Table 1. Areas, Lengths, and Elevation Changes from Site Map
Schubert Ranch Sand Resource Pit Phase I
Final Drainage Report

Calculated by: John Jankousky　　　　Revision: 1/31/2024

Design Point Number	Basin Designation	Area (ft^2)	Area (acres)	Area (mi^2)	Flow Length, L (ft)	Flow Length, L (mi)	Length of Overland Flow, L(OL) (ft)	Length of Concentrated Flow, L(P) (ft)	Top Elevation (ft)	Bottom Elevation (ft)	Change in elevation, H (ft)	Overall Slope, S = H/L (ft/ft)	Overland Flow Top Elevation (ft)	Overland Flow Bottom Elevation (ft)	Overland Change in elevation, H (ft)	Overland Flow Slope, S = H/L (ft/ft)	Concentrated Flow Top Elevation (ft)	Concentrated Flow Bottom Elevation (ft)	Concentrated Change in elevation, H (ft)	Concentrated Flow Slope, S = H/L (ft/ft)
EXISTING CONDITIONS																				
1	Existing 1	2,319,035	53.24	0.0832	2,529	0.48	500	2029	5874.0	5848.0	26.0	0.0103	5874.0	5869.0	5.0	0.0100	5869.0	5848.0	21.0	0.0103
	Basin OFF-1 is the same for Existing and Proposed Conditions. See the calculation below																			
PROPOSED CONDITIONS																				
1	Basin 1	2,319,035	53.24	0.0832	2,529	0.48	320	2209	5874.0	5790.0	84.0	0.0332	5874.0	5810.0	64.0	0.2000	5810.0	5790.0	20.0	0.0091
OFF-1	Basin OFF-1	16,420,861	376.97	0.5890	11,159	2.11	2000	9159	5965.0	5870.0	95.0	0.0085	5965.0	5948.0	17.0	0.0085	5948.0	5870.0	78.0	0.0085

The Site is evaluated as one basin. Basin 1 flows to the pit. There is a portion of the Site along the eastern edge that currently drains directly to Black Squirrel Creek. See the site plan. This drainage pattern will not change. Water quality at this location will be protected by the installation of silt fence as needed.

Note: If no large slope difference between overland flow area and concentrated flow area, use overall slope value only.
Source: Site AutoCAD drawings

Table 2. Percent Impervious Calculations and Rational Method "C" Calculations
Schubert Ranch Sand Resource Pit Phase I
Final Drainage Report

Calculated by: John Jankousky

Revision: 1/31/2024

Soil Hydrologic Group: A

Land Use	% Imp.	C2	C5	C10	C100
Greenbelt, Agriculture	2	0.03	0.09	0.17	0.36
Residential, One Acre	20	0.12	0.20	0.27	0.44
Railroad Yard Area	40	0.23	0.30	0.36	0.50
Street, Gravel	80	0.57	0.59	0.63	0.70
Light Industrial	80	0.57	0.59	0.63	0.70
Building/Roof Area	90	0.73	0.75	0.77	0.81
Pavement Area	100	0.84	0.86	0.87	0.89

Source: City of Colorado Springs Drainage Criteria Manual. May 2014. Revised January 2021. Volume 1. Table 6-6.

Design Point	Basin Designation	Total Area (ft^2)	Total Area (acres)	Greenbelt, Agriculture (ft^2)	Residential, One Acre (ft^2)	Railroad Yard Area (ft^2)	Street, Gravel (ft^2)	Light Industrial Area (ft^2)	Building/Roof Area (ft^2)	Pavement Area (ft^2)	Combined % Impervious	Combined C2	Combined C5	Combined C10	Combined C100
EXISTING CONDITIONS (HISTORIC, PRIOR TO DEVELOPMENT)															
1	Existing 1	2,319,035	53.24	2,319,035							2.00	0.03	0.09	0.17	0.36
	Basin OFF-1 is the same for Existing and Proposed Conditions. See the calculation below														
PROPOSED CONDITIONS AFTER PROJECT IMPLEMENTATION															
1	Basin 1	2,319,035	53.24	2,319,035					0	0	2.00	0.03	0.09	0.17	0.36
OFF-1	Basin OFF-1	16,420,861	376.97	10,664,806	5,601,043		155,012				8.88	0.07	0.13	0.21	0.39

Table 6-6. Runoff Coefficients for Rational Method

(Source: UDFCD 2001)

Land Use or Surface Characteristics	Percent Impervious	Runoff Coefficients											
		2-year		5-year		10-year		25-year		50-year		100-year	
		HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D
Business													
Commercial Areas	95	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.87	0.87	0.88	0.88	0.89
Neighborhood Areas	70	0.45	0.49	0.49	0.53	0.53	0.57	0.58	0.62	0.60	0.65	0.62	0.68
Residential													
1/8 Acre or less	65	0.41	0.45	0.45	0.49	0.49	0.54	0.54	0.59	0.57	0.62	0.59	0.65
1/4 Acre	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
1/3 Acre	30	0.18	0.22	0.25	0.30	0.32	0.38	0.39	0.47	0.43	0.52	0.47	0.57
1/2 Acre	25	0.15	0.20	0.22	0.28	0.30	0.36	0.37	0.46	0.41	0.51	0.46	0.56
1 Acre	20	0.12	0.17	0.20	0.26	0.27	0.34	0.35	0.44	0.40	0.50	0.44	0.55
Industrial													
Light Areas	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
Heavy Areas	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
Parks and Cemeteries	7	0.05	0.09	0.12	0.19	0.20	0.29	0.30	0.40	0.34	0.46	0.39	0.52
Playgrounds	13	0.07	0.13	0.16	0.23	0.24	0.31	0.32	0.42	0.37	0.48	0.41	0.54
Railroad Yard Areas	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
Undeveloped Areas													
Historic Flow Analysis-- Greenbelts, Agriculture	2	0.03	0.05	0.09	0.16	0.17	0.26	0.26	0.38	0.31	0.45	0.36	0.51
Pasture/Meadow	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Forest	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Exposed Rock	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Offsite Flow Analysis (when landuse is undefined)	45	0.26	0.31	0.32	0.37	0.38	0.44	0.44	0.51	0.48	0.55	0.51	0.59
Streets													
Paved	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Gravel	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
Drive and Walks	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Roofs	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
Lawns	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50

3.2 Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration can be an empirical value that results in reasonable and acceptable peak flow calculations.

For urban areas, the time of concentration (t_c) consists of an initial time or overland flow time (t_i) plus the travel time (t_t) in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time (t_i) plus the time of travel in a concentrated form, such as a swale or drainageway. The travel portion (t_t) of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway. Initial time, on the other hand, will vary with surface slope, depression storage, surface cover, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow. The time of concentration is represented by Equation 6-7 for both urban and non-urban areas.

Table 3. Time of Concentration
Schubert Ranch Sand Resource Pit Phase I
Final Drainage Report

Calculated by: John Jankousky   Revision: 1/31/2024

	Sub-Basin Data			Initial Overland Time (t_o)			Travel Time (t_t)					$t_c = t_i + t_t$	tc Check (urbanized)		Final t_c	Remarks
Number	Designation	Area, Ac	C5	Overland Flow Length, Ft.	Slope, %	t_o, min*	Concen-trated Flow Length, Ft.	Slope, %	K Conveyance Factor	Velocity, FPS **	t_t, min	Comp. t_c, min	Total Length, Ft.	t_c = (L/180) +10, min	Final t_c, min	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)	
EXISTING CONDITIONS (HISTORIC, PRIOR TO DEVELOPMENT)																
1	Existing 1	53.24	0.09	500	1.00	41.3	2029	1.03	10.00	10.2	3.3	44.7	2529	24.1	44.7	
	Basin OFF-1 is the same for Existing and Proposed Conditions. See the calculation below															
PROPOSED CONDITIONS AFTER PHASE I IMPLEMENTATION																
1	Basin 1	53.24	0.09	320	20.00	12.2	2209	0.91	10.00	9.5	3.9	16.1	2529	24.1	16.1	
OFF-1	Basin OFF-1	376.97	0.13	2000	0.85	83.8	9159	0.85	10.00	9.2	16.5	100.3	11159	72.0	100.3	

* Calculated using formula: $t_i = (0.395 * (1.1 - C5) * L^{0.5}) / (S^{0.333})$ (Urban Drainage Manual, Equation 6-3)

Where:

t_i = overland (initial) flow time (minutes)

C_5 = runoff coefficient for 5-year frequency (from Table 6-4)

L_i = length of overland flow (ft)

S_o = average slope along the overland flow path (ft/ft).

** For travel time velocity, channelized flow time equation 6-4: tt = Lt /60Vt

NOAA Atlas 14, Volume 8, Version 2
Location name: Calhan, Colorado, USA*
Latitude: 38.797°, Longitude: -104.3569°
Elevation: 5851 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

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	0.243 (0.194-0.307)	0.297 (0.238-0.377)	0.392 (0.312-0.498)	0.476 (0.378-0.607)	0.601 (0.464-0.798)	0.703 (0.529-0.942)	0.811 (0.591-1.11)	0.926 (0.648-1.30)	1.09 (0.732-1.56)	1.22 (0.796-1.76)
10-min	0.355 (0.284-0.450)	0.435 (0.348-0.551)	0.574 (0.458-0.729)	0.697 (0.553-0.889)	0.879 (0.679-1.17)	1.03 (0.775-1.38)	1.19 (0.865-1.63)	1.36 (0.949-1.90)	1.59 (1.07-2.28)	1.78 (1.16-2.58)
15-min	0.433 (0.347-0.549)	0.530 (0.424-0.672)	0.700 (0.558-0.889)	0.850 (0.674-1.08)	1.07 (0.829-1.42)	1.26 (0.945-1.68)	1.45 (1.06-1.98)	1.65 (1.16-2.32)	1.94 (1.31-2.79)	2.17 (1.42-3.14)
30-min	0.656 (0.525-0.831)	0.801 (0.640-1.02)	1.05 (0.840-1.34)	1.28 (1.01-1.63)	1.61 (1.24-2.14)	1.88 (1.42-2.53)	2.17 (1.58-2.98)	2.48 (1.74-3.48)	2.92 (1.96-4.18)	3.26 (2.13-4.72)
60-min	0.834 (0.668-1.06)	1.03 (0.825-1.31)	1.37 (1.09-1.74)	1.67 (1.33-2.13)	2.11 (1.63-2.81)	2.47 (1.86-3.32)	2.85 (2.08-3.90)	3.26 (2.28-4.56)	3.82 (2.57-5.47)	4.26 (2.79-6.16)
2-hr	1.01 (0.815-1.27)	1.26 (1.02-1.59)	1.69 (1.36-2.14)	2.07 (1.65-2.62)	2.62 (2.03-3.45)	3.06 (2.32-4.08)	3.53 (2.59-4.80)	4.03 (2.83-5.60)	4.72 (3.19-6.71)	5.26 (3.47-7.56)
3-hr	1.08 (0.870-1.35)	1.35 (1.09-1.70)	1.83 (1.47-2.30)	2.24 (1.79-2.83)	2.84 (2.21-3.73)	3.33 (2.53-4.41)	3.84 (2.82-5.19)	4.37 (3.08-6.05)	5.11 (3.48-7.24)	5.70 (3.77-8.15)
6-hr	1.24 (1.00-1.54)	1.48 (1.20-1.85)	1.92 (1.56-2.40)	2.33 (1.87-2.92)	2.93 (2.31-3.85)	3.45 (2.64-4.56)	4.00 (2.96-5.40)	4.59 (3.27-6.34)	5.44 (3.74-7.69)	6.12 (4.08-8.70)
12-hr	1.35 (1.10-1.67)	1.59 (1.30-1.97)	2.02 (1.64-2.51)	2.42 (1.96-3.02)	3.04 (2.41-3.96)	3.56 (2.75-4.68)	4.12 (3.08-5.53)	4.73 (3.40-6.50)	5.60 (3.88-7.87)	6.31 (4.24-8.91)
24-hr	1.44 (1.18-1.77)	1.69 (1.39-2.08)	2.14 (1.75-2.64)	2.56 (2.08-3.17)	3.20 (2.56-4.15)	3.75 (2.91-4.90)	4.34 (3.26-5.78)	4.98 (3.60-6.79)	5.90 (4.11-8.23)	6.65 (4.50-9.32)
2-day	1.60 (1.32-1.96)	1.85 (1.52-2.26)	2.30 (1.89-2.82)	2.73 (2.23-3.36)	3.39 (2.73-4.37)	3.96 (3.10-5.14)	4.58 (3.47-6.07)	5.26 (3.83-7.13)	6.23 (4.38-8.64)	7.03 (4.80-9.79)
3-day	1.74 (1.44-2.12)	2.03 (1.68-2.47)	2.54 (2.10-3.10)	3.02 (2.47-3.69)	3.73 (3.00-4.77)	4.33 (3.40-5.59)	4.98 (3.78-6.56)	5.68 (4.15-7.65)	6.68 (4.71-9.21)	7.49 (5.13-10.4)
4-day	1.88 (1.56-2.28)	2.20 (1.82-2.67)	2.76 (2.28-3.36)	3.27 (2.69-3.99)	4.02 (3.24-5.12)	4.66 (3.66-5.98)	5.33 (4.05-6.98)	6.05 (4.43-8.12)	7.07 (5.00-9.71)	7.89 (5.42-10.9)
7-day	2.26 (1.89-2.73)	2.62 (2.18-3.16)	3.25 (2.70-3.93)	3.81 (3.15-4.63)	4.64 (3.75-5.86)	5.33 (4.20-6.79)	6.05 (4.63-7.88)	6.83 (5.03-9.10)	7.92 (5.63-10.8)	8.80 (6.09-12.1)
10-day	2.57 (2.15-3.09)	2.97 (2.48-3.58)	3.66 (3.05-4.42)	4.28 (3.54-5.17)	5.17 (4.18-6.50)	5.91 (4.67-7.49)	6.68 (5.12-8.66)	7.51 (5.54-9.96)	8.66 (6.17-11.8)	9.57 (6.65-13.1)
20-day	3.33 (2.80-3.97)	3.90 (3.28-4.66)	4.85 (4.06-5.81)	5.65 (4.71-6.79)	6.77 (5.48-8.38)	7.66 (6.07-9.59)	8.55 (6.58-10.9)	9.47 (7.02-12.4)	10.7 (7.68-14.4)	11.7 (8.17-15.9)
30-day	3.98 (3.36-4.73)	4.68 (3.94-5.56)	5.81 (4.88-6.92)	6.74 (5.63-8.06)	8.01 (6.48-9.83)	8.98 (7.13-11.2)	9.94 (7.67-12.6)	10.9 (8.12-14.2)	12.2 (8.76-16.3)	13.1 (9.24-17.8)
45-day	4.88 (4.13-5.78)	5.69 (4.81-6.74)	6.98 (5.88-8.29)	8.02 (6.73-9.56)	9.42 (7.64-11.5)	10.5 (8.32-12.9)	11.5 (8.86-14.5)	12.5 (9.30-16.1)	13.7 (9.90-18.2)	14.7 (10.4-19.8)
60-day	5.72 (4.84-6.75)	6.58 (5.57-7.77)	7.95 (6.72-9.42)	9.05 (7.60-10.8)	10.5 (8.52-12.7)	11.6 (9.22-14.2)	12.6 (9.75-15.8)	13.6 (10.2-17.5)	14.8 (10.7-19.6)	15.7 (11.2-21.2)

[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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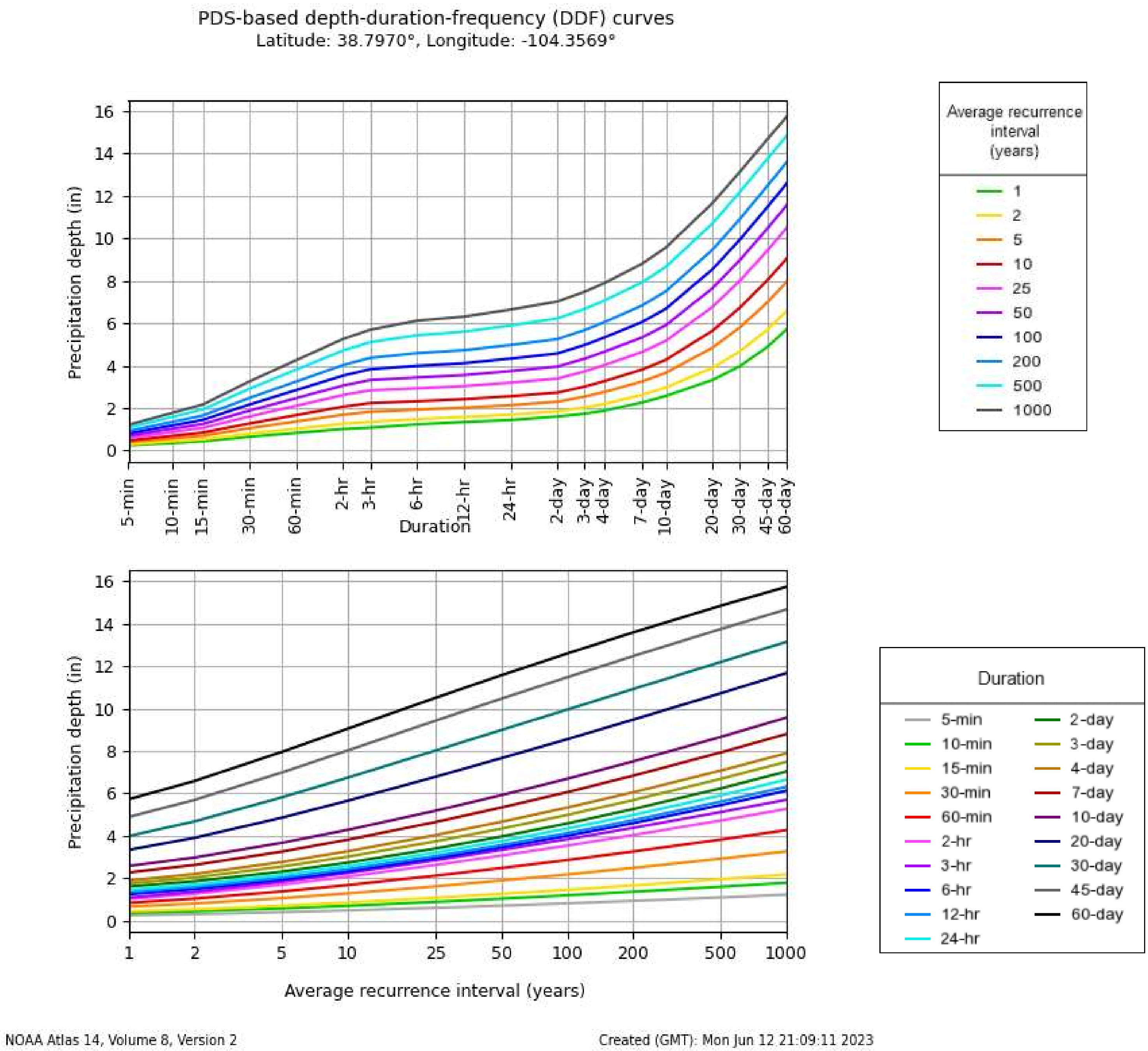
PF graphical



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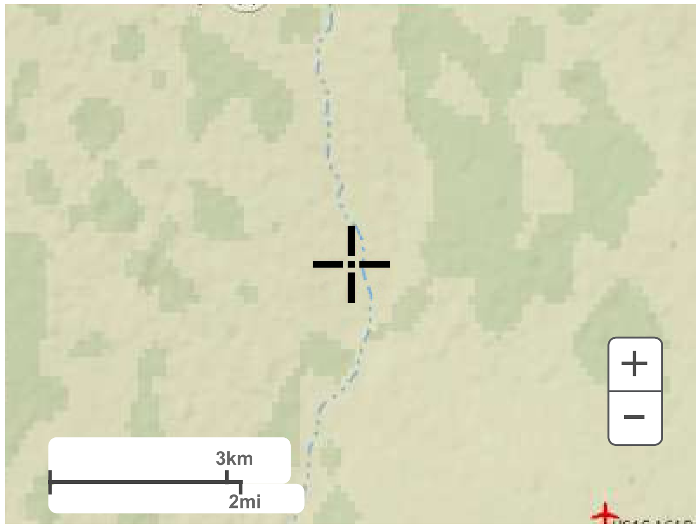
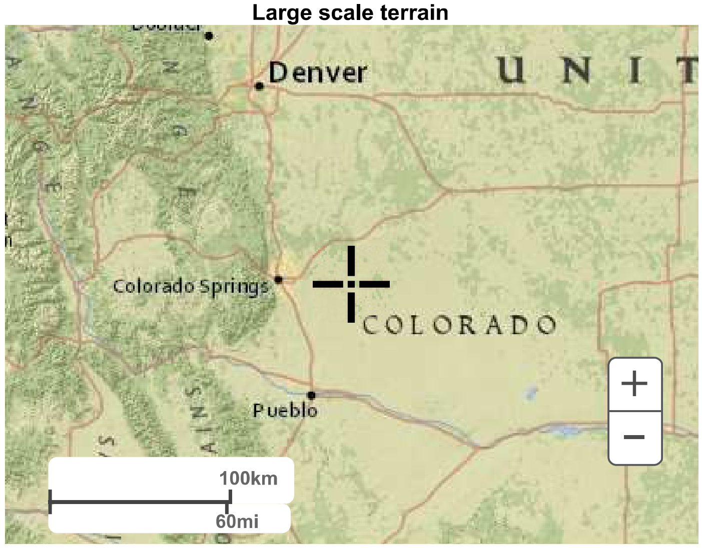
Maps & aerials

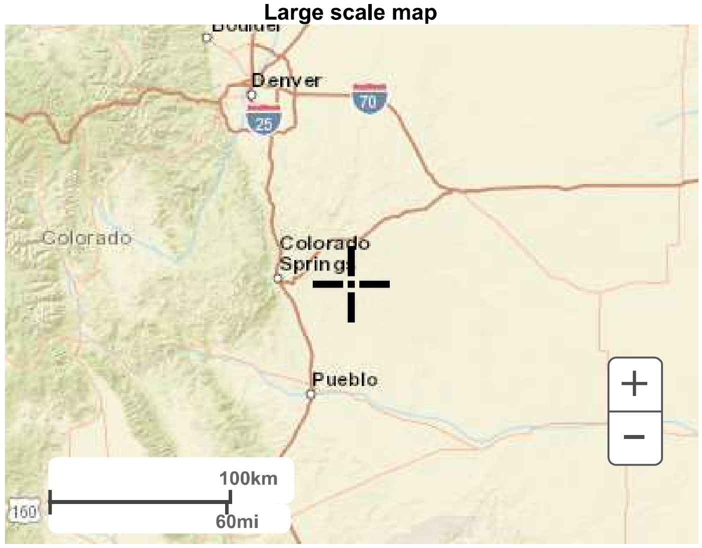
Small scale terrain



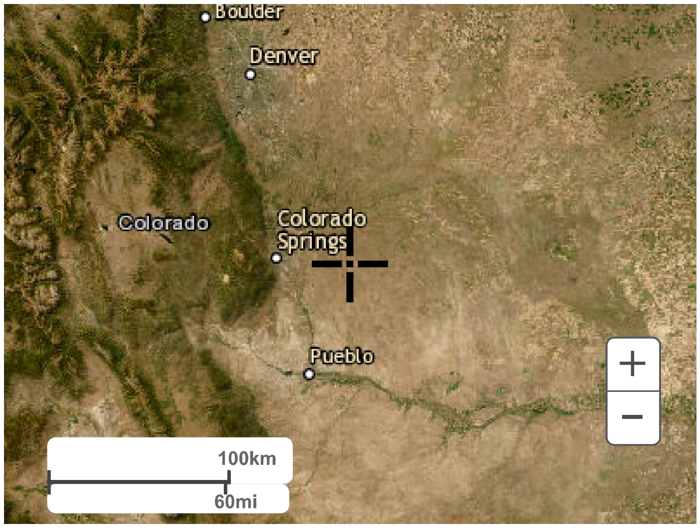
Large scale terrain



Large scale map



Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Rainfall Amounts and Rainfall Intensity from NOAA Atlas

Ellicott Sand Phase 1

Latitude	Longitude
38.79701	-104.356873

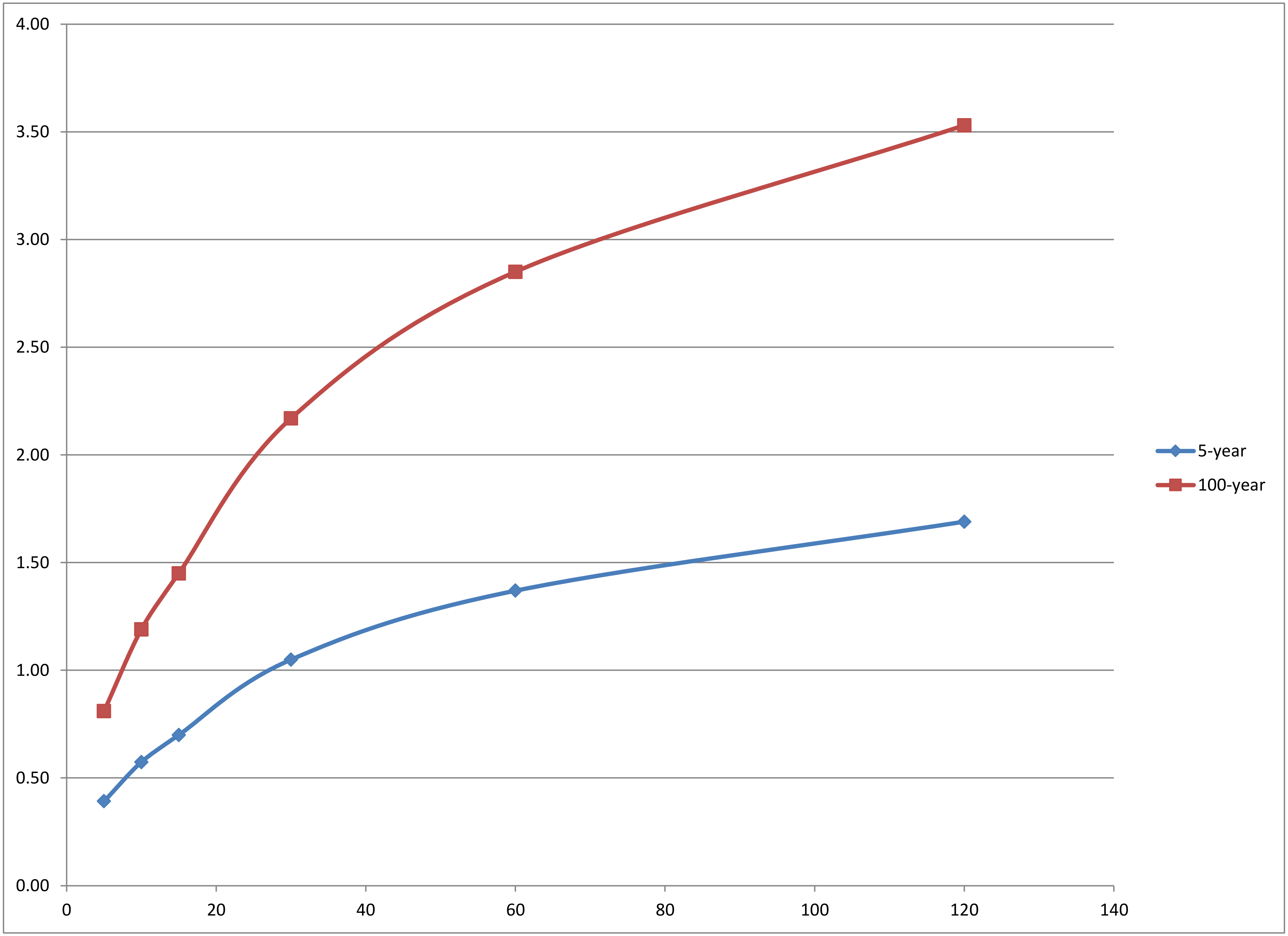
Rainfall From NOAA Atlas

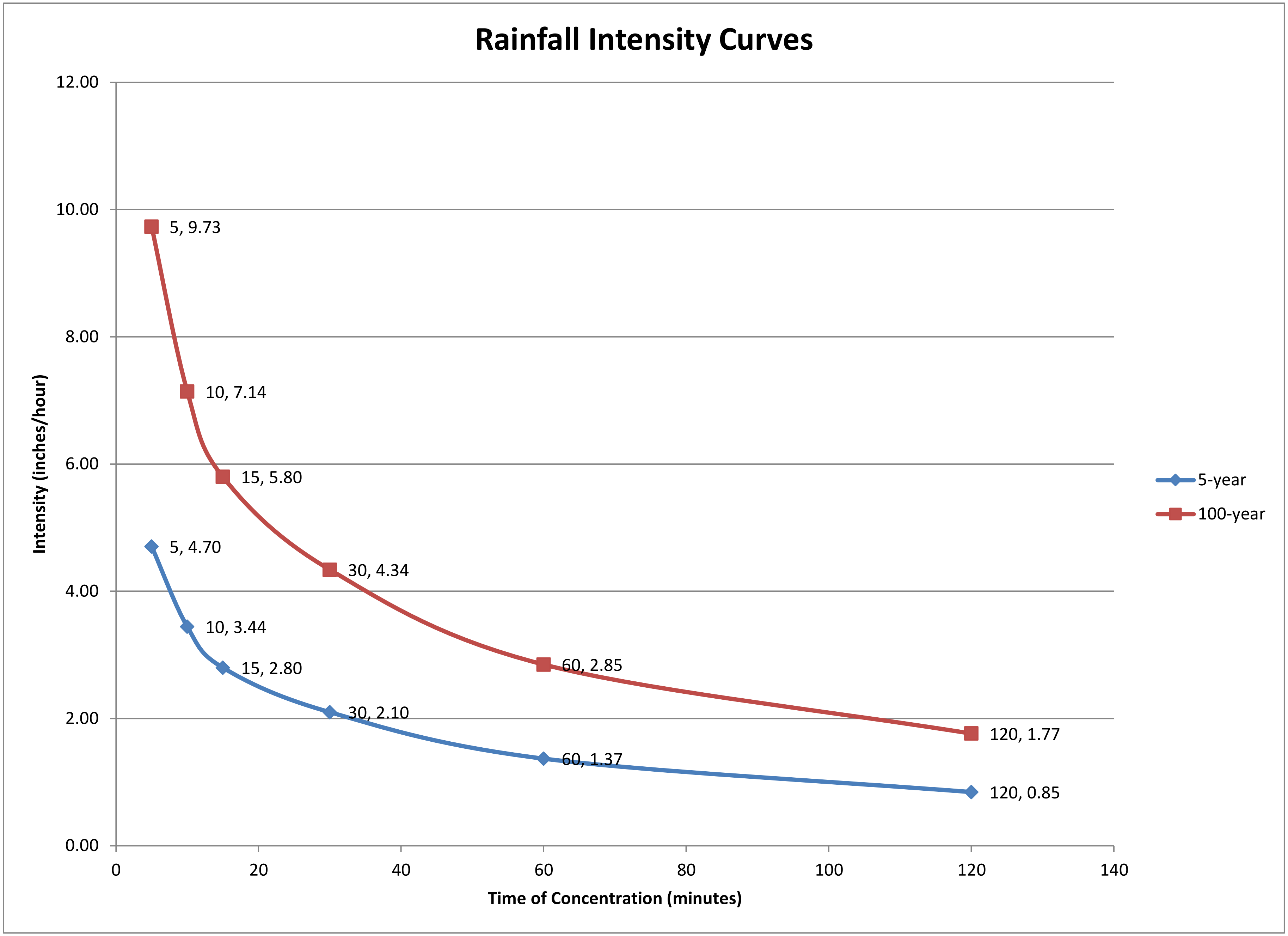
	One-hour Rainfall (inches)	Duration (minutes)					
		5	10	15	30	60	120
2-year							
5-year	1.37	0.39	0.57	0.70	1.05	1.37	1.69
10-year							
50-year							
100-year	2.85	0.81	1.19	1.45	2.17	2.85	3.53

Rainfall Amount		
Minutes	5-year	100-year
5	0.39	0.81
10	0.57	1.19
15	0.70	1.45
30	1.05	2.17
60	1.37	2.85
120	1.69	3.53

Rainfall Intensity (inches/hour)		
Minutes	5-year	100-year
5	4.70	9.73
10	3.44	7.14
15	2.80	5.80
30	2.10	4.34
60	1.37	2.85
120	0.85	1.77

Rainfall Amounts (inches)




Rainfall Intensity Curves
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Intensity (inches/hour)
0
20
40
60
80
100
120
140
Time of Concentration (minutes)
5, 9.73
10, 7.14
15, 5.80
30, 4.34
60, 2.85
120, 1.77
5, 4.70
10, 3.44
15, 2.80
30, 2.10
60, 1.37
120, 0.85
5-year
100-year

Standard Form SF-2

Table 4. Rational Method Procedure -- 5-year Design Storm

Schubert Ranch Sand Resource Pit Phase I

Calculated by: John Jankousky Revision: 1/31/2024

DESIGN STORM: 5-YR

PROPOSED FLOWS

			DIRECT RUNOFF							TOTAL RUNOFF				SWALE		PIPE			TRAVEL TIME			
	Street	Design Point	Area Designation	Area (ac)	Runoff Coeff., C	tc (min)	C*A (AC)	Intensity, I (in/hr)	Q (cfs)	t_c (min)	sum(C*A) (AC)	Intensity, I (in/hr)	Q (cfs)	Slope (%)	Swale Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (in)	Length (ft)	Velocity (fps)	t_t (min)	REMARKS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
HISTORIC CONDITIONS (PRE-DEVELOPMENT)																						
1		1	Existing 1	53.24	0.09	44.7	4.79	1.70	8.1													
PROPOSED CONDITIONS AFTER PROJECT IMPLEMENTATION																						
1		1	Basin 1	53.24	0.09	16.1	4.79	2.70	12.9													
2		OFF-1	Basin OFF-1	376.97	0.13	100.3	49.9	0.92	45.9													

Standard Form SF-2
Table 5. Rational Method Procedure -- 100-year Design Storm
Schubert Ranch Sand Resource Pit Phase I
Calculated by: John Jankousky Revision: 1/31/2024
DESIGN STORM: 100-YR
PROPOSED FLOWS

			DIRECT RUNOFF							TOTAL RUNOFF				SWALE		PIPE			TRAVEL TIME			
	Street	Design Point	Area Designation	Area (ac)	Runoff Coeff., C	tc (min)	C*A (AC)	Intensity, I (in/hr)	Q (cfs)	t_c (min)	sum(C*A) (AC)	Intensity, I (in/hr)	Q (cfs)	Slope (%)	Swale Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (in)	Length (ft)	Velocity (fps)	t_t (min)	REMARKS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
HISTORIC CONDITIONS (PRE-DEVELOPMENT)																						
1		1	Existing 1	53.24	0.36	44.7	19.2	3.30	63.2													
PROPOSED CONDITIONS AFTER PROJECT IMPLEMENTATION																						
1		1	Basin 1	53.24	0.36	16.1	19.2	5.00	95.8													
2		OFF-1	Basin OFF-1	376.97	0.39	100.3	147	1.15	169.3													

Table 6. Required Cross-Sectional Areas for Channel Flow
Schubert Ranch Sand Resource Pit Phase I

Designer: John Jankousky
Revision: 1/31/2024

Description	Shallow channel flow, Basin 1	Shallow channel flow, Basin 1
Flows Collected in Channel	Basin 1	Basin 1
Length of Channel (ft)	2209	2209
Change in Elevation (ft)	20.00	20.00
Slope, S (ft/ft)	0.0091	0.0091
Roughness Factor, n (dimension-less), for sandy swale	0.0180	0.0180
FLOW IN SMALL CHANNEL WEST OF BUILDING IN BASIN 1		
Design Storm	5 year, 24 hour	100 year, 24 hour
Required Peak Flow (cfs)	12.94	95.83
Manning Formula Peak Flow (cfs)	**13.24**	**98.31**
Left Side Slope factor, Z (Z:1)	50.00	50.00
Right Side Slope factor, Z (Z:1)	50.00	50.00
Cross-sectional Area, A (ft^2)	5.6	25.0
Wetted Perimeter, P (ft)	34.0	71.0
Hydraulic Radius, R (ft^2/ft)	0.16	0.35
Slope, S (ft/ft)	0.009	0.009
Flow Depth, Y (ft)	0.28	0.65
Top Width, T (ft), without freeboard	34.0	71.0
Bottom Width, W (ft)	6	6
Flow Velocity, V (fps)	2.4	3.9
Hydraulic Mean Depth, D	0.16	0.35
Froude Number, F	1.03	1.17
Subcritical/Supercritical	Supercritical	Supercritical

Source for Manning's n: Chow, 1959. 4. Excavated or Dredged Channels, a. Earth, straight, and uniform, 1. clean, recently completed

Note: this is flow in a large mine pit, no freeboard needed

Total depth (ft) =	**0.28**	**0.65**
Top Width, T (ft)	**34.00**	**71.00**

Equations:

Slope, S = Change in Elevation / Length of Channel

Area, $A = Z \times Y^2 + Y \times W$

Wetted Perimeter, $P = 2 \times Y \times (1 + Z^2)^{0.5} + W$

Hydraulic Radius, $R = A / P$

Top Width, $T = 2 \times Z \times Y + W$

Flow, $Q = (1.49 \times A \times R^{0.667} \times S^{0.5}) / n$

Flow Velocity, $V = Q / A$

Bottom Width, W = initial assumption

Height, Y = trial and error input

Hydraulic Mean Depth, $D = A / T$

Froude Number, $F = V / (g \times D)^{0.5}$

where: g = gravity acceleration = 32.2 ft/sec^2

Show

Manning's n Values

Reference tables for Manning's n values for Channels, Closed Conduits Flowing Partially Full, and Corrugated Metal Pipes.

Manning's n for Channels (Chow, 1959).

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. same as above, but more stones and weeds	0.030	0.035	0.040
c. clean, winding, some pools and shoals	0.033	0.040	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.050
e. same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. same as "d" with more stones	0.045	0.050	0.060
g. sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. bottom: cobbles with large boulders	0.040	0.050	0.070
3. Floodplains			
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 4. with flood stage reaching branches	0.100	0.120	0.160
4. Excavated or Dredged Channels			
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 as above, highest stage of flow	0.045	0.070	0.110
4. dense brush, high stage	0.080	0.100	0.140
5. Lined or Constructed Channels			
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. Concrete bottom float finish 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 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/stone paving	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

Manning's n for Closed Conduits Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
1. Brass, smooth:	0.009	0.010	0.013
2. Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.030
6. Cement:			

Neat Surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015
7. Concrete:			
Culvert, straight and free of debris	0.010	0.011	0.013
Culvert with bends, connections, and some debris	0.011	0.013	0.014
Finished	0.011	0.012	0.014
Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
Unfinished, steel form	0.012	0.013	0.014
Unfinished, smooth wood form	0.012	0.014	0.016
Unfinished, rough wood form	0.015	0.017	0.020
8. Wood:			
Stave	0.010	0.012	0.014
Laminated, treated	0.015	0.017	0.020
9. Clay:			
Common drainage tile	0.011	0.013	0.017
Vitrified sewer	0.011	0.014	0.017
Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
Vitrified Subdrain with open joint	0.014	0.016	0.018
10. Brickwork:			
Glazed	0.011	0.013	0.015
Lined with cement mortar	0.012	0.015	0.017
Sanitary sewers coated with sewage slime with bends and connections	0.012	0.013	0.016
Paved invert, sewer, smooth bottom	0.016	0.019	0.020
Rubble masonry, cemented	0.018	0.025	0.030

Manning's n for Corrugated Metal Pipe (AISI, 1980).

Type of Pipe, Diameter and Corrugation Dimension	n
1. Annular 2.67 x 1/2 inch (all diameters)	0.024
2. Helical 1.50 x 1/4 inch	
8" diameter	0.012
10" diameter	0.014
3. Helical 2.67 x 1/2 inch	
12" diameter	0.011
18" diameter	0.014
24" diameter	0.016
36" diameter	0.019
48" diameter	0.020
60" diameter	0.021
4. Annular 3x1 inch (all diameters)	0.027
5. Helical 3x1 inch	
48" diameter	0.023
54" diameter	0.023
60" diameter	0.024
66" diameter	0.025
72" diameter	0.026
78" diameter and larger	0.027
6. Corrugations 6x2 inches	
60" diameter	0.033
72" diameter	0.032
120" diameter	0.030
180" diameter	0.028

FishXing Version 3.0 Beta, 2006

Table 7. Riprap Calculations For Black Squirrel Creek at Stage I Project

Riprap calculations for Black Squirrel Creek at Stage I area.
From HEC-RAS model results, find the following information:
d = maximum depth of flow (m)
S = slope of channel (m/m)

Source of flow depth and slope is *Schubert Ranch Sand Resource Floodplain Modeling Technical Memorandum for Black Squirrel Creek*, El Paso County, Colorado, EME Solutions, Inc., J.L. Jankousky. P.E., 02/25/2020.

Cross Sections at Stage 1 (from North to South)	Water Surface Elevation (ft)	Channel Bottom Elevation at Bank (ft)	d = maximum depth of flow (ft)	d = maximum depth of flow (m)	S = slope of channel (m/m)	Maximum Shear Stress (N/m^2) =	Allowable Shear Stress > Max Shear Stress?	Required Riprap d50
29058	5872.79	5868.37	4.42	1.347	0.00285	37.666	Yes, okay	d50 = 6 inches OK
28752	5871.19	5865.79	5.40	1.646	0.005756	92.939	Yes, okay	d50 = 6 inches OK
28260	5868.61	5862.97	5.64	1.719	0.005269	88.857	Yes, okay	d50 = 6 inches OK
27887	5866.36	5860.27	6.09	1.856	0.004533	82.544	Yes, okay	d50 = 6 inches OK
27503	5863.4	5856.14	7.26	2.213	0.004448	96.557	Yes, okay	d50 = 6 inches OK
26962	5859.43	5852.51	6.92	2.109	0.006873	142.212	Yes, okay	d50 = 12 inches OK
26498	5856.28	5850.24	6.04	1.841	0.004885	88.224	Yes, okay	d50 = 6 inches OK
25826	5853.25	5848.74	4.51	1.375	0.004533	61.129	Yes, okay	d50 = 6 inches OK

Convert Feet to Meters, Divide by: 3.28084

Shear Stress	**For riprap d50 = 0.3 m = 12 inches**	**For riprap d50 = 0.15 m = 6 inches**
Allowable Shear Stress (N/m^2)	227	113

Maximum Shear Stress (N/m^2) = Tau(depth) = gamma x d x S
Where
gamma = unit mass of water (N/m^3) 9810
d = maximum depth of flow (m) See table above
S = slope of channel (m/m) See table above
Calculate Maximum Shear Stress (N/m^2) = See table above
Allowable Shear Stress > Max Shear Stress? Check whether Allowable Shear Stress is greater than Maximum Shear Stress

Riprap Shear Stress Reference: US Department of Transportation, Federal Highway Administration Publication FHWA-NHI-05-114, Sept. 2005

Appendix B Material Specifications

TABLE MT-1
Gradation Requirements for Riprap

	Pay Item Type	Stone Size d50 (inches)	Percent of Material Smaller Than Typical Stone	Typical Stone Dimensions (inches)	Typical Stone Weight (Pounds)
			70-100	12	85
Riprap	VL	6	50-70	9	35
			35-50	6	10
			2-10	2	0.4
Riprap			70-100	15	160
	L	9	50-70	12	85
			35-50	9	35
			2-10	3	1.3
Riprap			70-100	21	440
	M	12	50-70	18	275
			35-50	12	85
			2-10	4	3
Riprap			100	30	1,280
	H	18	50-70	24	650
			35-50	18	275
			2-10	6	10
Riprap			100	42	3,500
	VH	24	50-70	33	1,700
			35-50	24	650
			2-10	9	35

Table taken from CDOT's Standard Specifications for Road and Bridge Construction, 1999 and City of Colorado Springs/El Paso County Drainage Criteria Manual.

Table 8. Retention Basin Calculation
Schubert Ranch Sand Resource Pit Phase I

Designer: John Jankousky
Revision: 1/31/2024

The software (Excel spreadsheet with macros) MHFD-Detention, Version 4.06 (July 2022) from UDF
the runoff volumes for Basin 1 and Basin OFF-1. These runoff volumes for the WQCV, the 5-year st
storm are presented below and compared to the volume of the reclaimed pit. The results from the M
spreadsheet are attached.

The volume of available storage is much greater that the expected runoff volumes.

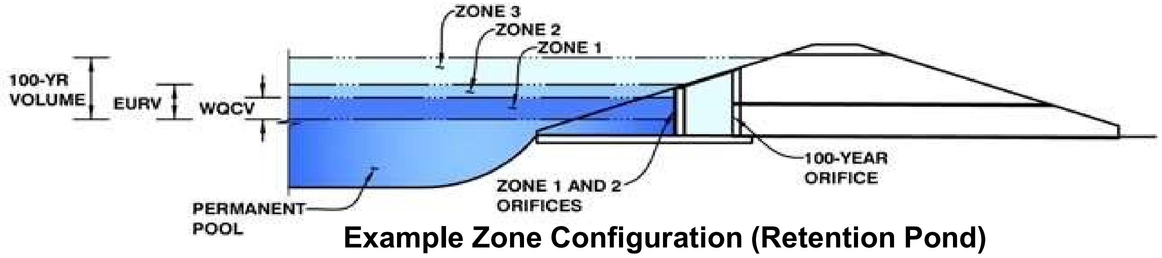
Note: The water quality capture volume (WQCV) is equivalent to the runoff from an 80th percentile s
means that 80 percent of the most frequently occurring storms are fully captured and treated and larg
treated.

Basin Designation	Runoff Volume, WQCV (acre-feet)	Runoff Volume, 5-year storm (acre-feet)	Runoff Volume, 100-year storm (acre-feet)
Basin 1	0.054	0.041	3.362
Basin OFF-1	1.521	1.613	27.863
Sum of Both Basins	**1.575**	**1.654**	**31.225**

Volume of Available Storage = The excavated and reclaimed pit will hold 2010 acre-feet

Project: Schubert Ranch

Basin ID: Basin 1



Example Zone Configuration (Retention Pond)

Depth Increement =

Stage - Storage Description
Permanent Pool

Watershed Information

Selected BMP Type =	**RP**	
Watershed Area =	53.24	acres
Watershed Length =	2,529	ft
Watershed Length to Centroid =	1,265	ft
Watershed Slope =	0.033	ft/ft
Watershed Imperviousness =	2.00%	percent
Percentage Hydrologic Soil Group A =	100.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Target WQCV Drain Time =	12.0	hours
Location for 1-hr Rainfall Depths =	User Input	

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.054	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.050	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.03 in.) =	0.012	acre-feet	1.03	inches
5-yr Runoff Volume (P1 = 1.37 in.) =	0.041	acre-feet	1.37	inches
10-yr Runoff Volume (P1 = 1.67 in.) =	0.067	acre-feet	1.67	inches
25-yr Runoff Volume (P1 = 2.11 in.) =	0.968	acre-feet	2.11	inches
50-yr Runoff Volume (P1 = 2.47 in.) =	1.945	acre-feet	2.47	inches
100-yr Runoff Volume (P1 = 2.85 in.) =	3.362	acre-feet	2.85	inches
500-yr Runoff Volume (P1 = 3.82 in.) =	7.243	acre-feet	3.82	inches
Approximate 2-yr Detention Volume =	0.024	acre-feet		
Approximate 5-yr Detention Volume =	0.036	acre-feet		
Approximate 10-yr Detention Volume =	0.054	acre-feet		
Approximate 25-yr Detention Volume =	0.089	acre-feet		
Approximate 50-yr Detention Volume =	0.230	acre-feet		
Approximate 100-yr Detention Volume =	0.651	acre-feet		

TORAGE TABLE BUILDER

n 4.06 (July 2022)

ft

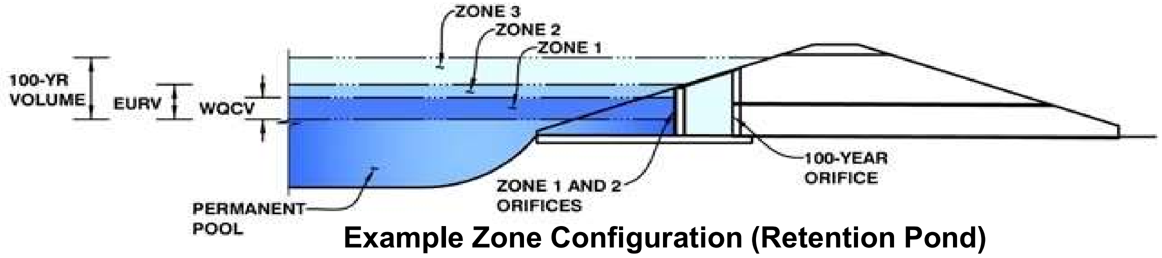
Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)

DETENTION BASIN STAGE-S

MHFD-Detention, Versio

Project: Schubert Ranch

Basin ID: Basin OFF-1



Example Zone Configuration (Retention Pond)

Depth Increment =

Stage - Storage Description
Permanent Pool

Watershed Information

Selected BMP Type =	**RP**	
Watershed Area =	376.97	acres
Watershed Length =	11,159	ft
Watershed Length to Centroid =	5,580	ft
Watershed Slope =	0.009	ft/ft
Watershed Imperviousness =	8.88%	percent
Percentage Hydrologic Soil Group A =	100.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Target WQCV Drain Time =	12.0	hours
Location for 1-hr Rainfall Depths =	User Input	

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	1.521	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	2.379	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.03 in.) =	0.655	acre-feet	1.03	inches
5-yr Runoff Volume (P1 = 1.37 in.) =	1.613	acre-feet	1.37	inches
10-yr Runoff Volume (P1 = 1.67 in.) =	2.441	acre-feet	1.67	inches
25-yr Runoff Volume (P1 = 2.11 in.) =	9.929	acre-feet	2.11	inches
50-yr Runoff Volume (P1 = 2.47 in.) =	17.291	acre-feet	2.47	inches
100-yr Runoff Volume (P1 = 2.85 in.) =	27.863	acre-feet	2.85	inches
500-yr Runoff Volume (P1 = 3.82 in.) =	55.651	acre-feet	3.82	inches
Approximate 2-yr Detention Volume =	1.227	acre-feet		
Approximate 5-yr Detention Volume =	1.783	acre-feet		
Approximate 10-yr Detention Volume =	2.466	acre-feet		
Approximate 25-yr Detention Volume =	3.719	acre-feet		
Approximate 50-yr Detention Volume =	5.349	acre-feet		
Approximate 100-yr Detention Volume =	9.315	acre-feet		

STORAGE TABLE BUILDER

n 4.06 (July 2022)

ft

Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)