

PRELIMINARY HYDROLOGY STUDY FOR 88 Vivian Street, San Rafael Project

Project Address:

88 Vivian Street,
San Rafael, California

Prepared For:

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1.0 PURPOSE OF STUDY:

The preliminary hydrology study will determine the amount of stormwater runoff generated from the project site under pre-development and post-development conditions. The values and statements within this report confirm the post-development site is designed and planned in accordance with the Marin County drainage requirements. This study will anticipate whether detention or other peak flow mitigation methods will be required by comparing the post-development and pre-development condition peak flow rates for the 100-year storm events.

2.0 SITE DESCRIPTION:

The proposed site is located at 88 Vivian Street, in the City of San Rafael, County of Marin. The site is made up of a rectangle shape bordered by Vivian Street to the northerly-west side, Belvedere Street to the northerly-east side, and commercial buildings to the southerly-east and southerly-west side. The Development site is approximately 2.41 acres in gross area and currently consists of an existing closed bowling alley building. The site is classified to be Hydrologic Soil Type “D” based on water table and soil type per soils report prepared by Geocon Consultants, Inc.

Refer to Vicinity Map located in Appendix A for location reference.

3.0 PRE-DEVELOPMENT CONDITIONS:

In the current onsite condition, stormwater generally sheet flows over land from the south-easterly portion of the site to the north-westerly portion of the site. There is no sign of drainage features to the site identified on the perimeter of the property line of the site due to pre-development site grading and/or Pre-Development perimeter controls. All tributary area of the site to the existing inlets eventually enters the storm system along Belvedere Street downstream.

According to the Federal Emergency Management Agency (FEMA), FIRM rate map Number 06041C0459F, effective date March 16, 2016, the site is located within flood Zone AE with based flood elevation of 10 feet. Zone AE is areas that present a 1% annual chance of flooding.

Refer to the FIRM rate map located in Appendix E for reference.

The topographic survey was utilized to identify pre-development onsite high points and overall site conveyance of storm water runoff. All the pre-development onsite stormwater runoff ultimately reaches the outlet on Vivian Street and into an exist catch basin downstream. The site was analyzed as a single area to approximately quantify the runoff based on the longest hydraulic path from the most remote high point to drain low point, which will be used to compare to the proposed condition.

Reference to Preliminary Pre-Development Conditions Hydrology Map located in Appendix B.

4.0 POST-DEVELOPMENT CONDITIONS:

The proposed project consists of 68 residential dwelling units on an approximate 2.41-acre site. The proposed development includes drive aisles, parking, landscaping, walkways, and common open space areas.

The proposed grading is designed for the site to generally sheet flow to the low points of the site with proposed catch basin inlets to collect the generated runoffs. The two (2) proposed onsite catch basins then routes the runoffs to the proposed bio-retention/ treatment vaults via storm drainpipe for water quality treatment, which eventually mitigates to the connected storm drain system to the 24" stormwater pipe along Belvedere Street. For the proposed buildings along the public street, proposed bio-treatment planters are proposed adjacent to the buildings for roof drainage treatment prior to be release to the street following existing drainage pattern. The bio-treatment vault and planters are designed with the internal bypass or d-vert system for any larger storm event.

In an event where the proposed onsite storm drain system exceeds full capacity, stormwater will overflow through street sheet flow to Vivian Street and Belvedere Street preserving historical drainage pattern.

Reference to Preliminary Post-Development Conditions Hydrology Map located in Appendix B.

5.0 METHODOLOGY:

The project drainage analysis considers two (2) sub-areas for the on-site drainage area to obtain the runoffs generated from the project site. The pre-development and post-development conditions peak flows for the 100-year storm event were analyzed using Rational Method.

$$Q = C_w(I - F_m)A$$

- Q – the flow of runoff measured in cubic feet per second (cfs)
C_w – the runoff coefficient (refer to Weighted Runoff Coefficient calculation)
I – the intensity of the storm measured in inches per hour (in/hr)
F_m – minor loss obtained with soil group and pervious area
A – area contributing to the flow at a given point of concentration measured in acres

$$C_w = \frac{\sum_{j=1}^n C_j A_j}{\sum_{j=1}^n A_j}$$

- C_w – the weighted runoff coefficient
C_j – runoff coefficient for area j
A_j – the acreage of area j
n – the number of areas with different land use or soil types

The peak flow rates corresponding with the post-development condition were compared to that of the pre-development condition. Storm intensity was derived using the Nation Oceanic and Atmospheric Administration's (NOAA) point precipitation frequency data.

Per the separately prepared Preliminary Stormwater Control Plan, the bio-retention/ treatment will also provide sufficient treatment flow for the BMP Design.

Refer to the Pre- and Post-Development Hydrology Calculation located in Appendix C.
Refer to NOAA's point precipitation frequency estimates located in Appendix E.

6.0 DESIGN ASSUMPTIONS:

1. The property is located in the City of San Rafael, Marin County rainfall region.
2. Design Runoff Coefficient C value are calculated per the weighted runoff coefficient equation shown above. C value assumed for hardscapes and pavement as (C=0.9) and pervious landscape as (C=0.1). Refer to Marin County Hydrology Manual.
3. The site is classified to be Hydrologic Soil Type "D" based on water table and clay soil type per soils report prepared by Geocon Consultants, Inc. (See separate Stormwater Control Plan for reference).
4. Peak flow rates and time of concentrations were calculated using Rational Method and overland flow described in Marin County Hydrology Manual.

7.0 RESULTS:

Hydrology Summary

The results from this preliminary hydrology study utilizing the Rational Method demonstrate that the post-development storm water runoffs from the project site are lower than the pre-development conditions due to the increase in pervious area and time of concentration in the post-development design. Refer to the hydrologic calculation summary below:

Project Site	Land use	Pervious Area	Percent Coverage of Project Site
Pre-Development	Commercial	0.094 acre	3.9%
Post-Development	Residential	0.366 acre	15.2%

Pre-Development	Area (ac)	C (weighted)	Q100 (cfs)	Runoff-volume (cf)
DMA-XA	2.408	0.87	7.61	7,240.79

Post-Development	Area (ac)	C (weighted)	Q100 (cfs)	Runoff-volume (cf)
DMA-A	1.296	0.76	3.70	3,347.22
DMA-B	1.112	0.80	3.38	3,078.50
Total	2.408	-	7.08	6,425.72

Pre-Project Q100 (cfs)	Post-Project Q100 (cfs)	Percent change in Q100
7.61	7.08	-7.0%

Per existing condition, tributary areas of the site that enter the existing inlets eventually enters the drainage system downstream along Belvedere Street. As the project proposes a direct connection to the 24” storm drain along Belvedere Street, tributary flow to the existing inlets will decrease due the decrease of the generated peak flow and runoff volume of the site per hydrology analysis.

The Q the summation of the flow generated by project site.
Refer to Pre and Post Development Condition Hydrology Map located in Appendix B.
Refer to Pre and Post Development Condition Calculation located in Appendix C.

Bio-Retention/ treatment Sizing

Refer to the separately prepared project Preliminary Stormwater Control Plan for additional information regarding the water quality design.

Catch Basin Sizing

Preliminary catch basins sizing is provided to ensure flow are properly mitigated within street capacity shown within Appendix D. Additional catch basin sizing analysis will be provided during Final Engineering as locations are to be confirmed with final site plan.

Pipe Sizing

A preliminary pipe sizing for onsite runoff conveyance inlets were accomplished using Hydraulic Toolbox ver. 5.0 based on the 100-year storm event peak flow rates and provided in Appendix D of this report. Additional analysis will be provided during Final Engineering as alignments are to be confirmed with final site plan.

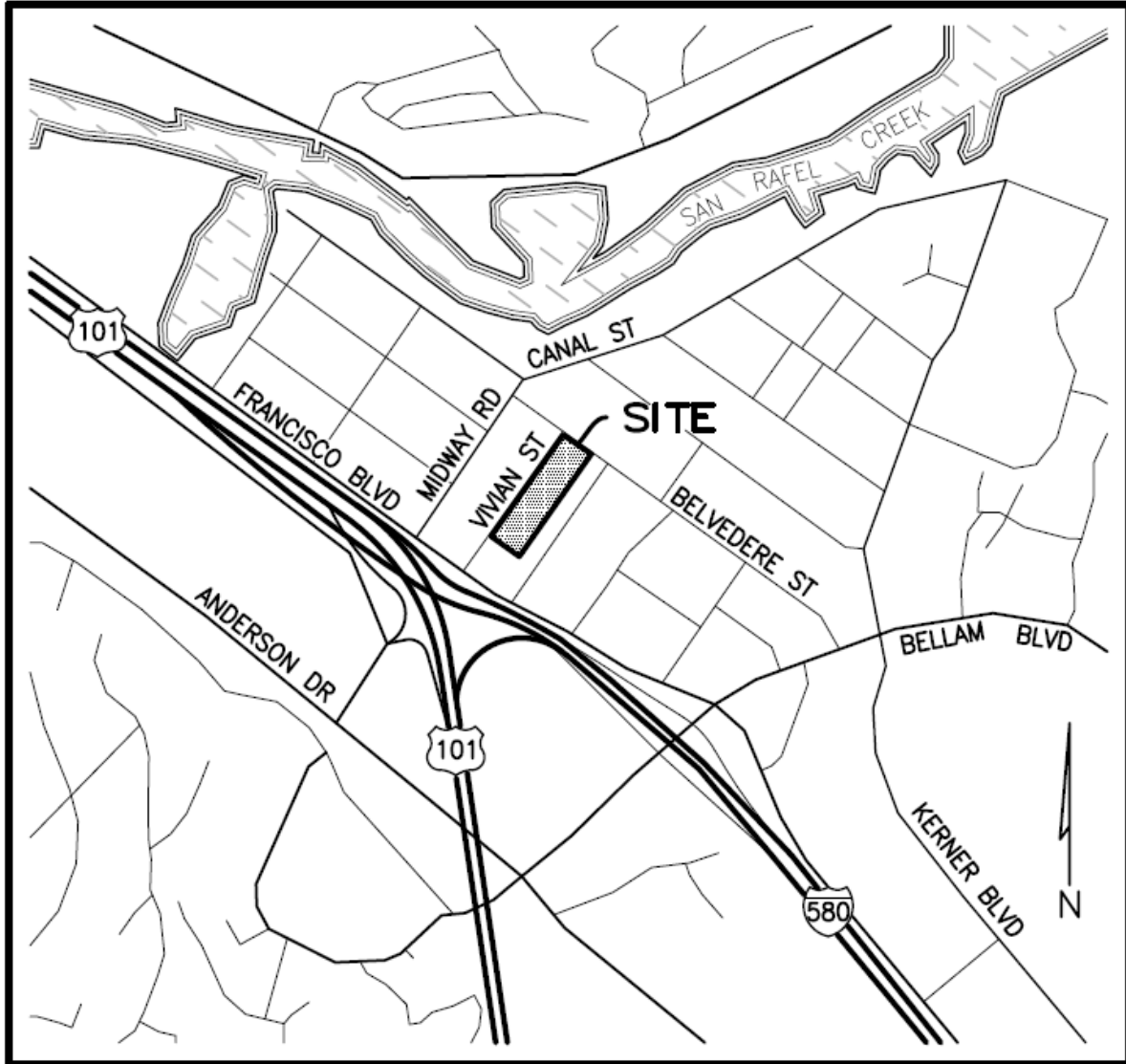
8.0 CONCLUSION:

The results from this preliminary hydrology study utilizing Rational Method demonstrate that the post-development condition stormwater peak flow for 100-year storm event from the subject site will decrease compared to the pre-development condition peak flow as indicated in the hydrology summary results in Section 7 of this report. Per existing condition, tributary areas of the site that enter the existing inlets eventually enters the drainage system downstream along Belvedere Street. As the project proposes a direct connection to the 24" storm drain along Belvedere Street, tributary flow to the existing inlets will decrease due the decreased generated peak flow and runoff volume of the site per hydrology analysis. This decrease is mainly due to the increased change in pervious area based on the type of development being proposed and this condition represents lower overall peak flow rates and runoff volume.

A preliminary pipe sizing for onsite runoff conveyance inlets were done using Hydraulic Toolbox ver. 5.0 based on the 100-year storm event peak flow rates and provided in Appendix D of this report.

As plans progress to an adequate level for construction, a Final Hydrology and Hydraulic Study should be provided to confirm that the proposed combination of site grading, routing of onsite storm water pipe facilities and storm water treatment systems are sized adequately to continue to mitigate the generated runoffs from the proposed site. Any additional effect to surrounding drainage system should be calculated at individual points of concentration around the site, to confirm its proposed runoff condition below pre-project conditions or properly mitigated.

APPENDIX A: Vicinity Map



N. T. S.

APPENDIX B: Hydrology Maps
Preliminary Pre-Development Conditions Hydrology
Map
Preliminary Post-Development Conditions Hydrology
Map

APPENDIX C: Hydrology Calculations

Pre-Development & Post-Development Conditions

Hydrology Calculations

ASHT-001 DMA Summary

Existing Conditions

ID	NAME	SURFACE TYPE	C	DMA XA (sf)
HS	HARDSCAPE	ASPALT/ CONCRETE/ ROOF	0.9	100,801.5
LS	LANDCAPE	ORNAMENTAL LANDSCAPING	0.1	4,095.3
IMPERVIOUS AREA				100,801.5
PERVIOUS AREA				4,095.3
TOTAL				104,896.8
C (weighted)				0.87

Proposed Conditions

ID	NAME	SURFACE TYPE	C	DMA A (sf)	DMA B (sf)
RF	HOMESITES	ROOF	0.9	22,385.6	23,955.3
PA	PAVEMENT	ASPALT/CONCRETE	0.9	16,088.8	14,879.7
HS	HARDSCAPE	ASPALT/CONCRETE	0.9	8,021.1	3,602.7
LS	LANDSCAPE	ORNAMENTAL LANDSCAPING	0.1	9,715.5	5,788.2
BIO	BIORETENTION	MANUFACTURING SPECIFICATION	0.1	230.0	230.0
IMPERVIOUS AREA				46,495.5	42,437.6
PERVIOUS AREA				9,945.5	6,018.2
TOTAL				56,441.0	48,455.8
C (weighted)				0.76	0.80

RATIONAL METHOD STUDY FORM

Marin County HYDROLOGY		STUDY NAME: 88 Vivian Street 100 YEAR STORM RATIONAL METHOD STUDY							CALCULATED BY: KL		DATE: 01/13/2022	
CONC. PT. (MAP AREA)	AREA (ACRES) SUBAREA	LAND USE	DEV. (Ap)	Tc MIN.	C	I in/hr	Fm in/hr	Q TOTAL	FLOW PATH, FT	SLOPE FT/FT	V FT/SEC	HYDRAULICS AND NOTES
Proposed Area												
A	1.30	RESIDENTIAL	0.1762	15.45	0.76	3.78	0.035	3.70	235	0.0072		Initial Subarea - NODE 100 to 101
B	1.11	RESIDENTIAL	0.1242	15.08	0.80	3.83	0.025	3.38	279	0.0072		Initial Subarea - NODE 100 to 201
Existing Area												
XA	2.41	COMMERCIAL	0.0390	16.71	0.87	3.64	0.008	7.61	434	0.004		Initial Subarea - NODE 100 to 101

NOTES: RATIONAL METHOD; $Q = C*(I - F_m)*A$; $F_m = A_p * F_p$; $F_p = 0.20$ (Soil D, USDA Soils Map)
Runoff Coefficient (C) is calculated per weighted runoff coefficient based on delineated surface type area.
Intensity is obtained from IDF curve per NOAA precipitation data
Time of Travel for overland sheet flow was determined using the overland flow formula per the County of Marin's Hydrology Manual.

COUNTY OF MARIN
DEPARTMENT OF PUBLIC WORKS

HYDROLOGY MANUAL
SIMPLIFIED INSTRUCTIONS

(Revision: 8/2/00)

The instructions:

1. Determine the Time of Concentration (t_c)

$$t_c = \frac{1.8(1.1-C)\sqrt{L}}{\sqrt[3]{S(100)}} + 5 \text{ Min}$$

C = Runoff Coefficient *

L = Longest run in feet

S = Average Slope in ft/ft = $\frac{\Delta H}{L}$

2. Determine Zone from Map V
3. Determine I_{60} from Map I
4. From appropriate Zone Chart (Chart K), find correct curve using the I_{60} and 1 hour intersect.
5. Follow this curve to the t_c intersect.
6. Read i on Y-axis.
7. Utilize this value into $Q=CiA$

C = Runoff Coefficient *

i = Intensity (I_{60})

A = Drainage Area in Acres

Q = Discharge/Capacity in Cubic Feet per Second (cfs)

- * There is often much discussion as to what value to use for "C" for a specific site. What we are concerned with here, however, is the major event. These often occur in the mid to late season and after one or more days of light rainfall. Thus the ground is close to saturation and "C" is approaching 1.0. To cut to the chase, we recommend a "C" value of at least 0.7.

Hydraulic Analysis Report

Project Data

Project Title: ASHT-001
Designer: KL
Project Date: Wednesday, March 3, 2021
Project Units: U.S. Customary Units
Notes:

Rational Analysis: EXISTING CONDITION

Notes:

Rational Method Input Parameters

Runoff Coefficient: 0.87
Basin Area: 2.4100 acres
Rainfall Intensity: 3.64 in/hr
Time of Concentration: 16.71 minutes
Recurrence Year: 100 year

Rational Method Results

Flowrate: 7.7 cfs

IDF Input Parameters

NOAA Atlas Data
State: California
Region: Region 4
2 yr, 6 hr: 2.0300 in
2 yr, 24 hr: 3.9800 in
100 yr, 6 hr: 4.8000 in
100 yr, 24 hr: 9.3700 in
Latitude: 37.9638

IDF Results

100 year IDF equation: $i = 45.909 / (T_c + 9.13962)^{0.779343}$
Intensity: 3.6401 in/hr

Time of Concentration Input Parameters

Minimum Time of Concentration: 5.00 min
Specified Time of Concentration
Time of Concentration: 16.71 min

Hydrograph - EXISTING CONDITION - Rational Hydrograph Method

100 year recurrence Interval, Peak Discharge: 7.696 cfs, Time to Peak: 16.00 (min), Total Volume: 7240.79 ft³

Time (minutes)	Flow cfs
0.00	0.00
1.00	0.46
2.00	0.92
3.00	1.38
4.00	1.84
5.00	2.30
6.00	2.76
7.00	3.22
8.00	3.68
9.00	4.14
10.00	4.61
11.00	5.07
12.00	5.53
13.00	5.99
14.00	6.45
15.00	6.91
16.00	7.70
17.00	7.21
18.00	6.73
19.00	6.25
20.00	5.77
21.00	5.29
22.00	4.81
23.00	4.33
24.00	3.85
25.00	3.37
26.00	2.89
27.00	2.40
28.00	1.92
29.00	1.44
30.00	0.96
31.00	0.48
32.00	0.00

Rational Analysis: PROPOSED CONDITION - DMA A

Notes:

Rational Method Input Parameters

Runoff Coefficient: 0.76

Basin Area: 1.3000 acres

Rainfall Intensity: 3.78 in/hr

Time of Concentration: 15.45 minutes

Recurrence Year: 100 year

Rational Method Results

Flowrate: 3.8 cfs

IDF Input Parameters

NOAA Atlas Data

State: California

Region: Region 4

2 yr, 6 hr: 2.0300 in

2 yr, 24 hr: 3.9800 in

100 yr, 6 hr: 4.8000 in

100 yr, 24 hr: 9.3700 in

Latitude: 37.9638

IDF Results

100 year IDF equation: $i = 45.909 / (T_c + 9.13962)^{0.779343}$

Intensity: 3.7846 in/hr

Time of Concentration Input Parameters

Minimum Time of Concentration: 5.00 min

Specified Time of Concentration

Time of Concentration: 15.45 min

Hydrograph - PROPOSED CONDITION - DMA A - Rational Hydrograph Method

100 year recurrence Interval, Peak Discharge: 3.770 cfs, Time to Peak: 15.00 (min), Total Volume: 3347.22 ft³

Time (minutes)	Flow cfs
0.00	0.00
1.00	0.24
2.00	0.49
3.00	0.73
4.00	0.98
5.00	1.22
6.00	1.46
7.00	1.71
8.00	1.95
9.00	2.20
10.00	2.44
11.00	2.68
12.00	2.93
13.00	3.17
14.00	3.42
15.00	3.77
16.00	3.52
17.00	3.27
18.00	3.02
19.00	2.76
20.00	2.51
21.00	2.26
22.00	2.01
23.00	1.76
24.00	1.51
25.00	1.26
26.00	1.01
27.00	0.75
28.00	0.50
29.00	0.25
30.00	0.00

Rational Analysis: PROPOSED CONDITION - DMA B

Notes:

Rational Method Input Parameters

Runoff Coefficient: 0.80

Basin Area: 1.1100 acres

Rainfall Intensity: 3.83 in/hr

Time of Concentration: 15.08 minutes

Recurrence Year: 100 year

Rational Method Results

Flowrate: 3.4 cfs

IDF Input Parameters

NOAA Atlas Data

State: California

Region: Region 4

2 yr, 6 hr: 2.0300 in

2 yr, 24 hr: 3.9800 in

100 yr, 6 hr: 4.8000 in

100 yr, 24 hr: 9.3700 in

Latitude: 37.9638

IDF Results

100 year IDF equation: $i = 45.909 / (T_c + 9.13962)^{0.779343}$

Intensity: 3.8296 in/hr

Time of Concentration Input Parameters

Minimum Time of Concentration: 5.00 min

Specified Time of Concentration

Time of Concentration: 15.08 min

Hydrograph - PROPOSED CONDITION - DMA B - Rational Hydrograph Method

100 year recurrence Interval, Peak Discharge: 3.429 cfs, Time to Peak: 15.00 (min), Total Volume: 3078.50 ft³

Time (minutes)	Flow cfs
0.00	0.00
1.00	0.23
2.00	0.45
3.00	0.68
4.00	0.91
5.00	1.14
6.00	1.36
7.00	1.59
8.00	1.82
9.00	2.05
10.00	2.27
11.00	2.50
12.00	2.73
13.00	2.96
14.00	3.18
15.00	3.43
16.00	3.20
17.00	2.97
18.00	2.74
19.00	2.51
20.00	2.29
21.00	2.06
22.00	1.83
23.00	1.60
24.00	1.37
25.00	1.14
26.00	0.91
27.00	0.69
28.00	0.46
29.00	0.23
30.00	0.00

IDF Table

	5-min	10-min	15-min	30-min	60-min
2-yr.	2.598	2.015	1.702	1.179	0.746
5-yr.	3.408	2.644	2.233	1.547	0.979
10-yr.	3.948	3.063	2.587	1.793	1.135
25-yr.	4.613	3.579	3.023	2.095	1.326
50-yr.	5.258	4.079	3.445	2.387	1.511
100-yr.	5.860	4.547	3.840	2.661	1.684

IDF Curves

Time(min)	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
1.00	3.35	4.39	5.09	5.94	6.77	7.55
2.00	3.11	4.08	4.73	5.52	6.29	7.01
3.00	2.91	3.82	4.42	5.16	5.89	6.56
4.00	2.73	3.59	4.16	4.86	5.53	6.17
5.00	2.58	3.39	3.92	4.59	5.23	5.83
6.00	2.45	3.21	3.72	4.35	4.96	5.52
7.00	2.33	3.06	3.54	4.14	4.71	5.25
8.00	2.22	2.92	3.38	3.95	4.50	5.01
9.00	2.13	2.79	3.23	3.78	4.30	4.80
10.00	2.04	2.68	3.10	3.62	4.13	4.60
11.00	1.96	2.57	2.98	3.48	3.97	4.42
12.00	1.89	2.48	2.87	3.35	3.82	4.26
13.00	1.82	2.39	2.77	3.23	3.68	4.11
14.00	1.76	2.31	2.67	3.12	3.56	3.97
15.00	1.70	2.23	2.59	3.02	3.44	3.84
16.00	1.65	2.16	2.51	2.93	3.34	3.72
17.00	1.60	2.10	2.43	2.84	3.24	3.61
18.00	1.55	2.04	2.36	2.76	3.14	3.50
19.00	1.51	1.98	2.30	2.68	3.06	3.41
20.00	1.47	1.93	2.23	2.61	2.97	3.32
21.00	1.43	1.88	2.18	2.54	2.90	3.23
22.00	1.40	1.83	2.12	2.48	2.82	3.15
23.00	1.36	1.79	2.07	2.42	2.76	3.07
24.00	1.33	1.74	2.02	2.36	2.69	3.00
25.00	1.30	1.70	1.97	2.31	2.63	2.93
26.00	1.27	1.67	1.93	2.26	2.57	2.87
27.00	1.24	1.63	1.89	2.21	2.52	2.80
28.00	1.22	1.60	1.85	2.16	2.46	2.74
29.00	1.19	1.56	1.81	2.12	2.41	2.69
30.00	1.17	1.53	1.78	2.07	2.36	2.63
31.00	1.15	1.50	1.74	2.03	2.32	2.58
32.00	1.12	1.47	1.71	1.99	2.27	2.53
33.00	1.10	1.45	1.68	1.96	2.23	2.49
34.00	1.08	1.42	1.65	1.92	2.19	2.44

35.00	1.06	1.40	1.62	1.89	2.15	2.40
36.00	1.04	1.37	1.59	1.86	2.11	2.36
37.00	1.03	1.35	1.56	1.82	2.08	2.32
38.00	1.01	1.33	1.54	1.79	2.04	2.28
39.00	0.99	1.30	1.51	1.77	2.01	2.24
40.00	0.98	1.28	1.49	1.74	1.98	2.21
41.00	0.96	1.26	1.46	1.71	1.95	2.17
42.00	0.95	1.24	1.44	1.68	1.92	2.14
43.00	0.93	1.23	1.42	1.66	1.89	2.11
44.00	0.92	1.21	1.40	1.63	1.86	2.08
45.00	0.91	1.19	1.38	1.61	1.84	2.05
46.00	0.89	1.17	1.36	1.59	1.81	2.02
47.00	0.88	1.16	1.34	1.57	1.78	1.99
48.00	0.87	1.14	1.32	1.54	1.76	1.96
49.00	0.86	1.13	1.30	1.52	1.74	1.94
50.00	0.85	1.11	1.29	1.50	1.71	1.91
51.00	0.84	1.10	1.27	1.48	1.69	1.89
52.00	0.82	1.08	1.25	1.47	1.67	1.86
53.00	0.81	1.07	1.24	1.45	1.65	1.84
54.00	0.80	1.06	1.22	1.43	1.63	1.81
55.00	0.79	1.04	1.21	1.41	1.61	1.79
56.00	0.79	1.03	1.19	1.39	1.59	1.77
57.00	0.78	1.02	1.18	1.38	1.57	1.75
58.00	0.77	1.01	1.17	1.36	1.55	1.73
59.00	0.76	0.99	1.15	1.35	1.53	1.71
60.00	0.75	0.98	1.14	1.33	1.52	1.69
61.00	0.74	0.97	1.13	1.32	1.50	1.67
62.00	0.73	0.96	1.11	1.30	1.48	1.65
63.00	0.73	0.95	1.10	1.29	1.47	1.64
64.00	0.72	0.94	1.09	1.27	1.45	1.62
65.00	0.71	0.93	1.08	1.26	1.44	1.60
66.00	0.70	0.92	1.07	1.25	1.42	1.58
67.00	0.70	0.91	1.06	1.23	1.41	1.57
68.00	0.69	0.90	1.05	1.22	1.39	1.55
69.00	0.68	0.89	1.04	1.21	1.38	1.54
70.00	0.67	0.89	1.03	1.20	1.37	1.52
71.00	0.67	0.88	1.02	1.19	1.35	1.51
72.00	0.66	0.87	1.01	1.18	1.34	1.49
73.00	0.66	0.86	1.00	1.16	1.33	1.48
74.00	0.65	0.85	0.99	1.15	1.31	1.46
75.00	0.64	0.84	0.98	1.14	1.30	1.45
76.00	0.64	0.84	0.97	1.13	1.29	1.44
77.00	0.63	0.83	0.96	1.12	1.28	1.42
78.00	0.63	0.82	0.95	1.11	1.27	1.41
79.00	0.62	0.81	0.94	1.10	1.26	1.40
80.00	0.61	0.81	0.93	1.09	1.24	1.39
81.00	0.61	0.80	0.93	1.08	1.23	1.38
82.00	0.60	0.79	0.92	1.07	1.22	1.36
83.00	0.60	0.79	0.91	1.06	1.21	1.35
84.00	0.59	0.78	0.90	1.06	1.20	1.34

85.00	0.59	0.77	0.90	1.05	1.19	1.33
86.00	0.58	0.77	0.89	1.04	1.18	1.32
87.00	0.58	0.76	0.88	1.03	1.17	1.31
88.00	0.58	0.75	0.87	1.02	1.16	1.30
89.00	0.57	0.75	0.87	1.01	1.15	1.29
90.00	0.57	0.74	0.86	1.01	1.15	1.28
91.00	0.56	0.74	0.85	1.00	1.14	1.27
92.00	0.56	0.73	0.85	0.99	1.13	1.26
93.00	0.55	0.73	0.84	0.98	1.12	1.25
94.00	0.55	0.72	0.83	0.97	1.11	1.24
95.00	0.54	0.71	0.83	0.97	1.10	1.23
96.00	0.54	0.71	0.82	0.96	1.09	1.22
97.00	0.54	0.70	0.82	0.95	1.09	1.21
98.00	0.53	0.70	0.81	0.95	1.08	1.20
99.00	0.53	0.69	0.80	0.94	1.07	1.19
100.00	0.53	0.69	0.80	0.93	1.06	1.18
101.00	0.52	0.68	0.79	0.93	1.06	1.18
102.00	0.52	0.68	0.79	0.92	1.05	1.17
103.00	0.51	0.67	0.78	0.91	1.04	1.16
104.00	0.51	0.67	0.78	0.91	1.03	1.15
105.00	0.51	0.67	0.77	0.90	1.03	1.14
106.00	0.50	0.66	0.77	0.89	1.02	1.14
107.00	0.50	0.66	0.76	0.89	1.01	1.13
108.00	0.50	0.65	0.76	0.88	1.01	1.12
109.00	0.49	0.65	0.75	0.88	1.00	1.11
110.00	0.49	0.64	0.75	0.87	0.99	1.11
111.00	0.49	0.64	0.74	0.87	0.99	1.10
112.00	0.48	0.64	0.74	0.86	0.98	1.09
113.00	0.48	0.63	0.73	0.85	0.97	1.09
114.00	0.48	0.63	0.73	0.85	0.97	1.08
115.00	0.47	0.62	0.72	0.84	0.96	1.07
116.00	0.47	0.62	0.72	0.84	0.96	1.06
117.00	0.47	0.62	0.71	0.83	0.95	1.06
118.00	0.47	0.61	0.71	0.83	0.94	1.05
119.00	0.46	0.61	0.70	0.82	0.94	1.05
120.00	0.46	0.60	0.70	0.82	0.93	1.04
121.00	0.46	0.60	0.70	0.81	0.93	1.03
122.00	0.46	0.60	0.69	0.81	0.92	1.03
123.00	0.45	0.59	0.69	0.80	0.92	1.02
124.00	0.45	0.59	0.68	0.80	0.91	1.01
125.00	0.45	0.59	0.68	0.79	0.91	1.01
126.00	0.44	0.58	0.68	0.79	0.90	1.00
127.00	0.44	0.58	0.67	0.79	0.89	1.00
128.00	0.44	0.58	0.67	0.78	0.89	0.99
129.00	0.44	0.57	0.66	0.78	0.88	0.99
130.00	0.43	0.57	0.66	0.77	0.88	0.98
131.00	0.43	0.57	0.66	0.77	0.87	0.97
132.00	0.43	0.56	0.65	0.76	0.87	0.97
133.00	0.43	0.56	0.65	0.76	0.87	0.96
134.00	0.43	0.56	0.65	0.75	0.86	0.96

135.00	0.42	0.55	0.64	0.75	0.86	0.95
136.00	0.42	0.55	0.64	0.75	0.85	0.95
137.00	0.42	0.55	0.64	0.74	0.85	0.94
138.00	0.42	0.55	0.63	0.74	0.84	0.94
139.00	0.41	0.54	0.63	0.74	0.84	0.93
140.00	0.41	0.54	0.63	0.73	0.83	0.93
141.00	0.41	0.54	0.62	0.73	0.83	0.92
142.00	0.41	0.53	0.62	0.72	0.82	0.92
143.00	0.41	0.53	0.62	0.72	0.82	0.91
144.00	0.40	0.53	0.61	0.72	0.82	0.91
145.00	0.40	0.53	0.61	0.71	0.81	0.91
146.00	0.40	0.52	0.61	0.71	0.81	0.90
147.00	0.40	0.52	0.60	0.71	0.80	0.90
148.00	0.40	0.52	0.60	0.70	0.80	0.89
149.00	0.39	0.52	0.60	0.70	0.80	0.89
150.00	0.39	0.51	0.59	0.70	0.79	0.88
151.00	0.39	0.51	0.59	0.69	0.79	0.88
152.00	0.39	0.51	0.59	0.69	0.78	0.87
153.00	0.39	0.51	0.59	0.69	0.78	0.87
154.00	0.38	0.50	0.58	0.68	0.78	0.87
155.00	0.38	0.50	0.58	0.68	0.77	0.86
156.00	0.38	0.50	0.58	0.68	0.77	0.86
157.00	0.38	0.50	0.58	0.67	0.77	0.85
158.00	0.38	0.49	0.57	0.67	0.76	0.85
159.00	0.37	0.49	0.57	0.67	0.76	0.85
160.00	0.37	0.49	0.57	0.66	0.76	0.84
161.00	0.37	0.49	0.56	0.66	0.75	0.84
162.00	0.37	0.49	0.56	0.66	0.75	0.83
163.00	0.37	0.48	0.56	0.65	0.75	0.83
164.00	0.37	0.48	0.56	0.65	0.74	0.83
165.00	0.36	0.48	0.55	0.65	0.74	0.82
166.00	0.36	0.48	0.55	0.65	0.74	0.82
167.00	0.36	0.47	0.55	0.64	0.73	0.82
168.00	0.36	0.47	0.55	0.64	0.73	0.81
169.00	0.36	0.47	0.54	0.64	0.73	0.81
170.00	0.36	0.47	0.54	0.63	0.72	0.81
171.00	0.36	0.47	0.54	0.63	0.72	0.80
172.00	0.35	0.46	0.54	0.63	0.72	0.80
173.00	0.35	0.46	0.54	0.63	0.71	0.79
174.00	0.35	0.46	0.53	0.62	0.71	0.79
175.00	0.35	0.46	0.53	0.62	0.71	0.79
176.00	0.35	0.46	0.53	0.62	0.70	0.78
177.00	0.35	0.45	0.53	0.62	0.70	0.78
178.00	0.34	0.45	0.52	0.61	0.70	0.78
179.00	0.34	0.45	0.52	0.61	0.70	0.77
180.00	0.34	0.45	0.52	0.61	0.69	0.77

APPENDIX D: Hydraulic Calculations

Catch Basin Sizing

Pipe Sizing

Hydraulic Analysis Report

Project Data

Project Title: ASHT-001

Designer: KL

Project Date: Wednesday, March 3, 2021

Project Units: U.S. Customary Units

Notes:

Curb and Gutter Analysis: DMA-A_CB

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0050 ft/ft

Cross-Slope of Pavement: 0.0200 ft/ft

Depressed Gutter Geometry

Cross-Slope of Gutter: 0.0833 ft/ft

Manning's n: 0.0150

Gutter Width: 1.5000 ft

Design Flow: 3.7000 cfs

Gutter Result Parameters

Width of Spread: 12.6056 ft

Gutter Depression: 1.1394 in

Area of Flow: 1.6602 ft²

E_o (Gutter Flow to Total Flow): 0.3550

Gutter Depth at Curb: 4.1647 in

Inlet Input Parameters

Inlet Location: Inlet in Sag

Percent Clogging: 0.0000 %

Inlet Type: Curb Opening

Length of Inlet: 4.0000 ft

Curb opening height: 6.0000 in

Local Depression: 0.0000 in

Inlet Result Parameters

Perimeter: 4.0000 ft

Effective Perimeter: 4.0000 ft

Area: 2.0000 ft²

Effective Area: 2.0000 ft²

Depth at curb face (upstream of local depression): 0.4564 ft

Computed Width of Spread at Sag: 18.0726 ft

Flow type: Weir Flow

Efficiency: 1.0000

Curb and Gutter Analysis: DMA-B_CB

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0050 ft/ft

Cross-Slope of Pavement: 0.0200 ft/ft

Depressed Gutter Geometry

Cross-Slope of Gutter: 0.0833 ft/ft

Manning's n: 0.0150

Gutter Width: 1.5000 ft

Design Flow: 3.3800 cfs

Gutter Result Parameters

Width of Spread: 12.1513 ft

Gutter Depression: 1.1394 in

Area of Flow: 1.5478 ft²

E_o (Gutter Flow to Total Flow): 0.3684

Gutter Depth at Curb: 4.0557 in

Inlet Input Parameters

Inlet Location: Inlet in Sag

Percent Clogging: 0.0000 %

Inlet Type: Curb Opening

Length of Inlet: 4.0000 ft

Curb opening height: 6.0000 in

Local Depression: 0.0000 in

Inlet Result Parameters

Perimeter: 4.0000 ft

Effective Perimeter: 4.0000 ft

Area: 2.0000 ft²

Effective Area: 2.0000 ft²

Depth at curb face (upstream of local depression): 0.4297 ft

Computed Width of Spread at Sag: 16.7371 ft

Flow type: Weir Flow

Efficiency: 1.0000

Channel Analysis: 18" Storm Drain Pipe

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 1.5000 ft

Longitudinal Slope: 0.0050 ft/ft

Manning's n: 0.0130

Flow: 7.0800 cfs

Result Parameters

Depth: 1.1708 ft

Area of Flow: 1.4798 ft²

Wetted Perimeter: 3.2496 ft

Hydraulic Radius: 0.4554 ft

Average Velocity: 4.7843 ft/s

Top Width: 1.2417 ft

Froude Number: 0.7723

Critical Depth: 1.0298 ft

Critical Velocity: 5.4744 ft/s

Critical Slope: 0.0068 ft/ft

Critical Top Width: 1.39 ft

Calculated Max Shear Stress: 0.3653 lb/ft²

Calculated Avg Shear Stress: 0.1421 lb/ft²

APPENDIX E: References

USDA Soil Map

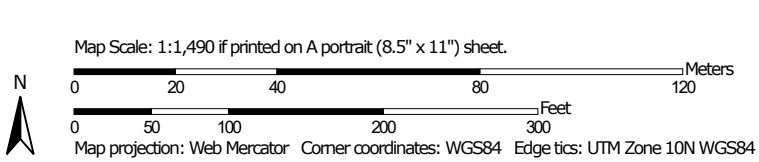
FEMA Flood Map

NOAA Precipitation

Soil Map—Marin County, California
(ASHT-001 Soil Map)



Soil Map may not be valid at this scale.





MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)

Soils

 Soil Map Unit Polygons

 Soil Map Unit Lines

 Soil Map Unit Points

Special Point Features



Blowout



Borrow Pit



Clay Spot



Closed Depression



Gravel Pit



Gravelly Spot



Landfill



Lava Flow



Marsh or swamp



Mine or Quarry



Miscellaneous Water



Perennial Water



Rock Outcrop



Saline Spot



Sandy Spot



Severely Eroded Spot



Sinkhole



Slide or Slip



Sodic Spot



Spoil Area



Stony Spot



Very Stony Spot



Wet Spot



Other



Special Line Features

Water Features



Streams and Canals

Transportation



Rails



Interstate Highways



US Routes



Major Roads



Local Roads

Background



Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service

Web Soil Survey URL:

Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Marin County, California

Survey Area Data: Version 14, May 29, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 22, 2019—Apr 25, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
202	Urban land-Xerorthents complex, 0 to 9 percent slopes	4.4	100.0%
Totals for Area of Interest		4.4	100.0%

Marin County, California

202—Urban land-Xerorthents complex, 0 to 9 percent slopes

Map Unit Setting

National map unit symbol: hf4d

Elevation: 0 to 500 feet

Mean annual precipitation: 20 to 30 inches

Mean annual air temperature: 55 to 63 degrees F

Frost-free period: 270 to 350 days

Farmland classification: Not prime farmland

Map Unit Composition

Urban land: 70 percent

Xerorthents and similar soils: 20 percent

Minor components: 9 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting

Landform: Valley floors

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Base slope

Down-slope shape: Linear

Across-slope shape: Linear

Interpretive groups

Land capability classification (irrigated): 8

Land capability classification (nonirrigated): 8

Hydric soil rating: No

Description of Xerorthents

Setting

Landform: Tidal flats, valley floors

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Base slope, tread

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Earth spread deposits derived from igneous, metamorphic and sedimentary rock

Properties and qualities

Slope: 0 to 9 percent

Depth to restrictive feature: More than 80 inches

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Interpretive groups

Land capability classification (irrigated): 8s

Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Minor Components

Hydraquents

Percent of map unit: 2 percent
Landform: Tidal flats
Landform position (two-dimensional): Backslope
Hydric soil rating: Yes

Reyes

Percent of map unit: 1 percent
Landform: Salt marshes
Landform position (two-dimensional): Backslope
Hydric soil rating: Yes

Blucher

Percent of map unit: 1 percent
Hydric soil rating: No

Slopes more than 9 percent

Percent of map unit: 1 percent
Hydric soil rating: No

Cole

Percent of map unit: 1 percent
Hydric soil rating: No

Unnamed, briefly flooded soils

Percent of map unit: 1 percent
Hydric soil rating: No

Ballard

Percent of map unit: 1 percent
Hydric soil rating: No

Novato

Percent of map unit: 1 percent
Landform: Salt marshes
Landform position (two-dimensional): Backslope
Hydric soil rating: Yes

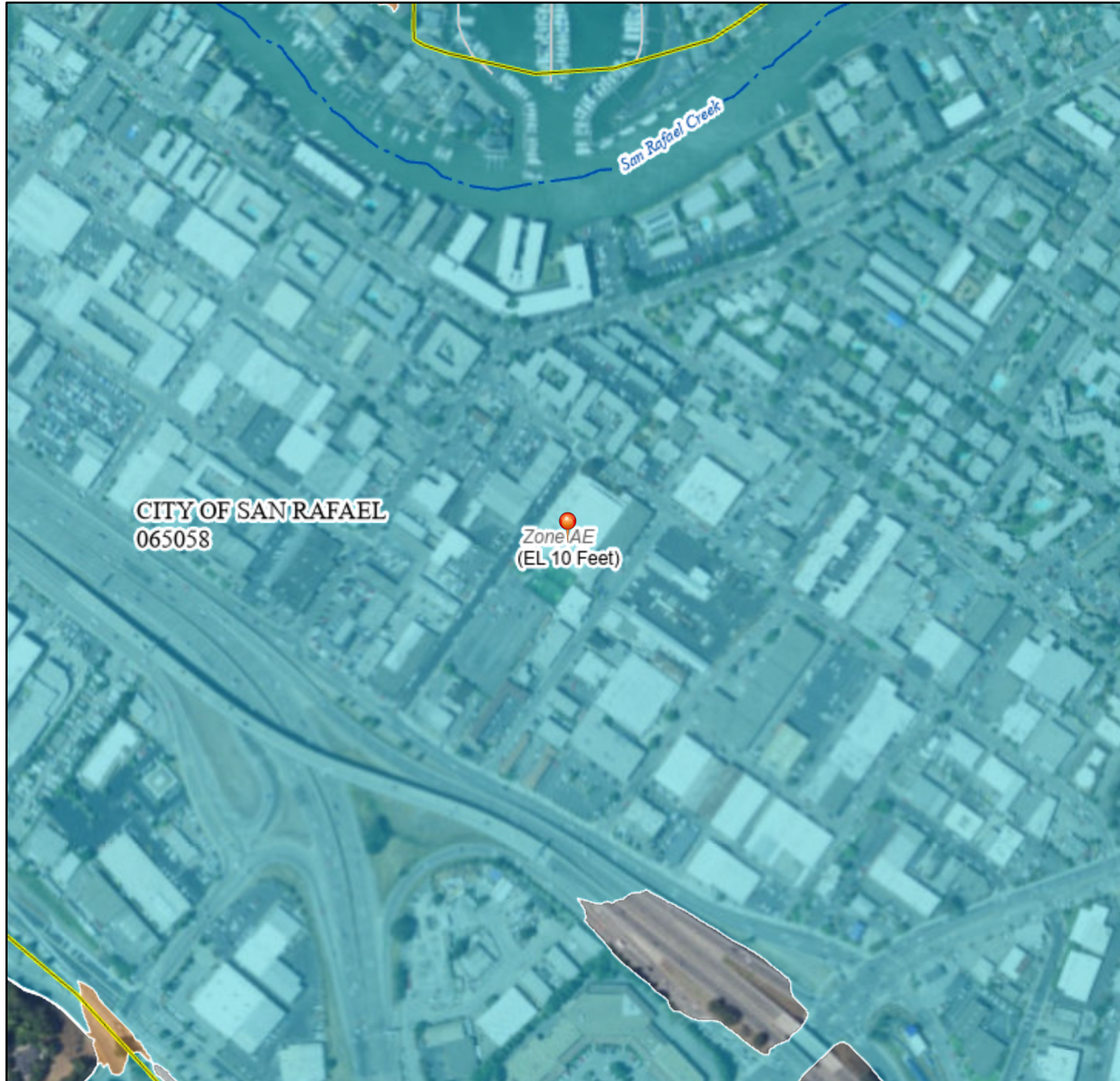
Data Source Information

Soil Survey Area: Marin County, California
Survey Area Data: Version 14, May 29, 2020

National Flood Hazard Layer FIRMette



122°30'46"W 37°58'4"N



0 250 500 1,000 1,500 2,000 Feet 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		20.2 Cross Sections with 1% Annual Chance
		17.5 Water Surface Elevation
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
OTHER FEATURES		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature

MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped

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 2/16/2021 at 12:19 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.





NOAA Atlas 14, Volume 6, Version 2
Location name: San Rafael, California, USA*
Latitude: 37.9638°, Longitude: -122.5075°
Elevation: 5.67 ft**



* source: ESRI Maps
 ** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Tryppaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

[PF_tabular](#) | [PF_graphical](#) | [Maps_&_aerials](#)

PF tabular

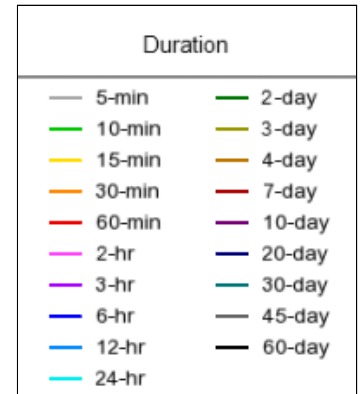
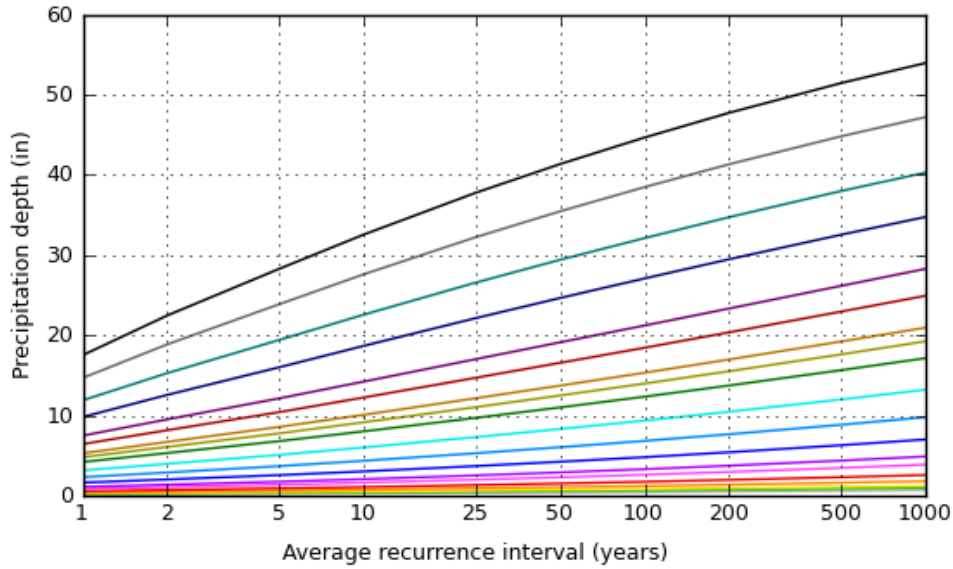
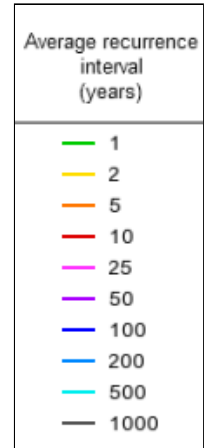
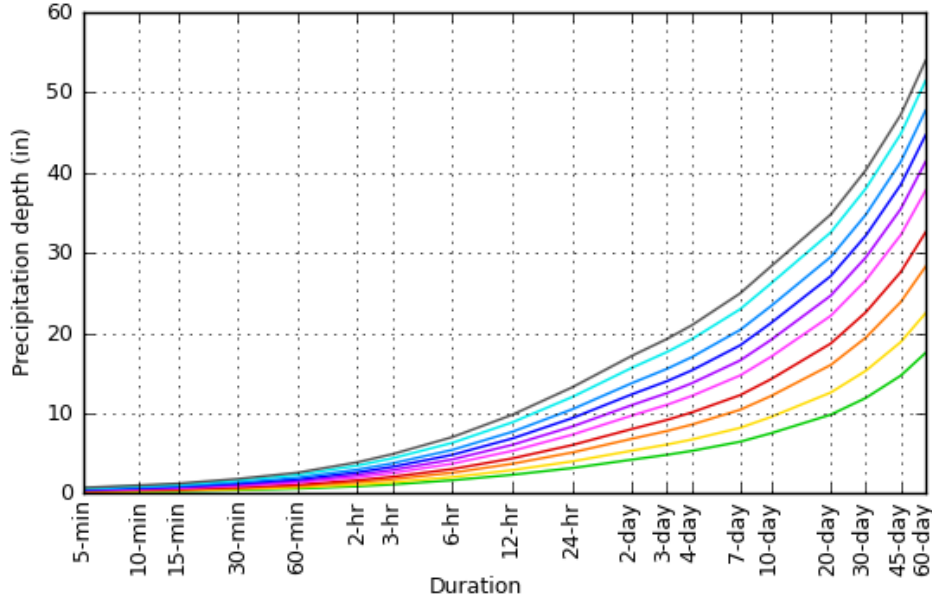
PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.159 (0.142-0.180)	0.197 (0.175-0.224)	0.250 (0.222-0.285)	0.296 (0.260-0.341)	0.363 (0.306-0.435)	0.417 (0.343-0.513)	0.476 (0.380-0.602)	0.539 (0.417-0.705)	0.631 (0.464-0.867)	0.706 (0.499-1.01)
10-min	0.228 (0.203-0.258)	0.283 (0.251-0.321)	0.359 (0.318-0.409)	0.425 (0.373-0.489)	0.520 (0.439-0.623)	0.598 (0.492-0.735)	0.682 (0.545-0.863)	0.773 (0.597-1.01)	0.904 (0.665-1.24)	1.01 (0.715-1.45)
15-min	0.276 (0.246-0.313)	0.342 (0.304-0.388)	0.434 (0.385-0.494)	0.514 (0.451-0.591)	0.629 (0.530-0.753)	0.724 (0.595-0.889)	0.825 (0.659-1.04)	0.935 (0.722-1.22)	1.09 (0.804-1.50)	1.22 (0.864-1.75)
30-min	0.407 (0.363-0.461)	0.504 (0.449-0.572)	0.640 (0.568-0.729)	0.758 (0.665-0.872)	0.928 (0.783-1.11)	1.07 (0.878-1.31)	1.22 (0.972-1.54)	1.38 (1.07-1.81)	1.61 (1.19-2.22)	1.81 (1.27-2.58)
60-min	0.582 (0.518-0.659)	0.721 (0.641-0.818)	0.915 (0.812-1.04)	1.08 (0.951-1.25)	1.33 (1.12-1.59)	1.53 (1.25-1.88)	1.74 (1.39-2.20)	1.97 (1.52-2.58)	2.31 (1.70-3.17)	2.58 (1.82-3.69)
2-hr	0.872 (0.777-0.988)	1.08 (0.962-1.23)	1.38 (1.22-1.57)	1.63 (1.43-1.87)	2.00 (1.68-2.39)	2.30 (1.89-2.82)	2.62 (2.09-3.31)	2.97 (2.29-3.88)	3.47 (2.55-4.76)	3.88 (2.74-5.55)
3-hr	1.11 (0.988-1.26)	1.38 (1.22-1.56)	1.75 (1.55-1.99)	2.07 (1.81-2.38)	2.53 (2.13-3.03)	2.90 (2.39-3.57)	3.31 (2.64-4.18)	3.75 (2.89-4.90)	4.37 (3.22-6.01)	4.89 (3.45-7.00)
6-hr	1.63 (1.45-1.85)	2.03 (1.80-2.30)	2.57 (2.28-2.92)	3.03 (2.66-3.49)	3.70 (3.12-4.43)	4.23 (3.48-5.20)	4.80 (3.84-6.08)	5.42 (4.19-7.09)	6.30 (4.63-8.65)	7.01 (4.95-10.0)
12-hr	2.31 (2.06-2.62)	2.90 (2.58-3.29)	3.69 (3.27-4.20)	4.35 (3.82-5.01)	5.29 (4.46-6.34)	6.05 (4.97-7.43)	6.83 (5.46-8.64)	7.67 (5.93-10.0)	8.85 (6.51-12.2)	9.79 (6.92-14.0)
24-hr	3.15 (2.84-3.57)	3.98 (3.58-4.51)	5.09 (4.57-5.79)	6.02 (5.36-6.89)	7.31 (6.32-8.62)	8.32 (7.06-10.0)	9.37 (7.78-11.5)	10.5 (8.48-13.2)	12.0 (9.36-15.7)	13.2 (9.98-17.9)
2-day	4.20 (3.78-4.76)	5.32 (4.78-6.03)	6.80 (6.10-7.74)	8.02 (7.15-9.19)	9.70 (8.39-11.5)	11.0 (9.34-13.2)	12.4 (10.3-15.2)	13.7 (11.1-17.3)	15.7 (12.2-20.5)	17.2 (13.0-23.2)
3-day	4.80 (4.32-5.44)	6.08 (5.47-6.90)	7.77 (6.97-8.84)	9.15 (8.15-10.5)	11.0 (9.55-13.0)	12.5 (10.6-15.0)	14.0 (11.6-17.2)	15.5 (12.6-19.6)	17.6 (13.7-23.1)	19.3 (14.5-26.0)
4-day	5.29 (4.76-6.00)	6.71 (6.04-7.61)	8.57 (7.69-9.75)	10.1 (8.99-11.6)	12.1 (10.5-14.3)	13.7 (11.6-16.5)	15.3 (12.7-18.9)	17.0 (13.8-21.4)	19.2 (15.0-25.2)	21.0 (15.8-28.3)
7-day	6.44 (5.80-7.30)	8.17 (7.34-9.27)	10.4 (9.35-11.9)	12.2 (10.9-14.0)	14.7 (12.7-17.4)	16.6 (14.1-19.9)	18.5 (15.3-22.7)	20.4 (16.5-25.7)	23.0 (17.9-30.1)	24.9 (18.8-33.7)
10-day	7.49 (6.74-8.49)	9.52 (8.56-10.8)	12.1 (10.9-13.8)	14.2 (12.7-16.3)	17.0 (14.7-20.1)	19.1 (16.2-23.0)	21.2 (17.6-26.1)	23.3 (18.9-29.4)	26.2 (20.4-34.3)	28.3 (21.4-38.2)
20-day	9.81 (8.83-11.1)	12.6 (11.3-14.3)	16.0 (14.4-18.2)	18.7 (16.6-21.4)	22.1 (19.1-26.1)	24.7 (20.9-29.7)	27.1 (22.5-33.3)	29.5 (23.9-37.2)	32.6 (25.4-42.6)	34.8 (26.3-47.0)
30-day	11.9 (10.7-13.5)	15.3 (13.7-17.3)	19.4 (17.4-22.1)	22.6 (20.1-25.9)	26.6 (23.0-31.4)	29.4 (25.0-35.4)	32.1 (26.7-39.5)	34.7 (28.1-43.8)	38.0 (29.6-49.7)	40.3 (30.4-54.4)
45-day	14.7 (13.2-16.6)	18.9 (17.0-21.4)	23.9 (21.4-27.1)	27.6 (24.6-31.6)	32.2 (27.9-38.0)	35.5 (30.1-42.7)	38.5 (31.9-47.3)	41.3 (33.5-52.1)	44.8 (34.9-58.7)	47.2 (35.7-63.8)
60-day	17.5 (15.8-19.9)	22.5 (20.2-25.5)	28.3 (25.4-32.2)	32.6 (29.0-37.3)	37.8 (32.7-44.6)	41.4 (35.1-49.7)	44.7 (37.1-54.9)	47.8 (38.6-60.2)	51.5 (40.1-67.4)	54.0 (40.8-72.9)

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

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PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 37.9638°, Longitude: -122.5075°



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Maps & aeriels

Small scale terrain



Large scale terrain



Large scale map



Large scale aerial



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