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Hydraulic Analysis

Cardey Residence Driveway Repair Use Permit Exception to
the Conservation Regulations, #P18-00116-UP &
Request for Exception to Road and Street Standards
Planning Commission Hearing June 20, 2018

HYDRAULIC ANALYSIS FOR THE CARDEY DRIVEWAY REPAIR 1100 MCCORMICK LANE NAPA COUNTY, CA APN 050-270-009

Prepared For:

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Principal Engineer

February 2018
Job No. 17-04

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HYDRAULIC ANALYSIS FOR THE CARDEY DRIVEWAY REPAIR 1100 MCCORMICK LANE, NAPA COUNTY, CA APN 050-270-009

As requested by the San Francisco Bay Regional Water Quality Control Board (SFRWQCB), Bartelt Engineering has prepared a storm drain Hydraulic Analysis for the driveway repair project to verify that the existing and proposed storm drain improvements are adequately sized to convey peak storm water runoff from the proposed driveway repair and contributing watersheds.

PROJECT DESCRIPTION

The 14.95± acre subject parcel is currently developed with an existing residence, driveway, parking area, landscape, grassland and forested areas. The proposed project will consist of the removal of a portion of the existing driveway that was compromised as a result of a landslide in February 2017. This section of the driveway will be reconstructed to the greatest extent practicable outside of the slide area. Approximately 320± lineal feet of the existing driveway damaged as a result of the landslide will be removed from the slide area and realigned. The area compromised by the landslide will be contoured to eliminate ponding and the concentration of stormwater and to encourage sheet flow of stormwater runoff to the greatest extent practicable. In addition, approximately 350± lineal feet of the existing driveway above the slide area will be reconstructed to provide a smooth transition from the realigned section of driveway to the existing driveway that serves the existing residence. The addition of road side drainage swales, storm drain pipes and catch basins are proposed as a part of the proposed driveway repair.

EXHIBITS

The attached Watershed Exhibit shows the approximate extent of the watershed areas that direct stormwater runoff towards the proposed driveway repair and associated storm drain improvements. The watershed areas were developed using Napa County Geographic Information System Maps of the Napa River Watershed with five (5) foot contour intervals.

SITE FEATURES

Slopes within the watershed areas range from three (3) percent and thirty (30) percent. According to the NRCS Soil Report, the soil type found within the watershed areas is primarily Fagan Clay Loam (map symbol 132, Hydrologic Soil Group "C").

METHODOLOGY

This study utilizes the Rational Method to calculate the potential stormwater runoff flow rates from each of the watershed areas for the 10 year and 100 year storm events. This methodology requires the identification of rainfall intensities, time of concentration (T_c) and watershed area characteristics.

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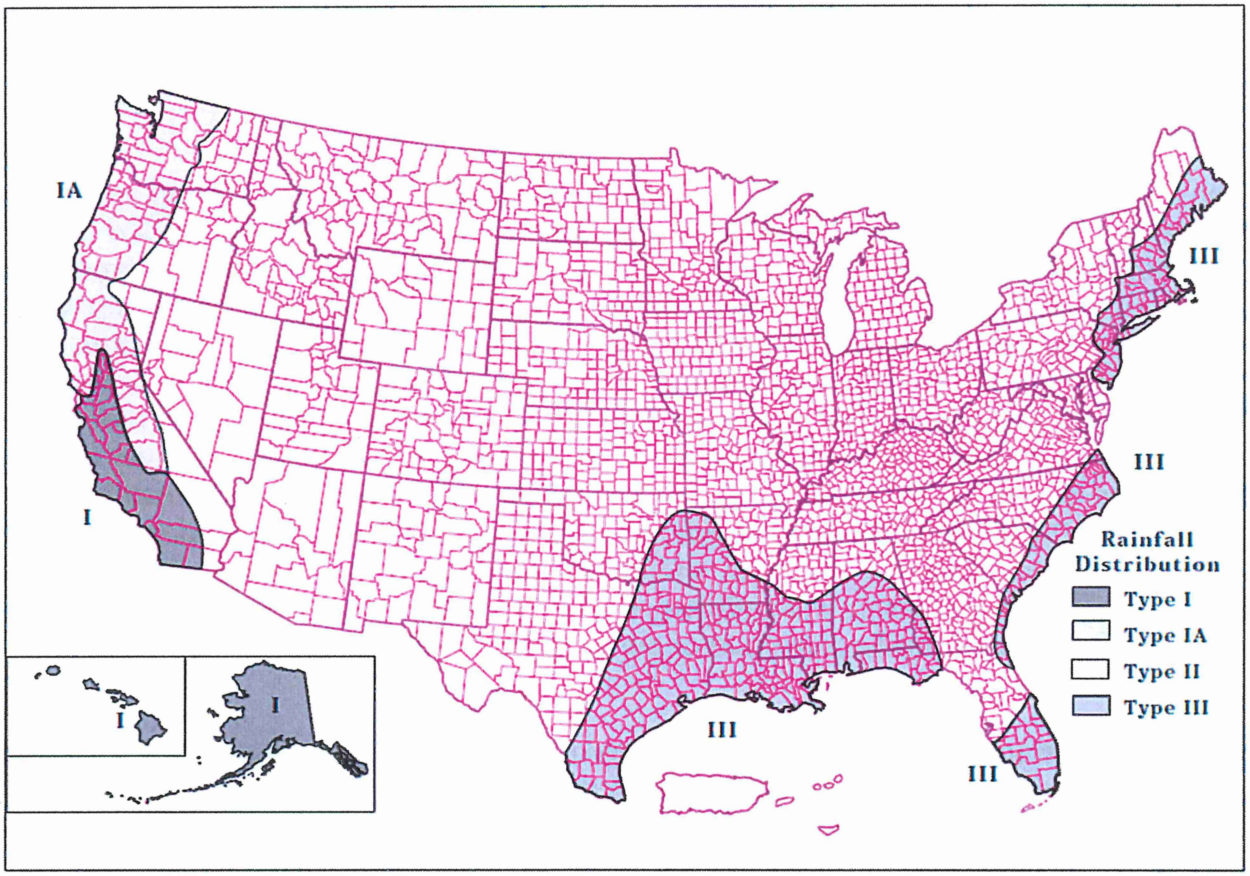
RAINFALL

Rainfall data used in the analysis includes four (4) regional rainfall time distributions (Types I, IA, II, and III) all over a 24-hr period. The rainfall distributions are based on geographic boundaries which are shown on the following figure:

FIGURE 1: APPROXIMATE GEOGRAPHIC BOUNDARIES FOR RAINFALL DISTRIBUTIONS



The 24-hr rainfall data utilized in this analysis are based on point precipitation frequency estimations provided by National Oceanic Atmosphere Administration (NOAA)[1] for a Type 1A rainfall distribution. The table below summarizes the precipitation (rainfall) over various storm recurrence intervals (storm frequency):

TABLE 1: RAINFALL DATA FOR A 24-HR PERIOD		
Storm Frequency:	10-Yr	100-Yr
Rainfall (in):	4.97	7.57

See the attached rainfall distribution for further information.

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS) from NOAA Atlas 14, Volume 6, Version 2; location name: Napa, CA, US, latitude: 38.302°, longitude: -122.3307° and elevation: 241.5 ft.

TIME OF CONCENTRATION

The time of concentration (Tc) represents the time it takes for stormwater runoff to travel to a point of interest from the hydraulically most distant point. The Kirpich Method was used to determine the time of concentration for small drainage basins that are dominated by channel flow with a minimum time of concentration of 10 minutes and is defined as the following equation.

$$T_c = 0.078\left(\frac{L^{3/2}}{H^{1/2}}\right)^{0.77} + 10_{minutes}$$

Where:

T_c = time of concentration (minutes)

L = length of main channel (feet)

H = relief along main channel (feet)

A time of concentration was determined for the entire watershed and storm drain system based on the site conditions with the proposed driveway and storm drain improvements as described below.

Site Conditions

Watershed Area 1 consists of 1.40± acres of woodland coverage and 0.05± acres of asphalt pavement with an overall watershed average slope of 19±%.

Watershed Area 2 consists of 2.09± acres of woodland coverage and 0.04± acres of asphalt pavement with an overall watershed average slope of 18±%.

Watershed Area 3 consists of 0.13± acres of grass with some woodland coverage and 0.04± acres of asphalt pavement with an overall watershed average slope of 30±%.

Watershed Area 4 consists of 0.03± acres of grass coverage with an overall watershed average slope of 26±%.

RUNOFF COEFFICIENTS

As part of the analysis, the watershed areas are evaluated based on the topography relief, soil infiltration, vegetated cover and surface per attached Figure 3[2]. A runoff factor is assigned based on the land characteristics and runoff producing features. A runoff coefficient is an empirical value which aids in predicting storm water runoff or infiltration. A lower coefficient means a lower potential for runoff and a higher coefficient means a higher potential for runoff.

The watershed area coefficients are shown on the attached calculation sheets and summarized in the following table:

[2] 2017 Napa County Road and Street Standards, Revised September 26, 2017

TABLE 2: CALCULATED RUNOFF COEFFICIENT SUMMARY		
Watershed Area	Area (acres)	Runoff Coefficient
1A	1.45	.52
1B	0.05	.90
2A	2.13	.52
2B	0.04	.90
3A	0.17	.56
3B	0.04	.90
4	0.03	.60

The site conditions, watershed areas, storm drain system and runoff coefficients are then used to calculate the Tc in order to determine the rainfall intensity and stormwater runoff for the site. The rainfall intensity based on the calculated Tc is summarized in the following table:

TABLE 3: RAINFALL DATA FOR A TC OF 10-MINUTES		
Storm Frequency:	10 Year	100 Year
Rainfall (in/hr):	2.05	3.16

STORMWATER RUNOFF RESULTS

The stormwater runoff for each of the watersheds is calculated using the following Rational Formula.

$$Q = CIA$$

Where:

Q = the peak rate of runoff (cfs)[3]

C = runoff coefficient – a non-dimensional coefficient equal to the ratio of runoff volume to rainfall volume

I = average intensity of rainfall for a duration equal to the time of concentration

[3] Cubic feet per second

A = tributary area (acres)

The calculated 10 year and 100 year peak runoff flow rate at the point of concentration for the drainage areas are shown on the attached calculations sheets, the maximum runoff flow rates are summarized in the following table:

TABLE 4: STORMWATER RUNOFF RESULTS

Watershed Area	Rainfall Runoff per Storm Event (cfs)	
	10 Year	100 Year
1A	1.49	2.30
1B	0.09	0.14
2A	2.23	3.43
2B	0.07	0.11
3A	0.15	0.23
3B	0.07	0.11
4	0.04	0.06

STORM DRAIN COMPARISON

The stormwater conveyed by the storm drain system is the amount of calculated stormwater runoff for the watershed based on the total Tc of the system. The maximum stormwater conveyance for each culvert associated with a particular inlet structure is shown on the attached calculations sheets and is summarized in the following table for a 100-year storm event.

TABLE 5: STORMWATER RUNOFF – 100-YEAR STORM EVENT

	Stormwater Flows (cfs)
Basin	2.42
DI #4	2.53
DI #3	6.23
DI #2	6.28

The stormwater conveyance capacity of the existing and proposed storm drain culverts are based on the pipe's material Roughness Coefficients[4] (n=0.024), the slope of the pipes and using Storm and Sanitary Analysis[5] software to calculate capacities. The culvert capacities associated with a particular inlet structure is summarized in the following table:

TABLE 6: CULVERT CAPACITY

	Culvert Capacity (cfs)
Basin	21.70
DI #4	24.64
DI #3	27.73
DI #2	72.89

CONCLUSIONS

The Hydraulic Analysis results show that both the proposed and existing storm drain system is sufficiently sized to convey the calculated stormwater runoff for the 10 year and 100 year storm events.

ATTACHMENTS

Drainage Report Calculations for Cardey Driveway Repair

Figure 3 – Run-off Producing Characteristics of Watersheds Showing factors for Each Characteristic for various Watershed Types

Rainfall Data

Table 5-6, Values of the Roughness Coefficient (n)

Custom Soil Resource Report for Napa County, California – Cardey Residence

Watershed Exhibit

[4] Table 5-6, Values of the Roughness Coefficient (n)

[5] Autodesk ® Storm and Sanitary Analysis 2016

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REFERENCES

2017 Napa County Road and Street Standards, Revised September 26, 2017

Chow, Ven Te. Open-Channel Hydraulics, 1959. McGraw-Hill Book Company, New York (page 110-113 Table 5-6 Values of Roughness Coefficient, n)

U.S. Department of Agriculture, Natural Resources Conservation Service, Web Soil Survey https://websoilsurvey.nrcs.usda.gov/app/

Thompson, David B. The Rational Method, September 20, 2006. Civil Engineering Department, Texas Tech University

SOFTWARE

Autodesk ® Storm and Sanitary Analysis 2016 – Version 12.0.42

WATERSHED AREAS AND RUNOFF COEFFICIENTS

		Watershed Areas						
Units	Total	1A	1B	2A	2B	3A	3B	4
Sq.Ft.	164,400	60,879	2,155	91,148	1,600	5,668	1,602	1,348
Acres	3.77	1.40	0.05	2.09	0.04	0.13	0.04	0.03
		Runoff Coefficient Ranges						
Relief:	min	0.20		0.20		0.20		0.20
	max	0.28		0.28		0.28		0.28
Soil Infiltration:	min	0.06		0.06		0.06		0.06
	max	0.08		0.08		0.08		0.08
Vegetal Cover:	min	0.04		0.04		0.06		0.08
	max	0.06		0.06		0.08		0.12
Surface:	min	0.08	0.90	0.08	0.90	0.10	0.90	0.10
	max	0.10	0.90	0.10	0.90	0.12	0.90	0.12
		Calculated Run-off Coefficients						
	min	0.38	0.90	0.38	0.90	0.42	0.90	0.44
	avg	0.45	0.90	0.45	0.90	0.49	0.90	0.52
	max	0.52	0.90	0.52	0.90	0.56	0.90	0.60

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WATERSHED AREAS AND RUNOFF COEFFICIENTS

Watershed Areas

Units	Total	1A	1B	2A	2B	3A	3B	4
Sq.Ft.	164,400	60,879	2,155	91,148	1,600	5,668	1,602	1,348
Acres	3.77	1.40	0.05	2.09	0.04	0.13	0.04	0.03

Runoff Coefficient Ranges

		1A	1B	2A	2B	3A	3B	4
Relief:	min	0.20		0.20		0.20		0.20
	max	0.28		0.28		0.28		0.28
Soil Infiltration:	min	0.06		0.06		0.06		0.06
	max	0.08		0.08		0.08		0.08
Vegetal Cover:	min	0.04		0.04		0.06		0.08
	max	0.06		0.06		0.08		0.12
Surface:	min	0.08	0.90	0.08	0.90	0.10	0.90	0.10
	max	0.10	0.90	0.10	0.90	0.12	0.90	0.12

Calculated Run-off Coefficients

	1A	1B	2A	2B	3A	3B	4
min	0.38	0.90	0.38	0.90	0.42	0.90	0.44
avg	0.45	0.90	0.45	0.90	0.49	0.90	0.52
max	0.52	0.90	0.52	0.90	0.56	0.90	0.60

SUBBASINS (10-YEAR)											
Element ID	Description	Area (acres)	Drainage Node ID	Weighted Runoff Coefficient	Average Slope (%)	Flow Length (ft)	Accumulated Precipitation (inches)	Total Runoff (inches)	Peak Runoff (cfs)	Rainfall Intensity (inches/hr)	Time of Concentration (days hh:mm:ss)
Sub-1A		1.4	Riser#1	0.52	19.6	510	0.34	0.18	1.49	2.05	0 00:10:00
Sub-1B	Driveway	0.05	Riser#1	0.9	12.5	180	0.34	0.31	0.09	2.05	0 00:10:00
Sub-2A		2.09	DI#3	0.52	18.3	640	0.34	0.18	2.23	2.05	0 00:10:00
Sub-2B	Driveway	0.04	DI#4	0.9	15.05	160	0.34	0.31	0.07	2.05	0 00:10:00
Sub-3A		0.13	DI#3	0.56	30	140	0.34	0.19	0.15	2.05	0 00:10:00
Sub-3B	Driveway	0.04	DI#3	0.9	20	120	0.34	0.31	0.07	2.05	0 00:10:00
Sub-4		0.03	DI#2	0.6	26	50	0.34	0.21	0.04	2.05	0 00:10:00

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JUNCTIONS (10-YEAR)																						
Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft²)	Minimum Pipe Cover (inches)	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Maximum HGL Elevation Attained (ft)	Maximum HGL Depth Attained (ft)	Maximum Surcharge Depth Attained (ft)	Minimum Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Maximum HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-inches)	Total Time Flooded (minutes)
DI#2	153.3	156	2.7	154	0.7	156.6	0.6	10	6	4.07	0.04	154.39	1.09	0	1.61	154	0.7	0 00:10	0 00:00	0	0
DI#3	162.5	168	5.5	162.5	0	168.5	0.5	10	36	4.04	2.45	163.89	1.39	0	4.11	163.5	1	0 00:10	0 00:00	0	0
DI#4	186	191.5	5.5	186	0	192	0.5	10	48	1.64	0.07	186.27	0.27	0	5.23	186	0	0 00:10	0 00:00	0	0
Fitting-01	139	141	2	139	0	141	0	0	0	4.07	0	139.34	0.34	0	1.66	139	0	0 00:10	0 00:00	0	0
Fitting-02	146.06	148.06	2	146.06	0	148.06	0	0	0	4.07	0	146.38	0.32	0	1.68	146.06	0	0 00:10	0 00:00	0	0
Riser#1	210	213	3	210	0	214	1	10	18	1.58	1.58	210.27	0.27	0	2.73	210	0	0 00:10	0 00:00	0	0

PIPES (10-YEAR)

Element ID	From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter (inches)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Max Flow Velocity (ft/sec)	Travel Time (min)	Design Flow Capacity (cfs)	Max Flow / Design Flow Ratio	Max Flow Depth / Total Depth Ratio	Total Time Surcharged (min)	Max Flow Depth (ft)
PIPE-01.01	Fitting-01	Out-01	27.11	139	131	29.51	CIRCULAR	24	0.024	0.5	0.5	0	0	4.07	0 00:10	11.7	0.04	66.57	0.06	0.17	0	0.34
PIPE-01.02	Fitting-02	Fitting-01	15.09	146.06	139	46.79	CIRCULAR	24	0.024	0.5	0.5	0	0	4.07	0 00:10	13.82	0.02	83.82	0.05	0.15	0	0.3
PIPE-01.03	DI#2	Fitting-02	20.46	153.3	146.06	35.39	CIRCULAR	24	0.024	0.5	0.5	0	0	4.07	0 00:10	12.5	0.03	72.89	0.06	0.16	0	0.32
PIPE-02	DI#3	DI#2	40	163.5	154	23.75	CIRCULAR	18	0.024	0.5	0.5	0	0	4.03	0 00:10	11.18	0.06	27.73	0.15	0.26	0	0.39
PIPE-03	DI#4	DI#3	120	186	163.5	18.75	CIRCULAR	18	0.024	0.5	0.5	0	0	1.64	0 00:10	7.97	0.25	24.64	0.07	0.18	0	0.26
PIPE-04	Riser#1	DI#4	165	210	186	14.55	CIRCULAR	18	0.024	0.5	0.5	0	0	1.57	0 00:10	9.07	0.3	21.7	0.07	0.18	0	0.27

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OUTFALLS (10-YEAR)								
Element ID	Invert Elevation (ft)	Boundary Type	Flap Gate	Fixed Water Elevation (ft)	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Maximum HGL Depth Attained (ft)	Maximum HGL Elevation Attained (ft)
Out-01	131.00	FREE	NO		4.07	0.00	0.33	131.33

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SUBBASINS (100-YEAR)											
Element ID	Description	Area (acres)	Drainage Node ID	Weighted Runoff Coefficient	Average Slope (%)	Flow Length (ft)	Accumulated Precipitation (inches)	Total Runoff (inches)	Peak Runoff (cfs)	Rainfall Intensity (inches/hr)	Time of Concentration (days hh:mm:ss)
Sub-1A		1.4	Riser#1	0.52	19.6	510	0.53	0.27	2.3	3.16	0 00:10:00
Sub-1B	Driveway	0.05	Riser#1	0.9	12.5	180	0.53	0.47	0.14	3.16	0 00:10:00
Sub-2A		2.09	DI#3	0.52	18.3	640	0.53	0.27	3.43	3.16	0 00:10:00
Sub-2B	Driveway	0.04	DI#4	0.9	15.05	160	0.53	0.47	0.11	3.16	0 00:10:00
Sub-3A		0.13	DI#3	0.56	30	140	0.53	0.3	0.23	3.16	0 00:10:00
Sub-3B	Driveway	0.04	DI#3	0.9	20	120	0.53	0.47	0.11	3.16	0 00:10:00
Sub-4		0.03	DI#2	0.6	26	50	0.53	0.32	0.06	3.16	0 00:10:00

JUNCTIONS (100-YEAR)																					
Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft²)	Minimum Pipe Cover (inches)	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Maximum HGL Elevation Attained (ft)	Maximum HGL Depth Attained (ft)	Maximum Surcharge Depth Attained (ft)	Minimum Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Maximum HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-inches)	Total Time Flooded (minutes)
DI#2	153.3	156	2.7	154	0.7	156.6	0.6	10	6	6.28	0.06	154.48	1.18	0	1.52	154	0.7	0 00:10	0 00:00	0	0
DI#3	162.5	168	5.5	162.5	0	168.5	0.5	10	36	6.23	3.78	163.98	1.48	0	4.02	163.5	1	0 00:10	0 00:00	0	0
DI#4	186	191.5	5.5	186	0	192	0.5	10	48	2.54	0.11	186.34	0.34	0	5.16	186	0	0 00:10	0 00:00	0	0
Fitting-01	139	141	2	139	0	141	0	0	0	6.28	0	139.41	0.41	0	1.59	139	0	0 00:10	0 00:00	0	0
Fitting-02	146.06	148.06	2	146.06	0	148.06	0	0	0	6.28	0	146.46	0.4	0	1.6	146.06	0	0 00:10	0 00:00	0	0
Riser#1	210	213	3	210	0	214	1	10	18	2.44	2.44	210.34	0.34	0	2.66	210	0	0 00:10	0 00:00	0	0

PIPES (100-YEAR)																					
Element ID	From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter (inches)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Max Flow Velocity (ft/sec)	Travel Time (min)	Design Flow Capacity (cfs)	Max Flow / Design Flow Ratio	Max Flow Depth / Total Depth Ratio	Total Time Surcharged (min)	Max Flow Depth (ft)
PIPE-01.01	Fitting-01	Out-01	27.11	139	131	29.51	CIRCULAR	24	0.024	0.5	0.5	0	0	6.28	0 00:10	13.33	0.03	66.57	0.09	0.21	0	0.41
PIPE-01.02	Fitting-02	Fitting-01	15.09	146.06	139	46.79	CIRCULAR	24	0.024	0.5	0.5	0	0	6.28	0 00:10	15.7	0.02	83.82	0.07	0.19	0	0.37
PIPE-01.03	DI#2	Fitting-02	20.46	153.3	146.06	35.39	CIRCULAR	24	0.024	0.5	0.5	0	0	6.28	0 00:10	14.21	0.02	72.89	0.09	0.2	0	0.4
PIPE-02	DI#3	DI#2	40	163.5	154	23.75	CIRCULAR	18	0.024	0.5	0.5	0	0	6.23	0 00:10	12.66	0.05	27.73	0.22	0.32	0	0.48
PIPE-03	DI#4	DI#3	120	186	163.5	18.75	CIRCULAR	18	0.024	0.5	0.5	0	0	2.53	0 00:10	9.01	0.22	24.64	0.1	0.22	0	0.32
PIPE-04	Riser#1	DI#4	165	210	186	14.55	CIRCULAR	18	0.024	0.5	0.5	0	0	2.42	0 00:10	10.01	0.27	21.7	0.11	0.23	0	0.34

OUTFALLS (100-YEAR)								
Element ID	Invert Elevation (ft)	Boundary Type	Flap Gate	Fixed Water Elevation (ft)	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Maximum HGL Depth Attained (ft)	Maximum HGL Elevation Attained (ft)
Out-01	131.00	FREE	NO		6.28	0.00	0.41	131.41

NOAA Atlas 14, Volume 6, Version 2
Location name: Napa, California, USA*
Latitude: 38.302°, Longitude: -122.3307°
Elevation: 241.57 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 Trypaluk, 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	0.127 (0.113-0.144)	0.159 (0.142-0.181)	0.203 (0.180-0.231)	0.238 (0.209-0.274)	0.288 (0.243-0.344)	0.327 (0.270-0.401)	0.367 (0.294-0.463)	0.410 (0.318-0.533)	0.468 (0.347-0.639)	0.515 (0.367-0.732)
10-min	0.182 (0.162-0.206)	0.228 (0.203-0.259)	0.290 (0.257-0.331)	0.342 (0.300-0.393)	0.413 (0.349-0.494)	0.469 (0.386-0.574)	0.526 (0.422-0.663)	0.587 (0.456-0.764)	0.671 (0.497-0.916)	0.739 (0.526-1.05)
15-min	0.220 (0.196-0.250)	0.276 (0.246-0.314)	0.351 (0.311-0.400)	0.413 (0.363-0.475)	0.499 (0.422-0.597)	0.567 (0.467-0.694)	0.637 (0.510-0.802)	0.710 (0.551-0.924)	0.812 (0.601-1.11)	0.893 (0.636-1.27)
30-min	0.314 (0.279-0.356)	0.394 (0.350-0.448)	0.501 (0.444-0.571)	0.589 (0.517-0.678)	0.712 (0.601-0.852)	0.808 (0.666-0.991)	0.908 (0.728-1.15)	1.01 (0.786-1.32)	1.16 (0.857-1.58)	1.27 (0.907-1.81)
60-min	0.454 (0.404-0.515)	0.570 (0.506-0.647)	0.724 (0.642-0.825)	0.852 (0.748-0.981)	1.03 (0.870-1.23)	1.17 (0.964-1.43)	1.31 (1.05-1.66)	1.47 (1.14-1.91)	1.68 (1.24-2.29)	1.84 (1.31-2.62)
2-hr	0.690 (0.615-0.783)	0.856 (0.761-0.973)	1.08 (0.952-1.23)	1.25 (1.10-1.44)	1.50 (1.27-1.79)	1.69 (1.39-2.07)	1.88 (1.51-2.37)	2.08 (1.62-2.71)	2.36 (1.75-3.22)	2.58 (1.84-3.66)
3-hr	0.883 (0.786-1.00)	1.09 (0.972-1.24)	1.37 (1.21-1.56)	1.59 (1.40-1.83)	1.90 (1.60-2.27)	2.13 (1.76-2.61)	2.37 (1.90-2.99)	2.62 (2.03-3.40)	2.95 (2.18-4.03)	3.22 (2.29-4.56)
6-hr	1.31 (1.16-1.48)	1.63 (1.45-1.85)	2.04 (1.81-2.33)	2.37 (2.08-2.73)	2.82 (2.38-3.38)	3.17 (2.61-3.88)	3.51 (2.81-4.43)	3.87 (3.00-5.03)	4.34 (3.21-5.93)	4.71 (3.35-6.69)
12-hr	1.79 (1.59-2.03)	2.29 (2.04-2.60)	2.93 (2.60-3.34)	3.45 (3.02-3.96)	4.13 (3.49-4.94)	4.65 (3.83-5.69)	5.16 (4.14-6.51)	5.69 (4.41-7.40)	6.39 (4.73-8.72)	6.92 (4.93-9.83)
24-hr	2.42 (2.17-2.74)	3.20 (2.87-3.63)	4.19 (3.76-4.76)	4.97 (4.43-5.70)	6.01 (5.21-7.08)	6.79 (5.79-8.14)	7.57 (6.32-9.25)	8.35 (6.81-10.4)	9.38 (7.39-12.1)	10.2 (7.78-13.6)
2-day	3.14 (2.82-3.56)	4.14 (3.72-4.70)	5.42 (4.86-6.17)	6.44 (5.74-7.37)	7.78 (6.75-9.16)	8.80 (7.49-10.5)	9.80 (8.18-12.0)	10.8 (8.82-13.5)	12.2 (9.59-15.8)	13.2 (10.1-17.6)
3-day	3.67 (3.30-4.16)	4.82 (4.34-5.48)	6.29 (5.65-7.16)	7.46 (6.65-8.55)	9.01 (7.81-10.6)	10.2 (8.67-12.2)	11.3 (9.46-13.8)	12.5 (10.2-15.6)	14.1 (11.1-18.2)	15.2 (11.7-20.3)
4-day	4.10 (3.69-4.65)	5.40 (4.85-6.12)	7.03 (6.31-8.00)	8.33 (7.42-9.54)	10.0 (8.70-11.8)	11.3 (9.64-13.5)	12.6 (10.5-15.4)	13.8 (11.3-17.3)	15.5 (12.2-20.1)	16.8 (12.9-22.4)
7-day	5.04 (4.53-5.71)	6.70 (6.03-7.61)	8.76 (7.86-9.97)	10.4 (9.23-11.9)	12.4 (10.8-14.6)	13.9 (11.9-16.7)	15.4 (12.8-18.8)	16.8 (13.7-21.1)	18.7 (14.7-24.2)	20.1 (15.4-26.8)
10-day	5.73 (5.16-6.50)	7.66 (6.89-8.70)	10.0 (8.99-11.4)	11.8 (10.5-13.5)	14.1 (12.2-16.6)	15.8 (13.5-18.9)	17.4 (14.5-21.3)	19.0 (15.5-23.7)	21.0 (16.5-27.2)	22.4 (17.2-29.9)
20-day	7.55 (6.79-8.56)	10.0 (9.03-11.4)	13.1 (11.7-14.9)	15.3 (13.7-17.6)	18.2 (15.8-21.4)	20.2 (17.2-24.2)	22.1 (18.5-27.0)	24.0 (19.6-30.0)	26.3 (20.7-34.1)	28.0 (21.5-37.4)
30-day	9.13 (8.21-10.4)	12.0 (10.8-13.6)	15.5 (13.9-17.6)	18.1 (16.1-20.7)	21.4 (18.5-25.1)	23.6 (20.1-28.3)	25.8 (21.6-31.6)	27.9 (22.8-34.9)	30.5 (24.0-39.5)	32.4 (24.8-43.2)
45-day	11.3 (10.2-12.8)	14.6 (13.1-16.6)	18.6 (16.7-21.1)	21.6 (19.2-24.7)	25.2 (21.9-29.7)	27.8 (23.7-33.3)	30.3 (25.3-37.0)	32.6 (26.6-40.8)	35.6 (28.0-46.1)	37.7 (28.8-50.2)
60-day	13.6 (12.2-15.4)	17.3 (15.5-19.6)	21.7 (19.4-24.7)	25.0 (22.2-28.6)	29.0 (25.2-34.2)	31.9 (27.2-38.2)	34.6 (28.9-42.3)	37.2 (30.4-46.5)	40.4 (31.9-52.4)	42.8 (32.7-57.0)

[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.

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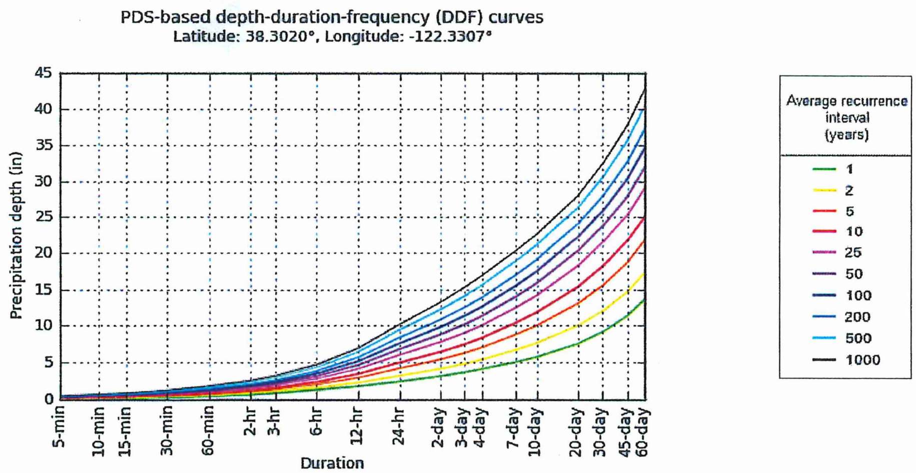
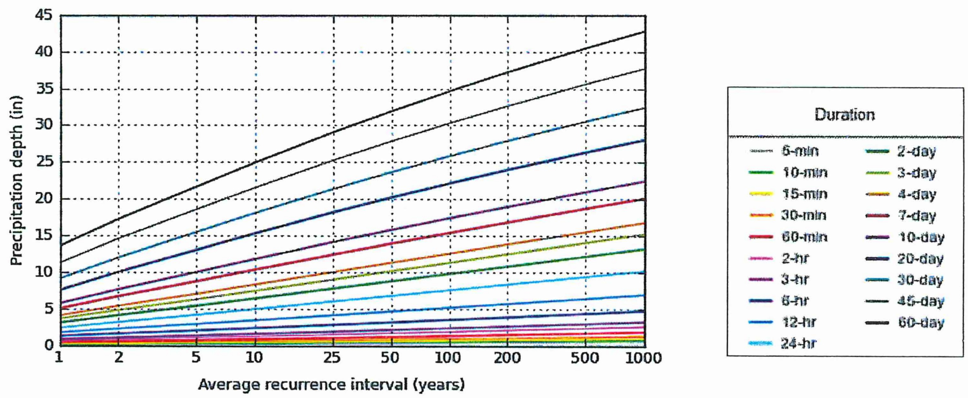
PF graphical





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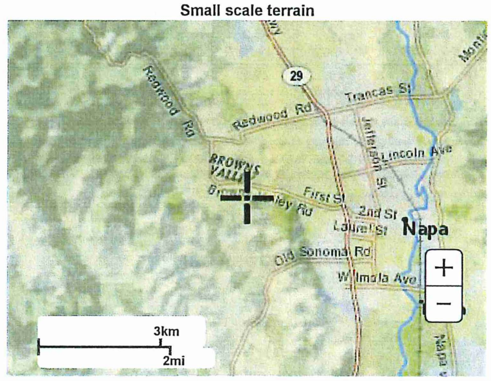
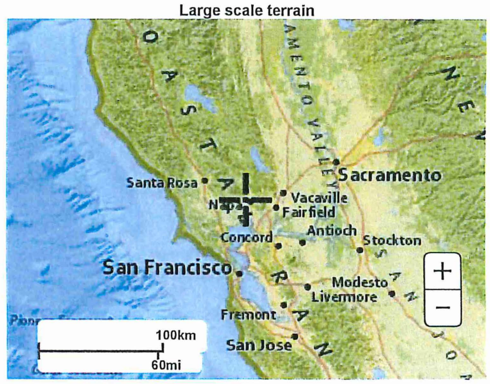
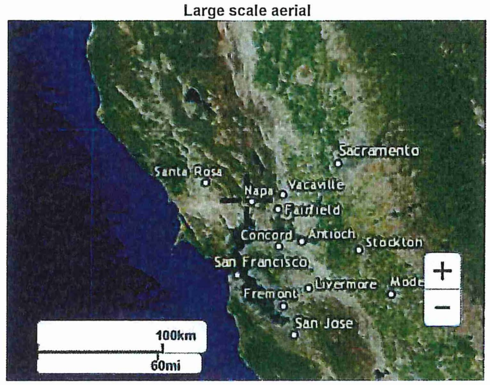


Large scale terrain



Large scale map

Large scale aerial



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NOAA Atlas 14, Volume 6, Version 2
Location name: Napa, California, USA*
Latitude: 38.302°, Longitude: -122.3307°
Elevation: 241.57 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 Trypaluk, 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/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	1.52 (1.36-1.73)	1.91 (1.70-2.17)	2.44 (2.16-2.77)	2.86 (2.51-3.29)	3.46 (2.92-4.13)	3.92 (3.24-4.81)	4.40 (3.53-5.56)	4.92 (3.82-6.40)	5.62 (4.16-7.67)	6.18 (4.40-8.78)
10-min	1.09 (0.972-1.24)	1.37 (1.22-1.55)	1.74 (1.54-1.99)	2.05 (1.80-2.36)	2.48 (2.09-2.96)	2.81 (2.32-3.44)	3.16 (2.53-3.98)	3.52 (2.74-4.58)	4.03 (2.98-5.50)	4.43 (3.16-6.29)
15-min	0.880 (0.784-1.00)	1.10 (0.984-1.26)	1.40 (1.24-1.60)	1.65 (1.45-1.90)	2.00 (1.69-2.39)	2.27 (1.87-2.78)	2.55 (2.04-3.21)	2.84 (2.20-3.70)	3.25 (2.40-4.43)	3.57 (2.54-5.07)
30-min	0.628 (0.558-0.712)	0.788 (0.700-0.896)	1.00 (0.888-1.14)	1.18 (1.03-1.36)	1.42 (1.20-1.70)	1.62 (1.33-1.98)	1.82 (1.46-2.29)	2.03 (1.57-2.64)	2.32 (1.71-3.16)	2.55 (1.81-3.62)
60-min	0.454 (0.404-0.515)	0.570 (0.506-0.647)	0.724 (0.642-0.825)	0.852 (0.748-0.981)	1.03 (0.870-1.23)	1.17 (0.964-1.43)	1.31 (1.05-1.66)	1.47 (1.14-1.91)	1.68 (1.24-2.29)	1.84 (1.31-2.62)
2-hr	0.345 (0.308-0.392)	0.428 (0.380-0.486)	0.538 (0.476-0.612)	0.627 (0.550-0.721)	0.749 (0.633-0.896)	0.844 (0.696-1.03)	0.941 (0.754-1.19)	1.04 (0.808-1.36)	1.18 (0.874-1.61)	1.29 (0.918-1.83)
3-hr	0.294 (0.262-0.334)	0.364 (0.324-0.413)	0.455 (0.404-0.519)	0.530 (0.465-0.610)	0.631 (0.533-0.755)	0.709 (0.585-0.869)	0.789 (0.632-0.994)	0.871 (0.676-1.13)	0.983 (0.727-1.34)	1.07 (0.762-1.52)
6-hr	0.218 (0.194-0.248)	0.272 (0.241-0.309)	0.341 (0.302-0.388)	0.396 (0.348-0.456)	0.471 (0.398-0.564)	0.529 (0.436-0.648)	0.586 (0.470-0.739)	0.645 (0.501-0.840)	0.725 (0.537-0.990)	0.787 (0.560-1.12)
12-hr	0.148 (0.132-0.168)	0.190 (0.169-0.216)	0.243 (0.216-0.277)	0.286 (0.251-0.329)	0.343 (0.289-0.410)	0.386 (0.318-0.473)	0.428 (0.343-0.540)	0.472 (0.366-0.614)	0.530 (0.392-0.724)	0.575 (0.409-0.816)
24-hr	0.101 (0.091-0.114)	0.133 (0.120-0.151)	0.174 (0.156-0.199)	0.207 (0.185-0.237)	0.251 (0.217-0.295)	0.283 (0.241-0.339)	0.315 (0.263-0.385)	0.348 (0.284-0.435)	0.391 (0.308-0.506)	0.424 (0.324-0.565)
2-day	0.065 (0.059-0.074)	0.086 (0.078-0.098)	0.113 (0.101-0.128)	0.134 (0.119-0.154)	0.162 (0.141-0.191)	0.183 (0.156-0.219)	0.204 (0.170-0.250)	0.225 (0.184-0.282)	0.254 (0.200-0.328)	0.275 (0.210-0.367)
3-day	0.051 (0.046-0.058)	0.067 (0.060-0.076)	0.087 (0.078-0.099)	0.104 (0.092-0.119)	0.125 (0.109-0.147)	0.141 (0.120-0.169)	0.157 (0.131-0.192)	0.174 (0.142-0.217)	0.195 (0.154-0.253)	0.212 (0.162-0.282)
4-day	0.043 (0.038-0.048)	0.056 (0.051-0.064)	0.073 (0.066-0.083)	0.087 (0.077-0.099)	0.105 (0.091-0.123)	0.118 (0.100-0.141)	0.131 (0.109-0.160)	0.144 (0.118-0.180)	0.162 (0.127-0.209)	0.175 (0.134-0.233)
7-day	0.030 (0.027-0.034)	0.040 (0.036-0.045)	0.052 (0.047-0.059)	0.062 (0.055-0.071)	0.074 (0.064-0.087)	0.083 (0.071-0.099)	0.092 (0.076-0.112)	0.100 (0.082-0.125)	0.111 (0.088-0.144)	0.120 (0.092-0.160)
10-day	0.024 (0.021-0.027)	0.032 (0.029-0.036)	0.042 (0.037-0.048)	0.049 (0.044-0.056)	0.059 (0.051-0.069)	0.066 (0.056-0.079)	0.072 (0.061-0.089)	0.079 (0.064-0.099)	0.087 (0.069-0.113)	0.094 (0.072-0.125)
20-day	0.016 (0.014-0.018)	0.021 (0.019-0.024)	0.027 (0.024-0.031)	0.032 (0.028-0.037)	0.038 (0.033-0.045)	0.042 (0.036-0.050)	0.046 (0.038-0.056)	0.050 (0.041-0.063)	0.055 (0.043-0.071)	0.058 (0.045-0.078)
30-day	0.013 (0.011-0.014)	0.017 (0.015-0.019)	0.022 (0.019-0.024)	0.025 (0.022-0.029)	0.030 (0.026-0.035)	0.033 (0.028-0.039)	0.036 (0.030-0.044)	0.039 (0.032-0.048)	0.042 (0.033-0.055)	0.045 (0.034-0.060)
45-day	0.010 (0.009-0.012)	0.014 (0.012-0.015)	0.017 (0.015-0.020)	0.020 (0.018-0.023)	0.023 (0.020-0.028)	0.026 (0.022-0.031)	0.028 (0.023-0.034)	0.030 (0.025-0.038)	0.033 (0.026-0.043)	0.035 (0.027-0.046)
60-day	0.009 (0.008-0.011)	0.012 (0.011-0.014)	0.015 (0.013-0.017)	0.017 (0.015-0.020)	0.020 (0.017-0.024)	0.022 (0.019-0.027)	0.024 (0.020-0.029)	0.026 (0.021-0.032)	0.028 (0.022-0.036)	0.030 (0.023-0.040)

[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.

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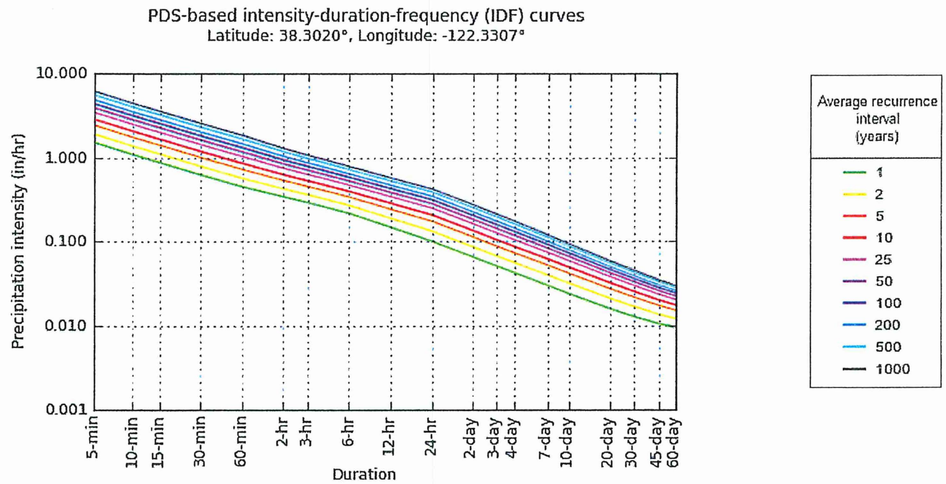
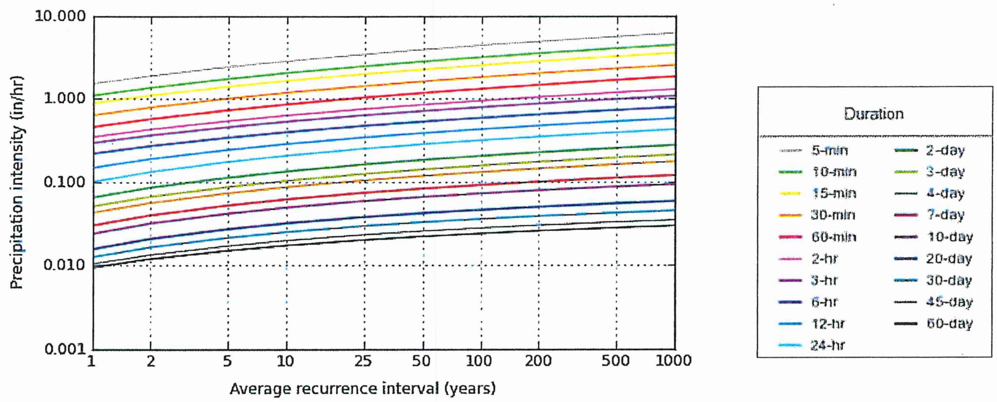
PF graphical





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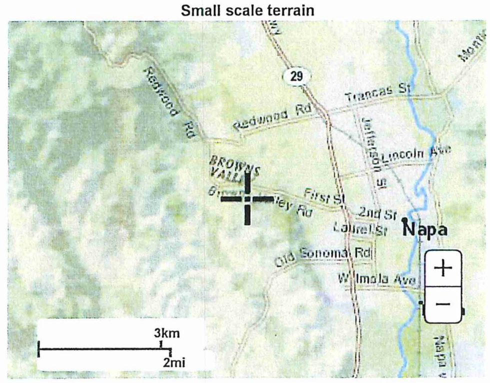

Large scale terrain

Large scale map

Large scale aerial

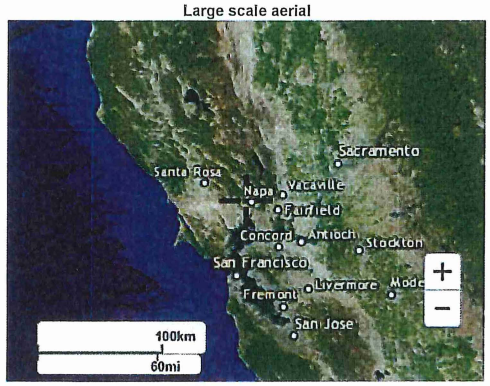

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Table 5-6 Values of the Roughness Coefficient n

Type of channel and description	Minimum	Normal	Maximum
A. Closed Conduits Flowing Partly Full			
A-1. Metal			
a. Brass, smooth	0.009	0.010	0.013
b. Steel			
1. Lockbar and welded	0.010	0.012	0.014
2. Riveted and spiral	0.013	0.016	0.017
c. Cast iron			
1. Coated	0.010	0.013	0.014
2. Uncoated	0.011	0.014	0.016
d. Wrought iron			
1. Black	0.012	0.014	0.015
2. Galvanized	0.013	0.016	0.017
d. Corrugated metal			
1. Subdrain	0.017	0.019	0.021
2. Storm drain	0.021	0.024	0.030
A-2. Nonmetal			
a. Lucite	0.008	0.009	0.010
b. Glass	0.009	0.010	0.013
c. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
d. Concrete			
1. Culvert, straight and free of debris	0.010	0.011	0.013
2. Culvert with bends, connections, and some debris	0.011	0.013	0.014
3. Finished	0.011	0.012	0.014
4. Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
5. Unfinished, steel form	0.012	0.013	0.014
6. Unfinished, smooth wood form	0.012	0.014	0.016
7. Unfinished, rough wood form	0.015	0.017	0.020
e. Wood			
1. Stave	0.010	0.012	0.014
2. Laminated, treated	0.015	0.017	0.020
f. Clay			
1. Common drainage tile	0.011	0.013	0.017
2. Vitrified sewer	0.011	0.014	0.017
3. Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
4. Vitrified subdrain with open joint	0.014	0.016	0.018
g. Brickwork			
1. Glazed	0.011	0.013	0.015
2. Lined with cement mortar	0.012	0.015	0.017
h. Sanitary sewers coated with sewage slimes, with bends and connections	0.012	0.013	0.016
i. Paved invert, sewer, smooth bottom	0.016	0.019	0.020
j. Rubble masonry, cemented	0.018	0.025	0.030

Table 5-6 Values of the Roughness Coefficient n (continued)

Type of channel and description	Minimum	Normal	Maximum
B. Lined or Built-up Channels			
B-1. Metal			
a. Smooth steel surface			
1. Unpainted	0.011	0.012	0.014
2. Painted	0.012	0.013	0.017
b. Corrugated	0.021	0.025	0.030
B-2. Nonmetal			
a. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
b. Wood			
1. Planed, untreated	0.010	0.012	0.014
2. Planed, creosoted	0.011	0.012	0.015
3. Unplaned	0.011	0.013	0.015
4. Plank with battens	0.012	0.015	0.018
5. Lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. Trowel finish	0.011	0.013	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	
8. On irregular excavated rock	0.022	0.027	
d. Concreted bottom float finished with sides of			
1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. Glazed	0.011	0.013	0.015
2. In cement mortar	0.012	0.015	0.018
g. Masonry			
1. Cemented rubble	0.017	0.025	0.030
2. Dry rubble	0.023	0.032	0.035
h. Dressed ashlar	0.013	0.015	0.017
i. Asphalt			
1. Smooth	0.013	0.013	
2. Rough	0.016	0.016	
j. Vegetal lining	0.030	...	0.500

Table 5-6 Values of the Roughness Coefficient n (continued)

Type of channel and description	**Minimum**	**Normal**	**Maximum**
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
D-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
D-3. Major streams (top width at flood stage >100 ft). The n value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	...	0.060
b. Irregular and rough section	0.035	...	0.100

Reference:

Chow, Ven Te. Open-Channel Hydraulics. 1959. McGraw-Hill Book Company, New York
(page 110-113 Table 5-6 Values of Roughness Coefficient n)

Table 5-6 Values of the Roughness Coefficient n (continued)

Type of channel and description	Minimum	Normal	Maximum
C. Excavated or Dredged			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
D. Natual Streams			
D-1. Minor streams (top width at flood stage <100 ft)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Napa County, California

Cardey Residence

January 3, 2018

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map

Map Scale: 1:2,730 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 40, 80, 160, 240

Feet: 0, 100, 200, 400, 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

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: Napa County, California
Survey Area Data: Version 10, Sep 25, 2017

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

Date(s) aerial images were photographed: Apr 17, 2015—Oct 18, 2016

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
105	Bale clay loam, 2 to 5 percent slopes	0.6	2.1%
112	Bressa-Dibble complex, 5 to 15 percent slopes	5.6	20.8%
118	Cole silt loam, 0 to 2 percent slopes, MLRA 14	3.1	11.4%
132	Fagan clay loam, 15 to 30 percent slopes	17.8	65.8%
Totals for Area of Interest		**27.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Napa County, California

105—Bale clay loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: hdk5
Elevation: 20 to 400 feet
Mean annual precipitation: 25 to 35 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 220 to 270 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Bale and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bale

Setting

Landform: Flood plains, terraces
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from rhyolite and/or alluvium derived from igneous rock

Typical profile

H1 - 0 to 24 inches: clay loam
H2 - 24 to 60 inches: stratified gravelly sandy loam to loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 48 to 72 inches
Frequency of flooding: Rare
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.2 inches)

Interpretive groups

Land capability classification (irrigated): 2w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: B
Hydric soil rating: No

112—Bressa-Dibble complex, 5 to 15 percent slopes

Map Unit Setting

National map unit symbol: hdkd
Elevation: 100 to 2,000 feet
Mean annual precipitation: 25 to 35 inches
Mean annual air temperature: 63 to 64 degrees F
Frost-free period: 220 to 260 days
Farmland classification: Not prime farmland

Map Unit Composition

Bressa and similar soils: 65 percent
Dibble and similar soils: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bressa

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from sandstone and shale

Typical profile

H1 - 0 to 10 inches: silt loam
H2 - 10 to 33 inches: silty clay loam
H3 - 33 to 59 inches: weathered bedrock

Properties and qualities

Slope: 5 to 15 percent
Depth to restrictive feature: 30 to 40 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 5.3 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: FINE LOAMY (R015XD024CA)
Hydric soil rating: No

Description of Dibble

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Residuum weathered from sandstone and shale

Typical profile

H1 - 0 to 9 inches: silty clay loam
H2 - 9 to 34 inches: clay
H3 - 34 to 59 inches: weathered bedrock

Properties and qualities

Slope: 5 to 15 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 5.5 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Ecological site: Steep Clayey Hills (R015XF006CA)
Hydric soil rating: No

118—Cole silt loam, 0 to 2 percent slopes, MLRA 14

Map Unit Setting

National map unit symbol: 2xc92
Elevation: 20 to 420 feet
Mean annual precipitation: 24 to 43 inches
Mean annual air temperature: 58 to 61 degrees F
Frost-free period: 296 to 319 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Cole and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cole

Setting

Landform: Flood-plain steps, alluvial fans
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Parent material: Alluvium derived from volcanic and sedimentary rock

Typical profile

Ap - 0 to 8 inches: silt loam
BAt - 8 to 18 inches: silty clay loam
Bt1 - 18 to 32 inches: silty clay loam
Bt2 - 32 to 41 inches: silty clay loam
Bt3 - 41 to 48 inches: clay loam
Bt4 - 48 to 60 inches: clay
BCt - 60 to 64 inches: clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 12 to 60 inches
Frequency of flooding: Rare
Frequency of ponding: Rare
Salinity, maximum in profile: Nonsaline (0.2 to 0.5 mmhos/cm)
Available water storage in profile: High (about 11.4 inches)

Interpretive groups

Land capability classification (irrigated): 2w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Bale

Percent of map unit: 4 percent

Cortina

Percent of map unit: 4 percent

Yolo

Percent of map unit: 4 percent

Clear lake

Percent of map unit: 3 percent
Landform: Basin floors
Hydric soil rating: Yes

132—Fagan clay loam, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: hdl1
Elevation: 200 to 1,500 feet
Mean annual precipitation: 20 to 30 inches
Mean annual air temperature: 59 to 63 degrees F
Frost-free period: 220 to 260 days
Farmland classification: Not prime farmland

Map Unit Composition

Fagan and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fagan

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from sandstone and shale

Typical profile

H1 - 0 to 16 inches: clay loam
H2 - 16 to 28 inches: clay
H3 - 28 to 46 inches: sandy clay loam
H4 - 46 to 59 inches: weathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 40 to 60 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: FINE LOAMY (R015XD024CA)
Hydric soil rating: No

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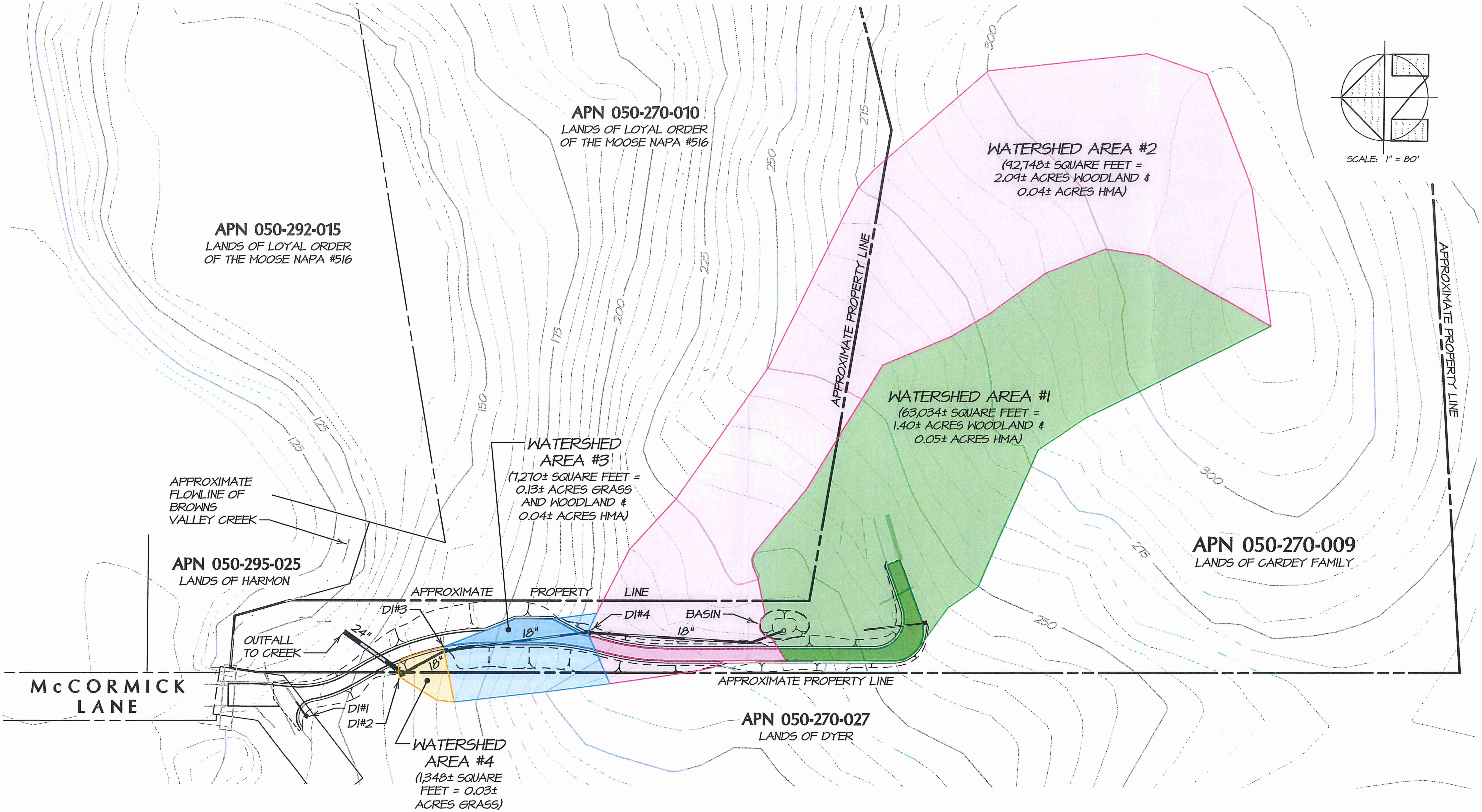

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WATERSHED EXHIBIT

SCALE: 1" = 80'

Cardey Driveway Repair
1100 McCormick Lane
Napa County, CA
APN 050-270-009
Job No. 17-04
February 2018
Sheet 1 of 1

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