10' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 10	W (ft) = 6	B (ft) = 1.17	C (ft) = 1.75
F (ft) = 1	E (ft) = 3.25	X (ft) = 1.33	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right)$$

$$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$$

Pp (lb) = 2161.35	Ph (lb) = 1846.567043	Pv (lb) = 0	Pa (lb) = 1846.57

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p} \qquad P_a \cos\alpha = P_h = P_a \qquad P_v = P_a \sin\alpha \qquad P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	32.5	3087.5	4.375	13507.8125
2	0	0	0	0
3	8.33	1250	2.33	2916.666667
4	0.85	127.5	2.31	293.8875
5	7	1050	3	3150
6	1.88	281.25	3.92	1101.65625

ΣV (lb) = 5796.25 ΣMr (lb*ft) = 20970.02

Overturning:

$$\mathrm{FS}_{(\text{overturning})} = \frac{\Sigma M_R}{\Sigma M_o}$$

ΣMo (lb*ft) = 6873.33

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 3.05

Sliding Along Base:

$$\mathrm{FS}_{(\text{sliding})} = \frac{(\Sigma V)\tan\delta' + Bc_a' + P_p}{P_a \cos\alpha}$$

FS (sliding) = 2.62

Bearing Capacity Failure:

$$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} \qquad e = \frac{B}{2} - \overline{X}$$

X(bar) (ft) = 2.43	e (ft) = 0.57

$$q_{\text{toe}} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{\text{heel}} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

q max/toe (psf) = 1514.72	q min/heel (psf) = 417.37

Nc = 16.88	Fcd = 1.06	Fci = 1
Nq = 7.82	Fqd = 1.01	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi_2'}$$

$$F_{qd} = 1 + 2\tan\phi_2'(1 - \sin\phi_2')^2\frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 10964.02

$$q_u = c_2' N_c F_{cd} F_{ci} + qN_q F_{qd} F_{qi} + \tfrac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

FS (BC Failure) = 7.24

$$\mathrm{FS}_{(\text{bearing capacity})} = \frac{q_u}{q_{\max}}$$

12' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 12	W (ft) = 7	B (ft) = 1.25	C (ft) = 2
F (ft) = 1	E (ft) = 4	X (ft) = 1.67	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right)$$

$$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$$

Pp (lb) = 2161.35	Ph (lb) = 2659.06	Pv (lb) = 0	Pa (lb) = 2659.06

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p} \qquad P_a \cos\alpha = P_h = P_a \qquad P_v = P_a \sin\alpha \qquad P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	48	4560	5	22800
2	0	0	0	0
3	10.00	1500	3	4500
4	1.02	153	2	306
5	8.75	1312.5	3.5	4593.75
6	1.88	281.25	4.58	1288.13
	ΣV (lb) =	7806.75	ΣMr (lb) =	33487.88

Overturning:

$$\mathrm{FS}_{(\text{overturning})} = \frac{\Sigma M_R}{\Sigma M_o}$$

ΣMo (lb*ft) = 11744.1664

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.85

Sliding Along Base:

$$\mathrm{FS}_{(\text{sliding})} = \frac{(\Sigma V)\tan\delta' + Bc_a' + P_p}{P_a \cos\alpha}$$

FS (sliding) = 2.17

Bearing Capacity Failure:

$$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} \qquad e = \frac{B}{2} - \overline{X}$$

X(bar) (ft) = 2.79	e (ft) = 0.71

$$q_{\text{toe}} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{\text{heel}} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

q max/toe (psf) = 1798.51	q min/heel (psf) = 431.99	

Nc = 16.88	Fcd = 1.05	Fci = 1
Nq = 7.82	Fqd = 1.01	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi_2'}$$

$$F_{qd} = 1 + 2\tan\phi_2'(1 - \sin\phi_2')^2\frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 11143.20

$$q_u = c_2' N_c F_{cd} F_{ci} + qN_q F_{qd} F_{qi} + \tfrac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

FS (BC Failure) = 6.20

$$\mathrm{FS}_{(\text{bearing capacity})} = \frac{q_u}{q_{\max}}$$

13' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 13	W (ft) = 7.5	B (ft) = 1.25	C (ft) = 2.25
F (ft) = 1	E (ft) = 4.25	X (ft) = 1.83	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right)$$

$$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$$

Pp (lb) = 2161.35	Ph (lb) = 3120.70	Pv (lb) = 0	Pa (lb) = 3120.70

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p} \qquad P_a \cos\alpha = P_h = P_a \qquad P_v = P_a \sin\alpha \qquad P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	55.25	5248.75	5.375	28212.03
2	0	0	0	0.00
3	10.83	1625	3.25	5281.25
4	1.11	165.75	2.25	372.94
5	9.375	1406.25	3.75	5273.44
6	1.88	281.25	4.92	1382.81
	ΣV (lb) =	8727	ΣMr (lb) =	40522.47

Overturning:

$$FS_{(overturning)} = \frac{\Sigma M_R}{\Sigma M_o}$$

ΣMo (lb*ft) = 14823.32

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.73

Sliding Along Base:

$$FS_{(sliding)} = \frac{(\Sigma V)\tan\delta' + Bc_a' + P_p}{P_a \cos\alpha}$$

FS (sliding) = 1.99

Bearing Capacity Failure:

$$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} \qquad e = \frac{B}{2} - \overline{X}$$

X(bar) (ft) = 2.94	e (ft) = 0.81

$$q_{toe} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{heel} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

q max/toe (psf) = 1913.16	q min/heel (psf) = 414.04

Nc = 16.88	Fcd = 1.05	Fci = 1
Nq = 7.82	Fqd = 1.01	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi_2'}$$

$$F_{qd} = 1 + 2\tan\phi_2'(1 - \sin\phi_2')^2 \frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 11227.24

$$q_u = c_2' N_c F_{cd} F_{ci} + qN_q F_{qd} F_{qi} + \tfrac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

FS (BC Failure) = 5.87

$$FS_{(bearing\ capacity)} = \frac{q_u}{q_{max}}$$

14' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 14	W (ft) = 8	B (ft) = 1.25	C (ft) = 2.25
F (ft) = 1.17	E (ft) = 4.58	X (ft) = 2	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right)$$

$$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$$

Pp (lb) = 2161.35	Ph (lb) = 3619.27	Pv (lb) = 0	Pa (lb) = 3619.271

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p} \qquad P_a \cos\alpha = P_h = P_a \qquad P_v = P_a \sin\alpha \qquad P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	64.17	6095.83	5.71	34797.05
2	0	0	0	0.00
3	11.67	1750	3.42	5979.17
4	1.19	178.5	2.25	401.63
5	10	1500	4	6000.00
6	1.88	281.25	5.25	1476.56
	ΣV (lb) =	9805.58	ΣMr (lb) =	48654.40

Overturning:

$$FS_{(overturning)} = \frac{\Sigma M_R}{\Sigma M_o}$$

ΣMo (lb*ft) = 18397.96

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.64

Sliding Along Base:

$$FS_{(sliding)} = \frac{(\Sigma V)\tan\delta' + Bc_a' + P_p}{P_a \cos\alpha}$$

FS (sliding) = 1.85

Bearing Capacity Failure:

$$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} \qquad e = \frac{B}{2} - \overline{X}$$

X(bar) (ft) = 3.09	e (ft) = 0.91

q max/toe (psf) = 2066.25	q min/heel (psf) = 385.15

$$q_{toe} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{heel} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

Nc = 16.88	Fcd = 1.04	Fci = 1
Nq = 7.82	Fqd = 1.01	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi_2'}$$

$$F_{qd} = 1 + 2\tan\phi_2'(1 - \sin\phi_2')^2\frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 11301.61

$$q_u = c_2' N_c F_{cd} F_{ci} + qN_q F_{qd} F_{qi} + \tfrac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

FS (BC Failure) = 5.47

$$FS_{(bearing\ capacity)} = \frac{q_u}{q_{max}}$$

15' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 15	W (ft) = 8.5	B (ft) = 1.25	C (ft) = 2.5
F (ft) = 1.25	E (ft) = 4.75	X (ft) = 1.17	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.389
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right)$$

$$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$$

Pp (lb) = 2161.35	Ph (lb) = 4154.78	Pv (lb) = 0	Pa (lb) = 4154.78

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p} \qquad P_a \cos\alpha = P_h = P_a \qquad P_v = P_a \sin\alpha \qquad P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	71.25	6768.75	6.13	41458.59
2	0	0	0	0.00
3	12.50	1875	3.75	7031.25
4	1.28	191.25	2.5	478.13
5	10.625	1593.75	4.25	6773.44
6	1.88	281.25	6.58	1851.56
	ΣV (lb) =	10710	ΣMr (lb) =	57592.97

Overturning:

$$FS_{(overturning)} = \frac{\Sigma M_R}{\Sigma M_o}$$

ΣMo (lb*ft) = 22505.04

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.56

Sliding Along Base:

$$FS_{(sliding)} = \frac{(\Sigma V)\tan\delta' + Bc_a' + P_p}{P_a \cos\alpha}$$

FS (sliding) = 1.71

Bearing Capacity Failure:

$$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} \qquad e = \frac{B}{2} - \overline{X}$$

$$q_{toe} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{heel} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

X(bar) (ft) = 3.28	e (ft) = 0.97

q max/toe (psf) = 2126.12	q min/heel (psf) = 393.88

Nc = 16.88	Fcd = 1.04	Fci = 1
Nq = 7.82	Fqd = 1.01	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi_2'}$$

$$F_{qd} = 1 + 2\tan\phi_2'(1 - \sin\phi_2')^2 \frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 11412.13

$$q_u = c_2' N_c F_{cd} F_{ci} + qN_q F_{qd} F_{qi} + \tfrac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

FS (BC Failure) = 5.37

$$FS_{(bearing\ capacity)} = \frac{q_u}{q_{max}}$$

17' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 17	W (ft) = 10.17	B (ft) = 1.33	C (ft) = 2.75
F (ft) = 1.42	E (ft) = 6	X (ft) = 2.5	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right)$$

$$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$$

Pp (lb) = 2161.35	Ph (lb) = 5336.58	Pv (lb) = 0	Pa (lb) = 5336.58

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p} \qquad P_a \cos\alpha = P_h = P_a \qquad P_v = P_a \sin\alpha \qquad P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	102	9690	6.835	66231.15
2	0	0	0	0
3	14.17	2125	4.17	8861.25
4	1.45	216.75	2.75	596.0625
5	13.521667	2028.25	4.75	9634.1875
6	1.88	281.25	6.25	1757.8125
	ΣV (lb) =	14341.25	ΣMr (lb) =	87080.46

Overturning:

$$FS_{(overturning)} = \frac{\Sigma M_R}{\Sigma M_o}$$

ΣMo (lb*ft) = 32606.50

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.67

Sliding Along Base:

$$FS_{(sliding)} = \frac{(\Sigma V)\tan\delta' + Bc_a' + P_p}{P_a \cos\alpha}$$

FS (sliding) = 1.65

Bearing Capacity Failure:

$$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} \qquad e = \frac{B}{2} - \overline{X}$$

$$q_{toe} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{heel} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

X(bar) (ft) = 3.80	e (ft) = 1.28

q max/toe (psf) = 2480.30	q min/heel (psf) = 340.92

Nc = 16.88	Fcd = 1.03	Fci = 1
Nq = 7.82	Fqd = 1.00	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi_2'}$$

$$F_{qd} = 1 + 2\tan\phi_2'(1 - \sin\phi_2')^2 \frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 11717.21

$$q_u = c_2' N_c F_{cd} F_{ci} + qN_q F_{qd} F_{qi} + \tfrac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

FS (BC Failure) = 4.72

$$FS_{(bearing\ capacity)} = \frac{q_u}{q_{max}}$$

21' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 21	W (ft) = 11.5	B (ft) = 1.58	C (ft) = 3.25
F (ft) = 1.75	E (ft) = 6.5	X (ft) = 3.17	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right)$$

$$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$$

Pp (lb) = 2992.73	Ph (lb) = 7881.28	Pv (lb) = 0	Pa (lb) = 8143.36

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p} \qquad P_a \cos\alpha = P_h = P_a \qquad P_v = P_a \sin\alpha \qquad P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	136.5	12967.5	8.25	106981.88
2	0	0	0	0.00
3	17.50	2625	5	13125.00
4	1.79	267.75	3.25	870.19
5	18.208333	2731.25	5.75	15704.69
6	3.75	562.5	7.58	4265.63
	ΣV (lb) =	19154	ΣMr (lb) =	140947.38

Slope Heel of Wall at 45° and Extend Key to H=2.5 ft

$$P_a = \frac{1}{2}\gamma_1 K_a (H' - D')^2 + \frac{A}{2}\gamma_1 K_a [H'^2 - (H' - D')^2]$$

Pa1 (lb) = 7881.276

Soil friction angle, ϕ_1' (deg)	A
20	0.28
25	0.14
30	0.06
35	0.03
40	0.018

Overturning: $\mathrm{FS}_{(\text{overturning})} = \dfrac{\Sigma M_R}{\Sigma M_o}$ ΣMo (lb*ft) = 61301.41

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.30

Sliding Along Base: $\mathrm{FS}_{(\text{sliding})} = \dfrac{(\Sigma V)\tan\delta' + Bc_a' + P_p}{P_a \cos\alpha}$

FS (sliding) = 1.51

Bearing Capacity Failure: $\overline{X} = \dfrac{\Sigma M_R - \Sigma M_o}{\Sigma V}$ $e = \dfrac{B}{2} - \overline{X}$

X(bar) (ft) = 4.16	e (ft) = 1.59

q max/toe (psf) = 3048.83	q min/heel (psf) = 282.30

$$q_{\text{toe}} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{\text{heel}} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

Nc = 16.88	Fcd = 1.03	Fci = 1
Nq = 7.82	Fqd = 1.00	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi_2'}$$

$$F_{qd} = 1 + 2\tan\phi_2'(1 - \sin\phi_2')^2 \frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 11932.13 $q_u = c_2' N_c F_{cd} F_{ci} + qN_q F_{qd} F_{qi} + \frac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$

FS (BC Failure) = 3.91 $\mathrm{FS}_{(\text{bearing capacity})} = \dfrac{q_u}{q_{\max}}$

100-YR Storm Rational Method Data

Time of Concentration (Tc)

$$T_c = 11.4L^{0.5}K_b{}^{0.52}S^{-0.31}i^{-0.38}$$

Units

L (ft) =	1160	L (mi) =	0.2197
ΔH (ft) =	36	(6834 ft - 6798 ft)	
S (ft/mi) =	163.8621		
Kb (paved) =	0.02		

	T(hr)	i (in/hr)	Tc (hr)	T-Tc =
60 min	1	2.44	0.102484	0.897516
30 min	0.5	3.94	0.0854232	0.414577
15 min	0.25	5.86	0.0734621	0.176538
10 min	0.167	7.09	0.0683311	0.098336
5 min	0.083	9.31	0.0616117	0.021722

Although 5 min Tc is closer to T, minimum Tc = 10 min
per ADOT Hydrology Manual 2.2.4

Runoff (Q) for Impervious Surfaces

$$Q_{Paved} = CiA$$

Units		
i (in/hr) =	7.09	
Road Area:	2	lanes
W (ft) =	12	
L (ft) =	1160	
A (Road) (ft^2) =	27840	
Gutter Area:	2	gutters
W (ft) =	3	
L (ft) =	700	
A (Gutter) (ft^2) =	4200	
Top of Walls Area:	2	walls
W (ft) =	0.833	10" Wall Tops per ADOT Retaining Wall Structural Detail SD 7.01
L (ft) =	700	
A (Top of Walls) (ft^2) =	1167	
A (total) (acres)=	0.762	(ft^2) / (43560ft^2/acre)
C (Impervious)=	0.95	Per ADOT Hydrology Manual Figure 2-1

Q (Impervious) (cfs) = 5.13461

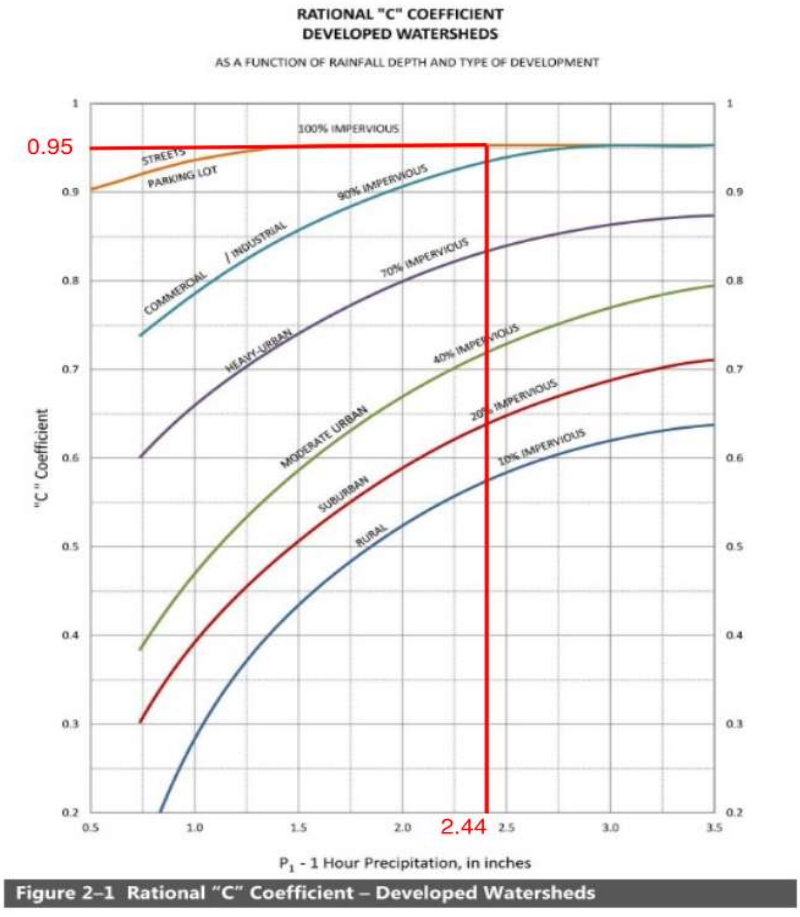


Figure 2–1 Rational "C" Coefficient – Developed Watersheds

Runoff (Q) for Pervious Surfaces

$$Q_{Pervious} = CiA$$

Units		
i (in/hr) =	7.09	
Wall 1 Area:	2	Walls
W (ft) =	13.25	(Width of Cantilever Heel + Height of Wall) 10+3.25
L (ft) =	100	
A (Road) (ft^2) =	2650	
Wall 2 Area:	2	Walls
W (ft) =	16	(Width of Cantilever Heel + Height of Wall) 12+4
L (ft) =	100	
A (Road) (ft^2) =	3200	
Wall 3 Area:	2	Walls
W (ft) =	17.25	(Width of Cantilever Heel + Height of Wall) 13+4.25
L (ft) =	100	
A (Road) (ft^2) =	3450	
Wall 4 Area:	2	Walls
W (ft) =	18.5	(Width of Cantilever Heel + Height of Wall) 14+4.5
L (ft) =	100	
A (Road) (ft^2) =	3700	
Wall 5 Area:	2	Walls
W (ft) =	19.75	(Width of Cantilever Heel + Height of Wall) 15+4.75
L (ft) =	100	
A (Road) (ft^2) =	3950	
Wall 6 Area:	2	Walls
W (ft) =	22.333	(Width of Cantilever Heel + Height of Wall) 17+5.333
L (ft) =	100	
A (Road) (ft^2) =	4466.6	
Wall 7 Area:	2	Walls
W (ft) =	27.5	(Width of Cantilever Heel + Height of Wall) 21+6.5
L (ft) =	100	
A (Road) (ft^2) =	5500	
A (Total) (acres) =	0.618	(ft^2) / (43560ft^2/acre)
C (Impervious)=	0.54	Per ADOT Hydrology Manual Figure 2-4

Q (Pervious) (cfs) = 2.36577

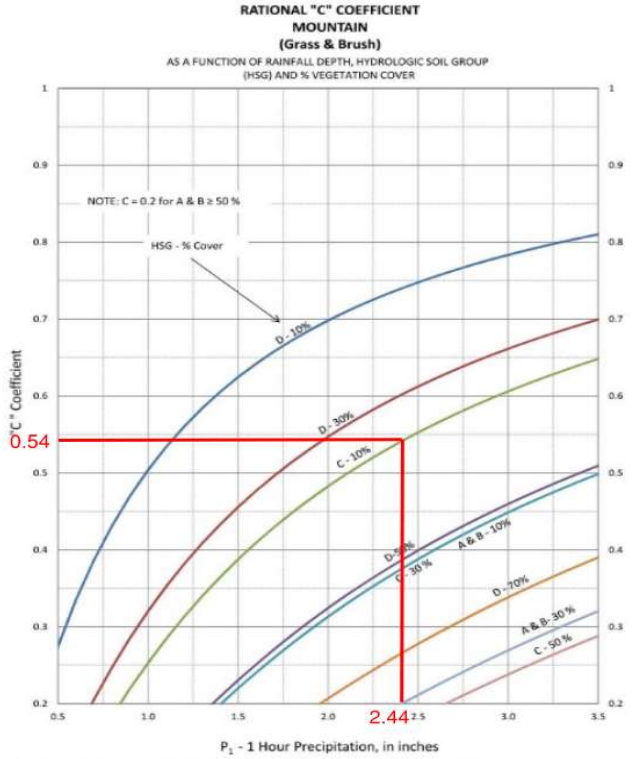


Figure 2–4 Rational "C" Coefficient – Mountain (Grass & Brush)

Total Water Storage Volume:

Q (Impervious) (cfs) =	5.135
Q (Pervious) (cfs) =	2.366
Q (Total) (cfs) =	7.500

Tc (min) =	10
Tc (sec) =	600

Required Storage Volume (ft^3)=	4500
Recommended Volume (133%) Required Volume (ft^3) =	6000

Chamber Storage:

Stormtech Chamer Volume (with 9" Stone Foundation Depth) (ft^3) =	267.3
Stormtech Chamer Volume (with 12" Stone Foundation Depth) (ft^3) =	273.3
Stormtech Chamer Volume (with 15" Stone Foundation Depth) (ft^3) =	279.3
Stormtech Chamer Volume (with 18" Stone Foundation Depth) (ft^3) =	285.3

Stormtech End Cap Volume (with 9" Stone Foundation Depth) (ft^3) =	115.3
Stormtech End Cap Volume (with 12" Stone Foundation Depth) (ft^3) =	118.6
Stormtech End Cap Volume (with 15" Stone Foundation Depth) (ft^3) =	121.9
Stormtech End Cap Volume (with 18" Stone Foundation Depth) (ft^3) =	125.2

2 Trenches, 4 Caps @ 9" Depth =	21 Chambers	Divisible by 2?	No	NO GOOD
2 Trenches, 4 Caps @ 12" Depth =	21 Chambers	Divisible by 2?	No	NO GOOD
2 Trenches, 4 Caps @ 15" Depth =	20 Chambers	Divisible by 2?	Yes	OK
2 Trenches, 4 Caps @ 18" Depth =	20 Chambers	Divisible by 2?	Yes	OK
3 Trenches, 6 Caps @ 9" Depth =	20 Chambers	Divisible by 3?	No	NO GOOD
3 Trenches, 6 Caps @ 12" Depth =	20 Chambers	Divisible by 3?	No	NO GOOD
3 Trenches, 6 Caps @ 15" Depth =	19 Chambers	Divisible by 3?	No	NO GOOD
3 Trenches, 6 Caps @ 18" Depth =	19 Chambers	Divisible by 3?	No	NO GOOD

Use 2 Rows of 10 Chambers each

Nominal Chamber Specifications
(not to scale)

Size (L x W x H)
83" x 100" x 60"
2108 mm x 2540 mm x 1524 mm

Chamber Storage
175.9 ft³ (4.98 m³)

Min. Installed Storage*
267.3 ft³ (7.57 m³)

Weight
202 lbs (91.6 kg)

Nominal End Cap Specifications
(not to scale)

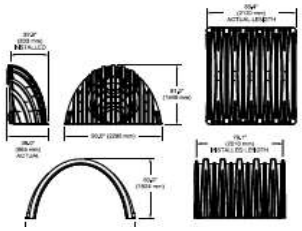
Size (L x W x H)
38" x 90" x 61"
965 mm x 2286 mm x 1549 mm

End Cap Storage
39.5 ft³ (1.12 m³)

Min. Installed Storage*
115.3 ft³ (3.26 m³)

Weight
Nominal 90.0 lbs (40.8 kg)

*Assumes a minimum of 12" (300 mm)



StormTech MC-7200 Specifications

Storage Volume Per Chamber

	Bare Chamber Storage ft³ (m³)	Chamber and Stone Foundation Depth in. (mm)			
		9 in (230 mm)	12 in (300 mm)	15 in (375 mm)	18 in (450 mm)
Chamber	175.9 (4.98)	267.3 (7.57)	273.3 (7.74)	279.3 (7.91)	285.3 (8.08)
End Cap	39.5 (1.12)	115.3 (3.26)	118.6 (3.36)	121.9 (3.45)	125.2 (3.54)

Note: Assumes 9" (230 mm) row spacing, 40% stone porosity, 12" (300 mm) stone above and includes the bare chamber/end cap volume. End cap volume assumes 12" (300 mm) stone perimeter in front of end cap.

Amount of Stone Per Chamber

English Tons (yds³)	Stone Foundation Depth			
	9 in	12 in	15 in	18 in
Chamber	12.1 (8.5)	12.9 (9.0)	13.6 (9.6)	14.3 (10.1)
End Cap	9.8 (7.0)	10.2 (7.3)	10.6 (7.6)	11.1 (7.9)
Metric Kilograms (m³)	**230 mm**	**300 mm**	**375 mm**	**450 mm**
Chamber	10977 (6.5)	11703 (6.9)	12338 (7.3)	12973 (7.7)
End Cap	8890 (5.3)	9253 (5.5)	9616 (5.8)	10069 (6.0)

Note: Assumes 12" (300 mm) of stone above and 9" (230 mm) row spacing and 12" (300 mm) of perimeter stone in front of end caps. 1 yd³ = 1.42 english tons.

Volume Excavation Per Chamber yd³ (m³)

	Stone Foundation Depth			
	9 in (230 mm)	12 in (300 mm)	15 in (375mm)	18 in (450 mm)
Chamber	17.2 (13.2)	17.7 (13.5)	18.3 (14.0)	18.8 (14.4)
End Cap	9.7 (7.4)	10.0 (7.6)	10.3 (7.9)	10.6 (8.1)

Note: Assumes 9" (230 mm) of separation between chamber rows, 12" (300 mm) of perimeter in front of the end caps, and 24" (600 mm) of cover. The volume of excavation will vary as depth of cover increases.