PRESCOTT DELLS RANCH FINAL REPORT

FOR: TAYLOR LAYLAND (CLIENT)

BY: CROSSED ARROW ENGINEERING
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Abbreviations

ADOT	–	*Arizona Department of Transportation*
cfs	–	*Cubic feet per second*
EG	–	*Existing Grade*
FF	–	*Finished Floor*
FG	–	*Finished Grade*
ft	–	*Foot*
fps	–	*Feet per second*
GIS	–	*Geographic Information System*
hr	–	*Hour*
HW	–	*Headwater*
IBC	–	*International Building Code*
in	–	*Inch*
mi	–	*Mile*
min	–	*Minute*
R1L	–	*Residential; Single Family Limited*
ROW	–	*Right-of-Way*
RV	–	*Recreational Vehicle*
s	–	*Second*
T_c	–	*Time of Concentration*
USGS	–	*United States Geological Survey*
yd	–	*Yard*

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Thank you to Ellie Dellard for her support with obtaining the contour map of the area.
Thank you to Adam Bringhurst for his guidance with the CulvertMaster calculations.

1.0 Project Introduction

1.1. Project Background

Crossed Arrow Engineering is providing engineering services for the development of a 5-acre lot. Prescott Dells Ranch will be a single-family home site according to Yavapai County standards. It is in Dewey-Humboldt, Arizona, about halfway between Flagstaff and Phoenix, and approximately 1.5 hours from Flagstaff, as shown in the *Figure 1-1.*

Figure 1-1 Vicinity Map of Approximate Location

The site is in Section 9, Township 13 North, Range 1 East of the Gila and Salt River Baseline and Meridian. The address of the site is 11800 E Prescott Dells Ranch Rd. *Figure 1-2* shows the parcel in the Prescott Valley, and *Figure 1-3* displays the site boundaries in the town of Dewey-Humboldt.

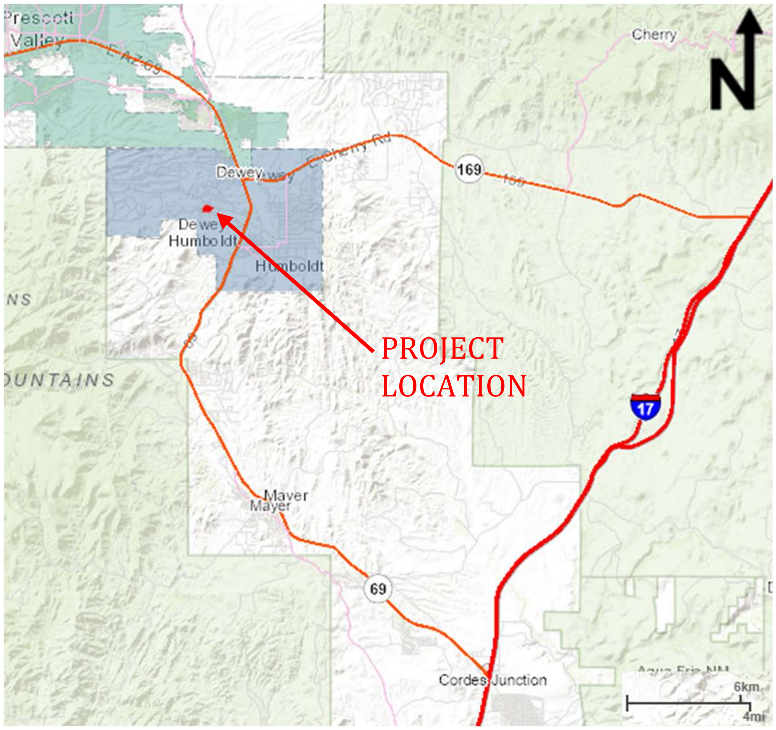

Figure 1-2 Local Area Map

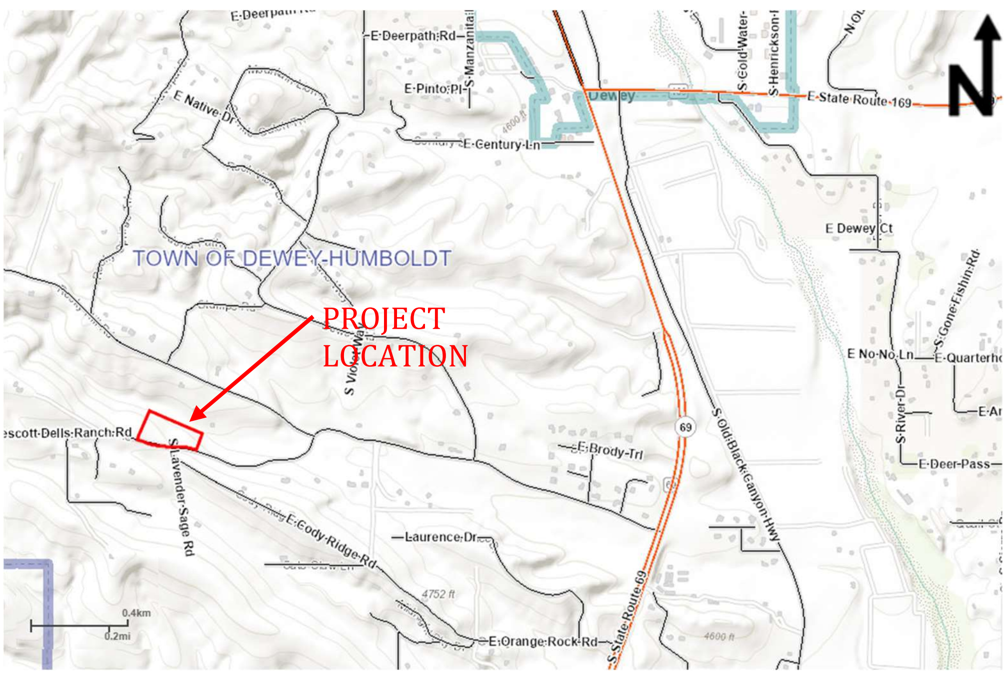

Figure 1-3 Project Location Map

Figure 1-4 shows the current conditions of the Dewey Site. There is a large wash north of the site boundary and a small ditch adjacent to Prescott Dells Ranch Rd. The site is undeveloped in a rural area, it is in a hilly area with small shrubs and weedy plain grass. The elevation of the area is around 4800 feet above sea level. There exists a mild 4 season climate, that has occasional snowfall. There are no structures on the site except for an RV. There is light vegetation with small bushes spread across the site.

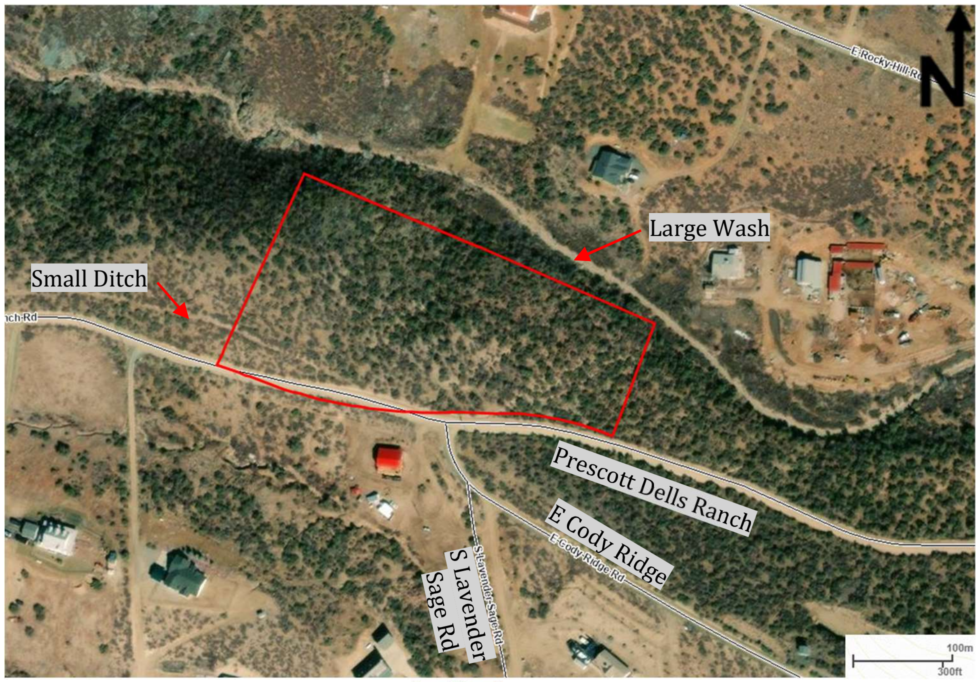

Figure 1-4 Satellite View of Project Site

The client plans to place a prefabricated, modular home from Coventry Log Homes on the property. A floorplan was obtained from the Coventry website and is shown in *Figure 1-5.* The floorplan was used as a reference for the grading design, as well as determining runoff flow rates.

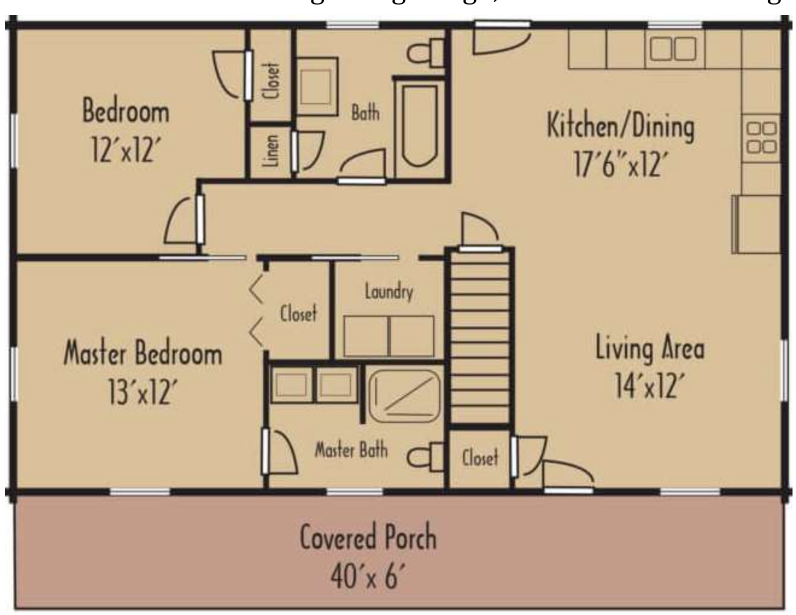

Figure 1-5 Coventry Lakeside Floorplan

1.2. Constraints and Limitations

The project parcel is zoned as zoning district R1L. [1] Homes built in this zoning district must be single-family residential site-built structures only. According to section 153.036 of the Dewey Humboldt Code of Ordinances, the minimum setback for both the front and rear of the lot is 50 feet. [2] The maximum building height is 2 stories, and the maximum lot coverage of building/structures is 10% of the lot. There is a small Right of Way (ROW) easement for Prescott Dells Ranch Road that passes through the lot. There is another capstone team that has designed the septic sewer system, and therefore, our design had to be compatible with their design. The site is located in Zone D FEMA Floodplain. This designation is an area of undetermined flood hazard, *Appendix A*.

This project is unique, as there have been no site visits because the client has not given permission to the team. Therefore, the team determined the necessary soil characteristics and site topography by other means.

There was no need to incorporate signing or striping since it is a gravel road and gravel driveway. Traffic volumes are low, and new traffic is so minimal that no traffic analysis was needed.

1.3. Major Objectives

The primary objective of the site development is to provide a safe site for the residents. By following engineering standards and jurisdictional codes, flooding, erosion, and poor soil qualities will be avoided [3]. The grading and drainage will provide a safe and proper way to move stormwater through the site. Additionally, the grading and drainage plan may work seamlessly with the septic design and other utility coordination.

2.0 Site Investigation

An in-person site investigation was not completed because the client has not given permission to the team. However, pertinent data was collected, and aerial images were taken to assess the site conditions. The Yavapai County Geographic Information System (GIS) division provided the topography of the area [1]. A soil report of an area close to the project site was used to determine the necessary soil and landform characteristics. This data and aerial images from Google Earth were sufficient to continue the project with accuracy. The calculations and the design assumed that that information was correct.

2.1. Existing Topography

In coordination with Yavapai County, the existing topographic maps were drawn in Civil3D. They sent the contours as linework, which is great as a visual, but does not work for grading calculations. The lines were assigned their respective elevations, and were added to Existing Grade surface in Civil3D. The linetype was changed to the dashed line, and the elevation labels were added on the major contours. This was checked by geo-referencing the aerial images of the area in the software. The contours were checked with a screenshot of the contours from the Yavapai County GIS map that was scaled to match the drawings scale. The scale was verified, and existing structures were drawn in based on the most recent satellite images of the location. They can be seen in *Figure 2-1.* The rest of the project was based on the surface created from the contours, including grading, drainage, and site design [4]. The property boundary can be seen as the thicker line in the figure below.

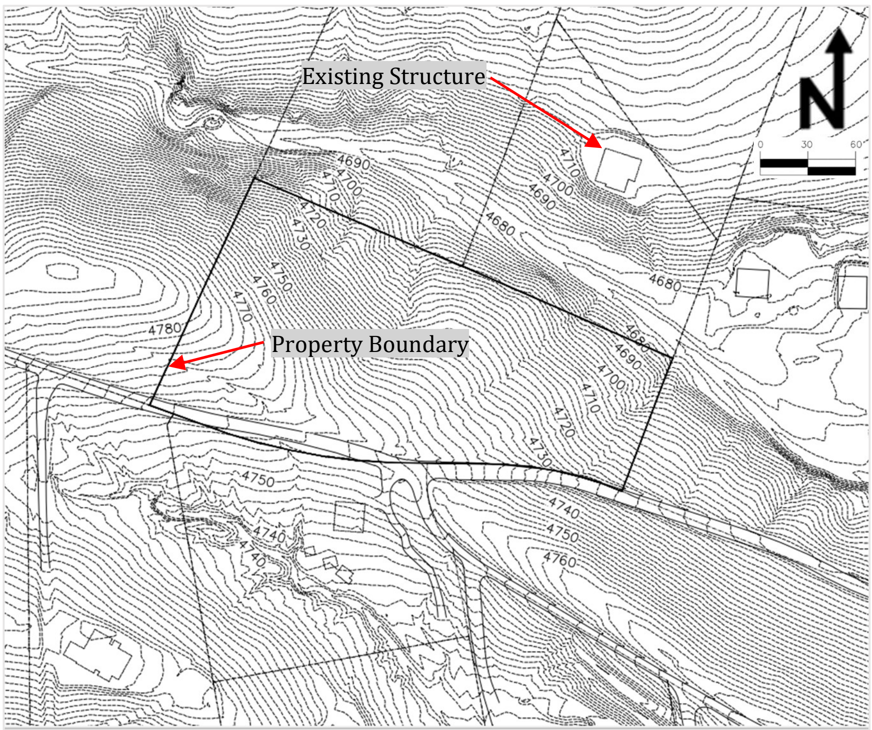

Figure 2-1 Contour Map

2.2. Geotechnical Analysis

It was necessary for the team to conduct a geotechnical analysis for the soil at the site location. With the constrains of the project, the team can only utilize Natural Resource Conservation Service official website providing the information related to the soil properties. *Figure 2-2* shows the soil survey area corresponding to the watershed area to determine the hydrology group type, which can impact the time of concentration used in the rational method analysis.

Figure 2-2 Soil Survey Area

Table 2-1 provides the necessary soil data. The hydrologic soil group was a necessary value to determine the discharge and T_c. This area's hydrologic soil group was C, indicating a slower water transmission and infiltration rate when wet. Because the geotechnical analysis was intended for subsequent hydrological analysis, the team focused more on the surface soil type, precisely the 0–3-inch soil sample. At this depth, the soil is gravelly sandy clay loam, a soil with poor water retention suitable for development. The NRCS Soil Survey can be found in *Appendix B*.

Table 2-1 Soil Properties

Hydrologic Soil Group	C
Soil Type	Balon gravelly sandy clay loam
Depth to Restrictive Feature (in.)	≥ 80
Depth to Water Table (in.)	≥ 80
Mean Annual Precipitation (in.)	≈ 14

3.0 Hydrologic Analysis

The hydrologic analysis was completed to be able to understand and calculate the pre-development flow rate in and out of the site. Watershed delineation is a method that defines an area that contributes to flow at an outlet based on knowledge of topography. The concentration point was determined to be the location of the culvert that was needed to go under the driveway. The contributing drainage area was determined by locating concentration points from the provided topography map that was provided to the team. Use of the USGS StreamStats tool, was used to find a possible watershed, but was inefficient and not giving an adequate portion to use for analysis.[6] A hand drawn delineation was created by finding the highest point on the topographic map and following all the high points where water will travel down from. For the flow path, tracing the valleys and any points that will receive runoff were followed crossing contours at a 90-degree angle, providing an adequate watershed to use and flow path. The proper image and delineation of the water shed Pre- and Post- development can be found in *Figure 3-1* and *Figure 3-2.*

After creating our watershed, we found our existing conditions and post-development conditions to utilize the ADOT Rational Method tool. The ADOT Rational method tool had provided the discharge, given the necessary variables such as rainfall factors, runoff coefficients, rainfall intensities, and drainage area. [5]. The Rational Method tool relates rainfall intensity, a runoff coefficient, and a drainage area size to the direct runoff from the drainage area by using *Equation 3-1.* This data was used to develop a future drainage plan.

Equation 3-1: Rational Method equation

$$Q = CiA$$

Where:

Q = the peak discharge of selected return periods (cfs)
C = the runoff coefficient
i = the average rainfall intensity of calculated rainfall duration for the selected rainfall return period ($^{\text{inches}}/_{\text{hr}}$)
A = the contributing drainage area (acres)

3.1. Pre-Development Runoff

A time of concentration is first needed of the existing conditions, these existing conditions will look at what the site is currently like and how water will move on the surface. The equation below, *Equation 3-2* is used to determine a time of concentration for a flow path that is on the site for existing, pre-development runoff.

Equation 3-2: Time of Concentration, T_c

$$T_c = 11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38}$$

Where:

T_c = Time of Concentration (hours)
L = Length of longest flow path (miles)
K_b = watershed resistance coefficient
S = slope of flow path (ft/mi)
i = average rainfall intensity (inches/hour)

Slope is determined using *Equation 3-3*.

Equation 3-3: Slope for flow path, S

$$S = \frac{\Delta H}{L}$$

Where:

S = Slope of flow path (ft/mi)
ΔH = change in elevation, along L (ft)
L = as Defined in *Equation 3-2*

The resistance coefficient, K_b, was found to be .1 from the Yavapai County Drainage Design Manual for rangeland cover with 0-10% slope, since the site has a slope of

348.269 ft/5280ft = 6.19% (see Appendix C: Resistance Coefficients). *Table 3-1* lists the data and results for a calculated time of concentration for the longest flow path of the ditch/channel for the needed culvert.

Table 3-1 Existing Conditions, Flow path characteristics

Length (mi.)	0.201
ΔElevation (ft)	70.0
Slope (ft/mi.)	348.26
Predominant Landform Type	Rangeland
K_b	0.1

From the Yavapai county drainage design manual, time of concentration can be no less than 10 minutes nor exceed 60 minutes. The calculated T_c of 5 minutes was smaller than 10 minutes for the 25-year storm. Per the county code for Yavapai, a T_c of 10 minutes was used. For runoff calculation, Table 3-2 shows the inputs and results of the flow rate calculations.

Table 3-2: Design Storm 25-Year Time of Concentration

Parameter	25-year
Discharge, Q (cfs)	8.92
Runoff Coefficient, C	0.775
Rainfall Intensity, I (in/hr)	5.86
Area (acre)	1.965
Computed T_c (minutes)	4.9
Applied T_c (minutes)	10

The data from *Table 3-2*, shows the discharge for the 25-year storm event, being our choice for a designed storm. Along with our intensity, of 5.86 inches per hour, which is all resulted from the ADOT Rational Method Tool. As our runoff coefficient, C, for the existing conditions is 0.775, used for the description of our site landscape being primarily desert land. The runoff coefficient and discharge will be compared to our post-development C to determine any changes.

In order to determine the rainfall intensity, National Oceanic and Atmospheric Administration (NOAA Atlas 14) was used. Inputting the site location address into NOAA atlas 14, gave results of the storm event years, and the intensity regarding to time of 5 minutes, 10 minutes, 15 minutes, and up to an hour and more. The intensity was imported into the ADOT Rational Method Tool and was used to calculate the times of concentration for storm events, as in *Table 3-3* The rainfall intensity data can be found in *Appendix D*.

Table 3-3 ADOT Rational Method Calculations

Design Storm Event	Discharge - Q (cfs)	Runoff Coefficient - C	Rainfall Intensity - I (in/hr)	Area - A (acres)	Calculated T_c (min)	Applied T_c (min)
2-Year	1.1	0.2	2.84	1.965	6.7	10
10-Year	1.5	0.23	4.68	1.965	5.4	10
25-Year	3.6	0.31	5.68	1.965	4.9	10
100-year	6.2	0.40	6.84	1.965	4.4	10

In terms of design storms, using the ADOT Rational Method, helped narrow down the span of years that would be designed for. The team chose to look at the 25-year storm event and picked it to be the best point of which, may be seen for the design life of the home. The 25-year storm will be used for the post-development analysis for the flow and rational coefficient, c.

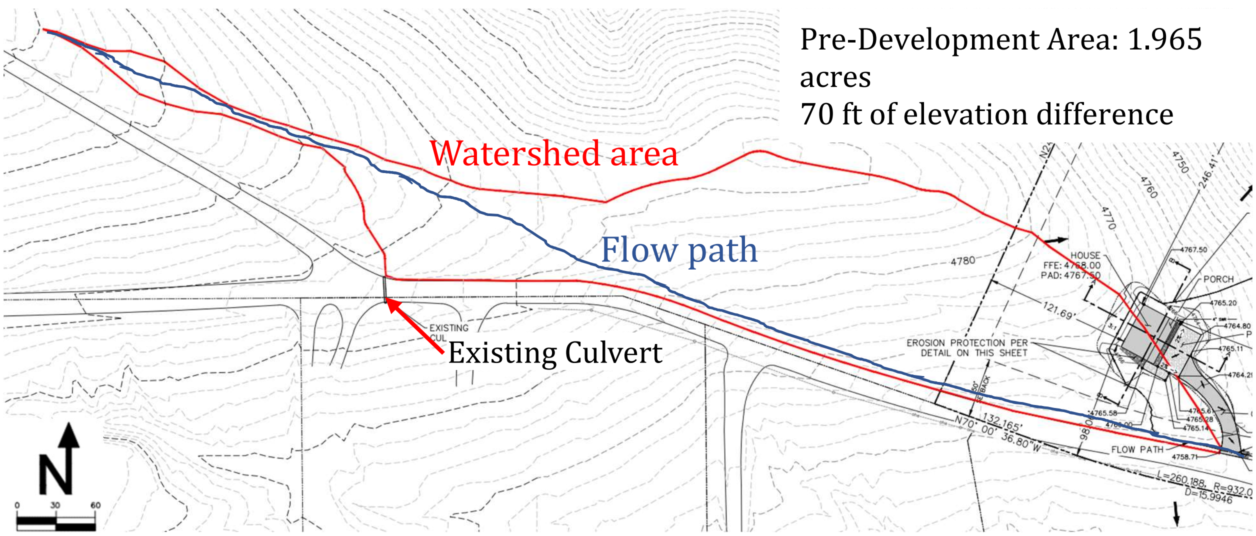

Figure 3-1 Pre-Development Watershed Area

3.2. Post-Development Runoff

The time of concentration did not change between pre and post development since the proposed structures and grading did not alter the longest flow path. But the area of the watershed as well as the runoff coefficient were changed to account for the impervious area that will be created when the building is erected on the site.

Yavapai county specifies that 'the user should delineate sub-basins around areas with a single land use, where possible. When that is not practical, then an area-averaged (C) value should be computed.' [3] The runoff coefficient for the post-development area was determined using *Equation 3-4.*

Equation 3-4 Area-averaged C-value

$$C_{comp} = \frac{\sum_{i=1}^{n} C_i A_i}{A_t}$$

Where:

C_{comp} = the area-averaged value of (C)
n = the number of different land use polygons within the sub-basin
C_i = the value of (C) corresponding to each land use in the sub-basin
A_i = the area of the corresponding land use within the sub-basin (acres)
A_t = the total area of the sub-basin (acres)

Table 3-4: C_{comp} Calculation

	min	**max**	**average**
Pavement and rooftops	0.83	0.94	0.885
Desert Landscaping 1	0.61	0.94	0.775

The post-development (C) value was calculated and is shown in the table below, along with other necessary values that were used to calculate the runoff. The same process was used to determine the post-development runoff values. The post development ADOT Rational Method Report is in *Appendix E*.

Table 3-5: Post Development Site Data

Length (mi.)	0.201
C_{comp}	0.776
ΔElevation (ft)	70
Slope (ft/mi.)	348.258
Predominant Landform Type	Rangeland
K_b	0.1
Tc, 25 yr-storm – hr (min)	0.083 (5)

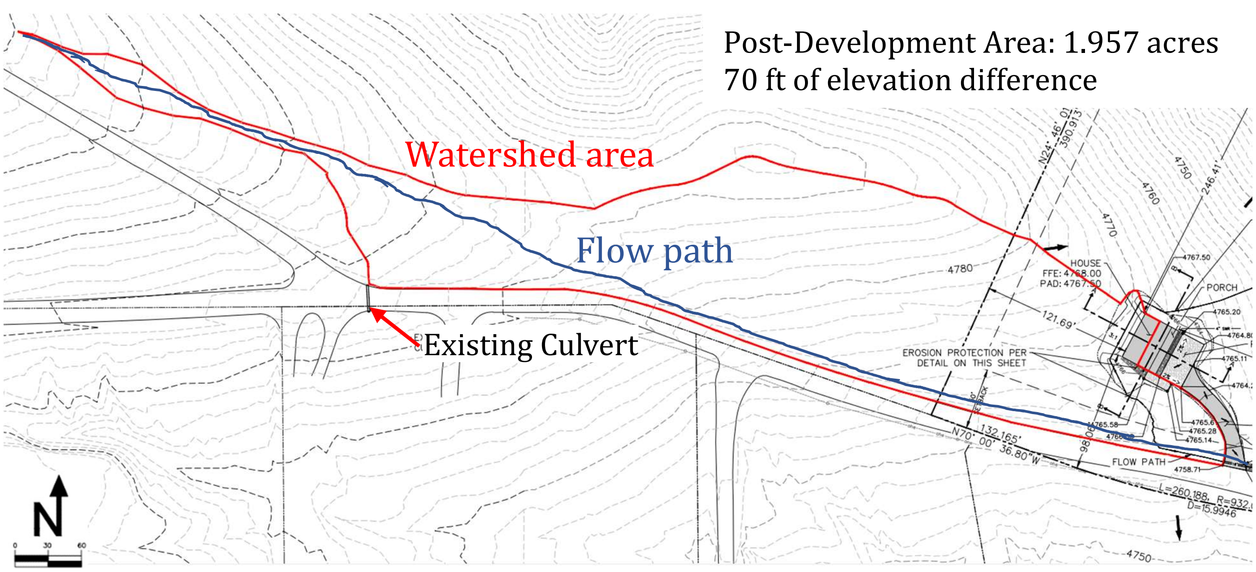

Figure 3-2 Post-Development Watershed Area

Table 3-6: Post Development Conditions, Area, Flow, and Time of Concentration

Post-Development Site Data		
Area (total)	1.965	acres
Coefficient C_1	0.885	Pavement and rooftops
Coefficient C_2	0.775	Desert Landscaping 1
Area (roof)	0.0127	acres
Area (Landscape)	1.9443	acres
C_{comp}	0.776	Coefficient C average
Q (flow)*	8.94	cfs
Intensity	5.86	in/hr
Length	0.201	mile
High Elevation	4829	feet
Bottom Elevation	4759	feet
ΔH Elevation	70	feet
Slope	348.258	ft/mi
Slope	6.59	%
Landform type	Rangeland	
K_b	0.1	
T_c (applied)	10	minutes
T_c (computed)	2.7	minutes

*Note: this is using Q=CiA, while C is C_{comp}

The above values are derived from the flow path that includes the home that has been built. This is in order to see how the roof material of the home changes and adds to the flow of the existing runoff. The flow post-development had increased, doubled from the existing flow. The time of concentration for computed value has decreased, being a faster flow at 2.7 minutes. Although, per the Yavapai Drainage Design Manual, the applied time of concentration will be 10 minutes. To calculate the flow, the new area of the post-development was needed, it included the area of the house, portioned to be the most impactful to the culvert that has been designed. Incorporation of these values, required the use of *Equation 3-4* to find an averaged rational coefficient C. This C value for the 25-year storm event had a minimum and maximum C that needed to be averaged, as seen below in *Table 3-6*. The K_b value did not change compared to the pre-development as there was not much change that was required to the land.

Post-development discharge, Q, was 8.94 cubic feet per second (cfs) and the pre-development was 8.92 cfs. The difference amongst the two was the inclusion of the roof of the home from post-development. The small area of the roof was significant enough to make a slight increase in discharge. This would be due to the surface choice of the roof, the material that was present was a shingled roof or asphalt type roofing material.

4.0 Hydraulic Analysis

According to the Drainage Design Manual for Yavapai County, all-natural drainage crossing roadways (and driveways) shall be culverted [3]. Hence, it was necessary to design the culvert to convey the flow downstream. The location of the culvert under the driveway can be seen in *Figure 4-1.*

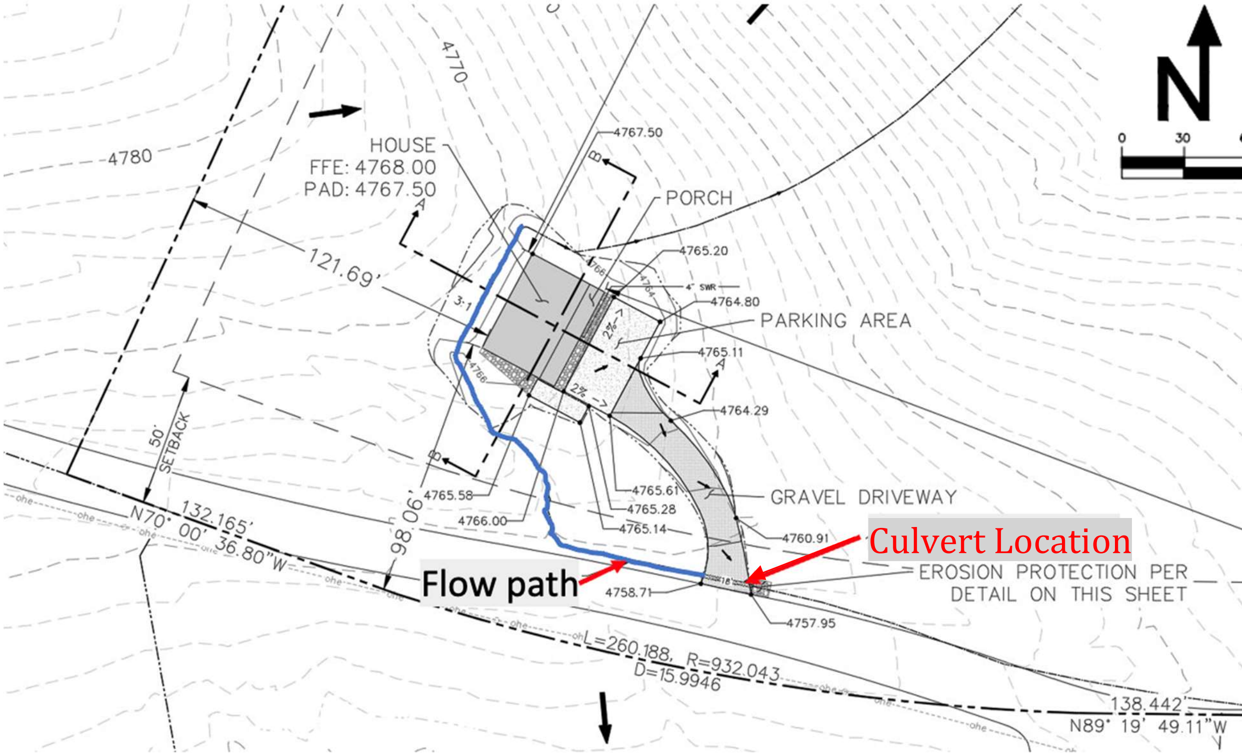

Figure 4-1 Culvert Location

The length of the culvert was uniform with values based on the width of the driveway, which is equal to 18 ft. Minimum cover of fill over culverts should be at least twelve (12) inches from the top of subgrade [3]. Based on the contours of the site, the elevation of the west side of the driveway was 4758.88' and the east side was 4758.29' where the culvert passes under the driveway. With the minimum cover of fill, the upstream invert elevation was 4756.38' and the downstream was 4755.79', which the difference of elevation was 0.59 ft or 7 inches. The slope of the culvert can be determined using *Equation 3-3,* which was equal to 0.039 ft/ft. This is greater than the minimum slope prescribed in the Drainage Design Manual for Yavapai County. The detailed information of the culvert can be seen in *Table 4-1*.

Table 4-1 Culvert Summary

Length – L (ft)	18
ΔH (ft)	0.59
Slope – S (ft/ft)	0.033
Shape	Circular

4.1. Culvert Modifications

As depicted in *Table 4-2* variety of different types of culverts were considered. All the spelling of the culvert should meet the requirements in the Drainage Design Manual for Yavapai County.

Table 4-2 Proposed Design Solutions

Potential Solution	Material	Pipe Size (in)
1	CMP	18
2	Concrete	15
3	Smooth walled-HDPE	15

Based on the culvert and the required design storm event (25-yr event), the downstream velocity can then be determined using the continuity equation seen in *Equation 4-1.*

Equation 4-1 Continuity Equation

$$Q = \nu A$$

Where:

- Q = the volumetric flow rate
- ν = flow velocity
- A= the cross-sectional area of flow

It is necessary to determine the headwater depth of the culvert by examining existing conditions, which influences the control type of the culvert and the protection type of the outlet or inlet. *Equation 4-2* is used to determine a headwater of the culvert.

Equation 4-2 Energy Equation in the culvert

$$HW_o + LS + \frac{V_u^2}{2g} = TW + \frac{V_d^2}{2g} + H_L$$

Where:

- HW_o = Headwater depth above the entrance invert in outlet control, ft (m)
- V_u = Approach velocity, ft/s (m/s)
- TW = Tailwater depth above the outlet invert, ft (m)
- V_d = Downstream velocity, ft/s (m/s)
- H_L = Sum of all losses including entrance (H_e), friction (H_f), exit (H_o) and other losses, (H_b), (H_j), ft (m)
- LS = Drop through the culvert, ft (m)

A simulation of the three potential culvert options was modeled in CulvertMaster where the design storm events were modeled (25-year events). As *Table 4-3* displays below all the hydraulic properties from the design storm reports using to identify the compliance for manual. According to Hydrology Design Manual for Yavapai County, the requirements related to the downstream velocity was between 5 fps and 20 fps. Refer to *Appendix F* for completed Bentley CulvertMaster reports.

Table 4-3 Analysis Results Using CulvertMaster

Solution ID	Flow Regime	Exit Velocity (ft/s)	Inlet HW Elev. (ft)	Tailwater Elev. (ft)	Normal Depth (ft)
1	Supercritical	6.56	4758.23	4756.75	1.02
2	Supercritical	9.07	4759.05	4756.75	0.78
3	Supercritical	9.47	4758.68	4756.75	0.77

From the table, flow regime and control type are all the same for these three potential solutions. Therefore, the criteria of the hydraulic analysis only focus on the exit velocity. There were two criteria using to make the decision, the lifespan of the pipe and the cost of the pipe. *Table 4-4* compared the lifespan for these three different materials. The CMP pipe has the shortest life span while the concrete has the longest one more than 100 year.

Table 4-4 Lifespan for Designed Culvert Pipe [7]

Potential Solution	Material	Lifespan (yr)
1	CMP	15~40
2	Concrete	>100
3	Smooth walled-HDPE	100

Another consideration for the culvert was the cost. Generally, the concrete was more expensive than the other two different material. *Table 4-5* presents the average cost for various material of the pipe, in which CMP is the cheapest and concrete pipe is the most expensive. These prices were retrieved from the ADOT Historical Unit Price page. [8]

Table 4-5 Average Cost for pipe

Potential Solution	Material	Cost ($/ft)
1	CMP	60.00
2	Concrete	125.00
3	Smooth walled-HDPE	55.00

Using these criteria, a decision matrix was created to determine the most effective potential solution. This is seen in *Table 4-6*. All the other criteria are assigned from 0 to 3 generating by comparing the three solutions against each other. Considering the higher exit velocity means the larger erosion, which needs the more outlet protection, the exit velocity was the crucial criteria during the selection. Through a CMP pipe was the smallest one, which referred as 3. Similarly, the price of the concrete was highest, therefore, the score of it in cost should be only 1.

Table 4-6 Decision Matrix

Solution	Lifespan	Exit Velocity	Cost	Total
1	1	3	3	7
2	3	1	1	5
3	3	1	2	6

The most effective potential solution is the CMP pipe because it obtained the highest score based on all criteria.

4.2. Post-development Analysis

After the grading of this site, the time of concentration and the flow rate volume will change in the future. It is necessary to ensure the current solution could still solve the problem. Using the CulvertMaster to analyze the final selection in the previous part, which was the 18" CMP culvert. The final calculations for hydraulic profile using CulvertMaster were shown in *Table 4-7* respectively. The detailed report from CulvertMaster displaying the analysis of the 3 different culvert options are in *Appendix F.*

Table 4-7 CulvertMaster Output

Control Type	Outlet Control
Flow Regime	Supercritical
Downstream Velocity (fps)	6.56
Normal Depth (ft)	1.02
Critical Depth (ft)	1.05
Outlet Control HW Elevation (ft)	4758.23
Inlet Control HW Elevation (ft)	4758.22

The requirements on the velocity of the culvert based on the Hydrology Design Manual for Yavapai County was between 5 fps and 20 fps, which the designed culvert meeting.

5.0 Site Design

5.1. Proposed Layout

Using the topographic contours provided by Yavapai County, the proposed lot layout was drawn in Civil3D at the location provided by the client. *Figure 5-1* The roof line was also observed to determine the new watershed area since part of it will contribute to the flow through the culvert.

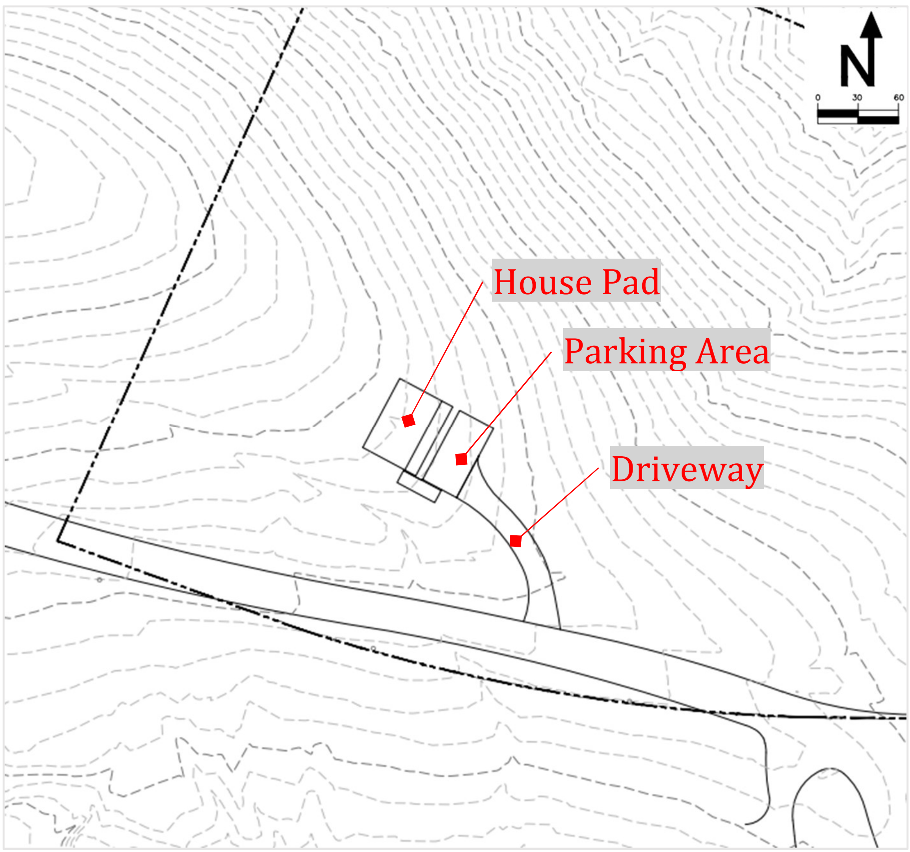

Figure 5-1 Existing Topographic Conditions with Proposed Layout

The client had asked that the Finish Floor (FF) elevation be 4766 feet above sea level, although this was adjusted per the client's approval to 4768 to accompany grading requirements. The pad elevation was then assumed to be 6 inches below the FF, since typical monolithic concrete slabs are 6 inches thick, with a footing dug around the perimeter of the floorplan. The Finish Grade (FG) will be 4767.5.

In front of the house, the client also asked for a 20-feet parking area that extends the width of the house. That was drawn to be about 2 feet below the pad elevation to reduce the amount of fill material. The proposed 12-foot wide driveway was also drawn to be geometrically pleasing, allowing for longer vehicles to enter and exit the lot, while providing a comfortable grade that meets the parking area. The curves started at a tangent to the driveway and the radius gradually decreased until it was about 6 ft from

Prescott Dells Ranch Rd, where it was flared outward to transition smoothly to the road. The cross slope was designed to convey water off of the driveway, so it was super-elevated instead of crowned. The design was completed according to the International Building Code (IBC) for site grading requirements. [9]

5.2. Proposed Grading

Feature lines were created to lay out the grading between the proposed pad to the existing grade. The ground was sloped away from the house at a 10% slope. This ensures that no water will puddle or run back into the foundation. Consideration was taken when designing the slopes that tie into the existing grade, as they were designed at a 3:1 slope ratio, which does not require erosion protection. A slope of 2:1 would require armoring or large rocks and would not be able to be walked up easily.

For the design to be effective and safe, the proposed surface was graded to mitigate flooding and ponding around the house. The runoff of stormwater from the roof of the proposed structure was routed away from it by means of sloped grades. The design conveys flow into existing ditches and flow paths. The erosion protection was designed for the outlet of the culvert.

5.3. Erosion Protection

The Yavapai County Drainage Design Manual outlines the requirements for erosion protection. The design criteria are based on the Froude number, *Equation 5-1*.

Equation 5-1 Froude number equation

$$Fr = \frac{v}{\sqrt{gd}}$$

Where:
v = velocity of flow (m/s)
g = acceleration of gravity (9.81 m/s^2)
d = depth of flow (m)

The Froude number that was calculated for the culvert is less than 2.5 *Table 5-1*, which permits the use of the simplified Riprap Apron Method.

Table 5-1 Calculations for Froude number

Velocity (v)	6.56	ft/s
Depth of Flow (d)	1.02	ft
Froude number	1.02	

Using the simplified Riprap Apron method, the required rock size was determined using *Figure 5-2* shown below. The figure is based on the design meeting the multiple criteria provided in the manual, which include velocity, depth to culvert diameter ratio and flowrate to culvert diameter ratio. These were checked and provided in *Table 5-2.*

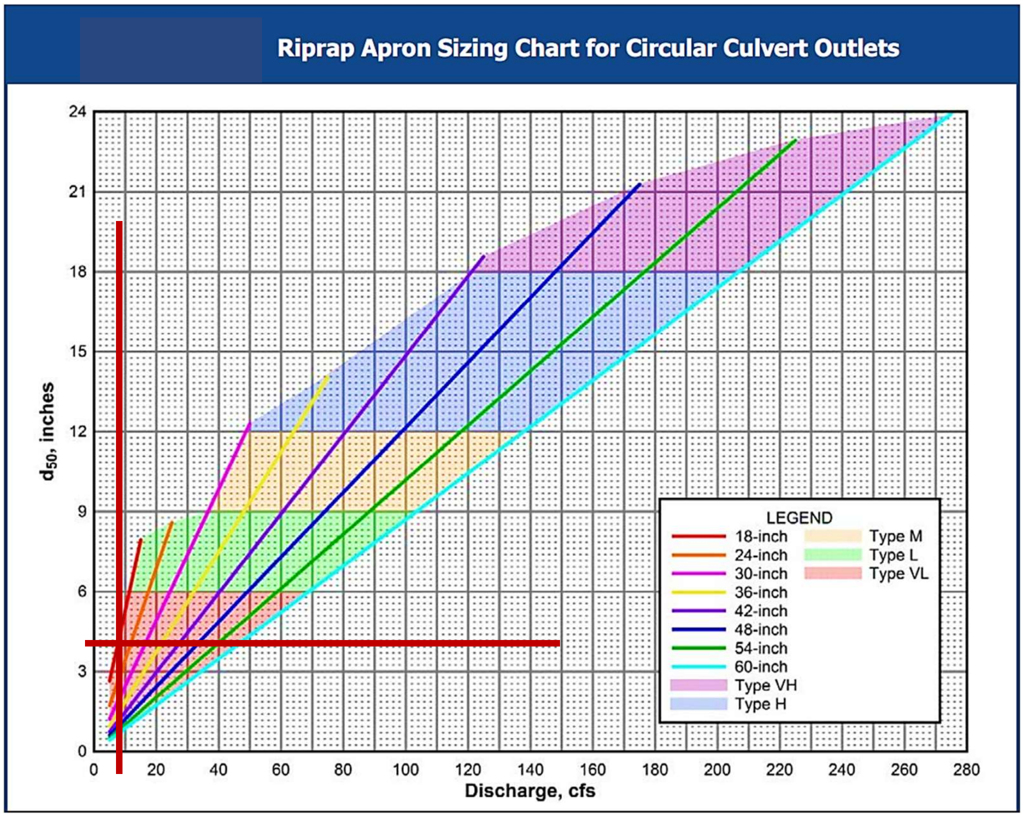

Figure 5-2 Riprap Apron Sizing Chart

The major characteristics of the riprap layer include: characteristic size, gradation, thickness and filter blanket requirements. The characteristic size is the d_{50}. This size represents the average diameter of a rock particle for which 50 percent of the gradation is finer, by weight. The recommended maximum stone size is 2 times the d_{50} and recommended minimum size is one-third of the d_{50}. The rock size was determined to be 4 inches.

Table 5-2 Design Criteria for Riprap Apron Sizing Chart

Criteria	Calculated value	Meets criteria
v (fps)	6.56	YES
D_c	18-inch	YES
$\frac{Q}{D_c^{2.5}}$	2.38	YES
$\frac{Y_t}{D_c}$	0.35	YES

The apron length was determined using *Figure 5-3.* The discharge was plotted along the line for the 18-inch culvert which provided the required length of apron. The length of the apron is the extent of the 4-inch rock. This will reduce the velocity to a point where scour and erosion are not an issue. The rock will be placed in the bottom

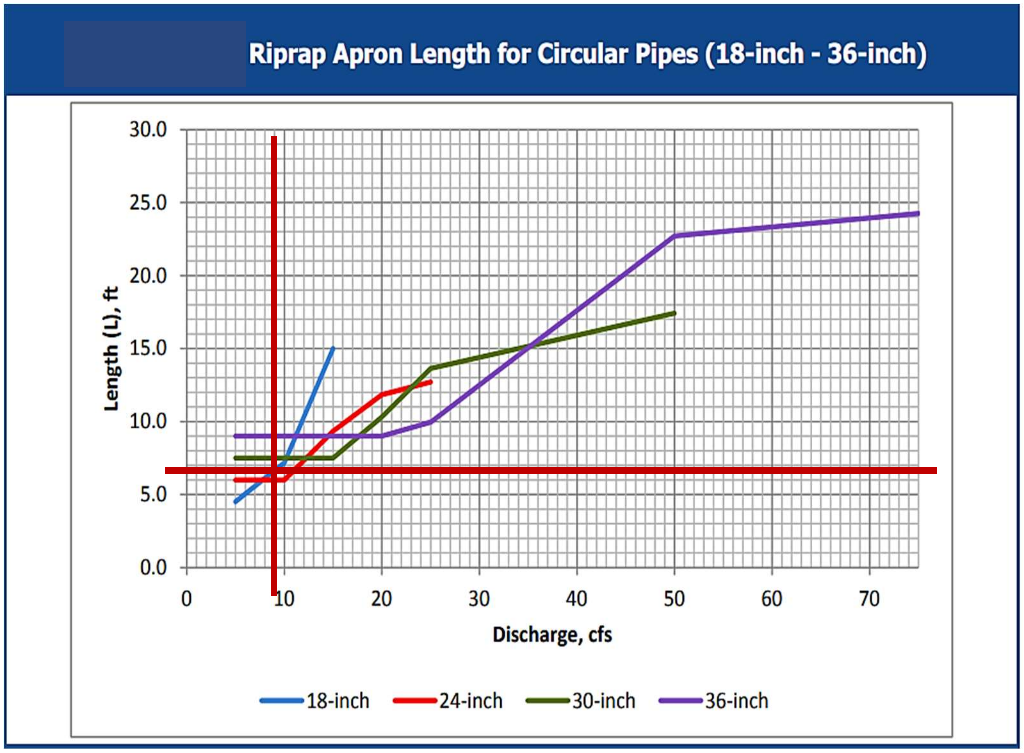

Figure 5-3 Riprap Apron Length Chart

of the channel so that undercutting will be reduced. Since there is an absence of a defined channel downstream from the culvert outlet, a trapezoidal apron configuration was used.

The dimensions of the riprap apron are summarized in *Table 5-3*. So, the 4-inch rock will be placed on top of a filter blanket for a length of 5 ft past the outlet of the culvert.

Table 5-3 Riprap Dimensions

d_{50} (in.)	4
L (ft)	6.5
Riprap apron shape	Trapezoidal

Figure 5-4 shows an example riprap installation for erosion protection.

Figure 5-4 Typical Erosion Protection [10]

5.4. Soil Cut and Fill

Another surface was created in Civil3D and used to calculated the volume between the existing grade and the finished grade surface. This provided an estimate of the volume difference to determine the cut/fill quantities *Table 5-4*.

Table 5-4 Civil3D Volume Comparison

Cut (yd^3)	Fill (yd^3)	Net (yd^3)
124.82	117.1	7.72 (Cut)

6.0 Plan Set Production

The client has required that the design team produce a plot plan, site plan, and grading & drainage sheets. A plan set was created to display the design that Crossed Arrow Engineering has developed.

Civil3D was used to create the plan set. General notes and details were found in the Yavapai County Quad City Standard Details [11], and the Yavapai County Drainage Design Manual [3]. A border was created, and the pertinent data was input into the sheets. The legal description and location of the site were determined and verified by the senior engineer. Crossed Arrow Engineering has created its logo and north arrow that will be specific to all documents. Accurate elevations are shown on the plans, and the scale has been checked and is accurate. Yavapai county requires that a permit be submitted prior to any excavation or grading, and they provide the requirements for this submittal. The grading/drainage sheet was created and includes the necessary data such as; cut/fill quantities, setback distances, spot elevations of certain points on the site, distances to the lot boundaries and the proposed grading contours. Yavapai County provides certain notes that are required for a grading submittal. Several different elevations were called out, such as the pad elevation, and multiple sides of the parking area and other elevations along the driveway. *Figure 6-1* shows the grading and drainage plan. Cross sections A-A and B-B were created to see the elevation change across the site.

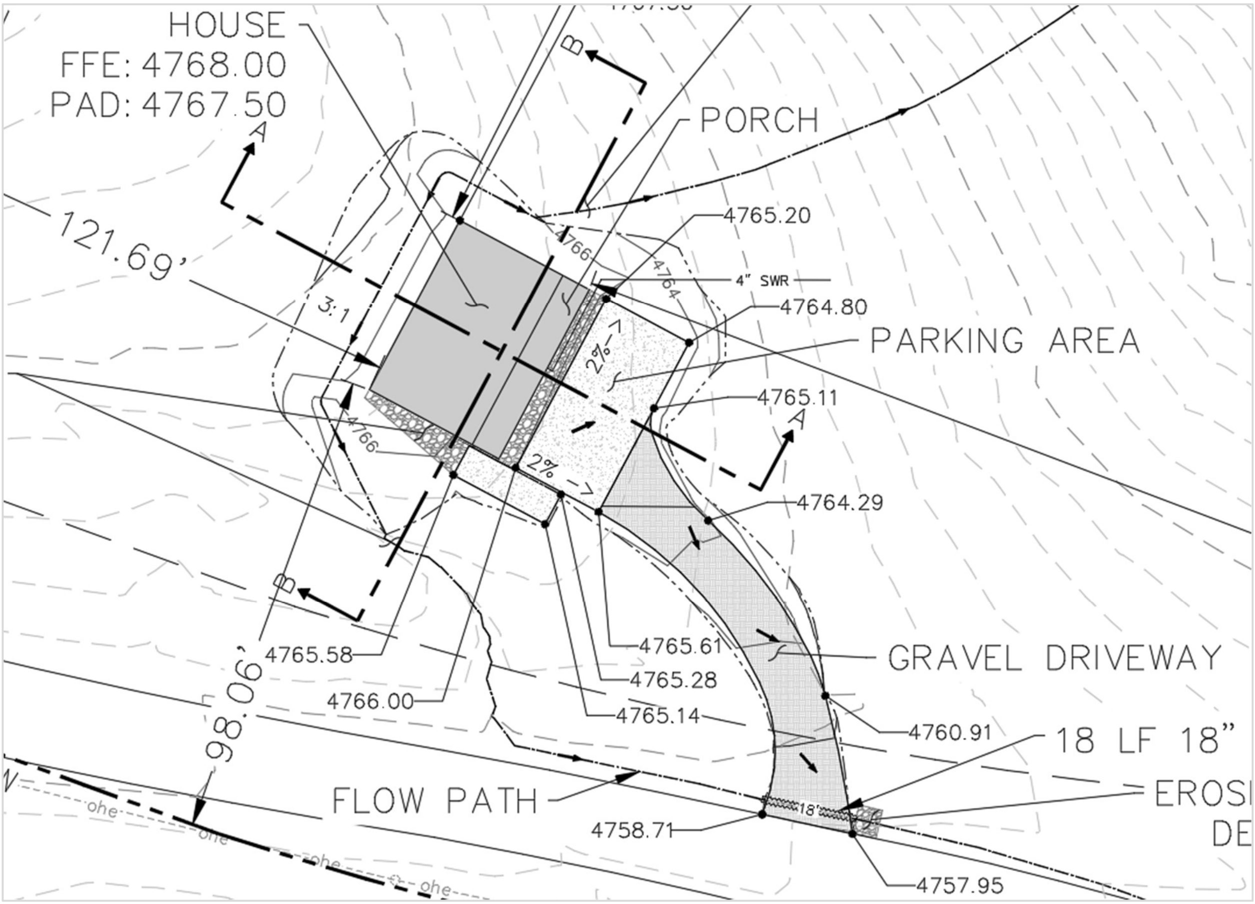

Figure 6-1 Grading/drainage exhibit

Cross sections were created perpendicular to one another, to show the side view of the site from two different angles. These sections include both the existing ground surface and the Finished Grade (FG) surface. In *Figure 6-2* and *Figure 6-3* the existing grade surface can be seen as the dashed line, and the FG surface can be seen as the solid line with the two horizontal parts being the house pad and the parking area. The vertical axis is feet of elevation above sea level and the horizontal axis is linear feet. The vertical scale is exaggerated by a factor of 2.

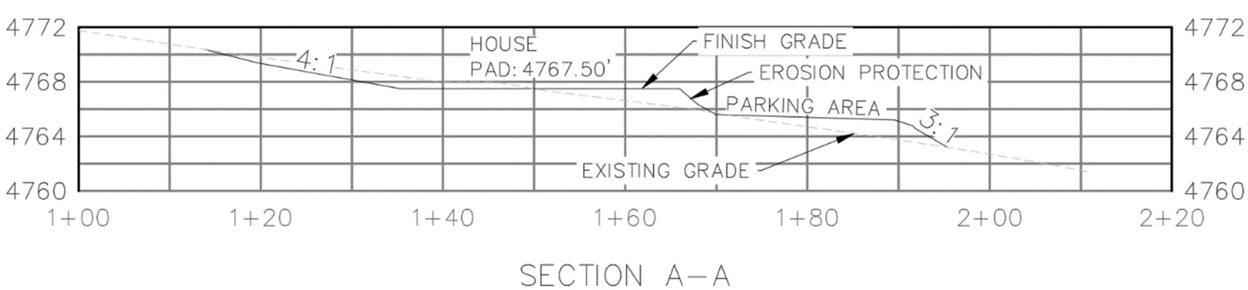

Figure 6-2 Section A-A of Project Site

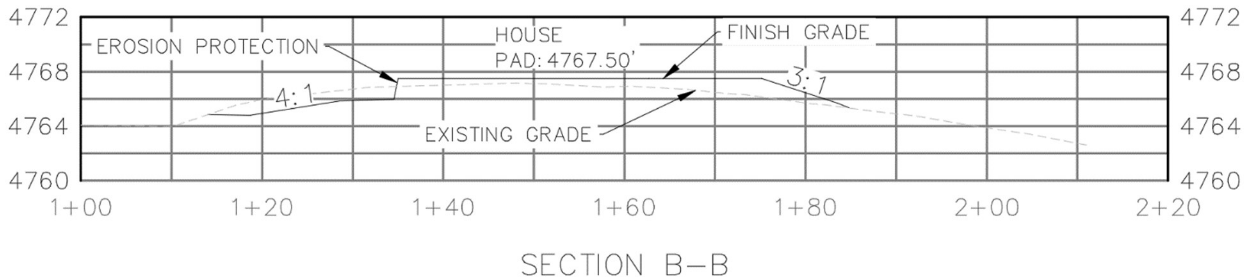

Figure 6-3 Section B-B of Project Site

The driveway was designed to be 12 feet wide. It has about a 3% slope towards the west. Both the plan and profile are shown below *Figure 6-4, Figure 6-5.* STA 1+00 starts at the centerline of Prescott Dells Ranch Road. The new driveway meets the existing road at STA 1+10 and maintains an average slope of 7% from the road to the parking area of the house. Large amounts of fill were required to maintain that slope throughout the entire driveway. At about STA 1+80, the driveway starts to level out to just under 5%. The slope of the parking area is -2%, so the grade break is only about 3%. Both the left and right sides of the driveway meet at grade of the existing road, Prescott Dells Ranch Road.

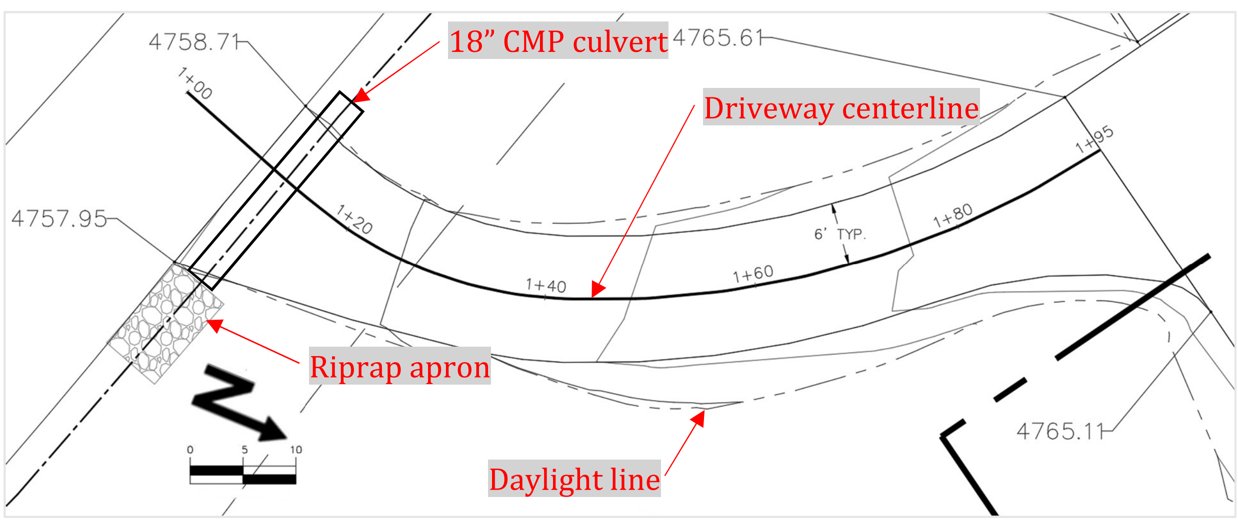

Figure 6-4 Driveway Plan View

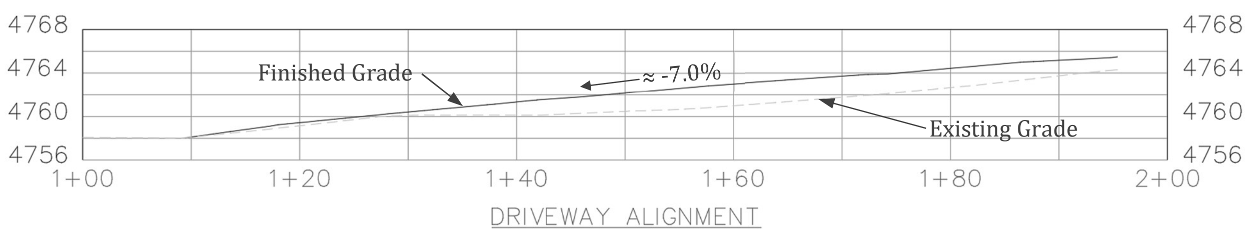

Figure 6-5 Driveway Profile

Figure 6-6 shows the cross section of the driveway. The dashed line represents the existing grade and the solid line represents the finished grade. Most of the runoff from the driveway will flow into and through the culvert. While this cross section was taken at driveway STA 1+60, the rest of the driveway looks similar to this.

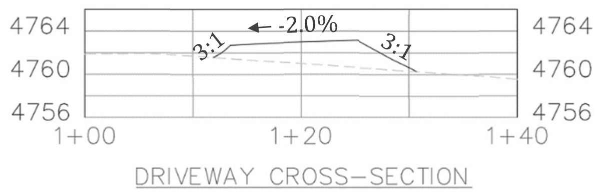

Figure 6-6 Driveway Cross-section at STA 1+60

The riprap at the outlet of the culvert was calculated in *Section 5.0* and *Figure 6-7* shows those dimensions with the culvert outlet. This was drawn based on the Yavapai County Riprap detail.

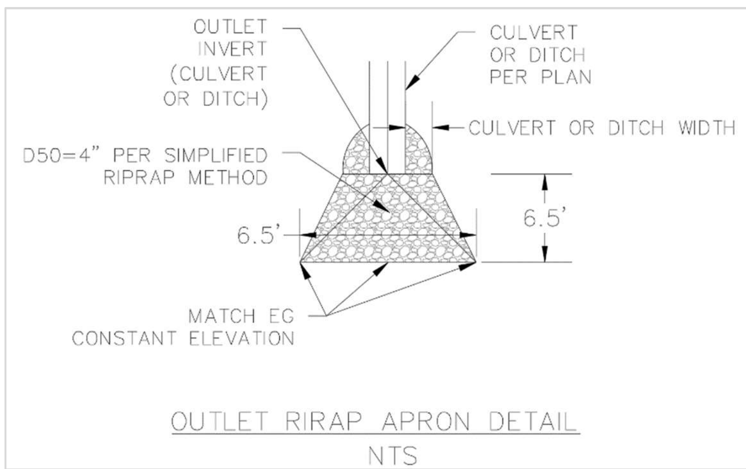

Figure 6-7 Outlet Riprap Apron Detail

A legend was also created with the several different linetypes and lineweights *Figure 6-8*. This was done to keep the drawing clean from the annotation that would have been required otherwise. The lines in the legend were drawn at the same scale as the lines in the drawing. A vicinity map, north arrow and scale were also included. This plan set was created to be submitted to Yavapai County and will show the grading limits, the slopes, spot elevations and profiles of the site, as well as the approximated cut and fill quantities. As with all engineering drawings, the quantities provided are only estimates, provided to the contractor. It is the contractor's responsibility to verify the actual quantities and work required.

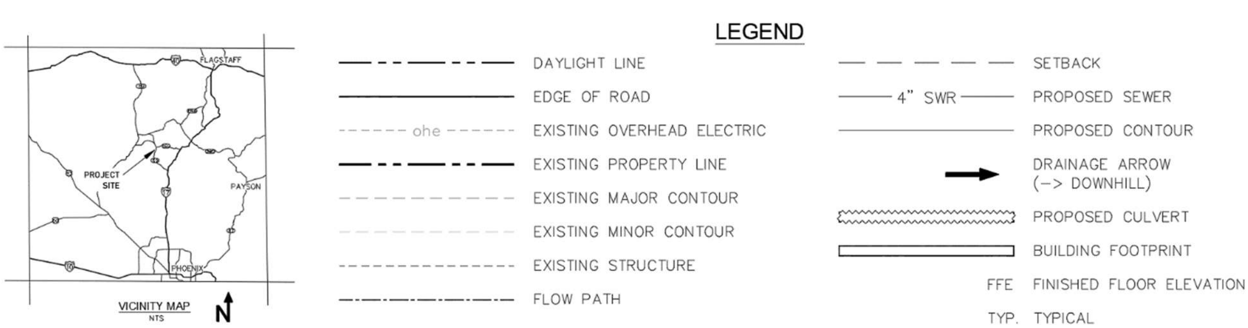

Figure 6-8 Sheet Legend

7.0 Construction Cost

The estimated cost of implementing the design is $16,000. The table below shows the cost breakdown by pay item. *Table 7-1*, shows the material cost, estimated to be $6,710. Shown in *Table 7-2*, are the estimated costs for labor and the wage for all involved by crew. This includes the labor involved for all tasks, such as excavation and grading of the site. This totaled at about $4,600, all labor for duration of hours needed to work. *Table 7-3*, shows the heavy equipment cost per day as needed per crew from *Table 7-2*, the estimated cost is $4,500. These values were determined from rsmeans.com. In *Appendix G*: Cost to Construct Tables, the tables for crew wage, hours, and equipment price will be listed, along with earthwork crews, material, labor, equipment costs. These will show the implementation of how much the cost will accrue to by the amount of soil being moved, and work needed done with concrete by the crews.

Table 7-1 Material Estimate

Material	Quantity	Cost per Unit ($)	Cost ($)
Excavation and grading	242 yd^3	18	4,500
Remove excess material from site	7.72 yd^3	65	510
18” CMP	20 ft	80	1,600
D_{50} = 4 in. Rock	0.33 yd^3	300	100
		Total	**6,710**

Table 7-2 Estimated Labor costs

Position	Wage ($/hr)	Labor hours	Cost ($)
Equipment Operator (medium)	39.25	48	1884
Equipment Operator (crane)	39.95	8	319.6
1 Laborer	28.70	64	1836.8
1 Labor Foreman (outside)	30.70	16	491.2
		Total	**4531.6**
		Total Estimate	**4600**

Heavy equipment that will be utilized in implementing the design has also been accommodated for construction use.

Table 7-3 Heavy Equipment costs

Equipment	Quantity	Duration (days)	Price/day	Cost
Tandem Axle Dump Truck	1	1	$ 111.00	$ 111
Dozer, 200 H.P.	1	2	$ 1,567.46	$ 3,135
Backhoe Loader, 80 H.P.	1	1	$ 240.94	$ 241
Hyd. Excavator	1	1	$ 32.77	$ 33
Vibrating Plate, Gas, 21"	1	2	$ 171.39	$ 343
F.E. Loader, T.M., 1.5 C.Y.	1	1	$ 589.09	$ 589
			Total	**$ 4,452**
			Total Estimated	**$ 4,500**

Table 7-4 Total Construction Costs

Cost Category	Cost ($)
Material	6710
Labor	4600
Equipment	4500
Total	**15810**

The total cost to implement this design is estimated to be $15,810.

8.0 Analysis of Impacts

8.1. Social Impacts

New developments in local areas can create strong feelings from the community surrounding the development. While these plans are submitted to both the town and the county for approval, there is no home owner's association that might prevent the construction of this house. The implementation of this design could affect the neighbors in both a positive and a negative way. The positive aspect is that the surrounding people have new neighbors, with whom they can associate and interact with. This can help with the overall mental health of the locals as well as future generations. It may increase the enrollment at local schools and the attendance at local churches as well. Another positive impact is that since this is designed to be a pre-fab log cabin, it might increase the local property value. A negative impact is that it could eliminate the view that the neighbors have. This could affect several people. Additionally, there will be more vehicle traffic along the dirt road, possibly leading to more delay since it is a one lane road in some places which could cause some frustration to both the owners and the neighbors.

During construction the noise levels will dramatically increase from the site. Heavy equipment including excavators, skid steers and concrete trucks will be present. Generators, compressors and other loud machines will also be there. This may be a nuisance to the neighbors if the start time is early. This will not be the case after construction and the noise levels will return to about where they were before.

8.2. Economic Impacts

The implementation of this design has multiple costs associated with it. These costs include the initial capital cost of design and construction. The cost of design and construction will most likely be covered by the client and will benefit local engineering firms and local construction companies. This project is a small residential development and will not require large contractors from the Phoenix valley area so no economic impact will be made there. The builder of the cabin would see an increase in their revenue, as well as any other sub-contractors that do work on the site. Since it is in a remote area in a small town, local companies could be used which would benefit the community. The development of this site would also add more people to the population of the town of Dewey-Humboldt, and in turn would increase the number of people using the local services. There will be a cost for electricity, water, and the occasional septic tank cleaning. With the development of this lot, if it is aesthetically pleasing, it will increase the surrounding property values, but that in turn increases the property tax which is a negative impact for neighboring land owners. But with future developments in the area and increased tax revenue, the town and county will be able to provide better services to the locals. This will then add to the social benefits that are seen in the future.

8.3. Environmental Impacts

Environmental impacts include the changes made to the site. Since the grading was altered, the flow of the stormwater runoff is also altered and re-directed. While all the flow runs into the large wash to the north of the site, its path was changed. The predevelopment runoff flowed like a sheet down to the large wash at the bottom of the hill. The post development runoff takes some of that water and puts it through the culvert which speeds up the water, but then it flows out across the riprap that was designed to slow the water. This will reduce sedimentation in both the channel and the wash. If the culvert fails it could cause erosion since the riprap protection will not be as effective as designed. The development of this site could affect the wildlife by creating more unfamiliar area around them. Some may see this as a benefit with less wild animals, but it is important to note that natural wildlife is important. The noise pollution that could be created from the appliances and generators could affect the wildlife as well and push them further away. The only vegetation that will be disturbed is what lies under the grading footprint of the house, as well as the disturbance of soil/vegetation due to the placing of the cabin and septic system. Since the footprint of the developed area is so small, the removal of plants and insects will be minimal. There will be more trips made on the road which will increase fuel consumption for the local area. But, in turn there will be less fuel consumed at the location of the owner's previous residence as well.

9.0 Summary of Engineering Work

Appendix H shows that the proposed schedule that was created last semester as well as the updated schedule. The two are different for several reasons. The proposed schedule was created based on minimal knowledge of the processes and methods required to complete the design work. Since then, we have lost a team member and there were items that were omitted from the schedule like the Site plan and Surveying. The Crossed Arrow Engineering team spent less time than anticipated on many tasks. This was most likely caused by basing our schedule on other projects completed in the past. The team was not permitted access to the Dewey site, so the time spent collecting survey data and geotechnical data was greatly reduced. The survey data was collected from Yavapai County and the soil data was collected from a local soil survey. The actual schedule was based more on the 30%, 60% and 90% deliverables. So, the work and analysis for existing conditions was completed for the 30% and the proposed conditions were completed for the 60% submittal. The details were then refined for the 90% and final submittals. Much more time was spent on the reports than anticipated. About 30 hours for each report was spent between the team members. There were also tasks that were completed that we did not plan for in our scope. Some of these tasks are, cost of construction and schedule management.

10.0 Summary of Engineering Costs

10.1. Staffing

The schedule and planned personnel hours strongly reflect the actual time usage recorded during the project. Shown in *Table 10-1* are the planned personnel hours estimated during the proposal of the project. Compared to the staffing in the proposal, there is no change in the actual classification of the staffing. However, the work hours have changed.

Table 10-1 Estimated Personnel Work Hours in Proposal

Classification	**Proposed Hours**	**Actual Hours**
Senior Engineer	83	81
Engineer	150	123.25
Drafting Technician	122	82.75
Survey Technician	30	4
Engineer in Training	247	43
Total	**632**	**334**

10.2. Budget

Staffing costs can be seen in *Table 10-2* with a total of $ 27,749.25 with 334 hours. This value is lower than expected due to the elimination of several early tasks, such as site visits, surveying, and geotechnical analysis, which decreased the work related to survey technician and engineering in training.

Table 10-2 Personnel/Staffing Costs

Classification	**Hours**	**Rate ($/hr)**	**Cost ($)**
Senior Engineer	81	120.00	9720
Engineer	123.25	85.00	10476.25
Drafting Technician	82.75	65.00	5378
Survey Technician	4	60.00	240
Engineer in Training	43	45.00	1935
Total	334		27749.25

**Update on Dec. 12th*

Originally the team expected to use survey equipment for two days at an estimated rate of $100 per day, but since a site visit could not be completed no survey equipment was used. This reduced the total cost of the project by $200. In the previous proposal, the team did not estimate the cost of computer lab. However, in the actual work, it should be mentioned to because these computer programs were not free for use. The cost of computer lab was assumed as $100 per day and the cost was $1325 with 132.5 hours.

In total, 334 hours were spent by the personnel and 132.5 hours by supplies for the completion of this project. The total hours for each part and the total cost can be seen in *Table 10-3.* It was observed that the estimates were not exactly the same as the time spent on the project. The lower hours worked slightly modified the estimate of personnel costs, but the use of the computer lab was considered but not mentioned in the proposal.

Table 10-3 Estimated Engineering Cost

	Hours	Cost
Personnel Classification	334	$27,750
Computer Lab	132.50	$1,325
Construction Labor	420	$12,600
Construction Materials	n/a	$7,800
Total	886.5	**$49,475**

11.0 Conclusion

The purpose of the project was to perform site design for a single-family house in Dewey-Humboldt. Recommendations presented by Crossed Arrow Engineering team including the site plan, the drainage plan, and grading plan. The proposed solution of the culvert design includes an 18” corrugated metal pipe to convey the accumulated precipitation after the development. The total cost of the construction regarding the scope of work defined and the exceptions mentioned is estimated to cost $49,475.

The finished floor elevation was adjusted to 4768 to accompany grading requirements. Flooding and ponding around the house were mitigated by grading the proposed surface. There was a 10% slope away from the house on the ground. In this way, the foundation is protected from puddles and water running back into it. Designing the slopes that tie into the existing grade was taken into consideration, since they have a 3:1 slope ratio, which does not require erosion protection. The Yavapai County Drainage Design Manual outlines the requirements for outlet protection related to Froude number, which is less than 2.5. 3-inch rock will be placed on top of a filter blanket for a length of 5 ft past the outlet of the culvert.

12.0 References

[1] "Yavapai County Interactive Map," ESRI, [Online]. Available: https://gis.yavapaiaz.gov/v4/. [Accessed 03 March 2022].

[2] A. L. Publishing, "Dewey-Humboldt, AZ Code of Ordinances," American Legal Publishing, [Online]. Available: https://codelibrary.amlegal.com/codes/deweyhumboldt/latest/deweyhum_az/0-0-0-3044. [Accessed 17 October 2022].

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[10] "Bing Images," Bing, [Online]. Available: https://www.bing.com/images/search?view=detailV2&ccid=Xd1%2fIXyE&id=35F349089916B3837E62C20D73A9816BF37EC391&thid=OIP.Xd1_IXyEzHCBwLpaiOz6oAHaFj&mediaurl https%3a%2f%2fth.bing.com%2fth%2fid%2fR.5ddd7f217c84cc7081c0ba5a88ecfaa0%3frik%3dkcN%252b82uBqXMNwg%2. [Accessed 21 October 2022].

[11] Y. County, "Quad-City-Standard-Details," [Online]. Available: https://prescott-az.gov/wp-content/uploads/2016/10/Quad-City-Standard-Details.pdf. [Accessed 26 09 2022].

[12] U. S. D. o. Agriculture, "Soil Survey of Yavapai County, Arizona," 1968. [Online]. Available: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=AZ. [Accessed 26 09 2022].

[13] Y. C. Arizona, "Grading Submittal Requirements," [Online]. Available: https://yavapaiaz.gov/Portals/34/Reference%20Materials/PB-22GradingSubmittalRequirements.pdf. [Accessed 20 October 2022].

National Flood Hazard Layer FIRMette

112°15'52"W 34°31'19"N

112°15'14"W 34°30'49"N

Feet 0 250 500 1,000 1,500 2,000

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) *Zone A, V, A99*
		With BFE or Depth *Zone AE, AO, AH, VE, AR*
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
		Future Conditions 1% Annual Chance Flood Hazard *Zone X*
		Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
		Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN	Area of Minimal Flood Hazard *Zone X*
		Effective LOMRs
		Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES	B 20.2 17.5	Cross Sections with 1% Annual Chance Water Surface Elevation
	8	Coastal Transect
	513	Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 11/28/2022 at 4:58 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Yavapai County, Arizona, Western Part

BgD—Balon gravelly sandy clay loam, 5 to 30 percent slopes

Map Unit Setting

National map unit symbol: 1ryz
Elevation: 4,000 to 5,000 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 50 to 58 degrees F
Frost-free period: 145 to 225 days
Farmland classification: Not prime farmland

Map Unit Composition

Balon and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Balon

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Summit, backslope, toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Mixed alluvium

Typical profile

H1 - 0 to 3 inches: gravelly sandy clay loam
H2 - 3 to 15 inches: gravelly clay loam
H3 - 15 to 23 inches: gravelly sandy clay loam
H4 - 23 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: R038XA109AZ - Loamy Upland 12-16 p.z.
Hydric soil rating: No

Minor Components

Unnamed soils

Percent of map unit: 5 percent
Hydric soil rating: No

Data Source Information

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 15, Aug 26, 2022

Table 7.4 Resistance Coefficient (K_b) for use in the Rational Method T_c Equation

Derived from: ADOT, 1993

Description of Landform	K_b	
	Defined Drainage Network	Shallow Overland Flow Only
Mountain, with forest and dense ground cover (overland slopes – 50% or greater)	0.15	0.30
Mountain, with rough rock and boulder cover, and sparse vegetation (overland slopes – 50% or greater)	0.12	0.25
Foothills (overland slopes – 10% to 50%)	0.10	0.20
Alluvial fans, Pediments and Rangeland (overland slopes – 10% or less)	0.05	0.10
Irrigated Pasture [a]	---	0.20
Tilled Agricultural Fields [a]	---	0.08
Urban		
Residential/ Commercial/Industrial, L < 1,000 ft [b]	0.04	---
Residential/ Commercial/Industrial, L > 1,000 ft [b]	0.025	---
Grass; parks, cemeteries, etc. [a]	---	0.20
Bare Ground; playgrounds, etc. [a]	---	0.08
Paved; parking lots, etc. [a]	---	0.02

Notes:

a – No defined drainage network.

b – L is the length in the T_c equation (Equation 7.2). Roadways serve as drainage network.

The user may select a non-default value provided the selection is within the range of values provided in Table 7.6, and engineering justification is provided and approved by Yavapai County or the controlling jurisdiction.

The user should delineate sub-basins around areas with a single land use, where possible. When that is not practical, then an area-averaged (C) value should be computed for the sub-basin using Equation 7.6.

Appendix D: ADOT Rational Method Report Pre-development

ADOT RATIONAL METHOD PROGRAM

Compution Date and Time: 10/24/2022 18:59:11

Project Name: Dewey Site Design
Project Location: 11800 E Prescott Dells Rd, Dewey, AZ
Company: Crossed Arrow Engineering
Project Notes:
Prepared by: Lance Quotskuyva Prepared by date: 10/17/22

Checked by: Checked by date:

Summary Table for 2-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Subbasin 1	0.5	0.20	2.84	0.84	6.7	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Summary Table for 5-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Subbasin 1	0.6	0.20	3.86	0.84	5.9	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Summary Table for 10-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Subbasin 1	0.9	0.23	4.68	0.84	5.4	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Summary Table for 25-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Subbasin 1	1.5	0.31	5.86	0.84	4.9	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Summary Table for 50-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Subbasin 1	2.1	0.36	6.84	0.84	4.6	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Summary Table for 100-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Subbasin 1	2.6	0.40	7.86	0.84	4.4	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

DETAILED RESULTS

Subbasin: Subbasin 1

Description: Channel/Ditch
Notes:
Area, A: 0.837 acres
Landform Type: Alluvial fans, pediments & Rangeland
Flow Type: Overland Flow Only
Watershed Resistance Coefficient, Kb: 0.1
Longest Flowpath Length, L: 0.0992 miles

Slope Method: Method 1
Change in Elevation, H (ft): 34
Computed Subbasin Slope, S:342.74 ft/mile

Subarea: Subarea 1

Area, A: 0.837 acres
Subbasin Type: Upland rangeland
Hydrologic Soil Group: C
Percent Vegetation Cover: 50%

Subarea C-Factors Table:

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Subarea C-Factor	0.2	0.2	0.23	0.31	0.36	0.4

Note:Some C values adjusted to fit within the curves in C-Factor Charts.

RESULTS TABLE

Parameters	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Discharge-Q (cfs)	0.5	0.6	0.9	1.5	2.1	2.6
Rational Coefficient-C	0.20	0.20	0.23	0.31	0.36	0.40
Rainfall intensity-i (inches/hour)	2.84	3.86	4.68	5.86	6.84	7.86
Subbasin Total Area-A (acres)	0.84	0.84	0.84	0.84	0.84	0.84
Computed Time of Concentration-Tc (minutes)	6.7	5.9	5.4	4.9	4.6	4.4
Applied Time of Concentration-Tc (minutes)	10.0*	10.0*	10.0*	10.0*	10.0*	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Appendix E: ADOT Rational Method Report Post-development

ADOT RATIONAL METHOD PROGRAM

Compution Date and Time: 11/02/2022 18:06:40

Project Name: Dewey Site Design
Project Location: 11800 E Prescott Dells Rd, Dewey, AZ
Company: Crossed Arrow Engineering
Project Notes:
Prepared by: Lance Quotskuyva Prepared by date: 10/17/22

Checked by: Checked by date:

Summary Table for 2-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Existing	0.5	0.20	2.84	0.84	6.7	10.0*
Post Development	1.1	0.20	2.84	1.85	3.6	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Summary Table for 5-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Existing	0.6	0.20	3.86	0.84	5.9	10.0*
Post Development	1.9	0.27	3.86	1.85	3.2	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Summary Table for 10-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Existing	0.9	0.23	4.68	0.84	5.4	10.0*
Post Development	2.9	0.34	4.68	1.85	2.9	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Summary Table for 25-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Existing	1.5	0.31	5.86	0.84	4.9	10.0*
Post Development	4.4	0.41	5.86	1.85	2.7	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Summary Table for 50-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Existing	2.1	0.36	6.84	0.84	4.6	10.0*
Post Development	5.8	0.46	6.84	1.85	2.5	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Summary Table for 100-Year event:

Subbasin ID	Discharge Q (cfs)	Rational Coeff. C	Rainfall Intensity i (inches/hour)	Area A (acres)	Time of Concentration Computed Tc (minutes)	Time of Concentration Applied Tc (minutes)
Existing	2.6	0.40	7.86	0.84	4.4	10.0*
Post Development	7.4	0.51	7.86	1.85	2.4	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

DETAILED RESULTS

Subbasin: Existing

Description: Channel/Ditch
Notes:
Area, A: 0.837 acres
Landform Type: Alluvial fans, pediments & Rangeland
Flow Type: Overland Flow Only
Watershed Resistance Coefficient, Kb: 0.1
Longest Flowpath Length, L: 0.0992 miles

Slope Method: Method 1
Change in Elevation, H (ft): 34
Computed Subbasin Slope, S:342.74 ft/mile

Subarea: Subarea 1

Area, A: 0.837 acres
Subbasin Type: Upland rangeland
Hydrologic Soil Group: C
Percent Vegetation Cover: 50%

Subarea C-Factors Table:

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Subarea C-Factor	0.2	0.2	0.23	0.31	0.36	0.4

Note:Some C values adjusted to fit within the curves in C-Factor Charts.

RESULTS TABLE

Parameters	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Discharge-Q (cfs)	0.5	0.6	0.9	1.5	2.1	2.6
Rational Coefficient-C	0.20	0.20	0.23	0.31	0.36	0.40
Rainfall intensity-i (inches/hour)	2.84	3.86	4.68	5.86	6.84	7.86
Subbasin Total Area-A (acres)	0.84	0.84	0.84	0.84	0.84	0.84
Computed Time of Concentration-Tc (minutes)	6.7	5.9	5.4	4.9	4.6	4.4
Applied Time of Concentration-Tc (minutes)	10.0*	10.0*	10.0*	10.0*	10.0*	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

DETAILED RESULTS

Subbasin: Post Development

Description: Channel/Ditch
Notes:
Area, A: 1.85 acres
Landform Type: Alluvial fans, pediments & Rangeland
Flow Type: Overland Flow Only
Watershed Resistance Coefficient, Kb: 0.1
Longest Flowpath Length, L: 0.0424 miles

Slope Method: Method 1
Change in Elevation, H (ft): 23
Computed Subbasin Slope, S:542.45 ft/mile

Subarea: Subarea 1

Area, A: 1.85 acres
Subbasin Type: Desert
Hydrologic Soil Group: C
Percent Vegetation Cover: 50%

Subarea C-Factors Table:

Parameter	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Subarea C-Factor	0.2	0.27	0.34	0.41	0.46	0.51

Note:Some C values adjusted to fit within the curves in C-Factor Charts.

RESULTS TABLE

Parameters	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Discharge-Q (cfs)	1.1	1.9	2.9	4.4	5.8	7.4
Rational Coefficient-C	0.20	0.27	0.34	0.41	0.46	0.51
Rainfall intensity-i (inches/hour)	2.84	3.86	4.68	5.86	6.84	7.86
Subbasin Total Area-A (acres)	1.85	1.85	1.85	1.85	1.85	1.85
Computed Time of Concentration-Tc (minutes)	3.6	3.2	2.9	2.7	2.5	2.4
Applied Time of Concentration-Tc (minutes)	10.0*	10.0*	10.0*	10.0*	10.0*	10.0*

*Some computed Tc values reduced to a maximum value of 1 hour

Culvert Designer/Analyzer Report
Driveway

Analysis Component			
Storm Event	Design	Discharge	8.90 cfs

Peak Discharge Method: User-Specified			
Design Discharge	8.90 cfs	Check Discharge	0.00 cfs

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	4,756.75 ft

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-18 inch Circular	8.90 cfs	4,758.23 ft	6.56 ft/s
Weir	Roadway (Constant Elevation)	0.00 cfs	4,758.23 ft	N/A
Total	----------------	8.90 cfs	4,758.23 ft	N/A

Culvert Designer/Analyzer Report
Driveway

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	4,758.23	ft	Discharge	8.90	cfs
Inlet Control HW Elev.	4,758.22	ft	Tailwater Elevation	4,756.75	ft
Outlet Control HW Elev.	4,758.23	ft	Control Type	Entrance Control	
Headwater Depth/Height	1.23				

Grades					
Upstream Invert	4,756.38	ft	Downstream Invert	4,755.79	ft
Length	18.00	ft	Constructed Slope	0.032778	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	1.08	ft
Slope Type	Steep		Normal Depth	1.08	ft
Flow Regime	Supercritical		Critical Depth	1.15	ft
Velocity Downstream	6.56	ft/s	Critical Slope	0.027741	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	4,758.23	ft	Upstream Velocity Head	0.58	ft
Ke	0.20		Entrance Loss	0.12	ft

Inlet Control Properties					
Inlet Control HW Elev.	4,758.22	ft	Flow Control	Submerged	
Inlet Type	Beveled ring, 33.7° (1.5:1) bevels		Area Full	1.8	ft²
K	0.00180		HDS 5 Chart	3	
M	2.50000		HDS 5 Scale	B	
C	0.02430		Equation Form	1	
Y	0.83000				

Culvert Designer/Analyzer Report
Driveway

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	0.00	cfs	Allowable HW Elevation	4,758.23	ft
Roadway Width	14.00	ft	Overtopping Coefficient	2.50	US
Length	20.00	ft	Crest Elevation	4,759.00	ft
Headwater Elevation	N/A	ft	Discharge Coefficient (Cr)	2.50	
Submergence Factor (Kt)	1.00				

Sta (ft)	Elev. (ft)
0.00	4,759.00
20.00	4,759.00

Culvert Designer/Analyzer Report
Driveway

Analysis Component			
Storm Event	Design	Discharge	8.90 cfs

Peak Discharge Method: User-Specified			
Design Discharge	8.90 cfs	Check Discharge	0.00 cfs

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	4,756.75 ft

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-15 inch Circular	8.90 cfs	4,758.67 ft	9.47 ft/s
Weir	Roadway (Constant Elevation)	0.00 cfs	4,758.67 ft	N/A
Total	----------------	8.90 cfs	4,758.67 ft	N/A

Culvert Designer/Analyzer Report
Driveway

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	4,758.68	ft	Discharge	8.90	cfs
Inlet Control HW Elev.	4,758.68	ft	Tailwater Elevation	4,756.75	ft
Outlet Control HW Elev.	4,758.59	ft	Control Type	Inlet Control	
Headwater Depth/Height	1.84				

Grades					
Upstream Invert	4,756.38	ft	Downstream Invert	4,755.79	ft
Length	18.00	ft	Constructed Slope	0.032778	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.89	ft
Slope Type	Steep		Normal Depth	0.77	ft
Flow Regime	Supercritical		Critical Depth	1.15	ft
Velocity Downstream	9.47	ft/s	Critical Slope	0.014036	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.012	
Section Material	Corrugated HDPE (Smooth Interior)		Span	1.25	ft
Section Size	15 inch		Rise	1.25	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	4,758.59	ft	Upstream Velocity Head	0.88	ft
Ke	0.20		Entrance Loss	0.18	ft

Inlet Control Properties					
Inlet Control HW Elev.	4,758.68	ft	Flow Control	Submerged	
Inlet Type	Beveled ring, 33.7° bevels		Area Full	1.2	ft²
K	0.00180		HDS 5 Chart	3	
M	2.50000		HDS 5 Scale	B	
C	0.02430		Equation Form	1	
Y	0.83000				

Culvert Designer/Analyzer Report
Driveway

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	0.00	cfs	Allowable HW Elevation	4,758.67	ft
Roadway Width	14.00	ft	Overtopping Coefficient	2.50	US
Length	20.00	ft	Crest Elevation	4,759.00	ft
Headwater Elevation	N/A	ft	Discharge Coefficient (Cr)	2.50	
Submergence Factor (Kt)	1.00				

Sta (ft)	Elev. (ft)
0.00	4,759.00
20.00	4,759.00

Culvert Designer/Analyzer Report
Driveway

Analysis Component			
Storm Event	Design	Discharge	8.90 cfs

Peak Discharge Method: User-Specified			
Design Discharge	8.90 cfs	Check Discharge	0.00 cfs

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	4,756.75 ft

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-15 inch Circular	8.37 cfs	4,759.05 ft	9.07 ft/s
Weir	Roadway (Constant Elevation)	0.53 cfs	4,759.05 ft	N/A
Total	----------------	8.90 cfs	4,759.05 ft	N/A

Culvert Designer/Analyzer Report
Driveway

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	4,759.05	ft	Discharge	8.37	cfs
Inlet Control HW Elev.	4,759.05	ft	Tailwater Elevation	4,756.75	ft
Outlet Control HW Elev.	4,758.71	ft	Control Type	Inlet Control	
Headwater Depth/Height	2.13				

Grades					
Upstream Invert	4,756.38	ft	Downstream Invert	4,755.79	ft
Length	18.00	ft	Constructed Slope	0.032778	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.88	ft
Slope Type	Steep		Normal Depth	0.78	ft
Flow Regime	Supercritical		Critical Depth	1.13	ft
Velocity Downstream	9.07	ft/s	Critical Slope	0.014714	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.25	ft
Section Size	15 inch		Rise	1.25	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	4,758.71	ft	Upstream Velocity Head	0.80	ft
Ke	0.50		Entrance Loss	0.40	ft

Inlet Control Properties					
Inlet Control HW Elev.	4,759.05	ft	Flow Control	Submerged	
Inlet Type	Square edge w/headwall		Area Full	1.2	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
Driveway

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	0.53	cfs	Allowable HW Elevation	4,759.05	ft
Roadway Width	14.00	ft	Overtopping Coefficient	2.52	US
Length	20.00	ft	Crest Elevation	4,759.00	ft
Headwater Elevation	4,759.05	ft	Discharge Coefficient (Cr)	2.52	
Submergence Factor (Kt)	1.00				

Sta (ft)	Elev. (ft)
0.00	4,759.00
20.00	4,759.00

Appendix G: Cost to Construct Tables

Concrete:		Cost	Amount		Price
Delivery of Concrete	$180.00	One Time Fee			$180.00
Concrete (4000 psi)	$144.00	Per Cubic Yard	40	Cu. Yd.	$5,760.00
House Floor	14.82	Cu. Yd.			
Footing	4.75	Cu. Yd.			
Parking Area	17.78	Cu. Yd.			
Total:	37.35	Cu. Yd.			
Exact Total:	38	Cu. Yd.	Will get 40 yards for spillage or varying depth		
Total:					$5,940.00

Rebar:

Rebar Size	Length	Price	Amount	Cost	Estimate Cost
#3 (3/8 in)	20	$7.88	100	$788.00	$ 790.00
#4 (1/2 in)	20	$19.88	15	$298.20	$ 300.00
Total Cost of Rebar				$1,086.20	
Total Cost of Rebar					$1,090.00

AGRI Supply

	size	length	Price	amount	cost
CMP Pipe	18"	20'	$704.99	1	$704.99

Grading								
Finish Grading :	unit	crew	Daily Output	labor hours	bare labor	bare equipment	bare total	total
Fine Grade for Slab on Grade, Machine	S.Y.	B11L	1040	0.015	0.47	0.52	0.99	1.35
Hand Grading	S.Y.	B18	700	0.034	0.93	0.06	0.99	1.62
Finishing grading slopes, gentle	S.Y.	B11L	8900	0.002	0.06	0.06	0.12	0.16

Riprap									
	unit	crew	Daily Output	labor hours	Bare Material	bare labor	bare equipment	bare total	total O&P
Dumped, 100-lb. Average	Ton	B11A	700	0.023	30.5	0.7	1.5	32.7	36.31

Excavation and Fill									
Excavation:	unit	crew	Daily Output	labor hours	Bare Material	bare labor	bare equipment	bare total	total
1' to 4' deep, 1/2 C.Y. Excavator	B.C.Y.	B11M	200	0.08		2.15	1.75	3.9	5.46
Excavator, hydraulic, crawler mtd., 1 C.Y. cap. = 100 C.Y./hr	B.C.Y.	B12A	800	0.02		0.54	0.91	1.45	1.9
Front end loader, track mtd., 1-1/2 C.Y. cap. = 70 C.Y./hr	B.C.Y.	B10N	560	0.014		0.7	0.66	1.36	1.86
Fill:	unit	crew	Daily Output	labor hours	Bare Material	bare labor	bare equipment	bare total	total
Backfill, 6" layers, compaction in layers, Vibrating Plate, add	E.C.Y.	A1D	60	0.133		2.98	0.51	3.149	5.56

Crew A1D	Bare Costs Hr.	Daily	Incl. Subs O&P Hr.	Daily	Cost Per Labor-hour Bare Costs	Incl. O&P
1 Building Laborer	$28.70	$229.60	$46.75	$374.00	$28.70	$46.75
1 Vibrating Plate, Gas, 18"		$32.77		$36.05	$4.10	$4.51
8 L.H., Daily Totals		$262.37		$410.05	$32.80	$51.26

Crew B11A	Bare Costs Hr.	Daily	Incl. Subs O&P Hr.	Daily	Cost Per Labor-hour Bare Costs	Incl. O&P
1 Equipment Oper. (med.)	$39.25	$314.00	$63.90	$511.20	$33.98	$55.33
1 Laborer	$28.70	$229.60	$46.75	$374.00		
1 Dozer, 200 H.P.		$1,567.46		$1,724.21	$97.97	$107.76
16 L.H., Daily Totals		$2,111.06		$2,609.41	$131.95	$163.09

Crew B11L	Bare Costs Hr.	Daily	Incl. Subs O&P Hr.	Daily	Cost Per Labor-hour Bare Costs	Incl. O&P
1 Equipment Oper. (med.)	$39.25	$314.00	$63.90	$511.20	$33.98	$55.33
1 Laborer	$28.70	$229.60	$46.75	$374.00		
1 Grader, 30,000 Lbs.		$1,108.49		$1,219.34	$69.28	$76.21
16 L.H., Daily Totals		$1,652.09		$2,104.54	$103.26	$131.54

Crew B11M	Bare Costs Hr.	Daily	Incl. Subs O&P Hr.	Daily	Cost Per Labor-hour Bare Costs	Incl. O&P
1 Equipment Oper. (med.)	$39.25	$314.00	$63.90	$511.20	$33.98	$55.33
1 Laborer	$28.70	$229.60	$46.75	$374.00		
1 Backhoe Loader, 80 H.P.		$240.94		$265.04	$15.06	$16.56
16 L.H., Daily Totals		$784.54		$1,150.24	$49.04	$71.89

Crew B12A	Bare Costs Hr.	Daily	Incl. Subs O&P Hr.	Daily	Cost Per Labor-hour Bare Costs	Incl. O&P
1 Equip. oper. (crane)	$39.95	$319.60	$65.05	$520.40	$37.33	$55.90
1 Laborer	$28.70	$229.60	$46.75	$374.00		
1 Hyd. Excavator		$32.77		$36.05	$53.61	$58.97
16 L.H., Daily Totals		$581.97		$930.45	$90.94	$114.87

Crew B18	Bare Costs Hr.	Daily	Incl. Subs O&P Hr.	Daily	Cost Per Labor-hour Bare Costs	Incl. O&P
1 Labor Foreman (outside)	$30.70	$245.60	$50.00	$400.00	$29.37	$47.83
2 Laborers	$28.70	$459.20	$46.75	$748.00		
1 Vibrating Plate, Gas, 21"		$171.39		$188.53	$7.14	$7.86
24 L.H., Daily Totals		$876.19		$1,336.53	$36.51	$55.69

Crew B10N	Bare Costs Hr.	Daily	Incl. Subs O&P Hr.	Daily	Cost Per Labor-hour Bare Costs	Incl. O&P
1 Equip. Oper. (medium)	$39.25	$314.00	$63.90	$511.20	$39.25	$63.90
1 F.E. Loader, T.M., 1.5 C.Y.		$589.09		$648.00	$73.64	$81.00
8 L.H., Daily Totals		$903.09		$1,159.20	$112.89	$144.90

Crew C1	Bare Costs Hr.	Daily	Incl. Subs O&P Hr.	Daily	Cost Per Labor-hour Bare Costs	Incl. O&P
2 Carpenters	$37.15	$594.40	$60.50	$968.00	$32.95	$53.83
1 Carpenter Helper	$28.80	$230.40	$47.55	$380.40		
1 Laborer	$28.70	$229.60	$46.75	$374.00		
32 L.H., Daily Totals		$1,054.40		$1,722.40	$32.95	$53.83

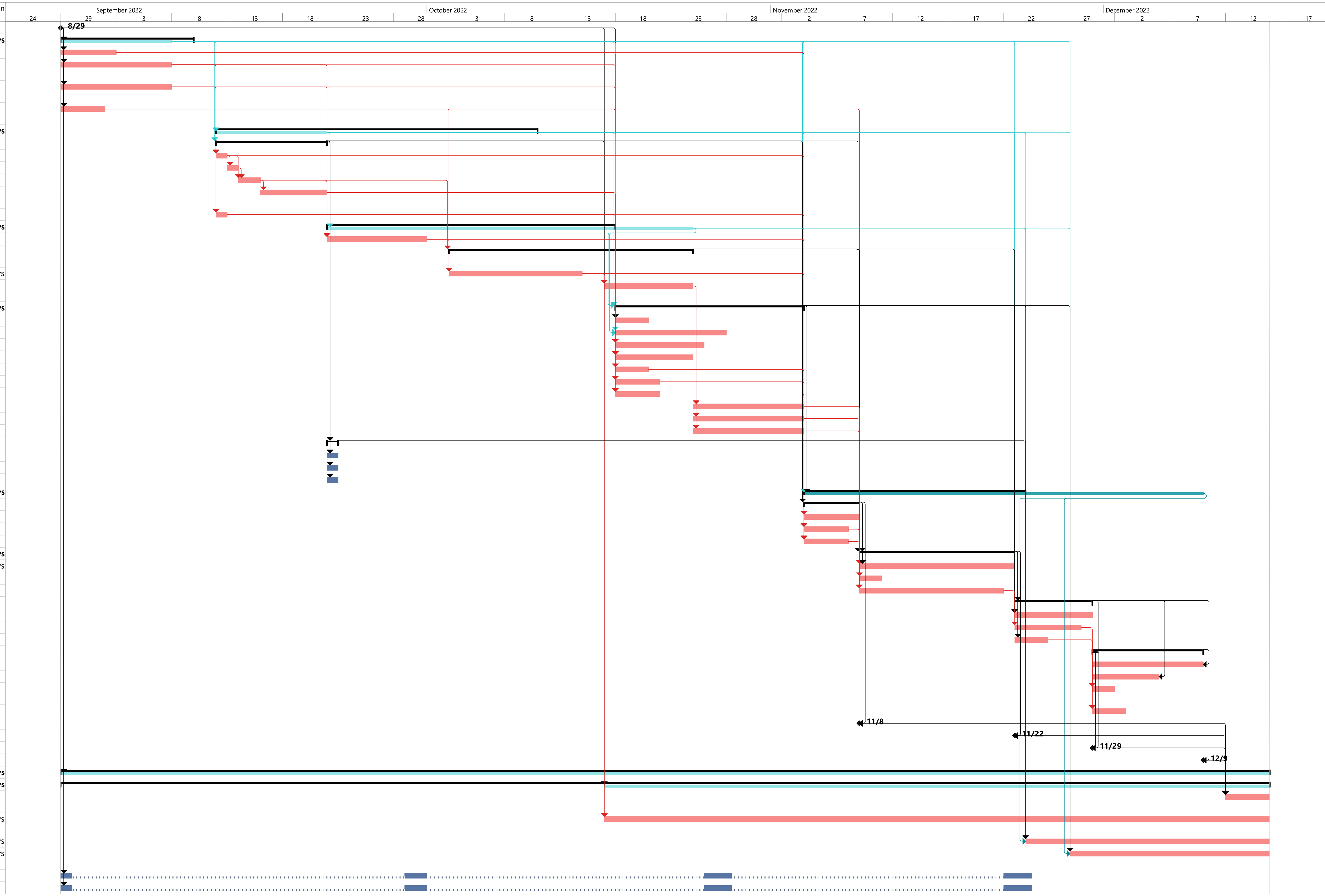
Crew C10	Bare Costs Hr.	Daily	Incl. Subs O&P Hr.	Daily	Cost Per Labor-hour Bare Costs	Incl. O&P
1 laborer	$28.70	$229.60	$46.75	$374.00	$34.37	$55.32
2 Cement Finishers	$37.20	$595.20	$59.60	$953.60		
24 L.H., Daily Totals		$824.80		$1,327.60	$34.37	$55.32

Crew C14C	Bare Costs Hr.	Daily	Incl. Subs O&P Hr.	Daily	Cost Per Labor-hour Bare Costs	Incl. O&P
1 Carpenter Foreman	$39.15	$313.20	$63.75	$510.00	$35.47	$57.73
6 Carpenters	$37.15	$1,783.20	$60.50	$2,904.00		
2 Rodmen (reinf.)	$41.25	$660.00	$67.40	$1,078.40		
4 Laborers	$28.70	$459.20	$46.75	$1,496.00		
1 Cement finisher	$37.20	$297.60	$59.60	$476.80		
1 Gas Engine Vibrator		$27.87		$30.65	$0.25	$0.27
112 L.H., Daily Totals		$3,541.07		$6,495.85	$35.72	$58.00

Appendix H: Pre and Post Gantt Charts

Proposed

ID	Task Name	Duration
1	Project Start	0 days
2	**2.1.0 Background Research**	**10 days**
3	2.1.1 Review Existing Codes	5 days
4	2.1.2 Obtain and Review Existing Studies	8 days
5	2.1.3 Obtain and Review Existing Survey Data	8 days
6	2.1.4 Obtain FEMA Floodplain Information	4 days
7	**2.2.0 Site Investigation**	**21 days**
8	**2.2.1 Site Visit**	**8 days**
9	2.1.1 Site Work Plan	1 day
10	2.1.2 Equipment	1 day
11	2.1.3 Land Survey	2 days
12	2.1.4 Process Collected Survey Data	4 days
13	2.2.2 Document Existing Topogra	1 day
14	**2.3.0 Hydrology Analysis**	**18 days**
15	2.3.1 Rational Method Analysis	7 days
16	**2.3.2 Determine Existing Channel Properties**	**16 days**
17	2.3.1.1 Channel Analysis	10 days
18	2.3.2.2 Design Recommended Channel Modifications	6 days
19	**2.4.0 Construction Plans**	**13 days**
20	2.4.1 Cover Sheet	3 days
21	2.4.2 Notes and Specifications	8 days
22	2.4.3 General Details	6 days
23	2.4.4 Elevation Profiles	5 days
24	2.4.5 Existing Channel Plans	3 days
25	2.4.6 Existing Topographic Survey	4 days
26	2.4.7 Existing Floodplain Map	4 days
27	2.4.8 Proposed Channel Plans	8 days
28	2.4.9 Proposed Grading Plans	8 days
29	2.4.10 Proposed Drainage Plans	8 days
30	**2.5.0 Impact Analysis**	**1 day**
31	2.5.1 Environmental Impacts	1 day
32	2.5.2 Societal Impacts	1 day
33	2.5.3 Economic Impacts	1 day
34	**2.6.0 Project Deliverables**	**14 days**
35	**2.6.1 30% Submittal**	**3 days**
36	2.6.1.1 30% Report	3 days
37	2.6.1.2 30% Presentation	2 days
38	2.6.1.3 30% Construction Draw	2 days
39	**2.6.2 60% Submittal**	**10 days**
40	2.6.2.1 60% Report	10 days
41	2.6.2.2 60% Presentation	2 days
42	2.6.2.3 60% Construction Draw	9 days
43	**2.6.3 90% Submittal**	**5 days**
44	2.6.3.1 90% Report	5 days
45	2.6.3.2 90% Construction Draw	4 days
46	2.6.3.3 90% Website	3 days
47	**2.6.4 Final Submittal**	**8 days**
48	2.6.4.1 Final Report	8 days
49	2.6.4.2 Final Presentation	4 days
50	2.6.4.3 100% Construction Drawings	2 days
51	2.6.4.4 Final Website	3 days
52	2.6.5 30% Completion	0 days
53	2.6.6 60% Completion	0 days
54	2.6.7 90% Completion	0 days
55	2.6.8 Full Completion	0 days
56	**2.7.0 Project Management**	**79 days**
57	**2.7.1 Project Meetings**	**79 days**
58	2.7.1.1 Grading Instructor Meetings	4 days
59	2.7.1.2 Technical Advisor Meetings	44 days
60	2.7.1.3 Client Meetings	16 days
61	2.7.1.4 Engineering Design Team Meetings	14 days
62	2.7.2 Schedule Management	8 days
63	2.7.3 Resource Management	8 days



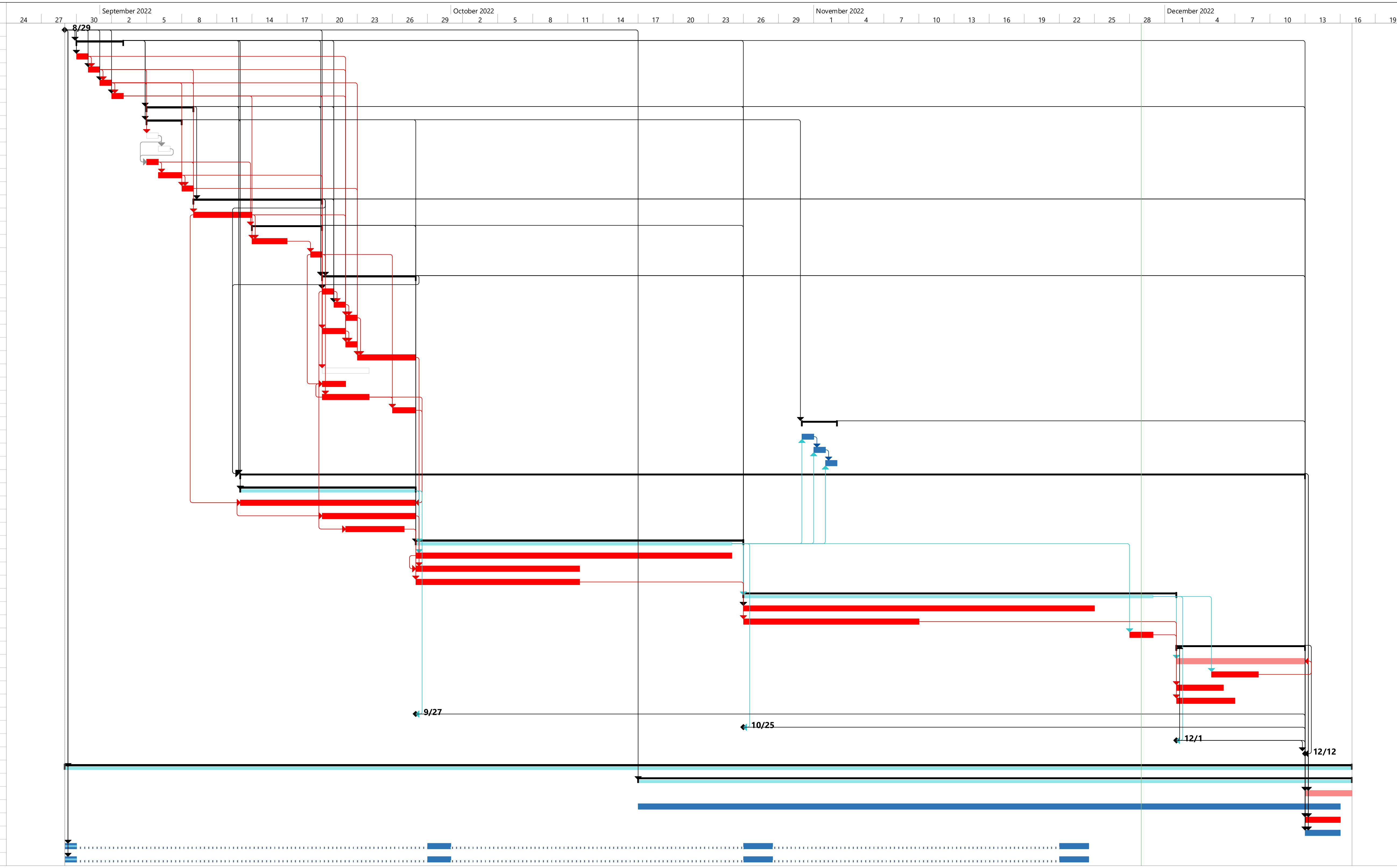
Project: CAPSTONE PROJECT N
Date: Tue 4/5/22

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

Critical Split
Progress
Manual Progress

Actual

ID	Task Name	Duration
1	Project Start	0 days
2	**2.1.0 Background Research**	**4 days**
3	2.1.1 Review Existing Codes	1 day
4	2.1.2 Obtain and Review Existing Studies	1 day
5	2.1.3 Obtain and Review Existing Survey Da	1 day
6	2.1.4 Obtain FEMA Floodplain Information	1 day
7	**2.2.0 Site Investigation**	**4 days**
8	**2.2.1 Site Visit**	**3 days**
9	~~2.1.1 Site Work Plan~~	~~1 day~~
10	~~2.1.2 Equipment~~	~~1 day~~
11	2.1.3 Land Survey	1 day
12	2.1.4 Process Collected Survey Data	2 days
13	2.2.2 Document Existing Topography	1 day
14	**2.3.0 Hydrology Analysis**	**7 days**
15	2.3.1 Rational Method Analysis	3 days
16	**2.3.2 Determine Existing Channel Properti**	**4 days**
17	2.3.1.1 Channel Analysis	3 days
18	2.3.2.2 Design Recommended Channel Modifications	1 day
19	**2.4.0 Construction Plans**	**6 days**
20	2.4.1 Cover Sheet	1 day
21	2.4.2 Notes and Specifications	1 day
22	2.4.3 General Details	1 day
23	2.4.4 Elevation Profiles	2 days
24	2.4.5 Existing Channel Plans	1 day
25	2.4.6 Existing Topographic Survey	3 days
26	~~2.4.7 Existing Floodplain Map~~	~~4 days~~
27	2.4.8 Proposed Channel Plans	2 days
28	2.4.9 Proposed Plot Plans	4 days
29	2.4.10 Erosion Protection Plans	2 days
30	**2.5.0 Impact Analysis**	**3 days**
31	2.5.1 Social Impacts	1 day
32	2.5.1 Economic Impacts	1 day
33	2.5.1 Environmental Impacts	1 day
34	**2.6.0 Project Deliverables**	**65 days**
35	**2.6.1 30% Submittal**	**11 days**
36	2.6.1.1 30% Report	11 days
37	2.6.1.2 30% Presentation	6 days
38	2.6.1.3 30% Construction Drawings	3 days
39	**2.6.2 60% Submittal**	**20 days**
40	2.6.2.1 60% Report	19 days
41	2.6.2.2 60% Presentation	10 days
42	2.6.2.3 60% Construction Drawings	10 days
43	**2.6.3 90% Submittal**	**27 days**
44	2.6.3.1 90% Report	22 days
45	2.6.3.2 90% Construction Drawings	11 days
46	2.6.3.3 90% Website	2 days
47	**2.6.4 Final Submittal**	**7 days**
48	2.6.4.1 Final Report	7 days
49	2.6.4.2 Final Presentation	4 days
50	2.6.4.3 100% Construction Drawings	2 days
51	2.6.4.4 Final Website	3 days
52	2.6.5 30% Completion	0 days
53	2.6.6 60% Completion	0 days
54	2.6.7 90% Completion	0 days
55	2.6.8 Full Completion	0 days
56	**2.7.0 Project Management**	**80 days**
57	**2.7.1 Project Meetings**	**45 days**
58	2.7.1.1 Grading Instructor Meetings	4 days
59	2.7.1.2 Technical Advisor Meetings	44 days
60	2.7.1.3 Client Meetings	3 days
61	2.7.1.4 Engineering Design Team Meetin	3 days
62	2.7.2 Schedule Management	8 days
63	2.7.3 Resource Management	8 days



Project: CAPSTONE PROJECT up
Date: Tue 11/29/22

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