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Intersect Power

2-D HYDRAULIC STUDY
SUMMARY ANALYSIS OF FINDINGS

IP DARDEN
Fresno County, CA

WRMA
WATER RESOURCES | ENGINEERING

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Section 1 Darden Hydrology

1.1 Watershed Delineation

The Watershed for the study area was determined by analyzing existing watershed boundaries provided by the National Hydrologic Dataset (NHD) generated by the USGS. The NHD is a dataset created by the USGS to delineate and identify the Nation's stream networks so that federal and state agencies can quickly identify streams using unique identifiers based on a network of rivers and streams within a defined hierarchy of watersheds. Based on the location of the Darden study area, which is located within the Upper-Dry Sub-Basin, five subwatersheds of interest were identified (See **Figure 1-1**).

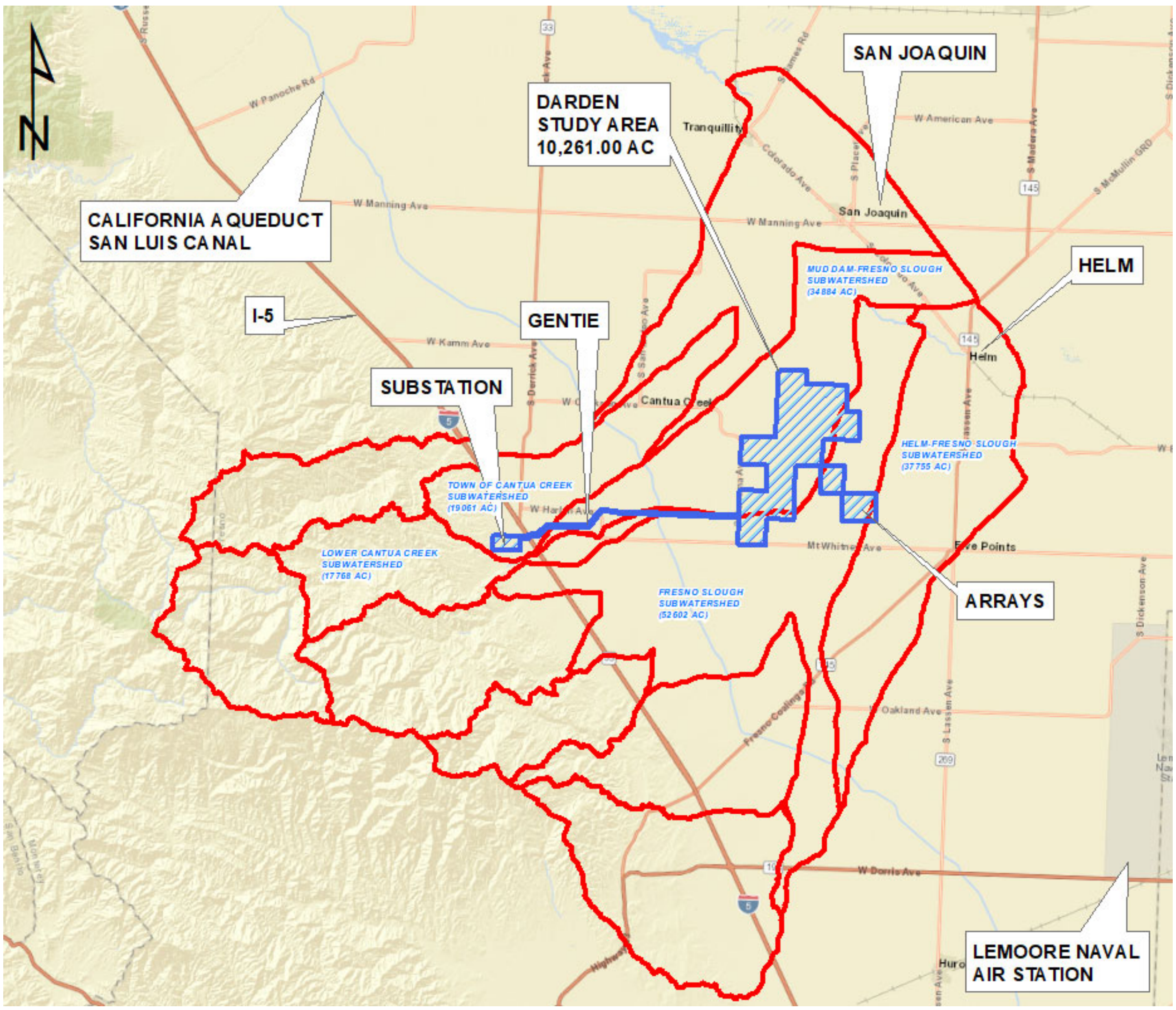

Figure 1-1 Darden Study Area (Blue) within Upper-Dry Sub-Basin & Relevant Features

1.2 Subwatersheds of Interest

Based on the NHD dataset, the Darden Study Area, is in Fresno County, California, approximately 28 miles Southwest of the City of Fresno, California and straddles five subwatersheds including Helm-Fresno Slough, Fresno Slough, and Mud Dam-Fresno Slough, Town of Cantua Creek and Lower Cantua Creek (See **Tables 1-1 to 1-5**).

Table 1-1 Town of Helm-Fresno Slough Subwatershed

NHD Identification Data – Helm-Fresno Slough Subwatershed	
HUC ID No.	180300090607
Region (HUC 2):	California Region
Sub-Region (HUC 4):	Tulare-Buena Vista Lakes
Basin (HUC 6):	Tulare-Buena Vista Lakes
Sub-Basin (HUC 8):	Upper Dry
Watershed (HUC 10):	Cantua Creek-Fresno Slough
Sub-Watershed (HUC 12):	Town of Helm-Fresno Slough

Helm-Fresno Slough subwatershed is approximately 37,755 Acres in size. Only a very small portion of the Darden study area is within the subwatershed. The most southern-easterly edge of the Study Area is located within the subwatershed. In addition, since the subwatershed is adjacent to the Fresno Slough subwatershed in which the majority of the study area resides, and likewise is also within the Cantua Creek-Fresno Slough watershed, this subwatershed was included in the analysis.

Table 1-2 Fresno Slough Subwatershed

NHD Identification Data – Fresno Slough Subwatershed	
HUC ID No.	180300090608
Region (HUC 2):	California Region
Sub-Region (HUC 4):	Tulare-Buena Vista Lakes
Basin (HUC 6):	Tulare-Buena Vista Lakes
Sub-Basin (HUC 8):	Upper Dry
Watershed (HUC 10):	Cantua Creek-Fresno Slough
Sub-Watershed (HUC 12):	Fresno Slough

Fresno Slough subwatershed is approximately 52,602 Acres in size, is adjacent to and west of the Helm-Fresno Slough subwatershed. About 25% of the study area is within this subwatershed. The southern eastern vicinity of study Area is located within the drainage area of Fresno Slough.

Table 1-3 Mud Dam-Fresno Slough Subwatershed

NHD Identification Data – Mud Dam-Fresno Slough Subwatershed	
HUC ID No.	1803000090803
Region (HUC 2):	California Region
Sub-Region (HUC 4):	Tulare-Buena Vista Lakes
Basin (HUC 6):	Tulare-Buena Vista Lakes
Sub-Basin (HUC 8):	Upper Dry
Watershed (HUC 10):	Arroyo Hondo-Fresno Slough
Sub-Watershed (HUC 12):	Mud Dam – Fresno Slough

Mud Dam-Fresno Slough subwatershed is approximately 34,884 Acres in size. About 60% of the study area is within this subwatershed. The north and western portions of the study Area is located within the drainage area of Mud Dam-Fresno Slough.

Table 1-4 Town of Cantua Creek Subwatershed

NHD Identification Data – Town of Cantua Creek Subwatershed	
HUC ID No.	180300090802
Region (HUC 2):	California Region
Sub-Region (HUC 4):	Tulare-Buena Vista Lakes
Basin (HUC 6):	Tulare-Buena Vista Lakes
Sub-Basin (HUC 8):	Upper Dry
Watershed (HUC 10):	Arroyo Hondo-Fresno Slough
Sub-Watershed (HUC 12):	Town of Cantua Creek

Town of Cantua Creek subwatershed is approximately 19,062 Acres in size. The subwatershed contains a parcel of land that is a proposed site for a future substation facility and is to the West of the main Darden site, interconnected to the main Darden solar array area by a Gentie connection which traverses East-West across I-5. The site is located along the western side of Interstate 5 at the foot of the mountain range. The entirety of the future substation parcel is located within this subwatershed.

Table 1-5 Lower Cantua Creek Subwatershed

NHD Identification Data – Town of Cantua Creek Subwatershed	
HUC ID No.	180300090605
Region (HUC 2):	California Region
Sub-Region (HUC 4):	Tulare-Buena Vista Lakes
Basin (HUC 6):	Tulare-Buena Vista Lakes
Sub-Basin (HUC 8):	Upper Dry
Watershed (HUC 10):	Arroyo Hondo-Fresno Slough
Sub-Watershed (HUC 12):	Town of Cantua Creek

The Lower Cantua Creek subwatershed is approximately 17,768 Acres in size. The subwatershed contains a short portion of the gentie connection line that connects the solar array area to the substation approximately 8.4 miles to the West and which is sited on the West side of Interstate-5.

1.3 Hydrologic Model

Hydrologic analysis was performed using the US Army Corps of Engineers HEC-RAS 6.4.1 modeling software direct precipitation (Rain-on-Grid) routine. Given that all five subwatersheds of interest lack defined hydrologic features in this predominantly dry and agricultural location, direct precipitation was selected as the rainfall-runoff hydrology method. HEC-RAS 6.4.1 provides for user inputs of various data sources to model the effect of infiltration, via the SCS method, of the soils. Data sources obtained for this analysis (See **Table 1-6**) included land cover, impervious area, soil permeability or hydrologic soil type and catchment areas. Rainfall data for the 100-year, 24-hour storm and the 500-year, 24-hour storm was obtained from NOAA Atlas 14, which provides the best available government provided rainfall data statistics for the contiguous United States.

Table 1-6 Hydrologic Model Data Inputs

Physical Hydrologic Model Input	
Land Cover	USGS National Land Cover Database 2021 Land Cover Classifications
Elevation (Topography)	LiDAR Aerial Topographic Survey 2-ft for proposed construction areas, with NextMap 5m and 10m USGS Topographic Digital Elevation Models for areas beyond the limits of the LiDAR data Datum: NAVD88 (vertical) and NAD83 (horizontal)
% Impervious Area	USGS National Land Cover Database 2021 Impervious Area
Hydrologic Soil Groups	NRCS gSSURGO 30 m 2021 and 10m Rasters for Dominant Conditions
Catchment Areas	Subwatersheds areas delineated by USGS via ArcHydro methods as published in the NHD (Hi-Resolution) Data Layer
SCS Curve Numbers	SCS Curve Numbers were selected based on (Moglen 2016) and the literature.

1.4 Rainfall

Using the NOAA Atlas-14 point rainfall statistics for the 100-YR /24-HR storm and the 500-YR / 24-HR storm, the NRCS Type II distribution (See **Figure 1-2**) was applied to determine the rainfall hyetograph over the 24 hour duration of the storm. This data was input into the HEC-RAS 6.4.1 precipitation (direct rainfall) model. The boundary of the 2D mesh was selected in part based on the five Sub-Watershed boundaries for the sub watersheds of interest as well as topographically significant terrain elements. Consequently, the model applies the rainfall event based on the NRCS Type II distribution, uniformly over the entirety of the 2-D Mesh area. The 24-hour rainfall was indicated to be 2.99 inches for the 100-YR event which has a 1% annual exceedance probability, and 3.87 inches for the 500-YR event which has 0.2% annual exceedance probability (See **Table 1-8**). NOAA Atlas 14 Rainfall Data for the area of study is provided in **Appendix A**.

Table 1-7 Hydrologic Model Rainfall and Loss Characteristics

Rainfall Model Input	
Rainfall	NOAA Atlas 14 provides the most up to date and accurate point rainfall estimates. For the Darden study area, the rainfall depth for the 100 year - 24 Hour storm is 2.99 inches, for the 500 year – 24 Hour storm it is 3.87 inches.
Rainfall Distribution	NRCS Type II
Infiltration Method	Soil Conservation Services (SCS) Curve Number
Baseflow Method	Not Applicable

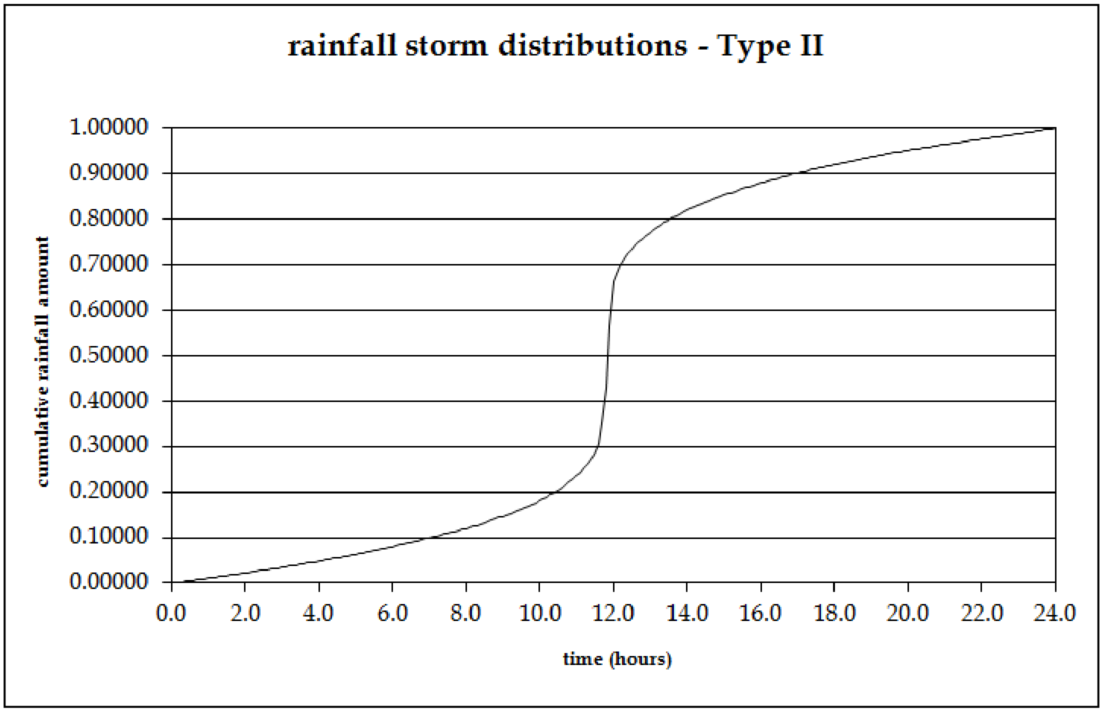

Figure 1-2 NRCS Type II Dimensionless Rainfall Distribution

Table 1-8 NOAA Atlas 14 Rainfall Data for Darden Study Area

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.067** (0.060-0.077)	**0.085** (0.075-0.097)	**0.110** (0.096-0.126)	**0.131** (0.114-0.152)	**0.163** (0.137-0.197)	**0.190** (0.156-0.235)	**0.220** (0.175-0.279)	**0.252** (0.194-0.331)	**0.300** (0.221-0.413)	**0.341** (0.241-0.488)
10-min	**0.096** (0.085-0.110)	**0.122** (0.107-0.139)	**0.157** (0.138-0.180)	**0.188** (0.164-0.218)	**0.234** (0.196-0.282)	**0.273** (0.223-0.336)	**0.315** (0.250-0.400)	**0.361** (0.278-0.474)	**0.430** (0.316-0.592)	**0.489** (0.345-0.700)
15-min	**0.117** (0.103-0.133)	**0.147** (0.130-0.168)	**0.190** (0.167-0.218)	**0.228** (0.198-0.264)	**0.283** (0.237-0.341)	**0.330** (0.270-0.407)	**0.380** (0.303-0.483)	**0.437** (0.336-0.573)	**0.521** (0.382-0.716)	**0.592** (0.418-0.846)
30-min	**0.160** (0.141-0.183)	**0.201** (0.178-0.230)	**0.260** (0.229-0.299)	**0.312** (0.272-0.361)	**0.388** (0.325-0.467)	**0.451** (0.369-0.557)	**0.521** (0.414-0.661)	**0.598** (0.461-0.784)	**0.713** (0.523-0.980)	**0.810** (0.572-1.16)
60-min	**0.223** (0.197-0.255)	**0.281** (0.248-0.322)	**0.363** (0.320-0.417)	**0.435** (0.379-0.504)	**0.541** (0.454-0.652)	**0.630** (0.516-0.778)	**0.727** (0.579-0.924)	**0.835** (0.643-1.10)	**0.995** (0.731-1.37)	**1.13** (0.799-1.62)
2-hr	**0.326** (0.289-0.373)	**0.403** (0.356-0.461)	**0.513** (0.451-0.588)	**0.609** (0.531-0.706)	**0.751** (0.630-0.905)	**0.871** (0.713-1.08)	**1.00** (0.797-1.27)	**1.15** (0.884-1.51)	**1.36** (1.00-1.87)	**1.55** (1.09-2.21)
3-hr	**0.400** (0.353-0.457)	**0.493** (0.435-0.564)	**0.625** (0.550-0.717)	**0.741** (0.646-0.859)	**0.913** (0.765-1.10)	**1.06** (0.864-1.30)	**1.21** (0.965-1.54)	**1.39** (1.07-1.82)	**1.64** (1.21-2.26)	**1.86** (1.31-2.66)
6-hr	**0.542** (0.480-0.620)	**0.674** (0.595-0.771)	**0.858** (0.755-0.985)	**1.02** (0.888-1.18)	**1.25** (1.05-1.51)	**1.45** (1.18-1.78)	**1.65** (1.32-2.10)	**1.88** (1.45-2.47)	**2.22** (1.63-3.05)	**2.49** (1.76-3.56)
12-hr	**0.695** (0.614-0.794)	**0.893** (0.788-1.02)	**1.16** (1.02-1.34)	**1.39** (1.21-1.61)	**1.71** (1.44-2.06)	**1.97** (1.61-2.43)	**2.24** (1.78-2.84)	**2.53** (1.95-3.31)	**2.93** (2.15-4.03)	**3.26** (2.30-4.67)
24-hr	**0.873** (0.789-0.987)	**1.16** (1.05-1.31)	**1.55** (1.39-1.75)	**1.86** (1.66-2.13)	**2.30** (1.98-2.72)	**2.64** (2.22-3.19)	**2.99** (2.46-3.71)	**3.36** (2.68-4.29)	**3.87** (2.96-5.16)	**4.27** (3.15-5.91)

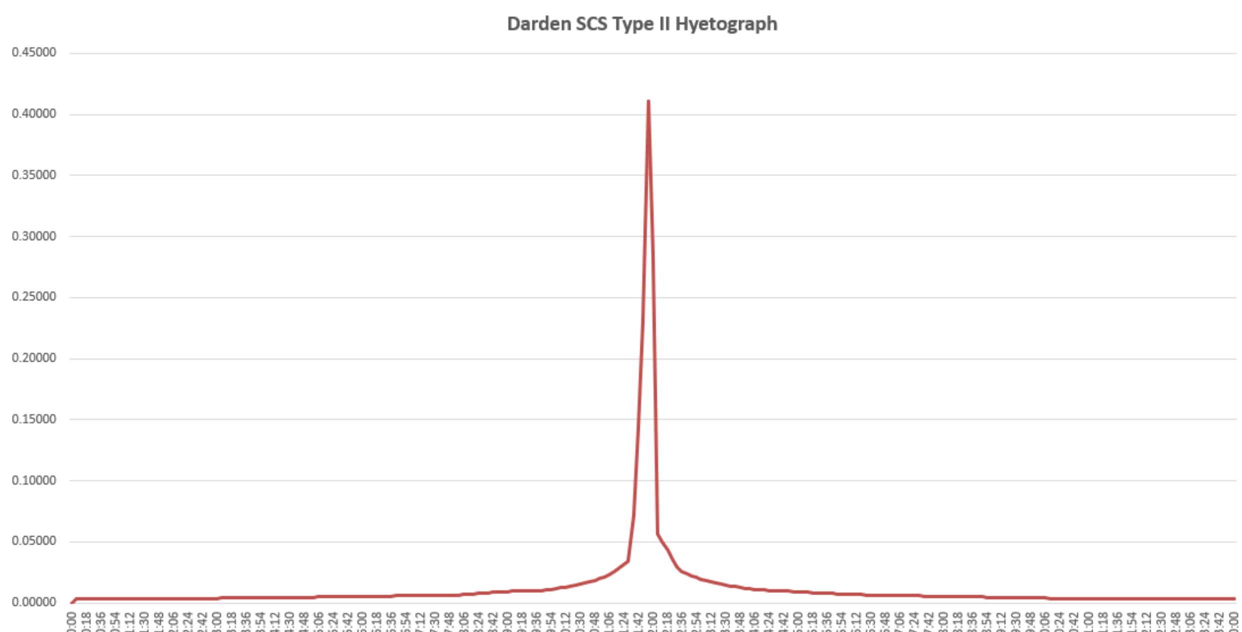

Figure 1-3 Darden Study Area Rainfall Hyetograph

Rainfall data from NOAA Atlas 14 was compared with other data sources from the literature, including TP-40, which likewise indicates a 24-hour rainfall of about 3 inches (+/-) for the 100-YR event (See **Figure 1-4**).

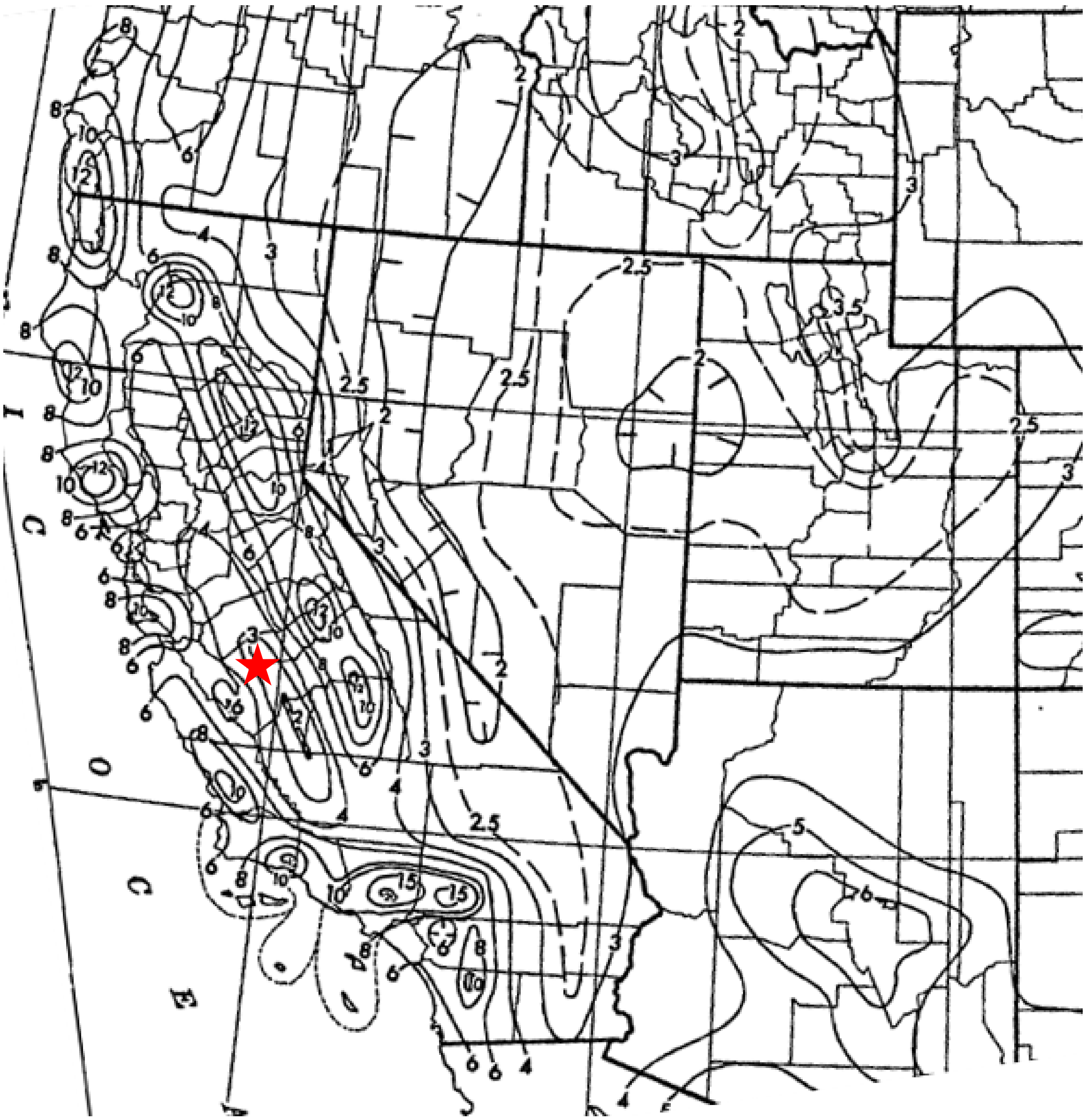

Figure 1-4 California Rainfall Isolines Based on TP-40 (Source: U.S. WB 1961)

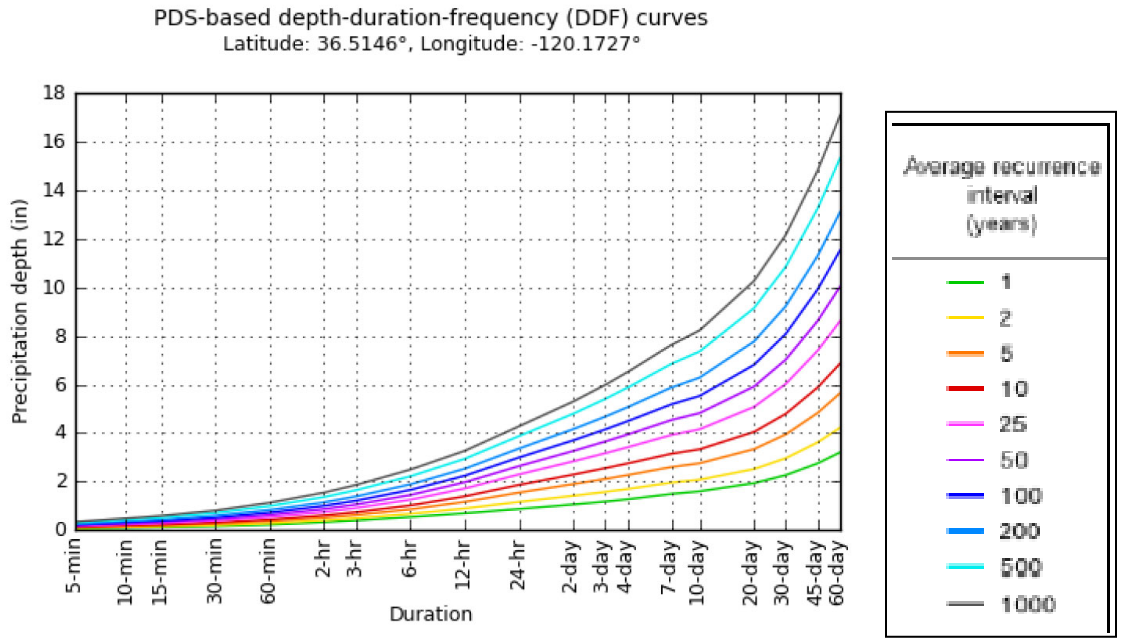

Figure 1-5 IDF Curves for the Darden Study Area (Source: NOAA Atlas 14, 2023)

1.5 Elevation & Slope

Topographic data for this analysis was obtained from three sources. For the main Darden study area aerial LiDAR at a 2-ft resolution was provided by Westwood Consultants. For areas beyond the limits of the LiDAR aerial survey, NextMap 5m digital terrain models (converted to ft, NAVD 88) were acquired from InterMap, Inc. For areas beyond the vicinity of the study area not likewise covered by the aerial LiDAR and 5m Nextmap data, such as the outer reaches of the peripheral subwatershed areas, USGS 10m (1/3 Arc Second) bare earth digital elevation models (converted to ft, NAVD 88) were utilized. The composite Digital Elevation Model indicated a vertical grade change between the high (270 ft above MSL) and low points (160 ft above MSL) of the sub-watershed, over an approximate length of 48,300 feet (9.2 miles) which equates to an average slope of 0.2% or 0.002 ft/ft. The change in grade is relatively gentle with few head cuts primarily man-made modified terrain features such U.S. Interstate Highway 5 and the California Aqueduct. Within the main Darden study area where the solar arrays would be sited, the terrain is primarily flat, mostly barren (un-sodded) with very light and in many cases, no vegetative cover, as the land use is pre-dominantly agricultural. The roadways include numerous unpaved dirt roads, with roadside irrigation ditches for water supply to farming operations. The grade is sloping from West to East (See **Figure 1-6**) which is consistent given the geography of the Valley.

Consequently, it would be expected that excess sheet flow runoff would flow in a North-Easterly direction.

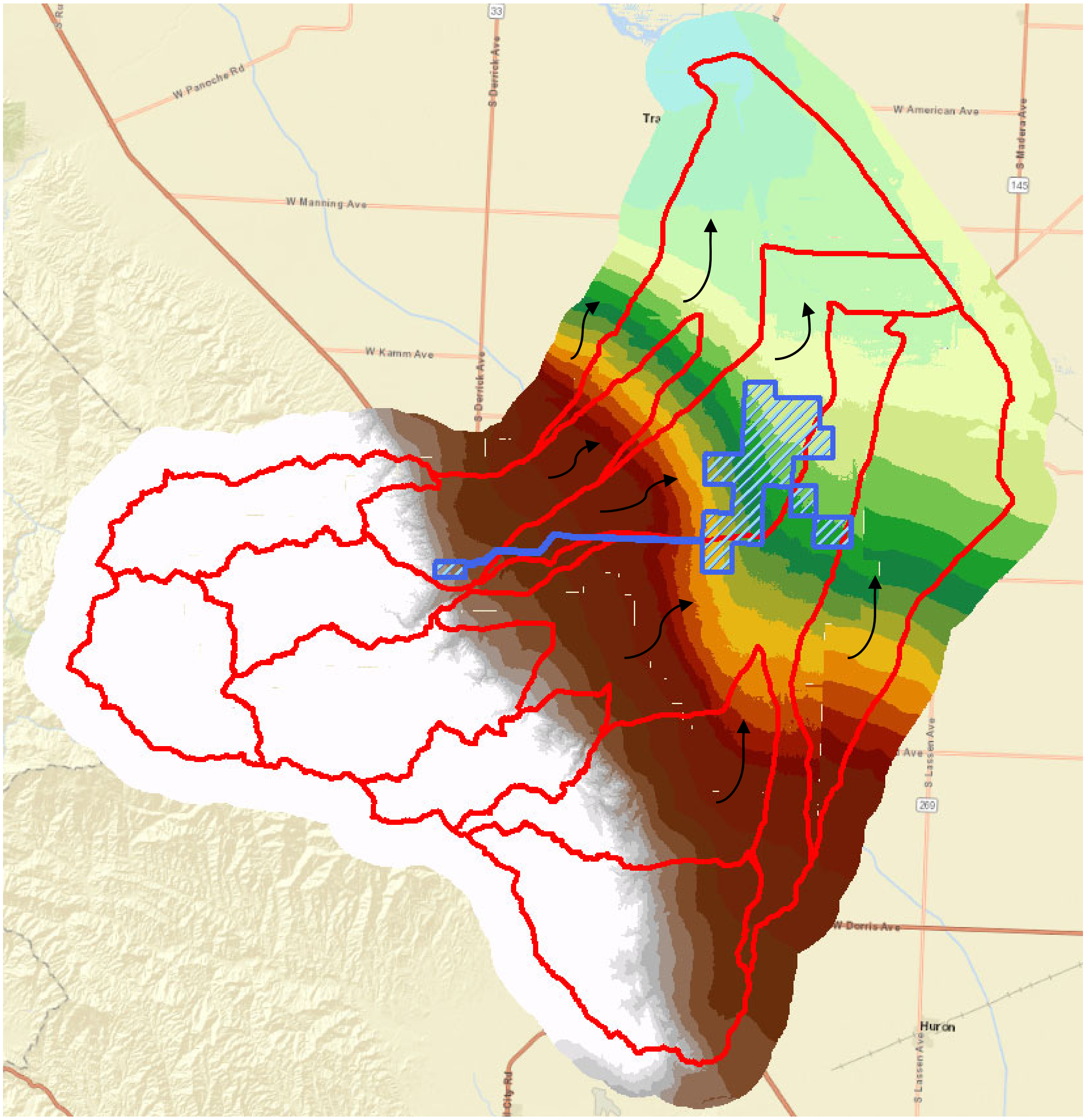

Figure 1-6 Elevation Model of the Darden Study Area (Source: Westwood, NextMap & USGS)

As previously stated, the slope of the terrain is relatively gentle with the substantial majority of the Darden study area having a slope between 0 to 2.5% (See **Figure 1-7**). Due the relatively flatter slopes, there are not any particularly well-defined hydrologic features which would indicate concentrated flow through the study area with the exception of various irrigation ditches located along the perimeter of various dirt roads in the main Darden array area. The NHD flowline data layer does not indicate any existing intermittent or ephemeral flowlines. The watershed boundary data layer identifies all five subwatersheds are sloped to the eastern limits of the subwatershed boundaries where runoff is collected into a series of agricultural ditches. This fact then suggests that rainfall infiltrates into the soil strata with any remaining excess runoff then concentrating into shallow pools distributed throughout the watershed and at the lowest points on the terrain such as the man-made agricultural irrigation conveyance ditches. This type of runoff response would be consistent with the HSG classification shown in **Figure 1-13**, which indicates that 95% of the soils within the subwatershed area are classified by the USGS as either Group C or Group D soils, both of which generally have lower rates of infiltration and therefore have a high runoff potential due to the presence of clay content in the soil strata. Generally, rates of infiltration for C and D soils will be between 0 to 0.15 inches per hour. Given the lack of any significant hydrologic features, once the surficial top soil layer is saturated, runoff will sheet flow across the surface, causing ponding of runoff in depressional areas, rills, gullies and irrigation ditches as the runoff moves in the direction of positive slope.

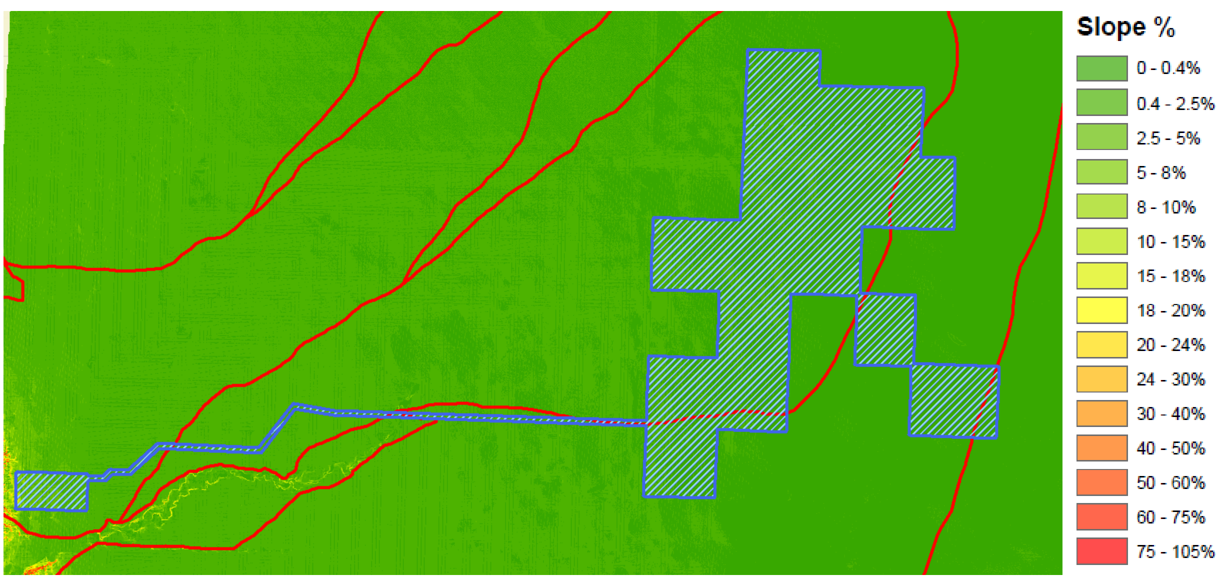

Figure 1-7 Slope Model of the Darden Study Area (Source: NLCD, 2021)

1.6 Land Cover

The Darden study area is located in the southwestern corner of Fresno County, California, in an area where the land cover is best described as primarily cultivated croplands due to the predominantly agricultural land uses (See **Figure 1-9**). This area of California receives on average about 12.8 inches of rainfall, or less, annually and therefore irrigation ditches and canals, manmade or otherwise, are common in the landscape to meet the demand for agricultural operations. Therefore, the hydrologic features, where found in the vicinity are primarily "intermittent" or ephemeral features and most of the time are barren or void of any moisture. It should be noted that the National Hydrologic Dataset does not indicate the presence of any defined or intermittent features, however there are some well-defined irrigation ditches and canals, some of which are man-made while others are naturally formed. The entirety of the study area is cultivated cropland, gently sloping from West to East over a 9-mile length. The study area is relatively dry. The hydrologic features are poorly defined and there is no consistent hydrologic network as the areas have consistent gentle slopes which push surface runoff as sheet flow down-gradient, towards the lower eastern portions of the subwatershed areas.

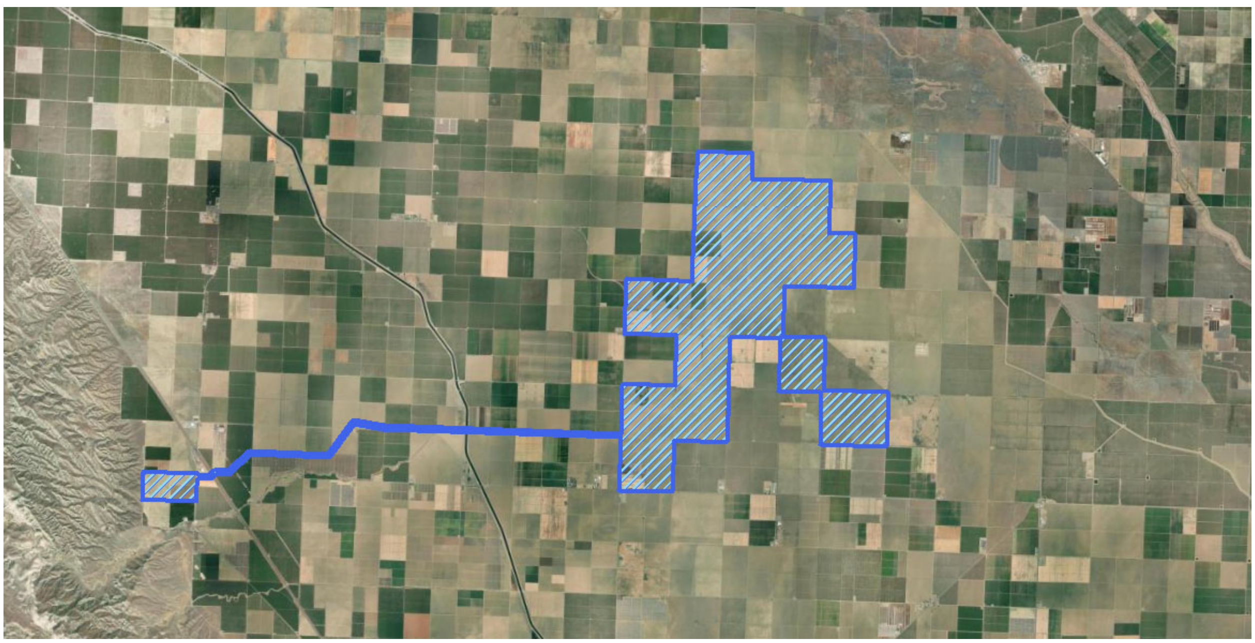

Figure 1-8 Darden Study Area Aerial Imagery (Source: ESRI, 2021)

1.7 Manning's n

Land Cover categories are taken from the National Land Cover Database (2021) via USGS. The Land Cover categories were used to determine ground cover roughness characteristics which are necessary for performing the 2D hydraulic computations. Manning's "n" roughness values are taken from the literature and recommended roughness values provided by the NRCS (See **Table 1-9**). The two predominant land cover categories in the Darden study area are cultivated crops (Manning's n of 0.035) and developed open space (Manning's n of 0.04).

Table 1-9 NRCS Manning's n Coefficients for NLCD Land Cover Values

NLCD[1] Value	Normal Manning's n Value	Allowable Range of n values	Land Cover Definition	Reference
11	**0.040**	0.025--0.05	Open Water - All areas of open water, generally with less than 25% cover or vegetation or soil	[2] Table 5-6 D-1.a.3
21	**0.040**	0.03--0.05	Developed, Open Space - Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.	[3] Figure 3-19
22	**0.100**	0.08--0.12	Developed, Low Intensity -Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.	[3] Figure 3-19
23	**0.080**	0.06--0.14	Developed, Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single- family housing units.	[3] Figure 3-19
24	**0.150**	0.12-0.20	Developed, High Intensity - Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to 100 percent of the total cover.	[3] Figure 3-19
31	**0.025**	0.023--0.030	Barren Land (Rock/Sand/Clay) - Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.	[2] Table 5-6 C.b.1
41	**0.160**	0.10--0.16	Deciduous Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.	[2] Table 5-6 D-2.d.5 Max. Debris
42	**0.160**	0.10--0.16	Evergreen Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.	[2] Table 5-6 D-2.d.5 Max. Debris
43	**0.160**	0.10--0.16	Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.	[2] Table 5-6 D-2.d.5 Max. Debris
52	**0.100**	0.07--0.16	Shrub/Scrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.	[2] Table 5-6 D-2.c.5
71	**0.035**	0.025--0.050	Grassland/Herbaceous - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.	[2] Table 5-6 D-2.a.2
81	**0.030**	0.025--0.050	Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.	[2] Table 5-6 D-2.a.1
82	**0.035**	0.025--0.050	Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.	[2] Table 5-6 D-2.b.2
90	**0.120**	0.045--0.15	Woody Wetlands - Areas Where forest or shrub land vegetation accounts for greater than 20 percent of r substrate is periodically saturated with or covered with water.	[2] Table 5-6 D-1.a.8
95	**0.070**	0.05--0.085	Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.	[2] Table 5-6 D-1.a.7

[1] 2011 National Land Cover Data Set (NLCD)

[2] Open-Channel Hydraulics, by Chow, Ven Te, 1959

[3] HEC-RAS River Analysis System 2D Modeling User's Manual, Version 5.0, February 2016, Figure 3-19

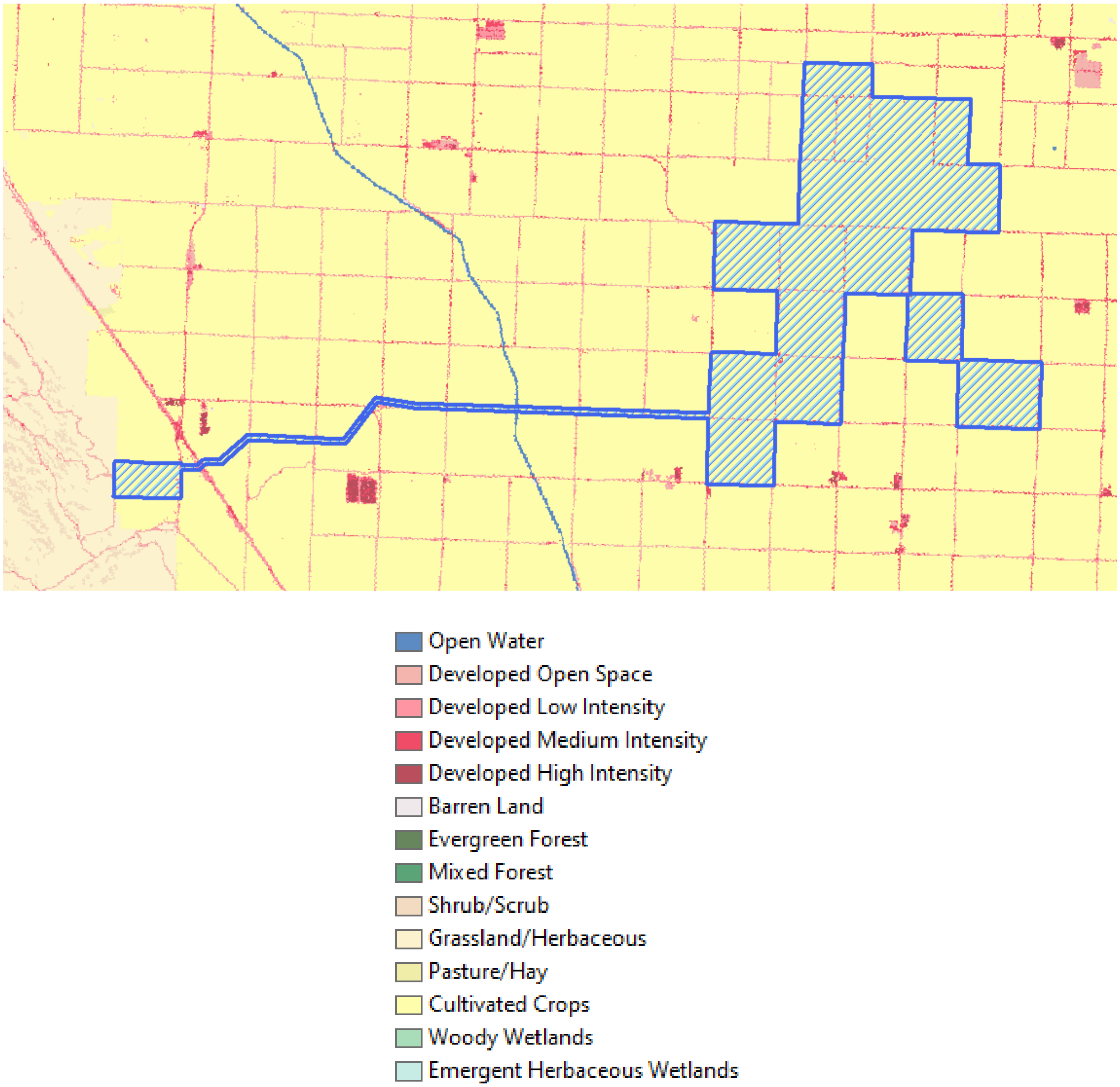

Figure 1-9 Land Cover Model for Darden Study Area (Source: NLCD, 2021)

1.8 Impervious Area

The Darden study area is located in undeveloped agricultural crop areas (See **Figure 1-12**) with virtually no impervious area. The only existing impervious areas within proximity to the study areas are paved highways, however most of the roadways that are not county or state-maintained road corridors, consist of dirt roads. To the South of Darden is Mt. Whitney Avenue a two-lane asphalt roadway which traverses the watershed on an east-west alignment, just south of the Darden study area boundary. Likewise, to the West, Interstate Highway 5 traverses the watershed on a north-south alignment. State Road 145 is to the East of the study area and is a 2-lane asphalt paved roadway on a north-south alignment. West David Road (See **Figures 1-10 & 1-11**) is a dirt road on an east-west alignment which enters the study area from the Eastern side. For the purpose of the hydrologic and 2D hydraulic model analysis, all low, medium, and high density-developed land cover types (including dirt roads) are assumed to be 100% impervious.

Figure 1-10 West David Road East of the Darden Study Area (Westbound)

Figure 1-11 West David Road East of the Darden Study Area (Eastbound)

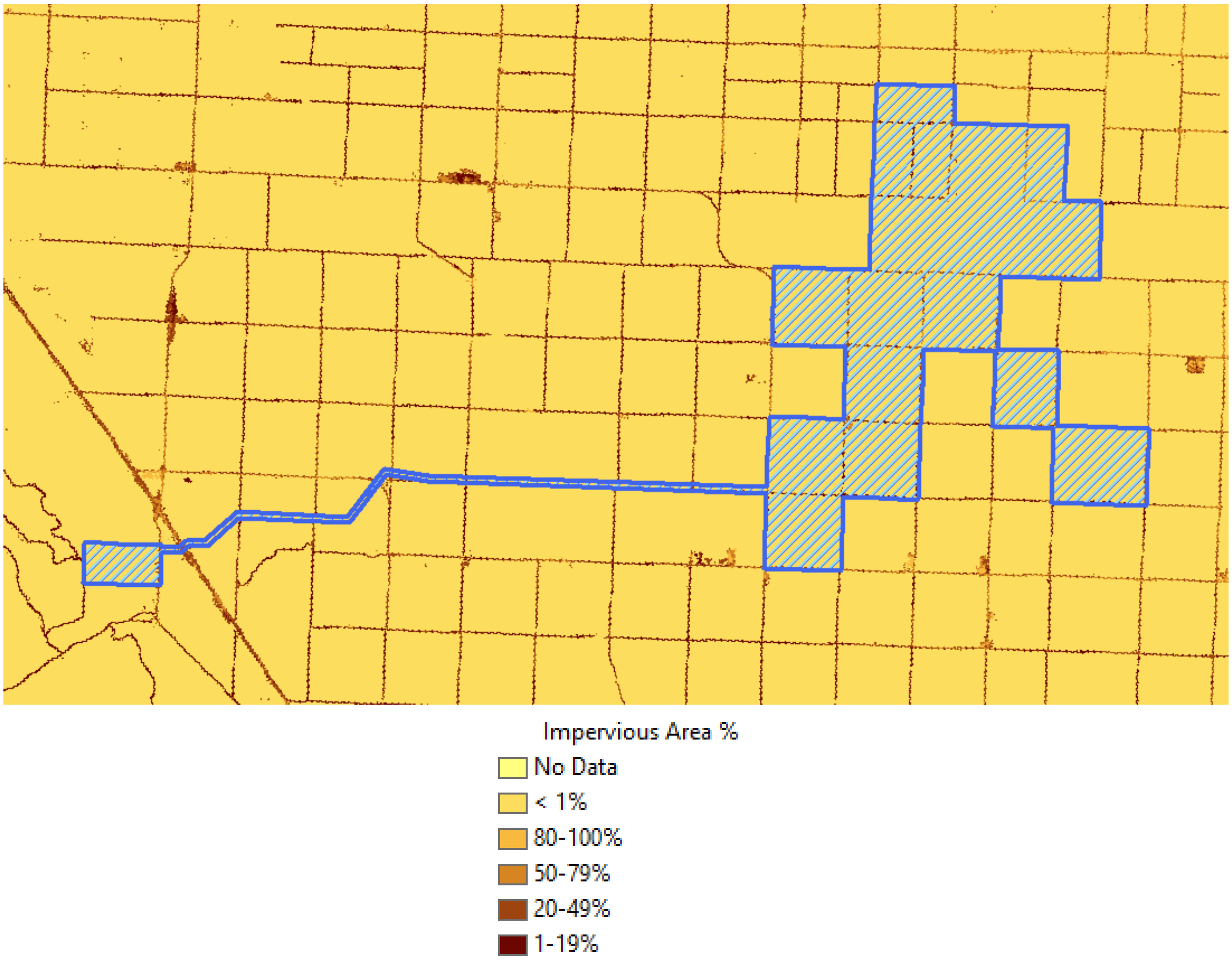

Figure 1-12 Darden Study Area Impervious Area Percent Classification

1.9 Soils

Hydrologic soils were obtained from gSSURGO and the National Landcover Database, respectively. Soils data including both Hydrologic Soil Group and Map Unit symbols, were available for the entirety of the study area the NRCS soil report is included in **Appendices B** for the study area. Any "unclassified" areas are assumed to be in hydrologic soil group D (poor infiltration). The dominant soil class for the Darden Study area is primarily soil group D, which are soils with a low rate of infiltration. The Hydrologic soil group raster data (See **Figure 1-13**) was coupled with impervious area percentages for the land cover types in order to characterize the infiltration of runoff within the model (See Infiltration). A Map Book with the Hydrologic Soil Group classification is included in the map package of the deliverable. **Table 1-10** identifies the soil names for each soil map unit within IP Darden.

HYDROLOGIC & HYDRAULIC 2D ANALYSIS

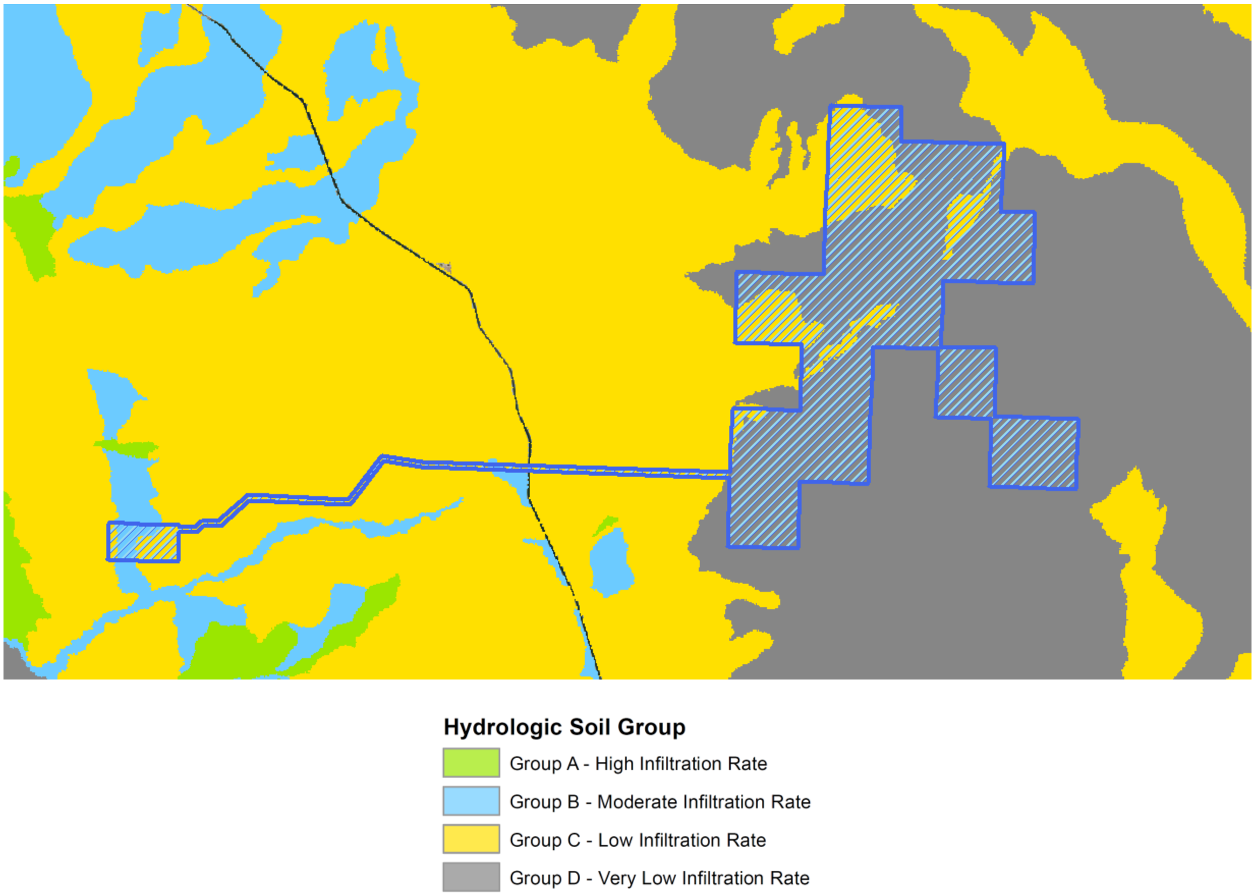

Figure 1-13 Darden Study Area Hydrologic Soil Groups

HYDROLOGIC & HYDRAULIC 2D ANALYSIS

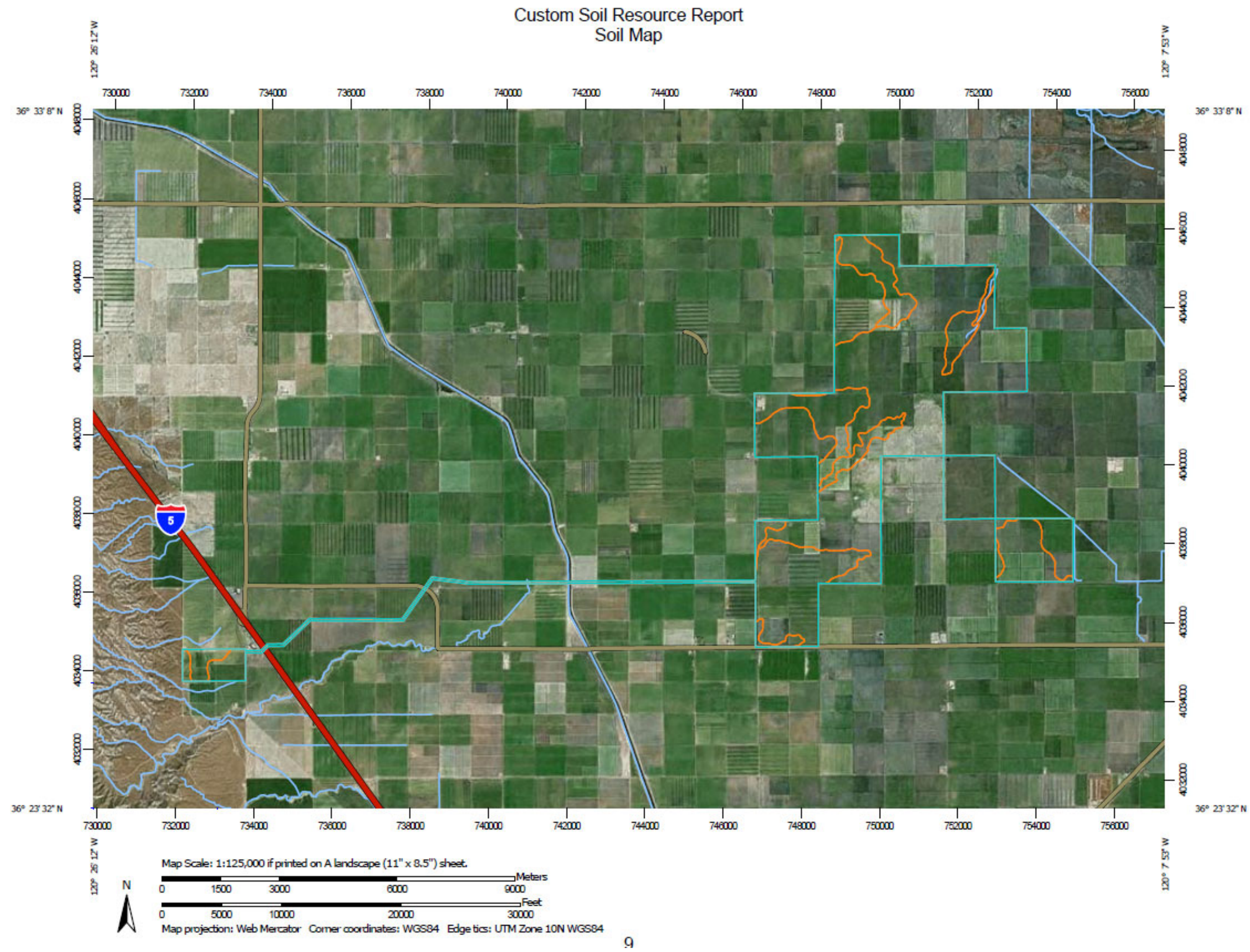

Figure 1-14 Darden Study Area Soil Map

Table 1-10 Darden Study Area – Soil Map Units

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
285	Tranquillity-Tranquillity, wet, complex, saline-sodic, 0 to 1 percent slopes	48.1	0.5%
286	Tranquillity clay, saline-sodic, wet, 0 to 1 percent slopes	5,491.0	53.5%
405	Polvadero-Guijarral complex, 5 to 15 percent slopes	38.6	0.4%
436	Panoche loam, 0 to 2 percent slopes	191.2	1.9%
437	Panoche sandy loam, 0 to 2 percent slopes	126.5	1.2%
442	Panoche clay loam, 0 to 2 percent slopes	45.8	0.4%
459	Ciervo clay, 0 to 2 percent slopes	664.8	6.5%
461	Ciervo clay, saline-sodic, wet, 0 to 1 percent slopes	70.9	0.7%
462	Ciervo, wet-Ciervo complex, saline-sodic, 0 to 1 percent slopes	2,231.0	21.7%
475	Posochanet clay loam, saline-sodic, wet, 0 to 1 percent slopes	421.8	4.1%
478	Cerini sandy loam, 0 to 2 percent slopes, MLRA 17	6.4	0.1%
479	Cerini clay loam, 0 to 2 percent slopes	10.7	0.1%
482	Calflax clay loam, saline-sodic, wet, 0 to 1 percent slopes, MLRA 17	907.6	8.8%
960	Excelsior, sandy substratum-westhaven association, flooded, 0 to 2 percent slopes	5.9	0.1%
982	Water	0.9	0.0%
Totals for Area of Interest		**10,262.1**	**100.0%**

1.10 Infiltration

The selected infiltration method for the hydrologic model is the NRCS SCS Curve Number method. This method was implemented in HEC-RAS 6.4.1 by generating an infiltration layer through intersection of the Land Cover layer with the Soils layer. SCS Curve Numbers were taken from the literature and reflect the latest updates in Curve Number estimation. Curve Numbers were specified for each Hydrologic Soil Group given the NLCD Land Cover type. The infiltration layer in the model takes into consideration surface losses from a precipitation event in the 2D hydraulic computations. **Table 1-11** provides Curve Numbers applied in this analysis.

Table 1-11 SCS Curve Numbers for Darden Study Area by HSG Soil Group

SCS CURVE NUMBERS FOR EXCESS RUNOFF AND INFILTRATION					
NLCD ID	**NLCD Land Cover**	**A**	**B**	**C**	**D**
11	Open Water	100	100	100	100
21	Developed, Open Space	52	68	78	84
22	Developed, Low Intensity	81	88	90	93
23	Developed, Medium Intensity	84	89	93	94
24	Developed, High Intensity	88	92	93	94
31	Barren Land (Rock/Sand/Clay)	70	81	88	92
41	Deciduous Forest	30	55	70	77
42	Evergreen Forest	30	55	70	77
43	Mixed Forest	30	55	70	77
52	Shrub/Scrub	63	77	85	88
71	Grassland/Herbaceous	30	63	75	85
81	Pasture/Hay	40	61	73	79
82	Cultivated Crops	62	74	82	86
90	Woody Wetlands	86	86	86	86
95	Emergent Herbaceous Wetlands	80	80	80	80

1.11 Wetlands

Wetlands were absent from the study area based on NLCD land cover data, as well as the National Wetlands Inventory data layer and visual observation of the aerial imagery.

1.12 Existing Regulatory Effective FEMA Floodplains

Portions of the study area have been mapped by FEMA, and there are currently regulatory floodplains in some portions of the study area. Floodzone "A" was identified as the predominant floodzone type. Floodzone A are areas with a 1% annual chance of flooding, but for which no detailed analyses have been performed by FEMA, and as such no depths or base flood elevations will be shown on digital flood maps provided by FEMA in Zone A floodzones which are delineated using "approximate methods". FEMA typically uses a 1-Dimensional analysis in the development of regulatory base flood maps, thus the means and methods used to derive the regulatory base flood both in terms of hydrologic methods and hydraulic methods will be substantially different from those used in a 2-Dimensional rain-on-grid analysis. Consequently, a 2D analysis may produce a floodplain delineation that is not similar to those developed using a 1D analysis, or other "approximate methods" such as those which might be employed by FEMA in the delineation of a Zone "A" floodzone. A 2D floodplain delineation has a high sensitivity to the quality of the topographic data used as an input into the model. The presence of regulatory floodplains with the study area should be considered in the event portions of the study area are sought to be developed, due to existing floodplain regulations that may exist within the relevant jurisdiction which may prevent development in the regulatory floodplain, or which might require reviews or additional permit approvals from the Fresno County floodplain administrator.

A conditional letter of map revision is *typically* required when development occurs within regulatory floodzones, with some exceptions. With regard specifically to Zone A (or approximate) floodzones (or Zones A1-A30), with no stated base flood elevations shown on the flood insurance rate map, the local floodplain administrator has the option of requesting a CLOMR review by FEMA if (1) the local jurisdiction's floodplain ordinance requires it, or (2) where no local ordinance exists, if the proposed project would increase the BFE (if a BFE is stated) by more than 1 foot at any point in the vicinity of the proposed project.

Section 2 Darden 2D Hydraulic Model

2.1 2D Hydraulic Model

A 2-Dimensional hydraulic analysis was performed in HEC-RAS Version 6.4.1, by generating a 2D mesh from the composite Digital Elevation Model (DEM) raster image, coupled with a land cover layer characterizing the manning's n surface roughness coefficients, the impervious area percentages for given land cover types, and the soils layer with HSG defined by the gSSURGO database. The model then generates an intersection of the Land Cover with the soils to compute infiltration losses. The model had an approximate 43 hour run time due to the large acreages involved.

2.2 Watershed Size and 2D Mesh Cell Size

The Darden Study Area is approximately 10,262 acres total. The total contributing watershed size for Darden is 327,146 Acres. The 2D mesh cell size used to generate mesh is 100 ft x 100 ft for areas outside the study area boundary limits. This value is appropriate for a desktop analysis. Reasonable cell size for a watershed of this size is between 100 to 300 ft. For the Darden study area within the study area boundary limit, the resolution of the 2D Mesh cell size was refined (See *refinement regions*) to 25 ft x 25 ft cells, to reflect the higher resolution of Aerial LiDAR 2-ft terrain data, and the NextMap 5m terrain data used for the study areas in the composite Digital Terrain Model. The 2D Mesh area generated resulted in a mesh of approximately 2.14 million cells.

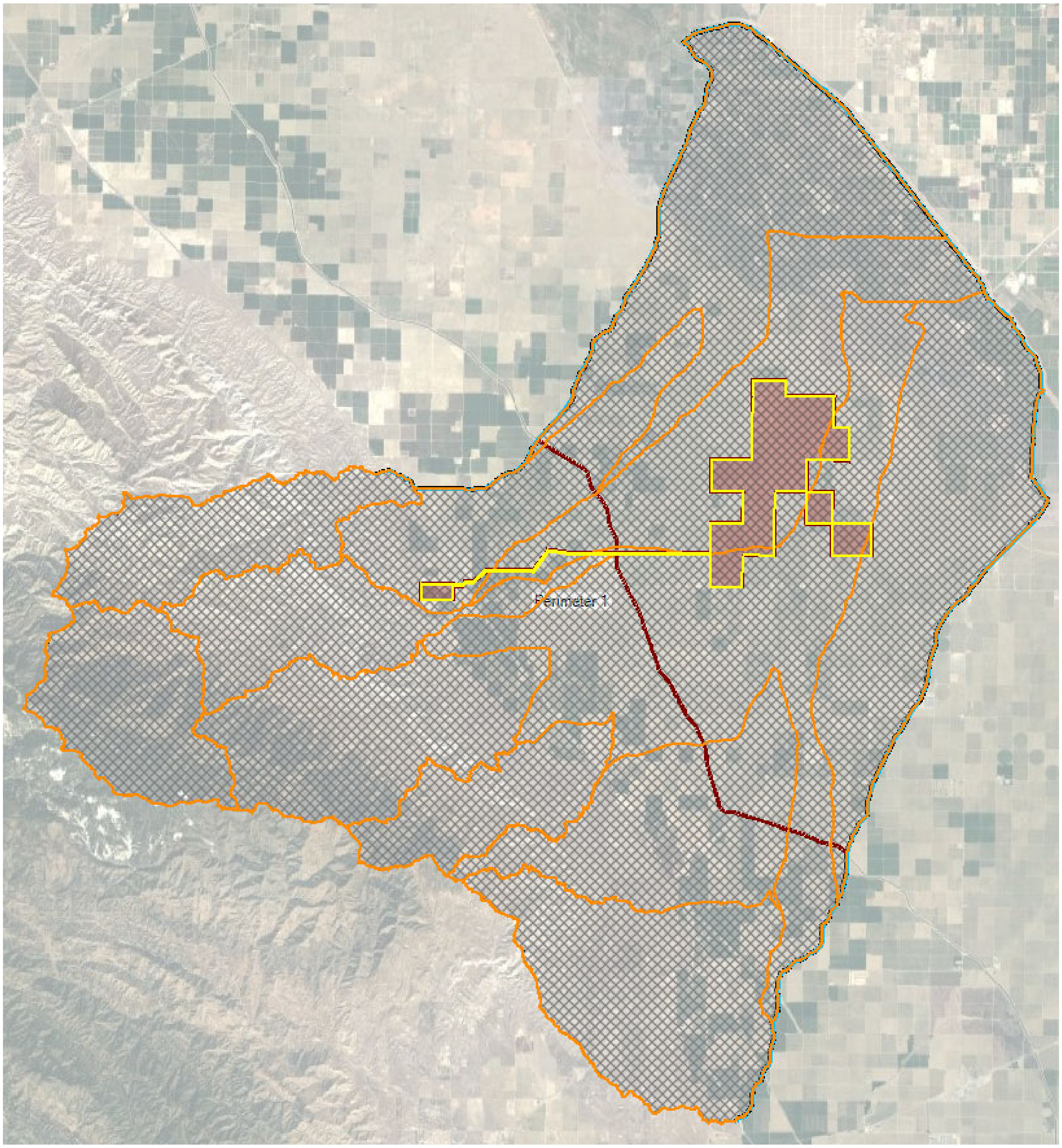

Figure 2-1 2D Mesh for Darden Study Area

2.3 2D Refinement Regions

For this analysis, Aerial 2-ft LiDAR and NextMap 5m Digital Terrain Model raster data was acquired. The Aerial LiDAR and NextMap 5m data was merged with the USGS 10m (1/3 arc second) DEM bare earth terrain models into a composite terrain model. Since the areas within the limits of the study areas have a higher resolution terrain than the areas outside the study limits, refinement regions in the 2D mesh were created with a smaller mesh cell size (25 ft x 25 ft) to reflect the higher resolution terrain within the study area limits.

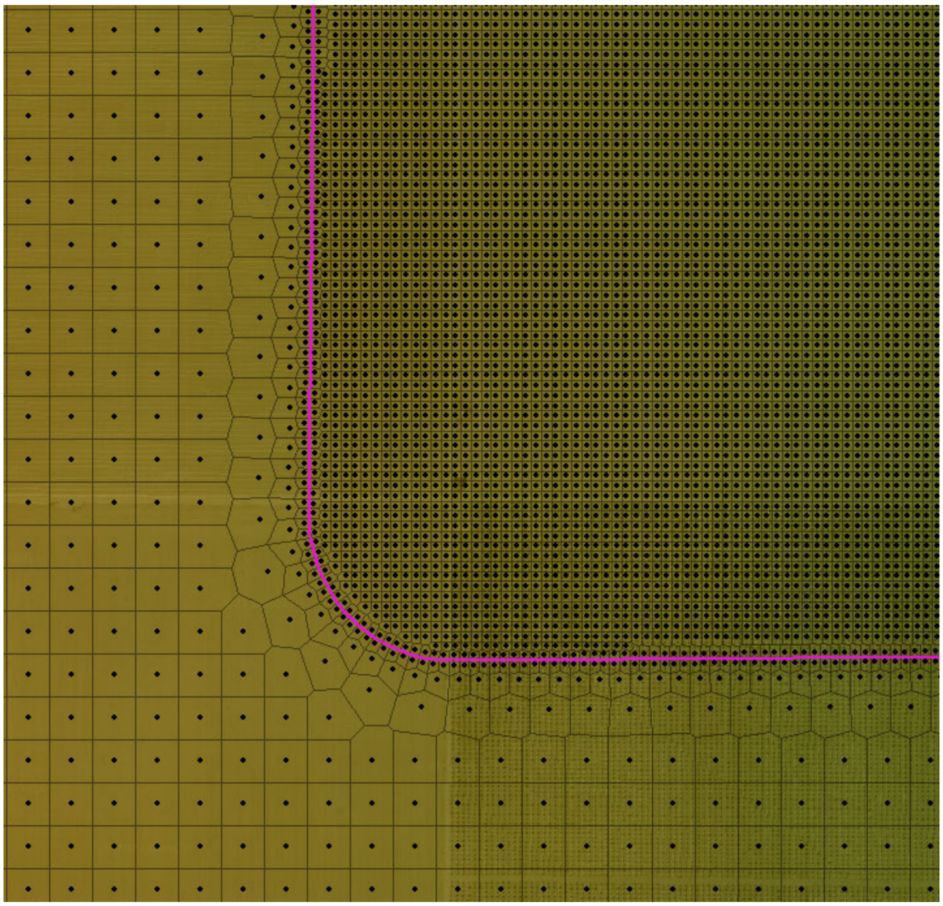

Figure 2-2 2D Mesh Refinement Region Within Study Area Limits

2.4 Boundary Conditions

Due to the hydrologic character of the subwatersheds, and a lack of existing defined hydrologic features the hydrology flow data was modeled using a single storage/2D Flow Area taken as the subwatershed boundary, which was selected as the 2D flow area, with a direct precipitation boundary condition (or Rain-on-Mesh). The direct precipitation boundary condition was populated with the 100-YR and 500-YR event rainfall hyetographs values for a 24-hour duration using plan files. An unsteady flow data file was then generated as an input for the 2D analysis in HEC-RAS.

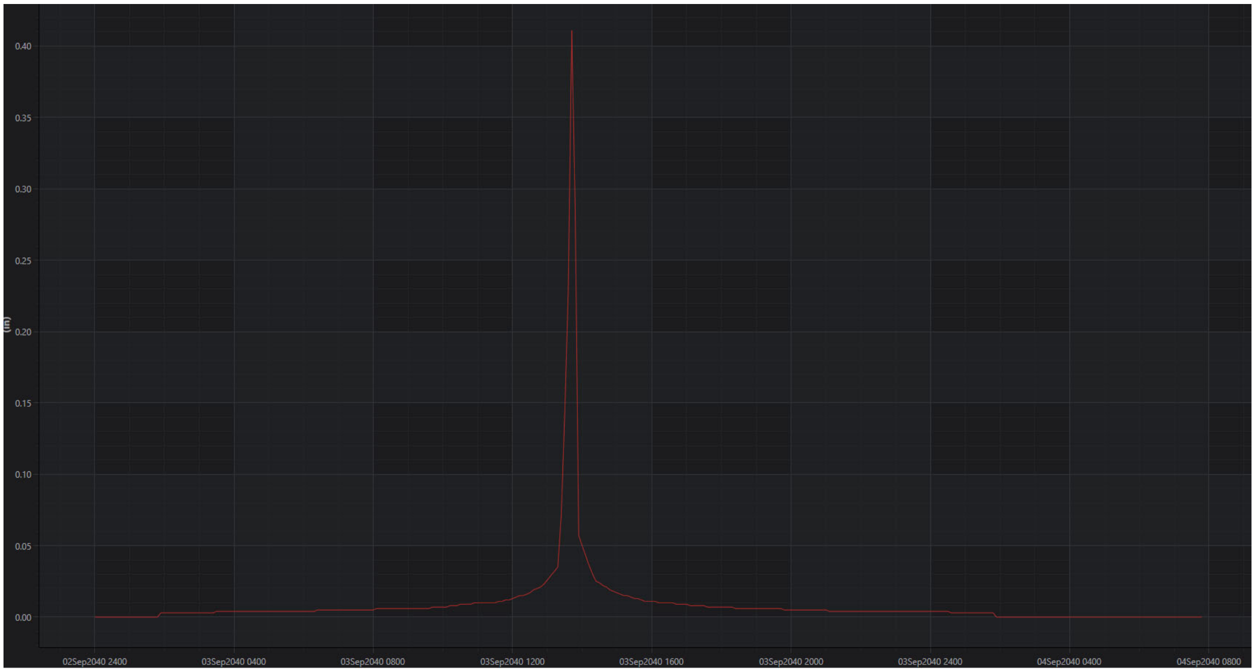

Figure 2-3 Unsteady Flow Data for the Direct Precipitation (Rain-on-Mesh) Boundary Condition

2.5 Time Step and 2D Flow Settings

The time step was controlled by a fixed time step. A fixed time step of 10 seconds was used with an output interval of 6 minutes. The full Saint-Venant equations were used in the computations using the shallow water equation (SWE-ELM) set. Water Surface Tolerance 0.01, Volume Tolerance 0.01. The model run time was approximately 43 hours at this setting.

2.6 2D Flow Area Characteristics

The hydraulic characteristics of the study area are cultivated crop lands with some depressional storage in localized areas. Any excess runoff concentrates in shallow pools at low points in the terrain. Pooling of excess runoff is common near the roadway due to the runoff from the impervious paved asphalt roads, however many of the local roads in the study area are dirt roads. The topography is more or less consistently flat with a predominant slope of 0 to 2.5%. Excess runoff is distributed or dispersed into shallow sheet flow as it traverses the surface at low velocity of less than 1 fps. The runoff eventually reaches the lowest area of elevation and begins to collect into conveyances such as ditches or rills.

2.7 Depth of Flow within Floodplain for Darden Study Area

The characteristics of the terrain coupled with the low rainfall volume produced in this area of the Southwestern US, produces a floodplain that is dispersed and not particularly well defined, except in those areas where runoff begins to pool at low elevation. The 100-year rainfall for this area is determined by Atlas 14 to be 2.99 (3) inches, which is very low. The flat and gentle sloping of the topography at the foot of the mountainous area to the west distributes the rainfall uniformly across the watershed area into very shallow sheet flows. The maximum depth of the floodplain, where the water does not pool, is for the most part between 0 and 0.70 feet for the 100-year event (or 0 and 1.2 ft for the 500-year event), with most flood depths shown by the model to be less than 0.5 ft for the 100-year event (or 0.8 ft for the 500-year event) for the vast majority of the Darden Study Area. Water begins to pool at lower elevations towards the easterly side of the study area. Man-made grade breaks in the form of agricultural water supply ditches and roads border the agricultural areas on all sides of the Study Area. The ditch systems are primarily for irrigation purposes, including the California Aqueduct which is well off to the West of the Study area which is operated by the State of California. The San Luis Canal is a man-made canal lined with concrete on both sides. The canal traverses the subwatershed area to the southwest of the Study Area and does not contribute any runoff discharges into the subwatershed. The canal is on north-south alignment.

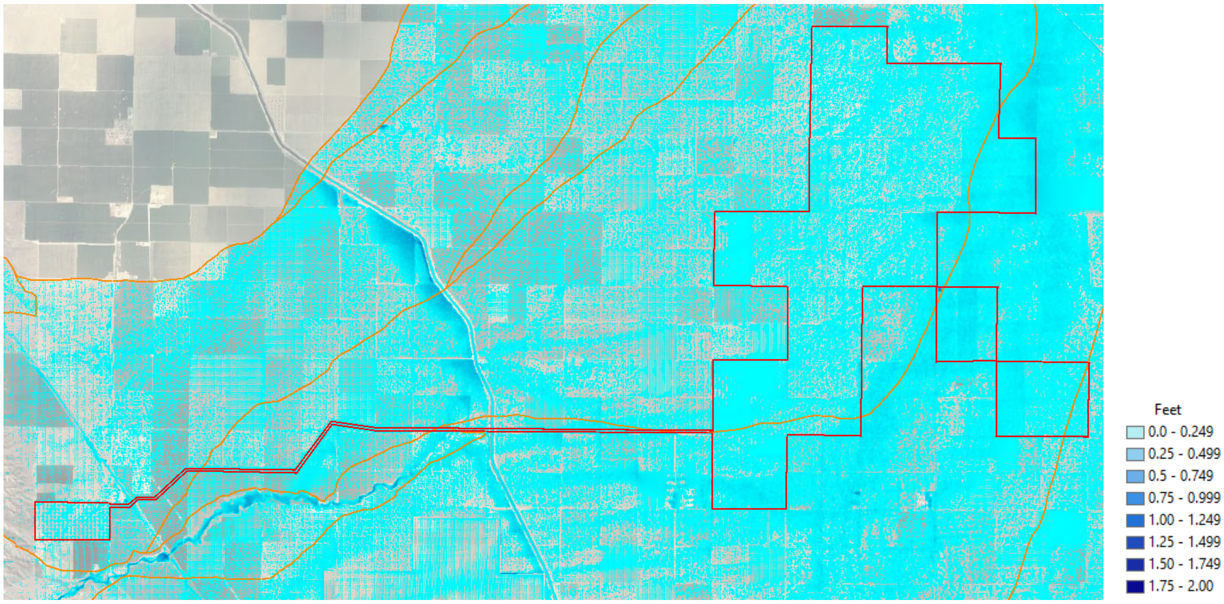

Figure 2-4 100-Yr/24-Hour Max Floodplain Depth for Darden Study Area

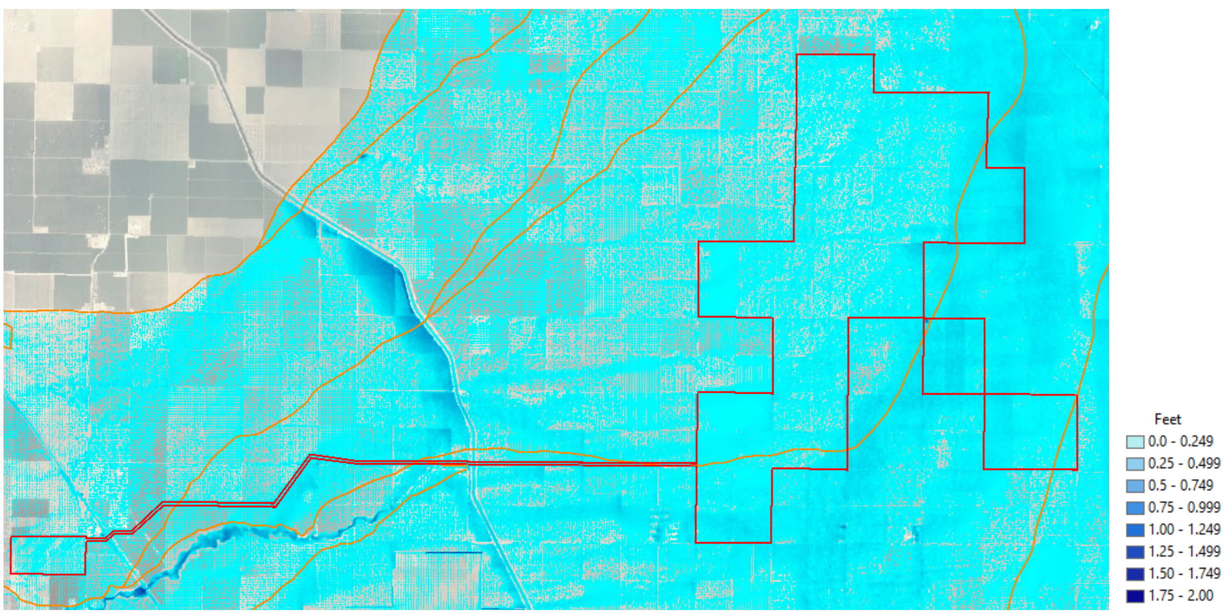

Figure 2-5 500-Yr/24-Hour Max Floodplain Depth for Darden Study Area

The areas of study most affected by the flood inundation from the 100-year and 500-year flood were shown to be those areas at the lowest elevations within the Terrain model which is consistent with the grades indicated by the DEM. *Given the limited extents, shallow depth and undefined character of the computed flood inundation boundaries, the desktop analysis indicates that the Darden study areas have a low flood risk profile, when considering that the rainfall events modeled including the 100-Yr/24-Hr (1%*

annual chance) storm event, 500-Yr/24-Hr (0.2% annual chance) storm event, and given the resultant max depths indicated by the model.

Within the locale of the substation area to the west of the main Darden study area, and West of I-5 (See **Figure 1-1**) the results are in many similar in many respects to the main Darden study area in that the terrain and soil characteristics produce a floodplain that is dispersed and not particularly well defined, except in those areas where runoff begins to pool at low elevation. The terrain is flat and gentle sloping at the foot of the mountains. As the concentrated flow from the mountains reaches the level terrain at the foot of the hills, the runoff is distributed uniformly across the subwatershed area into very shallow sheet flows. The maximum depth of the floodplain, where the water does not pool, is for the most part between 0 and 0.70 feet, with most flood depths shown by the model to be less than 0.5 ft for the vast majority of the Darden Study Area. Man-made grade breaks in the form of agricultural water supply ditches and roads border the agricultural areas on all sides of the substation parcel which is composed of a crop of trees, presumably oranges. The ditch systems are primarily for irrigation purposes, including the California Aqueduct which is to the East of the future facility parcel, and is operated by the State of California.

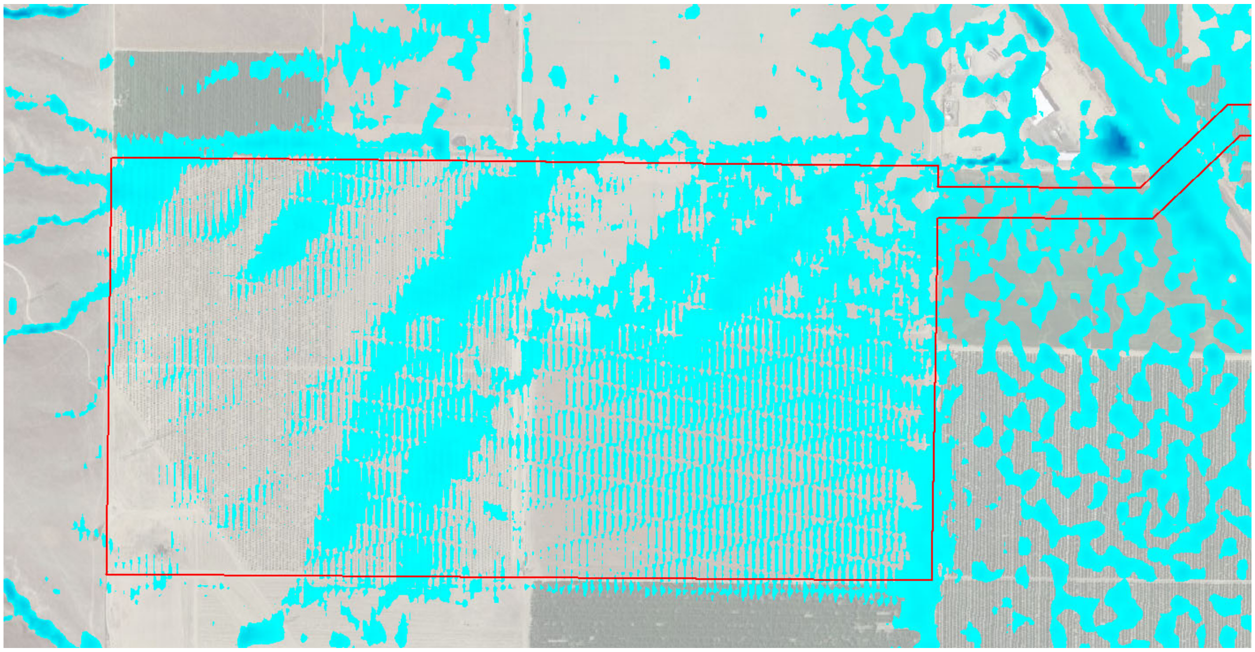

Figure 2-6 100-YR/24-HR Max Floodplain Depth at Proposed Substation Location

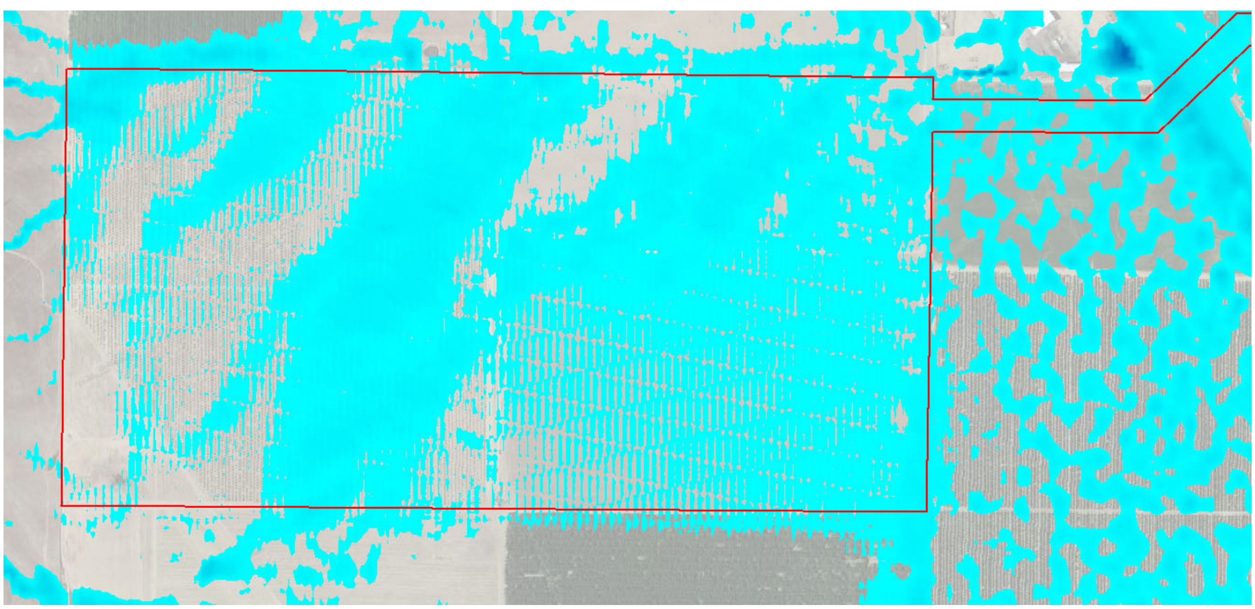

Figure 2-7 500-YR/24-HR Max Floodplain Depth at Proposed Substation Location

2.8 Velocity of Flow within Floodplain for Darden Study Area

In general velocities within the floodplain were shown to be within 0 to 1 ft per second (100-year) and 1 to 1.5 ft per second (500-year). In some isolated areas the velocity may reach 2 ft per second (100-

year) and 3.5 ft per second or greater (500-year), however, these velocities would brief, as the flow velocity would drop significantly following the peak of the response. The flat nature of the Darden main study area effectively distributes the flow into low velocity distributed "sheet" flow.

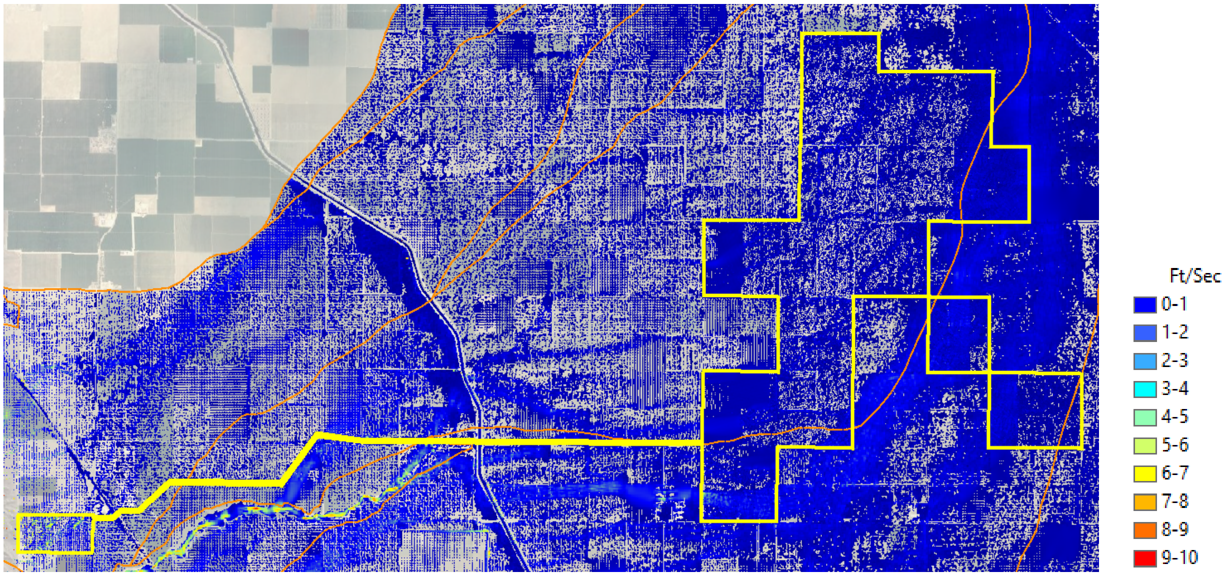

Figure 2-8 100-Yr/24-Hour Max Floodplain Velocity for Darden Study Area

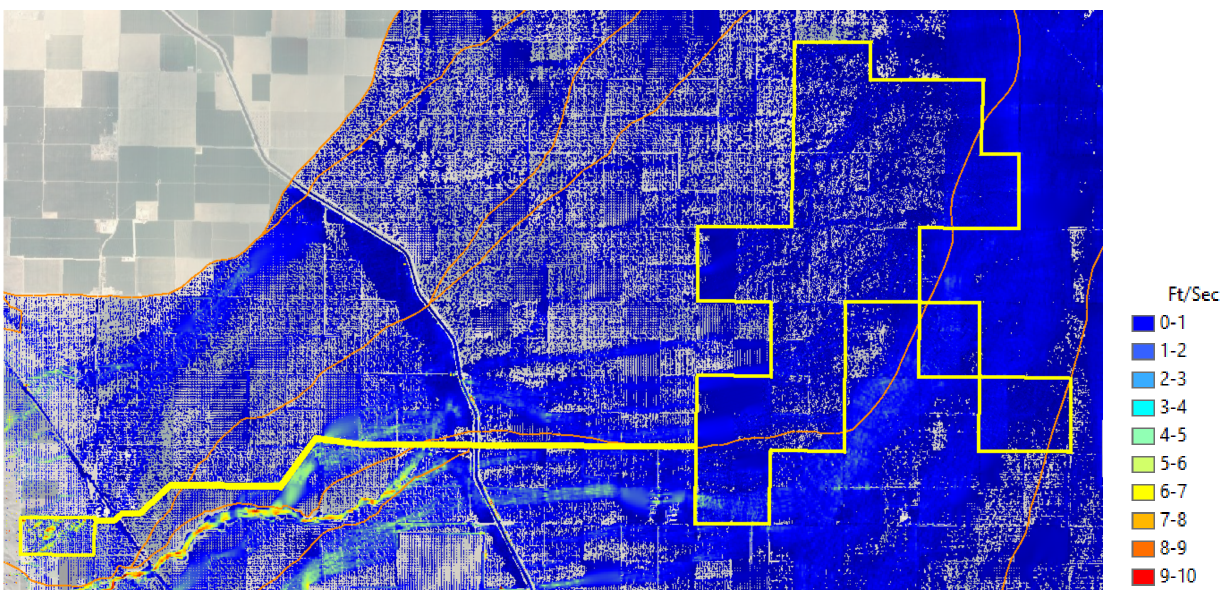

Figure 2-9 500-Yr/24-Hour Max Floodplain Velocity for Darden Study Area

The velocities within the floodplain at the substation parcel were also shown to be within 0 to 1 ft per second (100-year) and 2 to 3 ft per second (500-year) on the majority of the parcel, with some areas indicating 4-6 ft per second in the case of the 500-year (0.2% annual chance). Overall, the velocities are still on the lower end and even in the case of the higher values, these velocities would very brief in duration, as the flow velocity would drop significantly following the peak of the runoff response to close to 1 fps or less. The flat nature of the study areas effectively distributes the flow into low velocity distributed sheet flow.

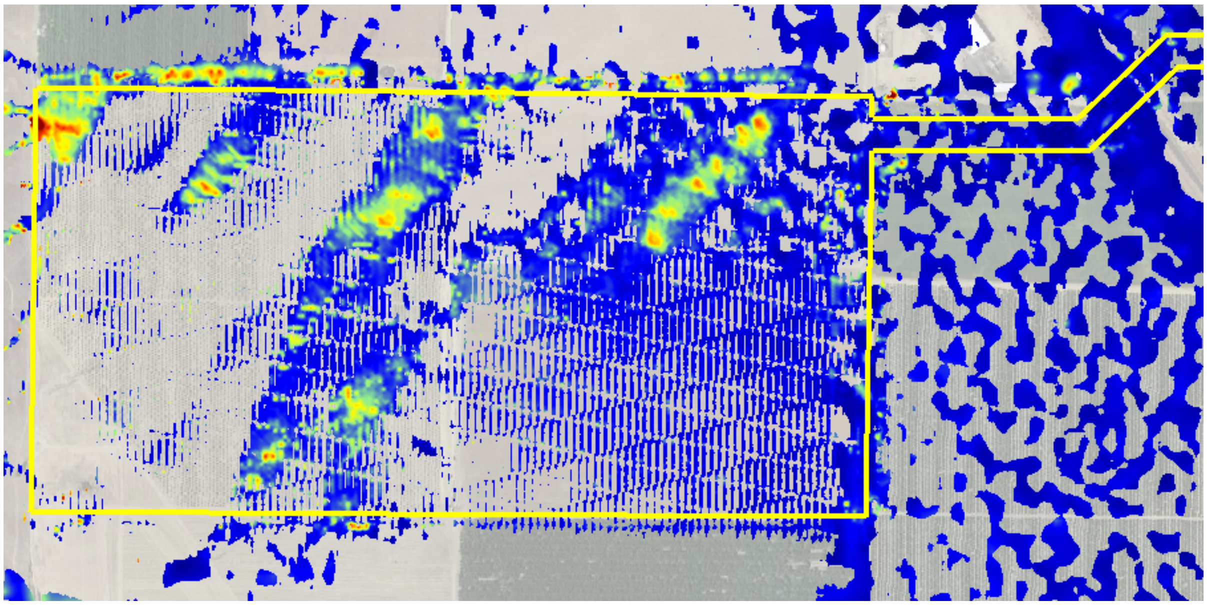

Figure 2-10 100-YR/24-HR Max Floodplain Velocity at Proposed Substation Location

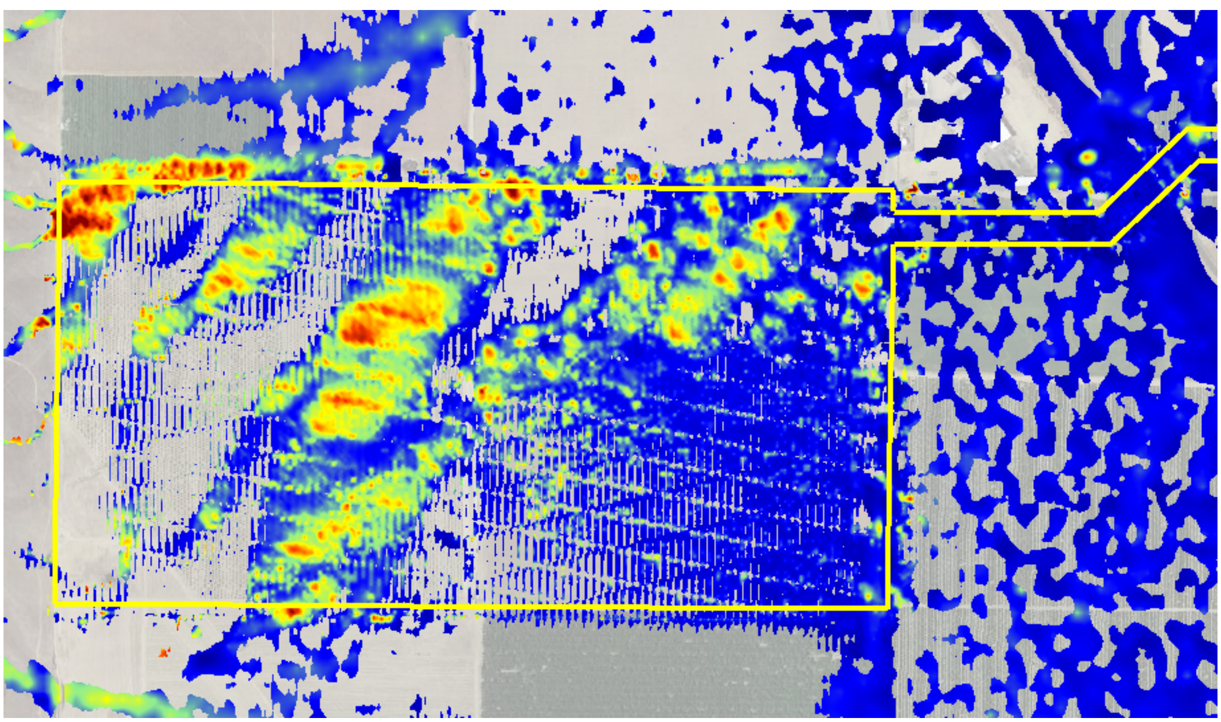

Figure 2-11 500-YR/24-HR Max Floodplain Velocity at Proposed Substation Location

2.9 Discussion of Results

The Darden study area generally has a low maximum floodplain inundation depth of 0.7 ft or less, with velocities of 2 fps or less for the 100-Year event, and an inundation depth of 1.5 ft or less, with velocities of 2-3 fps or less for the 500-Year event. Consequently, the Darden Study area *has a low flood risk* which is consistent with the hydrologic characteristics, including Group C/D soils (low infiltration), low annual rainfall (12.8 inches +/-), and relatively low 100-YR/24-Hr point rainfall volume of 2.99 inches, or 3.87 inches for the 500-YR/24-Hr point rainfall volume (NOAA Atlas 14).

The results shown by the model are in line with expectations given the dry and mostly flat topography of the study area. Due to the flat nature of the terrain in the vicinity of the study areas, and the relatively low rainfall for the 100-year storm event (and 500-year event), a more detailed analysis would likely not yield results that would produce a significantly different output. However, for the purposes of a desktop analysis, these results appear to show a reasonable output based on terrain and climate, the data sets utilized, the quality of the digital elevation model and the underlying assumptions used in the hydrologic and hydraulic models.