# APPENDIX E-3

OFFSITE HYDROLOGY STUDY

# "Off-Site" Hydrology Study

*for*

# Yermo Travel Plaza

## Calico Road and Telstar Court

## Yermo, California

***June 12th, 2019***

Project No. 18-858


*Submitted by:* Matthew K. VoVilla 6-12-19

*Matthew K. VoVilla, R.C.E. 43130* *Date*

*LAV//Pinnacle* Engineering, Inc.
12418 Rosedale Highway, Suite A
Bakersfield, CA 93312
(661) 869-0184

# Table of Contents

## 1.0 Background

This report has been prepared as an "off-site" hydrology study for the development of a 5.7-acre commercial site located in the city of Yermo, San Bernardino County, California, and sometimes referred to in this report as the "Project". The purpose of this report is to show the effect of site development on run-on stormwater.

At the time of this report, the site plan is getting approved by the county. Therefore, the site plan may undergo some changes which would have an impact on the "on-site" hydrology. A separate "on-site" hydrology study will be submitted pending approval of the site plan.

The Project is located on the southwest corner of Calico Road and Telstar Court Yermo, California. The APN for the site is 0637-162-06. The proposed Project is a 13,000 square foot travel plaza that will include a food store/convenience market, a food court, rest rooms and showers. Specifically, the travel center includes a 11,000 square foot convenience market, restrooms, a food court, 10 vehicle fueling stations for cars and 4 fueling stations for trucks. The Project Site improvements will include truck and vehicle parking, a storm drain system, and terminal storm drain sump.

Exhibit "A" herein Exhibit "A" is a present-day aerial photo which shows the site as an undeveloped lot with natural grasses and shrubs. There are no existing buildings or other structures on the site. The site is relatively flat with a mild 0.7% slope the east-northeast. "Off-site" storm water flows onto the site from the west. West of the Project is undeveloped desert. As shown on Exhibit "F", development of the Project site will render 45% of the surface impermeable.

Exhibit "E" provides the site layout. Within the Project Site is a 0.55 acre area that will be left undeveloped at this phase of the Project. While the site plan shows a possible fast food restaurant in the location, at the time of this writing there are no plans for development.

The current site condition is an undeveloped lot with exposed natural soil and grassy shrubs. Figure 1 below shows the current site condition. The area directly west of the project site is similarly undeveloped. There is a single-family residential development directly to the west and a gas station commercial development to the northwest of the Project site.

*Figure 1: "On-Site" Terrain Conditions*

Exhibit "B" is an enlarged excerpt from the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps (FIRM). The entirety of the Project site is within Zone "X". Zone "X" is defined by the FIRM maps as an area determined to be outside the 0.2% annual chance floodplain. The FIRM map also shows the Yermo Flood Channel, which is discussed in Section 2.1 herein.

## 2.0 "Off-Site" Hydrology Study

The "off-site" hydrology study evaluates the effect of proposed improvements on the water surface profile of storm flow through and around the site. It compares the water surface profile of undeveloped and developed conditions. The Project is obligated to discharge run-on storm water such that abutting and surrounding properties shall be impacted no more than the pre-development conditions.

## 2.1 Watershed Characteristics

The tributary area to the site was determined using United State Geologic Survey (USGS) Quadrangle Maps, which provide historic ground contours.

Exhibit "C" is a small-scale excerpt from the USGS Quadrangle Map which shows the Project site, and the natural ground contours. Exhibit "C" shows the Mojave River to the south, which is an intermittent river that runs east-northeast approximately 1-mile south of the Project site. The tributary area to the Project site is within a larger watershed area, named the Mojave Watershed, which drains into the Mojave River. The water in the river is mostly underground and the surface channel is dry except during storm events. Due to the distance from the Project site and the lack of surface water in the river, the effect of the Mojave River on the Project is considered negligible.

Also shown on Exhibit "C" is the Yermo Flood Channel, a concrete lined channel approximately 0.5-miles north of the Project. The channel runs east-west and is designed to convey runoff flowing south off the Calico Mountains east and south to the Mojave River. The channel is part of the San Bernardino Flood Control Zone 4 and is maintained by the county.[1] The capacity of the flood control channel is unknown and is beyond the scope of this study. Furthermore, the benefit of the flood control channel was not considered for this study.

Exhibit "D" is a larger scale excerpt of the USGS map which shows the Project site and shows the drainage tributary area that will impact the site. This tributary area impacting the Project site, at 88.3 acres, is small.

Exhibit "A" is an aerial photo of Yermo showing the Project site roughly in the center. In the area south of the Project, the surface channel of the Mojave River is evident. To the north, the Yermo Flood Channel is also visible and coincides with the FEMA maps.

[1] Rachel Struglia, *Initial Study for the San Bernardino County Master Stormwater System Maintenance Program, (*San Bernardino County Flood Control District, 2014)

## 2.2 "Off-Site" Hydrology and Water Surface Profile

As shown on Exhibit "D", the "off-site" tributary area to the Project is 88.3 acres. Given the relatively small size of said tributary area, the San Bernardino County Rational Method was used to determine the 100-year storm water runoff that would reach the site.[2]

The Rational Method is an equation used in order to estimate the stormwater runoff from small watersheds. The Rational Method is based on a formula that equates stormwater runoff to the average rainfall intensity (at a time the watershed is producing the maximum instantaneous runoff, the time of concentration), the watershed drainage area, and the permeability of the natural soil or developed conditions. The formula is:

$$Q = CiA$$

where:

Q = design discharge (cfs),
C = runoff coefficient (dimensionless),
i = design rainfall intensity (in/hr), and
A = watershed drainage area (acre).

Calculations for storm water run-on from the "off-site" watershed have been included in Appendix B of this report. An overland sheet flow velocity of 1.3 feet per second was conservatively used to calculate a time of concentration. Due to the long, narrow shape of the watershed area, the time of concentration was calculated from the centroid of the watershed instead of along the entire length. Based on the centroid length and the sheet flow velocity, a time of concentration of 44 minutes was calculated. The Rational Method yields a maximum instantaneous flow of 27.9 cubic feet per second (cfs).

The water surface profile, or depth of flow of storm water, was calculated using the Manning's Equation. The Manning's Equation is an empirical equation that applies to uniform flow in open channels and is a function of the channel velocity, flow area and channel slope. The formula is:

[2] AJ Kielhold, *San Bernardino County Hydrology Manual, (*San Bernardino County, 1986)

$$Q = VA = \frac{1.49}{n} AR^{\frac{2}{3}}\sqrt{S}$$

where:

Q = Flow Rate, ($ft^3/s$)

v = Velocity, (ft/s)

A = Flow Area, ($ft^2$)

n = Manning's Roughness Coefficient

R = Hydraulic Radius, (ft)

S = Channel Slope, (ft/ft)

In order to determine an appropriate Manning's "n" value, Table 3-5 from the EPA's Storm Water Management Model Reference Manual was consulted. Given the characteristics of upstream undeveloped watershed, natural ground lightly vegetated with desert scrub, a Manning's "n" value of 0.045 was selected.[3] The depth of flow at the west property line was calculated as approximately 1.2 inches. The velocity of water at the west property line of the Project site was calculated as 0.34 feet per second.

The low flow rate and velocity of runoff calculated did not warrant further analysis using the Unit Hydrograph Method or HEC-RAS.

## 3.0 Conclusions and Recommendations

This study has shown that the 100-year storm event will have less than significant impact on the Project. San Bernardino County Ordinance 4011(b) states that structures in Zone X shall have the lowest floor elevated one foot above the highest adjacent grade. For safety, building finished floor elevations will be elevated 1 foot above the maximum water surface elevations to ensure no stormwater will impact the proposed building.

[3] Lewis Rossman, *Storm Water Management Model Reference Manual Volume I – Hydrology (Revised), (*United States Environmental Protection Agency, 2016)

# APPENDIX “A”

# EXHIBIT "A" - AERIAL MAP


NORTH

SCALE: 1" = 1000'

0 500 1000 2000


LAV// Pinnacle Engineering
ENGINEERING • PLANNING • SURVEYING
12418 Rosedale Hwy., Suite A, Bakersfield, CA 93312
Phone: (661) 869-0184 Fax: (661) 885-4155


REGISTERED PROFESSIONAL ENGINEER
MATTHEW K. VOVILLA
RCE 43130
Exp. 3-31-20
CIVIL
STATE OF CALIFORNIA

MATTHEW K. VOVILLA
RCE 43130 EXP. 3/31/20

EXHIBIT "A" - AERIAL MAP
YERMO TRAVEL CENTER
TELSTAR CT AND CALICO RD
YERMO, CALIFORNIA

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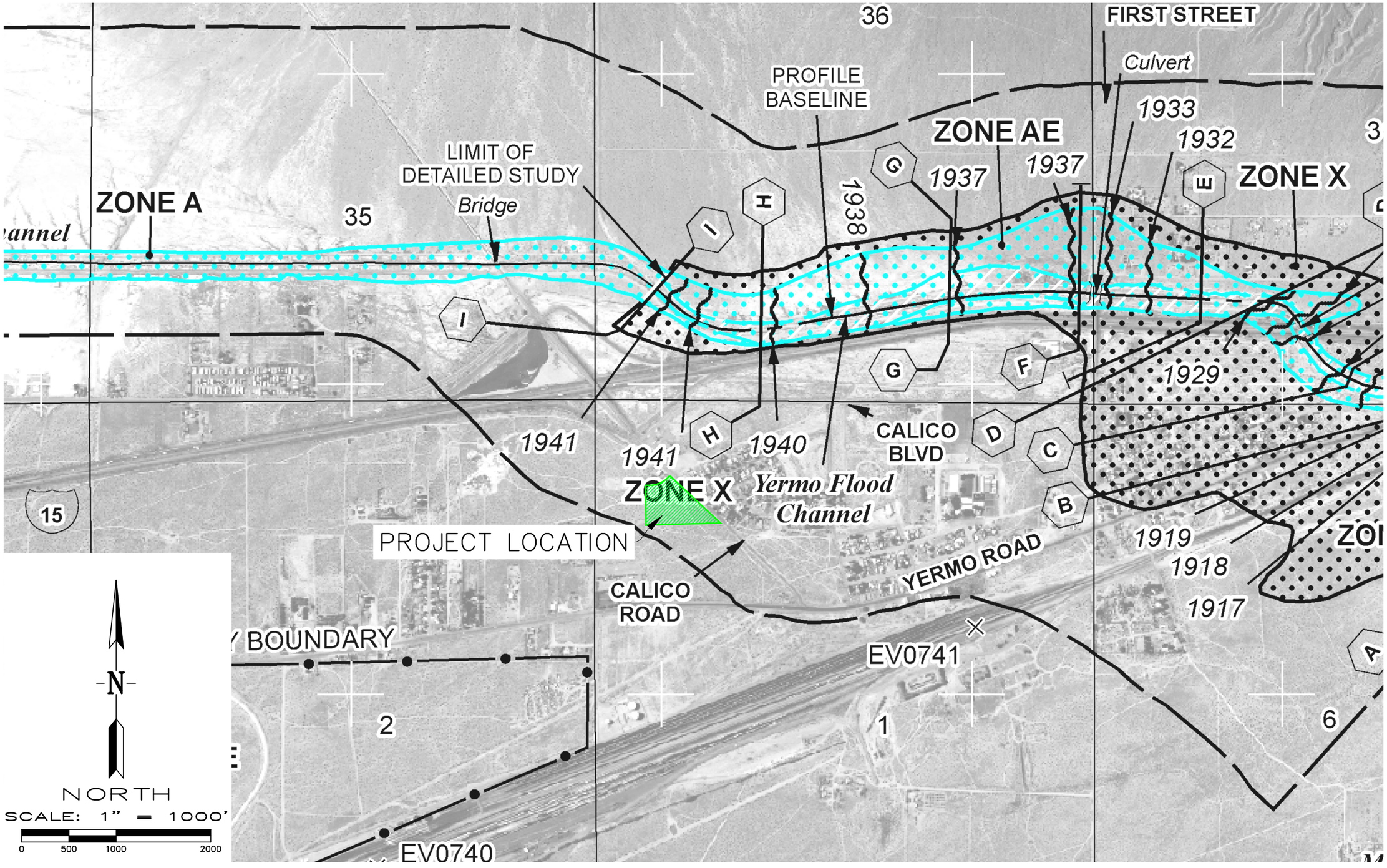
|---|---|
| JOB No.: | 18-858 |
| DWG NO.: | EXHIBIT |
| DATE: | 06/04/2019 |
| DRAWN BY: | BMB |
| CHECKED BY: | MKV |
| SHEET | 1 |
| OF | 1 SHEETS |

# EXHIBIT "B" - FEMA MAP





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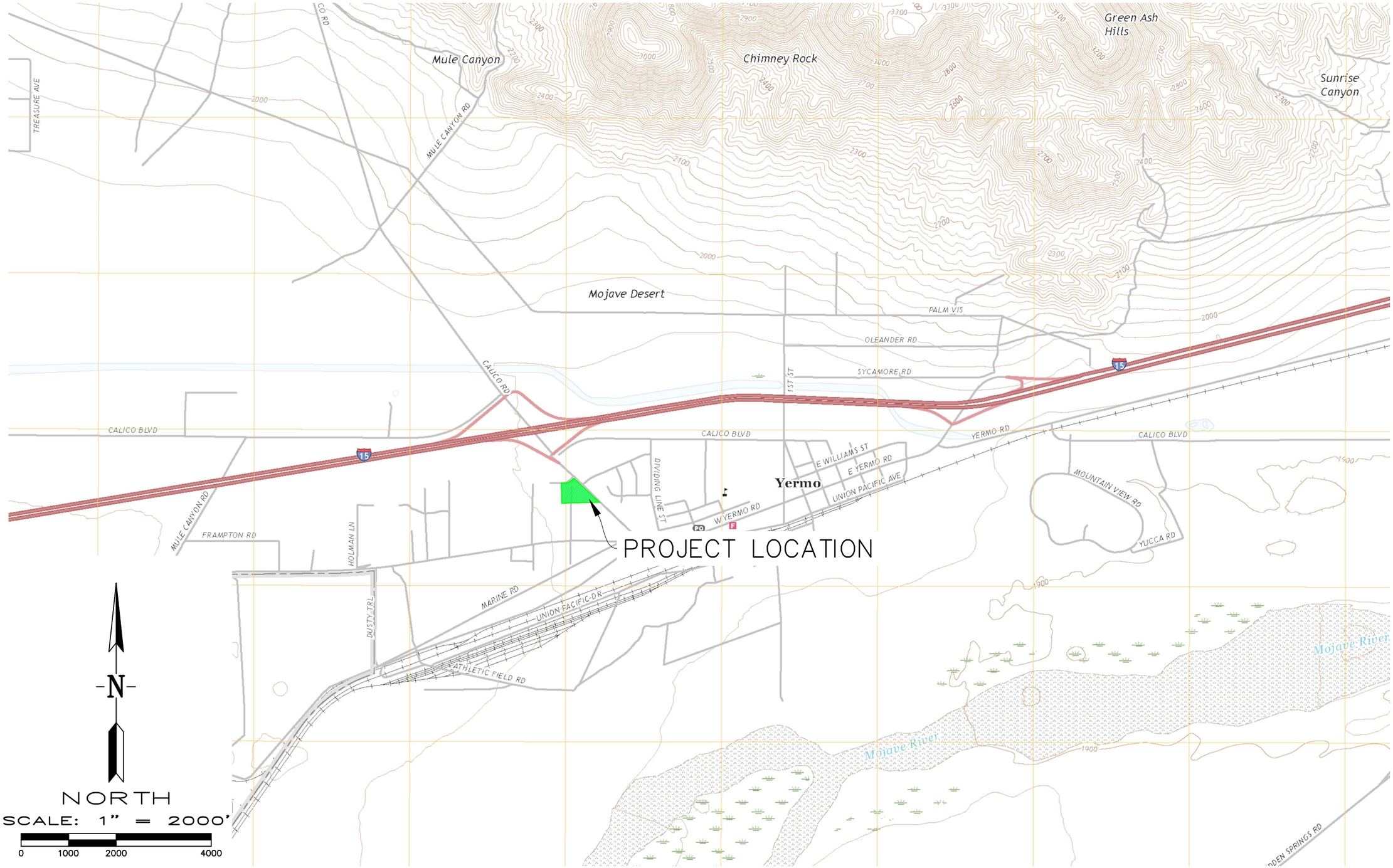
# EXHIBIT "C" - USGS MAP





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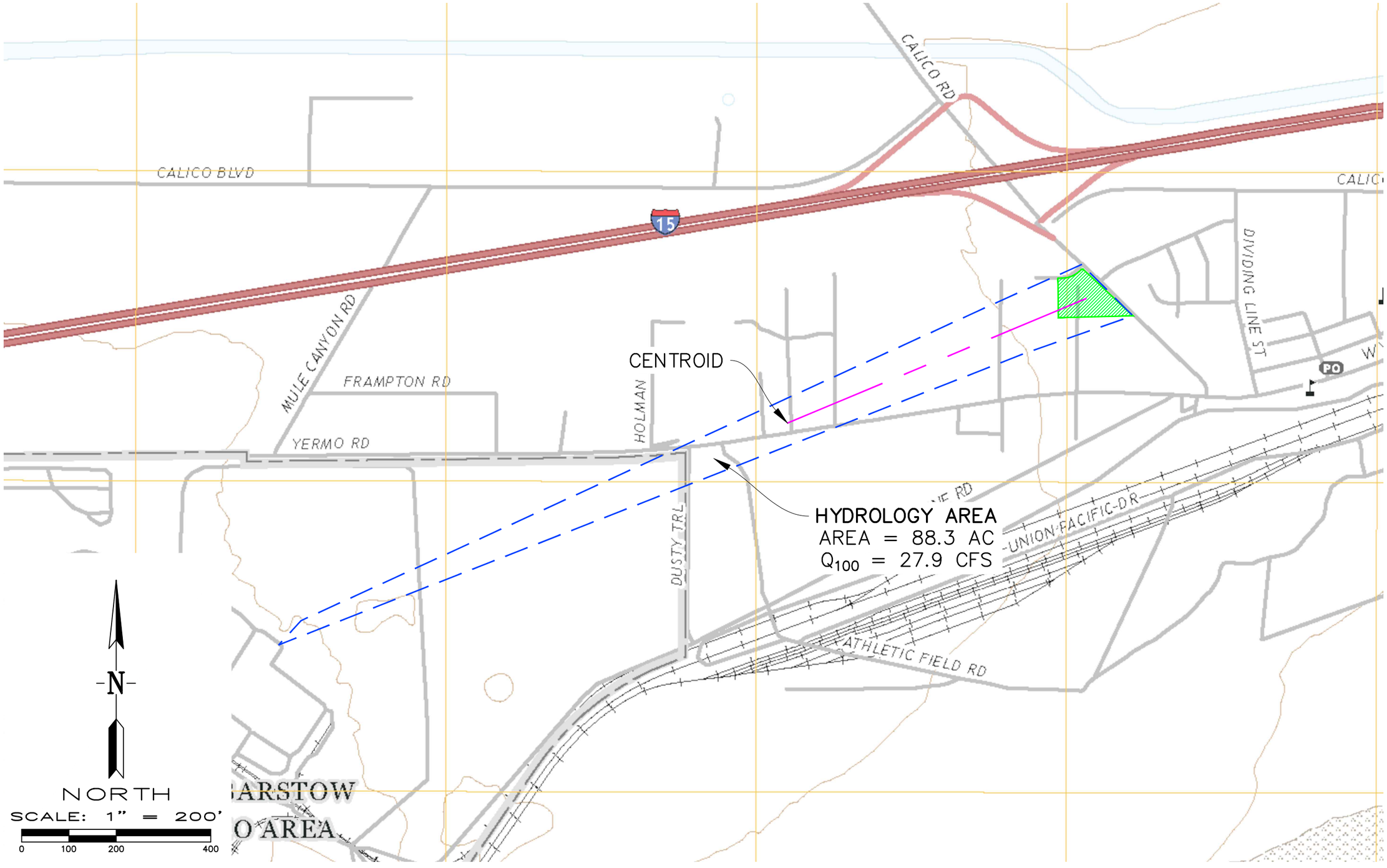
# EXHIBIT "D" - HYDROLOGY AREA





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RCE 43130 EXP. 3/31/20

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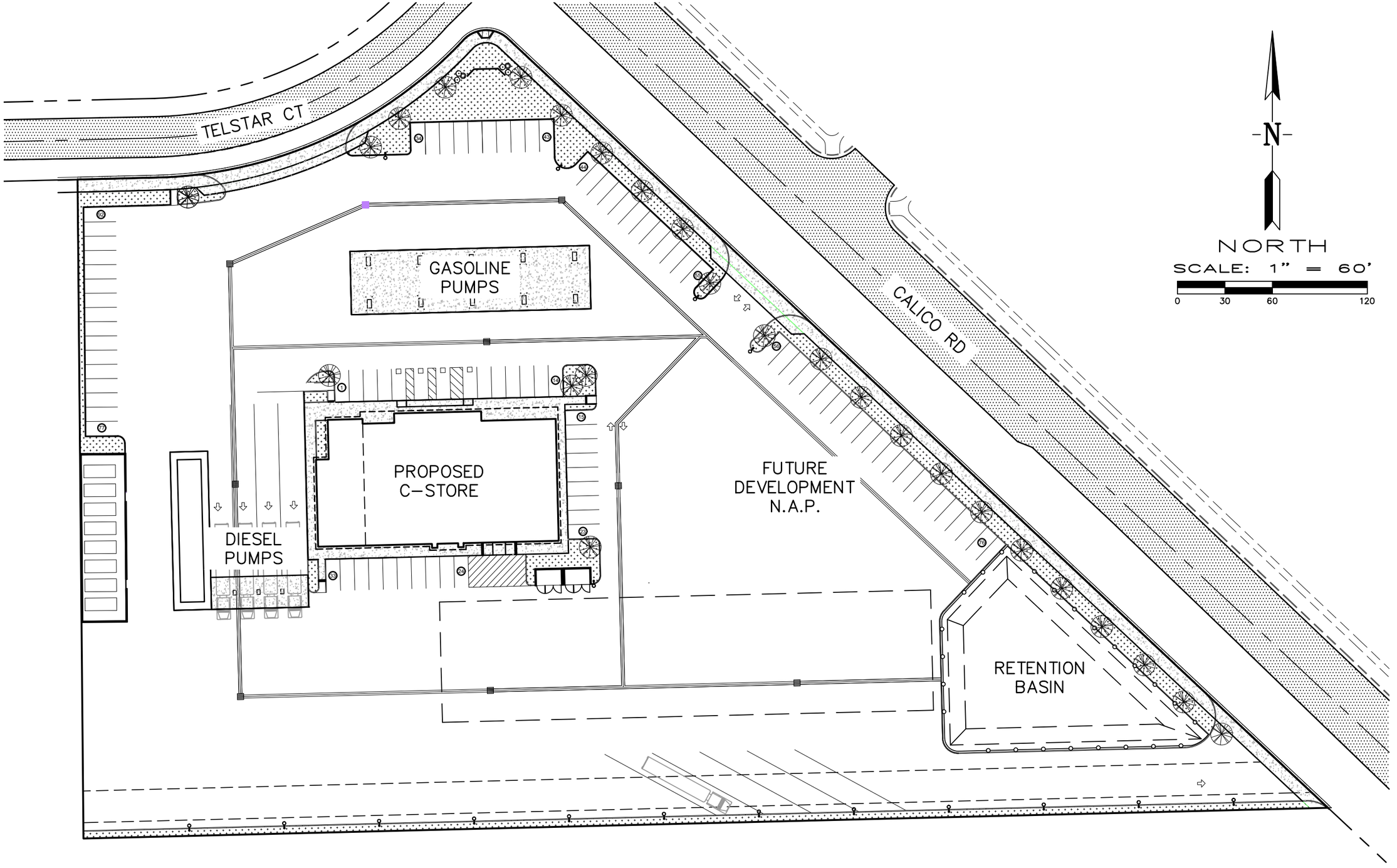
# EXHIBIT "E" - SITE PLAN




NORTH

SCALE: 1" = 60'

0 30 60 120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# APPENDIX “B”

Table 1

**Rational Method "Off-Site" Flow - 100 Year Event**

Job #: 18-858
Date: 6/12/2019
Created by: BMB

| Sub-Area | Area (Acres) | Hydrologic Soil Group | Length Watercourse (ft) | Elevation Change (ft) | $T_c$ 100-yr (min) | I 100-yr (in/hr) | C 100-yr | $Q_{100}$ (cfs) | Pervious Area | Impervious Area | % Impervious |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 88.30 | A | 3,424 | 21 | 152 | 0.74 | 0.43 | 28.10 | 88.30 | 0.00 | 0% |