Hydrologic Analysis-Babu Vineyard Block C
3300 White Sulphur Springs Road
St. Helena, Napa County, California
APN 027-010-033

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Introduction

A hydrologic analysis was performed with the TR-55 model to assess potential Project impacts on storm runoff in an unnamed tributary of the Sulphur Creek watershed. The project site is located within the northwest portion of the watershed about two miles west of the town of St Helena in Napa County (Figure 1). The Project is the proposed Babu Vineyard Block C which consists of the conversion of approximately 0.42 gross acres (0.24 net acres) to vineyard within a parcel of about 67 acres. Approximately 2.05 acres of vineyard exist on the project parcel. Vineyard Block A (1.43 acres gross, 1.14 acres net) is adjacent to the existing paved access road and existing vineyard on the westernmost portion of the parcel. Vineyard Block B (0.62 acres gross, 0.45 acres net) is adjacent to the existing paved access road and is about 200 ft east of Block A. Proposed vineyard Block C is located just off of the road. on a ridge south of Block B.

This hydrologic analysis documents compliance with County of Napa General Plan Conservation Element Policy CON-50(c) states that: "[T]he County shall require discretionary projects to meet performance standards designed to ensure peak runoff in 2-, 10-, 50-, and 100-year events following development is not greater than predevelopment conditions." O'Connor Environmental, Inc. (OEI) has developed a drainage plan to mitigate potential increases in runoff from the site. The drainage plan was developed in coordination with erosion mitigation measures embodied in the Erosion Control Plan (ECP) and described in "Erosion Analysis-Babu Vineyard Block C".

TR-55 is a U.S. Department of Agriculture hydrologic model commonly used in Napa County to estimate storm runoff in terms of peak runoff rates and total runoff volume. The model simulates hydrographs for small basins using unit hydrograph theory and routing procedures that depend on runoff travel time through segments of the watershed (USDA, 1986). This analysis was performed using the GIS interface in the Watershed Modeling System (WMS 10.0) software developed by Aquaveo. Various parameters are required as inputs for the development of the model including rainfall, soil hydrologic groups, and ground cover types along with stream/ditch characteristics and dimensions.

For this project, it was necessary to include runoff attenuation in the drainage plan to prevent increases in total runoff volume and peak runoff rates from the Project site for the 2-, 10-, 50- and 100-year design storms. Changes in peak flow for the Project site were predicted using the TR-55 analysis. The effect of proposed attenuation basins was evaluated using WMS 10.0 software to model storage and release of runoff.

Site Conditions

The Project site is in western Napa County in the upper reaches of Sulphur Creek within the Heath Canyon planning watershed (Figure 1). The project parcel drains into Sulphur Creek which reaches its confluence with the Napa River about 5.5 miles downstream.

The Project site is located on gently to moderately sloping terrain and is comprised of a mixture of mostly divergent and planar slopes. In the fall of 2020 the Glass fire burned through the project area destroying most vegetation and ground cover. Since then, salvage logging of dead trees has been conducted further altering ground cover conditions. Although currently ground cover is very sparse due to the recent fire and subsequent clean up activities, per Napa County PBES recommendations our erosion analysis has modeled existing conditions with pre-fire cover. Existing conditions vegetation canopy cover in the proposed working area of the project parcel was determined from review of aerial photography combined

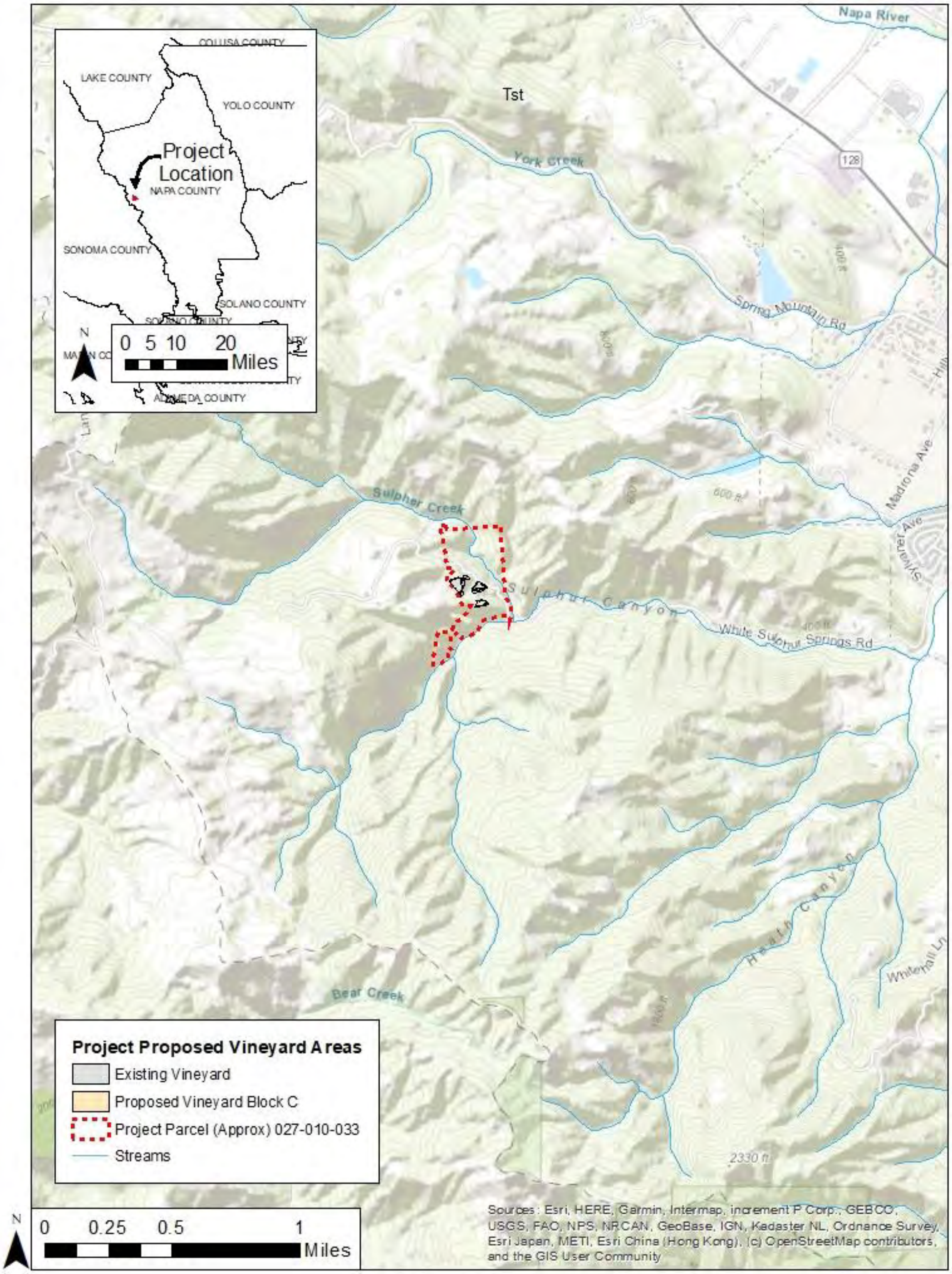

Figure 1 Site location map

with field observations. Within proposed vineyard Block C the dominant vegetation type prior to the Glass Fire was mixed conifer and hardwood forest. Web Soil Survey (USDA) data for the project site indicate Boomer-Forward-Felta complex (111) in the western portion and Felton Gravelly loam (136) in the eastern portion of the Project area (Figure 3).

Approach to Analysis

The objective of this analysis is to evaluate potential Project effects on peak runoff rates and runoff volume from rainstorms. The hydrologic model of the site under existing conditions is used to establish the baseline hydrologic conditions. Post-Project peak runoff is simulated by modifying the hydrologic model to represent proposed changes to drainage patterns by the addition of diversion ditches, piping, and an attenuation basin (Figure 2; see also the ECP), and changes in land cover (vegetation). All surface runoff from the project site is simulated, and runoff leaving the project site is quantified along the project boundary. Comparison of peak flow leaving the project site is accomplished by summing all resultant sub-basin hydrographs to create one composite hydrograph representing runoff at the Project boundary for existing conditions and one for proposed conditions. This approach allows for analysis of runoff at the project scale.

Modeling

The USDA model TR-55 is the primary hydrologic model used. It requires inputs to describe rainfall for design storms, topographic definition of Drainage Basins, and descriptions of vegetative cover and soils to determine runoff characteristics.

Rainfall

Rainfall distributions for 24-hour rainstorms in the northwestern coastal United State are classified as Type IA (USDA, 1986). Rainfall Type IA rainfall intensity represents a typical Mediterranean climate with dry summers and wet winters. Rainfall events of 24-hour duration were simulated with the model for the 2, 10, 50 and 100-year recurrence interval storms. Rainfall depths (Table 1) were determined from queries of the NOAA Atlas 14 Volume 6 Version 2 (NOAA, 2011).

Table 1: Rainfall depths for typical recurrence interval storms at the project site.

Recurrence Interval Storm (24-hour Duration)	Precipitation Depth (inches)
2 year	4.41
10 year	6.22
50 year	8.14
100 year	8.98

Project Watersheds

Figure 2 displays the project watersheds analyzed under existing pre-project conditions and proposed project conditions along with the proposed vineyard footprint and flow paths analyzed with TR-55.

Figure 2 Project watersheds for existing conditions (top) and proposed Project conditions (bottom).

An Erosion Control Plan (ECP) has been developed to provide information required for project review by County on Napa. The ECP proposes modifications of drainage patterns on the Project site to collect runoff in an attenuation basin in Block C to prevent increases in peak runoff rates. To mitigate potential surface erosion in the vineyard block, along-contour diversion ditches are proposed; the effects of these ditches are incorporated in the TR-55 analysis of post-Project conditions.

Pre-Project watershed areas were initially defined based on a topographic analysis in the WMS software of a 1 m square grid LiDAR-based digital elevation model (DEM) from 2020 LACO topographic survey data. Adjustments were made to the project site boundaries based on topographic surveys performed by OEI and on field observations of the site in spring 2021. For pre-Project baseline conditions, two project watersheds were defined. Drainage patterns at the site are controlled by White Sulphur Springs Road which diverts flows in a inboard ditch away from proposed Vineyard Block C (Figure 2). Consequently, the proposed vineyard block is isolated from upstream drainage areas. TR-55 modeling is therefore confined to the area in between the up-slope outside edge of the road and the down-slope perimeter of the proposed vineyard block.

Two pre-Project watershed areas were defined (Figure 2) with contributing areas of 0.05 acres in Watershed 1 and 0.42 acres in Watershed 2. All watersheds are bounded on the downhill edge by the proposed vineyard/Project boundary; flows crossing these boundaries are all assumed to be sheet flow or shallow concentrated flow.

Post-Project watersheds were defined by modifying the pre-Project watersheds to reflect the changes in flow paths proposed in the ECP (Figure 2). A new watershed was created in the model where runoff would be delivered to a drainage ditch or pipe inlet for the post-Project analysis. The two watersheds created for the pre-Project baseline condition were sub-divided resulting in a total of 10 watersheds (Figure 2). The watershed areas range from 0.01 to 0.11 acres. The post-Project watershed total area is identical to that of the pre-Project area, which allows for direct pre- and post-Project comparison. Under proposed Project conditions, drainage patterns were modified in some areas as described below to mitigate potential increases in surface erosion and runoff per County of Napa permit requirements.

Attenuation Basin 2 (Figure 2) will collect flows from approximately 93% of the watershed drainage area of vineyard Block C Diversion ditches within the block will collect flows from sub-watersheds 1a, 1b, 2a, 2b, 2c, 2d and route them into rock lined ditches located along the northern and southern vineyard edges. The rock lined ditches will collect flows from the diversion ditches and route them into pipes via drop inlets and then to Attenuation Basin 2. Flows from sub-watershed 1c will be collected in the northern rock lined ditch and routed to the Attenuation Basin via the drop inlet and pipe. Diversion ditches will route runoff from sub-watershed 2e to Attenuation Basin 2 via ditch inverts at grade with the up-hill edge of the Attenuation Basin. Flow from Attenuation Basin 2 will be routed to a level flow spreader located to the north on the forested slope adjacent to the proposed vineyard perimeter (See ECP, Sheet 2). Uncollected flows from sub-watershed 2f which includes the outer edges of Attenuation Basin 2 will drain across the vineyard perimeter as sheet flow.

Runoff

Curve Number Assignment

The critical model parameter in TR-55 is the Runoff Curve Number (CN) assigned to each land use/cover type. CN's are dependent on land cover types and the hydrologic soil groups found in the area and are used in the calculations of runoff. Land cover is typically a vegetation type, but can include developed areas with roads and buildings. Area-weighted composite CN's for each watershed were calculated by the WMS software using the distribution of the land use and soils coverages within each simulated watershed.

Two land cover types were used for current conditions and three were used for proposed conditions to help determine the composite curve numbers for each simulated watershed. Land cover maps made for the project area were created from a combination of interpretation of 2007 Napa County digital ortho-photos (Figure 3) using ESRI's ArcGIS and field mapping. Land cover types found within the project drainage basins are summarized in Table 2.

Tables 2-2 a-d in the TR-55 guidance manual provide runoff curve numbers for varying types of land uses (USDA, 1986). Additional values were used from Exhibit 2.1-3 "Runoff Curve Numbers For Hydrologic Soil-Cover Complexes" (NRCS, 2008). Land cover types were selected specifically from Table 2-2a "Runoff curve numbers for urban areas", Table 2-2b "Runoff curve numbers for cultivated agricultural lands" and Table 2-2c "Runoff curve numbers for other agricultural lands". The undeveloped land cover type used was selected from Table 2-2c. This was "Forest" with "good" hydrologic conditions ("good" conditions assume average and better than average infiltration and tend to decrease runoff).

As specified in the ECP project narrative, permanent erosion control measures require that a permanent cover crop shall be seeded and only mowed with no use of herbicide spray. Tilling will only occur to replant cover crop if self-reseeding ceases. These limitations on vineyard management will provide 85% ground cover. To simulate the proposed no-till permanent 85% cover with no spray land use the "Annual grass" cover type was chosen from Exhibit 2.1-3 (pg 2.1-7) (NRCS, 2008). The "Annual grass" land use type was assumed to have a "good" hydrologic condition. For the vegetated swale with rock check dams the "Open space" was used from Table 2-2a (USDA, 1986) with a "Fair" condition which assumes a grass cover of 50% to 75%.

Soils data were obtained in GIS format from the National Resources Conservation Service Soil Survey Geographic (SSURGO) database for Napa County (Figure 3). The hydrologic soil group classification is based on the minimum infiltration rate obtained for bare soil after prolonged wetting (USDA, 1986). Soils mapped at the site and within the contributing drainage areas are the Boomer-Forward-Felta Complex (111) and Felton gravelly loam (136). The Boomer-Forward-Felta Complex soils are categorized in hydrologic soil group B described as having "moderately low runoff potential when thoroughly wet," (USDA, 2007). The Felton gravelly loam is in hydrologic soil group C which has "moderately high runoff potential when thoroughly wet," (USDA, 2007). The hydrologic soil group for each soil was attached to this spatial dataset using ESRI ArcGIS software; this information was imported to the WMS software to calculate curve numbers.

Area-weighted composite curve numbers for each watershed were calculated in the WMS software using the distribution of the land use and soils coverages within each drainage basin. Runoff Curve Number reports generated by WMS for both existing and proposed conditions are provided in Appendix A.

Hydraulic Parameters

Time of concentration (T_c) is the time required for runoff to travel to a point of interest from the hydraulically most distant point of the basin. The flow path taken from the hydraulically most distant point is called the time of concentration arc in the WMS hydrologic modeling tool implementing TR-55. Time of concentration is the sum of travel times for each flow segment representing flow types beginning with sheet flow, then shallow concentrated flow, followed by open channel flow. Flow paths were digitized in WMS using automated methods for the pre-project scenario and manually digitized for the proposed scenario (Figure 2). Flow paths for existing and proposed conditions are displayed in Figure 2.

Flow paths were digitized in WMS using automated methods for the pre-project scenario and manually digitized for the proposed scenario. Flow paths for existing and proposed conditions are displayed in Figure 2. Appendix C contains summaries of the T_c calculations made in WMS.

The maximum length of sheet flow simulated by TR-55 is 300 ft, after which it is assumed shallow concentrated flow begins and continues until open channel flow begins. Neither of the two Pre-Project flow paths are longer than 300 ft and so all flows are assumed to be sheetflow in the Pre-Project condition. Flows within proposed diversion ditches and rock lined ditches were modeled as open channel flow.

Open channel flow calculations were made using the Channel calculator tool (part of the Hydraulic Toolbox in WMS) where all calculations are made using Manning's equation. Flow lengths and slope are calculated by the WMS software; other specific channel characteristics are required as inputs by the modeler. Manning's roughness values were required to calculate T_c for sheet flow and open channel flow. Table 3-1 in the TR-55 Manual (USDA, 1986) provides roughness coefficients for various sheet flow surface types. A roughness value for "Dense Grass" of 0.24 was determined to be most characteristic for sheet flows in existing forest and grassland and the proposed vineyard fields. Flow paths for existing and proposed conditions are displayed in Figure 2.

For the open channel flow segments, time of concentration is based on average flow velocity at bankfull elevation so all roughness values are assigned accordingly. A roughness value of 0.04 was assigned for existing roadside ditches. A roughness value of 0.04 is appropriate for "mountain streams with rocky beds and rivers with variable sections and some vegetation along banks" (Table 16-1, Dunne and Leopold, 1978, p. 593). For flow within the diversion ditches (found in 1a, 1b, 1c, 2a, 2b, 2c and 2d) a roughness value of 0.025 was adopted at the request of Napa County; this is consistent with a lined channel with open-weave textile in (Kilgore and Cotton, 2005). As mentioned above, flow lengths and slopes are calculated by the WMS software however, in the case of the proposed diversion ditches the slopes were manually entered to ensure a maximum slope of 4% as described in the ECP. The rock lined ditch located in watershed 1d was assigned a roughness of 0.05, consistent with an "Excavated channel with a cobble bottom and clean sides" (Chow, 1959). All ditch dimensions were taken from the ECP.

To simplify calculations, it was assumed that all flows collected by diversion ditches and routed into the rock lined ditch and then pipes instantaneously arrived at the greater basin outlet. This assumption is conservative in that it does not take into account the potential lag time associated with flow through the rock lined ditch, pipe network, passage through rock energy dissipation structures or other routing mechanisms. This does not create as much of an offset between drainage basin hydrographs so when they are summed to generate a composite hydrograph the timing of the peaks will align more closely and may generate a peak value that could be an overestimate. TR-55 works on a six-minute time step and most of the routing times that may be overlooked because of this assumption are likely on the order of one or two time steps and would be unlikely to substantially affect peak flow estimates.

Runoff Attenuation

Initial analyses with TR-55 predicted increases in runoff from the Project site owing to changes in vegetative cover from brush and woodland cover to cultivated crops. One attenuation basin is proposed to mitigate potential increases in runoff from Block C. The basin was initially sized to accommodate 100 year recurrence interval storm flows using methods detailed in Chapter 6 of the TR-55 guidance document (NRCS, 1986). Final sizing of the basin was guided by project constraints and confirmed once preliminary model evaluations showed adequate storage and functionality.

The effects of the attenuation basin on peak flows were evaluated using the storage indication method. The storage indication method requires numerical relationships between depth and storage volume and depth and outflow to quantify flow through an attenuation basin. The effects of the attenuation basin storage were evaluated using the WMS Detention (Attenuation) Basin Calculator which performs the storage indication calculations.

The storage-discharge curves for Attenuation Basin 2 are shown in Figure 4. The maximum proposed storage volume is approximately 0.0436acre-feet (~1,900 cubic feet). The outlet structures proposed are an eight-inch diameter drop inlet 3.75 above the pond bottom directed into an eight-inch diameter pipe and then a level spreader located to the north of the attenuation basin (Figure 2). In addition, there will be a 10-foot long emergency spillway (modeled as a broad crested weir) 4.5 feet above the pond bottom (0.75 ft above the drop inlet elevation). Appropriate energy dissipation of flows exiting via level spreaders and spillways is required to prevent erosion.

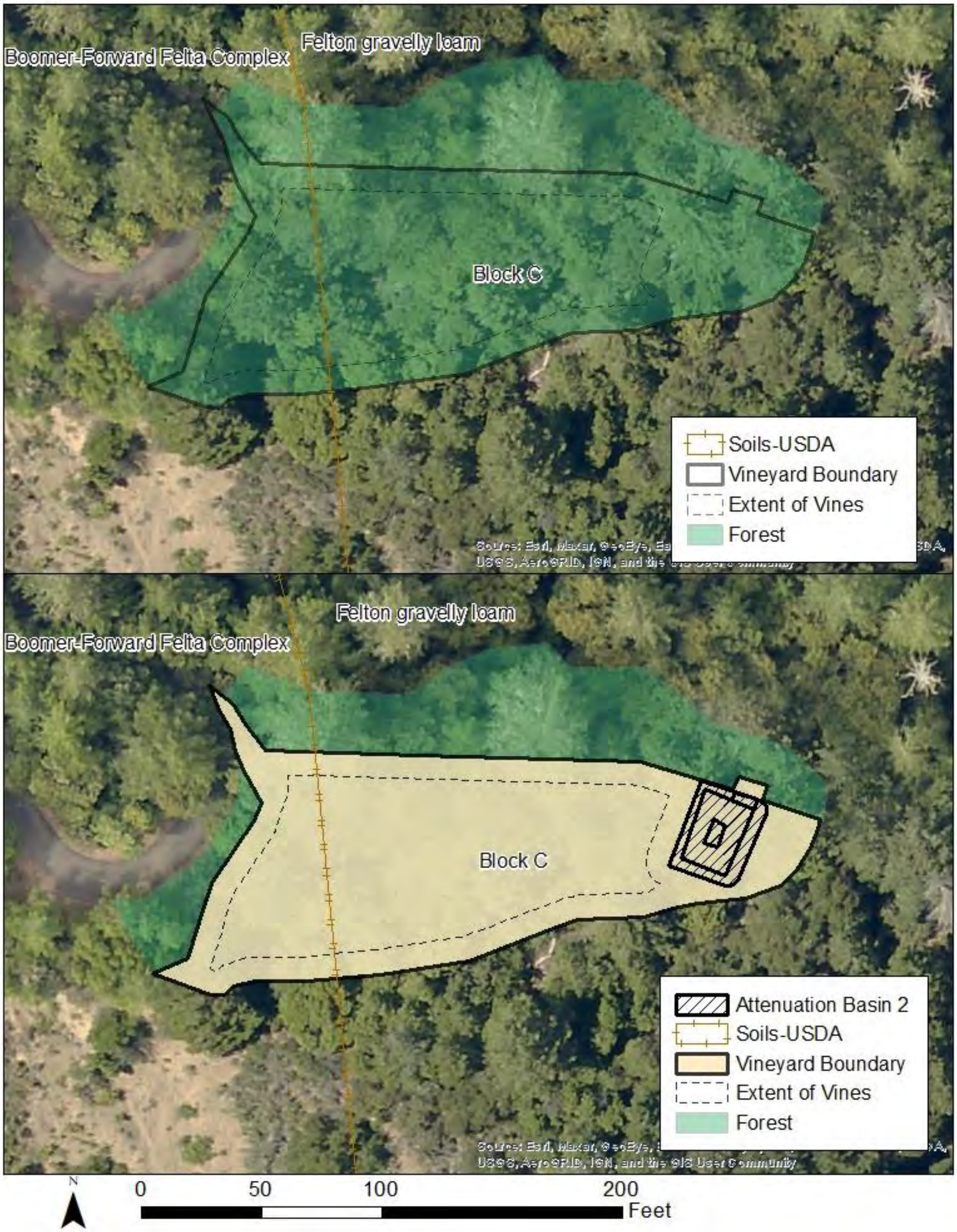

Figure 3 – Pre- and post-Project land use and soils.

Table 2: Land cover type summary tables.

Pre-Project Land Use Summary				Post-Project Landuse Summary			
Basin	Landuse	Area Acres	Percent Total	Basin	Landuse	Area Acres	Percent Total
Basin 1	Forest (Good)	0.2	100%	Basin 1A	Vineyard (Annual Grass Good)	0.02	51%
Basin 2	Forest (Good)	0.43	100%	Basin 1A	Forest (Good)	0.02	49%
				Basin 1B	Vineyard (Annual Grass Good)	0.02	99%
				Basin 1C	Vineyard (Annual Grass Good)	0.01	100%
				Basin 2A	Vineyard (Annual Grass Good)	0.04	56%
				Basin 2A	Forest (Good)	0.03	44%
				Basin 2B	Vineyard (Annual Grass Good)	0.05	100%
				Basin 2C	Vineyard (Annual Grass Good)	0.11	100%
				Basin 2D	Vineyard (Annual Grass Good)	0.08	100%
				Basin 2E	Vineyard (Annual Grass Good)	0.06	90%
				Basin 2E	Forest (Good)	0.01	10%
				Basin 2F	Vineyard (Annual Grass Good)	0.04	100%

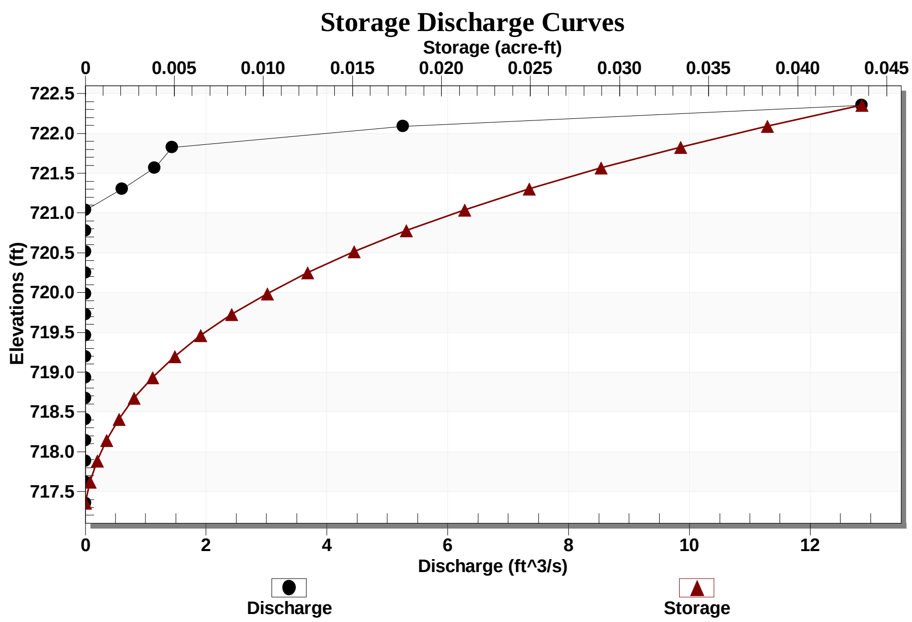

Figure 4: Storage discharge curves calculated for Attenuation Basin 2.

Results

Hydrographs were computed for all rainfall events in WMS using the TR-55 tabular hydrograph method (USDA, 1986). The effects on flow of the proposed attenuation basins were computed using the flow indication method in the WMS Detention [Attenuation] Basin Calculator. A composite hydrograph for runoff was calculated for existing conditions by summing the TR-55 output hydrographs for both Pre-project watersheds. The composite hydrograph for proposed Project conditions was computed as the sum of the TR-55 output hydrographs for all 10 of the post-Project sub-watersheds.

A comparison of the composite hydrographs for each storm event analyzed is presented in Table 3. Without the proposed attenuation basins change in peak runoff over the entire Project area ranges from 18% (100-year 24-hour event) to 43% (2-year 24-hour event). With attenuation basins including the proposed modifications to the existing reservoir, change in peak runoff over the entire Project area ranges from -70% (100-year 24-hour event) to -22% (2-year 24-hour event) under proposed Project conditions. Figure 5 shows a comparison of the composite hydrographs for the entire project area under all three scenarios (existing pre-Project conditions, proposed Project conditions without new attenuation, and proposed Project conditions with attenuation).

Table 3. Composite peak flow comparison for entire Project area.

24-hour Rainfall event	Existing Conditions Peak Runoff (cfs)	Proposed Conditions Peak Runoff Without Attenuation (cfs)	% Change	Proposed Conditions Peak Runoff With Attenuation (cfs)	% Change
100 year	0.8	0.9	18%	0.6	-22%
50 year	0.6	0.8	20%	0.5	-24%
10 year	0.4	0.5	27%	0.1	-61%
2 year	0.2	0.2	43%	0.05	-70%

Table 4. Estimated Runoff Volumes for the 100-, 50-, 10- and 2-year 24 hour events comparing existing conditions to proposed conditions with and without attenuation basins.

Runoff Volumes Estimated from TR-55 Peak Runoff Hydrographs (acre feet)				
Time Minutes	1320	1320	1320	1320
Storm	2 year 24 hour	10 year 24 hour	50 year 24 hour	100 year 24 hour
Pre-Project	0.06	0.12	0.19	0.23
Post-Project (No Attenuation)	0.08	0.14	0.22	0.25
Post-Project (With Attenuation)	0.04	0.08	0.14	0.16
Net Change	-0.03	-0.04	-0.06	-0.07
Net Change %	-44%	-33%	-30%	-29%

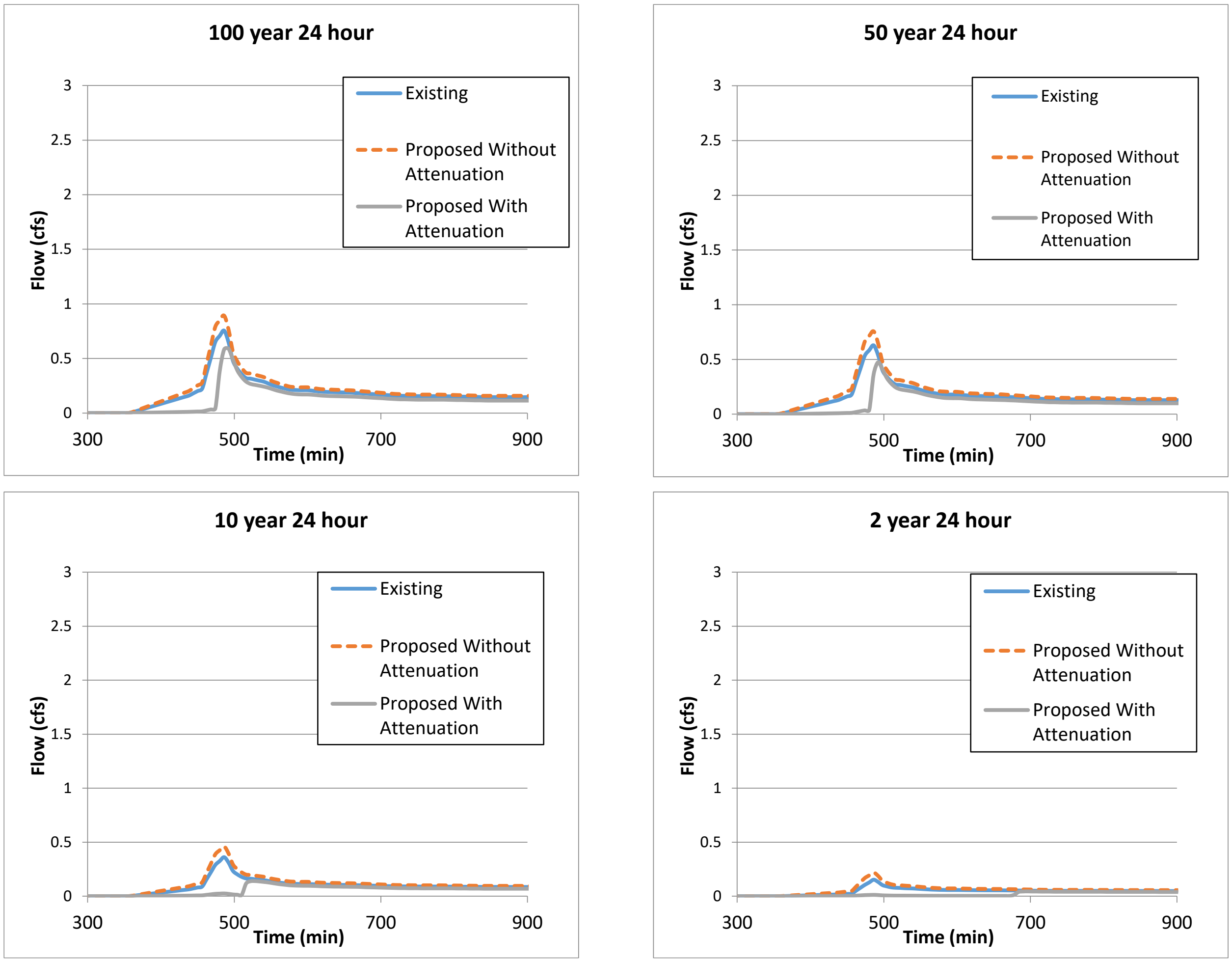

Figure 5 Composite hydrographs displaying peak runoff events for the 100, 50, 10 and 2 year 24-hour events comparing existing conditions to proposed conditions with and without attenuation basins.

Table 4 shows a summary of total runoff volume estimates for composite hydrographs for the for the 100-, 50-, 10- and 2-year 24 hour events. Without the proposed attenuation basins change in runoff volume over the entire Project area increases and values range from 0.02 acre-feet (2-year 24-hour event) to 0.03 acre-feet (100-year 24-hour event). With attenuation basins, change in runoff volume over the entire Project area ranges from -0.03 acre feet (2-year 24-hour event) to -0.07 acre-feet (100-year 24-hour event) under proposed Project conditions.

A summary of basin areas and a breakdown of the calculations of the TR-55 curve numbers are presented in Appendix A. All TR-55 input values for existing and proposed project site conditions are compared in each basin in Appendix B. Due to changes in basin areas and the effect of the attenuation basins a comparison of the composite hydrograph is the appropriate approach to evaluate overall Project hydrologic impacts. There are no increases in peak runoff from the Project site under proposed conditions with attenuation basins.

Conclusion

Simulation of all potential Project effects on runoff at the Project site using TR-55 to estimate runoff changes and simulating the effects of the proposed attenuation basin that peak runoff rates and total runoff volume will decline for all design storms over the entire Project area. Increases in peak flow from the Project site resulting from expected increases in runoff rates caused by land cover changes from woodland to cultivated land cover are mitigated by the proposed attenuation basin and reduced runoff rates from existing road area to be reclaimed for agricultural production.

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Appendix A

TR55 Runoff Curve Number Reports

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Runoff Curve Number Report
(Generated by WMS)

Babu Pre-Project

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Runoff Curve Number Report for Basin 1

HSG	Land Use Description	CN	Area cres	Product CN x A
B	Paved roads, parking lots, roofs, driveways,	98	0.000	0.016
B	Forest (Good)	55	0.023	1.242
C	Forest (Good)	70	0.026	1.838

CN (Weighted) = Total Product \ Total Area
==
63.1804

Runoff Curve Number Report for Basin 2

HSG	Land Use Description	CN	Area cres	Product CN x A
B	Forest (Good)	55	0.113	6.230
C	Forest (Good)	70	0.303	21.191

CN (Weighted) = Total Product \ Total Area
==
65.9159

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Runoff Curve Number Report
(Generated by WMS)

Post-Project Babu

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Thu Jul 22 15:12:24 2021

Runoff Curve Number Report for Basin 1A

HSG	Land Use Description	CN	Area cres	Product CN x A
B	Forest (Good)	55	0.007	0.359
B	Vineyard (Annual Grass Good)	61	0.011	0.668

CN (Weighted) = Total Product \ Total Area
==
58.7612

Runoff Curve Number Report for Basin 1B

HSG	Land Use Description	CN	Area cres	Product CN x A
B	Vineyard (Annual Grass Good)	61	0.001	0.068
C	Vineyard (Annual Grass Good)	75	0.019	1.390

CN (Weighted) = Total Product \ Total Area
==
74.2079

Runoff Curve Number Report for Basin 1C

HSG	Land Use Description	CN	Area cres	Product CN x A
C	Vineyard (Annual Grass Good)	75	0.007	0.535

CN (Weighted) = Total Product \ Total Area
==
75

Runoff Curve Number Report for Basin 2A

HSG	Land Use Description	CN	Area cres	Product CN x A
B	Forest (Good)	55	0.033	1.821
B	Vineyard (Annual Grass Good)	61	0.042	2.586

CN (Weighted) = Total Product \ Total Area
==
58.369

Runoff Curve Number Report for Basin 2B

HSG	Land Use Description	CN	Area cres	Product CN x A
B	Vineyard (Annual Grass Good)	61	0.035	2.148
C	Vineyard (Annual Grass Good)	75	0.018	1.313

CN (Weighted) = Total Product \ Total Area
==
65.6483

Runoff Curve Number Report for Basin 2C

HSG	Land Use Description	CN	Area cres	Product CN x A
B	Vineyard (Annual Grass Good)	61	0.003	0.177
C	Vineyard (Annual Grass Good)	75	0.105	7.911

CN (Weighted) = Total Product \ Total Area
==
74.6247

Runoff Curve Number Report for Basin 2D

HSG	Land Use Description	CN	Area cres	Product CN x A
C	Vineyard (Annual Grass Good)	75	0.077	5.804
C	Forest (Good)	70	0.005	0.334

CN (Weighted) = Total Product \ Total Area
==
74.7097

Runoff Curve Number Report for Basin 2E

HSG	Land Use Description	CN	Area cres	Product CN x A
C	Vineyard (Annual Grass Good)	75	0.062	4.677
C	Forest (Good)	70	0.006	0.417

CN (Weighted) = Total Product \ Total Area
==
74.5638

Runoff Curve Number Report for Basin 2F

HSG	Land Use Description	CN	Area cres	Product CN x A
C	Vineyard (Annual Grass Good)	75	0.029	2.145
C	Forest (Good)	70	0.000	0.010

CN (Weighted) = Total Product \ Total Area
==
74.9762

Appendix B

Estimated Peak Runoff for Existing and Proposed Conditions

Project Watersheds

					Peak Flow CFS			
	Watershed	Area acres	TC hours	Weighted CN	2 year	10 year	50 year	100 year
Pre-Project	1	0.05	0.079	66.90	0.05	0.12	0.21	0.25
	2	0.42	0.112	66.04	0.10	0.24	0.42	0.50
Peaks from Pre-Project composite hydrograph					0.15	0.36	0.63	0.76
Post-Project	1a	0.041	0.022	58.66	0.002	0.01	0.01	0.02
	1b	0.042	0.034	74.50	0.01	0.02	0.03	0.03
	1c	0.056	0.05	75.00	0.00	0.01	0.01	0.01
	2a	0.08	0.021	58.37	0.01	0.03	0.05	0.06
	2b	0.05	0.032	65.65	0.01	0.03	0.05	0.06
	2c	0.11	0.051	74.63	0.05	0.09	0.15	0.17
	2d	0.082	0.034	74.99	0.04	0.07	0.11	0.13
	2e	0.084	0.034	75.00	0.03	0.06	0.09	0.11
	2f	0.042	0.021	74.98	0.01	0.02	0.04	0.05
Peaks from Post-Project composite hydrograph Pre-Attenuation					0.16	0.33	0.54	0.64
Peaks from Post-Project composite hydrograph With-Attenuation					0.05	0.14	0.47	0.59

Appendix C

TR55 Time of Concentration Calculations

BABU PRE-PROJECT

Arc Travel Time Data Computed in WMS

Wed Aug 18 11:42:04 2021

BABU PRE-PROJECT

BASIN 1 AREA 0.05 acres

ARC 3 Travel Time

0.08 hrs

TYPE: TR55 Sheet Flow

EQN: .007*((n*L)^.8)*(P^-.5)*(s^-.4)

S Slope 0.2341

L Length 104.63 ft

n Manning's n 0.2400

P 2 yr 24 hr Rainfall 4.41 in

Time of Concentration for 1 0.08 hrs.

BASIN 2 AREA 0.42 acres

ARC 1 Travel Time

0.11 hrs

TYPE: TR55 Sheet Flow

EQN: .007*((n*L)^.8)*(P^-.5)*(s^-.4)

S Slope 0.2454

L Length 167.16 ft

n Manning's n 0.2400

P 2 yr 24 hr Rainfall 4.41 in

Time of Concentration for 2 0.11 hrs.

BABU POST-PROJECT

Arc Travel Time Data Computed in WMS
Wed Aug 18 11:19:12 2021

Arc Travel Time Data Computed in WMS
Thu Oct 21 16:57:53 2021

BASIN 1A   AREA 0.02 acres

ARC 1   Travel Time
0.00 hrs
TYPE: TR55 Open Channel Flow
EQN: (L*n)/(3600*1.486*(r^.6667)*(s^.5))
S Slope   0.0540
L Length   19.50 ft
n Manning's n   0.0250
r Hydraulic Radius 0.45 ft

ARC 14   Travel Time
0.02 hrs
TYPE: TR55 Sheet Flow
EQN: .007*((n*L)^.8)*(P^-.5)*(s^-.4)
S Slope   0.2406
L Length   19.34 ft
n Manning's n   0.2400
P 2 yr 24 hr Rainfall 4.41 in

Time of Concentration for 1A   0.02 hrs.

BASIN 1B   AREA 0.02 acres

ARC 3   Travel Time
0.00 hrs
 TYPE: TR55 Open Channel Flow
  EQN: (L*n)/(3600*1.486*(r^.6667)*(s^.5))
    S Slope   0.0426
    L Length   12.97 ft
    n Manning's n   0.0250
    r Hydraulic Radius 0.45 ft

ARC 15   Travel Time
0.03 hrs
 TYPE: TR55 Sheet Flow
  EQN: .007*((n*L)^.8)*(P^-.5)*(s^-.4)
    S Slope   0.2460
    L Length   36.10 ft
    n Manning's n   0.2400
    P 2 yr 24 hr Rainfall 4.41 in

Time of Concentration for 1B   0.03 hrs.

Arc Travel Time Data Computed in WMS
Thu Oct 21 17:00:58 2021

BASIN 1C   AREA 0.01 acres

ARC 16   Travel Time
0.03 hrs
 TYPE: TR55 Sheet Flow
  EQN: .007*((n*L)^.8)*(P^-.5)*(s^-.4)
    S Slope   0.1974
    L Length   31.77 ft
    n Manning's n   0.2400
    P 2 yr 24 hr Rainfall 4.41 in

Time of Concentration for 1C   0.03 hrs.

Arc Travel Time Data Computed in WMS
Wed Aug 18 11:19:59 2021

BASIN 2A   AREA 0.08 acres

ARC 4   Travel Time
0.00 hrs
TYPE: TR55 Open Channel Flow
EQN: (L*n)/(3600*1.486*(r^.6667)*(s^.5))
S Slope   0.0594
L Length   77.47 ft
n Manning's n   0.0250
r Hydraulic Radius 0.45 ft

ARC 5   Travel Time
0.02 hrs
TYPE: TR55 Sheet Flow
EQN: .007*((n*L)^.8)*(P^-.5)*(s^-.4)
S Slope   0.2370
L Length   16.85 ft
n Manning's n   0.2400
P 2 yr 24 hr Rainfall 4.41 in

Time of Concentration for 2A   0.02 hrs.

Arc Travel Time Data Computed in WMS
Wed Aug 18 11:20:08 2021

BASIN 2B   AREA 0.05 acres

ARC 6   Travel Time
0.00 hrs
  TYPE: TR55 Open Channel Flow
   EQN: (L*n)/(3600*1.486*(r^.6667)*(s^.5))
      S Slope   0.0664
      L Length   64.58 ft
      n Manning's n   0.0250
      r Hydraulic Radius 0.45 ft

ARC 7   Travel Time
0.03 hrs
  TYPE: TR55 Sheet Flow
   EQN: .007*((n*L)^.8)*(P^-.5)*(s^-.4)
      S Slope   0.2552
      L Length   33.19 ft
      n Manning's n   0.2400
      P 2 yr 24 hr Rainfall 4.41 in

Time of Concentration for 2B   0.03 hrs.

Arc Travel Time Data Computed in WMS
Thu Oct 21 17:02:20 2021

BASIN 2C   AREA 0.11 acres

ARC 2   Travel Time
0.05 hrs
  TYPE: TR55 Sheet Flow
   EQN: .007*((n*L)^.8)*(P^-.5)*(s^-.4)
      S Slope   0.2322
      L Length   55.61 ft
      n Manning's n   0.2400
      P 2 yr 24 hr Rainfall 4.41 in

ARC 8   Travel Time

0.00 hrs
TYPE: TR55 Open Channel Flow
EQN: (L*n)/(3600*1.486*(r^.6667)*(s^.5))
S Slope 0.0479
L Length 80.66 ft
n Manning's n 0.0250
r Hydraulic Radius 0.45 ft

Time of Concentration for 2C 0.05 hrs.

Arc Travel Time Data Computed in WMS
Thu Oct 21 17:03:19 2021

BASIN 2D AREA 0.08 acres

ARC 9 Travel Time
0.00 hrs
TYPE: TR55 Open Channel Flow
EQN: (L*n)/(3600*1.486*(r^.6667)*(s^.5))
S Slope 0.0396
L Length 69.28 ft
n Manning's n 0.0250
r Hydraulic Radius 0.45 ft

ARC 18 Travel Time
0.03 hrs
TYPE: TR55 Sheet Flow
EQN: .007*((n*L)^.8)*(P^-.5)*(s^-.4)
S Slope 0.1981
L Length 30.60 ft
n Manning's n 0.2400
P 2 yr 24 hr Rainfall 4.41 in

Time of Concentration for 2D 0.03 hrs.

Arc Travel Time Data Computed in WMS
Thu Oct 21 17:03:47 2021

BASIN 2E   AREA 0.07 acres

ARC 19   Travel Time
0.03 hrs
TYPE: TR55 Sheet Flow
EQN: .007*((n*L)^.8)*(P^-.5)*(s^-.4)
S Slope   0.2127
L Length   34.92 ft
n Manning's n   0.2400
P 2 yr 24 hr Rainfall 4.41 in

Time of Concentration for 2E   0.03 hrs.

Arc Travel Time Data Computed in WMS
Wed Aug 18 11:20:44 2021

BASIN 2F   AREA 0.04 acres

ARC 11   Travel Time
0.02 hrs
TYPE: TR55 Sheet Flow
EQN: .007*((n*L)^.8)*(P^-.5)*(s^-.4)
S Slope   0.3024
L Length   22.70 ft
n Manning's n   0.2400
P 2 yr 24 hr Rainfall 4.41 in

Time of Concentration for 2F   0.02 hrs.