below in the table.

Equation 5: Plastic limit.

$$PL = W_1 - W_2 / W_2 - W_c * 100$$

The plastic limit is simply the moisture content, w, reported without a percentage sign.

Liquid Limit Procedure [1]

Cleaned, tested and calibrated the Casagrande device. Ensured that the cup fell exactly 1 cm onto the base. Figure 2 below shows the way the grooving tools was used to calibrate the Casagrande device. Labeled and weighed each soil moisture can. Slowly added water to the second soil sample to form a well-mixed paste. Filled the Casagrande cup with sample to a depth of 10 mm. The depth of the Casagrande cup was 27mm. Used the Spatula to smooth the surface of your sample. Used the grooving tool to form a trench down the center of the sample. Once the sample was prepared as it is shown below the crank was turned at 2 rotations per second. When the gap in the soil closed as shown in part b of the figure the crank was stopped. The number of drops (N) was recorded. This was repeated 5 times for each sample to have enough plotting data. Then the moisture content for each sample was found once again. The moisture content was plotted on a semi-logarithmic graph against the number of drops, and the moisture content at exactly 25 drops in the liquid limit.

# Soil Classification

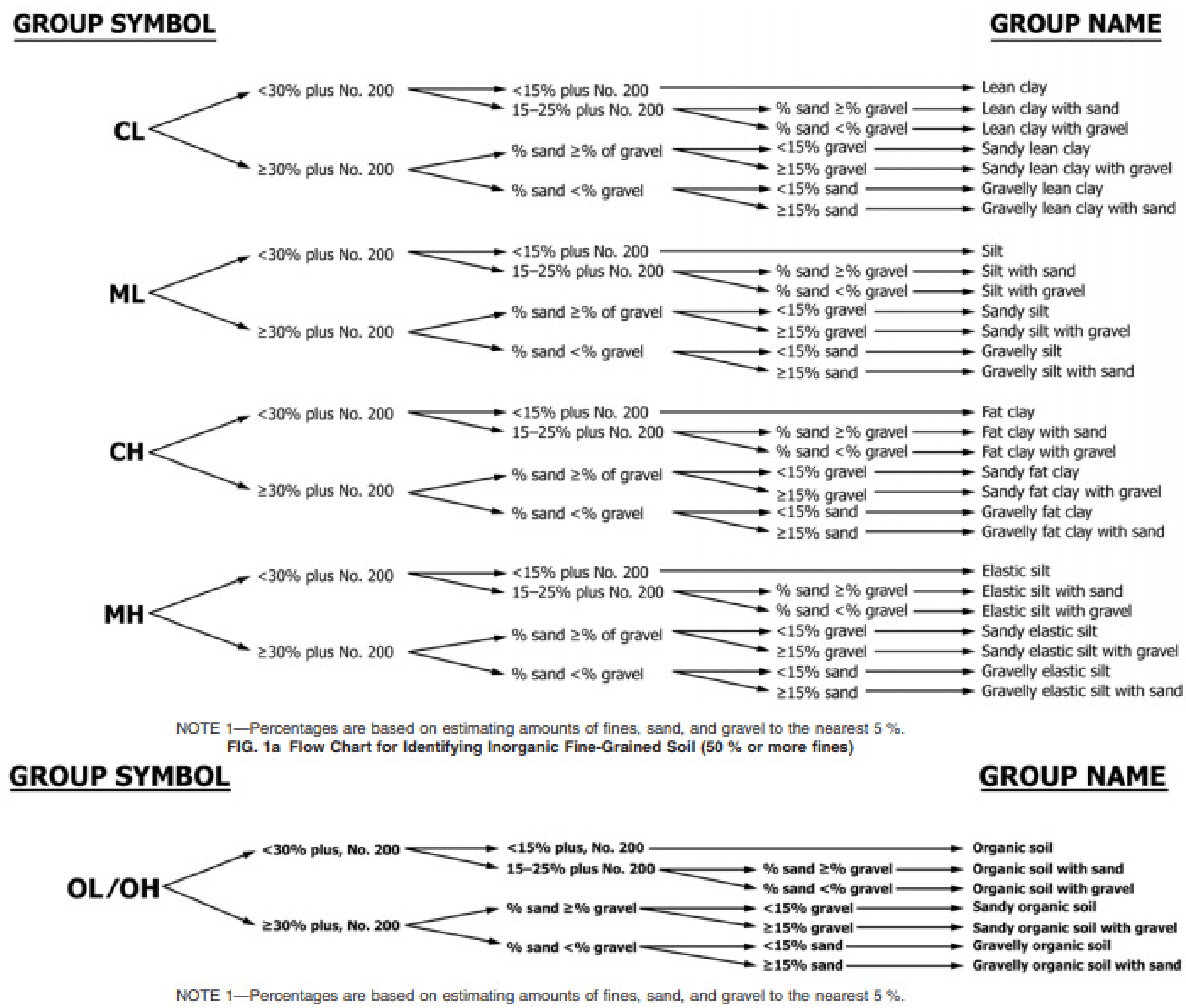


Figure 3: ASTM D2488 Soil Classification Chart.

Table 5: Summary of Results

| Sample | South | Middle | Wall |
|---|---|---|---|
| Moisture Content | 13% | 13.1% | 24.6% |
| Passing No. 200 Sieve | 23.6% | 32% | 39.9% |
| Liquid Limit | 27 | 28 | 48 |
| Plastic Limit | 20 | 17 | 18 |
| Plasticity Index | 7 | 11 | 30 |
| **Soil Classification** | Sandy Clay | Gravely Clay | Fatty Clay |

# Drainage Analysis

*Table 7. Precipitation depth values* [4].

| PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Duration | Average recurrence interval (years) | | | | | | | | | |
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | **0.212** (0.180-0.249) | **0.274** (0.232-0.322) | **0.371** (0.314-0.436) | **0.452** (0.381-0.530) | **0.569** (0.474-0.663) | **0.665** (0.550-0.775) | **0.771** (0.629-0.899) | **0.885** (0.713-1.03) | **1.05** (0.829-1.23) | **1.19** (0.923-1.40) |
| 10-min | **0.322** (0.274-0.379) | **0.416** (0.353-0.490) | **0.565** (0.478-0.663) | **0.688** (0.580-0.806) | **0.865** (0.722-1.01) | **1.01** (0.838-1.18) | **1.17** (0.958-1.37) | **1.35** (1.09-1.57) | **1.60** (1.26-1.88) | **1.81** (1.40-2.13) |
| 15-min | **0.399** (0.339-0.471) | **0.516** (0.438-0.607) | **0.701** (0.593-0.822) | **0.853** (0.719-0.999) | **1.07** (0.895-1.25) | **1.26** (1.04-1.46) | **1.45** (1.19-1.70) | **1.67** (1.35-1.95) | **1.98** (1.56-2.33) | **2.24** (1.74-2.65) |
| 30-min | **0.539** (0.457-0.634) | **0.695** (0.589-0.817) | **0.944** (0.799-1.11) | **1.15** (0.969-1.35) | **1.45** (1.21-1.69) | **1.69** (1.40-1.97) | **1.96** (1.60-2.29) | **2.25** (1.81-2.63) | **2.67** (2.11-3.14) | **3.02** (2.35-3.56) |
| 60-min | **0.666** (0.566-0.784) | **0.861** (0.730-1.01) | **1.17** (0.988-1.37) | **1.42** (1.20-1.67) | **1.79** (1.49-2.09) | **2.09** (1.73-2.44) | **2.42** (1.98-2.83) | **2.78** (2.24-3.25) | **3.30** (2.61-3.88) | **3.74** (2.90-4.41) |
| 2-hr | **0.778** (0.676-0.898) | **0.986** (0.855-1.14) | **1.31** (1.13-1.51) | **1.58** (1.35-1.81) | **1.97** (1.68-2.26) | **2.30** (1.93-2.64) | **2.66** (2.20-3.05) | **3.05** (2.49-3.50) | **3.62** (2.90-4.18) | **4.10** (3.22-4.75) |
| 3-hr | **0.839** (0.740-0.963) | **1.06** (0.935-1.22) | **1.37** (1.21-1.57) | **1.63** (1.43-1.86) | **2.01** (1.75-2.29) | **2.33** (2.00-2.65) | **2.68** (2.28-3.06) | **3.07** (2.57-3.51) | **3.63** (2.98-4.20) | **4.11** (3.30-4.76) |
| 6-hr | **1.01** (0.897-1.14) | **1.25** (1.12-1.42) | **1.57** (1.39-1.77) | **1.84** (1.63-2.08) | **2.23** (1.96-2.52) | **2.55** (2.22-2.88) | **2.90** (2.49-3.28) | **3.28** (2.78-3.72) | **3.83** (3.17-4.37) | **4.29** (3.49-4.92) |
| 12-hr | **1.20** (1.07-1.36) | **1.48** (1.32-1.68) | **1.82** (1.62-2.06) | **2.10** (1.87-2.37) | **2.48** (2.19-2.79) | **2.78** (2.44-3.12) | **3.09** (2.69-3.48) | **3.40** (2.93-3.84) | **3.86** (3.29-4.39) | **4.33** (3.58-4.97) |
| 24-hr | **1.40** (1.28-1.54) | **1.75** (1.60-1.93) | **2.19** (2.00-2.42) | **2.55** (2.32-2.80) | **3.03** (2.75-3.32) | **3.40** (3.07-3.73) | **3.78** (3.40-4.15) | **4.18** (3.73-4.58) | **4.70** (4.17-5.17) | **5.12** (4.50-5.64) |
| 2-day | **1.58** (1.45-1.73) | **1.97** (1.81-2.16) | **2.47** (2.26-2.70) | **2.86** (2.63-3.13) | **3.41** (3.11-3.73) | **3.84** (3.49-4.19) | **4.27** (3.86-4.67) | **4.72** (4.24-5.16) | **5.33** (4.74-5.84) | **5.80** (5.12-6.39) |
| 3-day | **1.67** (1.54-1.81) | **2.08** (1.92-2.27) | **2.61** (2.41-2.84) | **3.03** (2.79-3.29) | **3.60** (3.31-3.91) | **4.04** (3.70-4.39) | **4.50** (4.10-4.89) | **4.97** (4.49-5.41) | **5.60** (5.02-6.11) | **6.09** (5.41-6.66) |
| 4-day | **1.76** (1.63-1.90) | **2.20** (2.04-2.37) | **2.75** (2.56-2.97) | **3.19** (2.96-3.44) | **3.79** (3.50-4.08) | **4.25** (3.92-4.59) | **4.73** (4.34-5.11) | **5.22** (4.75-5.65) | **5.87** (5.30-6.37) | **6.38** (5.70-6.94) |
| 7-day | **2.05** (1.90-2.23) | **2.57** (2.38-2.79) | **3.21** (2.97-3.47) | **3.71** (3.43-4.00) | **4.38** (4.04-4.72) | **4.90** (4.50-5.29) | **5.42** (4.96-5.87) | **5.95** (5.42-6.45) | **6.66** (6.02-7.23) | **7.19** (6.46-7.83) |
| 10-day | **2.31** (2.13-2.50) | **2.89** (2.67-3.13) | **3.61** (3.33-3.91) | **4.16** (3.84-4.50) | **4.89** (4.50-5.28) | **5.44** (5.00-5.89) | **6.00** (5.48-6.50) | **6.55** (5.96-7.12) | **7.28** (6.58-7.92) | **7.83** (7.05-8.54) |
| 20-day | **2.94** (2.71-3.18) | **3.68** (3.40-3.99) | **4.53** (4.20-4.91) | **5.15** (4.76-5.58) | **5.94** (5.48-6.42) | **6.49** (5.98-7.02) | **7.02** (6.45-7.60) | **7.53** (6.89-8.15) | **8.14** (7.43-8.83) | **8.57** (7.80-9.32) |
| 30-day | **3.48** (3.22-3.75) | **4.36** (4.04-4.70) | **5.40** (5.01-5.82) | **6.16** (5.72-6.63) | **7.13** (6.61-7.68) | **7.83** (7.25-8.44) | **8.51** (7.86-9.18) | **9.16** (8.43-9.89) | **9.96** (9.14-10.8) | **10.5** (9.64-11.4) |
| 45-day | **4.11** (3.81-4.45) | **5.16** (4.78-5.58) | **6.43** (5.95-6.93) | **7.36** (6.81-7.92) | **8.56** (7.91-9.19) | **9.44** (8.69-10.1) | **10.3** (9.46-11.0) | **11.1** (10.2-11.9) | **12.1** (11.1-13.1) | **12.9** (11.7-13.9) |
| 60-day | **4.63** (4.30-5.00) | **5.83** (5.41-6.27) | **7.22** (6.70-7.77) | **8.25** (7.65-8.85) | **9.54** (8.82-10.2) | **10.5** (9.65-11.2) | **11.4** (10.5-12.2) | **12.2** (11.2-13.1) | **13.3** (12.1-14.3) | **14.0** (12.8-15.1) |

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.
Please refer to NOAA Atlas 14 document for more information.

*Table 8. Precipitation intensity values* [4].

| PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Duration | Average recurrence interval (years) | | | | | | | | | |
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | **2.54** (2.16-2.99) | **3.29** (2.78-3.86) | **4.45** (3.77-5.23) | **5.42** (4.57-6.36) | **6.83** (5.69-7.96) | **7.98** (6.60-9.30) | **9.25** (7.55-10.8) | **10.6** (8.56-12.4) | **12.6** (9.95-14.8) | **14.3** (11.1-16.8) |
| 10-min | **1.93** (1.64-2.27) | **2.50** (2.12-2.94) | **3.39** (2.87-3.98) | **4.13** (3.48-4.84) | **5.19** (4.33-6.05) | **6.08** (5.03-7.08) | **7.04** (5.75-8.21) | **8.08** (6.51-9.44) | **9.59** (7.57-11.3) | **10.8** (8.42-12.8) |
| 15-min | **1.60** (1.36-1.88) | **2.06** (1.75-2.43) | **2.80** (2.37-3.29) | **3.41** (2.88-4.00) | **4.29** (3.58-5.01) | **5.02** (4.15-5.85) | **5.82** (4.75-6.79) | **6.68** (5.38-7.80) | **7.93** (6.26-9.32) | **8.97** (6.96-10.6) |
| 30-min | **1.08** (0.914-1.27) | **1.39** (1.18-1.63) | **1.89** (1.60-2.21) | **2.30** (1.94-2.69) | **2.89** (2.41-3.37) | **3.38** (2.80-3.94) | **3.92** (3.20-4.57) | **4.50** (3.62-5.25) | **5.34** (4.21-6.27) | **6.04** (4.69-7.13) |
| 60-min | **0.666** (0.566-0.784) | **0.861** (0.730-1.01) | **1.17** (0.988-1.37) | **1.42** (1.20-1.67) | **1.79** (1.49-2.09) | **2.09** (1.73-2.44) | **2.42** (1.98-2.83) | **2.78** (2.24-3.25) | **3.30** (2.61-3.88) | **3.74** (2.90-4.41) |
| 2-hr | **0.389** (0.338-0.449) | **0.493** (0.428-0.571) | **0.654** (0.564-0.754) | **0.788** (0.677-0.906) | **0.985** (0.838-1.13) | **1.15** (0.965-1.32) | **1.33** (1.10-1.52) | **1.52** (1.25-1.75) | **1.81** (1.45-2.09) | **2.05** (1.61-2.37) |
| 3-hr | **0.279** (0.246-0.321) | **0.353** (0.311-0.405) | **0.456** (0.402-0.522) | **0.543** (0.477-0.620) | **0.670** (0.581-0.764) | **0.776** (0.666-0.883) | **0.892** (0.758-1.02) | **1.02** (0.854-1.17) | **1.21** (0.991-1.40) | **1.37** (1.10-1.59) |
| 6-hr | **0.168** (0.150-0.190) | **0.209** (0.186-0.237) | **0.262** (0.232-0.296) | **0.307** (0.272-0.347) | **0.373** (0.327-0.421) | **0.427** (0.370-0.481) | **0.485** (0.416-0.548) | **0.547** (0.464-0.621) | **0.639** (0.530-0.730) | **0.716** (0.583-0.822) |
| 12-hr | **0.099** (0.089-0.112) | **0.123** (0.110-0.140) | **0.151** (0.135-0.171) | **0.174** (0.155-0.196) | **0.206** (0.182-0.232) | **0.231** (0.202-0.259) | **0.256** (0.223-0.289) | **0.282** (0.243-0.319) | **0.321** (0.273-0.365) | **0.359** (0.297-0.413) |
| 24-hr | **0.058** (0.053-0.064) | **0.073** (0.067-0.080) | **0.091** (0.083-0.101) | **0.106** (0.097-0.117) | **0.126** (0.114-0.138) | **0.142** (0.128-0.155) | **0.158** (0.142-0.173) | **0.174** (0.156-0.191) | **0.196** (0.174-0.216) | **0.213** (0.187-0.235) |
| 2-day | **0.033** (0.030-0.036) | **0.041** (0.038-0.045) | **0.051** (0.047-0.056) | **0.060** (0.055-0.065) | **0.071** (0.065-0.078) | **0.080** (0.073-0.087) | **0.089** (0.080-0.097) | **0.098** (0.088-0.108) | **0.111** (0.099-0.122) | **0.121** (0.107-0.133) |
| 3-day | **0.023** (0.021-0.025) | **0.029** (0.027-0.032) | **0.036** (0.033-0.039) | **0.042** (0.039-0.046) | **0.050** (0.046-0.054) | **0.056** (0.051-0.061) | **0.063** (0.057-0.068) | **0.069** (0.062-0.075) | **0.078** (0.070-0.085) | **0.085** (0.075-0.093) |
| 4-day | **0.018** (0.017-0.020) | **0.023** (0.021-0.025) | **0.029** (0.027-0.031) | **0.033** (0.031-0.036) | **0.039** (0.036-0.043) | **0.044** (0.041-0.048) | **0.049** (0.045-0.053) | **0.054** (0.049-0.059) | **0.061** (0.055-0.066) | **0.066** (0.059-0.072) |
| 7-day | **0.012** (0.011-0.013) | **0.015** (0.014-0.017) | **0.019** (0.018-0.021) | **0.022** (0.020-0.024) | **0.026** (0.024-0.028) | **0.029** (0.027-0.031) | **0.032** (0.030-0.035) | **0.035** (0.032-0.038) | **0.040** (0.036-0.043) | **0.043** (0.038-0.047) |
| 10-day | **0.010** (0.009-0.010) | **0.012** (0.011-0.013) | **0.015** (0.014-0.016) | **0.017** (0.016-0.019) | **0.020** (0.019-0.022) | **0.023** (0.021-0.025) | **0.025** (0.023-0.027) | **0.027** (0.025-0.030) | **0.030** (0.027-0.033) | **0.033** (0.029-0.036) |
| 20-day | **0.006** (0.006-0.007) | **0.008** (0.007-0.008) | **0.009** (0.009-0.010) | **0.011** (0.010-0.012) | **0.012** (0.011-0.013) | **0.014** (0.012-0.015) | **0.015** (0.013-0.016) | **0.016** (0.014-0.017) | **0.017** (0.015-0.018) | **0.018** (0.016-0.019) |
| 30-day | **0.005** (0.004-0.005) | **0.006** (0.006-0.007) | **0.008** (0.007-0.008) | **0.009** (0.008-0.009) | **0.010** (0.009-0.011) | **0.011** (0.010-0.012) | **0.012** (0.011-0.013) | **0.013** (0.012-0.014) | **0.014** (0.013-0.015) | **0.015** (0.013-0.016) |
| 45-day | **0.004** (0.004-0.004) | **0.005** (0.004-0.005) | **0.006** (0.006-0.006) | **0.007** (0.006-0.007) | **0.008** (0.007-0.009) | **0.009** (0.008-0.009) | **0.010** (0.009-0.010) | **0.010** (0.009-0.011) | **0.011** (0.010-0.012) | **0.012** (0.011-0.013) |
| 60-day | **0.003** (0.003-0.003) | **0.004** (0.004-0.004) | **0.005** (0.005-0.005) | **0.006** (0.005-0.006) | **0.007** (0.006-0.007) | **0.007** (0.007-0.008) | **0.008** (0.007-0.008) | **0.008** (0.008-0.009) | **0.009** (0.008-0.010) | **0.010** (0.009-0.010) |

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

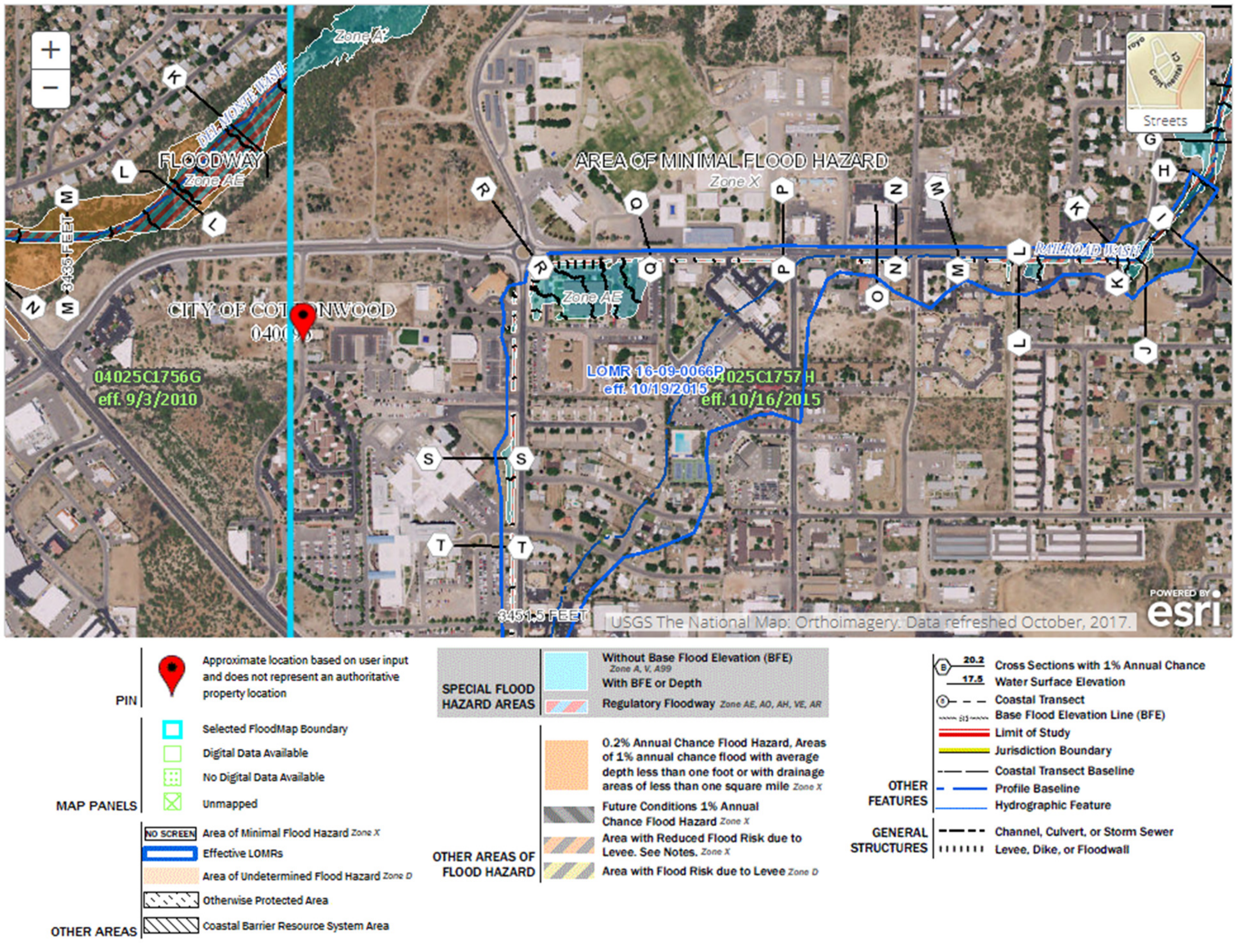


*Figure 9. Flood Hazard Data. USGS. 2019.*

# Reference

[1] Geotechnical Engineering 1 Lab, CENE383L. Prof. Nye McCarthy. 2017.
[2] Soil Classification Chart. AASHTO. 2019.
[3] Soil Classification Chart. USCS. 2019.