Beau Schoch

Agricultural Engineer
United States Department of Agriculture (USDA)
Natural Resources Conservation Service (NRCS)
Salinas Service Center
(831) 424-1036 ext. 116

Stormwater

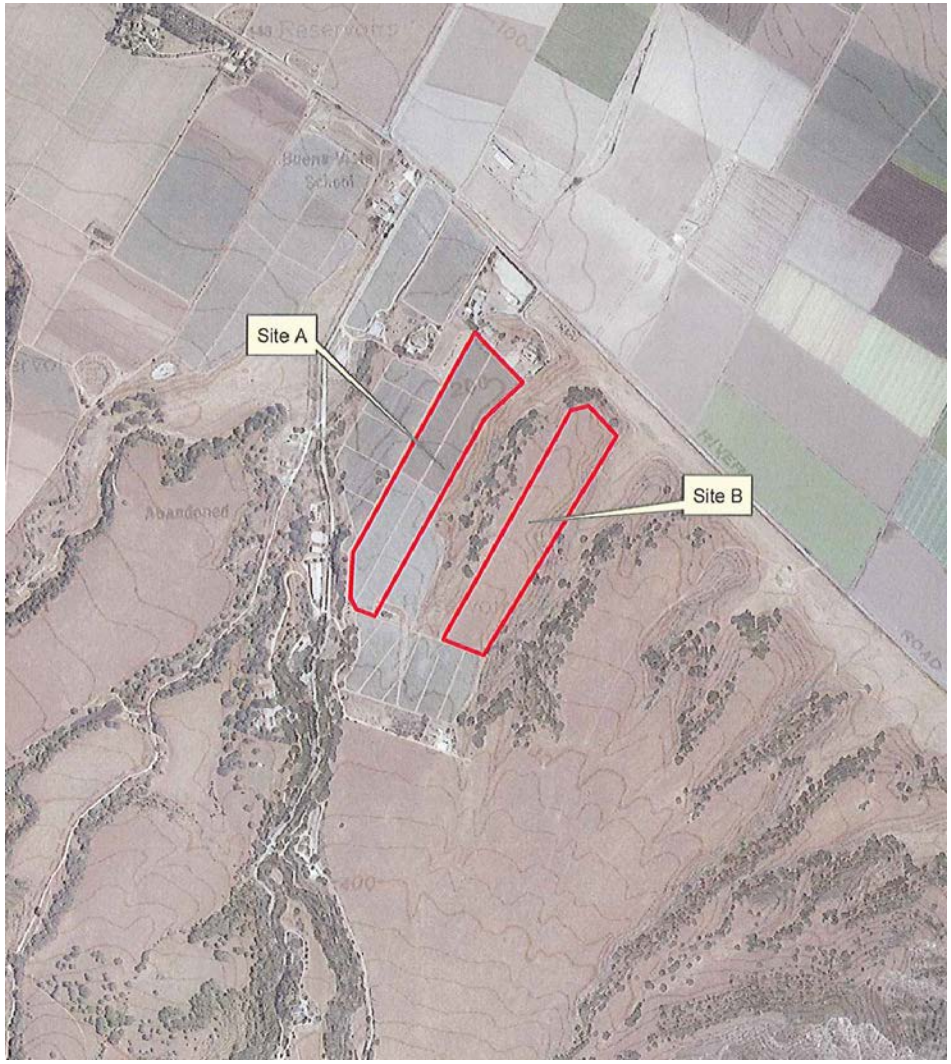
Are YOU Ready?

What Happens With Land Use Conversion?

Why Do We Care?

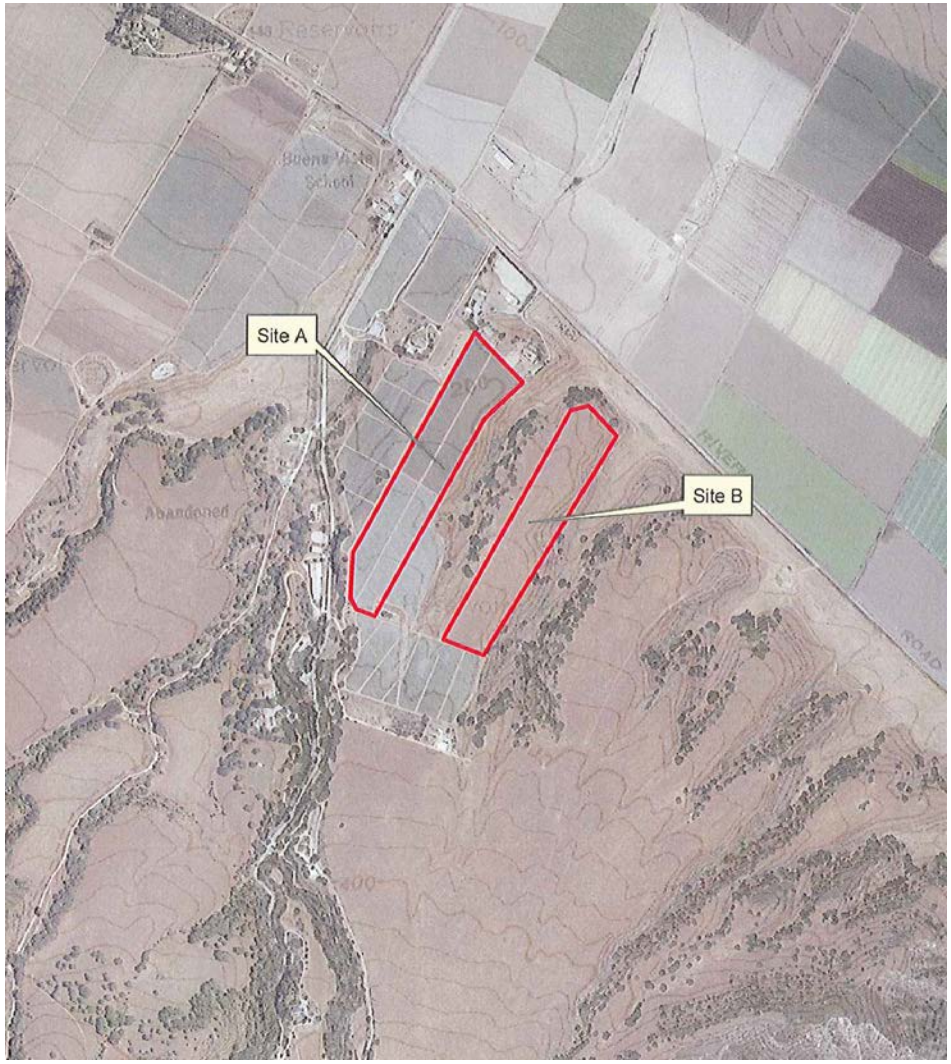
Should We Care?

Lets Compare!



Lets Compare!
Site Runoff Example

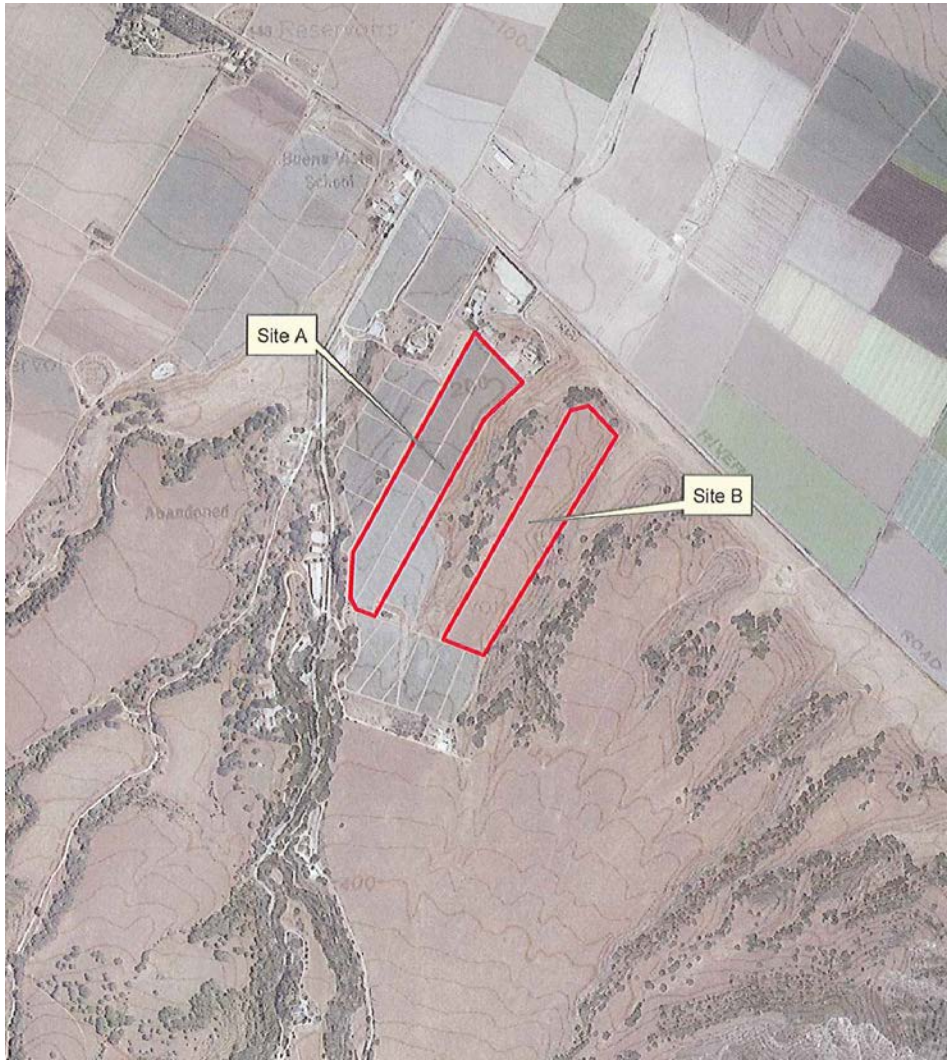
Site A
18 acres
5-10% slope
Sandy Loam soils
Berry Production



Site B
18 acres
5-10% slope
Sandy Loam soils
Native Pasture

Site Runoff Example
Hydrology 101

Site A
18 acres
5-10% slope
Sandy Loam soils
Berry Production



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Site Runoff Example
Hydrology 101

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Sandy Loam soils
Berry Production

Site B
18 acres
5-10% slope
Sandy Loam soils
Native Pasture

The Rational Method

The Math 

$$Q = c\ i\ A$$

Q = peak discharge, ft.3/sec. (1 cfs = 450 gpm)
c = runoff coefficient, unitless
i = rainfall intensity, inches/hour
A = area, sq.ft.

The Rational Method

$$Q = c\ i\ A$$

c = runoff coefficient, unitless

Site A
18 acres
5-10% slope
Sandy Loam soils
Berry Production

C = 0.85

Table 1 Runoff Coefficients for the Rational Method

	FLAT	ROLLING	HILLY
Pavement & Roofs	**0.90**	**0.90**	**0.90**
Earth Shoulders	0.50	0.50	0.50
Drives & Walks	0.75	**0.80**	**0.85**
Gravel Pavement	**0.85**	**0.85**	**0.85**
City Business Areas	0.80	**0.85**	**0.85**
Apartment Dwelling Areas	0.50	0.60	0.70
Light Residential: 1 to 3 units/acre	0.35	0.40	0.45
Normal Residential: 3 to 6 units/acre	0.50	0.55	0.60
Dense Residential: 6 to 15 units/acre	0.70	0.75	0.80
Lawns	0.17	0.22	0.35
Grass Shoulders	0.25	0.25	0.25
Side Slopes, Earth	0.60	0.60	0.60
Side Slopes, Turf	0.30	0.30	0.30
Median Areas, Turf	0.25	0.30	0.30
Cultivated Land, Clay & Loam	0.50	0.55	0.60
Cultivated Land, Sand & Gravel	0.25	0.30	0.35
Industrial Areas, Light	0.50	0.70	0.80
Industrial Areas, Heavy	0.60	0.80	**0.90**
Parks & Cemeteries	0.10	0.15	0.25
Playgrounds	0.20	0.25	0.30
Woodland & Forests	0.10	0.15	**0.20**
Meadows & Pasture Land	0.25	0.30	0.35
Unimproved Areas	0.10	0.20	**0.30**

Note:

- ***Impervious surfaces in bold***
- *Rolling = ground slope between 2 percent to 10 percent*
- *Hilly = ground slope greater than 10 percent*

Site B
18 acres
5-10% slope
Sandy Loam soils
Native Pasture

C = 0.35

The Rational Method

$$Q = c\ i\ A$$

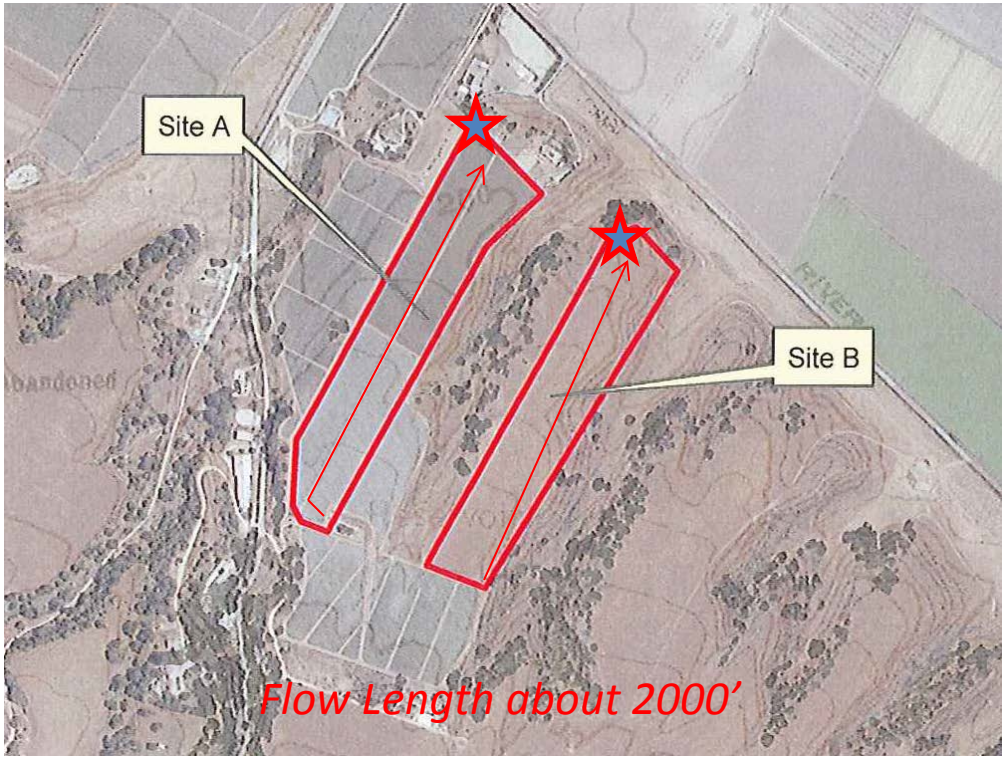
c = runoff coefficient, unitless

i = rainfall intensity, inches/hour

Time of Concentration (Tc): How long does it take for the most "distant raindrop" to reach the design point?

Site A
18 acres
5-10% slope
Sandy Loam soils
Berry Production
C = 0.85
Tc = assume 10 min.

Site B
18 acres
5-10% slope
Sandy Loam soils
Native Pasture
C = 0.35
Tc = assume 2 hrs.



The Rational Method

$$Q = c\ i\ A$$

c = runoff coefficient, unitless

i = rainfall intensity, inches/hour

Site A

18 acres

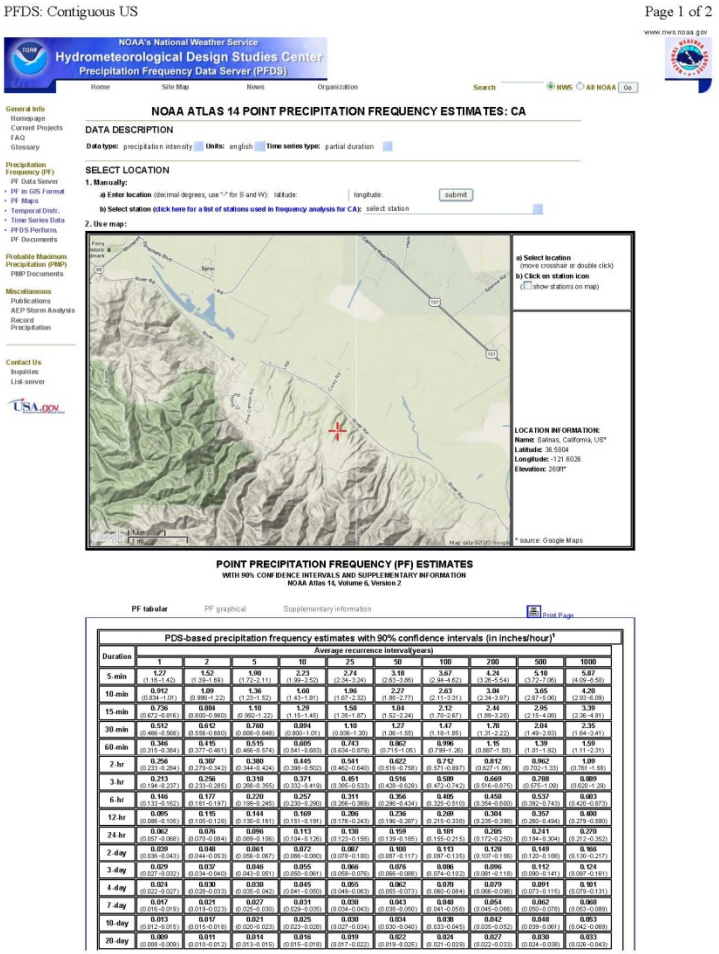
5-10% slope

Sandy Loam soils

Berry Production

C = 0.85

Tc = assume 10 min.



PFDS: Contiguous US

Page 1 of 2

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NOAA's National Weather Service

Hydrometeorological Design Studies Center

Precipitation Frequency Data Server (PFDS)

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General Info
Homepage
Current Projects
FAQ
Glossary

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• PF Maps
• Temporal Distr.
• Time Series Data
• PFDS Perform.
PF Documents

Probable Maximum Precipitation (PMP)
PMP Documents

Miscellaneous
Publications
AEP Storm Analysis
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NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: CA

DATA DESCRIPTION

Data type: precipitation intensity | Units: english | Time series type: partial duration

SELECT LOCATION

1. Manually:

a) Enter location (decimal degrees, use "-" for S and W): latitude: longitude: submit

b) Select station (click here for a list of stations used in frequency analysis for CA): select station

2. Use map:

a) Select location (move crosshair or double click)

b) Click on station icon (show stations on map)

LOCATION INFORMATION:
Name: Salinas, California, US*
Latitude: 36.5004
Longitude: -121.6026
Elevation: 269ft*

* source: Google Maps

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 6, Version 2

PF tabular | PF graphical | Supplementary information | Print Page

PDS-based 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	1.27 (1.16-1.42)	1.52 (1.39-1.69)	1.90 (1.72-2.11)	2.23 (1.99-2.52)	2.74 (2.34-3.24)	3.18 (2.63-3.86)	3.67 (2.94-4.62)	4.24 (3.26-5.54)	5.10 (3.72-7.06)	5.87 (4.09-8.50)
10-min	0.992 (0.934-1.05)	1.89 (0.996-1.22)	1.36 (1.23-1.52)	1.69 (1.43-1.89)	1.96 (1.67-2.32)	2.27 (1.86-2.77)	2.63 (2.11-3.31)	3.04 (2.34-3.97)	3.65 (2.67-5.06)	4.20 (2.93-6.09)
15-min	0.736 (0.672-0.816)	0.884 (0.800-0.980)	1.10 (0.962-1.22)	1.29 (1.15-1.46)	1.58 (1.35-1.87)	1.84 (1.52-2.24)	2.12 (1.75-2.67)	2.44 (1.89-3.20)	2.95 (2.15-4.08)	3.39 (2.36-4.91)
30-min	0.512 (0.466-0.566)	0.612 (0.556-0.680)	0.760 (0.688-0.848)	0.894 (0.800-1.01)	1.10 (0.936-1.30)	1.27 (1.06-1.55)	1.47 (1.19-1.85)	1.70 (1.31-2.22)	2.04 (1.49-2.83)	2.35 (1.64-3.41)
60-min	0.346 (0.315-0.384)	0.415 (0.377-0.461)	0.515 (0.466-0.574)	0.605 (0.541-0.683)	0.743 (0.634-0.879)	0.862 (0.715-1.05)	0.996 (0.799-1.26)	1.15 (0.887-1.50)	1.39 (1.01-1.92)	1.59 (1.11-2.31)
2-hr	0.256 (0.233-0.284)	0.307 (0.279-0.342)	0.380 (0.344-0.424)	0.445 (0.396-0.502)	0.541 (0.462-0.640)	0.622 (0.516-0.768)	0.712 (0.574-0.897)	0.812 (0.627-1.06)	0.962 (0.702-1.33)	1.09 (0.781-1.58)
3-hr	0.213 (0.194-0.237)	0.256 (0.233-0.285)	0.318 (0.288-0.355)	0.371 (0.332-0.419)	0.451 (0.385-0.533)	0.516 (0.428-0.629)	0.589 (0.472-0.742)	0.669 (0.516-0.875)	0.788 (0.575-1.09)	0.889 (0.628-1.29)
6-hr	0.146 (0.133-0.162)	0.177 (0.161-0.197)	0.220 (0.199-0.245)	0.257 (0.230-0.290)	0.311 (0.266-0.369)	0.356 (0.296-0.434)	0.405 (0.325-0.510)	0.458 (0.354-0.600)	0.537 (0.392-0.743)	0.603 (0.426-0.873)
12-hr	0.095 (0.086-0.105)	0.115 (0.105-0.128)	0.144 (0.130-0.161)	0.169 (0.151-0.191)	0.206 (0.176-0.243)	0.236 (0.196-0.287)	0.269 (0.216-0.338)	0.304 (0.235-0.398)	0.357 (0.260-0.494)	0.400 (0.279-0.580)
24-hr	0.062 (0.057-0.068)	0.076 (0.070-0.084)	0.096 (0.089-0.106)	0.113 (0.104-0.126)	0.138 (0.123-0.159)	0.159 (0.139-0.185)	0.181 (0.155-0.215)	0.205 (0.172-0.250)	0.241 (0.194-0.304)	0.270 (0.212-0.352)
2-day	0.039 (0.036-0.043)	0.048 (0.044-0.053)	0.061 (0.056-0.067)	0.072 (0.066-0.080)	0.087 (0.078-0.100)	0.100 (0.087-0.117)	0.113 (0.097-0.135)	0.128 (0.107-0.158)	0.149 (0.120-0.188)	0.166 (0.130-0.217)
3-day	0.029 (0.027-0.032)	0.037 (0.034-0.040)	0.046 (0.043-0.051)	0.055 (0.050-0.061)	0.066 (0.059-0.076)	0.076 (0.066-0.088)	0.086 (0.074-0.102)	0.096 (0.081-0.118)	0.112 (0.090-0.141)	0.124 (0.097-0.161)
4-day	0.024 (0.022-0.027)	0.030 (0.028-0.033)	0.038 (0.035-0.042)	0.045 (0.041-0.050)	0.055 (0.049-0.063)	0.062 (0.055-0.073)	0.070 (0.060-0.084)	0.079 (0.066-0.095)	0.091 (0.073-0.115)	0.101 (0.079-0.131)
7-day	0.017 (0.016-0.019)	0.021 (0.019-0.023)	0.027 (0.025-0.030)	0.031 (0.029-0.035)	0.038 (0.034-0.043)	0.043 (0.039-0.050)	0.048 (0.041-0.058)	0.053 (0.045-0.065)	0.062 (0.050-0.078)	0.069 (0.053-0.089)
10-day	0.013 (0.012-0.015)	0.017 (0.015-0.018)	0.021 (0.020-0.023)	0.025 (0.023-0.028)	0.030 (0.027-0.034)	0.034 (0.030-0.040)	0.038 (0.033-0.045)	0.042 (0.035-0.052)	0.048 (0.039-0.061)	0.053 (0.042-0.069)
20-day	0.009 (0.008-0.009)	0.011 (0.010-0.012)	0.014 (0.013-0.015)	0.016 (0.015-0.018)	0.019 (0.017-0.022)	0.022 (0.019-0.025)	0.024 (0.021-0.029)	0.027 (0.022-0.033)	0.030 (0.024-0.038)	0.033 (0.026-0.043)

http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ca 2/25/2013

Site B

18 acres

5-10% slope

Sandy Loam soils

Native Pasture

C = 0.35

Tc = assume 2 hrs.

The Rational Method

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i = rainfall intensity, inches/hour

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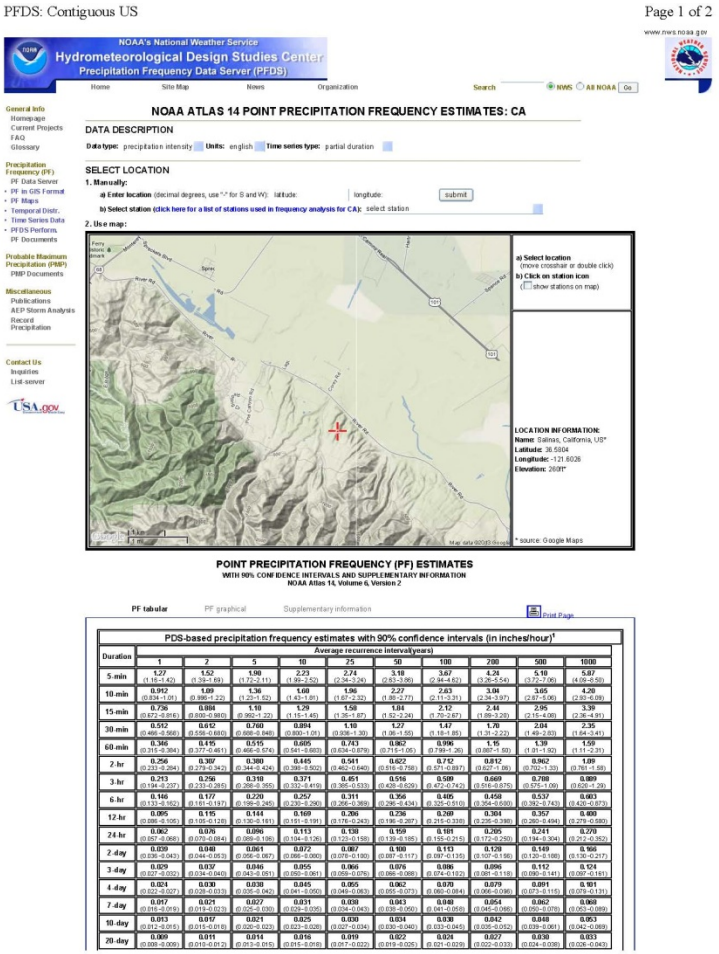

PFDS: Contiguous US

Page 1 of 2

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NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: CA

DATA DESCRIPTION

Data type: precipitation intensity | Units: english | Time series type: partial duration

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WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
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10-min	0.992 (0.934-1.05)	1.89 (0.996-1.22)	1.36 (1.23-1.52)	1.69 (1.43-1.89)	1.96 (1.67-2.32)	2.27 (1.86-2.77)	2.63 (2.11-3.31)	3.04 (2.34-3.97)	3.65 (2.67-5.06)	4.20 (2.93-6.09)
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7-day	0.017 (0.016-0.019)	0.021 (0.019-0.023)	0.027 (0.025-0.030)	0.031 (0.029-0.035)	0.038 (0.034-0.043)	0.043 (0.039-0.050)	0.048 (0.041-0.058)	0.053 (0.045-0.065)	0.062 (0.050-0.078)	0.069 (0.053-0.089)
10-day	0.013 (0.012-0.015)	0.017 (0.015-0.018)	0.021 (0.020-0.023)	0.025 (0.023-0.028)	0.030 (0.027-0.034)	0.034 (0.030-0.040)	0.038 (0.033-0.045)	0.042 (0.035-0.052)	0.048 (0.039-0.061)	0.053 (0.042-0.069)
20-day	0.009 (0.008-0.009)	0.011 (0.010-0.012)	0.014 (0.013-0.015)	0.016 (0.015-0.018)	0.019 (0.017-0.022)	0.022 (0.019-0.025)	0.024 (0.021-0.029)	0.027 (0.022-0.033)	0.030 (0.024-0.038)	0.033 (0.026-0.043)

http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ca 2/25/2013

Site B

18 acres

5-10% slope

Sandy Loam soils

Native Pasture

C = 0.35

Tc = assume 2 hrs.

The Rational Method

$$Q = c\ i\ A$$

c = runoff coefficient, unitless

i = rainfall intensity, inches/hour

Site A
18 acres
5-10% slope
Sandy Loam soils
Berry Production
C = 0.85
Tc = assume 10 min.

Site B
18 acres
5-10% slope
Sandy Loam soils
Native Pasture
C = 0.35
Tc = assume 2 hrs.

What Size Storm to Design For?

- Minimum 10 year storm event on all infrastructure
  - Primary Spillways
  - All inlets and outlets
  - Non-erosive velocities
- Consideration of the 100 year storm event
  - Emergency Spillways
  - Protect life and property

The Rational Method

$$Q = c\ i\ A$$

c = runoff coefficient, unitless

i = rainfall intensity, inches/hour

Site A

18 acres

5-10% slope

Sandy Loam soils

Berry Production

C = 0.85

Tc = assume 10 min.

i (10yr) = 1.6 in./hr.

Site B

18 acres

5-10% slope

Sandy Loam soils

Native Pasture

C = 0.35

Tc = assume 2 hrs.

i = .45 in./hr.

Lets Consider the 10-year Storm

PDS-based 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
5-min	1.27 (1.16-1.42)	1.52 (1.39-1.69)	1.90 (1.72-2.11)	2.23 (1.99-2.52)	2.74 (2.34-3.24)	3.18 (2.63-3.86)	3.67 (2.94-4.62)	4.24 (3.26-5.54)	5.10 (3.72-7.06)
10-min	0.912 (0.834-1.01)	1.09 (0.996-1.22)	1.36 (1.23-1.52)	1.60 (1.43-1.81)	1.96 (1.67-2.32)	2.27 (1.88-2.77)	2.63 (2.11-3.31)	3.04 (2.34-3.97)	3.65 (2.67-5.06)
15-min	0.736 (0.672-0.816)	0.884 (0.800-0.980)	1.10 (0.992-1.22)	1.29 (1.15-1.45)	1.58 (1.35-1.87)	1.84 (1.52-2.24)	2.12 (1.70-2.67)	2.44 (1.89-3.20)	2.95 (2.15-4.08)
30-min	0.512 (0.466-0.568)	0.612 (0.556-0.680)	0.760 (0.688-0.848)	0.894 (0.800-1.01)	1.10 (0.936-1.30)	1.27 (1.06-1.55)	1.47 (1.18-1.85)	1.70 (1.31-2.22)	2.04 (1.49-2.83)
60-min	0.346 (0.315-0.384)	0.415 (0.377-0.461)	0.515 (0.466-0.574)	0.605 (0.541-0.683)	0.743 (0.634-0.879)	0.862 (0.715-1.05)	0.996 (0.799-1.26)	1.15 (0.887-1.50)	1.39 (1.01-1.92)
2-hr	0.256 (0.233-0.284)	0.307 (0.279-0.342)	0.380 (0.344-0.424)	0.445 (0.398-0.502)	0.541 (0.462-0.640)	0.622 (0.516-0.758)	0.712 (0.571-0.897)	0.812 (0.627-1.06)	0.962 (0.702-1.33)
3-hr	0.213 (0.194-0.237)	0.256 (0.233-0.285)	0.318 (0.288-0.355)	0.371 (0.332-0.419)	0.451 (0.385-0.533)	0.516 (0.428-0.629)	0.589 (0.472-0.742)	0.669 (0.516-0.875)	0.788 (0.575-1.09)
6-hr	0.146 (0.133-0.162)	0.177 (0.161-0.197)	0.220 (0.199-0.245)	0.257 (0.230-0.290)	0.311 (0.266-0.369)	0.356 (0.296-0.434)	0.405 (0.325-0.510)	0.458 (0.354-0.600)	0.537 (0.392-0.743)
12-hr	0.095 (0.086-0.105)	0.115 (0.105-0.128)	0.144 (0.130-0.161)	0.169 (0.151-0.191)	0.206 (0.176-0.243)	0.236 (0.196-0.287)	0.269 (0.215-0.338)	0.304 (0.235-0.398)	0.357 (0.260-0.494)
24-hr	0.062 (0.057-0.068)	0.076 (0.070-0.084)	0.096 (0.089-0.106)	0.113 (0.104-0.126)	0.138 (0.123-0.158)	0.159 (0.139-0.185)	0.181 (0.155-0.215)	0.205 (0.172-0.250)	0.241 (0.194-0.304)

The Rational Method

$$Q = c\ i\ A$$

c = runoff coefficient, unitless

i = rainfall intensity, inches/hour

A = 18 acres = 784,080 sq.ft.

Lets Consider the 10-year Storm

Site A

18 acres

5-10% slope

Sandy Loam soils

Berry Production

C = 0.85

Tc = assume 10 min.

i (10yr) = 1.6 in./hr.

Site B

18 acres

5-10% slope

Sandy Loam soils

Native Pasture

C = 0.35

Tc = assume 2 hrs.

i = .45 in./hr.

The Rational Method

$$Q = c\ i\ A$$

c = runoff coefficient, unitless

i = rainfall intensity, inches/hour

A = 18 acres = 784,080 sq.ft.

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Lets Consider the 10-year Storm

= 0.000037 ft./sec. (unit conversion)

The Math

Q = (0.85)*(0.000037 ft./sec.)*(784,080 ft.2)

Q = 25 ft.3/sec (cfs)

The Rational Method

$$Q = c\ i\ A$$

c = runoff coefficient, unitless

i = rainfall intensity, inches/hour

A = 18 acres = 784,080 sq.ft.

Lets Consider the 10-year Storm

Site A

18 acres

5-10% slope

Sandy Loam soils

Berry Production

C = 0.85

Tc = assume 10 min.

i (10yr) = 1.6 in./hr.

The Math

Q = 25 ft.3/sec (cfs)

.vs

Site B

18 acres

5-10% slope

Sandy Loam soils

Native Pasture

C = 0.35

Tc = assume 2 hrs.

i = .45 in./hr.

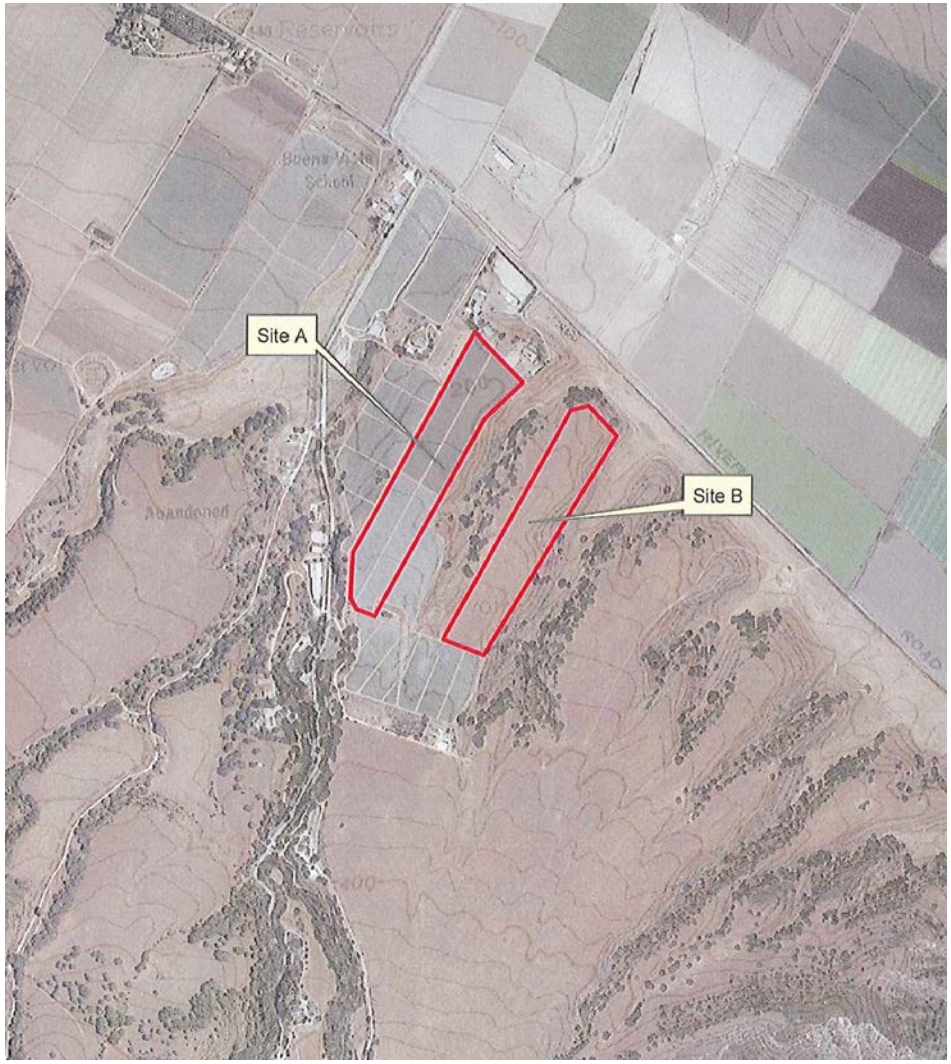
The Math

Q = 2.9 cfs

Lets Compare!
Site Runoff Example

Site A
18 acres
5-10% slope
Sandy Loam soils
Berry Production

Q = 25 cfs



Site B
18 acres
5-10% slope
Sandy Loam soils
Native Pasture

Q = 2.9 cfs

Identifying the Problem is Easy

Figuring the Solution is Difficult

Proactive

vs.

Reactive

Why all the fuss?

Sediment vs. Water Control

How big are we talking?

Questions/Comments?