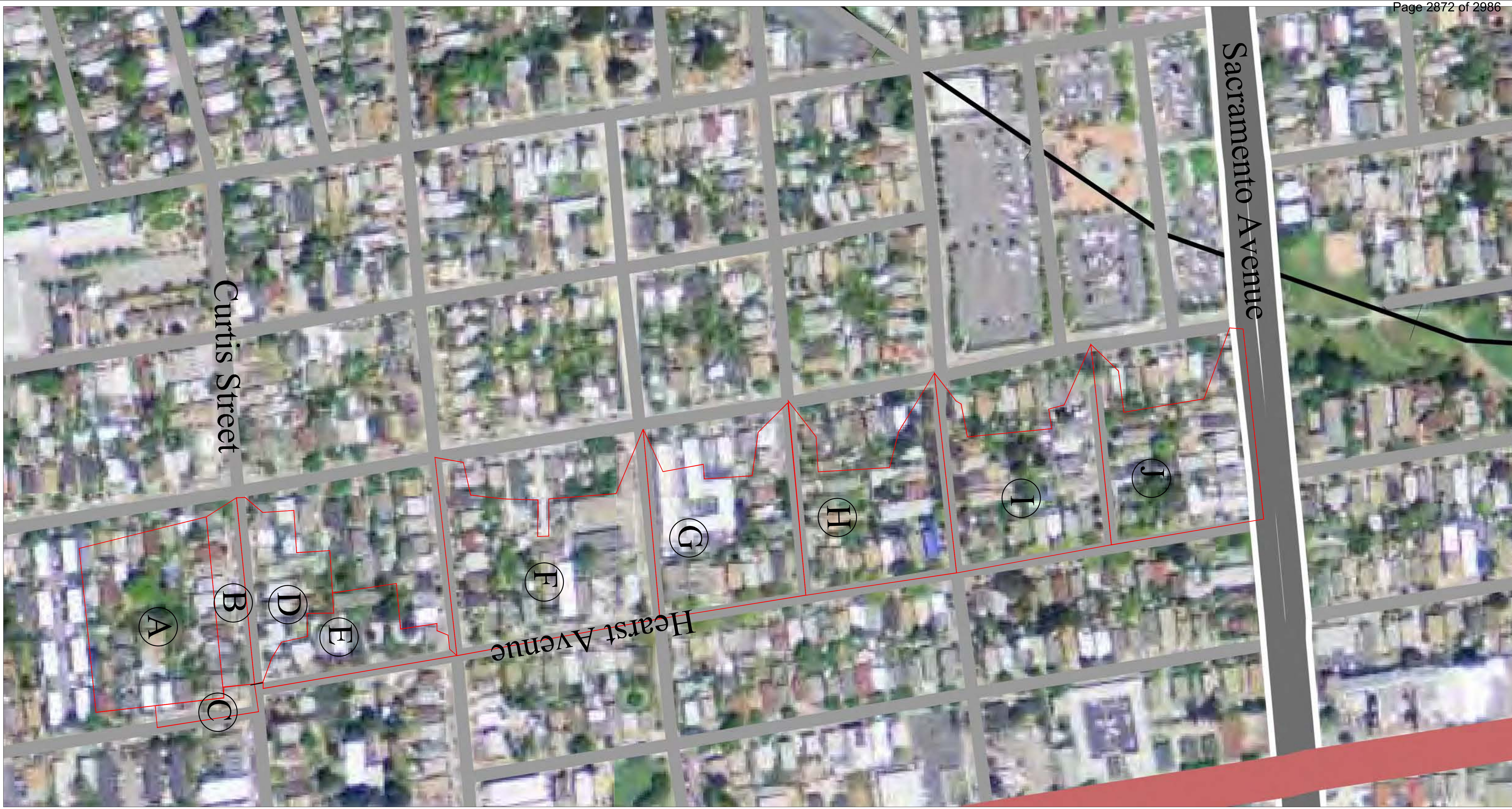
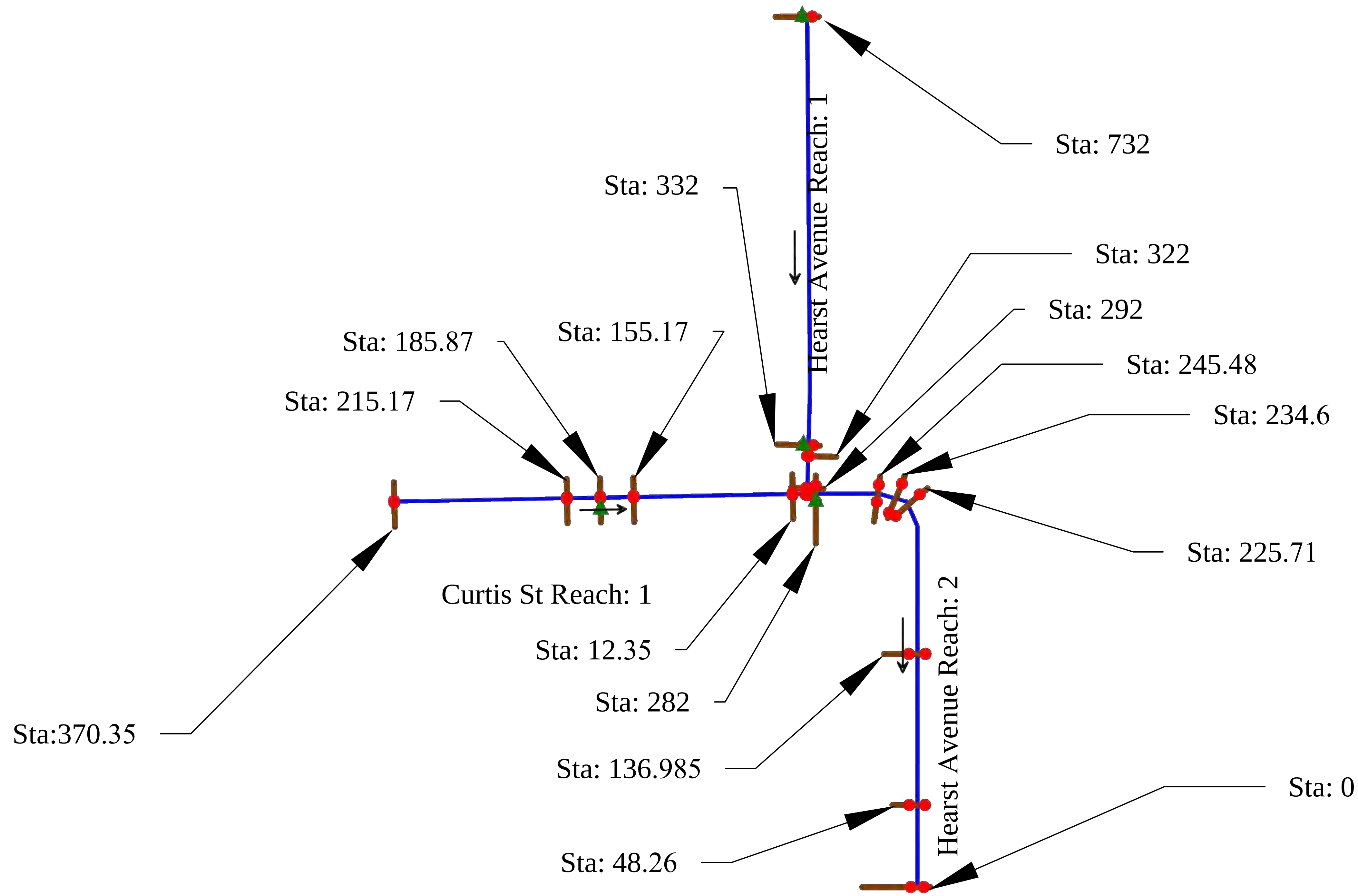


CLEARWATER HYDROLOGY

N

Figure 2 : Northside Hearst Avenue Sub Watersheds

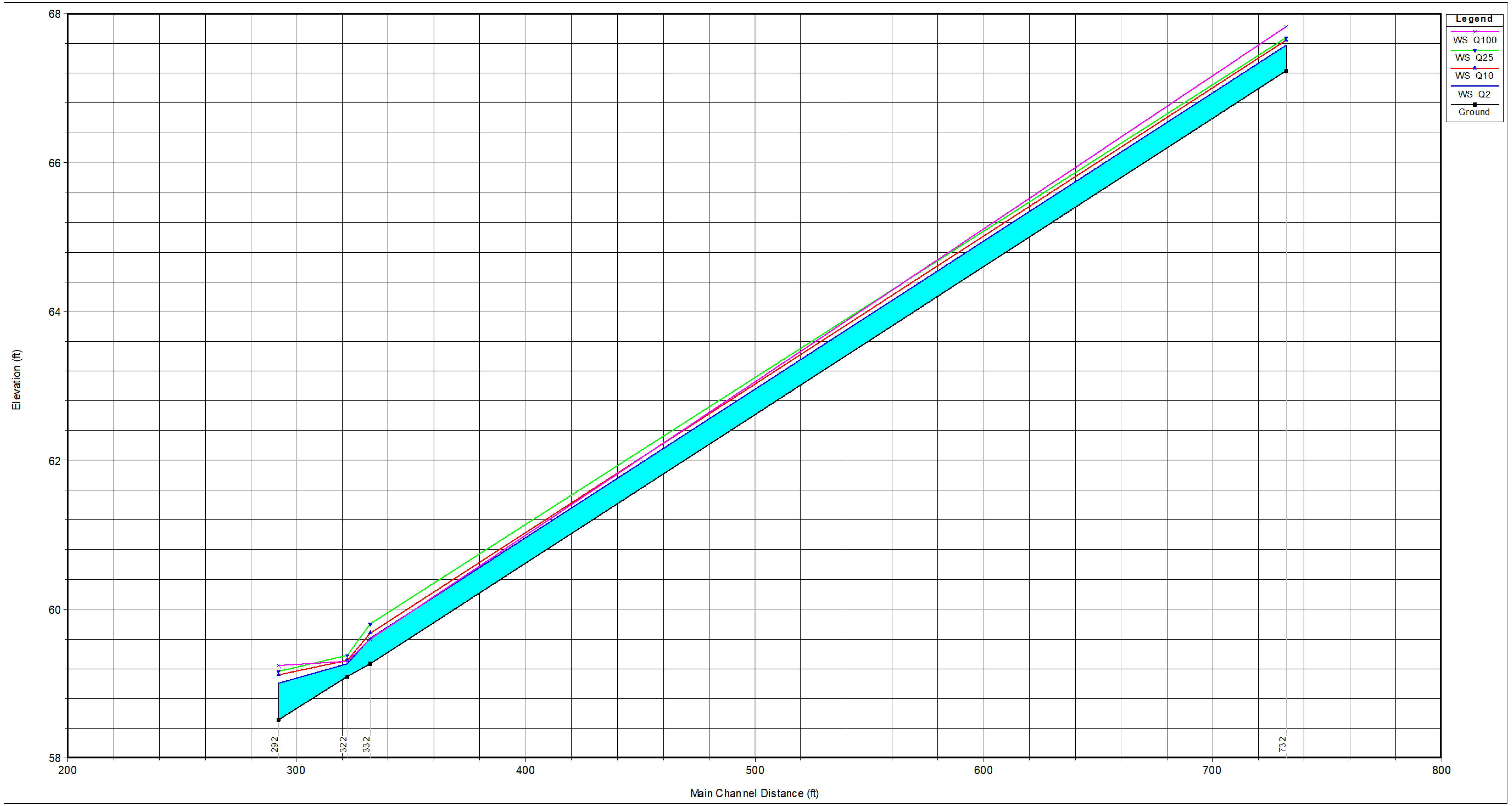
Project: 1155-1173 Hearst Avenue Project
Date: 12/30/2015



CLEARWATER HYDROLOGY

Figure 3 : HEC RAS Schematic Diagram

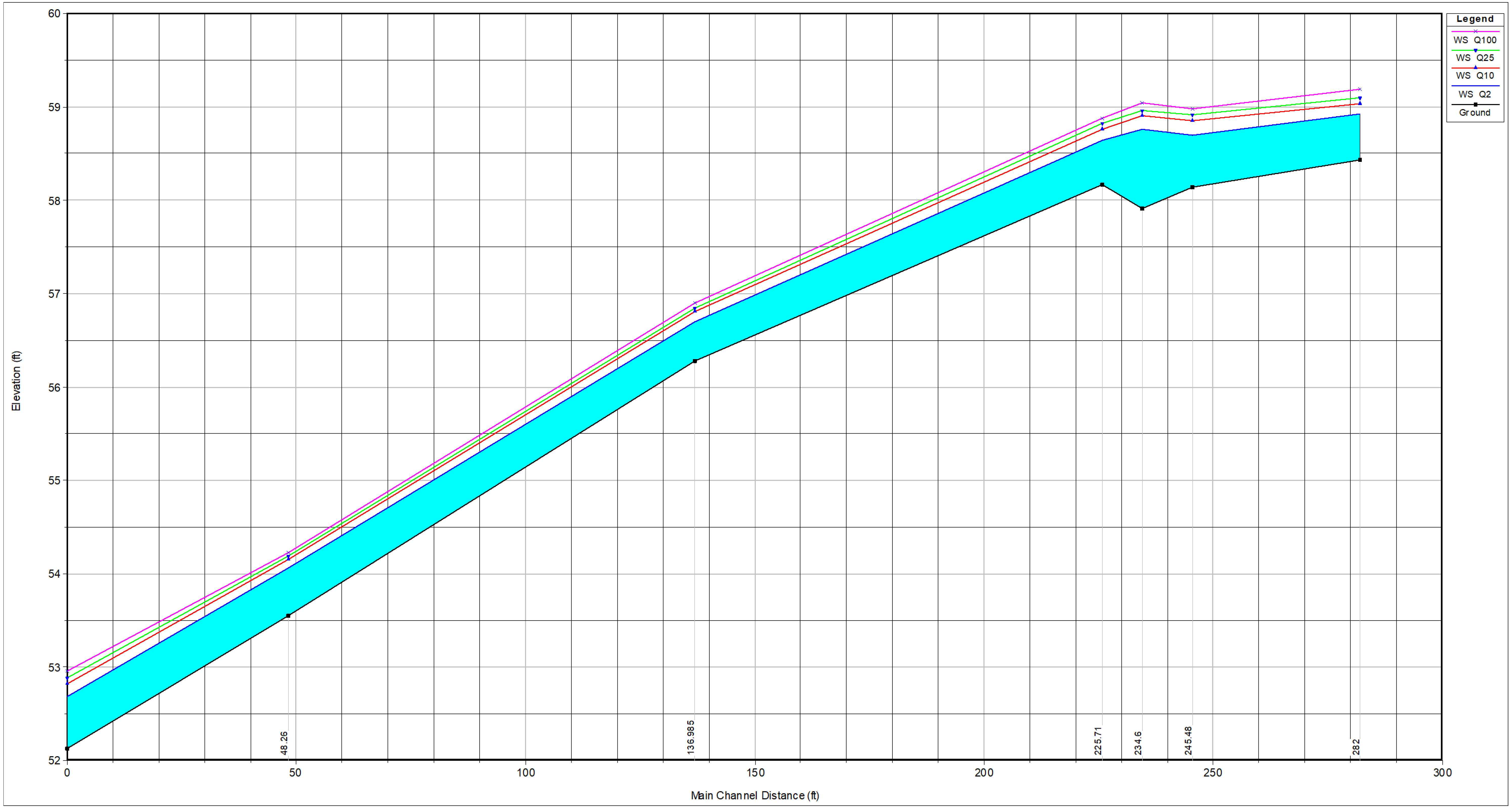
Project: 1155-1173 Hearst Avenue Project
Date: 12/30/2015



CLEARWATER HYDROLOGY

Figure 4 : HEC RAS WS Profiles (Hearst Avenue Reach 1)

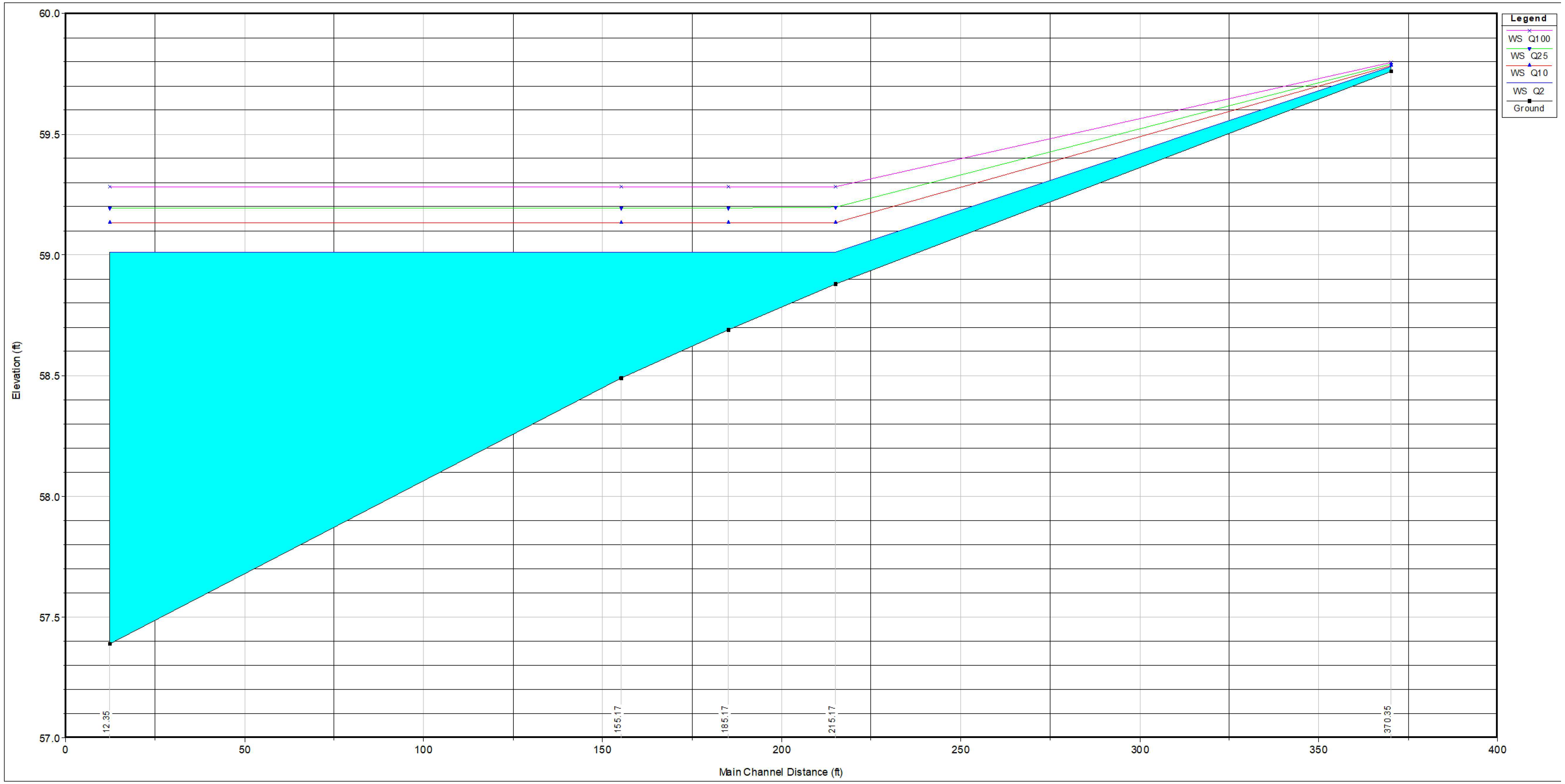
Project: 1155-1173 Hearst Avenue Project
Date: 7/11/2017



CLEARWATER HYDROLOGY

Figure 5 : HEC RAS WS Profiles (Hearst Avenue Reach 2)

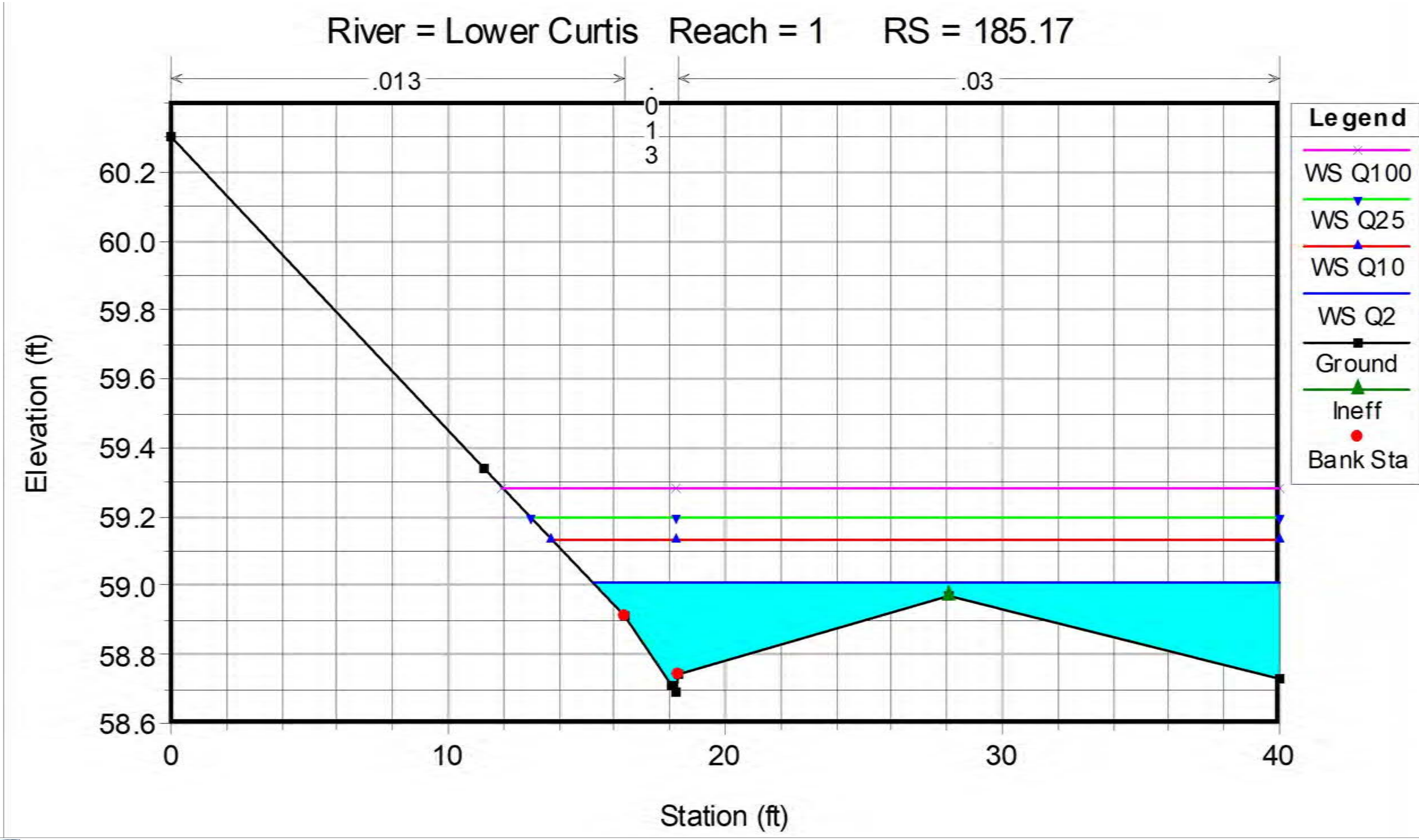
Project: 1155-1173 Hearst Avenue Project
Date: 7/11/2017



CLEARWATER HYDROLOGY

Figure 6 : HEC RAS WS Profiles (Curtis Street Reach 1)

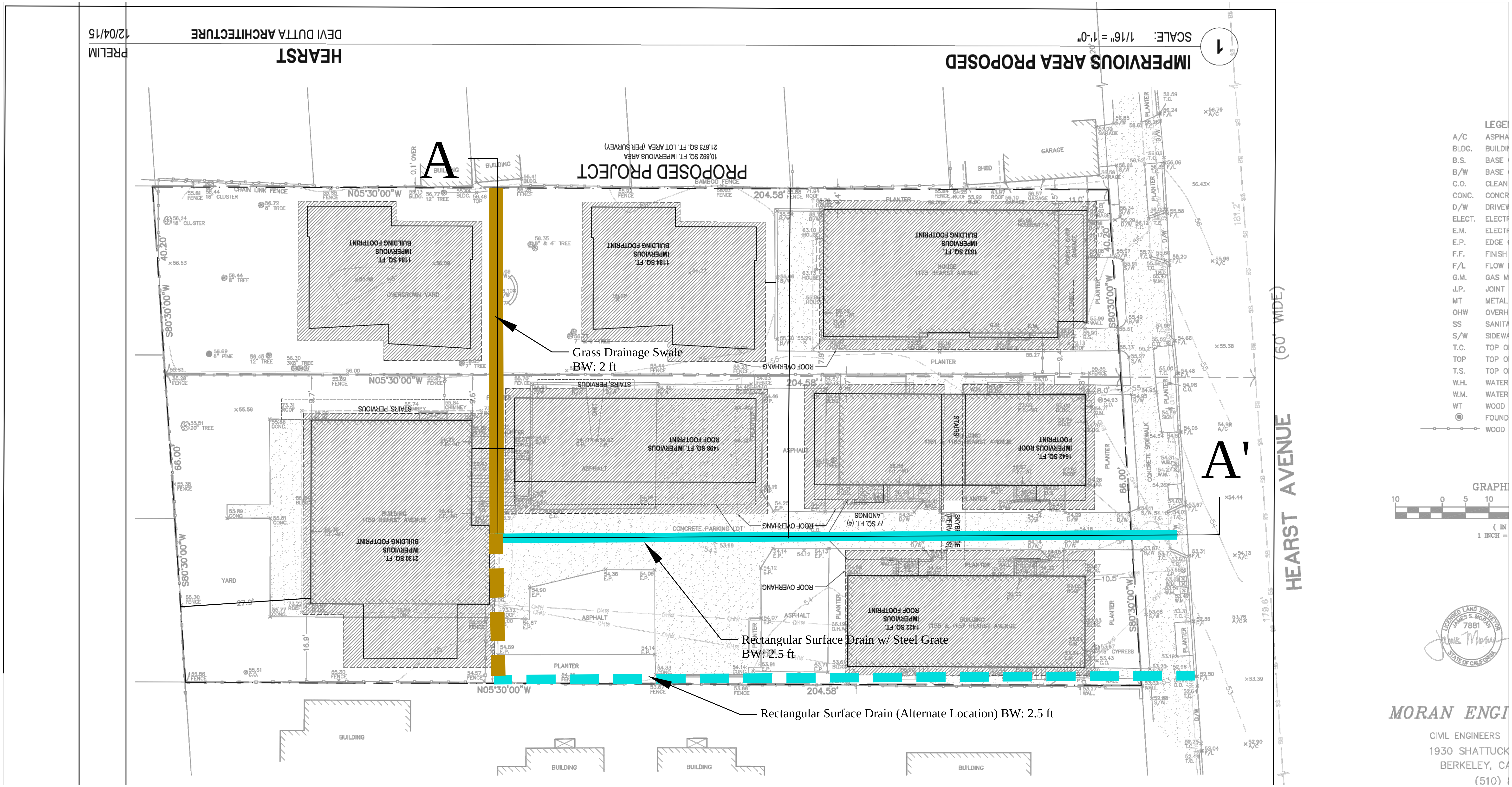
Project: 1155-1173 Hearst Avenue Project
Date: 7/11/2017



CLEARWATER HYDROLOGY

Figure 7 : HEC RAS Curtis Street Driveway XS w/ WS Elevations

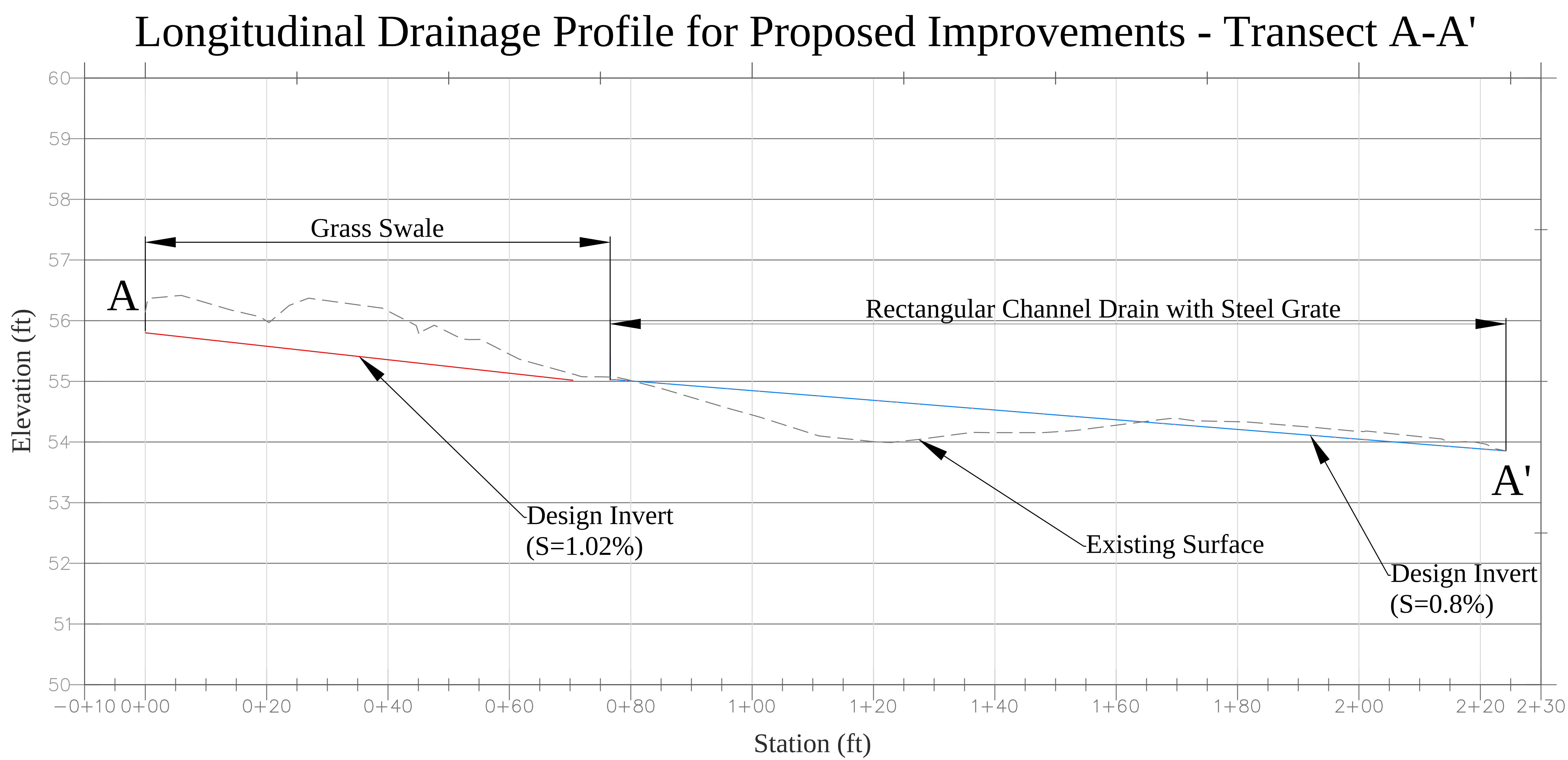
Project: 1155-1173 Hearst Avenue Project
Date: 7/11/2017



CLEARWATER HYDROLOGY

Figure 8 : Proposed Drainage Improvements

Project: 1155-1173 Hearst Avenue Project
Date: 7/11/2017



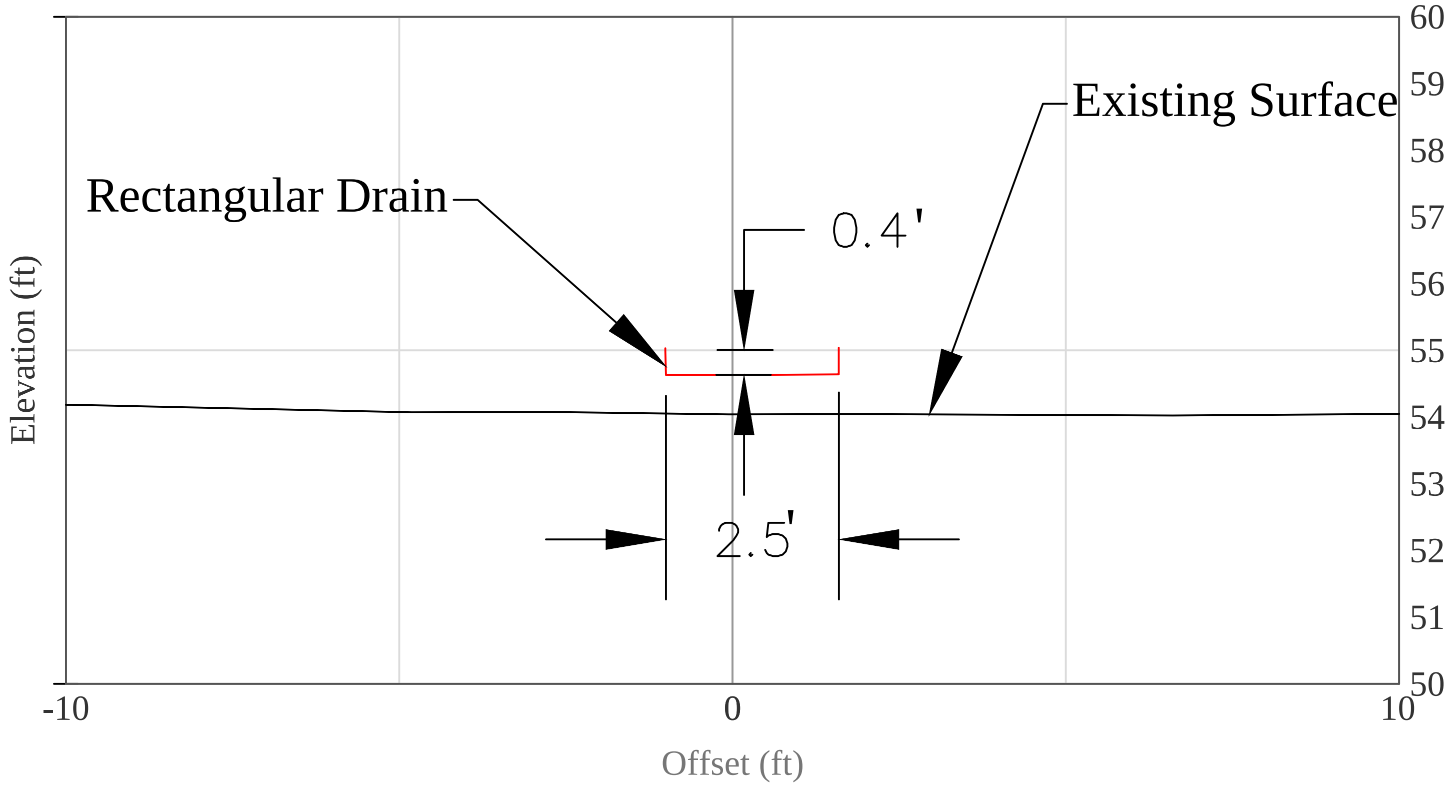
CLEARWATER HYDROLOGY

Figure 9 : Longitudinal Drainage Profile

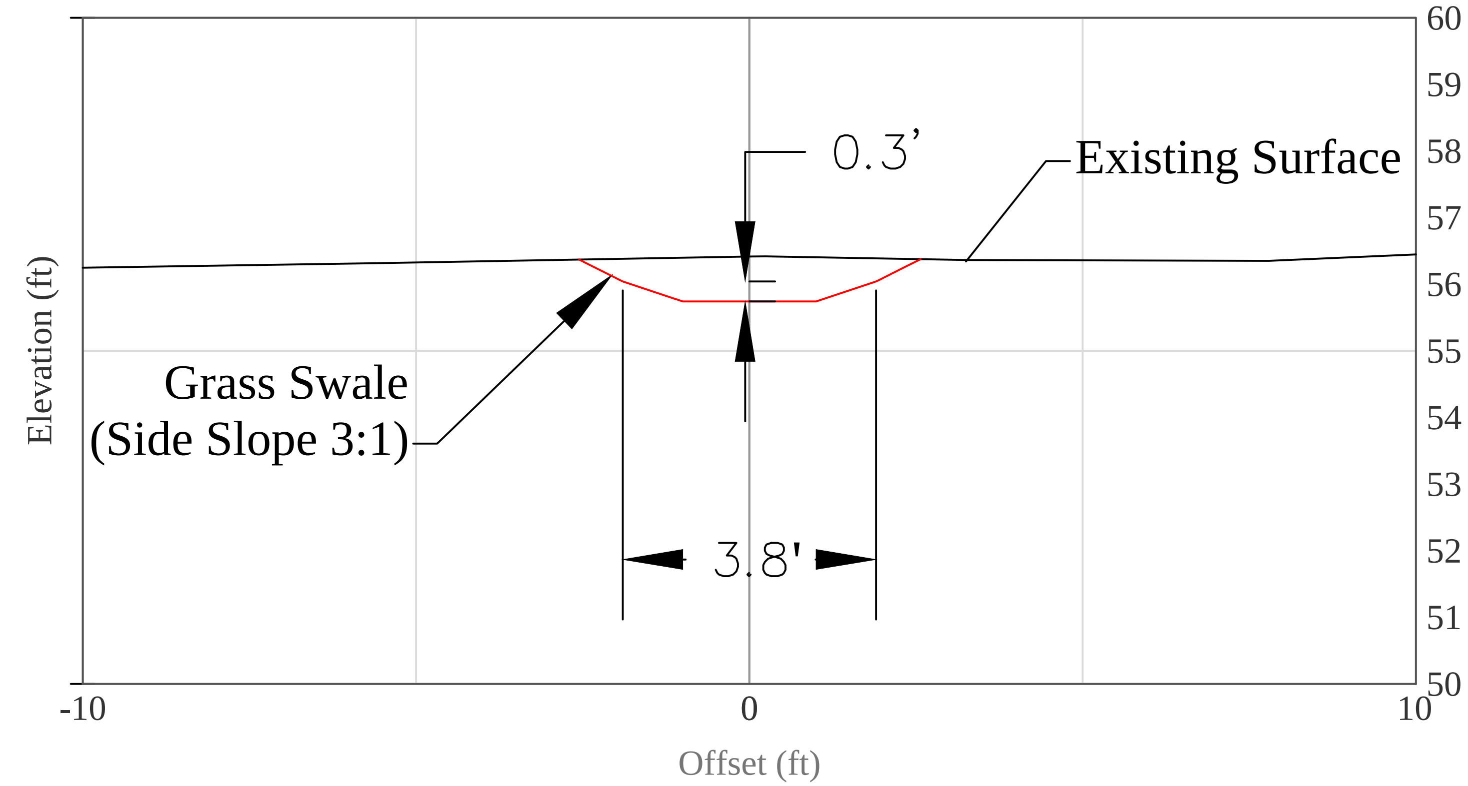
Project:1155-1173 Hearst Avenue Project
Date: 7/11/2017

Typical Drainage Channel Cross Sections

Rectangular Drain



Grass Swale



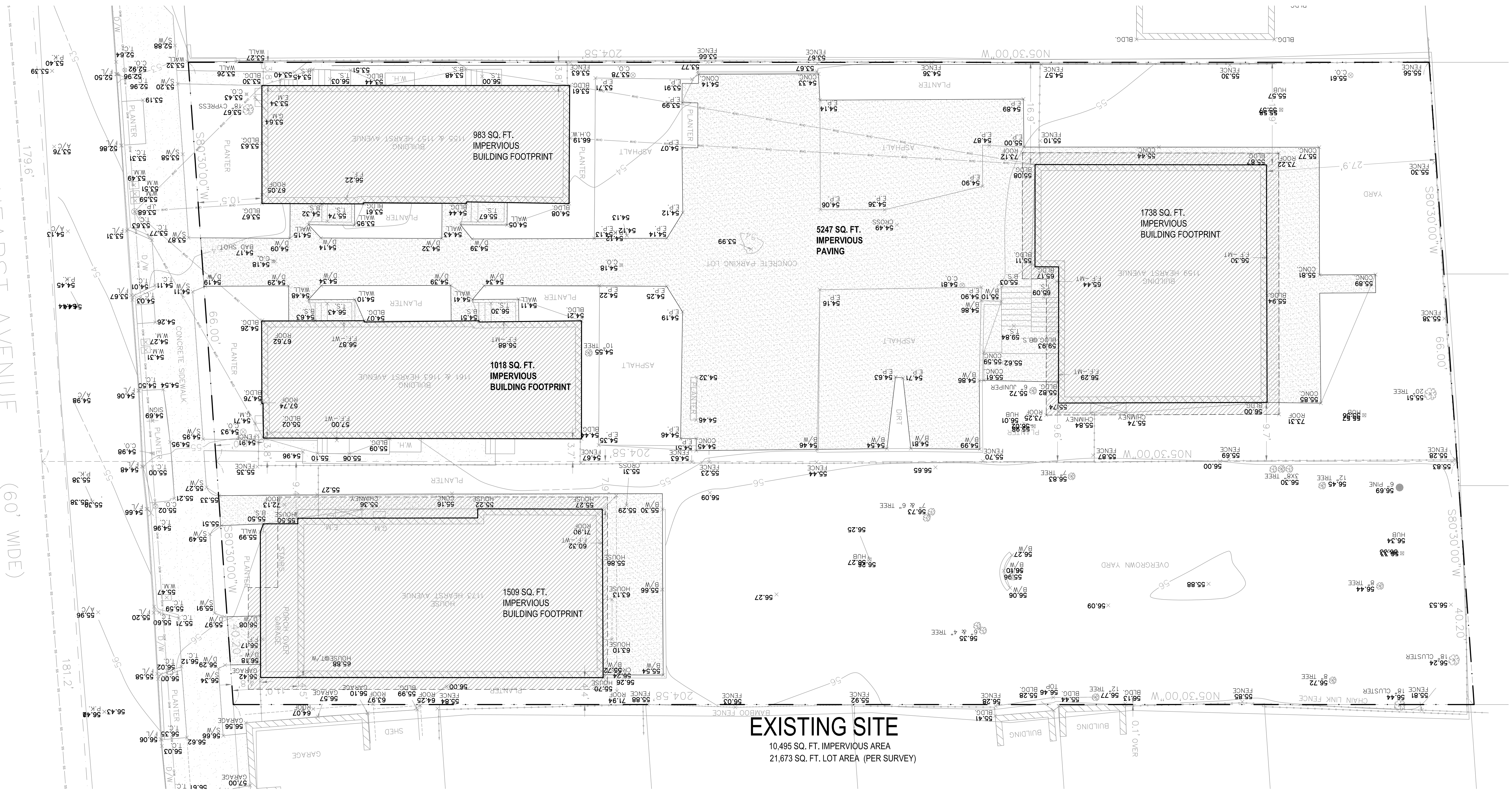
CLEARWATER HYDROLOGY

Figure 10 : Typical Cross Sections

Project:1155-1173 Hearst Avenue Project
Date: 7/11/2017

TECHNICAL APPENDIX:

- Existing and Project Plans with Topography
- Peak Discharge Computations- Hearst Ave. System:
  ACFCWCD Rational Method-2016
  USGS Rantz Rational Method-1971
- HEC-RAS Tabular Output Data Summaries
- Hydraflow Express- Normal Depth Computation
- Peak Flow Computations: Pre- vs. Post-Project



EXISTING SITE

10,495 SQ. FT. IMPERVIOUS AREA
21,673 SQ. FT. LOT AREA (PER SURVEY)

1

IMPERVIOUS AREA EXISTING

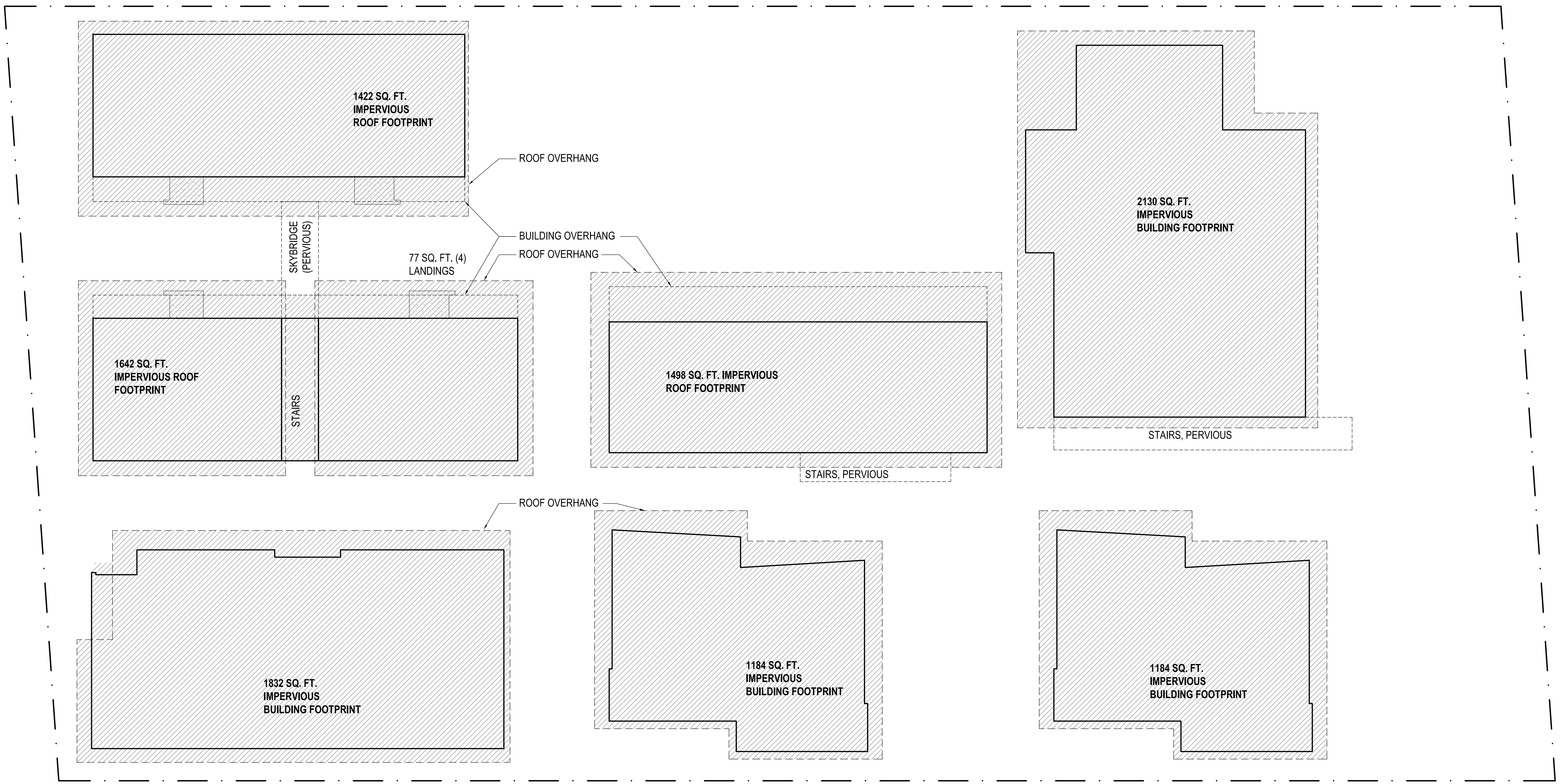
SCALE: 1/16" = 1'-0"

HEARST

PRELIM

DEVI DUTTA **ARCHITECTURE**

12/04/15



PROPOSED PROJECT

10,892 SQ. FT. IMPERVIOUS AREA
21,673 SQ. FT. LOT AREA (PER SURVEY)

1 IMPERVIOUS AREA PROPOSED

SCALE: 1/16" = 1'-0"

HEARST PRELIM

DEVI DUTTA **ARCHITECTURE** 12/04/15

Alameda County Flood Control & Water Conservation District. Hydrology and Hydraulics Manual 2016

Q= C'iA
where C= runoff coeff.;
i= rainfall intensity at duration equal to Tc;
A= drainage area, ac.

Watershed Areas											
	A	B	C	D	E	F	G	H	I	J	SUM F-J
Sq Ft	102,189.7	25,984.9	10,730.1	50,480.9	47,700.4	141,259.3	101,045.8	98,928.7	106,217.6	105,749.2	553,201
Sq Miles	0.0037	0.0009	0.0004	0.0018	0.0017	0.0051	0.0036	0.0035	0.0038	0.0038	0.02
Total Acres	2.35	0.60	0.25	1.16	1.10	3.24	2.32	2.27	2.44	2.43	12.70
Roadway Sq Ft		9875	6900	9850	10375	20600	31175	28925	30450	29725	140,875
Roadway acres		0.23	0.16	0.23	0.24	0.47	0.72	0.66	0.70	0.68	3.23
%roadway		0.38	0.64	0.20	0.22	0.15	0.31	0.29	0.29	0.28	0.25

For Watershed A

Area 2.35 Acres
Slope 0.82 %
Gutter Length N/A ft

a)Computing Time of Concentration, Tc

roof to gutter time — Source/Reference

2 yr recurrence interval 5 minutes — Attachment A4, Alameda County Flood Control & Water Conservation District. Hydrology and Hydraulics Manual 2016
10 yr recurrence interval 5 minutes
25 yr recurrence interval 5 minutes
100 yr recurrence interval 5 minutes

Overland flow = 432 ft slope = 0.82 % — Attachment 3
Velocity= 0.75 ft/sec
2 yr recurrence interval 9.60 minutes
10 yr recurrence interval 9.60 minutes
25 yr recurrence interval 9.60 minutes
100 yr recurrence interval 9.60 minutes

Time of concentration Tc=

2 yr recurrence interval		14.60	minutes
10 yr recurrence interval		14.60	minutes
25 yr recurrence interval		14.60	minutes
100 yr recurrence interval		14.60	minutes

b) Precipitation intensity, i

23 inches of rain-attachment 6
attachment 7

Tc=14.6

2 yr recurrence interval		1.25	in/hr
10 yr recurrence interval		2.12	in/hr
25 yr recurrence interval		2.53	in/hr
100 yr recurrence interval		3.16	in/hr

C)Runoff Coeff., C **Base Runoff**

Residential (3600-5000 SF)

2 yr recurrence interval, C 0.43
10 yr recurrence interval, C 0.43
25 yr recurrence interval, C 0.43
100 yr recurrence interval, C 0.43

Ground Slope Adjustment

2 yr recurrence interval, C 0 — Equation 8
10 yr recurrence interval, C 0 — Slope-Attachment 10
25 yr recurrence interval, C 0
100 yr recurrence interval, C 0
0

Rainfall Intensity Factor

2 yr recurrence interval, C 0.03 — Equation 9
10 yr recurrence interval, C 0.08
25 yr recurrence interval, C 0.09
100 yr recurrence interval, C 0.12

Total

2 yr recurrence interval, C		0.46
10 yr recurrence interval, C		0.51
25 yr recurrence interval, C		0.52
100 yr recurrence interval, C		0.55

Therefore,

Q2		**1.36**	**cfs**
Q10		**2.52**	**cfs**
Q25		**3.11**	**cfs**
Q100		**4.06**	**cfs**

For Watershed B

Gutter Length 394.65 feet
Slope 0.01 % — *Google earth elev change from 68 ft @ Curtis & Delaware to 66 ft at hearst & curtis
Area 0.60 Acres
Roadway Area 0.23 Acres

a)Computing Time of Concentration, Tc

roof to gutter time

2 yr recurrence interval 5 minutes — Attachment A4,
10 yr recurrence interval 5 minutes
25 yr recurrence interval 5 minutes
100 yr recurrence interval 5 minutes

Overland flow = 50 ft slope = 0.01 %
Velocity= 0.75 ft/sec
2 yr recurrence interval 1.11 minutes
10 yr recurrence interval 1.11 minutes
25 yr recurrence interval 1.11 minutes
100 yr recurrence interval 1.11 minutes

Channel Travel time V= (1.49/n)*((A/WP)^(2/3))*S^(1/2)
Area of gutter flow from CAD 0.39 Sq ft
Wetted perimeter 2.87 ft

V 3.04 ft per second
therefore Channel travel time = L/(60V) 2.17 Minutes

Time of concentration Tc=

2 yr recurrence interval	8.28	minutes
10 yr recurrence interval	8.28	minutes
25 yr recurrence interval	8.28	minutes
100 yr recurrence interval	8.28	minutes

b) Precipitation intensity, i

23 inches of rain-attachment 6
attachment 7

	2 yr recurrence interval	1.70	in/hr
	10 yr recurrence interval	2.86	in/hr
	25 yr recurrence interval	3.48	in/hr
	100 yr recurrence interval	4.31	in/hr

C)Runoff Coeff., C **Base Runoff**

		Roadway	
2 yr recurrence interval, C	0.43	**2 yr recurrence interval, C**	0.9
10 yr recurrence interval, C	0.43	**10 yr recurrence interval, C**	0.9
25 yr recurrence interval, C	0.43	**25 yr recurrence interval, C**	0.9
100 yr recurrence interval, C	0.43	**100 yr recurrence interval, C**	0.9

Composite C

2 yr recurrence interval, C	**0.61**
10 yr recurrence interval, C	**0.61**
25 yr recurrence interval, C	**0.61**
100 yr recurrence interval, C	**0.61**

Ground Slope Adjustment

2 yr recurrence interval, C	0
10 yr recurrence interval, C	0
25 yr recurrence interval, C	0
100 yr recurrence interval, C	0

Rainfall Intensity Factor

2 yr recurrence interval, C	0.03
10 yr recurrence interval, C	0.06
25 yr recurrence interval, C	0.07
100 yr recurrence interval, C	0.08

Total

2 yr recurrence interval, C		0.64
10 yr recurrence interval, C		0.66
25 yr recurrence interval, C		0.67
100 yr recurrence interval, C		0.69

Therefore,

Q2	**0.65**	**cfs**
Q10	**1.13**	**cfs**
Q25	**1.40**	**cfs**
Q100	**1.76**	**cfs**

For Watershed C

Gutter Length 253.91 feet
Slope 2.36 % — *Google earth elev change from 66 ft to 60 ft
Area 0.25 Acres
Roadway Area 0.16 Acres

a)Computing Time of Concentration, Tc

roof to gutter time — Source/Reference: Attachment A4

2 yr recurrence interval 5 minutes
10 yr recurrence interval 5 minutes
25 yr recurrence interval 5 minutes
100 yr recurrence interval 5 minutes

Overland flow = 50 ft slope = 0.01 %
Velocity= 0.75 ft/sec
2 yr recurrence interval 1.11 minutes
10 yr recurrence interval 1.11 minutes
25 yr recurrence interval 1.11 minutes
100 yr recurrence interval 1.11 minutes

Channel Travel time V= (1.49/n)*((A/WP)^(2/3))*S^(1/2)
Area of gutter flow from CAD 0.39 Sq ft
Wetted perimeter 2.87 ft

V 3.04 ft per second
therefore Channel travel time = L/(60V) 1.39 Minutes

Time of concentration Tc=

2 yr recurrence interval		7.51	minutes
10 yr recurrence interval		7.51	minutes
25 yr recurrence interval		7.51	minutes
100 yr recurrence interval		7.51	minutes

b) Precipitation intensity, i

2 yr recurrence interval		1.82	in/hr
10 yr recurrence interval		3.07	in/hr
25 yr recurrence interval		3.69	in/hr
100 yr recurrence interval		4.58	in/hr

23 inches of rain-attachment 6
attachment 7

Depth

C)Runoff Coeff., C **Base Runoff**

		Roadway	
2 yr recurrence interval, C	0.43	**2 yr recurrence interval, C**	0.9
10 yr recurrence interval, C	0.43	**10 yr recurrence interval, C**	0.9
25 yr recurrence interval, C	0.43	**25 yr recurrence interval, C**	0.9
100 yr recurrence interval, C	0.43	**100 yr recurrence interval, C**	0.9

Composite C

2 yr recurrence interval, C **0.73**
10 yr recurrence interval, C **0.73**
25 yr recurrence interval, C **0.73**
100 yr recurrence interval, C **0.73**

Ground Slope Adjustment

2 yr recurrence interval, C 0
10 yr recurrence interval, C 0
25 yr recurrence interval, C 0
100 yr recurrence interval, C 0

Rainfall Intensity Factor

2 yr recurrence interval, C 0.01
10 yr recurrence interval, C 0.02
25 yr recurrence interval, C 0.02
100 yr recurrence interval, C 0.03

Total

2 yr recurrence interval, C		0.74
10 yr recurrence interval, C		0.75
25 yr recurrence interval, C		0.76
100 yr recurrence interval, C		0.76

Therefore,

Q2		0.33	**cfs**
Q10		0.57	**cfs**
Q25		0.69	**cfs**
Q100		0.86	**cfs**

For Watershed D

Gutter Length 395.81 feet
Slope 0.01 % — *Google earth elev change from 68 ft @ Curtis & Delaware to 66 ft at hearst & curtis
Area 1.16 Acres
Roadway Area 0.23 Acres

a)Computing Time of Concentration, Tc

roof to gutter time — Source/Reference: Attachment A4, Alameda County Flood Control & Water Conservation District. Hydrology and Hydraulics Manual 2016

2 yr recurrence interval 5 minutes
10 yr recurrence interval 5 minutes
25 yr recurrence interval 5 minutes
100 yr recurrence interval 5 minutes

Overland flow = 50 ft slope = 0.01 %
Velocity= 0.75 ft/sec
2 yr recurrence interval 1.11 minutes
10 yr recurrence interval 1.11 minutes
25 yr recurrence interval 1.11 minutes
100 yr recurrence interval 1.11 minutes

Channel Travel time V= (1.49/n)*((A/WP)^(2/3))*S^(1/2)
Area of gutter flow from CAD 0.39 Sq ft
Wetted perimeter 2.87 ft

V 3.04 ft per second
therefore Channel travel time = L/(60V) 2.17 Minutes

Time of concentration Tc=

2 yr recurrence interval		8.28	minutes
10 yr recurrence interval		8.28	minutes
25 yr recurrence interval		8.28	minutes
100 yr recurrence interval		8.28	minutes

b) Precipitation intensity, i

2 yr recurrence interval		1.70	in/hr
10 yr recurrence interval		2.86	in/hr
25 yr recurrence interval		3.48	in/hr
100 yr recurrence interval		4.31	in/hr

23 inches of rain-attachment 6
attachment 7

C)Runoff Coeff., C **Base Runoff**

		Roadway	
2 yr recurrence interval, C	0.43	2 yr recurrence interval, C	0.9
10 yr recurrence interval, C	0.43	10 yr recurrence interval, C	0.9
25 yr recurrence interval, C	0.43	25 yr recurrence interval, C	0.9
100 yr recurrence interval, C	0.43	100 yr recurrence interval, C	0.9

Composite C

2 yr recurrence interval, C	**0.52**
10 yr recurrence interval, C	**0.52**
25 yr recurrence interval, C	**0.52**
100 yr recurrence interval, C	**0.52**

Ground Slope Adjustment

2 yr recurrence interval, C	0
10 yr recurrence interval, C	0
25 yr recurrence interval, C	0
100 yr recurrence interval, C	0

Rainfall Intensity Factor

2 yr recurrence interval, C	0.04
10 yr recurrence interval, C	0.08
25 yr recurrence interval, C	0.10
100 yr recurrence interval, C	0.11

Total

2 yr recurrence interval, C			0.56
10 yr recurrence interval, C			0.60
25 yr recurrence interval, C			0.62
100 yr recurrence interval, C			0.63

Therefore,		
Q2	**1.11**	cfs
Q10	**2.00**	cfs
Q25	**2.49**	cfs
Q100	**3.17**	cfs

For Watershed E

Length	405.78	feet
Slope	0.02	%
Area	1.10	Acres
Roadway Area	0.24	Acres

*Google earth elev change from 74 ft @Chestnut and Hearst to 66 ft at hearst & curtis

a)Computing Time of Concentration, Tc

roof to gutter time

2 yr recurrence interval	5	minutes
10 yr recurrence interval	5	minutes
25 yr recurrence interval	5	minutes
100 yr recurrence interval	5	minutes

Source/Reference
Attachment A4, Alameda County Flood Control & Water Conservation District. Hydrology and Hydraulics Manual 2016

Overland flow = 50 ft slope = 0.02 %

Velocity=	0.75	ft/sec
2 yr recurrence interval	1.11	minutes
10 yr recurrence interval	1.11	minutes
25 yr recurrence interval	1.11	minutes
100 yr recurrence interval	1.11	minutes

Channel Travel time

V= (1.49/n)*((A/WP)^(2/3))*S^(1/2)
Area of gutter flow from CAD 0.39 Sq ft
Wetted perimeter 2.87 ft

V 4.29 ft per second
therefore Channel travel time = L/(60V) 2.23 Minutes

Time of concentration Tc=

2 yr recurrence interval		8.34	minutes
10 yr recurrence interval		8.34	minutes
25 yr recurrence interval		8.34	minutes
100 yr recurrence interval		8.34	minutes

b) Precipitation intensity, i

2 yr recurrence interval		1.70	in/hr
10 yr recurrence interval		2.86	in/hr
25 yr recurrence interval		3.48	in/hr
100 yr recurrence interval		4.31	in/hr

23 inches of rain-attachment 6
attachment 7

C)Runoff Coeff., C **Base Runoff**

		Roadway	
2 yr recurrence interval, C	0.43	2 yr recurrence interval, C	0.9
10 yr recurrence interval, C	0.43	10 yr recurrence interval, C	0.9
25 yr recurrence interval, C	0.43	25 yr recurrence interval, C	0.9
100 yr recurrence interval, C	0.43	100 yr recurrence interval, C	0.9

Composite C

2 yr recurrence interval, C	**0.53**
10 yr recurrence interval, C	**0.53**
25 yr recurrence interval, C	**0.53**
100 yr recurrence interval, C	**0.53**

Ground Slope Adjustment

2 yr recurrence interval, C	0
10 yr recurrence interval, C	0
25 yr recurrence interval, C	0
100 yr recurrence interval, C	0

Rainfall Intensity Factor

2 yr recurrence interval, C	0.04
10 yr recurrence interval, C	0.08
25 yr recurrence interval, C	0.09
100 yr recurrence interval, C	0.11

Total

2 yr recurrence interval, C		0.57
10 yr recurrence interval, C		0.61
25 yr recurrence interval, C		0.63
100 yr recurrence interval, C		0.64

Therefore,

Q2	**1.07**	cfs
Q10	**1.91**	cfs
Q25	**2.38**	cfs
Q100	**3.02**	cfs

For Watersheds F,G,H,I & J

Total Area	**12.70**	**Acres**
Longest path	2,120.20	feet
Slope	1.98	%
Roadway Area	3.23	Acres

a)Computing Time of Concentration

roof to gutter time

2 yr recurrence interval	5	minutes
10 yr recurrence interval	5	minutes
25 yr recurrence interval	5	minutes
100 yr recurrence interval	5	minutes

Overland flow = 50 ft slope = 0.02 %

Velocity=	0.75	ft/sec
2 yr recurrence interval	1.11	minutes
10 yr recurrence interval	1.11	minutes
25 yr recurrence interval	1.11	minutes
100 yr recurrence interval	1.11	minutes

Open channel flow (gutter flow) 2,120.20 ft slope 0.02

Channel Travel time V= (1.49/n)*((A/WP)^(2/3))*S^(1/2)
Area of gutter flow from CAD 0.3913 Sq ft
Wetted perimeter 2.8705 ft

Watershed J, Tc1 (elev change from Sac and Delaware to Short & Hearst = 116 to 98ft)	V	4.849458276	ft per second
	Channel travel time =	2.424360137	Minutes
Watershed I, Tc2 (elev change = 98 to 92ft)	V	4.063458531	ft per second
	Channel travel time =	1.373624617	Minutes
Watershed H, Tc3 (elev change = 92 to 86ft)	V	4.124376277	ft per second
	Channel travel time =	1.313653177	Minutes
Watershed G, Tc4 (elev change = 86 to 81ft)	V	3.841120033	ft per second
	Channel travel time =	1.35519153	Minutes
Watershed F, Tc4 (elev change =81 to 74ft)	V	3.838429429	ft per second
	Channel travel time =	1.901260694	Minutes

Time of concentration Tc=

2 yr recurrence interval	14.48	minutes
10 yr recurrence interval	14.48	minutes
25 yr recurrence interval	14.48	minutes
100 yr recurrence interval	14.48	minutes

b) Precipitation intensity, i

2 yr recurrence interval	1.25	in/hr	23 inches of rain-attachment 6
10 yr recurrence interval	2.11	in/hr	attachment 7
25 yr recurrence interval	2.54	in/hr	
100 yr recurrence interval	3.15	in/hr	

C)Runoff Coeff., C **Base Runoff**

		Roadway	
2 yr recurrence interval, C	0.43	**2 yr recurrence interval, C**	0.9
10 yr recurrence interval, C	0.43	**10 yr recurrence interval, C**	0.9
25 yr recurrence interval, C	0.43	**25 yr recurrence interval, C**	0.9
100 yr recurrence interval, C	0.43	**100 yr recurrence interval, C**	0.9

Composite C

2 yr recurrence interval, C	**0.55**
10 yr recurrence interval, C	**0.55**
25 yr recurrence interval, C	**0.55**
100 yr recurrence interval, C	**0.55**

Ground Slope Adjustment

2 yr recurrence interval, C	0
10 yr recurrence interval, C	0
25 yr recurrence interval, C	0
100 yr recurrence interval, C	0

Rainfall Intensity Factor

2 yr recurrence interval, C	0.02
10 yr recurrence interval, C	0.05
25 yr recurrence interval, C	0.06
100 yr recurrence interval, C	0.08

Total

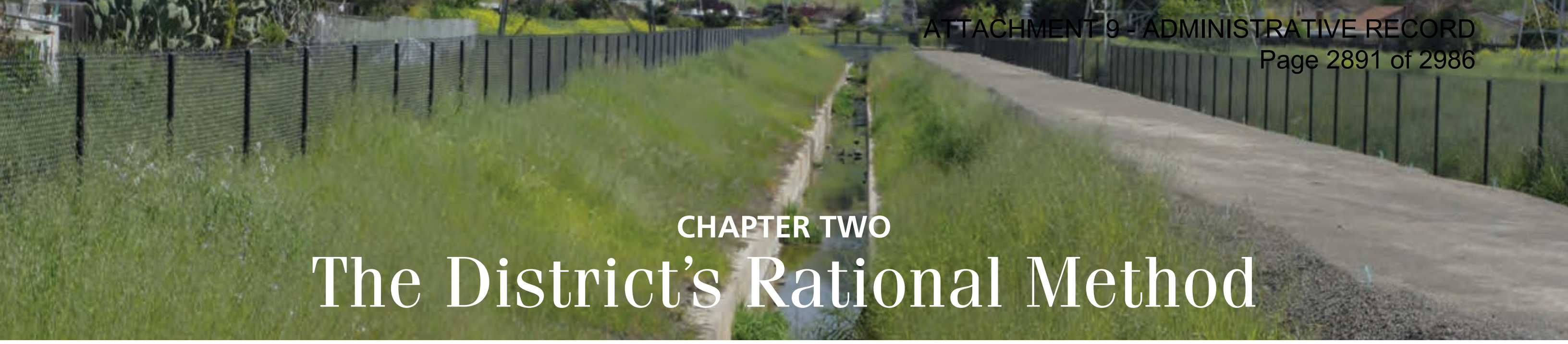
2 yr recurrence interval, C		0.57
10 yr recurrence interval, C		0.60
25 yr recurrence interval, C		0.61
100 yr recurrence interval, C		0.63

Therefore,

Q2		**9.08**	**cfs**
Q10		**16.10**	**cfs**
Q25		**19.79**	**cfs**
Q100		**25.17**	**cfs**

Flood Control & Water Conservation DISTRICT

Alameda County Hydrology & Hydraulics Manual



CHAPTER TWO

The District's Rational Method

The District uses a modified form of the Rational Method to determine the peak discharge of a watershed for areas up to 0.5 square miles (320 acres). Calculations for the District's Rational Method can be made using ***Attachment 2*** or an equivalent method for design of drainage facilities for urban development and roadway crossings.

To use this method, the overall watershed should be broken down into smaller areas that contribute to hydraulically significant points of concentration. The subcatchment boundaries should be established based on topographic boundaries such as ridges, streets, drainage systems, etc., using good engineering judgment. The peak design discharge or flow rate should be calculated using ***Equation 1***, the District's Rational Formula.

EQUATION 1 DISTRICT'S RATIONAL FORMULA

$$Q = C'iA \qquad (1)$$

where:

Q = *discharge (cfs)*
C' = *District's runoff coefficient (from **Equation 7)***
i = *rainfall intensity (inches/hr from **Equation 5)***
A = *drainage area (acres)*

(District 1989)

When using the District's Rational Method, it is critical to compare the peak discharge rate of a tributary area to the peak discharge in the main stem downstream of the tributary and use the greater of the two flow rates for the downstream drainage system.

TIME OF CONCENTRATION

The time of concentration (T_c) is the time required for the runoff from the most remote region of the watershed to reach the point of interest at which the flow is to be calculated. Calculate T_c using ***Equation 2.***

EQUATION 2 TIME OF CONCENTRATION

$$T_c = t_o + t_{cond} \qquad (2)$$

where:

T_c = *time of concentration (min)*
t_o = *roof-to-gutter and/or overland time of concentration (min, from **Equation 3** or **4)***
t_{cond} = *conduit time (min)*

(District 2015)

To design a drainage system, use a minimum time of concentration based on hydraulic conditions that maximize flow velocities.

Overland Time of Concentration

The overland time of concentration (t_o) is that time required for runoff to travel from the most remote point in the drainage area to the first point of concentration. Often, this first point of concentration is the furthest upstream inlet of the stormwater system or the upstream end of a defined ditch or swale. This time is seldom less than three minutes or more than 20 minutes. The overland time of concentration (t_o) depends on the surface conditions, i.e., whether the watershed is rural (undeveloped) or urban (developed).

For undeveloped watersheds, use ***Equation 3*** to determine t_o.

EQUATION 3 OVERLAND TIME OF CONCENTRATION — UNDEVELOPED WATERSHEDS

$$t_o = \frac{L_o}{60V_o} \qquad (3)$$

where:

t_o = *roof-to-gutter and/or overland time of concentration (min)*
L_o = *overland flow length (ft)*
V_o = *overland flow velocity (ft/sec from **Attachment 3**)*

(NRCS 1986)

For urbanized watersheds, the t_o is "roof-to-gutter" time, plus the time required for the water to flow from the street gutter at the uppermost part of the drainage basin to the furthest upstream inlet of the stormwater system. For developed watersheds, use ***Equation 4*** to determine t_o.

EQUATION 4 OVERLAND TIME OF CONCENTRATION — DEVELOPED WATERSHEDS

$$t_o = t_{rg} + \frac{L_g}{60V_g} \qquad (4)$$

where:

t_o = *roof-to-gutter and/or overland time of concentration (min)*
t_{rg} = *roof-to-gutter time (min from **Attachment 4**)*
L_g = *gutter flow length (ft)*
V_g = *gutter flow velocity (ft/sec from **Attachment 5**)*

(District 1989)

Roof-to-street gutter time is a function of ground slope and type of drainage facility, as determined from ***Attachment 4***. Use sound engineering practices for other-than-typical residential areas. Then, estimate the time for the water to flow from the upstream end of the gutter to the first inlet based on the gutter flow velocity in ***Attachment 5***. In other-than-typical residential situations, use Manning's equation (***Equation 15***) to estimate velocity and travel time, or reference other charts, such as those for flow in small conduits or gullies.

Conduit Time

Conduit time (t_{cond}) is the length of time required for the water to flow from one point of concentration, or inlet, to the next. The calculated average velocity, or weighted incremental velocities, must accurately reflect the hydraulic conditions (i.e. closed conduit or open channel) within the stormwater system. Where the flow takes place in natural streams, channels, or closed conduits, use Manning's Equation to calculate the conduit time. For conduits under pressure, divide the discharge (Q) by the conduit cross-sectional area to determine the average flow velocity and conduit time.

RAINFALL INTENSITY AND DEPTH

Compute rainfall intensity for the appropriate time of concentration and storm recurrence interval using ***Equation 5***:

EQUATION 5 RAINFALL INTENSITY

$$i_{ij} = \frac{D_{ij}}{t_d} \tag{5}$$

where:

i_{ij} = *rainfall intensity (inches/hr) for recurrence interval j and storm duration i*

D_{ij} = *design rainfall depth (inches) for recurrence interval j and storm duration i (from **Equation 6**)*

t_d = *storm duration (hr) = $T_c/60$*

T_c = *time of concentration (min)*

(District 2015)

Alternatively, in lieu of using ***Equation 5***, rainfall intensity (i) may be determined from the tables in ***Attachment 7***. Select the proper chart depending on recurrence interval, then use the time of concentration (T_c) and mean annual precipitation $(\overline{P})$ to select the rainfall intensity value from the chart.

EQUATION 6 RAINFALL DEPTH

$$D_{ij} = (0.32665 + 0.091144\overline{P})(1 + K_j\,CV)t_i^{0.43287} \qquad (6)$$

where:

D_{ij} = *design rainfall depth (inches) for recurrence interval j and storm duration i*

$\overline{P}$ = *mean annual precipitation (inches)*

K_j = *frequency factor for recurrence interval j (from **Table 1** for storm durations up to 24 hours or **Attachment 12** for storm durations greater than 24 hours)*

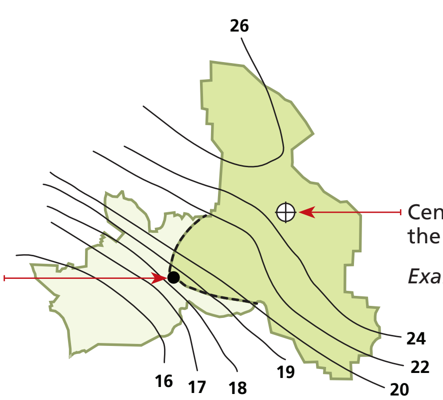
CV = *coefficient of variation (from **Attachment 12**)*

t_i = *consecutive time (days)*

(District 2015)

Determine the mean annual precipitation ($\overline{P}$) of a drainage area using the District's isohyetal map ***Attachment 6***. The $\overline{P}$ to be used is located at the centroid of the drainage area above the point of concentration at which the flow rate is being determined, as shown in ***Figure 2***.

FIGURE 2 DETERMINING MEAN ANNUAL PRECIPITATION



Note: Graphic for illustration purposes only.

TABLE 1 FREQUENCY FACTORS FOR SELECT RECURRENCE INTERVALS*

Recurrence interval *(yrs)*	2	5	10	15	25	100	200	500	1000
Frequency Factor, K_j	-0.210	0.719	1.339	1.684	2.108	3.211	3.745	4.417	4.955

*Table 1 presents frequency factors (K_j) for storm durations (t_d) up to 24 hours. See ***Attachment 12*** for storm durations greater than 24 hours.

(District 2015)

Alternatively, in lieu of using ***Equation 6***, design rainfall depth (D_{ij}) may be determined from the tables in ***Attachment 8***. Select the proper chart depending on recurrence interval, then use the mean annual precipitation ($\overline{P}$) and storm duration (t_d) to select the rainfall depth from the chart.

RUNOFF COEFFICIENT

The District requires the use of the District's runoff coefficient (C') for design of flood control facilities. Calculate the runoff coefficient using ***Equation 7***. Each of the components that comprise C' is described below.

EQUATION 7 DISTRICT'S RUNOFF COEFFICIENT

$$C' = C + C_s + C_i \quad (7)$$

where:

C' = *District's runoff coefficient*
C = *basic runoff coefficient (from **Table 2**)*
C_s = *ground slope adjustment factor (from **Equation 8**)*
C_i = *rainfall intensity factor (from **Equation 9**)*

(District 1989)

Basic Runoff Coefficient

To design conveyance elements, choose the basic runoff coefficient (C) to reflect the proposed or ultimate development of the drainage area. Ultimate development is normally based on City/County general plans. If general plans are not available, make a reasonable estimate of ultimate land use.

The basic runoff coefficient (C) is a function of the percent of the watershed that is impervious and the hydrologic soil group. The percent impervious is normally based on land use category; however, it may be measured. To determine the appropriate C for any given drainage area, overlay the applicable land use onto the soil group maps provided in ***Attachment 9***. Using the area of each land use category within each soil group, determine an area-weighted average C using the information provided in ***Table 2***.

Table 2 applies to typical land use situations. For conditions not covered by ***Table 2***, calculate an appropriate runoff coefficient based on impervious area, to be determined using aerial photographs and site plans. Calculate the runoff coefficient based on an area-weighted average using $C = 0.9$ for all impervious areas, and the appropriate pervious area C value for soil groups present from the first row of ***Table 2***.

TABLE 2 BASIC RUNOFF COEFFICIENTS FOR PARTICULAR LAND USE AND SOIL TYPE

Land Use Description	Hydrologic Soil Group			
	A	B	C	D
Undeveloped land, parks, and golf courses	0.10	0.15	0.20	0.25
Rural Residential (larger than 1 ac lot)	0.13	0.18	0.23	0.28
Residential 10,000 - 1 ac lot	0.20	0.25	0.30	0.35
Residential 1/4 ac (8,000 - 10,000 sf lot)	0.25	0.30	0.35	0.40
Residential 1/8 ac (5,000 - 8,000 sf lot)	0.27	0.32	0.37	0.42
Residential (3600 - 5000 sf lot)	0.28	0.33	0.38	0.43
Residential (2700 - 3600 sf lot)	0.29	0.34	0.39	0.44
Zero Lot Line Residential & Less than 2700 sf	0.34	0.39	0.44	0.49
Townhouse	0.44	0.49	0.54	0.59
Condominium	0.51	0.56	0.61	0.66
Industrials	0.58	0.63	0.68	0.73
Apartment	0.65	0.70	0.75	0.80
Commercial	0.69	0.74	0.79	0.84
Freeway*	0.72	0.77	0.82	0.87
Mobile Home Park*	0.34	0.39	0.44	0.49
School (large open space)	0.24	0.29	0.34	0.39
School (small open space)	0.44	0.49	0.54	0.59

* For freeways, use aerial imagery to estimate percent impervious area.
** For mobile home parks, a minimum of 50% of the NCIA roof area should be counted as DCIA; for example, DCIA = 17+(37/2) = 35.5

(District 2015)

HYDROLOGIC SOIL GROUPS

Attachment 9 provides a map that shows the areas of hydrologic soil groups A, B, C, and D based on Natural Resource Conservation Service (NRCS – formerly Soil Conservation Service, SCS) mapping.

Soil Type A: Sand, loamy sand, or sandy loam. Low runoff potential and high infiltration rate even when thoroughly wetted. Primarily deep, well- to excessively-drained sand or gravel that has a high rate of water transmission.

Soil Type B: Silt loam or loam. Moderately low runoff potential and moderate infiltration rate when thoroughly wetted. Moderately deep to deep, moderately well- to well-drained soil with moderately fine to moderately coarse texture.

Soil Type C: Sandy clay loam. Moderately high runoff potential and low infiltration rate when thoroughly wetted that impedes downward movement of water. Soil with moderately fine to fine structure.

Soil Type D: Clay loam, silty clay loam, sandy clay, silty clay, or clay. High runoff potential and very low infiltration rate when thoroughly wetted. Consists chiefly of clay soil with a high swelling potential, soil with a permanent high water table, soil with a claypan or clay layer at or near the surface, and shallow soil over nearly impervious material.

Ground Slope Adjustment Factor

The ground slope adjustment factor (C_s) is used to adjust for increases in runoff as the average slope of the incremental drainage area increases. Use an area-weighted average slope (S) from the slope map provided in ***Attachment 10*** as a basis for determining C_s.

Rainfall Intensity Factor

The rainfall intensity factor (C_i) is used to account for the decrease in soil permeability that can be expected with an increase in ground slope and rainfall intensity.

EQUATION 8 GROUND SLOPE ADJUSTMENT FACTOR

$$C_s = \frac{(0.8 - C)[ln(S-1)]S^{0.5}}{56} \qquad (8)$$

$$C_s = 0 \text{ for } C \circ 0.8$$

where:

C_s = *ground slope adjustment factor*
C = *basic runoff coefficient*
S = *slope (percent from **Attachment 10**)*

(District 1989)

EQUATION 9 RAINFALL INTENSITY FACTOR

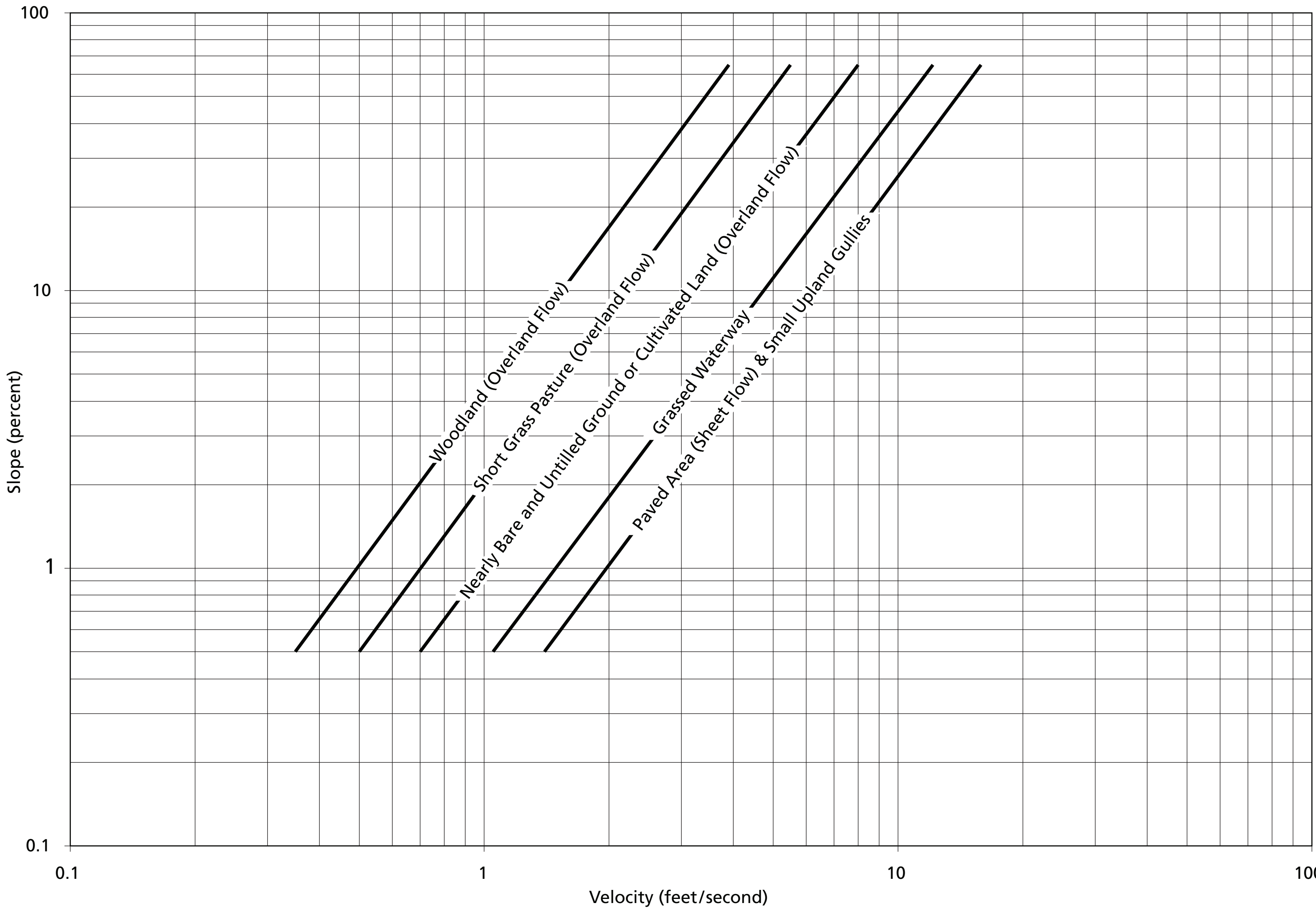
$$C_i = 0.8 - (C + C_s)\left(1 - \frac{1}{\frac{1}{e^i} + ln(i+1)}\right) \qquad (9)$$

$$C_i = 0 \text{ for } C + C_s \circ 0.8$$

where:

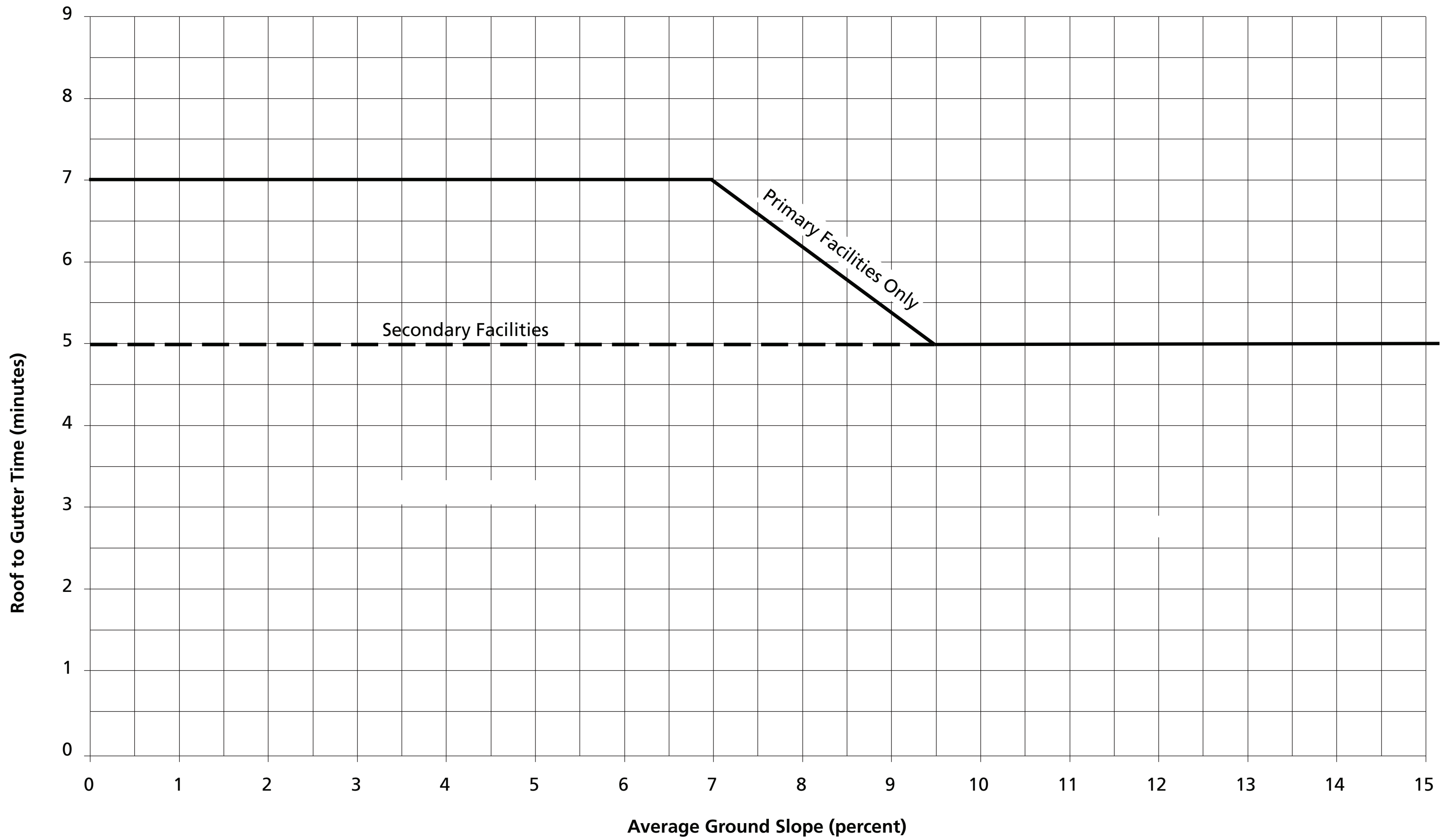
C_i = *rainfall intensity factor*
C = *basic runoff coefficient*
C_s = *ground slope adjustment factor*
i = *rainfall intensity (inches / hr from **Equation 5** or **Attachment 7**)*

(District 1989)



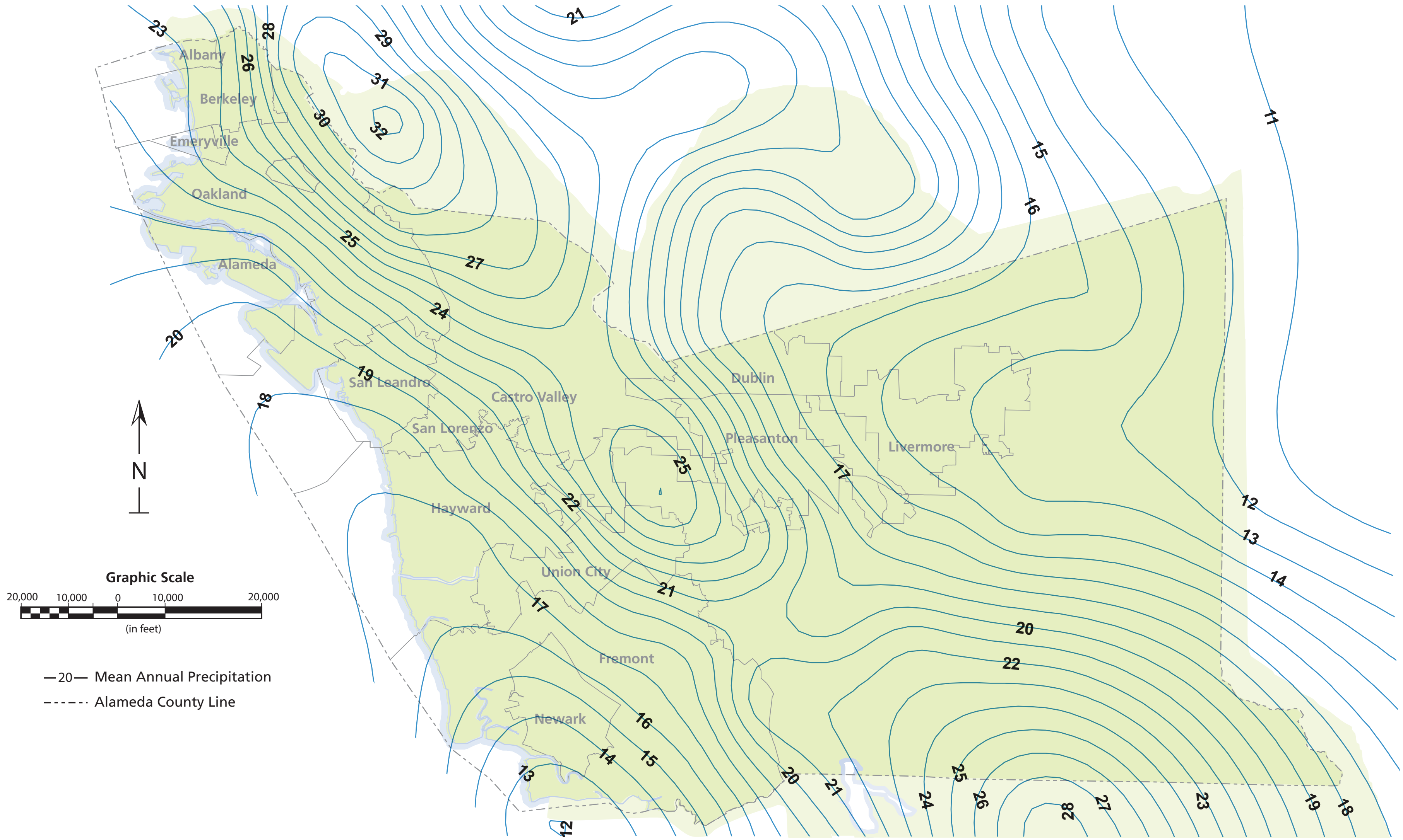
(NRCS 2010)

Flood Control & Water Conservation DISTRICT	Alameda County Hydrology & Hydraulics Manual 2016 Overland Flow Velocity	Attachment 3



(District 1989)

Roof to Gutter Time



Attachment 6 available for download as a GIS file from the Alameda County Flood Control District website.

(District 2011)

Flood Control & Water Conservation DISTRICT	Alameda County Hydrology & Hydraulics Manual 2016 Mean Annual Precipitation	Attachment 6

T_c (min)	Mean Annual Precipitation (in)																					
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	3.13	3.35	3.56	3.78	3.99	4.21	4.42	4.64	4.85	5.07	5.28	5.50	5.71	5.93	6.14	6.36	6.57	6.79	7.00	7.22	7.43	7.65
2	2.12	2.26	2.41	2.55	2.70	2.84	2.99	3.13	3.28	3.42	3.57	3.71	3.86	4.00	4.15	4.29	4.44	4.58	4.73	4.87	5.02	5.16
3	1.68	1.80	1.91	2.03	2.14	2.26	2.37	2.49	2.60	2.72	2.83	2.95	3.06	3.18	3.29	3.41	3.53	3.64	3.76	3.87	3.99	4.10
4	1.43	1.53	1.62	1.72	1.82	1.92	2.02	2.11	2.21	2.31	2.41	2.50	2.60	2.70	2.80	2.90	2.99	3.09	3.19	3.29	3.39	3.48
5	1.26	1.34	1.43	1.52	1.60	1.69	1.78	1.86	1.95	2.03	2.12	2.21	2.29	2.38	2.47	2.55	2.64	2.72	2.81	2.90	2.98	3.07
6	1.13	1.21	1.29	1.37	1.45	1.52	1.60	1.68	1.76	1.83	1.91	1.99	2.07	2.15	2.22	2.30	2.38	2.46	2.53	2.61	2.69	2.77
7	1.04	1.11	1.18	1.25	1.32	1.40	1.47	1.54	1.61	1.68	1.75	1.82	1.89	1.97	2.04	2.11	2.18	2.25	2.32	2.39	2.47	2.54
8	0.96	1.03	1.10	1.16	1.23	1.29	1.36	1.43	1.49	1.56	1.62	1.69	1.76	1.82	1.89	1.96	2.02	2.09	2.15	2.22	2.29	2.35
9	0.90	0.96	1.03	1.09	1.15	1.21	1.27	1.33	1.40	1.46	1.52	1.58	1.64	1.71	1.77	1.83	1.89	1.95	2.01	2.08	2.14	2.20
10	0.85	0.91	0.97	1.02	1.08	1.14	1.20	1.26	1.32	1.37	1.43	1.49	1.55	1.61	1.66	1.72	1.78	1.84	1.90	1.96	2.01	2.07
11	0.80	0.86	0.91	0.97	1.03	1.08	1.14	1.19	1.25	1.30	1.36	1.41	1.47	1.52	1.58	1.63	1.69	1.74	1.80	1.85	1.91	1.96
12	0.77	0.82	0.87	0.92	0.98	1.03	1.08	1.13	1.19	1.24	1.29	1.34	1.40	1.45	1.50	1.55	1.61	1.66	1.71	1.76	1.82	1.87
13	0.73	0.78	0.83	0.88	0.93	0.98	1.03	1.08	1.13	1.18	1.23	1.28	1.33	1.38	1.43	1.48	1.53	1.58	1.64	1.69	1.74	1.79
14	0.70	0.75	0.80	0.85	0.89	0.94	0.99	1.04	1.09	1.13	1.18	1.23	1.28	1.33	1.38	1.42	1.47	1.52	1.57	1.62	1.66	1.71
15	0.67	0.72	0.77	0.81	0.86	0.91	0.95	1.00	1.04	1.09	1.14	1.18	1.23	1.28	1.32	1.37	1.42	1.46	1.51	1.55	1.60	1.65
16	0.65	0.70	0.74	0.78	0.83	0.87	0.92	0.96	1.01	1.05	1.10	1.14	1.19	1.23	1.27	1.32	1.36	1.41	1.45	1.50	1.54	1.59
17	0.63	0.67	0.71	0.76	0.80	0.84	0.89	0.93	0.97	1.02	1.06	1.10	1.15	1.19	1.23	1.27	1.32	1.36	1.40	1.45	1.49	1.53
18	0.61	0.65	0.69	0.73	0.78	0.82	0.86	0.90	0.94	0.98	1.03	1.07	1.11	1.15	1.19	1.23	1.28	1.32	1.36	1.40	1.44	1.48
19	0.59	0.63	0.67	0.71	0.75	0.79	0.83	0.87	0.91	0.95	0.99	1.04	1.08	1.12	1.16	1.20	1.24	1.28	1.32	1.36	1.40	1.44
20	0.57	0.61	0.65	0.69	0.73	0.77	0.81	0.85	0.89	0.93	0.97	1.01	1.04	1.08	1.12	1.16	1.20	1.24	1.28	1.32	1.36	1.40
21	0.56	0.60	0.63	0.67	0.71	0.75	0.79	0.83	0.86	0.90	0.94	0.98	1.02	1.05	1.09	1.13	1.17	1.21	1.25	1.28	1.32	1.36
22	0.54	0.58	0.62	0.65	0.69	0.73	0.77	0.80	0.84	0.88	0.92	0.95	0.99	1.03	1.06	1.10	1.14	1.18	1.21	1.25	1.29	1.32
23	0.53	0.57	0.60	0.64	0.67	0.71	0.75	0.78	0.82	0.86	0.89	0.93	0.97	1.00	1.04	1.07	1.11	1.15	1.18	1.22	1.26	1.29
24	0.52	0.55	0.59	0.62	0.66	0.69	0.73	0.76	0.80	0.84	0.87	0.91	0.94	0.98	1.01	1.05	1.08	1.12	1.15	1.19	1.23	1.26
25	0.51	0.54	0.57	0.61	0.64	0.68	0.71	0.75	0.78	0.82	0.85	0.89	0.92	0.96	0.99	1.02	1.06	1.09	1.13	1.16	1.20	1.23
26	0.49	0.53	0.56	0.60	0.63	0.66	0.70	0.73	0.76	0.80	0.83	0.87	0.90	0.93	0.97	1.00	1.04	1.07	1.10	1.14	1.17	1.21
27	0.48	0.52	0.55	0.58	0.62	0.65	0.68	0.72	0.75	0.78	0.81	0.85	0.88	0.91	0.95	0.98	1.01	1.05	1.08	1.11	1.15	1.18
28	0.47	0.51	0.54	0.57	0.60	0.64	0.67	0.70	0.73	0.77	0.80	0.83	0.86	0.90	0.93	0.96	0.99	1.03	1.06	1.09	1.12	1.16
29	0.46	0.50	0.53	0.56	0.59	0.62	0.66	0.69	0.72	0.75	0.78	0.81	0.85	0.88	0.91	0.94	0.97	1.01	1.04	1.07	1.10	1.13
30	0.46	0.49	0.52	0.55	0.58	0.61	0.64	0.67	0.71	0.74	0.77	0.80	0.83	0.86	0.89	0.92	0.96	0.99	1.02	1.05	1.08	1.11
31	0.45	0.48	0.51	0.54	0.57	0.60	0.63	0.66	0.69	0.72	0.75	0.78	0.81	0.85	0.88	0.91	0.94	0.97	1.00	1.03	1.06	1.09
32	0.44	0.47	0.50	0.53	0.56	0.59	0.62	0.65	0.68	0.71	0.74	0.77	0.80	0.83	0.86	0.89	0.92	0.95	0.98	1.01	1.04	1.07
33	0.43	0.46	0.49	0.52	0.55	0.58	0.61	0.64	0.67	0.70	0.73	0.76	0.79	0.82	0.85	0.88	0.90	0.93	0.96	0.99	1.02	1.05
34	0.42	0.45	0.48	0.51	0.54	0.57	0.60	0.63	0.66	0.69	0.72	0.74	0.77	0.80	0.83	0.86	0.89	0.92	0.95	0.98	1.01	1.04
35	0.42	0.45	0.47	0.50	0.53	0.56	0.59	0.62	0.65	0.67	0.70	0.73	0.76	0.79	0.82	0.85	0.88	0.90	0.93	0.96	0.99	1.02
36	0.41	0.44	0.47	0.50	0.52	0.55	0.58	0.61	0.64	0.66	0.69	0.72	0.75	0.78	0.80	0.83	0.86	0.89	0.92	0.95	0.97	1.00
37	0.40	0.43	0.46	0.49	0.52	0.54	0.57	0.60	0.63	0.65	0.68	0.71	0.74	0.76	0.79	0.82	0.85	0.88	0.90	0.93	0.96	0.99
38	0.40	0.43	0.45	0.48	0.51	0.53	0.56	0.59	0.62	0.64	0.67	0.70	0.73	0.75	0.78	0.81	0.84	0.86	0.89	0.92	0.94	0.97
39	0.39	0.42	0.45	0.47	0.50	0.53	0.55	0.58	0.61	0.63	0.66	0.69	0.72	0.74	0.77	0.80	0.82	0.85	0.88	0.90	0.93	0.96
40	0.39	0.41	0.44	0.47	0.49	0.52	0.55	0.57	0.60	0.63	0.65	0.68	0.71	0.73	0.76	0.78	0.81	0.84	0.86	0.89	0.92	0.94
41	0.38	0.41	0.43	0.46	0.49	0.51	0.54	0.56	0.59	0.62	0.64	0.67	0.70	0.72	0.75	0.77	0.80	0.83	0.85	0.88	0.90	0.93
42	0.38	0.40	0.43	0.45	0.48	0.51	0.53	0.56	0.58	0.61	0.63	0.66	0.69	0.71	0.74	0.76	0.79	0.81	0.84	0.87	0.89	0.92
43	0.37	0.40	0.42	0.45	0.47	0.50	0.52	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.86	0.88	0.91
44	0.37	0.39	0.42	0.44	0.47	0.49	0.52	0.54	0.57	0.59	0.62	0.64	0.67	0.69	0.72	0.74	0.77	0.79	0.82	0.84	0.87	0.89
45	0.36	0.39	0.41	0.44	0.46	0.49	0.51	0.54	0.56	0.59	0.61	0.63	0.66	0.68	0.71	0.73	0.76	0.78	0.81	0.83	0.86	0.88
46	0.36	0.38	0.41	0.43	0.46	0.48	0.50	0.53	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.72	0.75	0.77	0.80	0.82	0.85	0.87
47	0.35	0.38	0.40	0.43	0.45	0.47	0.50	0.52	0.55	0.57	0.60	0.62	0.64	0.67	0.69	0.72	0.74	0.76	0.79	0.81	0.84	0.86
48	0.35	0.37	0.40	0.42	0.44	0.47	0.49	0.52	0.54	0.56	0.59	0.61	0.64	0.66	0.68	0.71	0.73	0.76	0.78	0.80	0.83	0.85
49	0.34	0.37	0.39	0.42	0.44	0.46	0.49	0.51	0.53	0.56	0.58	0.60	0.63	0.65	0.68	0.70	0.72	0.75	0.77	0.79	0.82	0.84
50	0.34	0.36	0.39	0.41	0.43	0.46	0.48	0.50	0.53	0.55	0.57	0.60	0.62	0.64	0.67	0.69	0.71	0.74	0.76	0.78	0.81	0.83
51	0.34	0.36	0.38	0.41	0.43	0.45	0.48	0.50	0.52	0.55	0.57	0.59	0.61	0.64	0.66	0.68	0.71	0.73	0.75	0.78	0.80	0.82
52	0.33	0.36	0.38	0.40	0.42	0.45	0.47	0.49	0.52	0.54	0.56	0.58	0.61	0.63	0.65	0.68	0.70	0.72	0.74	0.77	0.79	0.81
53	0.33	0.35	0.38	0.40	0.42	0.44	0.47	0.49	0.51	0.53	0.56	0.58	0.60	0.62	0.65	0.67	0.69	0.71	0.74	0.76	0.78	0.80
54	0.33	0.35	0.37	0.39	0.42	0.44	0.46	0.48	0.51	0.53	0.55	0.57	0.59	0.62	0.64	0.66	0.68	0.71	0.73	0.75	0.77	0.80
55	0.32	0.35	0.37	0.39	0.41	0.43	0.46	0.48	0.50	0.52	0.54	0.57	0.59	0.61	0.63	0.66	0.68	0.70	0.72	0.74	0.77	0.79
56	0.32	0.34	0.36	0.39	0.41	0.43	0.45	0.47	0.50	0.52	0.54	0.56	0.58	0.60	0.63	0.65	0.67	0.69	0.71	0.74	0.76	0.78
57	0.32	0.34	0.36	0.38	0.40	0.42	0.45	0.47	0.49	0.51	0.53	0.56	0.58	0.60	0.62	0.64	0.66	0.69	0.71	0.73	0.75	0.77
58	0.31	0.33	0.36	0.38	0.40	0.42	0.44	0.46	0.49	0.51	0.53	0.55	0.57	0.59	0.61	0.64	0.66	0.68	0.70	0.72	0.74	0.76
59	0.31	0.33	0.35	0.37	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.57	0.59	0.61	0.63	0.65	0.67	0.69	0.71	0.74	0.76
60	0.31	0.33	0.35	0.37	0.39	0.41	0.43	0.45	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.67	0.69	0.71	0.73	0.75

(District 2011)

Flood Control & Water Conservation DISTRICT

Rainfall Intensity – 2 Year Storm

(inches/hour)

Attachment 7

T_c (min)	Mean Annual Precipitation (in)																					
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	5.28	5.64	6.00	6.36	6.73	7.09	7.45	7.81	8.17	8.53	8.90	9.26	9.62	9.98	10.34	10.71	11.07	11.43	11.79	12.15	12.52	12.88
2	3.56	3.81	4.05	4.30	4.54	4.78	5.03	5.27	5.52	5.76	6.00	6.25	6.49	6.74	6.98	7.23	7.47	7.71	7.96	8.20	8.45	8.69
3	2.83	3.02	3.22	3.41	3.61	3.80	4.00	4.19	4.38	4.58	4.77	4.97	5.16	5.35	5.55	5.74	5.94	6.13	6.32	6.52	6.71	6.91
4	2.40	2.57	2.73	2.90	3.06	3.23	3.39	3.56	3.72	3.89	4.05	4.22	4.38	4.55	4.71	4.88	5.04	5.21	5.37	5.54	5.70	5.87
5	2.12	2.26	2.41	2.55	2.70	2.84	2.99	3.14	3.28	3.43	3.57	3.72	3.86	4.01	4.15	4.30	4.44	4.59	4.73	4.88	5.02	5.17
6	1.91	2.04	2.17	2.30	2.43	2.57	2.70	2.83	2.96	3.09	3.22	3.35	3.48	3.61	3.74	3.88	4.01	4.14	4.27	4.40	4.53	4.66
7	1.75	1.87	1.99	2.11	2.23	2.35	2.47	2.59	2.71	2.83	2.95	3.07	3.19	3.31	3.43	3.55	3.67	3.79	3.91	4.03	4.15	4.27
8	1.62	1.73	1.85	1.96	2.07	2.18	2.29	2.40	2.51	2.62	2.74	2.85	2.96	3.07	3.18	3.29	3.40	3.51	3.63	3.74	3.85	3.96
9	1.52	1.62	1.73	1.83	1.93	2.04	2.14	2.25	2.35	2.45	2.56	2.66	2.77	2.87	2.98	3.08	3.18	3.29	3.39	3.50	3.60	3.70
10	1.43	1.53	1.63	1.72	1.82	1.92	2.02	2.12	2.21	2.31	2.41	2.51	2.61	2.70	2.80	2.90	3.00	3.10	3.19	3.29	3.39	3.49
11	1.35	1.45	1.54	1.63	1.73	1.82	1.91	2.00	2.10	2.19	2.28	2.38	2.47	2.56	2.66	2.75	2.84	2.93	3.03	3.12	3.21	3.31
12	1.29	1.38	1.47	1.55	1.64	1.73	1.82	1.91	2.00	2.09	2.17	2.26	2.35	2.44	2.53	2.62	2.70	2.79	2.88	2.97	3.06	3.15
13	1.23	1.32	1.40	1.49	1.57	1.65	1.74	1.82	1.91	1.99	2.08	2.16	2.25	2.33	2.42	2.50	2.58	2.67	2.75	2.84	2.92	3.01
14	1.18	1.26	1.34	1.42	1.51	1.59	1.67	1.75	1.83	1.91	1.99	2.07	2.15	2.23	2.32	2.40	2.48	2.56	2.64	2.72	2.80	2.88
15	1.14	1.21	1.29	1.37	1.45	1.53	1.60	1.68	1.76	1.84	1.92	1.99	2.07	2.15	2.23	2.30	2.38	2.46	2.54	2.62	2.69	2.77
16	1.10	1.17	1.25	1.32	1.40	1.47	1.55	1.62	1.70	1.77	1.85	1.92	2.00	2.07	2.15	2.22	2.30	2.37	2.45	2.52	2.60	2.67
17	1.06	1.13	1.20	1.28	1.35	1.42	1.49	1.57	1.64	1.71	1.78	1.86	1.93	2.00	2.07	2.15	2.22	2.29	2.36	2.44	2.51	2.58
18	1.02	1.09	1.17	1.24	1.31	1.38	1.45	1.52	1.59	1.66	1.73	1.80	1.87	1.94	2.01	2.08	2.15	2.22	2.29	2.36	2.43	2.50
19	0.99	1.06	1.13	1.20	1.27	1.33	1.40	1.47	1.54	1.61	1.67	1.74	1.81	1.88	1.95	2.02	2.08	2.15	2.22	2.29	2.36	2.42
20	0.97	1.03	1.10	1.16	1.23	1.30	1.36	1.43	1.49	1.56	1.63	1.69	1.76	1.83	1.89	1.96	2.02	2.09	2.16	2.22	2.29	2.35
21	0.94	1.00	1.07	1.13	1.20	1.26	1.33	1.39	1.45	1.52	1.58	1.65	1.71	1.78	1.84	1.90	1.97	2.03	2.10	2.16	2.23	2.29
22	0.91	0.98	1.04	1.10	1.17	1.23	1.29	1.35	1.42	1.48	1.54	1.60	1.67	1.73	1.79	1.85	1.92	1.98	2.04	2.11	2.17	2.23
23	0.89	0.95	1.01	1.08	1.14	1.20	1.26	1.32	1.38	1.44	1.50	1.56	1.63	1.69	1.75	1.81	1.87	1.93	1.99	2.05	2.11	2.18
24	0.87	0.93	0.99	1.05	1.11	1.17	1.23	1.29	1.35	1.41	1.47	1.53	1.59	1.65	1.71	1.77	1.83	1.88	1.94	2.00	2.06	2.12
25	0.85	0.91	0.97	1.03	1.08	1.14	1.20	1.26	1.32	1.38	1.43	1.49	1.55	1.61	1.67	1.73	1.78	1.84	1.90	1.96	2.02	2.08
26	0.83	0.89	0.95	1.00	1.06	1.12	1.17	1.23	1.29	1.34	1.40	1.46	1.52	1.57	1.63	1.69	1.74	1.80	1.86	1.92	1.97	2.03
27	0.81	0.87	0.93	0.98	1.04	1.09	1.15	1.20	1.26	1.32	1.37	1.43	1.48	1.54	1.60	1.65	1.71	1.76	1.82	1.87	1.93	1.99
28	0.80	0.85	0.91	0.96	1.02	1.07	1.13	1.18	1.23	1.29	1.34	1.40	1.45	1.51	1.56	1.62	1.67	1.73	1.78	1.84	1.89	1.95
29	0.78	0.84	0.89	0.94	1.00	1.05	1.10	1.16	1.21	1.26	1.32	1.37	1.43	1.48	1.53	1.59	1.64	1.69	1.75	1.80	1.85	1.91
30	0.77	0.82	0.87	0.92	0.98	1.03	1.08	1.13	1.19	1.24	1.29	1.35	1.40	1.45	1.50	1.56	1.61	1.66	1.71	1.77	1.82	1.87
31	0.75	0.80	0.86	0.91	0.96	1.01	1.06	1.11	1.17	1.22	1.27	1.32	1.37	1.42	1.48	1.53	1.58	1.63	1.68	1.73	1.79	1.84
32	0.74	0.79	0.84	0.89	0.94	0.99	1.04	1.09	1.14	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80
33	0.73	0.78	0.83	0.88	0.93	0.98	1.03	1.08	1.13	1.17	1.22	1.27	1.32	1.37	1.42	1.47	1.52	1.57	1.62	1.67	1.72	1.77
34	0.71	0.76	0.81	0.86	0.91	0.96	1.01	1.06	1.11	1.16	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.64	1.69	1.74
35	0.70	0.75	0.80	0.85	0.90	0.94	0.99	1.04	1.09	1.14	1.18	1.23	1.28	1.33	1.38	1.43	1.47	1.52	1.57	1.62	1.67	1.71
36	0.69	0.74	0.79	0.83	0.88	0.93	0.98	1.02	1.07	1.12	1.17	1.21	1.26	1.31	1.36	1.40	1.45	1.50	1.55	1.59	1.64	1.69
37	0.68	0.73	0.77	0.82	0.87	0.91	0.96	1.01	1.05	1.10	1.15	1.19	1.24	1.29	1.33	1.38	1.43	1.47	1.52	1.57	1.61	1.66
38	0.67	0.72	0.76	0.81	0.85	0.90	0.95	0.99	1.04	1.08	1.13	1.18	1.22	1.27	1.31	1.36	1.41	1.45	1.50	1.54	1.59	1.64
39	0.66	0.71	0.75	0.80	0.84	0.89	0.93	0.98	1.02	1.07	1.11	1.16	1.20	1.25	1.30	1.34	1.39	1.43	1.48	1.52	1.57	1.61
40	0.65	0.70	0.74	0.79	0.83	0.87	0.92	0.96	1.01	1.05	1.10	1.14	1.19	1.23	1.28	1.32	1.37	1.41	1.46	1.50	1.54	1.59
41	0.64	0.69	0.73	0.77	0.82	0.86	0.91	0.95	0.99	1.04	1.08	1.13	1.17	1.22	1.26	1.30	1.35	1.39	1.44	1.48	1.52	1.57
42	0.63	0.68	0.72	0.76	0.81	0.85	0.89	0.94	0.98	1.02	1.07	1.11	1.16	1.20	1.24	1.29	1.33	1.37	1.42	1.46	1.50	1.55
43	0.63	0.67	0.71	0.75	0.80	0.84	0.88	0.93	0.97	1.01	1.05	1.10	1.14	1.18	1.23	1.27	1.31	1.35	1.40	1.44	1.48	1.53
44	0.62	0.66	0.70	0.74	0.79	0.83	0.87	0.91	0.96	1.00	1.04	1.08	1.12	1.17	1.21	1.25	1.29	1.34	1.38	1.42	1.46	1.51
45	0.61	0.65	0.69	0.73	0.78	0.82	0.86	0.90	0.94	0.99	1.03	1.07	1.11	1.15	1.19	1.24	1.28	1.32	1.36	1.40	1.44	1.49
46	0.60	0.64	0.68	0.73	0.77	0.81	0.85	0.89	0.93	0.97	1.01	1.06	1.10	1.14	1.18	1.22	1.26	1.30	1.34	1.39	1.43	1.47
47	0.59	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.17	1.21	1.25	1.29	1.33	1.37	1.41	1.45
48	0.59	0.63	0.67	0.71	0.75	0.79	0.83	0.87	0.91	0.95	0.99	1.03	1.07	1.11	1.15	1.19	1.23	1.27	1.31	1.35	1.39	1.43
49	0.58	0.62	0.66	0.70	0.74	0.78	0.82	0.86	0.90	0.94	0.98	1.02	1.06	1.10	1.14	1.18	1.22	1.26	1.30	1.34	1.38	1.42
50	0.57	0.61	0.65	0.69	0.73	0.77	0.81	0.85	0.89	0.93	0.97	1.01	1.05	1.09	1.13	1.16	1.20	1.24	1.28	1.32	1.36	1.40
51	0.57	0.61	0.65	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.03	1.07	1.11	1.15	1.19	1.23	1.27	1.31	1.35	1.38
52	0.56	0.60	0.64	0.68	0.72	0.75	0.79	0.83	0.87	0.91	0.95	0.98	1.02	1.06	1.10	1.14	1.18	1.22	1.25	1.29	1.33	1.37
53	0.56	0.59	0.63	0.67	0.71	0.75	0.78	0.82	0.86	0.90	0.94	0.97	1.01	1.05	1.09	1.13	1.16	1.20	1.24	1.28	1.32	1.36
54	0.55	0.59	0.62	0.66	0.70	0.74	0.78	0.81	0.85	0.89	0.93	0.96	1.00	1.04	1.08	1.11	1.15	1.19	1.23	1.27	1.30	1.34
55	0.54	0.58	0.62	0.66	0.69	0.73	0.77	0.80	0.84	0.88	0.92	0.95	0.99	1.03	1.07	1.10	1.14	1.18	1.21	1.25	1.29	1.33
56	0.54	0.58	0.61	0.65	0.69	0.72	0.76	0.80	0.83	0.87	0.91	0.94	0.98	1.02	1.05	1.09	1.13	1.17	1.20	1.24	1.28	1.31
57	0.53	0.57	0.61	0.64	0.68	0.72	0.75	0.79	0.83	0.86	0.90	0.93	0.97	1.01	1.04	1.08	1.12	1.15	1.19	1.23	1.26	1.30
58	0.53	0.56	0.60	0.64	0.67	0.71	0.74	0.78	0.82	0.85	0.89	0.93	0.96	1.00	1.03	1.07	1.11	1.14	1.18	1.22	1.25	1.29
59	0.52	0.56	0.59	0.63	0.67	0.70	0.74	0.77	0.81	0.85	0.88	0.92	0.95	0.99	1.02	1.06	1.10	1.13	1.17	1.20	1.24	1.28
60	0.52	0.55	0.59	0.62	0.66	0.70	0.73	0.77	0.80	0.84	0.87	0.91	0.94	0.98	1.01	1.05	1.09	1.12	1.16	1.19	1.23	1.26

T_c (min)	Mean Annual Precipitation (in)																				
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	6.34	6.78	7.21	7.65	8.08	8.52	8.95	9.39	9.82	10.26	10.69	11.13	11.56	12.00	12.43	12.86	13.30	13.73	14.17	14.60	15.04	15.47
2	4.28	4.57	4.87	5.16	5.45	5.75	6.04	6.34	6.63	6.92	7.22	7.51	7.80	8.10	8.39	8.68	8.98	9.27	9.56	9.86	10.15	10.44
3	3.40	3.63	3.87	4.10	4.33	4.57	4.80	5.03	5.27	5.50	5.73	5.97	6.20	6.43	6.67	6.90	7.13	7.37	7.60	7.83	8.07	8.30
4	2.89	3.09	3.29	3.48	3.68	3.88	4.08	4.28	4.47	4.67	4.87	5.07	5.27	5.46	5.66	5.86	6.06	6.26	6.46	6.65	6.85	7.05
5	2.55	2.72	2.89	3.07	3.24	3.42	3.59	3.77	3.94	4.12	4.29	4.47	4.64	4.82	4.99	5.16	5.34	5.51	5.69	5.86	6.04	6.21
6	2.30	2.45	2.61	2.77	2.93	3.08	3.24	3.40	3.55	3.71	3.87	4.03	4.18	4.34	4.50	4.66	4.81	4.97	5.13	5.29	5.44	5.60
7	2.10	2.25	2.39	2.54	2.68	2.82	2.97	3.11	3.26	3.40	3.55	3.69	3.83	3.98	4.12	4.27	4.41	4.56	4.70	4.84	4.99	5.13
8	1.95	2.08	2.22	2.35	2.48	2.62	2.75	2.89	3.02	3.15	3.29	3.42	3.55	3.69	3.82	3.96	4.09	4.22	4.36	4.49	4.62	4.76
9	1.82	1.95	2.07	2.20	2.32	2.45	2.57	2.70	2.82	2.95	3.07	3.20	3.32	3.45	3.58	3.70	3.83	3.95	4.08	4.20	4.33	4.45
10	1.72	1.84	1.95	2.07	2.19	2.31	2.43	2.54	2.66	2.78	2.90	3.01	3.13	3.25	3.37	3.49	3.60	3.72	3.84	3.96	4.07	4.19
11	1.63	1.74	1.85	1.96	2.07	2.19	2.30	2.41	2.52	2.63	2.74	2.86	2.97	3.08	3.19	3.30	3.41	3.53	3.64	3.75	3.86	3.97
12	1.55	1.66	1.76	1.87	1.97	2.08	2.19	2.29	2.40	2.51	2.61	2.72	2.82	2.93	3.04	3.14	3.25	3.36	3.46	3.57	3.67	3.78
13	1.48	1.58	1.68	1.79	1.89	1.99	2.09	2.19	2.29	2.39	2.50	2.60	2.70	2.80	2.90	3.00	3.11	3.21	3.31	3.41	3.51	3.61
14	1.42	1.52	1.61	1.71	1.81	1.91	2.00	2.10	2.20	2.30	2.39	2.49	2.59	2.69	2.78	2.88	2.98	3.07	3.17	3.27	3.37	3.46
15	1.37	1.46	1.55	1.65	1.74	1.83	1.93	2.02	2.11	2.21	2.30	2.40	2.49	2.58	2.68	2.77	2.86	2.96	3.05	3.14	3.24	3.33
16	1.32	1.41	1.50	1.59	1.68	1.77	1.86	1.95	2.04	2.13	2.22	2.31	2.40	2.49	2.58	2.67	2.76	2.85	2.94	3.03	3.12	3.21
17	1.27	1.36	1.45	1.53	1.62	1.71	1.79	1.88	1.97	2.06	2.14	2.23	2.32	2.41	2.49	2.58	2.67	2.75	2.84	2.93	3.02	3.10
18	1.23	1.32	1.40	1.48	1.57	1.65	1.74	1.82	1.91	1.99	2.08	2.16	2.24	2.33	2.41	2.50	2.58	2.67	2.75	2.84	2.92	3.00
19	1.19	1.28	1.36	1.44	1.52	1.60	1.69	1.77	1.85	1.93	2.01	2.09	2.18	2.26	2.34	2.42	2.50	2.59	2.67	2.75	2.83	2.91
20	1.16	1.24	1.32	1.40	1.48	1.56	1.64	1.72	1.80	1.88	1.95	2.03	2.11	2.19	2.27	2.35	2.43	2.51	2.59	2.67	2.75	2.83
21	1.13	1.21	1.28	1.36	1.44	1.51	1.59	1.67	1.75	1.82	1.90	1.98	2.06	2.13	2.21	2.29	2.37	2.44	2.52	2.60	2.68	2.75
22	1.10	1.17	1.25	1.32	1.40	1.48	1.55	1.63	1.70	1.78	1.85	1.93	2.00	2.08	2.15	2.23	2.30	2.38	2.45	2.53	2.61	2.68
23	1.07	1.14	1.22	1.29	1.37	1.44	1.51	1.59	1.66	1.73	1.81	1.88	1.95	2.03	2.10	2.17	2.25	2.32	2.39	2.47	2.54	2.61
24	1.05	1.12	1.19	1.26	1.33	1.40	1.48	1.55	1.62	1.69	1.76	1.83	1.91	1.98	2.05	2.12	2.19	2.26	2.34	2.41	2.48	2.55
25	1.02	1.09	1.16	1.23	1.30	1.37	1.44	1.51	1.58	1.65	1.72	1.79	1.86	1.93	2.00	2.07	2.14	2.21	2.28	2.35	2.42	2.49
26	1.00	1.07	1.14	1.21	1.27	1.34	1.41	1.48	1.55	1.62	1.68	1.75	1.82	1.89	1.96	2.03	2.10	2.16	2.23	2.30	2.37	2.44
27	0.98	1.05	1.11	1.18	1.25	1.31	1.38	1.45	1.51	1.58	1.65	1.72	1.78	1.85	1.92	1.98	2.05	2.12	2.19	2.25	2.32	2.39
28	0.96	1.02	1.09	1.16	1.22	1.29	1.35	1.42	1.48	1.55	1.62	1.68	1.75	1.81	1.88	1.94	2.01	2.08	2.14	2.21	2.27	2.34
29	0.94	1.00	1.07	1.13	1.20	1.26	1.33	1.39	1.45	1.52	1.58	1.65	1.71	1.78	1.84	1.91	1.97	2.03	2.10	2.16	2.23	2.29
30	0.92	0.98	1.05	1.11	1.17	1.24	1.30	1.36	1.43	1.49	1.55	1.62	1.68	1.74	1.81	1.87	1.93	2.00	2.06	2.12	2.19	2.25
31	0.90	0.97	1.03	1.09	1.15	1.21	1.28	1.34	1.40	1.46	1.52	1.59	1.65	1.71	1.77	1.83	1.90	1.96	2.02	2.08	2.14	2.21
32	0.89	0.95	1.01	1.07	1.13	1.19	1.25	1.31	1.38	1.44	1.50	1.56	1.62	1.68	1.74	1.80	1.86	1.92	1.98	2.05	2.11	2.17
33	0.87	0.93	0.99	1.05	1.11	1.17	1.23	1.29	1.35	1.41	1.47	1.53	1.59	1.65	1.71	1.77	1.83	1.89	1.95	2.01	2.07	2.13
34	0.86	0.92	0.98	1.03	1.09	1.15	1.21	1.27	1.33	1.39	1.45	1.51	1.56	1.62	1.68	1.74	1.80	1.86	1.92	1.98	2.04	2.09
35	0.84	0.90	0.96	1.02	1.08	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.54	1.60	1.65	1.71	1.77	1.83	1.89	1.94	2.00	2.06
36	0.83	0.89	0.94	1.00	1.06	1.12	1.17	1.23	1.29	1.34	1.40	1.46	1.51	1.57	1.63	1.69	1.74	1.80	1.86	1.91	1.97	2.03
37	0.82	0.87	0.93	0.99	1.04	1.10	1.15	1.21	1.27	1.32	1.38	1.44	1.49	1.55	1.60	1.66	1.72	1.77	1.83	1.88	1.94	2.00
38	0.81	0.86	0.92	0.97	1.03	1.08	1.14	1.19	1.25	1.30	1.36	1.41	1.47	1.52	1.58	1.63	1.69	1.75	1.80	1.86	1.91	1.97
39	0.79	0.85	0.90	0.96	1.01	1.07	1.12	1.18	1.23	1.28	1.34	1.39	1.45	1.50	1.56	1.61	1.67	1.72	1.77	1.83	1.88	1.94
40	0.78	0.84	0.89	0.94	1.00	1.05	1.10	1.16	1.21	1.27	1.32	1.37	1.43	1.48	1.53	1.59	1.64	1.70	1.75	1.80	1.86	1.91
41	0.77	0.82	0.88	0.93	0.98	1.04	1.09	1.14	1.20	1.25	1.30	1.35	1.41	1.46	1.51	1.57	1.62	1.67	1.72	1.78	1.83	1.88
42	0.76	0.81	0.87	0.92	0.97	1.02	1.07	1.13	1.18	1.23	1.28	1.34	1.39	1.44	1.49	1.54	1.60	1.65	1.70	1.75	1.81	1.86
43	0.75	0.80	0.85	0.91	0.96	1.01	1.06	1.11	1.16	1.21	1.27	1.32	1.37	1.42	1.47	1.52	1.58	1.63	1.68	1.73	1.78	1.83
44	0.74	0.79	0.84	0.89	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.56	1.61	1.66	1.71	1.76	1.81
45	0.73	0.78	0.83	0.88	0.93	0.98	1.03	1.08	1.13	1.18	1.23	1.28	1.33	1.38	1.44	1.49	1.54	1.59	1.64	1.69	1.74	1.79
46	0.72	0.77	0.82	0.87	0.92	0.97	1.02	1.07	1.12	1.17	1.22	1.27	1.32	1.37	1.42	1.47	1.52	1.57	1.62	1.67	1.71	1.76
47	0.71	0.76	0.81	0.86	0.91	0.96	1.01	1.06	1.11	1.16	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.69	1.74
48	0.71	0.75	0.80	0.85	0.90	0.95	1.00	1.04	1.09	1.14	1.19	1.24	1.29	1.34	1.38	1.43	1.48	1.53	1.58	1.63	1.67	1.72
49	0.70	0.75	0.79	0.84	0.89	0.94	0.98	1.03	1.08	1.13	1.18	1.22	1.27	1.32	1.37	1.42	1.46	1.51	1.56	1.61	1.65	1.70
50	0.69	0.74	0.78	0.83	0.88	0.93	0.97	1.02	1.07	1.12	1.16	1.21	1.26	1.30	1.35	1.40	1.45	1.49	1.54	1.59	1.64	1.68
51	0.68	0.73	0.78	0.82	0.87	0.92	0.96	1.01	1.06	1.10	1.15	1.20	1.24	1.29	1.34	1.38	1.43	1.48	1.52	1.57	1.62	1.66
52	0.67	0.72	0.77	0.81	0.86	0.91	0.95	1.00	1.04	1.09	1.14	1.18	1.23	1.28	1.32	1.37	1.41	1.46	1.51	1.55	1.60	1.65
53	0.67	0.71	0.76	0.80	0.85	0.90	0.94	0.99	1.03	1.08	1.12	1.17	1.22	1.26	1.31	1.35	1.40	1.45	1.49	1.54	1.58	1.63
54	0.66	0.71	0.75	0.80	0.84	0.89	0.93	0.98	1.02	1.07	1.11	1.16	1.20	1.25	1.29	1.34	1.38	1.43	1.48	1.52	1.57	1.61
55	0.65	0.70	0.74	0.79	0.83	0.88	0.92	0.97	1.01	1.06	1.10	1.15	1.19	1.24	1.28	1.33	1.37	1.42	1.46	1.50	1.55	1.59
56	0.65	0.69	0.74	0.78	0.82	0.87	0.91	0.96	1.00	1.05	1.09	1.13	1.18	1.22	1.27	1.31	1.36	1.40	1.45	1.49	1.53	1.58
57	0.64	0.68	0.73	0.77	0.82	0.86	0.90	0.95	0.99	1.04	1.08	1.12	1.17	1.21	1.26	1.30	1.34	1.39	1.43	1.47	1.52	1.56
58	0.63	0.68	0.72	0.76	0.81	0.85	0.89	0.94	0.98	1.03	1.07	1.11	1.16	1.20	1.24	1.29	1.33	1.37	1.42	1.46	1.50	1.55
59	0.63	0.67	0.71	0.76	0.80	0.84	0.89	0.93	0.97	1.02	1.06	1.10	1.14	1.19	1.23	1.27	1.32	1.36	1.40	1.45	1.49	1.53
60	0.62	0.66	0.71	0.75	0.79	0.84	0.88	0.92	0.96	1.01	1.05	1.09	1.13	1.18	1.22	1.26	1.30	1.35	1.39	1.43	1.47	1.52

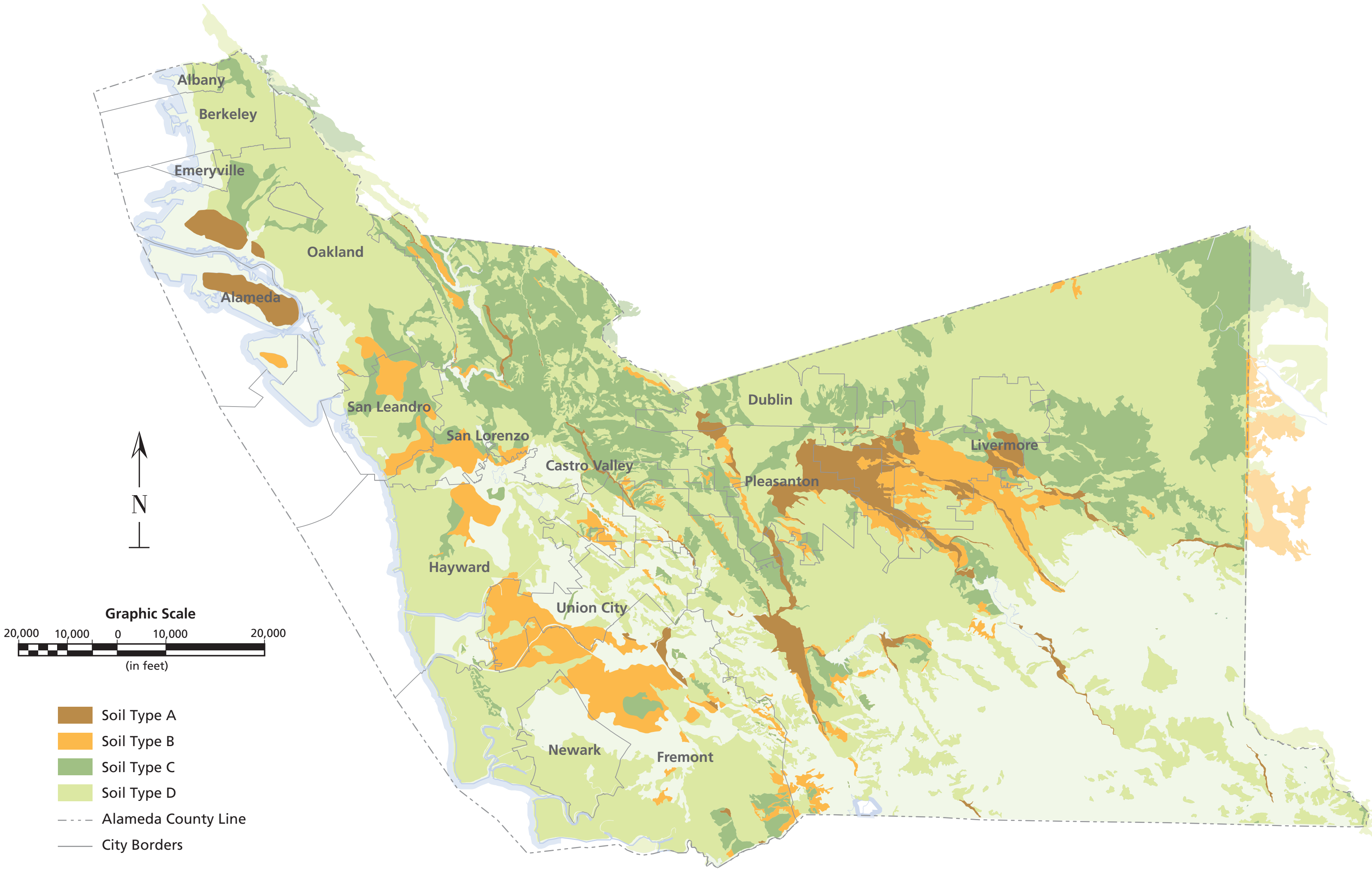
Rainfall Intensity – 25 Year Storm

(inches/hour)

T_c (min)	Mean Annual Precipitation (in)																					
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	7.87	8.41	8.95	9.49	10.03	10.57	11.11	11.64	12.18	12.72	13.26	13.80	14.34	14.88	15.42	15.96	16.50	17.04	17.58	18.12	18.66	19.20
2	5.31	5.67	6.04	6.40	6.77	7.13	7.50	7.86	8.22	8.59	8.95	9.32	9.68	10.04	10.41	10.77	11.14	11.50	11.87	12.23	12.59	12.96
3	4.22	4.51	4.80	5.09	5.38	5.67	5.96	6.25	6.53	6.82	7.11	7.40	7.69	7.98	8.27	8.56	8.85	9.14	9.43	9.72	10.01	10.30
4	3.58	3.83	4.08	4.32	4.57	4.81	5.06	5.31	5.55	5.80	6.04	6.29	6.53	6.78	7.03	7.27	7.52	7.76	8.01	8.25	8.50	8.75
5	3.16	3.38	3.59	3.81	4.02	4.24	4.46	4.67	4.89	5.11	5.32	5.54	5.76	5.97	6.19	6.41	6.62	6.84	7.06	7.27	7.49	7.71
6	2.85	3.04	3.24	3.43	3.63	3.82	4.02	4.22	4.41	4.61	4.80	5.00	5.19	5.39	5.58	5.78	5.97	6.17	6.36	6.56	6.75	6.95
7	2.61	2.79	2.97	3.15	3.33	3.50	3.68	3.86	4.04	4.22	4.40	4.58	4.76	4.94	5.12	5.29	5.47	5.65	5.83	6.01	6.19	6.37
8	2.42	2.59	2.75	2.92	3.08	3.25	3.41	3.58	3.75	3.91	4.08	4.24	4.41	4.58	4.74	4.91	5.07	5.24	5.41	5.57	5.74	5.90
9	2.26	2.42	2.57	2.73	2.88	3.04	3.19	3.35	3.50	3.66	3.81	3.97	4.13	4.28	4.44	4.59	4.75	4.90	5.06	5.21	5.37	5.52
10	2.13	2.28	2.42	2.57	2.72	2.86	3.01	3.16	3.30	3.45	3.59	3.74	3.89	4.03	4.18	4.32	4.47	4.62	4.76	4.91	5.06	5.20
11	2.02	2.16	2.30	2.44	2.57	2.71	2.85	2.99	3.13	3.27	3.40	3.54	3.68	3.82	3.96	4.10	4.24	4.37	4.51	4.65	4.79	4.93
12	1.92	2.05	2.19	2.32	2.45	2.58	2.71	2.85	2.98	3.11	3.24	3.37	3.50	3.64	3.77	3.90	4.03	4.16	4.30	4.43	4.56	4.69
13	1.84	1.96	2.09	2.21	2.34	2.47	2.59	2.72	2.84	2.97	3.10	3.22	3.35	3.47	3.60	3.73	3.85	3.98	4.10	4.23	4.36	4.48
14	1.76	1.88	2.00	2.12	2.24	2.37	2.49	2.61	2.73	2.85	2.97	3.09	3.21	3.33	3.45	3.57	3.69	3.81	3.94	4.06	4.18	4.30
15	1.69	1.81	1.93	2.04	2.16	2.27	2.39	2.51	2.62	2.74	2.86	2.97	3.09	3.20	3.32	3.44	3.55	3.67	3.78	3.90	4.02	4.13
16	1.63	1.74	1.86	1.97	2.08	2.19	2.30	2.42	2.53	2.64	2.75	2.86	2.98	3.09	3.20	3.31	3.42	3.54	3.65	3.76	3.87	3.98
17	1.58	1.69	1.79	1.90	2.01	2.12	2.23	2.34	2.44	2.55	2.66	2.77	2.88	2.98	3.09	3.20	3.31	3.42	3.53	3.63	3.74	3.85
18	1.53	1.63	1.74	1.84	1.95	2.05	2.16	2.26	2.37	2.47	2.57	2.68	2.78	2.89	2.99	3.10	3.20	3.31	3.41	3.52	3.62	3.73
19	1.48	1.58	1.68	1.79	1.89	1.99	2.09	2.19	2.29	2.40	2.50	2.60	2.70	2.80	2.90	3.00	3.11	3.21	3.31	3.41	3.51	3.61
20	1.44	1.54	1.64	1.73	1.83	1.93	2.03	2.13	2.23	2.33	2.43	2.52	2.62	2.72	2.82	2.92	3.02	3.12	3.21	3.31	3.41	3.51
21	1.40	1.50	1.59	1.69	1.78	1.88	1.98	2.07	2.17	2.26	2.36	2.46	2.55	2.65	2.74	2.84	2.94	3.03	3.13	3.22	3.32	3.41
22	1.36	1.46	1.55	1.64	1.74	1.83	1.92	2.02	2.11	2.20	2.30	2.39	2.48	2.58	2.67	2.77	2.86	2.95	3.05	3.14	3.23	3.33
23	1.33	1.42	1.51	1.60	1.69	1.78	1.88	1.97	2.06	2.15	2.24	2.33	2.42	2.51	2.61	2.70	2.79	2.88	2.97	3.06	3.15	3.24
24	1.30	1.39	1.48	1.56	1.65	1.74	1.83	1.92	2.01	2.10	2.19	2.28	2.37	2.45	2.54	2.63	2.72	2.81	2.90	2.99	3.08	3.17
25	1.27	1.35	1.44	1.53	1.62	1.70	1.79	1.88	1.96	2.05	2.14	2.22	2.31	2.40	2.48	2.57	2.66	2.75	2.83	2.92	3.01	3.09
26	1.24	1.32	1.41	1.50	1.58	1.67	1.75	1.84	1.92	2.01	2.09	2.18	2.26	2.35	2.43	2.52	2.60	2.69	2.77	2.86	2.94	3.03
27	1.21	1.30	1.38	1.46	1.55	1.63	1.71	1.80	1.88	1.96	2.05	2.13	2.21	2.30	2.38	2.46	2.55	2.63	2.71	2.79	2.88	2.96
28	1.19	1.27	1.35	1.43	1.52	1.60	1.68	1.76	1.84	1.92	2.00	2.09	2.17	2.25	2.33	2.41	2.49	2.57	2.66	2.74	2.82	2.90
29	1.17	1.25	1.33	1.41	1.49	1.57	1.64	1.72	1.80	1.88	1.96	2.04	2.12	2.20	2.28	2.36	2.44	2.52	2.60	2.68	2.76	2.84
30	1.14	1.22	1.30	1.38	1.46	1.54	1.61	1.69	1.77	1.85	1.93	2.01	2.08	2.16	2.24	2.32	2.40	2.48	2.55	2.63	2.71	2.79
31	1.12	1.20	1.28	1.35	1.43	1.51	1.58	1.66	1.74	1.81	1.89	1.97	2.05	2.12	2.20	2.28	2.35	2.43	2.51	2.58	2.66	2.74
32	1.10	1.18	1.25	1.33	1.40	1.48	1.56	1.63	1.71	1.78	1.86	1.93	2.01	2.08	2.16	2.24	2.31	2.39	2.46	2.54	2.61	2.69
33	1.08	1.16	1.23	1.31	1.38	1.45	1.53	1.60	1.68	1.75	1.83	1.90	1.97	2.05	2.12	2.20	2.27	2.35	2.42	2.49	2.57	2.64
34	1.06	1.14	1.21	1.28	1.36	1.43	1.50	1.58	1.65	1.72	1.80	1.87	1.94	2.01	2.09	2.16	2.23	2.31	2.38	2.45	2.53	2.60
35	1.05	1.12	1.19	1.26	1.33	1.41	1.48	1.55	1.62	1.69	1.77	1.84	1.91	1.98	2.05	2.13	2.20	2.27	2.34	2.41	2.48	2.56
36	1.03	1.10	1.17	1.24	1.31	1.38	1.46	1.53	1.60	1.67	1.74	1.81	1.88	1.95	2.02	2.09	2.16	2.23	2.30	2.37	2.44	2.52
37	1.02	1.08	1.15	1.22	1.29	1.36	1.43	1.50	1.57	1.64	1.71	1.78	1.85	1.92	1.99	2.06	2.13	2.20	2.27	2.34	2.41	2.48
38	1.00	1.07	1.14	1.21	1.27	1.34	1.41	1.48	1.55	1.62	1.69	1.75	1.82	1.89	1.96	2.03	2.10	2.17	2.23	2.30	2.37	2.44
39	0.99	1.05	1.12	1.19	1.26	1.32	1.39	1.46	1.53	1.59	1.66	1.73	1.80	1.86	1.93	2.00	2.07	2.13	2.20	2.27	2.34	2.40
40	0.97	1.04	1.10	1.17	1.24	1.30	1.37	1.44	1.50	1.57	1.64	1.70	1.77	1.84	1.90	1.97	2.04	2.10	2.17	2.24	2.30	2.37
41	0.96	1.02	1.09	1.15	1.22	1.29	1.35	1.42	1.48	1.55	1.61	1.68	1.75	1.81	1.88	1.94	2.01	2.07	2.14	2.21	2.27	2.34
42	0.94	1.01	1.07	1.14	1.20	1.27	1.33	1.40	1.46	1.53	1.59	1.66	1.72	1.79	1.85	1.92	1.98	2.05	2.11	2.18	2.24	2.30
43	0.93	1.00	1.06	1.12	1.19	1.25	1.32	1.38	1.44	1.51	1.57	1.64	1.70	1.76	1.83	1.89	1.95	2.02	2.08	2.15	2.21	2.27
44	0.92	0.98	1.05	1.11	1.17	1.24	1.30	1.36	1.42	1.49	1.55	1.61	1.68	1.74	1.80	1.87	1.93	1.99	2.06	2.12	2.18	2.24
45	0.91	0.97	1.03	1.10	1.16	1.22	1.28	1.34	1.41	1.47	1.53	1.59	1.66	1.72	1.78	1.84	1.91	1.97	2.03	2.09	2.15	2.22
46	0.90	0.96	1.02	1.08	1.14	1.20	1.27	1.33	1.39	1.45	1.51	1.57	1.64	1.70	1.76	1.82	1.88	1.94	2.00	2.07	2.13	2.19
47	0.89	0.95	1.01	1.07	1.13	1.19	1.25	1.31	1.37	1.43	1.49	1.55	1.62	1.68	1.74	1.80	1.86	1.92	1.98	2.04	2.10	2.16
48	0.88	0.94	1.00	1.06	1.12	1.18	1.24	1.30	1.36	1.42	1.48	1.54	1.60	1.66	1.72	1.78	1.84	1.90	1.96	2.02	2.08	2.14
49	0.87	0.92	0.98	1.04	1.10	1.16	1.22	1.28	1.34	1.40	1.46	1.52	1.58	1.64	1.70	1.76	1.82	1.87	1.93	1.99	2.05	2.11
50	0.86	0.91	0.97	1.03	1.09	1.15	1.21	1.27	1.33	1.38	1.44	1.50	1.56	1.62	1.68	1.74	1.79	1.85	1.91	1.97	2.03	2.09
51	0.85	0.90	0.96	1.02	1.08	1.14	1.19	1.25	1.31	1.37	1.43	1.48	1.54	1.60	1.66	1.72	1.77	1.83	1.89	1.95	2.01	2.06
52	0.84	0.89	0.95	1.01	1.07	1.12	1.18	1.24	1.30	1.35	1.41	1.47	1.53	1.58	1.64	1.70	1.76	1.81	1.87	1.93	1.98	2.04
53	0.83	0.88	0.94	1.00	1.06	1.11	1.17	1.23	1.28	1.34	1.40	1.45	1.51	1.57	1.62	1.68	1.74	1.79	1.85	1.91	1.96	2.02
54	0.82	0.88	0.93	0.99	1.04	1.10	1.16	1.21	1.27	1.32	1.38	1.44	1.49	1.55	1.61	1.66	1.72	1.77	1.83	1.89	1.94	2.00
55	0.81	0.87	0.92	0.98	1.03	1.09	1.14	1.20	1.26	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.70	1.76	1.81	1.87	1.92	1.98
56	0.80	0.86	0.91	0.97	1.02	1.08	1.13	1.19	1.24	1.30	1.35	1.41	1.46	1.52	1.57	1.63	1.68	1.74	1.79	1.85	1.90	1.96
57	0.79	0.85	0.90	0.96	1.01	1.07	1.12	1.18	1.23	1.28	1.34	1.39	1.45	1.50	1.56	1.61	1.67	1.72	1.78	1.83	1.88	1.94
58	0.79	0.84	0.89	0.95	1.00	1.06	1.11	1.16	1.22	1.27	1.33	1.38	1.43	1.49	1.54	1.60	1.65	1.70	1.76	1.81	1.87	1.92
59	0.78	0.83	0.89	0.94	0.99	1.05	1.10	1.15	1.21	1.26	1.31	1.37	1.42	1.47	1.53	1.58	1.63	1.69	1.74	1.79	1.85	1.90
60	0.77	0.82	0.88	0.93	0.98	1.04	1.09	1.14	1.19	1.25	1.30	1.35	1.41	1.46	1.51	1.57	1.62	1.67	1.72	1.78	1.83	1.88

Rainfall Intensity – 100 Year Storm

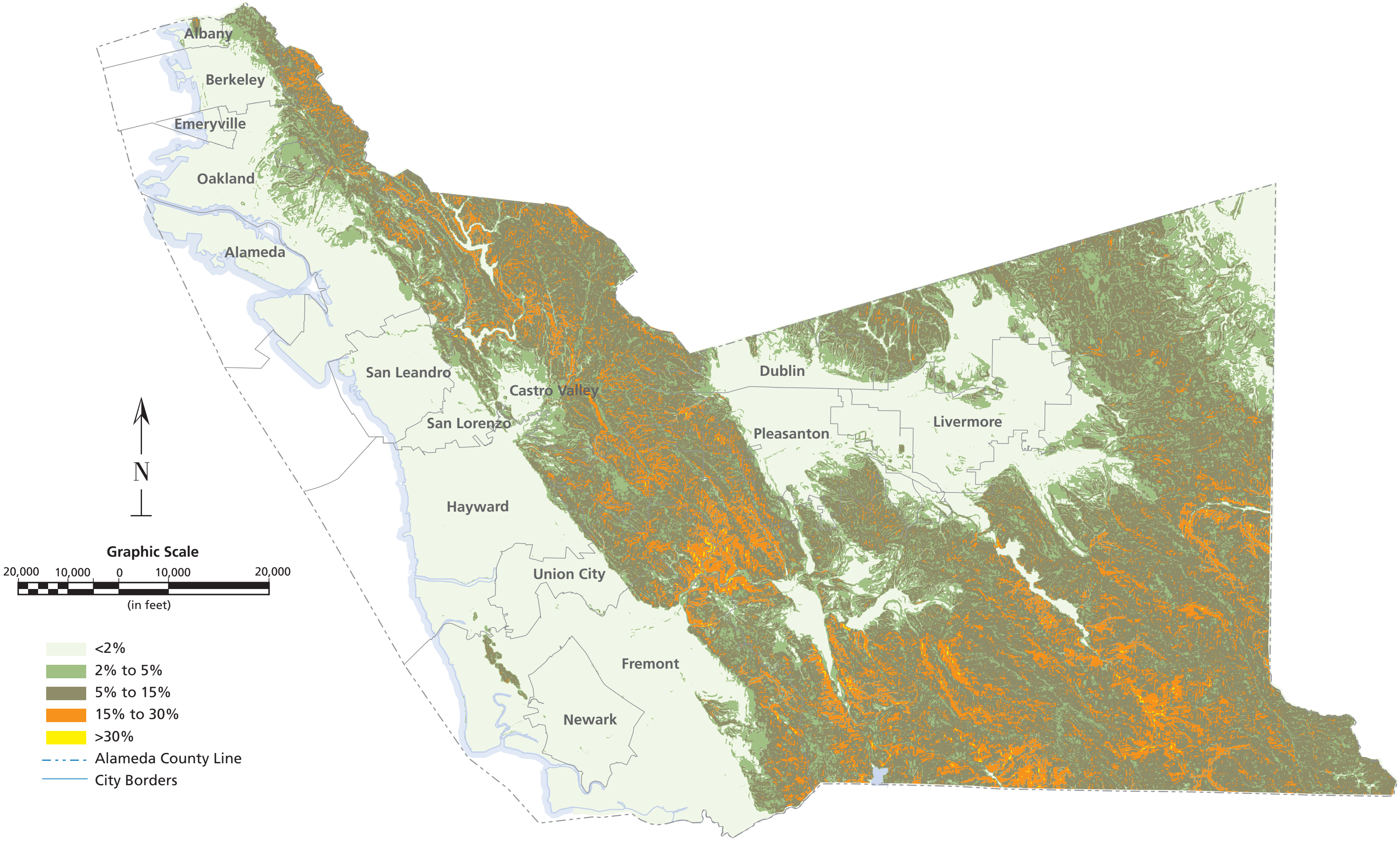
(inches/hour)



Attachment 9 available for download in GIS file from the Alameda County Flood Control District website.

(NRCS 2015) and (District 2015)

Flood Control & Water Conservation District	Alameda County Hydrology & Hydraulics Manual 2016 Hydrologic Soil Groups	Attachment 9



Attachment 10 available for download as a GIS file from the Alameda County Flood Control District website.

(District 2015)

Flood Control & Water Conservation District	Alameda County Hydrology & Hydraulics Manual 2016 Slope	Attachment 10

Rational Method (Rantz 1971*)

*Rantz, S.E. 1971. *Suggested Criteria for Hydrologic Design of Storm Drainage Facilities in the San Francisco Bay Region, CA*. U.S. Geological Survey Open-File Report, Menlo Park, CA.

Q= CiA
where C= runoff coeff.;
i= rainfall intensity at duration equal to Tc;
A= drainage area, ac.

Watershed Areas										
	A	B	C	D	E	F	G	H	I	J
Sq Ft	102,189.7	25,984.9	10,730.1	50,480.9	47,700.4	141,259.3	101,045.8	98,928.7	106,217.6	105,749.2
Sq Miles	0.0037	0.0009	0.0004	0.0018	0.0017	0.0051	0.0036	0.0035	0.0038	0.0038
Acres	2.35	0.60	0.25	1.16	1.10	3.24	2.32	2.27	2.44	2.43

For Watershed A

Area 2.35 Acres

a)Computing Time of Concentration

Overland flow = 430 ft slope = 0.43 %

@Q2	35 minutes	for C =0.325	From Fig 6 (Rantz1971)
@Q10	27 minutes	for C= 0.40	
@25	25 minutes	for C= 0.52	
@Q100	21 minutes	for C =0.61	

Time of concentration Tc=

@Q2	35 minutes
@Q10	27 minutes
@25	25 minutes
@Q100	21 minutes

b)Runoff Coeff., C

Per Table 1 - impervious area for high end of medium density residential is 40% (Upper end of Med. Residential, or low end of Heavy Urbanization (apartments))

2 yr recurrence interval, C	**0.45**
10 yr recurrence interval, C	**0.55**
25 yr recurrence interval, C	**0.7**
100 yr recurrence interval, C	**0.76**

c) Precipitation Intensity, i MAP from Alameda Cty C3 22 inches

	Depth		
2 yr	0.41 inch	**0.70 inches per hour**	From Table 4(Rantz 1971)
10 yr	0.57 inch	**1.27 inches per hour**	
25 yr	0.65 inch	**1.56 inches per hour**	
100 yr	0.67 inch	**1.91 inches per hour**	

Therefore,

Q2	**0.74**	**cfs**
Q10	**1.63**	**cfs**
Q25	**2.56**	**cfs**
Q100	**3.41**	**cfs**

For Watershed B

Length 394.65 feet
Slope 0.01 % *Google earth elev change from 68 ft @ Curtis & Delaware to 66 ft at hearst & curtis
Area 0.60 Acres

a)Computing Time of Concentration

Overland flow = 50 ft slope = 2%

@Q2	7.5 minutes	for C =0.325	From Fig 6 (Rantz1971)
@Q10	7 minutes	for C= 0.40	
@25	6 minutes	for C= 0.52	
@Q100	5 minutes	for C =0.61	

Open channel flow (gutter flow) 394.653 slope 0.01 %

Channel Travel time V= (1.49/n)*((A/WP)^(2/3))*S^(1/2)
Area of gutter flow from CAD 0.39 Sq ft
Wetted perimeter 2.87 ft

V 2.16 ft per second
therefore Channel travel time = L/(60V) 3.04 Minutes

Time of concentration Tc= Toverlandflow+ Tchnnelflow

10.54	minutes	for C as0.325	Q2
10.04	minutes	for C as0.40	Q10
9.04	minutes	for C as0.52	Q25
8.04	minutes	for C as0.61	Q100

b)Runoff Coeff., C

Per Table 1 - impervious area for medium density residential is 25%

2 yr recurrence interval, C	**0.325**
10 yr recurrence interval, C	**0.4**
25 yr recurrence interval, C	**0.52**
100 yr recurrence interval, C	**0.61**

c) Precipitation Intensity, i MAP from Alameda Cty C3 22 inches

	Depth		
2 yr	0.23 inch	**1.32 inches per hour**	From Table 4(Rantz 1971)
10 yr	0.34 inch	**2.04 inches per hour**	
25 yr	0.52 inch	**3.44 inches per hour**	
100 yr	0.57 inch	**4.21 inches per hour**	

Therefore,

Q2	**0.26**	**cfs**
Q10	**0.49**	**cfs**
Q25	**1.07**	**cfs**
Q100	**1.53**	**cfs**

For Watershed C

Length	253.91 feet	
Slope	2.36 %	*Google earth elev change from 66 ft to 60 ft
Area	0.25 Acres	

a)Computing Time of Concentration

Overland flow =		50 ft	slope =		2%	
	@Q2		7.5 minutes	for C =0.325		From Fig 6 (Rantz1971)
	@Q10		7 minutes	for C= 0.40		
	@25		6 minutes	for C= 0.52		
	@Q100		5 minutes	for C =0.61		

Open channel flow (gutter flow) 253.91 slope 0.02 %

Channel Travel time V= (1.49/n)*((A/WP)^(2/3))*S^(1/2)
Area of gutter flow from CAD 0.39 Sq ft
Wetted perimeter 2.87 ft

V 4.67 ft per second
therfore Channel travel time = L/(60V) 0.91 Minutes

Time of concentration Tc= Toverlandflow+ Tchnnelflow

8.41	minutes	for C as0.325	Q2
7.91	minutes	for C as0.40	Q10
6.91	minutes	for C as0.52	Q25
5.91	minutes	for C as0.61	Q100

b)Runoff Coeff., C

Per Table 1 - impervious area for medium density residential is 25%

2 yr recurrence interval, C	**0.325**
10 yr recurrence interval, C	**0.4**
25 yr recurrence interval, C	**0.52**
100 yr recurrence interval, C	**0.61**

c) Precipitation Intensity, i MAP from Alameda Cty C3 22 inches

	Depth		
2 yr	0.12 inch	**0.86 inches per hour**	From Table 4(Rantz 1971)
10 yr	0.292 inch	**2.22 inches per hour**	
25 yr	0.313 inch	**2.72 inches per hour**	
100 yr	0.328 inch	**3.33 inches per hour**	

Therefore,

Q2	**0.07**	cfs
Q10	**0.22**	cfs
Q25	**0.35**	cfs
Q100	**0.50**	cfs

For Watershed D

Length	395.81 feet	
Slope	0.01 %	*Google earth elev change from 68 ft @ Curtis & Delaware to 66 ft at hearst & curtis
Area	1.16 Acres	

a)Computing Time of Concentration

Overland flow =		50 ft	slope =		2%	
	@Q2		7.5 minutes	for C =0.325		From Fig 6 (Rantz1971)
	@Q10		7 minutes	for C= 0.40		
	@25		6 minutes	for C= 0.52		
	@Q100		5 minutes	for C =0.61		

Open channel flow (gutter flow) 395.81 slope 0.01 %

Channel Travel time V= (1.49/n)*((A/WP)^(2/3))*S^(1/2)
Area of gutter flow from CAD 0.39 Sq ft
Wetted perimeter 2.87 ft

V 2.16 ft per second
therefore Channel travel time = L/(60V) 3.06 Minutes

Time of concentration Tc= Toverlandflow+ Tchnnelflow

10.56	minutes	for C as0.325	Q2
10.06	minutes	for C as0.40	Q10
9.06	minutes	for C as0.52	Q25
8.06	minutes	for C as0.61	Q100

b)Runoff Coeff., C

Per Table 1 - impervious area for medium density residential is 25%

2 yr recurrence interval, C	**0.325**
10 yr recurrence interval, C	**0.4**
25 yr recurrence interval, C	**0.52**
100 yr recurrence interval, C	**0.61**

c) Precipitation Intensity, i MAP from Alameda Cty C3 22 inches

	Depth		
2 yr	0.23 inch	**1.32 inches per hour**	From Table 4(Rantz 1971)
10 yr	0.34 inch	**2.03 inches per hour**	
25 yr	0.37 inch	**2.48 inches per hour**	
100 yr	0.40 inch	**2.98 inches per hour**	

Therefore,

Q2	**0.50**	cfs
Q10	**0.94**	cfs
Q25	**1.50**	cfs
Q100	**2.10**	cfs

For Watershed E

Length	405.78	feet
Slope	0.02	%
Area	1.10	Acres

*Google earth elev change from 74 ft @Chestnut and Hearst to 66 ft at hearst & curtis

a)Computing Time of Concentration

Overland flow = 50 ft, slope = 2%

@Q2	7.5 minutes	for C =0.325	From Fig 6 (Rantz1971)
@Q10	7 minutes	for C= 0.40	
@25	6 minutes	for C= 0.52	
@Q100	5 minutes	for C =0.61	

Open channel flow (gutter flow) 405.783, slope 0.02 %

Channel Travel time: V= (1.49/n)*((A/WP)^(2/3))*S^(1/2)
Area of gutter flow from CAD 0.39 Sq ft
Wetted perimeter 2.87 ft

V 4.26 ft per second
therefore Channel travel time = L/(60V) 1.59 Minutes

Time of concentration Tc= Toverlandflow+ Tchnnelflow

9.09	minutes	for C as0.325	Q2
8.59	minutes	for C as0.40	Q10
7.59	minutes	for C as0.52	Q25
6.59	minutes	for C as0.61	Q100

b)Runoff Coeff., C

Per Table 1 - impervious area for medium density residential is 25%

2 yr recurrence interval, C	**0.325**
10 yr recurrence interval, C	**0.4**
25 yr recurrence interval, C	**0.52**
100 yr recurrence interval, C	**0.61**

c) Precipitation Intensity, i MAP from Alameda Cty C3= 22 inches

	Depth		
2 yr	0.21 inch	**1.39 inches per hour**	From Table 4(Rantz 1971)
10 yr	0.31 inch	**2.15 inches per hour**	
25 yr	0.33 inch	**2.63 inches per hour**	
100 yr	0.35 inch	**3.20 inches per hour**	

Therefore,

Q2	**0.50**	**cfs**
Q10	**0.94**	**cfs**
Q25	**1.50**	**cfs**
Q100	**2.13**	**cfs**

For Watersheds F,G,H,I & J

Total Area	**12.70**	**Acres**
Longest path	2,120.20	feet
Slope	1.98	%

a)Computing Time of Concentration

Overland flow = 50 ft, slope = 2%

@Q2	7.5 minutes	for C =0.325	From Fig 6 (Rantz1971)
@Q10	7 minutes	for C= 0.40	
@25	6 minutes	for C= 0.52	
@Q100	5 minutes	for C =0.61	

Open channel flow (gutter flow) 2,120.20 ft, slope 0.02

Channel Travel time: V= (1.49/n)*((A/WP)^(2/3))*S^(1/2)
Area of gutter flow from CAD 0.3913 Sq ft
Wetted perimeter 2.8705 ft

Watershed J, Tc1 (elev change from Sac and Delaware to Short & Hearst = 116 to 98ft)	V	4.849458276 ft per second
	Channel travel time =	2.424360137 Minutes
Watershed I, Tc2 (elev change = 98 to 92ft)	V	4.063458531 ft per second
	Channel travel time =	1.373624617 Minutes
Watershed H, Tc3 (elev change = 92 to 86ft)	V	4.124376277 ft per second
	Channel travel time =	1.313653177 Minutes
Watershed G, Tc4 (elev change = 86 to 81ft)	V	3.841120033 ft per second
	Channel travel time =	1.35519153 Minutes
Watershed F, Tc4 (elev change =81 to 74ft)	V	3.838429429 ft per second
	Channel travel time =	1.901260694 Minutes

Total time of concentration to reach c	**15.87 minutes**	**Q2**
	15.37 minutes	**Q10**
	14.37 minutes	**Q25**
	13.37 minutes	**Q100**

b)Runoff Coeff., C

Per Table 1 - impervious area for medium density residential is 25%

2 yr recurrence interval, C	**0.33**
10 yr recurrence interval, C	**0.40**
25 yr recurrence interval, C	**0.49**
100 yr recurrence interval, C	**0.61**

Precipitation Intensity MAP from Alameda Cty C3 22 inches

	Depth		
2 yr	0.29 inch	**1.08 inches per hour**	From Table 4(Rantz 1971)
10 yr	0.44 inch	**1.70 inches per hour**	
25 yr	0.52 inch	**2.16 inches per hour**	
100 yr	0.55 inch	**2.46 inches per hour**	

Therefore,

Q2	**4.47**	**cfs**
Q10	**8.65**	**cfs**
Q25	**13.50**	**cfs**
Q100	**19.04**	**cfs**

Rational Method (Rantz 1971*)

*Rantz, S.E. 1971. *Suggested Criteria for Hydrologic Design of Storm Drainage Facilities in the San Francisco Bay Region, CA*. U.S. Geological Survey Open-File Report, Menlo Park, CA.

Q= CiA
where C= runoff coeff.;
i= rainfall intensity at duration equal to Tc;
A= drainage area, ac.

Watershed Areas

	A	B	C	D	E	F	G	H	I	J
Sq Ft	102,189.7	25,984.9	10,730.1	50,480.9	47,700.4	141,259.3	101,045.8	98,928.7	106,217.6	105,749.2
Sq Miles	0.0037	0.0009	0.0004	0.0018	0.0017	0.0051	0.0036	0.0035	0.0038	0.0038
Acres	2.35	0.60	0.25	1.16	1.10	3.24	2.32	2.27	2.44	2.43
Roadway	0	9875	6900	9850	10375	20600	31175	28925	30450	29725
Roadway acres	0	0.23	0.16	0.23	0.24	0.47	0.72	0.66	0.70	0.68
%roadway	0	0.38	0.64	0.20	0.22	0.15	0.31	0.29	0.29	0.28

For Watershed D

Length 395.81 feet
Slope 0.01 % — *Google earth elev change from 68 ft @ Curtis & Delaware to 66 ft at hearst & curtis
Area 1.16 Acres
Roadway 0.23 Acres

a)Computing Time of Concentration

Overland flow = 50 ft slope = 2%

@Q2	7.5 minutes	for C =0.325	From Fig 6 (Rantz1971)
@Q10	7 minutes	for C= 0.40	
@25	6 minutes	for C= 0.52	
@Q100	5 minutes	for C =0.61	

Open channel flow (gutter flow) 395.81 slope 0.01 %

Channel Travel time V= (1.49/n)*((A/WP)^(2/3))*S^(1/2)
Area of gutter flow from CAD 0.39 Sq ft
Wetted perimeter 2.87 ft

V 2.16 ft per second
therefore Channel travel time = L/(60V) 3.06 Minutes

Time of concentration Tc= Toverlandflow+ Tchnnelflow

10.56	minutes	for C as0.325	Q2
10.06	minutes	for C as0.40	Q10
9.06	minutes	for C as0.52	Q25
8.06	minutes	for C as0.61	Q100

b)Runoff Coeff., C

Per Table 1 - impervious area for medium density residential is 25%

2 yr recurrence interval, C	**0.325**
10 yr recurrence interval, C	**0.4**
25 yr recurrence interval, C	**0.52**
100 yr recurrence interval, C	**0.61**

Roadway, Per figure 6

2 yr recurrence interval, C	0.6
10 yr recurrence interval, C	0.75
25 yr recurrence interval, C	0.9
100 yr recurrence interval, C	0.95

Caculating Composite C

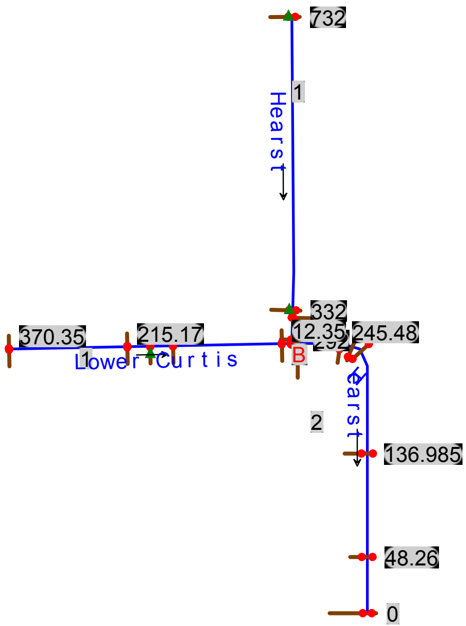
2 yr recurrence interval, C	**0.38**
10 yr recurrence interval, C	**0.47**
25 yr recurrence interval, C	**0.59**
100 yr recurrence interval, C	**0.68**

c) Precipitation Intensity, i MAP from Alameda Cty C3 22 inches

	Depth		
2 yr	0.23 inch	**1.32 inches per hour**	From Table 4(Rantz 1971)
10 yr	0.34 inch	**2.03 inches per hour**	
25 yr	0.37 inch	**2.48 inches per hour**	
100 yr	0.40 inch	**2.98 inches per hour**	

Therefore,

Q2		**0.58**	**cfs**
Q10		**1.10**	**cfs**
Q25		**1.71**	**cfs**
Q100		**2.33**	**cfs**



None of the XS's are Geo-Referenced (Geo-Ref user entered XS Geo-Ref interpolated XS Non Geo-Ref user entered XS Non Geo-Ref interpolated XS)

HEC-RAS Plan: Plan 03

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Hearst	2	0	Q2	12.24	52.13	52.68	52.90	53.46	0.030056	7.21	1.83	7.25	2.43
Hearst	2	0	Q10	21.71	52.13	52.82	53.09	53.76	0.024963	7.97	3.03	9.50	2.27
Hearst	2	0	Q25	26.75	52.13	52.88	53.18	53.89	0.023264	8.34	3.63	10.41	2.21
Hearst	2	0	Q100	33.98	52.13	52.96	53.26	54.06	0.021921	8.80	4.49	11.97	2.15
Hearst	2	48.26	Q2	11.91	53.55	54.06	54.23	54.72	0.022422	6.78	2.37	16.18	2.35
Hearst	2	48.26	Q10	21.14	53.55	54.15	54.34	54.95	0.024231	7.87	3.85	17.22	2.52
Hearst	2	48.26	Q25	26.06	53.55	54.19	54.41	55.06	0.024784	8.30	4.51	17.67	2.57
Hearst	2	48.26	Q100	33.12	53.55	54.23	54.49	55.24	0.026822	9.02	5.26	18.16	2.71
Hearst	2	136.985	Q2	11.91	56.28	56.70	56.93	57.78	0.053615	8.38	1.49	8.99	3.21
Hearst	2	136.985	Q10	21.14	56.28	56.80	57.07	58.05	0.048694	9.19	2.68	14.05	3.15
Hearst	2	136.985	Q25	26.06	56.28	56.84	57.15	58.21	0.048831	9.70	3.24	16.28	3.19
Hearst	2	136.985	Q100	33.12	56.28	56.90	57.22	58.31	0.042422	10.03	4.19	18.12	3.02
Hearst	2	225.71	Q2	11.91	58.17	58.64	58.64	58.76	0.004052	2.78	4.29	18.14	1.01
Hearst	2	225.71	Q10	21.14	58.17	58.76	58.76	58.92	0.003390	3.24	6.84	24.58	0.98
Hearst	2	225.71	Q25	26.06	58.17	58.82	58.82	58.99	0.002829	3.31	8.47	27.00	0.92
Hearst	2	225.71	Q100	33.12	58.17	58.88	58.88	59.07	0.002821	3.61	10.00	27.00	0.94
Hearst	2	234.6	Q2	11.91	57.91	58.76	58.43	58.78	0.000227	1.13	11.29	27.00	0.27
Hearst	2	234.6	Q10	21.14	57.91	58.91	58.56	58.94	0.000299	1.52	15.19	27.00	0.33
Hearst	2	234.6	Q25	26.06	57.91	58.96	58.62	59.01	0.000335	1.71	16.79	27.00	0.35
Hearst	2	234.6	Q100	33.12	57.91	59.04	58.69	59.09	0.000381	1.94	18.82	27.00	0.38
Hearst	2	245.48	Q2	11.91	58.14	58.69	58.73	58.86	0.004234	3.39	4.45	23.08	1.06
Hearst	2	245.48	Q10	21.14	58.14	58.85	58.85	59.02	0.002847	3.61	8.21	26.13	0.93
Hearst	2	245.48	Q25	26.06	58.14	58.91	58.91	59.09	0.002572	3.74	9.94	27.00	0.90
Hearst	2	245.48	Q100	33.12	58.14	58.98	58.98	59.18	0.002632	4.08	11.66	27.00	0.93
Hearst	2	282	Q2	11.91	58.43	58.92	58.92	59.00	0.002916	2.68	7.39	39.00	0.80
Hearst	2	282	Q10	21.14	58.43	59.04	59.00	59.12	0.002465	2.90	11.90	39.00	0.75
Hearst	2	282	Q25	26.06	58.43	59.10	59.03	59.19	0.002197	2.92	14.28	39.00	0.71
Hearst	2	282	Q100	33.12	58.43	59.19	59.08	59.27	0.001875	2.93	17.67	39.00	0.66
Hearst	1	292	Q2	11.26	58.51	59.00	58.73	59.01	0.000172	0.92	13.16	30.00	0.23
Hearst	1	292	Q10	20.01	58.51	59.11	58.81	59.14	0.000260	1.30	16.49	30.00	0.30
Hearst	1	292	Q25	24.66	58.51	59.17	58.84	59.20	0.000289	1.45	18.15	30.00	0.32
Hearst	1	292	Q100	31.36	58.51	59.25	58.89	59.28	0.000311	1.63	20.54	30.00	0.34
Hearst	1	322	Q2	11.26	59.10	59.26	59.38	59.71	0.041180	6.43	2.12	19.60	2.97
Hearst	1	322	Q10	20.01	59.10	59.32	59.47	59.93	0.039312	7.70	3.23	22.86	3.05
Hearst	1	322	Q25	24.66	59.10	59.38	59.50	59.80	0.019140	6.48	4.82	26.49	2.23
Hearst	1	322	Q100	31.36	59.10	59.30	59.55	61.10	0.122864	13.08	2.97	22.13	5.34
Hearst	1	332	Q2	9.08	59.26	59.60	59.71	60.00	0.019001	5.10	1.84	24.10	1.95
Hearst	1	332	Q10	16.10	59.26	59.68	59.77	60.23	0.019032	6.13	2.87	36.10	2.01
Hearst	1	332	Q25	19.79	59.26	59.80	59.80	59.92	0.003747	3.33	9.82	39.00	0.91
Hearst	1	332	Q100	25.17	59.26	59.59	59.85	63.00	0.171058	14.88	1.74	22.50	5.82
Hearst	1	732	Q2	9.08	67.24	67.57	67.69	67.99	0.021020	5.23	1.79	23.10	2.04
Hearst	1	732	Q10	16.10	67.24	67.65	67.75	68.23	0.021031	6.31	2.78	35.24	2.11
Hearst	1	732	Q25	19.79	67.24	67.68	67.78	68.33	0.021028	6.70	3.23	38.72	2.12
Hearst	1	732	Q100	25.17	67.24	67.83	67.83	67.96	0.003828	3.55	11.53	39.20	0.93
Lower Curtis	1	12.35	Q2	0.65	57.39	59.01		59.01	0.000000	0.02	36.22	40.00	0.00
Lower Curtis	1	12.35	Q10	1.13	57.39	59.13		59.13	0.000000	0.04	41.12	40.00	0.01
Lower Curtis	1	12.35	Q25	1.40	57.39	59.19		59.19	0.000000	0.04	43.60	40.00	0.01
Lower Curtis	1	12.35	Q100	1.76	57.39	59.28		59.28	0.000000	0.05	47.11	40.00	0.01
Lower Curtis	1	155.17	Q2	0.32	58.49	59.01		59.01	0.000037	0.26	2.01	12.54	0.07
Lower Curtis	1	155.17	Q10	0.56	58.49	59.13		59.13	0.000024	0.23	3.86	18.32	0.06
Lower Curtis	1	155.17	Q25	0.70	58.49	59.19		59.20	0.000020	0.22	5.12	22.13	0.05
Lower Curtis	1	155.17	Q100	0.88	58.49	59.28		59.28	0.000014	0.20	7.30	27.56	0.04
Lower Curtis	1	185.17	Q2	0.32	58.69	59.01	58.84	59.01	0.000023	0.19	3.91	24.80	0.07
Lower Curtis	1	185.17	Q10	0.56	58.69	59.13	58.87	59.13	0.000011	0.18	7.03	26.25	0.05
Lower Curtis	1	185.17	Q25	0.70	58.69	59.20	58.89	59.20	0.000009	0.18	8.68	26.99	0.05
Lower Curtis	1	185.17	Q100	0.88	58.69	59.28	58.91	59.28	0.000006	0.17	11.09	28.03	0.04
Lower Curtis	1	215.17	Q2	0.00	58.88	59.01	58.90	59.01	0.000000	0.01	0.04	0.46	0.01
Lower Curtis	1	215.17	Q10	0.00	58.88	59.13	58.90	59.13	0.000000	0.01	0.17	1.82	0.00
Lower Curtis	1	215.17	Q25	0.00	58.88	59.20	58.91	59.20	0.000000	0.01	0.33	3.75	0.00
Lower Curtis	1	215.17	Q100	0.00	58.88	59.28	58.92	59.28	0.000000	0.01	0.83	7.63	0.00
Lower Curtis	1	370.35	Q2	0.00	59.76	59.78	59.78	59.78	0.005005	0.38	0.00	0.15	0.65
Lower Curtis	1	370.35	Q10	0.00	59.76	59.78	59.78	59.79	0.016275	0.71	0.00	0.15	1.18

HEC-RAS Plan: Plan 03 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Lower Curtis	1	370.35	Q25	0.00	59.76	59.79	59.79	59.80	0.012646	0.79	0.00	0.22	1.10
Lower Curtis	1	370.35	Q100	0.00	59.76	59.80	59.80	59.81	0.010047	0.79	0.00	0.26	1.01

Plan: Plan 03 Hearst 1 RS: 732 Profile: Q2

E.G. Elev (ft)	67.99	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.42	Wt. n-Val.	0.013	0.013	
W.S. Elev (ft)	67.57	Reach Len. (ft)	400.00	400.00	400.00
Crit W.S. (ft)	67.69	Flow Area (sq ft)	0.07	1.72	
E.G. Slope (ft/ft)	0.021020	Area (sq ft)	0.07	1.72	0.72
Q Total (cfs)	9.08	Flow (cfs)	0.10	8.98	
Top Width (ft)	23.10	Top Width (ft)	2.62	8.46	12.02
Vel Total (ft/s)	5.08	Avg. Vel. (ft/s)	1.48	5.23	
Max Chl Dpth (ft)	0.33	Hydr. Depth (ft)	0.03	0.20	
Conv. Total (cfs)	62.6	Conv. (cfs)	0.7	61.9	
Length Wtd. (ft)	400.00	Wetted Per. (ft)	2.62	9.69	
Min Ch El (ft)	67.24	Shear (lb/sq ft)	0.03	0.23	
Alpha	1.05	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)		Cum Volume (acre-ft)	0.00	0.02	0.01
C & E Loss (ft)		Cum SA (acres)	0.04	0.08	0.12

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.

Plan: Plan 03 Hearst 1 RS: 732 Profile: Q10

E.G. Elev (ft)	68.23	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.58	Wt. n-Val.	0.013	0.013	
W.S. Elev (ft)	67.65	Reach Len. (ft)	400.00	400.00	400.00
Crit W.S. (ft)	67.75	Flow Area (sq ft)	0.41	2.37	
E.G. Slope (ft/ft)	0.021031	Area (sq ft)	0.41	2.37	1.98
Q Total (cfs)	16.10	Flow (cfs)	1.17	14.93	
Top Width (ft)	35.24	Top Width (ft)	5.88	8.49	20.86
Vel Total (ft/s)	5.79	Avg. Vel. (ft/s)	2.82	6.31	
Max Chl Dpth (ft)	0.41	Hydr. Depth (ft)	0.07	0.28	
Conv. Total (cfs)	111.0	Conv. (cfs)	8.1	103.0	
Length Wtd. (ft)	400.00	Wetted Per. (ft)	5.89	10.08	
Min Ch El (ft)	67.24	Shear (lb/sq ft)	0.09	0.31	
Alpha	1.12	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)		Cum Volume (acre-ft)	0.01	0.02	0.02
C & E Loss (ft)		Cum SA (acres)	0.07	0.08	0.21

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.

Plan: Plan 03   Hearst   1 RS: 732   Profile: Q25

E.G. Elev (ft)	68.33	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.64	Wt. n-Val.	0.013	0.013	
W.S. Elev (ft)	67.68	Reach Len. (ft)	400.00	400.00	400.00
Crit W.S. (ft)	67.78	Flow Area (sq ft)	0.60	2.63	
E.G. Slope (ft/ft)	0.021028	Area (sq ft)	0.60	2.63	2.68
Q Total (cfs)	19.79	Flow (cfs)	2.15	17.64	
Top Width (ft)	38.72	Top Width (ft)	5.88	8.51	24.33
Vel Total (ft/s)	6.13	Avg. Vel. (ft/s)	3.59	6.70	
Max Chl Dpth (ft)	0.44	Hydr. Depth (ft)	0.10	0.31	
Conv. Total (cfs)	136.5	Conv. (cfs)	14.8	121.7	
Length Wtd. (ft)	400.00	Wetted Per. (ft)	5.92	10.24	
Min Ch El (ft)	67.24	Shear (lb/sq ft)	0.13	0.34	
Alpha	1.10	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)		Cum Volume (acre-ft)	0.01	0.03	0.04
C & E Loss (ft)		Cum SA (acres)	0.07	0.08	0.23

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.

Plan: Plan 03   Hearst   1 RS: 732   Profile: Q100

E.G. Elev (ft)	67.96	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.13	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	67.83	Reach Len. (ft)	400.00	400.00	400.00
Crit W.S. (ft)	67.83	Flow Area (sq ft)	1.44	3.85	6.24
E.G. Slope (ft/ft)	0.003828	Area (sq ft)	1.44	3.85	6.24
Q Total (cfs)	25.17	Flow (cfs)	3.91	13.68	7.58
Top Width (ft)	39.20	Top Width (ft)	5.88	8.51	24.81
Vel Total (ft/s)	2.18	Avg. Vel. (ft/s)	2.71	3.55	1.22
Max Chl Dpth (ft)	0.59	Hydr. Depth (ft)	0.24	0.45	0.25
Conv. Total (cfs)	406.8	Conv. (cfs)	63.1	221.1	122.6
Length Wtd. (ft)	400.00	Wetted Per. (ft)	6.07	10.82	24.96
Min Ch El (ft)	67.24	Shear (lb/sq ft)	0.06	0.09	0.06
Alpha	1.77	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	1.55	Cum Volume (acre-ft)	0.01	0.03	0.04
C & E Loss (ft)	0.00	Cum SA (acres)	0.05	0.08	0.18

Errors Warnings and Notes

Warning:	The energy equation could not be balanced within the specified number of iterations. The program used critical depth
	for the water surface and continued on with the calculations.
Warning:	Divided flow computed for this cross-section.

Errors Warnings and Notes (Continued)

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.

Plan: Plan 03 Hearst 1 RS: 332 Profile: Q2

E.G. Elev (ft)	60.00	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.40	Wt. n-Val.	0.013	0.013	
W.S. Elev (ft)	59.60	Reach Len. (ft)	10.00	10.00	10.00
Crit W.S. (ft)	59.71	Flow Area (sq ft)	0.09	1.75	
E.G. Slope (ft/ft)	0.019001	Area (sq ft)	0.09	1.75	0.81
Q Total (cfs)	9.08	Flow (cfs)	0.14	8.94	
Top Width (ft)	24.10	Top Width (ft)	2.98	8.26	12.85
Vel Total (ft/s)	4.92	Avg. Vel. (ft/s)	1.53	5.10	
Max Chl Dpth (ft)	0.34	Hydr. Depth (ft)	0.03	0.21	
Conv. Total (cfs)	65.9	Conv. (cfs)	1.0	64.9	
Length Wtd. (ft)	10.00	Wetted Per. (ft)	2.98	9.53	
Min Ch El (ft)	59.26	Shear (lb/sq ft)	0.04	0.22	
Alpha	1.06	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	7.99	Cum Volume (acre-ft)	0.00	0.00	0.00
C & E Loss (ft)	0.01	Cum SA (acres)	0.01	0.00	0.01

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.

Plan: Plan 03 Hearst 1 RS: 332 Profile: Q10

E.G. Elev (ft)	60.23	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.54	Wt. n-Val.	0.013	0.013	
W.S. Elev (ft)	59.68	Reach Len. (ft)	10.00	10.00	10.00
Crit W.S. (ft)	59.77	Flow Area (sq ft)	0.47	2.41	
E.G. Slope (ft/ft)	0.019032	Area (sq ft)	0.47	2.41	2.17
Q Total (cfs)	16.10	Flow (cfs)	1.36	14.74	
Top Width (ft)	36.10	Top Width (ft)	5.88	8.30	21.93
Vel Total (ft/s)	5.60	Avg. Vel. (ft/s)	2.91	6.13	
Max Chl Dpth (ft)	0.42	Hydr. Depth (ft)	0.08	0.29	
Conv. Total (cfs)	116.7	Conv. (cfs)	9.9	106.8	
Length Wtd. (ft)	10.00	Wetted Per. (ft)	5.90	9.93	
Min Ch El (ft)	59.26	Shear (lb/sq ft)	0.09	0.29	

Plan: Plan 03 Hearst 1 RS: 332 Profile: Q10 (Continued)

Alpha	1.12	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	8.00	Cum Volume (acre-ft)	0.01	0.00	0.00
C & E Loss (ft)	0.01	Cum SA (acres)	0.01	0.00	0.01

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.

Plan: Plan 03 Hearst 1 RS: 332 Profile: Q25

E.G. Elev (ft)	59.92	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.12	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.80	Reach Len. (ft)	10.00	10.00	10.00
Crit W.S. (ft)	59.80	Flow Area (sq ft)	1.19	3.43	5.20
E.G. Slope (ft/ft)	0.003747	Area (sq ft)	1.19	3.43	5.20
Q Total (cfs)	19.79	Flow (cfs)	2.84	11.41	5.54
Top Width (ft)	39.00	Top Width (ft)	5.88	8.31	24.81
Vel Total (ft/s)	2.02	Avg. Vel. (ft/s)	2.38	3.33	1.07
Max Chl Dpth (ft)	0.54	Hydr. Depth (ft)	0.20	0.41	0.21
Conv. Total (cfs)	323.3	Conv. (cfs)	46.4	186.5	90.5
Length Wtd. (ft)	10.00	Wetted Per. (ft)	6.03	10.45	24.92
Min Ch El (ft)	59.26	Shear (lb/sq ft)	0.05	0.08	0.05
Alpha	1.85	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.04	Cum Volume (acre-ft)	0.01	0.00	0.01
C & E Loss (ft)	0.00	Cum SA (acres)	0.02	0.00	0.01

Errors Warnings and Notes

Warning:	The energy equation could not be balanced within the specified number of iterations. The program used critical depth
	for the water surface and continued on with the calculations.
Warning:	Divided flow computed for this cross-section.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.

Plan: Plan 03 Hearst 1 RS: 332 Profile: Q100

E.G. Elev (ft)	63.00	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.41	Wt. n-Val.	0.013	0.013	
W.S. Elev (ft)	59.59	Reach Len. (ft)	10.00	10.00	10.00
Crit W.S. (ft)	59.85	Flow Area (sq ft)	0.06	1.67	
E.G. Slope (ft/ft)	0.171058	Area (sq ft)	0.06	1.67	0.69

Plan: Plan 03 Hearst 1 RS: 332 Profile: Q100 (Continued)

Q Total (cfs)	25.17	Flow (cfs)	0.26	24.91	
Top Width (ft)	22.50	Top Width (ft)	2.50	8.26	11.74
Vel Total (ft/s)	14.49	Avg. Vel. (ft/s)	4.09	14.88	
Max Chl Dpth (ft)	0.33	Hydr. Depth (ft)	0.03	0.20	
Conv. Total (cfs)	60.9	Conv. (cfs)	0.6	60.2	
Length Wtd. (ft)	10.00	Wetted Per. (ft)	2.50	9.48	
Min Ch El (ft)	59.26	Shear (lb/sq ft)	0.27	1.89	
Alpha	1.05	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	4.63	Cum Volume (acre-ft)	0.01	0.00	0.01
C & E Loss (ft)	0.33	Cum SA (acres)	0.01	0.00	0.01

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.

Plan: Plan 03 Hearst 1 RS: 322 Profile: Q2

E.G. Elev (ft)	59.71	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.45	Wt. n-Val.	0.013	0.013	0.013
W.S. Elev (ft)	59.26	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	59.38	Flow Area (sq ft)	1.46	0.29	0.37
E.G. Slope (ft/ft)	0.041180	Area (sq ft)	1.46	0.29	0.37
Q Total (cfs)	11.26	Flow (cfs)	7.30	1.89	2.07
Top Width (ft)	19.60	Top Width (ft)	14.60	2.01	2.99
Vel Total (ft/s)	5.30	Avg. Vel. (ft/s)	5.00	6.43	5.59
Max Chl Dpth (ft)	0.16	Hydr. Depth (ft)	0.10	0.15	0.12
Conv. Total (cfs)	55.5	Conv. (cfs)	36.0	9.3	10.2
Length Wtd. (ft)	30.00	Wetted Per. (ft)	14.60	2.01	3.12
Min Ch El (ft)	59.10	Shear (lb/sq ft)	0.26	0.38	0.30
Alpha	1.03	Stream Power (lb/ft s)	30.00	0.00	0.00
Frctn Loss (ft)	0.28	Cum Volume (acre-ft)	0.00	0.00	0.00
C & E Loss (ft)	0.01	Cum SA (acres)	0.01	0.00	0.01

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.

Plan: Plan 03 Hearst 1 RS: 322 Profile: Q10

E.G. Elev (ft)	59.93	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.62	Wt. n-Val.	0.013	0.013	0.013
W.S. Elev (ft)	59.32	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	59.47	Flow Area (sq ft)	2.31	0.40	0.53
E.G. Slope (ft/ft)	0.039312	Area (sq ft)	2.31	0.40	0.53
Q Total (cfs)	20.01	Flow (cfs)	13.35	3.07	3.59
Top Width (ft)	22.86	Top Width (ft)	17.86	2.01	2.99
Vel Total (ft/s)	6.20	Avg. Vel. (ft/s)	5.79	7.70	6.83
Max Chl Dpth (ft)	0.22	Hydr. Depth (ft)	0.13	0.20	0.18
Conv. Total (cfs)	100.9	Conv. (cfs)	67.3	15.5	18.1
Length Wtd. (ft)	30.00	Wetted Per. (ft)	17.86	2.01	3.18
Min Ch El (ft)	59.10	Shear (lb/sq ft)	0.32	0.49	0.41
Alpha	1.04	Stream Power (lb/ft s)	30.00	0.00	0.00
Frctn Loss (ft)	0.28	Cum Volume (acre-ft)	0.00	0.00	0.00
C & E Loss (ft)	0.01	Cum SA (acres)	0.01	0.00	0.01

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.

Plan: Plan 03 Hearst 1 RS: 322 Profile: Q25

E.G. Elev (ft)	59.80	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.42	Wt. n-Val.	0.013	0.013	0.013
W.S. Elev (ft)	59.38	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	59.50	Flow Area (sq ft)	3.57	0.53	0.72
E.G. Slope (ft/ft)	0.019140	Area (sq ft)	3.57	0.53	0.72
Q Total (cfs)	24.66	Flow (cfs)	17.09	3.42	4.15
Top Width (ft)	26.49	Top Width (ft)	21.49	2.01	2.99
Vel Total (ft/s)	5.12	Avg. Vel. (ft/s)	4.78	6.48	5.79
Max Chl Dpth (ft)	0.28	Hydr. Depth (ft)	0.17	0.26	0.24
Conv. Total (cfs)	178.2	Conv. (cfs)	123.6	24.7	30.0
Length Wtd. (ft)	30.00	Wetted Per. (ft)	21.49	2.01	3.24
Min Ch El (ft)	59.10	Shear (lb/sq ft)	0.20	0.31	0.26
Alpha	1.04	Stream Power (lb/ft s)	30.00	0.00	0.00
Frctn Loss (ft)	0.08	Cum Volume (acre-ft)	0.01	0.00	0.00
C & E Loss (ft)	0.03	Cum SA (acres)	0.01	0.00	0.01

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.

Plan: Plan 03 Hearst 1 RS: 322 Profile: Q100

E.G. Elev (ft)	61.10	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.80	Wt. n-Val.	0.013	0.013	0.013
W.S. Elev (ft)	59.30	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	59.55	Flow Area (sq ft)	2.10	0.37	0.49
E.G. Slope (ft/ft)	0.122864	Area (sq ft)	2.10	0.37	0.49
Q Total (cfs)	31.36	Flow (cfs)	20.79	4.90	5.67
Top Width (ft)	22.13	Top Width (ft)	17.13	2.01	2.99
Vel Total (ft/s)	10.57	Avg. Vel. (ft/s)	9.89	13.08	11.56
Max Chl Dpth (ft)	0.20	Hydr. Depth (ft)	0.12	0.19	0.16
Conv. Total (cfs)	89.5	Conv. (cfs)	59.3	14.0	16.2
Length Wtd. (ft)	30.00	Wetted Per. (ft)	17.13	2.01	3.16
Min Ch El (ft)	59.10	Shear (lb/sq ft)	0.94	1.43	1.19
Alpha	1.04	Stream Power (lb/ft s)	30.00	0.00	0.00
Frctn Loss (ft)	1.41	Cum Volume (acre-ft)	0.01	0.00	0.01
C & E Loss (ft)	0.48	Cum SA (acres)	0.01	0.00	0.01

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.

Plan: Plan 03 Hearst 1 RS: 292 Profile: Q2

E.G. Elev (ft)	59.01	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.01	Wt. n-Val.	0.013	0.013	0.013
W.S. Elev (ft)	59.00	Reach Len. (ft)	10.00	10.00	10.00
Crit W.S. (ft)	58.73	Flow Area (sq ft)	6.61	1.14	5.42
E.G. Slope (ft/ft)	0.000172	Area (sq ft)	6.61	1.14	5.42
Q Total (cfs)	11.26	Flow (cfs)	5.97	1.04	4.24
Top Width (ft)	30.00	Top Width (ft)	13.60	2.38	14.02
Vel Total (ft/s)	0.86	Avg. Vel. (ft/s)	0.90	0.92	0.78
Max Chl Dpth (ft)	0.51	Hydr. Depth (ft)	0.49	0.48	0.39
Conv. Total (cfs)	858.9	Conv. (cfs)	455.4	79.7	323.8
Length Wtd. (ft)	10.00	Wetted Per. (ft)	14.11	2.38	14.32
Min Ch El (ft)	58.51	Shear (lb/sq ft)	0.01	0.01	0.00
Alpha	1.01	Stream Power (lb/ft s)	30.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.00	0.00	0.00
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Errors Warnings and Notes (Continued)

Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.

Plan: Plan 03 Hearst 1 RS: 292 Profile: Q10

E.G. Elev (ft)	59.14	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.02	Wt. n-Val.	0.013	0.013	0.013
W.S. Elev (ft)	59.11	Reach Len. (ft)	10.00	10.00	10.00
Crit W.S. (ft)	58.81	Flow Area (sq ft)	8.12	1.40	6.97
E.G. Slope (ft/ft)	0.000260	Area (sq ft)	8.12	1.40	6.97
Q Total (cfs)	20.01	Flow (cfs)	10.29	1.82	7.91
Top Width (ft)	30.00	Top Width (ft)	13.60	2.38	14.02
Vel Total (ft/s)	1.21	Avg. Vel. (ft/s)	1.27	1.30	1.13
Max Chl Dpth (ft)	0.62	Hydr. Depth (ft)	0.60	0.59	0.50
Conv. Total (cfs)	1241.4	Conv. (cfs)	638.1	112.8	490.5
Length Wtd. (ft)	10.00	Wetted Per. (ft)	14.22	2.38	14.43
Min Ch El (ft)	58.51	Shear (lb/sq ft)	0.01	0.01	0.01
Alpha	1.01	Stream Power (lb/ft s)	30.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	0.00	0.00
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.

Plan: Plan 03 Hearst 1 RS: 292 Profile: Q25

E.G. Elev (ft)	59.20	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.03	Wt. n-Val.	0.013	0.013	0.013
W.S. Elev (ft)	59.17	Reach Len. (ft)	10.00	10.00	10.00
Crit W.S. (ft)	58.84	Flow Area (sq ft)	8.87	1.53	7.75
E.G. Slope (ft/ft)	0.000289	Area (sq ft)	8.87	1.53	7.75
Q Total (cfs)	24.66	Flow (cfs)	12.53	2.22	9.91
Top Width (ft)	30.00	Top Width (ft)	13.60	2.38	14.02
Vel Total (ft/s)	1.36	Avg. Vel. (ft/s)	1.41	1.45	1.28
Max Chl Dpth (ft)	0.68	Hydr. Depth (ft)	0.65	0.64	0.55
Conv. Total (cfs)	1451.7	Conv. (cfs)	737.7	130.9	583.1
Length Wtd. (ft)	10.00	Wetted Per. (ft)	14.28	2.38	14.49
Min Ch El (ft)	58.51	Shear (lb/sq ft)	0.01	0.01	0.01
Alpha	1.01	Stream Power (lb/ft s)	30.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	0.00	0.00
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Errors Warnings and Notes (Continued)

Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.

Plan: Plan 03   Hearst   1 RS: 292   Profile: Q100

E.G. Elev (ft)	59.28	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.04	Wt. n-Val.	0.013	0.013	0.013
W.S. Elev (ft)	59.25	Reach Len. (ft)	10.00	10.00	10.00
Crit W.S. (ft)	58.89	Flow Area (sq ft)	9.95	1.72	8.87
E.G. Slope (ft/ft)	0.000311	Area (sq ft)	9.95	1.72	8.87
Q Total (cfs)	31.36	Flow (cfs)	15.72	2.81	12.84
Top Width (ft)	30.00	Top Width (ft)	13.60	2.38	14.02
Vel Total (ft/s)	1.53	Avg. Vel. (ft/s)	1.58	1.63	1.45
Max Chl Dpth (ft)	0.76	Hydr. Depth (ft)	0.73	0.72	0.63
Conv. Total (cfs)	1777.9	Conv. (cfs)	891.1	159.0	727.7
Length Wtd. (ft)	10.00	Wetted Per. (ft)	14.36	2.38	14.57
Min Ch El (ft)	58.51	Shear (lb/sq ft)	0.01	0.01	0.01
Alpha	1.01	Stream Power (lb/ft s)	30.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	0.00	0.00
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.

Plan: Plan 03   Hearst   2 RS: 282   Profile: Q2

E.G. Elev (ft)	59.00	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.08	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	58.92	Reach Len. (ft)	36.52	36.52	36.52
Crit W.S. (ft)	58.92	Flow Area (sq ft)	0.83	2.92	3.64
E.G. Slope (ft/ft)	0.002916	Area (sq ft)	0.83	2.92	3.64
Q Total (cfs)	11.91	Flow (cfs)	1.36	7.83	2.71
Top Width (ft)	39.00	Top Width (ft)	5.88	8.31	24.81
Vel Total (ft/s)	1.61	Avg. Vel. (ft/s)	1.65	2.68	0.74
Max Chl Dpth (ft)	0.49	Hydr. Depth (ft)	0.14	0.35	0.15
Conv. Total (cfs)	220.6	Conv. (cfs)	25.3	145.1	50.2
Length Wtd. (ft)	36.52	Wetted Per. (ft)	5.96	10.18	24.86
Min Ch El (ft)	58.43	Shear (lb/sq ft)	0.03	0.05	0.03
Alpha	1.99	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.10	Cum Volume (acre-ft)	0.00	0.02	0.00
C & E Loss (ft)	0.00	Cum SA (acres)	0.01	0.06	0.04

Errors Warnings and Notes

Errors Warnings and Notes (Continued)

	for the water surface and continued on with the calculations.
Warning:	Divided flow computed for this cross-section.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.

Plan: Plan 03 Hearst 2 RS: 282 Profile: Q10

E.G. Elev (ft)	59.12	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.09	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.04	Reach Len. (ft)	36.52	36.52	36.52
Crit W.S. (ft)	59.00	Flow Area (sq ft)	1.51	3.88	6.51
E.G. Slope (ft/ft)	0.002465	Area (sq ft)	1.51	3.88	6.51
Q Total (cfs)	21.14	Flow (cfs)	3.37	11.23	6.54
Top Width (ft)	39.00	Top Width (ft)	5.88	8.31	24.81
Vel Total (ft/s)	1.78	Avg. Vel. (ft/s)	2.24	2.90	1.00
Max Chl Dpth (ft)	0.61	Hydr. Depth (ft)	0.26	0.47	0.26
Conv. Total (cfs)	425.8	Conv. (cfs)	67.9	226.3	131.6
Length Wtd. (ft)	36.52	Wetted Per. (ft)	6.08	10.64	24.97
Min Ch El (ft)	58.43	Shear (lb/sq ft)	0.04	0.06	0.04
Alpha	1.76	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.10	Cum Volume (acre-ft)	0.00	0.02	0.01
C & E Loss (ft)	0.01	Cum SA (acres)	0.01	0.07	0.05

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.

Plan: Plan 03 Hearst 2 RS: 282 Profile: Q25

E.G. Elev (ft)	59.19	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.09	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.10	Reach Len. (ft)	36.52	36.52	36.52
Crit W.S. (ft)	59.03	Flow Area (sq ft)	1.86	4.39	8.03
E.G. Slope (ft/ft)	0.002197	Area (sq ft)	1.86	4.39	8.03
Q Total (cfs)	26.06	Flow (cfs)	4.51	12.82	8.73
Top Width (ft)	39.00	Top Width (ft)	5.88	8.31	24.81
Vel Total (ft/s)	1.83	Avg. Vel. (ft/s)	2.42	2.92	1.09
Max Chl Dpth (ft)	0.67	Hydr. Depth (ft)	0.32	0.53	0.32
Conv. Total (cfs)	556.0	Conv. (cfs)	96.3	273.5	186.2
Length Wtd. (ft)	36.52	Wetted Per. (ft)	6.14	10.88	25.03
Min Ch El (ft)	58.43	Shear (lb/sq ft)	0.04	0.06	0.04

Plan: Plan 03 Hearst 2 RS: 282 Profile: Q25 (Continued)

Alpha	1.68	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.09	Cum Volume (acre-ft)	0.00	0.03	0.01
C & E Loss (ft)	0.01	Cum SA (acres)	0.02	0.07	0.05

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.

Plan: Plan 03 Hearst 2 RS: 282 Profile: Q100

E.G. Elev (ft)	59.27	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.09	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.19	Reach Len. (ft)	36.52	36.52	36.52
Crit W.S. (ft)	59.08	Flow Area (sq ft)	2.38	5.11	10.19
E.G. Slope (ft/ft)	0.001875	Area (sq ft)	2.38	5.11	10.19
Q Total (cfs)	33.12	Flow (cfs)	6.19	14.96	11.97
Top Width (ft)	39.00	Top Width (ft)	5.88	8.31	24.81
Vel Total (ft/s)	1.87	Avg. Vel. (ft/s)	2.60	2.93	1.17
Max Chl Dpth (ft)	0.76	Hydr. Depth (ft)	0.40	0.61	0.41
Conv. Total (cfs)	765.0	Conv. (cfs)	142.9	345.5	276.5
Length Wtd. (ft)	36.52	Wetted Per. (ft)	6.23	11.23	25.12
Min Ch El (ft)	58.43	Shear (lb/sq ft)	0.04	0.05	0.05
Alpha	1.61	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.08	Cum Volume (acre-ft)	0.00	0.03	0.01
C & E Loss (ft)	0.01	Cum SA (acres)	0.02	0.07	0.05

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.

Plan: Plan 03 Hearst 2 RS: 245.48 Profile: Q2

E.G. Elev (ft)	58.86	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.17	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	58.69	Reach Len. (ft)	23.36	10.88	0.75
Crit W.S. (ft)	58.73	Flow Area (sq ft)	0.03	3.28	1.14
E.G. Slope (ft/ft)	0.004234	Area (sq ft)	0.03	3.28	1.14
Q Total (cfs)	11.91	Flow (cfs)	0.02	11.11	0.78
Top Width (ft)	23.08	Top Width (ft)	1.08	10.31	11.69
Vel Total (ft/s)	2.68	Avg. Vel. (ft/s)	0.67	3.39	0.68
Max Chl Dpth (ft)	0.55	Hydr. Depth (ft)	0.03	0.32	0.10

Plan: Plan 03 Hearst 2 RS: 245.48 Profile: Q2 (Continued)

Conv. Total (cfs)	183.0	Conv. (cfs)	0.3	170.7	12.0
Length Wtd. (ft)	10.64	Wetted Per. (ft)	1.08	10.65	11.74
Min Ch El (ft)	58.14	Shear (lb/sq ft)	0.01	0.08	0.03
Alpha	1.50	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.13	Cum Volume (acre-ft)	0.00	0.01	0.00
C & E Loss (ft)	0.01	Cum SA (acres)	0.00	0.05	0.02

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.

Plan: Plan 03 Hearst 2 RS: 245.48 Profile: Q10

E.G. Elev (ft)	59.02	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.17	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	58.85	Reach Len. (ft)	23.36	10.88	0.75
Crit W.S. (ft)	58.85	Flow Area (sq ft)	0.43	4.85	2.93
E.G. Slope (ft/ft)	0.002847	Area (sq ft)	0.43	4.85	2.93
Q Total (cfs)	21.14	Flow (cfs)	0.57	17.52	3.04
Top Width (ft)	26.13	Top Width (ft)	4.13	10.31	11.69
Vel Total (ft/s)	2.57	Avg. Vel. (ft/s)	1.34	3.61	1.04
Max Chl Dpth (ft)	0.71	Hydr. Depth (ft)	0.10	0.47	0.25
Conv. Total (cfs)	396.2	Conv. (cfs)	10.7	328.4	57.0
Length Wtd. (ft)	10.65	Wetted Per. (ft)	4.14	10.65	11.90
Min Ch El (ft)	58.14	Shear (lb/sq ft)	0.02	0.08	0.04
Alpha	1.66	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	0.02	0.00
C & E Loss (ft)	0.04	Cum SA (acres)	0.01	0.06	0.03

Errors Warnings and Notes

Warning:	The energy equation could not be balanced within the specified number of iterations. The program used critical depth
	for the water surface and continued on with the calculations.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.

Plan: Plan 03 Hearst 2 RS: 245.48 Profile: Q25

E.G. Elev (ft)	59.09	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.18	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	58.91	Reach Len. (ft)	23.36	10.88	0.75

Plan: Plan 03 Hearst 2 RS: 245.48 Profile: Q25 (Continued)

Crit W.S. (ft)	58.91	Flow Area (sq ft)	0.73	5.52	3.69
E.G. Slope (ft/ft)	0.002572	Area (sq ft)	0.73	5.52	3.69
Q Total (cfs)	26.06	Flow (cfs)	1.18	20.65	4.23
Top Width (ft)	27.00	Top Width (ft)	5.00	10.31	11.69
Vel Total (ft/s)	2.62	Avg. Vel. (ft/s)	1.61	3.74	1.15
Max Chl Dpth (ft)	0.77	Hydr. Depth (ft)	0.15	0.54	0.32
Conv. Total (cfs)	513.8	Conv. (cfs)	23.2	407.2	83.4
Length Wtd. (ft)	10.71	Wetted Per. (ft)	5.03	10.65	11.96
Min Ch El (ft)	58.14	Shear (lb/sq ft)	0.02	0.08	0.05
Alpha	1.66	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	0.02	0.01
C & E Loss (ft)	0.04	Cum SA (acres)	0.01	0.06	0.03

Errors Warnings and Notes

Warning:	The energy equation could not be balanced within the specified number of iterations. The program used critical depth
	for the water surface and continued on with the calculations.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.
Warning:	The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
	method to find critical depth.

Plan: Plan 03 Hearst 2 RS: 245.48 Profile: Q100

E.G. Elev (ft)	59.18	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.21	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	58.98	Reach Len. (ft)	23.36	10.88	0.75
Crit W.S. (ft)	58.98	Flow Area (sq ft)	1.05	6.18	4.43
E.G. Slope (ft/ft)	0.002632	Area (sq ft)	1.05	6.18	4.43
Q Total (cfs)	33.12	Flow (cfs)	2.15	25.18	5.79
Top Width (ft)	27.00	Top Width (ft)	5.00	10.31	11.69
Vel Total (ft/s)	2.84	Avg. Vel. (ft/s)	2.05	4.08	1.31
Max Chl Dpth (ft)	0.83	Hydr. Depth (ft)	0.21	0.60	0.38
Conv. Total (cfs)	645.6	Conv. (cfs)	41.9	490.9	112.8
Length Wtd. (ft)	10.82	Wetted Per. (ft)	5.09	10.65	12.03
Min Ch El (ft)	58.14	Shear (lb/sq ft)	0.03	0.10	0.06
Alpha	1.64	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	0.03	0.01
C & E Loss (ft)	0.05	Cum SA (acres)	0.01	0.06	0.04

Errors Warnings and Notes

Errors Warnings and Notes (Continued)

	for the water surface and continued on with the calculations.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Warning:	The cross section had to be extended vertically during the critical depth calculations.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.
Warning:	The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
	method to find critical depth.

Plan: Plan 03 Hearst 2 RS: 234.6 Profile: Q2

E.G. Elev (ft)	58.78	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.02	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	58.76	Reach Len. (ft)	18.87	8.89	0.90
Crit W.S. (ft)	58.43	Flow Area (sq ft)	0.80	10.09	0.40
E.G. Slope (ft/ft)	0.000227	Area (sq ft)	0.80	10.09	0.40
Q Total (cfs)	11.91	Flow (cfs)	0.41	11.43	0.07
Top Width (ft)	27.00	Top Width (ft)	5.00	18.88	3.12
Vel Total (ft/s)	1.05	Avg. Vel. (ft/s)	0.51	1.13	0.18
Max Chl Dpth (ft)	0.85	Hydr. Depth (ft)	0.16	0.53	0.13
Conv. Total (cfs)	790.0	Conv. (cfs)	27.0	758.1	4.9
Length Wtd. (ft)	9.04	Wetted Per. (ft)	5.04	18.93	3.24
Min Ch El (ft)	57.91	Shear (lb/sq ft)	0.00	0.01	0.00
Alpha	1.11	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	0.01	0.00
C & E Loss (ft)	0.01	Cum SA (acres)	0.00	0.05	0.02

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.

Plan: Plan 03 Hearst 2 RS: 234.6 Profile: Q10

E.G. Elev (ft)	58.94	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.03	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	58.91	Reach Len. (ft)	18.87	8.89	0.90
Crit W.S. (ft)	58.56	Flow Area (sq ft)	1.53	12.81	0.85
E.G. Slope (ft/ft)	0.000299	Area (sq ft)	1.53	12.81	0.85
Q Total (cfs)	21.14	Flow (cfs)	1.33	19.52	0.29
Top Width (ft)	27.00	Top Width (ft)	5.00	18.88	3.12
Vel Total (ft/s)	1.39	Avg. Vel. (ft/s)	0.87	1.52	0.34

Plan: Plan 03 Hearst 2 RS: 234.6 Profile: Q10 (Continued)

Max Chl Dpth (ft)	1.00	Hydr. Depth (ft)	0.31	0.68	0.27
Conv. Total (cfs)	1223.3	Conv. (cfs)	77.2	1129.4	16.7
Length Wtd. (ft)	9.15	Wetted Per. (ft)	5.18	18.93	3.39
Min Ch El (ft)	57.91	Shear (lb/sq ft)	0.01	0.01	0.00
Alpha	1.13	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	0.02	0.00
C & E Loss (ft)	0.01	Cum SA (acres)	0.01	0.06	0.03

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.

Plan: Plan 03 Hearst 2 RS: 234.6 Profile: Q25

E.G. Elev (ft)	59.01	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.04	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	58.96	Reach Len. (ft)	18.87	8.89	0.90
Crit W.S. (ft)	58.62	Flow Area (sq ft)	1.82	13.93	1.03
E.G. Slope (ft/ft)	0.000335	Area (sq ft)	1.82	13.93	1.03
Q Total (cfs)	26.06	Flow (cfs)	1.88	23.76	0.42
Top Width (ft)	27.00	Top Width (ft)	5.00	18.88	3.12
Vel Total (ft/s)	1.55	Avg. Vel. (ft/s)	1.03	1.71	0.41
Max Chl Dpth (ft)	1.05	Hydr. Depth (ft)	0.36	0.74	0.33
Conv. Total (cfs)	1424.3	Conv. (cfs)	102.9	1298.5	22.9
Length Wtd. (ft)	9.23	Wetted Per. (ft)	5.24	18.93	3.44
Min Ch El (ft)	57.91	Shear (lb/sq ft)	0.01	0.02	0.01
Alpha	1.13	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	0.02	0.01
C & E Loss (ft)	0.01	Cum SA (acres)	0.01	0.06	0.03

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.

Plan: Plan 03 Hearst 2 RS: 234.6 Profile: Q100

E.G. Elev (ft)	59.09	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.05	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.04	Reach Len. (ft)	18.87	8.89	0.90
Crit W.S. (ft)	58.69	Flow Area (sq ft)	2.20	15.35	1.27
E.G. Slope (ft/ft)	0.000381	Area (sq ft)	2.20	15.35	1.27

Plan: Plan 03   Hearst   2 RS: 234.6   Profile: Q100 (Continued)

Q Total (cfs)	33.12	Flow (cfs)	2.72	29.78	0.62
Top Width (ft)	27.00	Top Width (ft)	5.00	18.88	3.12
Vel Total (ft/s)	1.76	Avg. Vel. (ft/s)	1.24	1.94	0.49
Max Chl Dpth (ft)	1.13	Hydr. Depth (ft)	0.44	0.81	0.41
Conv. Total (cfs)	1697.9	Conv. (cfs)	139.4	1526.6	31.8
Length Wtd. (ft)	9.35	Wetted Per. (ft)	5.32	18.93	3.52
Min Ch El (ft)	57.91	Shear (lb/sq ft)	0.01	0.02	0.01
Alpha	1.13	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	0.02	0.01
C & E Loss (ft)	0.01	Cum SA (acres)	0.01	0.06	0.04

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.

Plan: Plan 03   Hearst   2 RS: 225.71   Profile: Q2

E.G. Elev (ft)	58.76	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.12	Wt. n-Val.		0.013	
W.S. Elev (ft)	58.64	Reach Len. (ft)	88.73	88.73	88.73
Crit W.S. (ft)	58.64	Flow Area (sq ft)		4.29	
E.G. Slope (ft/ft)	0.004052	Area (sq ft)		4.29	
Q Total (cfs)	11.91	Flow (cfs)		11.91	
Top Width (ft)	18.14	Top Width (ft)		18.14	
Vel Total (ft/s)	2.78	Avg. Vel. (ft/s)		2.78	
Max Chl Dpth (ft)	0.47	Hydr. Depth (ft)		0.24	
Conv. Total (cfs)	187.1	Conv. (cfs)		187.1	
Length Wtd. (ft)	88.72	Wetted Per. (ft)		18.17	
Min Ch El (ft)	58.17	Shear (lb/sq ft)		0.06	
Alpha	1.00	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.35	Cum Volume (acre-ft)		0.01	0.00
C & E Loss (ft)	0.00	Cum SA (acres)		0.05	0.02

Errors Warnings and Notes

Warning:	The energy equation could not be balanced within the specified number of iterations. The program used critical depth
	for the water surface and continued on with the calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.

Plan: Plan 03 Hearst 2 RS: 225.71 Profile: Q10

E.G. Elev (ft)	58.92	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.16	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	58.76	Reach Len. (ft)	88.73	88.73	88.73
Crit W.S. (ft)	58.76	Flow Area (sq ft)	0.15	6.44	0.25
E.G. Slope (ft/ft)	0.003390	Area (sq ft)	0.15	6.44	0.25
Q Total (cfs)	21.14	Flow (cfs)	0.12	20.85	0.16
Top Width (ft)	24.58	Top Width (ft)	3.34	18.92	2.32
Vel Total (ft/s)	3.09	Avg. Vel. (ft/s)	0.84	3.24	0.64
Max Chl Dpth (ft)	0.59	Hydr. Depth (ft)	0.04	0.34	0.11
Conv. Total (cfs)	363.1	Conv. (cfs)	2.1	358.2	2.8
Length Wtd. (ft)	88.73	Wetted Per. (ft)	3.34	18.95	2.43
Min Ch El (ft)	58.17	Shear (lb/sq ft)	0.01	0.07	0.02
Alpha	1.08	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.32	Cum Volume (acre-ft)	0.00	0.02	0.00
C & E Loss (ft)	0.00	Cum SA (acres)	0.00	0.05	0.03

Errors Warnings and Notes

Warning:	The energy equation could not be balanced within the specified number of iterations. The program used critical depth
	for the water surface and continued on with the calculations.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.

Plan: Plan 03 Hearst 2 RS: 225.71 Profile: Q25

E.G. Elev (ft)	58.99	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.17	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	58.82	Reach Len. (ft)	88.73	88.73	88.73
Crit W.S. (ft)	58.82	Flow Area (sq ft)	0.45	7.62	0.40
E.G. Slope (ft/ft)	0.002829	Area (sq ft)	0.45	7.62	0.40
Q Total (cfs)	26.06	Flow (cfs)	0.49	25.26	0.31
Top Width (ft)	27.00	Top Width (ft)	5.76	18.92	2.32
Vel Total (ft/s)	3.08	Avg. Vel. (ft/s)	1.10	3.31	0.78
Max Chl Dpth (ft)	0.65	Hydr. Depth (ft)	0.08	0.40	0.17
Conv. Total (cfs)	490.0	Conv. (cfs)	9.2	475.0	5.8
Length Wtd. (ft)	88.73	Wetted Per. (ft)	5.77	18.95	2.49
Min Ch El (ft)	58.17	Shear (lb/sq ft)	0.01	0.07	0.03
Alpha	1.13	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.28	Cum Volume (acre-ft)	0.00	0.02	0.01
C & E Loss (ft)	0.00	Cum SA (acres)	0.01	0.05	0.03

Errors Warnings and Notes (Continued)

	for the water surface and continued on with the calculations.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.
Warning:	The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
	method to find critical depth.

Plan: Plan 03 Hearst 2 RS: 225.71 Profile: Q100

E.G. Elev (ft)	59.07	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.19	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	58.88	Reach Len. (ft)	88.73	88.73	88.73
Crit W.S. (ft)	58.88	Flow Area (sq ft)	0.77	8.70	0.53
E.G. Slope (ft/ft)	0.002821	Area (sq ft)	0.77	8.70	0.53
Q Total (cfs)	33.12	Flow (cfs)	1.22	31.41	0.49
Top Width (ft)	27.00	Top Width (ft)	5.76	18.92	2.32
Vel Total (ft/s)	3.31	Avg. Vel. (ft/s)	1.58	3.61	0.92
Max Chl Dpth (ft)	0.71	Hydr. Depth (ft)	0.13	0.46	0.23
Conv. Total (cfs)	623.5	Conv. (cfs)	22.9	591.4	9.2
Length Wtd. (ft)	88.73	Wetted Per. (ft)	5.83	18.95	2.55
Min Ch El (ft)	58.17	Shear (lb/sq ft)	0.02	0.08	0.04
Alpha	1.14	Stream Power (lb/ft s)	27.00	0.00	0.00
Frctn Loss (ft)	0.28	Cum Volume (acre-ft)	0.00	0.02	0.01
C & E Loss (ft)	0.00	Cum SA (acres)	0.01	0.05	0.04

Errors Warnings and Notes

Warning:	The energy equation could not be balanced within the specified number of iterations. The program used critical depth
	for the water surface and continued on with the calculations.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.
Warning:	The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
	method to find critical depth.

Plan: Plan 03 Hearst 2 RS: 136.985 Profile: Q2

E.G. Elev (ft)	57.78	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.08	Wt. n-Val.		0.013	0.030
W.S. Elev (ft)	56.70	Reach Len. (ft)	88.73	88.73	88.73
Crit W.S. (ft)	56.93	Flow Area (sq ft)		1.41	0.08
E.G. Slope (ft/ft)	0.053615	Area (sq ft)		1.41	0.08

Plan: Plan 03 Hearst 2 RS: 136.985 Profile: Q2 (Continued)

Q Total (cfs)	11.91	Flow (cfs)		11.81	0.10
Top Width (ft)	8.99	Top Width (ft)		6.67	2.31
Vel Total (ft/s)	7.99	Avg. Vel. (ft/s)		8.38	1.22
Max Chl Dpth (ft)	0.42	Hydr. Depth (ft)		0.21	0.03
Conv. Total (cfs)	51.4	Conv. (cfs)		51.0	0.4
Length Wtd. (ft)	88.72	Wetted Per. (ft)		7.91	2.31
Min Ch El (ft)	56.28	Shear (lb/sq ft)		0.60	0.12
Alpha	1.09	Stream Power (lb/ft s)	24.96	0.00	0.00
Frctn Loss (ft)	0.88	Cum Volume (acre-ft)		0.00	0.00
C & E Loss (ft)	0.10	Cum SA (acres)		0.02	0.02

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Note:	Program found supercritical flow starting at this cross section.

Plan: Plan 03 Hearst 2 RS: 136.985 Profile: Q10

E.G. Elev (ft)	58.05	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.25	Wt. n-Val.		0.013	0.030
W.S. Elev (ft)	56.80	Reach Len. (ft)	88.73	88.73	88.73
Crit W.S. (ft)	57.07	Flow Area (sq ft)		2.18	0.50
E.G. Slope (ft/ft)	0.048694	Area (sq ft)		2.18	0.50
Q Total (cfs)	21.14	Flow (cfs)		20.07	1.07
Top Width (ft)	14.05	Top Width (ft)		8.28	5.76
Vel Total (ft/s)	7.88	Avg. Vel. (ft/s)		9.19	2.14
Max Chl Dpth (ft)	0.52	Hydr. Depth (ft)		0.26	0.09
Conv. Total (cfs)	95.8	Conv. (cfs)		91.0	4.8
Length Wtd. (ft)	88.73	Wetted Per. (ft)		9.94	5.76
Min Ch El (ft)	56.28	Shear (lb/sq ft)		0.67	0.26
Alpha	1.30	Stream Power (lb/ft s)	24.96	0.00	0.00
Frctn Loss (ft)	0.75	Cum Volume (acre-ft)	0.00	0.01	0.00
C & E Loss (ft)	0.11	Cum SA (acres)	0.00	0.02	0.02

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Note:	Program found supercritical flow starting at this cross section.

Plan: Plan 03 Hearst 2 RS: 136.985 Profile: Q25

E.G. Elev (ft)	58.21	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.37	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	56.84	Reach Len. (ft)	88.73	88.73	88.73
Crit W.S. (ft)	57.15	Flow Area (sq ft)	0.01	2.50	0.73
E.G. Slope (ft/ft)	0.048831	Area (sq ft)	0.01	2.50	0.73
Q Total (cfs)	26.06	Flow (cfs)	0.01	24.26	1.79
Top Width (ft)	16.28	Top Width (ft)	0.59	8.70	6.99
Vel Total (ft/s)	8.04	Avg. Vel. (ft/s)	1.17	9.70	2.44
Max Chl Dpth (ft)	0.56	Hydr. Depth (ft)	0.01	0.29	0.11
Conv. Total (cfs)	117.9	Conv. (cfs)	0.0	109.8	8.1
Length Wtd. (ft)	88.73	Wetted Per. (ft)	0.60	10.50	6.99
Min Ch El (ft)	56.28	Shear (lb/sq ft)	0.03	0.73	0.32
Alpha	1.36	Stream Power (lb/ft s)	24.96	0.00	0.00
Frctn Loss (ft)	0.65	Cum Volume (acre-ft)	0.00	0.01	0.00
C & E Loss (ft)	0.12	Cum SA (acres)	0.00	0.02	0.02

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Warning:	The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
	method to find critical depth.
Note:	Program found supercritical flow starting at this cross section.

Plan: Plan 03 Hearst 2 RS: 136.985 Profile: Q100

E.G. Elev (ft)	58.31	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.42	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	56.90	Reach Len. (ft)	88.73	88.73	88.73
Crit W.S. (ft)	57.22	Flow Area (sq ft)	0.04	2.98	1.17
E.G. Slope (ft/ft)	0.042422	Area (sq ft)	0.04	2.98	1.17
Q Total (cfs)	33.12	Flow (cfs)	0.14	29.88	3.10
Top Width (ft)	18.12	Top Width (ft)	0.59	8.70	8.83
Vel Total (ft/s)	7.91	Avg. Vel. (ft/s)	3.56	10.03	2.65
Max Chl Dpth (ft)	0.62	Hydr. Depth (ft)	0.07	0.34	0.13
Conv. Total (cfs)	160.8	Conv. (cfs)	0.7	145.1	15.1
Length Wtd. (ft)	88.73	Wetted Per. (ft)	0.66	10.72	8.83
Min Ch El (ft)	56.28	Shear (lb/sq ft)	0.16	0.74	0.35
Alpha	1.46	Stream Power (lb/ft s)	24.96	0.00	0.00
Frctn Loss (ft)	0.63	Cum Volume (acre-ft)	0.00	0.01	0.01

Plan: Plan 03 Hearst 2 RS: 136.985 Profile: Q100 (Continued)

C & E Loss (ft)	0.12	Cum SA (acres)	0.00	0.03	0.03

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Warning:	The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
	method to find critical depth.
Note:	Program found supercritical flow starting at this cross section.

Plan: Plan 03 Hearst 2 RS: 48.26 Profile: Q2

E.G. Elev (ft)	54.72	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.65	Wt. n-Val.		0.013	0.030
W.S. Elev (ft)	54.06	Reach Len. (ft)	48.26	48.26	48.26
Crit W.S. (ft)	54.23	Flow Area (sq ft)		1.61	0.76
E.G. Slope (ft/ft)	0.022422	Area (sq ft)		1.61	0.76
Q Total (cfs)	11.91	Flow (cfs)		10.89	1.02
Top Width (ft)	16.18	Top Width (ft)		6.22	9.96
Vel Total (ft/s)	5.03	Avg. Vel. (ft/s)		6.78	1.33
Max Chl Dpth (ft)	0.51	Hydr. Depth (ft)		0.26	0.08
Conv. Total (cfs)	79.5	Conv. (cfs)		72.8	6.8
Length Wtd. (ft)	48.26	Wetted Per. (ft)		6.45	10.01
Min Ch El (ft)	53.55	Shear (lb/sq ft)		0.35	0.11
Alpha	1.67	Stream Power (lb/ft s)	20.86	0.00	0.00
Frctn Loss (ft)	2.93	Cum Volume (acre-ft)		0.00	0.00
C & E Loss (ft)	0.13	Cum SA (acres)		0.01	0.01

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.

Plan: Plan 03 Hearst 2 RS: 48.26 Profile: Q10

E.G. Elev (ft)	54.95	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.80	Wt. n-Val.		0.013	0.030
W.S. Elev (ft)	54.15	Reach Len. (ft)	48.26	48.26	48.26
Crit W.S. (ft)	54.34	Flow Area (sq ft)		2.21	1.65
E.G. Slope (ft/ft)	0.024231	Area (sq ft)		2.21	1.65
Q Total (cfs)	21.14	Flow (cfs)		17.36	3.78

Plan: Plan 03 Hearst 2 RS: 48.26 Profile: Q10 (Continued)

Top Width (ft)	17.22	Top Width (ft)		7.26	9.96
Vel Total (ft/s)	5.49	Avg. Vel. (ft/s)		7.87	2.30
Max Chl Dpth (ft)	0.60	Hydr. Depth (ft)		0.30	0.17
Conv. Total (cfs)	135.8	Conv. (cfs)		111.5	24.3
Length Wtd. (ft)	48.26	Wetted Per. (ft)		7.50	10.10
Min Ch El (ft)	53.55	Shear (lb/sq ft)		0.45	0.25
Alpha	1.72	Stream Power (lb/ft s)	20.86	0.00	0.00
Frctn Loss (ft)	2.96	Cum Volume (acre-ft)	0.00	0.00	0.00
C & E Loss (ft)	0.13	Cum SA (acres)	0.00	0.01	0.01

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.

Plan: Plan 03 Hearst 2 RS: 48.26 Profile: Q25

E.G. Elev (ft)	55.06	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.87	Wt. n-Val.		0.013	0.030
W.S. Elev (ft)	54.19	Reach Len. (ft)	48.26	48.26	48.26
Crit W.S. (ft)	54.41	Flow Area (sq ft)		2.49	2.02
E.G. Slope (ft/ft)	0.024784	Area (sq ft)		2.49	2.02
Q Total (cfs)	26.06	Flow (cfs)		20.67	5.39
Top Width (ft)	17.67	Top Width (ft)		7.71	9.96
Vel Total (ft/s)	5.77	Avg. Vel. (ft/s)		8.30	2.66
Max Chl Dpth (ft)	0.64	Hydr. Depth (ft)		0.32	0.20
Conv. Total (cfs)	165.5	Conv. (cfs)		131.3	34.2
Length Wtd. (ft)	48.26	Wetted Per. (ft)		7.94	10.14
Min Ch El (ft)	53.55	Shear (lb/sq ft)		0.49	0.31
Alpha	1.68	Stream Power (lb/ft s)	20.86	0.00	0.00
Frctn Loss (ft)	3.00	Cum Volume (acre-ft)	0.00	0.00	0.00
C & E Loss (ft)	0.15	Cum SA (acres)	0.00	0.01	0.01

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The cross section had to be extended vertically during the critical depth calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.
Warning:	The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
	method to find critical depth.

Plan: Plan 03 Hearst 2 RS: 48.26 Profile: Q100

E.G. Elev (ft)	55.24	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.01	Wt. n-Val.		0.013	0.030
W.S. Elev (ft)	54.23	Reach Len. (ft)	48.26	48.26	48.26
Crit W.S. (ft)	54.49	Flow Area (sq ft)		2.82	2.44
E.G. Slope (ft/ft)	0.026822	Area (sq ft)		2.82	2.44
Q Total (cfs)	33.12	Flow (cfs)		25.48	7.64
Top Width (ft)	18.16	Top Width (ft)		8.20	9.96
Vel Total (ft/s)	6.29	Avg. Vel. (ft/s)		9.02	3.13
Max Chl Dpth (ft)	0.68	Hydr. Depth (ft)		0.34	0.25
Conv. Total (cfs)	202.2	Conv. (cfs)		155.6	46.7
Length Wtd. (ft)	48.26	Wetted Per. (ft)		8.44	10.18
Min Ch El (ft)	53.55	Shear (lb/sq ft)		0.56	0.40
Alpha	1.64	Stream Power (lb/ft s)	20.86	0.00	0.00
Frctn Loss (ft)	2.95	Cum Volume (acre-ft)	0.00	0.00	0.00
C & E Loss (ft)	0.12	Cum SA (acres)	0.00	0.01	0.01

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The cross section had to be extended vertically during the critical depth calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
Warning:	The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.

Plan: Plan 03 Hearst 2 RS: 0 Profile: Q2

E.G. Elev (ft)	53.46	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.78	Wt. n-Val.		0.013	0.030
W.S. Elev (ft)	52.68	Reach Len. (ft)			
Crit W.S. (ft)	52.90	Flow Area (sq ft)		1.62	0.21
E.G. Slope (ft/ft)	0.030056	Area (sq ft)		1.62	0.21
Q Total (cfs)	12.24	Flow (cfs)		11.72	0.52
Top Width (ft)	7.25	Top Width (ft)		5.95	1.30
Vel Total (ft/s)	6.68	Avg. Vel. (ft/s)		7.21	2.49
Max Chl Dpth (ft)	0.55	Hydr. Depth (ft)		0.27	0.16
Conv. Total (cfs)	70.6	Conv. (cfs)		67.6	3.0
Length Wtd. (ft)		Wetted Per. (ft)		7.40	1.34
Min Ch El (ft)	52.13	Shear (lb/sq ft)		0.41	0.29
Alpha	1.12	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	1.25	Cum Volume (acre-ft)			
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Errors Warnings and Notes (Continued)

Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.

Plan: Plan 03 Hearst 2 RS: 0 Profile: Q10

E.G. Elev (ft)	53.76	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.93	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	52.82	Reach Len. (ft)			
Crit W.S. (ft)	53.09	Flow Area (sq ft)	0.04	2.56	0.43
E.G. Slope (ft/ft)	0.024963	Area (sq ft)	0.04	2.56	0.43
Q Total (cfs)	21.71	Flow (cfs)	0.08	20.37	1.26
Top Width (ft)	9.50	Top Width (ft)	0.91	6.71	1.87
Vel Total (ft/s)	7.17	Avg. Vel. (ft/s)	2.17	7.97	2.89
Max Chl Dpth (ft)	0.69	Hydr. Depth (ft)	0.04	0.38	0.23
Conv. Total (cfs)	137.4	Conv. (cfs)	0.5	128.9	7.9
Length Wtd. (ft)		Wetted Per. (ft)	0.92	8.72	1.93
Min Ch El (ft)	52.13	Shear (lb/sq ft)	0.06	0.46	0.35
Alpha	1.17	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	1.19	Cum Volume (acre-ft)			
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.

Plan: Plan 03 Hearst 2 RS: 0 Profile: Q25

E.G. Elev (ft)	53.89	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.01	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	52.88	Reach Len. (ft)			
Crit W.S. (ft)	53.18	Flow Area (sq ft)	0.11	2.97	0.56
E.G. Slope (ft/ft)	0.023264	Area (sq ft)	0.11	2.97	0.56
Q Total (cfs)	26.75	Flow (cfs)	0.34	24.72	1.68
Top Width (ft)	10.41	Top Width (ft)	1.58	6.71	2.12
Vel Total (ft/s)	7.36	Avg. Vel. (ft/s)	3.02	8.34	3.03
Max Chl Dpth (ft)	0.75	Hydr. Depth (ft)	0.07	0.44	0.26
Conv. Total (cfs)	175.4	Conv. (cfs)	2.3	162.1	11.0
Length Wtd. (ft)		Wetted Per. (ft)	1.59	8.97	2.18
Min Ch El (ft)	52.13	Shear (lb/sq ft)	0.10	0.48	0.37
Alpha	1.20	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	1.16	Cum Volume (acre-ft)			
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Errors Warnings and Notes (Continued)

Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.

Plan: Plan 03 Hearst 2 RS: 0 Profile: Q100

E.G. Elev (ft)	54.06	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.10	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	52.96	Reach Len. (ft)			
Crit W.S. (ft)	53.26	Flow Area (sq ft)	0.28	3.48	0.73
E.G. Slope (ft/ft)	0.021921	Area (sq ft)	0.28	3.48	0.73
Q Total (cfs)	33.98	Flow (cfs)	1.01	30.62	2.35
Top Width (ft)	11.97	Top Width (ft)	2.84	6.71	2.43
Vel Total (ft/s)	7.57	Avg. Vel. (ft/s)	3.60	8.80	3.23
Max Chl Dpth (ft)	0.83	Hydr. Depth (ft)	0.10	0.52	0.30
Conv. Total (cfs)	229.5	Conv. (cfs)	6.8	206.8	15.9
Length Wtd. (ft)		Wetted Per. (ft)	2.84	9.27	2.50
Min Ch El (ft)	52.13	Shear (lb/sq ft)	0.13	0.51	0.40
Alpha	1.24	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	1.17	Cum Volume (acre-ft)			
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the
	need for additional cross sections.

Plan: Plan 03 Lower Curtis 1 RS: 370.35 Profile: Q2

E.G. Elev (ft)	59.78	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.		0.013	
W.S. Elev (ft)	59.78	Reach Len. (ft)	155.18	155.18	155.18
Crit W.S. (ft)	59.78	Flow Area (sq ft)		0.00	
E.G. Slope (ft/ft)	0.005005	Area (sq ft)		0.00	
Q Total (cfs)	0.00	Flow (cfs)		0.00	
Top Width (ft)	0.15	Top Width (ft)		0.15	
Vel Total (ft/s)	0.38	Avg. Vel. (ft/s)		0.38	
Max Chl Dpth (ft)	0.02	Hydr. Depth (ft)		0.01	
Conv. Total (cfs)	0.0	Conv. (cfs)		0.0	
Length Wtd. (ft)	155.18	Wetted Per. (ft)		0.15	
Min Ch El (ft)	59.76	Shear (lb/sq ft)			
Alpha	1.00	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)		Cum Volume (acre-ft)	0.02	0.01	0.05
C & E Loss (ft)		Cum SA (acres)	0.03	0.01	0.07

Plan: Plan 03 Lower Curtis 1 RS: 370.35 Profile: Q10

E.G. Elev (ft)	59.79	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.01	Wt. n-Val.		0.013	
W.S. Elev (ft)	59.78	Reach Len. (ft)	155.18	155.18	155.18
Crit W.S. (ft)	59.78	Flow Area (sq ft)		0.00	
E.G. Slope (ft/ft)	0.016275	Area (sq ft)		0.00	
Q Total (cfs)	0.00	Flow (cfs)		0.00	
Top Width (ft)	0.15	Top Width (ft)		0.15	
Vel Total (ft/s)	0.71	Avg. Vel. (ft/s)		0.71	
Max Chl Dpth (ft)	0.02	Hydr. Depth (ft)		0.01	
Conv. Total (cfs)	0.0	Conv. (cfs)		0.0	
Length Wtd. (ft)	155.18	Wetted Per. (ft)		0.16	
Min Ch El (ft)	59.76	Shear (lb/sq ft)			
Alpha	1.00	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.06
C & E Loss (ft)	0.00	Cum SA (acres)	0.04	0.01	0.08

Errors Warnings and Notes

Warning:	The energy equation could not be balanced within the specified number of iterations. The program used critical depth
	for the water surface and continued on with the calculations.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.

Plan: Plan 03 Lower Curtis 1 RS: 370.35 Profile: Q25

E.G. Elev (ft)	59.80	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.01	Wt. n-Val.		0.013	
W.S. Elev (ft)	59.79	Reach Len. (ft)	155.18	155.18	155.18
Crit W.S. (ft)	59.79	Flow Area (sq ft)		0.00	
E.G. Slope (ft/ft)	0.012646	Area (sq ft)		0.00	
Q Total (cfs)	0.00	Flow (cfs)		0.00	
Top Width (ft)	0.22	Top Width (ft)		0.22	
Vel Total (ft/s)	0.79	Avg. Vel. (ft/s)		0.79	
Max Chl Dpth (ft)	0.03	Hydr. Depth (ft)		0.02	
Conv. Total (cfs)	0.0	Conv. (cfs)		0.0	
Length Wtd. (ft)	155.18	Wetted Per. (ft)		0.23	
Min Ch El (ft)	59.76	Shear (lb/sq ft)		0.01	
Alpha	1.00	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.06
C & E Loss (ft)	0.00	Cum SA (acres)	0.04	0.01	0.08

Errors Warnings and Notes (Continued)

	for the water surface and continued on with the calculations.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.

Plan: Plan 03 Lower Curtis 1 RS: 370.35 Profile: Q100

E.G. Elev (ft)	59.81	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.01	Wt. n-Val.		0.013	
W.S. Elev (ft)	59.80	Reach Len. (ft)	155.18	155.18	155.18
Crit W.S. (ft)	59.80	Flow Area (sq ft)		0.00	
E.G. Slope (ft/ft)	0.010047	Area (sq ft)		0.00	
Q Total (cfs)	0.00	Flow (cfs)		0.00	
Top Width (ft)	0.26	Top Width (ft)		0.26	
Vel Total (ft/s)	0.79	Avg. Vel. (ft/s)		0.79	
Max Chl Dpth (ft)	0.04	Hydr. Depth (ft)		0.02	
Conv. Total (cfs)	0.0	Conv. (cfs)		0.0	
Length Wtd. (ft)	155.18	Wetted Per. (ft)		0.27	
Min Ch El (ft)	59.76	Shear (lb/sq ft)		0.01	
Alpha	1.00	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.07
C & E Loss (ft)	0.00	Cum SA (acres)	0.05	0.01	0.10

Errors Warnings and Notes

Warning:	The energy equation could not be balanced within the specified number of iterations. The program used critical depth
	for the water surface and continued on with the calculations.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
	water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
	defaulted to critical depth.

Plan: Plan 03 Lower Curtis 1 RS: 215.17 Profile: Q2

E.G. Elev (ft)	59.01	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.		0.013	
W.S. Elev (ft)	59.01	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	58.90	Flow Area (sq ft)		0.04	
E.G. Slope (ft/ft)	0.000000	Area (sq ft)		0.04	
Q Total (cfs)	0.00	Flow (cfs)		0.00	
Top Width (ft)	0.46	Top Width (ft)		0.46	
Vel Total (ft/s)	0.01	Avg. Vel. (ft/s)		0.01	
Max Chl Dpth (ft)	0.13	Hydr. Depth (ft)		0.10	

Plan: Plan 03 Lower Curtis 1 RS: 215.17 Profile: Q2 (Continued)

Conv. Total (cfs)	0.9	Conv. (cfs)		0.9	
Length Wtd. (ft)	30.00	Wetted Per. (ft)		0.60	
Min Ch El (ft)	58.88	Shear (lb/sq ft)		0.00	
Alpha	1.00	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.02	0.01	0.05
C & E Loss (ft)	0.00	Cum SA (acres)	0.03	0.01	0.07

Errors Warnings and Notes

Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.

Plan: Plan 03 Lower Curtis 1 RS: 215.17 Profile: Q10

E.G. Elev (ft)	59.13	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	
W.S. Elev (ft)	59.13	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	58.90	Flow Area (sq ft)	0.01	0.16	
E.G. Slope (ft/ft)	0.000000	Area (sq ft)	0.01	0.16	
Q Total (cfs)	0.00	Flow (cfs)	0.00	0.00	
Top Width (ft)	1.82	Top Width (ft)	0.44	1.38	
Vel Total (ft/s)	0.01	Avg. Vel. (ft/s)	0.00	0.01	
Max Chl Dpth (ft)	0.25	Hydr. Depth (ft)	0.02	0.12	
Conv. Total (cfs)	3.8	Conv. (cfs)	0.1	3.7	
Length Wtd. (ft)	30.00	Wetted Per. (ft)	0.44	1.84	
Min Ch El (ft)	58.88	Shear (lb/sq ft)	0.00	0.00	
Alpha	1.05	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.06
C & E Loss (ft)	0.00	Cum SA (acres)	0.04	0.01	0.08

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.

Plan: Plan 03 Lower Curtis 1 RS: 215.17 Profile: Q25

E.G. Elev (ft)	59.20	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.20	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	58.91	Flow Area (sq ft)	0.06	0.25	0.02
E.G. Slope (ft/ft)	0.000000	Area (sq ft)	0.06	0.25	0.02

Plan: Plan 03 Lower Curtis 1 RS: 215.17 Profile: Q25 (Continued)

Q Total (cfs)	0.00	Flow (cfs)	0.00	0.00	0.00
Top Width (ft)	3.75	Top Width (ft)	1.24	1.39	1.13
Vel Total (ft/s)	0.01	Avg. Vel. (ft/s)	0.01	0.01	0.00
Max Chl Dpth (ft)	0.32	Hydr. Depth (ft)	0.05	0.18	0.02
Conv. Total (cfs)	8.1	Conv. (cfs)	0.9	7.1	0.1
Length Wtd. (ft)	30.00	Wetted Per. (ft)	1.24	1.99	1.13
Min Ch El (ft)	58.88	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.23	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.06
C & E Loss (ft)	0.00	Cum SA (acres)	0.04	0.01	0.08

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.

Plan: Plan 03 Lower Curtis 1 RS: 215.17 Profile: Q100

E.G. Elev (ft)	59.28	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.28	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	58.92	Flow Area (sq ft)	0.22	0.37	0.24
E.G. Slope (ft/ft)	0.000000	Area (sq ft)	0.22	0.37	0.24
Q Total (cfs)	0.00	Flow (cfs)	0.00	0.00	0.00
Top Width (ft)	7.63	Top Width (ft)	2.36	1.39	3.88
Vel Total (ft/s)	0.00	Avg. Vel. (ft/s)	0.00	0.01	0.00
Max Chl Dpth (ft)	0.40	Hydr. Depth (ft)	0.09	0.27	0.06
Conv. Total (cfs)	19.9	Conv. (cfs)	5.0	13.1	1.8
Length Wtd. (ft)	30.00	Wetted Per. (ft)	2.37	2.17	3.88
Min Ch El (ft)	58.88	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.64	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.07
C & E Loss (ft)	0.00	Cum SA (acres)	0.04	0.01	0.09

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.

Plan: Plan 03 Lower Curtis 1 RS: 185.17 Profile: Q2

E.G. Elev (ft)	59.01	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.01	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	58.84	Flow Area (sq ft)	0.06	0.40	3.45
E.G. Slope (ft/ft)	0.000023	Area (sq ft)	0.06	0.40	3.45
Q Total (cfs)	0.32	Flow (cfs)	0.00	0.08	0.24
Top Width (ft)	24.80	Top Width (ft)	1.21	1.89	21.70
Vel Total (ft/s)	0.08	Avg. Vel. (ft/s)	0.07	0.19	0.07
Max Chl Dpth (ft)	0.32	Hydr. Depth (ft)	0.05	0.21	0.16
Conv. Total (cfs)	66.8	Conv. (cfs)	1.0	16.2	49.7
Length Wtd. (ft)	30.00	Wetted Per. (ft)	1.21	1.92	21.99
Min Ch El (ft)	58.69	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.89	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.02	0.01	0.05
C & E Loss (ft)	0.00	Cum SA (acres)	0.03	0.01	0.06

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid, energy was used.

Plan: Plan 03 Lower Curtis 1 RS: 185.17 Profile: Q10

E.G. Elev (ft)	59.13	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.13	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	58.87	Flow Area (sq ft)	0.30	0.63	6.10
E.G. Slope (ft/ft)	0.000011	Area (sq ft)	0.30	0.63	6.10
Q Total (cfs)	0.56	Flow (cfs)	0.03	0.11	0.42
Top Width (ft)	26.25	Top Width (ft)	2.66	1.89	21.70
Vel Total (ft/s)	0.08	Avg. Vel. (ft/s)	0.09	0.18	0.07
Max Chl Dpth (ft)	0.44	Hydr. Depth (ft)	0.11	0.33	0.28
Conv. Total (cfs)	170.4	Conv. (cfs)	7.9	34.5	128.1
Length Wtd. (ft)	30.00	Wetted Per. (ft)	2.67	1.92	22.11
Min Ch El (ft)	58.69	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.64	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.05
C & E Loss (ft)	0.00	Cum SA (acres)	0.04	0.01	0.07

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.

Errors Warnings and Notes (Continued)

	This may indicate the need for additional cross sections.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid, energy was used.

Plan: Plan 03 Lower Curtis 1 RS: 185.17 Profile: Q25

E.G. Elev (ft)	59.20	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.20	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	58.89	Flow Area (sq ft)	0.49	0.75	7.44
E.G. Slope (ft/ft)	0.000009	Area (sq ft)	0.49	0.75	7.44
Q Total (cfs)	0.70	Flow (cfs)	0.04	0.13	0.52
Top Width (ft)	26.99	Top Width (ft)	3.40	1.89	21.70
Vel Total (ft/s)	0.08	Avg. Vel. (ft/s)	0.09	0.18	0.07
Max Chl Dpth (ft)	0.51	Hydr. Depth (ft)	0.14	0.40	0.34
Conv. Total (cfs)	238.9	Conv. (cfs)	15.1	45.8	178.1
Length Wtd. (ft)	30.00	Wetted Per. (ft)	3.41	1.92	22.17
Min Ch El (ft)	58.69	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.59	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.06
C & E Loss (ft)	0.00	Cum SA (acres)	0.04	0.01	0.07

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid, energy was used.

Plan: Plan 03 Lower Curtis 1 RS: 185.17 Profile: Q100

E.G. Elev (ft)	59.28	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.28	Reach Len. (ft)	30.00	30.00	30.00
Crit W.S. (ft)	58.91	Flow Area (sq ft)	0.83	0.91	9.34
E.G. Slope (ft/ft)	0.000006	Area (sq ft)	0.83	0.91	9.34
Q Total (cfs)	0.88	Flow (cfs)	0.08	0.16	0.64
Top Width (ft)	28.03	Top Width (ft)	4.44	1.89	21.70
Vel Total (ft/s)	0.08	Avg. Vel. (ft/s)	0.09	0.17	0.07
Max Chl Dpth (ft)	0.59	Hydr. Depth (ft)	0.19	0.48	0.43
Conv. Total (cfs)	354.1	Conv. (cfs)	30.8	63.8	259.5
Length Wtd. (ft)	30.00	Wetted Per. (ft)	4.46	1.92	22.26
Min Ch El (ft)	58.69	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.53	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.07

Plan: Plan 03 Lower Curtis 1 RS: 185.17 Profile: Q100 (Continued)

C & E Loss (ft)	0.00	Cum SA (acres)	0.04	0.01	0.08

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid, energy was used.

Plan: Plan 03 Lower Curtis 1 RS: 155.17 Profile: Q2

E.G. Elev (ft)	59.01	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.01	Reach Len. (ft)	142.82	142.82	142.82
Crit W.S. (ft)		Flow Area (sq ft)	0.58	0.53	0.90
E.G. Slope (ft/ft)	0.000037	Area (sq ft)	0.58	0.53	0.90
Q Total (cfs)	0.32	Flow (cfs)	0.12	0.14	0.07
Top Width (ft)	12.54	Top Width (ft)	3.61	1.39	7.54
Vel Total (ft/s)	0.16	Avg. Vel. (ft/s)	0.20	0.26	0.07
Max Chl Dpth (ft)	0.52	Hydr. Depth (ft)	0.16	0.38	0.12
Conv. Total (cfs)	52.6	Conv. (cfs)	19.3	22.3	10.9
Length Wtd. (ft)	142.82	Wetted Per. (ft)	3.64	2.40	7.54
Min Ch El (ft)	58.49	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.75	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.02	0.01	0.04
C & E Loss (ft)	0.00	Cum SA (acres)	0.03	0.01	0.05

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.

Plan: Plan 03 Lower Curtis 1 RS: 155.17 Profile: Q10

E.G. Elev (ft)	59.13	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.13	Reach Len. (ft)	142.82	142.82	142.82
Crit W.S. (ft)		Flow Area (sq ft)	1.07	0.70	2.09
E.G. Slope (ft/ft)	0.000024	Area (sq ft)	1.07	0.70	2.09
Q Total (cfs)	0.56	Flow (cfs)	0.24	0.16	0.15
Top Width (ft)	18.32	Top Width (ft)	4.55	1.39	12.37
Vel Total (ft/s)	0.14	Avg. Vel. (ft/s)	0.23	0.23	0.07
Max Chl Dpth (ft)	0.64	Hydr. Depth (ft)	0.23	0.51	0.17
Conv. Total (cfs)	114.5	Conv. (cfs)	49.6	33.2	31.7

Plan: Plan 03 Lower Curtis 1 RS: 155.17 Profile: Q10 (Continued)

Length Wtd. (ft)	142.82	Wetted Per. (ft)	4.81	2.65	12.38
Min Ch El (ft)	58.49	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.87	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.05
C & E Loss (ft)	0.00	Cum SA (acres)	0.03	0.01	0.06

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.

Plan: Plan 03 Lower Curtis 1 RS: 155.17 Profile: Q25

E.G. Elev (ft)	59.20	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.19	Reach Len. (ft)	142.82	142.82	142.82
Crit W.S. (ft)		Flow Area (sq ft)	1.37	0.79	2.95
E.G. Slope (ft/ft)	0.000020	Area (sq ft)	1.37	0.79	2.95
Q Total (cfs)	0.70	Flow (cfs)	0.31	0.17	0.22
Top Width (ft)	22.13	Top Width (ft)	5.26	1.39	15.48
Vel Total (ft/s)	0.14	Avg. Vel. (ft/s)	0.23	0.22	0.07
Max Chl Dpth (ft)	0.70	Hydr. Depth (ft)	0.26	0.57	0.19
Conv. Total (cfs)	157.3	Conv. (cfs)	69.7	39.1	48.5
Length Wtd. (ft)	142.82	Wetted Per. (ft)	5.65	2.77	15.48
Min Ch El (ft)	58.49	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.94	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.06
C & E Loss (ft)	0.00	Cum SA (acres)	0.04	0.01	0.06

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.

Plan: Plan 03 Lower Curtis 1 RS: 155.17 Profile: Q100

E.G. Elev (ft)	59.28	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.28	Reach Len. (ft)	142.82	142.82	142.82
Crit W.S. (ft)		Flow Area (sq ft)	1.88	0.91	4.51
E.G. Slope (ft/ft)	0.000014	Area (sq ft)	1.88	0.91	4.51
Q Total (cfs)	0.88	Flow (cfs)	0.39	0.18	0.31
Top Width (ft)	27.56	Top Width (ft)	6.30	1.39	19.87

Plan: Plan 03 Lower Curtis 1 RS: 155.17 Profile: Q100 (Continued)

Vel Total (ft/s)	0.12	Avg. Vel. (ft/s)	0.21	0.20	0.07
Max Chl Dpth (ft)	0.79	Hydr. Depth (ft)	0.30	0.66	0.23
Conv. Total (cfs)	235.6	Conv. (cfs)	105.0	47.7	83.0
Length Wtd. (ft)	142.82	Wetted Per. (ft)	6.86	2.95	19.88
Min Ch El (ft)	58.49	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.98	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.03	0.01	0.06
C & E Loss (ft)	0.00	Cum SA (acres)	0.04	0.01	0.07

Errors Warnings and Notes

Warning:	Divided flow computed for this cross-section.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
	This may indicate the need for additional cross sections.

Plan: Plan 03 Lower Curtis 1 RS: 12.35 Profile: Q2

E.G. Elev (ft)	59.01	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.01	Reach Len. (ft)	18.10	18.10	18.10
Crit W.S. (ft)		Flow Area (sq ft)	11.34	2.44	22.44
E.G. Slope (ft/ft)	0.000000	Area (sq ft)	11.34	2.44	22.44
Q Total (cfs)	0.65	Flow (cfs)	0.27	0.06	0.32
Top Width (ft)	40.00	Top Width (ft)	16.41	1.89	21.70
Vel Total (ft/s)	0.02	Avg. Vel. (ft/s)	0.02	0.02	0.01
Max Chl Dpth (ft)	1.62	Hydr. Depth (ft)	0.69	1.29	1.03
Conv. Total (cfs)	2278.6	Conv. (cfs)	960.1	208.9	1109.6
Length Wtd. (ft)	18.10	Wetted Per. (ft)	17.80	3.75	22.50
Min Ch El (ft)	57.39	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.23	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.00	0.00	0.01
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.

Plan: Plan 03 Lower Curtis 1 RS: 12.35 Profile: Q10

E.G. Elev (ft)	59.13	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.13	Reach Len. (ft)	18.10	18.10	18.10
Crit W.S. (ft)		Flow Area (sq ft)	13.35	2.67	25.10
E.G. Slope (ft/ft)	0.000000	Area (sq ft)	13.35	2.67	25.10

Plan: Plan 03 Lower Curtis 1 RS: 12.35 Profile: Q10 (Continued)

Q Total (cfs)	1.13	Flow (cfs)	0.50	0.10	0.53
Top Width (ft)	40.00	Top Width (ft)	16.41	1.89	21.70
Vel Total (ft/s)	0.03	Avg. Vel. (ft/s)	0.04	0.04	0.02
Max Chl Dpth (ft)	1.74	Hydr. Depth (ft)	0.81	1.41	1.16
Conv. Total (cfs)	2830.2	Conv. (cfs)	1254.6	243.1	1332.5
Length Wtd. (ft)	18.10	Wetted Per. (ft)	17.92	3.75	22.62
Min Ch El (ft)	57.39	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.26	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.00	0.00	0.01
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.

Plan: Plan 03 Lower Curtis 1 RS: 12.35 Profile: Q25

E.G. Elev (ft)	59.19	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.19	Reach Len. (ft)	18.10	18.10	18.10
Crit W.S. (ft)		Flow Area (sq ft)	14.37	2.79	26.44
E.G. Slope (ft/ft)	0.000000	Area (sq ft)	14.37	2.79	26.44
Q Total (cfs)	1.40	Flow (cfs)	0.63	0.12	0.65
Top Width (ft)	40.00	Top Width (ft)	16.41	1.89	21.70
Vel Total (ft/s)	0.03	Avg. Vel. (ft/s)	0.04	0.04	0.02
Max Chl Dpth (ft)	1.80	Hydr. Depth (ft)	0.88	1.47	1.22
Conv. Total (cfs)	3126.5	Conv. (cfs)	1414.5	261.1	1450.9
Length Wtd. (ft)	18.10	Wetted Per. (ft)	17.98	3.75	22.68
Min Ch El (ft)	57.39	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.27	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.00	0.00	0.01
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.

Plan: Plan 03 Lower Curtis 1 RS: 12.35 Profile: Q100

E.G. Elev (ft)	59.28	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.013	0.013	0.030
W.S. Elev (ft)	59.28	Reach Len. (ft)	18.10	18.10	18.10
Crit W.S. (ft)		Flow Area (sq ft)	15.81	2.95	28.35

Plan: Plan 03 Lower Curtis 1 RS: 12.35 Profile: Q100 (Continued)

E.G. Slope (ft/ft)	0.000000	Area (sq ft)	15.81	2.95	28.35
Q Total (cfs)	1.76	Flow (cfs)	0.82	0.14	0.80
Top Width (ft)	40.00	Top Width (ft)	16.41	1.89	21.70
Vel Total (ft/s)	0.04	Avg. Vel. (ft/s)	0.05	0.05	0.03
Max Chl Dpth (ft)	1.89	Hydr. Depth (ft)	0.96	1.56	1.31
Conv. Total (cfs)	3565.5	Conv. (cfs)	1653.1	287.5	1624.9
Length Wtd. (ft)	18.10	Wetted Per. (ft)	18.07	3.75	22.77
Min Ch El (ft)	57.39	Shear (lb/sq ft)	0.00	0.00	0.00
Alpha	1.28	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.00	0.00	0.01
C & E Loss (ft)	0.01	Cum SA (acres)			

Errors Warnings and Notes

Warning:	The cross-section end points had to be extended vertically for the computed water surface.

PIPE-BASED DRAINAGE SCENARIOS FOR HEARST AVE. PROJECT AND TOPOGRAPHIC DEPRESSION

Compute pipe discharge capacities for possible subsurface drainage of Hearst Ave. Project site:

For pipe flow: use Manning formula for full flow
Q=vA

Peak Q10 for Subwatersheds A + B= 3.65 cfs
Peak Q25 for Subwatersheds A + B= 4.51 cfs

v= (0.59/n)*(D^0.67)* (S^0.5)   where: n= pipe hydraulic roughness   (King et al. 1949)
D= pipe diameter, ft.
S= pipe slope, ft/ft.   (for east boundary to Hearst Ave. outlet, S= 0.008)

For 4-inch, smooth wall pipe:

n=	0.011	
D=	0.33	ft.
S=	0.008	ft/ft.
A=	0.085541	

v= 2.282489
Q= 0.195246

Therefore, for 2@ 4-inch pipes, total capacity= 0.4 cfs, which is insufficient for site stormwater evacuation.

Try 6-inch, smooth wall pipe:

D=	0.5	ft.
S=	0.008	ft/ft.
A=	0.196375	

v= 3.015187
Q= 0.592107

Therefore, for 2@ 6-inch pipes, total capacity= 1.18 cfs, still insufficient for site stormwater evacuation.

Also, 6-inch pipes will not fit physically between the sidewalk and 10-yr. HGL

Thus, analyze the potential for a shallow surface swale or various configurations (see FlowMaster computations).

Channel Report

<Name>

Rectangular

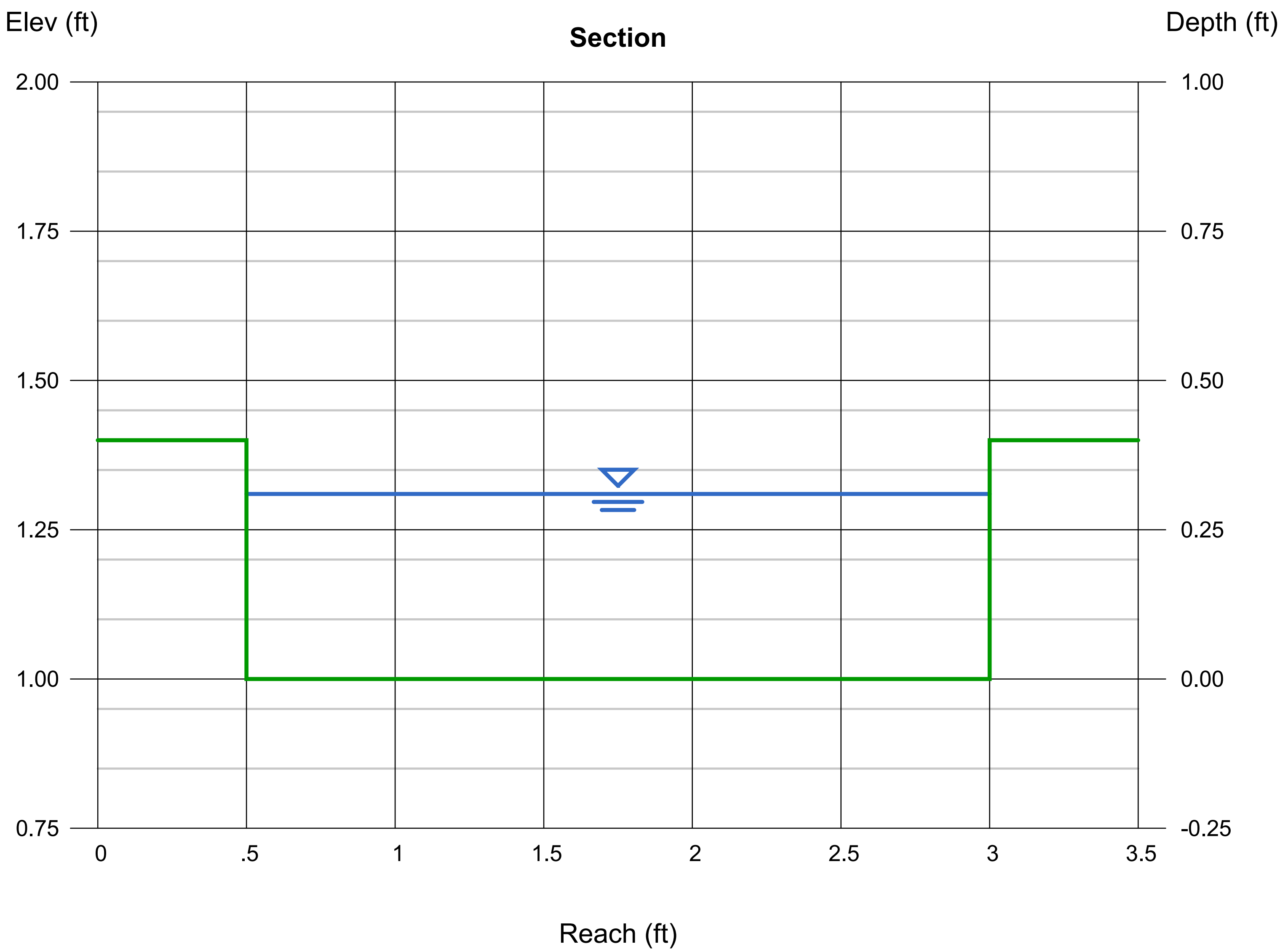
Bottom Width (ft)	=	2.50
Total Depth (ft)	=	0.40
Invert Elev (ft)	=	1.00
Slope (%)	=	0.80
N-Value	=	0.011

Calculations

Compute by:		Known Q
Known Q (cfs)	=	3.65

Highlighted

Depth (ft)	=	0.31
Q (cfs)	=	3.650
Area (sqft)	=	0.77
Velocity (ft/s)	=	4.71
Wetted Perim (ft)	=	3.12
Crit Depth, Yc (ft)	=	0.40
Top Width (ft)	=	2.50
EGL (ft)	=	0.65



Channel Report

<Name>

Trapezoidal

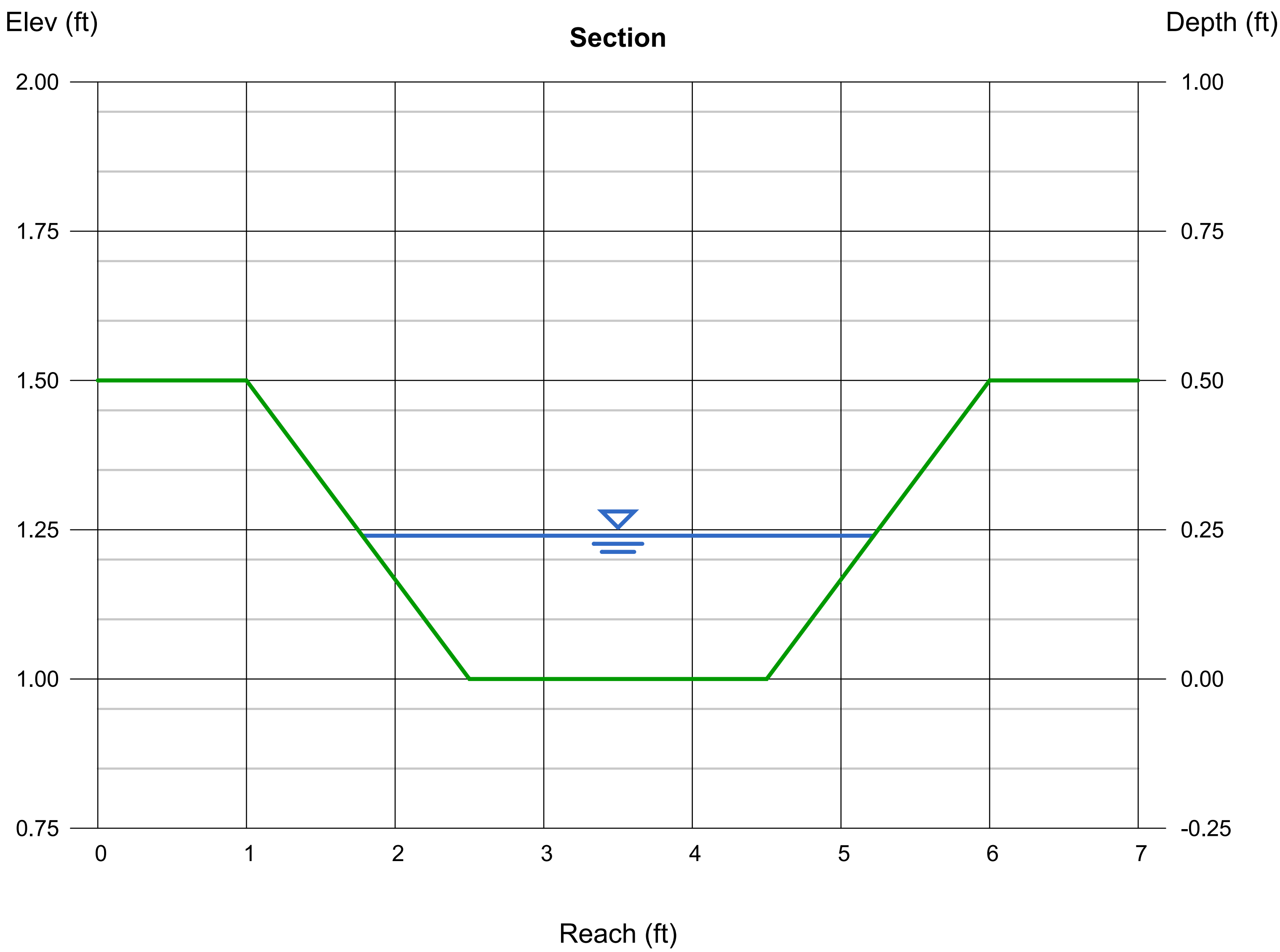
Bottom Width (ft)	= 2.00
Side Slopes (z:1)	= 3.00, 3.00
Total Depth (ft)	= 0.50
Invert Elev (ft)	= 1.00
Slope (%)	= 1.00
N-Value	= 0.027

Calculations

Compute by:	Known Q
Known Q (cfs)	= 1.13

Highlighted

Depth (ft)	= 0.24
Q (cfs)	= 1.130
Area (sqft)	= 0.65
Velocity (ft/s)	= 1.73
Wetted Perim (ft)	= 3.52
Crit Depth, Yc (ft)	= 0.20
Top Width (ft)	= 3.44
EGL (ft)	= 0.29



HEARST AVE. PROJECT: PRE- VS. POST-PROJECT PEAK DISCHARGE COMPUTATIONS FOR PROJECT WATERSHED

Alameda County Flood Control & Water Conservation District. Hydrology and Hydraulics Manual 2016

Q= C'iA
where C= runoff coeff.;
i= rainfall intensity at duration equal to Tc;
A= drainage area, ac.

A= 21,673 sf 0.5 acre

	Watershed Impervious Area	
	Exist.	Post-Project
Sq Ft	10,495.00	10,892.00
Acres	0.2409	0.2500
% Imperv.	0.48	0.50
% Incr.		0.02

For Site Watershed Existing Condition

Total Area	0.50	Acres		
Longest path	311.00	feet	[NE corner to NW corner, then south to SW prop. Corner]	
Slope	0.80	%	(55.81-53.32)/311	ft/ft

a)Computing Time of Concentration, Tc

roof to gutter time

10 yr recurrence interval 5 minutes
100 yr recurrence interval 5 minutes

Overland flow = 311.00 ft slope = 0.80
Velocity= 0.75 ft/sec

10 yr recurrence interval 6.91 minutes
100 yr recurrence interval 6.91 minutes

Time of concentration Tc=

10 yr recurrence interval	11.91	minutes
100 yr recurrence interval	11.91	minutes

b) Precipitation intensity, i

10 yr recurrence interval	2.34	in/hr
100 yr recurrence interval	3.52	in/hr

C)Runoff Coeff., C **Base Runoff**

		Impervious Area	
10 yr recurrence interval, C	0.43	**10 yr recurrence interval, C**	0.9
100 yr recurrence interval, C	0.43	**100 yr recurrence interval, C**	0.9

Composite C

10 yr recurrence interval, C **0.66**
100 yr recurrence interval, C **0.66**

Ground Slope Adjustment

10 yr recurrence interval, C	0
100 yr recurrence interval, C	0

Rainfall Intensity Factor

10 yr recurrence interval, C	0.03
100 yr recurrence interval, C	0.05

Total

10 yr recurrence interval, C	0.69
100 yr recurrence interval, C	0.71

Q=CiA

10 yr recurrence interval, C	0.81	cfs
100 yr recurrence interval, C	1.25	cfs

For Site Watershed Post-Project Condition

Total Area	**0.50**	**Acres**		
Longest path	314.00	feet	[NE corner to rear of 1173 bldg., west to w. bdy, then south to SW prop. corner]	
Slope	0.8	%	(55.81-53.32)/314	ft/ft

a)Computing Time of Concentration, Tc

roof to gutter time

10 yr recurrence interval	5	minutes
100 yr recurrence interval	5	minutes

Overland flow = 314.00 ft slope =

Velocity=	0.75	ft/sec
10 yr recurrence interval	6.98	minutes
100 yr recurrence interval	6.98	minutes

Time of concentration Tc=

10 yr recurrence interval	11.98	minutes
100 yr recurrence interval	11.98	minutes

HEARST AVE. PROJECT: PRE- VS. POST-PROJECT PEAK DISCHARGE COMPUTATIONS FOR PROJECT WATERSHED

b) Precipitation intensity, i

Tc=12

10 yr recurrence interval	2.35	in/hr
100 yr recurrence interval	3.5	in/hr

C)Runoff Coeff., C

Base Runoff

		Impervious Area	
10 yr recurrence interval, C	0.43	**10 yr recurrence interval, C**	0.9
100 yr recurrence interval, C	0.43	**100 yr recurrence interval, C**	0.9

Composite C

10 yr recurrence interval, C	**0.67**
100 yr recurrence interval, C	**0.67**

Ground Slope Adjustment

10 yr recurrence interval, C	0
100 yr recurrence interval, C	0

Rainfall Intensity Factor

10 yr recurrence interval, C	0.03
100 yr recurrence interval, C	0.05

Total

10 yr recurrence interval, C	0.70	
100 yr recurrence interval, C	0.71	**0.01**

Q=CiA

10 yr recurrence interval, C	0.82	cfs
100 yr recurrence interval, C	1.25	cfs

HEARST AVE. PROJECT: VOLUMETRIC STORAGE REQUIRED TO MAINTAIN EXISTING SITE PEAK DISCHARGE- DESIGN Q10 RAINSTORM

Compute volumetric storage requirement for project modification of 10-yr. design rainstorm hydrograph:

Assume SCS triangular synthetic hydrograph:

Tp= hydrograph time to peak, min. =	0.6 Tc+0.5 D	where Tc= time of concentration for runoff, D= duration of rainfall
Tr= hydrograph recession time, min.=	1.67 Tp	excess for current analysis, D= Tc
Tb= hydrograph base time= Tp + Tr		

From Site Pre- vs. Post-Project Peak Discharge Computations:

D= 11.91 min.	for Q10 under existing conditions	(Note: there was no difference in the pre- vs. post
D= 11.98 min.	for Q10 under post-Project conditions	Q100 peak discharges.)

For existing condition:			For post-Project condition:	
Tp=	13.1	min.	Tp=	13.2
Tr=	21.9	min.	Tr=	22.0
Tb=	35.0	min.	Tb=	35.2

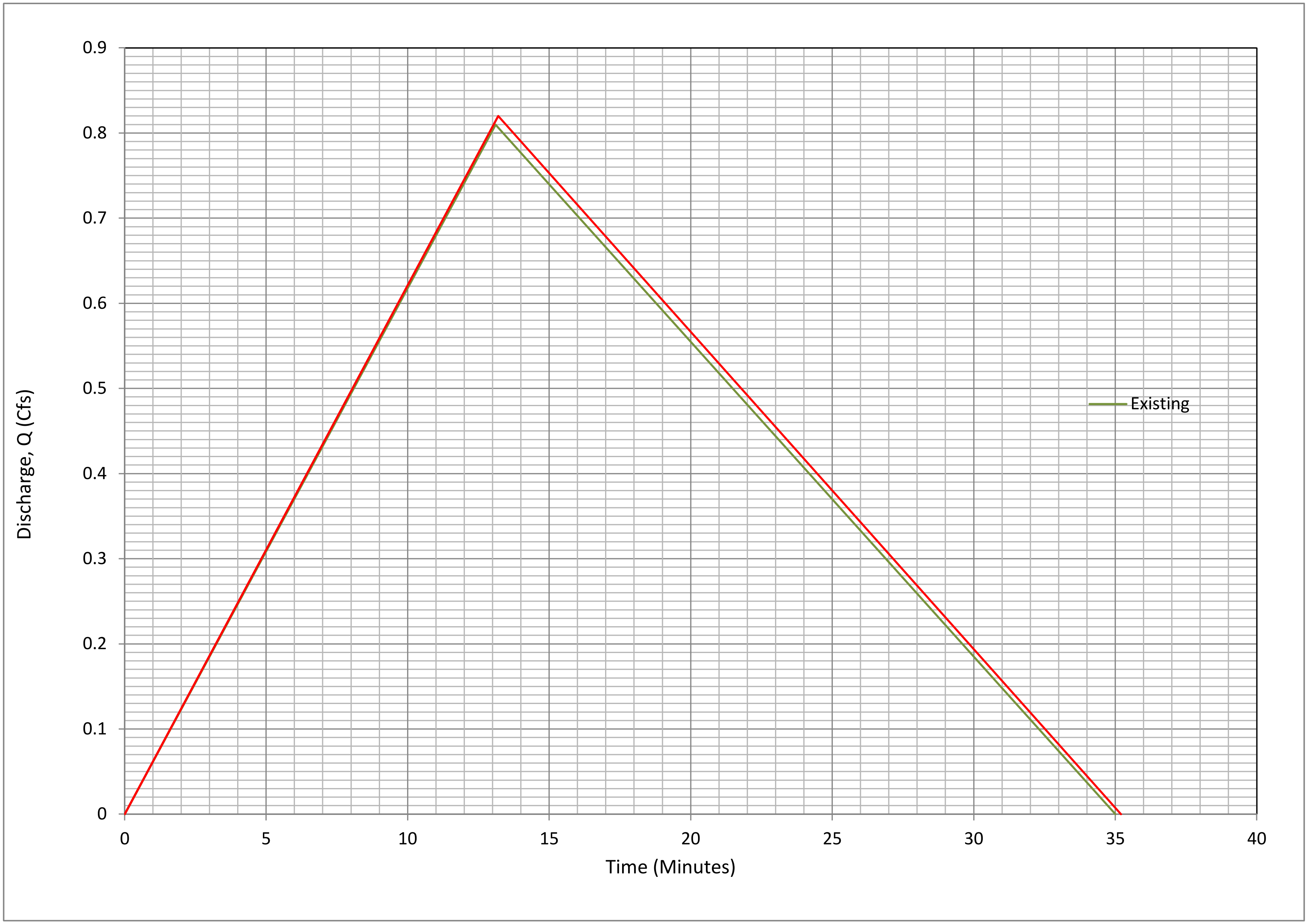
See superimposed hydrographs below for surcharge volume required to maintain existing Q10 peak discharge:

Volume of runoff:	ft^3	Gal		Gal
Exist Condition	850.0	6358.045	Increase Runoff	116.3
Post project	865.6	6474.369		

Volume of storage required= 116 gal

This volume can be captured and detained during runoff events by a rain cistern attached to the roof gutter of one of the Project buildings.

HEARST AVE. PROJECT: VOLUMETRIC STORAGE REQUIRED TO MAINTAIN EXISTING
SITE PEAK DISCHARGE AND RUNOFF VOLUME- DESIGN Q10 RAINSTORM



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March 16, 2017

Ms. Leslie Mendez
Land Use Planning Division
City of Berkeley
1947 Center Street, 3rd Floor
Berkeley, California 94704

RE: Peer Review of the Stormwater and Flooding Assessment for the Hearst Avenue Project, City of Berkeley

Dear Ms. Mendez:

Thank you again for contacting Balance Hydrologics regarding peer review of the drainage analyses completed for the proposed Hearst Avenue Project ("Project"). Specifically, you have requested a review of the document titled "Stormwater and Flooding Assessment and Mitigation Design for the Hearst Avenue Project, 1161 – 1173 Hearst Avenue, Berkeley, CA" prepared by Clearwater Hydrology and dated January 7, 2016. I have completed my review of the Project document (herein, "report"), and this letter summarizes my observations and comments related to the information presented therein.

Overall, the document presents a good discussion and supporting analyses related to the stormwater management issues pertinent to the site in question. Perhaps most notably, it acknowledges the impaired drainage conditions at the site and neighboring properties, such as flooding at the back of adjacent lots off Curtis Street. The drainage design explicitly pursues solutions that would avoid worsening those conditions, with the potential to improve them as well.

Peer Review Comments

The following comments relate to clarifications or additional information that should be provided to assure that the proposed project has fully addressed the pertinent issues and requirements for stormwater management.

1. *Soil Characteristics and Depth to Groundwater*. The report acknowledges (Section 2.3) that information on soil properties and depth to groundwater had not been collected. However, both parameters will be important in the ultimate design of the site facilities. Absent specific information the report should be clear on use of the published soil survey data for the site, which identifies the soils as essentially completely Urban Land – Tierra Complex falling in Hydrologic Soil Group D (highest runoff potential). If information on seasonal high

groundwater data is not available, then the drainage design should proceed under the assumption that high groundwater conditions will prevail.

2. *Design Guidance*. The report relies almost exclusively on generalized urban drainage design parameters provided in the U.S. Geological Survey Open-File Report authored by Rantz in 1971. Though I acknowledge the past value of this document in providing a standardized design framework for urban drainage systems in the Bay Area, the project report does not clearly establish reasoning for not using more up-to-date and specific design guidance at this site. Absent specific information from the City of Berkeley, the Hydrology and Hydraulics Manual prepared by the Alameda County Flood Control and Water Conservation District ("ACFC") provides a more detailed and current calculational framework, particularly for the rational method runoff calculations that are presented. The following items are of particular note:

    a. Runoff Coefficients. Back-checks of the runoff coefficients from Rantz versus those used by ACFC show that the latter will generally be higher and therefore indicate a higher peak flow potential than currently presented in the report.

    b. Impervious Cover. Directly associated with the above, the calculations in the Technical Appendix appear to use land use classifications from Rantz such as "medium density residential" that are called out as 25% impervious cover. This would appear to significantly underestimate the actual impervious cover in the respective sub-watersheds, particularly those such as Sub-Watershed B which are largely street surfaces. In such cases, a composite runoff coefficient approach should be considered.

    c. Time of Concentration. The project site itself comprises a part of the identified Sub-Watershed A. The calculations in the Appendix (pdf page 29) give a time of concentration of 20 minutes for that Sub-Watershed for the 10-year design condition. However, calculations later in the Appendix for the project site itself yield an existing condition time of concentration of 27 minutes (pdf page 72). The calculations need to be reviewed, as it is difficult to reconcile how a smaller sub-area can have a higher time of concentration in this case.

    d. Rainfall Intensity. Back-checks of the rainfall intensity for a given time of concentration show that values from the ACFC manual are consistently higher (by 30% or more) than those used from Rantz, calling into question whether the analyses are sufficiently conservative.

3. *HEC-RAS Modeling and Overflow from Curtis*. HEC-RAS modeling was apparently completed, in part, to provide insight into the amount of gutter flow that might overtop driveways along Curtis Street and therefore ultimately result in run-on to the project site. The completed model would appear to have sufficient information to use the predicted flow depths to calculate peak overflow rates, which could be quite large. However, the report states that a conservative assumption is that only the Sub-Watershed B runoff flows through the yards along Curtis to reach the east side of the project, and it is that relatively low flow rate which is used to inform the drainage channel sizing. The report should be revised to clarify why potentially even larger backflows from upper Hearst Avenue are not to be expected or to include provision for larger on-site conveyance capacity.

4. *Project Drainage*. Section 3 of the report and the Appendix present options for draining the depressed site topography out to Hearst Avenue and identify a grated rectangular channel and a gravel swale at the primary stormwater conveyance facilities. It is understood that the site topography imposes significant constraints on the use of piped drainage. However, the calculations presented in the Appendix use a Manning's roughness coefficient of 0.011, a very low value for a gravel lined conveyance. The low roughness values will need to be justified or these calculations (and the conveyance channel dimensions) will need to be updated to use more conservative roughness values.

5. *Changes in Peak Flow*. As noted previously, the report is commendable for considering the impaired drainage conditions existing along the eastern boundary (flooding depths of up to 12 inches in adjoining yards). However, the report concludes that there will be no increase in peak discharge from the site for the 100-year event and only a small (0.02 cfs) increase for the 10-year event. This conclusion should be reviewed in light of the following:

   a. Loss of De Facto Detention Storage. The report states that site grading and drainage enhancements are such that flooding depths on adjacent properties may be lowered by as much as 6 inches (pdf page 10). The flooding of the neighboring properties, though an acknowledged problem, almost certainly represents de facto detention storage that modulates peak flow rates out to Hearst Avenue, as does the cited impaired side lot drainage from the project property itself. The report should be revised to directly address how reduced flooding depths and more efficient on-site conveyance can be accomplished without increasing peak flow rates to Hearst Avenue and/or how any increases are acceptable in the downstream drainage system.

   b. Post-project Impervious Cover. Central to the report's conclusion related to minimal increase in peak flow is a small (1.8%) increase in impervious cover compared to pre-project conditions. However, this value is achieved by completely discounting the contribution from driveways, parking areas, and walkways, which are proposed to be constructed of pervious paving or brick pavers. Such pervious surface treatments are definite improvements from traditional asphalt and concrete surfaces. However, given the low soil permeability and potential high ground levels, the report should be revised to substantiate the conclusion that those surfaces can indeed be discounted entirely in the rational method calculations of peak flow.

6. *C.3 Compliance*. The report appropriately cites the Alameda County C.3 Guidance as a source of design information for stormwater quality management at the site. The proposed bioretention planters are an excellent approach to meeting the pertinent requirements for roof runoff. However, it should be noted that, per the C.3 Guidance, pervious pavement surfaces overlying low permeability soils can only be considered self-treating if underlain by a course of sub-grade material sufficient to store the required treatment volume. The report should be revised to acknowledge this constraint and confirm that such an under-course could be actively drained out to Hearst Avenue.

Closing

Thank you again for the opportunity to provide peer review comments related to stormwater management for the Hearst Avenue Project. Though the site presents several challenges, it appears that the major issues are being addressed, subject to the recommended additional information needs I have noted.

Do not hesitate to contact us if you have questions related to the scope of my review or the conclusions presented herein.

Sincerely,

BALANCE HYDROLOGICS, Inc.

Edward D. Ballman, P.E. 64095
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
EDWARD D. BALLMAN
No. C 64095
Exp. 09/30/2018
STATE OF CALIFORNIA

Mendez, Leslie

From:	Mia Perkins <mia@rhoadesplanninggroup.com>
Sent:	Wednesday, October 16, 2019 2:52 PM
To:	rain.sussman@gmail.com; vcv@sbcglobal.net
Cc:	Mark Rhoades; Mendez, Leslie
Subject:	1155-1173 Hearst Avenue Hydrology and Geotechnical analyses

Dear Rain and Vijay,

Yesterday RPG submitted supplemental hydrology and geotechnical analyses to the City, along with the previous reports that correspond to the supplemental report. The file is pretty large (22MB), so I can email it to you via dropbox if that works for you, or we can mail you a thumb drive if that is better. It is likely that the City will post it to the project website in a day or two. Please let me know what you'd prefer.

We asked the hydrologist to directly address the issue of Curtis Street flooding in his supplemental report, as it has been presented by Dr. Paz at several meetings. You will note that on Page 6 of Clearwater Hydrology's supplemental report, dated October 9, 2019, it is explained, regarding Curtis Street backyard flooding:

"The CH design recognized this existing impediment to more efficient drainage along the Curtis Street backyard areas and developed a solution that would provide for construction of a surface drainage channel to capture and drain off roughly 50% of the ponded water during higher recurrence interval (i.e. more intense) rainstorms."

The report shows the drainage diagram and explains how it will benefit the Curtis Street neighbors.

Please let us know if you have any questions.

Thank you,
Mia

Mia Perkins
RhoadesPlanningGroup
510.545.4341

CLEARWATER HYDROLOGY

Consultants in Hydrology and Water Resources

Watershed Management

Stream and Wetland Restoration

Wetland Delineation and Permit Acquisition

Stormwater Drainage and Flooding

2974 Adeline St.
Berkeley, CA 94703
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Nov. 4, 2019

Mark Rhoades
Hearst Avenue Cottages LLC
Oakland, CA

RE: Supplemental Discussion of Hydrologic and Hydraulic Concerns Raised by Terraphase Engineering- Proposed Hearst Gardens Residential Project, 1161-1173 Hearst. Ave., Berkeley,
CA

Dear Mark,

In 2016-2017, Clearwater Hydrology evaluated the hydrology of the project site and adjoining areas that contribute surface runoff to the Hearst Avenue corridor west of Sacramento Street in Berkeley. We also modeled the hydraulic behavior of storm flows as they accumulate along Hearst Avenue and Curtis Street to the east of the site and are conveyed west toward storm drain system inlets at San Pablo Avenue. Our final results were detailed in our design report, entitled: "Stormwater and Flooding Assessment and Mitigation Design for the Hearst Avenue Project, 1161-1173 Hearst Ave., Berkeley, CA, July 12, 2017". An earlier version of our report, submitted in January of 2016, was reviewed by Lucas Paz, PhD, of Terraphase Engineering. The Draft Technical Memorandum from Terraphase presenting preliminary review comments was submitted to Rain and Guy Sussman of 1824 Curtis Street on Feb. 19, 2016.

Subsequent to our final report, Dr. Paz has appeared at one or more City hearings and expressed his technical opinions and concerns regarding the proposed project. The purpose of the present discussion is to address the main concerns he raised at the hearing(s), as well as to reiterate CH's well-documented findings regarding the behavior of on-site and off-site stormwater flows during significant rainstorms

PRINCIPAL ISSUES RAISED BY TERRAPHASE (DR. PAZ)

Alan Kropp, G.E. of Alan Kropp & Associates, Inc. has prepared responses that address some of Dr. Paz's contentions on geotechnical grounds. Based on review of the Terraphase Draft Technical Memorandums (Oct 7, 2015, Feb. 2016) and the video and oral testimony of Dr. Paz's testimony at the City Zoning Adjustment Board (ZAB) hearing on May 13, 2019, the primary hydrologic issues raised focus on the following contentions:

1. The foundations of the proposed new structures slated for the currently pervious eastern portion of the project site will create subsurface conditions that will "dam" groundwater flow and induce more frequent ponding/flooding along the adjoining backyards of Curtis Street residences. This supposition was originally put forth by Greg Kamman of Kamman Hydrology and Engineering in a consulting proposal submitted to Marc Mathieu and Elaine Eastman in 2002. It was noted as his "biggest concern" about the proposed project in its 2002 derivation.

2. The on-site groundwater conditions are dictated by the presence of a historical tributary of Strawberry Creek, which was buried by fill for development in the early part of the 20th century, and whose subsurface sediments form an unconfined groundwater body in direct hydraulic connection with the surface soils at the site and two or more properties to the east along Curtis Street (between Delaware Street and Hearst Avenue). Furthermore, the summer borings drilled and logged by Kropp & Associates in Aug. 2018 were insufficient to determine the likely winter elevations/depths of groundwater at the site.

3. The topographic depression that covers the central portion of the current site functions as a "rain garden" wherein accumulated storm runoff ponds and infiltrates into the subsurface; whereas the post-project condition would replace this rain garden with impervious surface, thus eliminating site infiltration capacity.

4. The development of the site as proposed would worsen the existing nuisance flooding conditions for the properties along the west side of Curtis Street (east of the project site) due to the introduction of new impervious surfaces and additional stormwater runoff.

CH RESPONSES TO TERRAPHASE CONTENTIONS:

Issue 1: "Damming" of Groundwater Flow

The analogy made equating the placement of a dam across an above-ground stream or river with the placement of very shallow and discontinuous engineered fill and mat foundations on the project site is misleading and wholly inaccurate. A surface dam creates an impermeable barrier across the entire width of a stream channel and its floodplain, and must seamlessly tie-into similarly impermeable formations to either side of the dam structure or embankment. It is also vertically keyed into an impermeable bedrock or other impermeable material (e.g. clay) such that it severely restricts seepage underneath the dam. The project conditions would replicate <u>none</u> of the physical constraints on hydraulic characteristics that are imposed by dam and reservoir construction.

Figure 1 below depicts the actual conditions that would occur along the eastern edge of the site where two new buildings are proposed. The soil profile layers delineated in the Figure were derived from three soil borings drilled by Kropp & Associates in the summer of 2018.

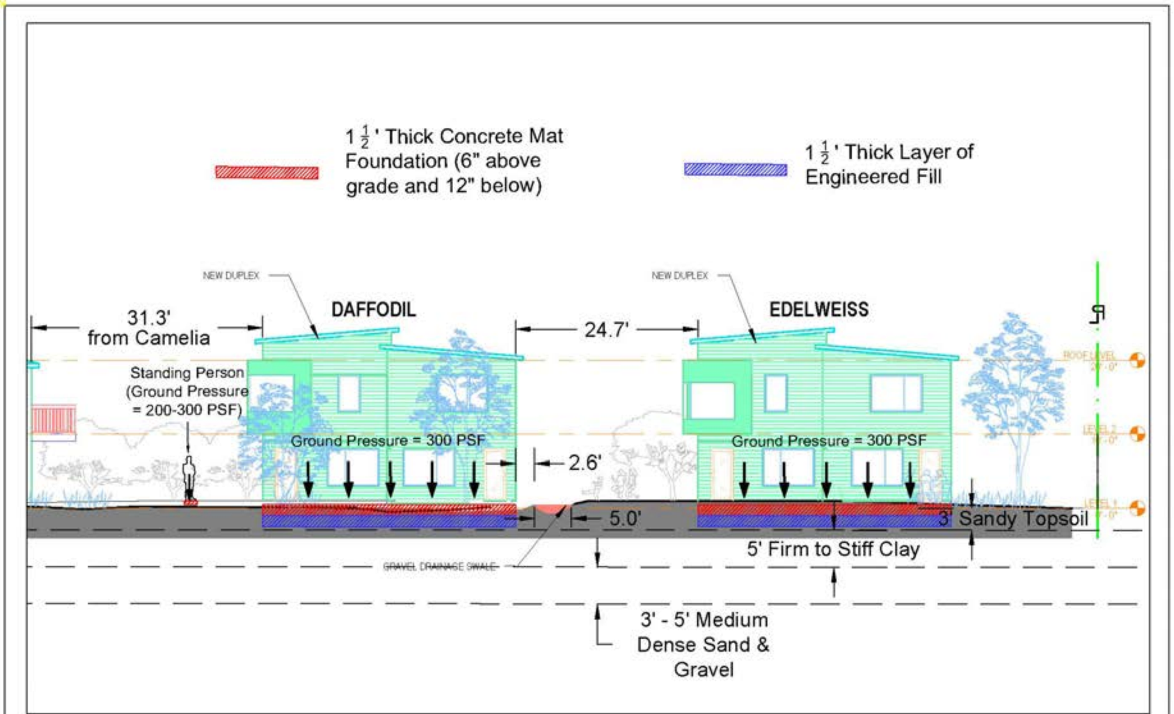


Figure 1: Load Bearing Diagram for Hearst Gardens Soil Profile with June 2018 Project Design and Adjusted Daffodil Building Location

Project: Hearst Gardens
1161-1173 Hearst Ave Project
Date: 10-09-2019

Information Source: Base Plan from Devi Dutta Architecture

Figure 1 is scaled, and reference to the scale bar shows that the new building foundations do not span the entire site as a single structure, as a dam would. Rather, openings of roughly 15 ft. will exist to either side of these buildings. More importantly, the vertical extents of the engineered fill that would be placed beneath the mat foundations and the overlying mat foundations would not extend to more than 3 ft. below the existing ground. As shown, this depth matches that of the surface soil layer, which is underlain by 3-5 feet of firm clay. Such clay layers are typically considered non-water bearing soil strata and do not readily transmit water vertically, either from the surface via infiltration or from the subsurface via rising groundwater tables.

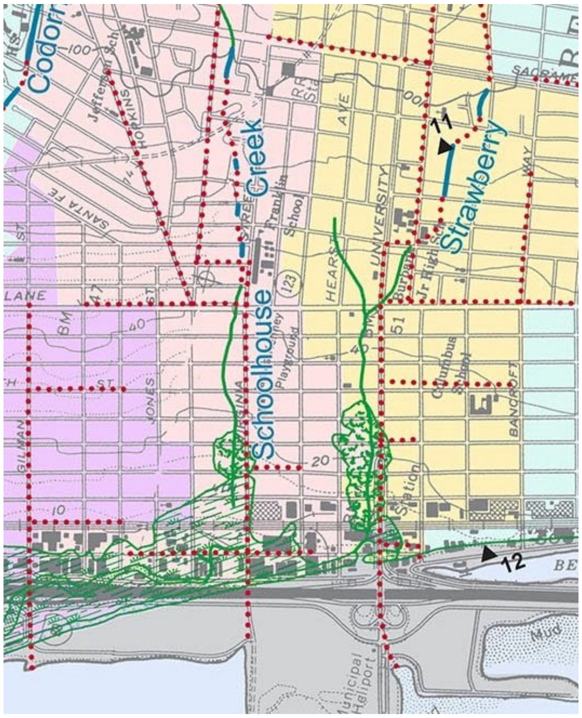
Groundwater that occurs under the site flows in a roughly east-west direction and will preferentially favor the coarser materials that underlie the clay layer. At this depth and at the ground pressures exerted by the buildings (300 pounds per square foot, psf), no effects from the mat foundations would be transmitted that could alter the hydraulic conductivity of the water bearing layer. Groundwater would continue to flow freely under the shallow foundations within the dense sand and gravel layer beneath the clay. As is also shown in Figure 1, the ground pressure exerted by a standing person of moderate stature (200-300 psf) is not substantially different from the pressure exerted by the mat foundations.

Issue 2: Unconfined Character of the Local Groundwater System

The Terraphase Memorandum and Dr. Paz's testimony, as well as Kamman's proposal rationale, infer that the soil materials underlying the site comprise a single, unconfined groundwater system, i.e. that groundwater is free to rise or fall without impediment in response to seasonal groundwater recharge from areas to the east of the site. Based on the results of the Kropp & Assoc. geotechnical investigation, this is not technically accurate. The local groundwater system is at least partially confined, as discussed below.

First, it is important to note that the majority of historical, pre-urbanized groundwater recharge to this now-filled tributary channel has been captured and diverted to streets by impervious surfaces and subsurface drains (e.g. French drains) installed for residential development. So a small fraction of the pre-urbanized recharge zone actually contributes infiltrated rainfall to the shallow water bearing layer that the Kropp & Assoc. borings suggest lies roughly 8-13 ft. below the ground surface (bgs). As discussed below, those borings were drilled in August and only one of the three showed any evidence of groundwater interception, and that was at a depth of 10 ft. bgs. A. Kropp has stated that based on those borehole results and his familiarity with groundwater conditions in this area of Berkeley, the expected winter groundwater depths would be about 5 ft. bgs.

The historical map of Strawberry Creek and its tributaries (Sowers 1993-2000) published by the Oakland Museum of CA shows the pre-development trace of the former project area tributary as originating on the properties along the east side of Curtis Street (see below). There is evidence, therefore, that all or portions of multiple properties along the north side of Hearst Avenue and both sides of Curtis Street (e.g. 1819, 1820, 1821, 1824, 1825 and 1827 Curtis Street), between Hearst Avenue and Delaware Street), were also founded on fills placed within that former tributary.



Source: Sowers (1993-2000)

Second, the available evidence from the aforementioned site boring logs indicates that the on-site groundwater system does not comprise a single unconfined aquifer with an unimpeded water table that can respond linearly to seasonal infiltrated rainfall/recharge (winter) and evapotranspiration (loss of water through atmospheric evaporation and plant transpiration during the dry season). Instead, the logs suggest that the water bearing stratum, consisting of dense sands and gravels, is overlain by lower permeability clays that restrict the free vertical exchange of water, both downward and upward.

The site boring log location map and borehole logs are attached. Two of the borings, B-2 and B-3, are located along the eastern portion of the property, while the third (B-1) was drilled in the uneven and cracked concrete driveway that forms a topographic depression in the middle of the currently developed site where surface runoff ponds before moving south out the driveway toward the Hearst Avenue gutter. An actual groundwater table was intercepted in Boring B-1 at about 10 ft. below the ground surface (i.e. bgs), within the dense, but coarser sand and gravel deposits. Sands and gravels are the normal constituents of water bearing deposits that yield water to wells. Borings B-2 and B-3 weren't as deep as B-1, but no groundwater was detected in those borings at depths of 11.5 feet bgs. If a continuous water table did exist through the site, similar observation of groundwater in the borings would have been expected. More likely, the presence of the 3-5 ft. thick clay layer at roughly 3-8 ft. bgs severely restricts percolation of rainfall that infiltrates the upper 3 ft. of the soil profile. This condition is known as a perched groundwater condition, because the extent of this "aquifer" is localized, discontinuous and the impeding clay layer transmits water vertically much more slowly than coarser soil materials.

As such, perched groundwater essentially lacks a direct hydraulic connection to the deeper, regional groundwater system. In this case, infiltrated rainfall or local runoff eventually saturates the surface soil layer and induces surface ponding. This can occur independent of the relative position of the underlying regional groundwater table. Typically, monitoring wells in perched aquifers will exhibit groundwater levels at higher elevations than wells established in the deeper regional aquifer.

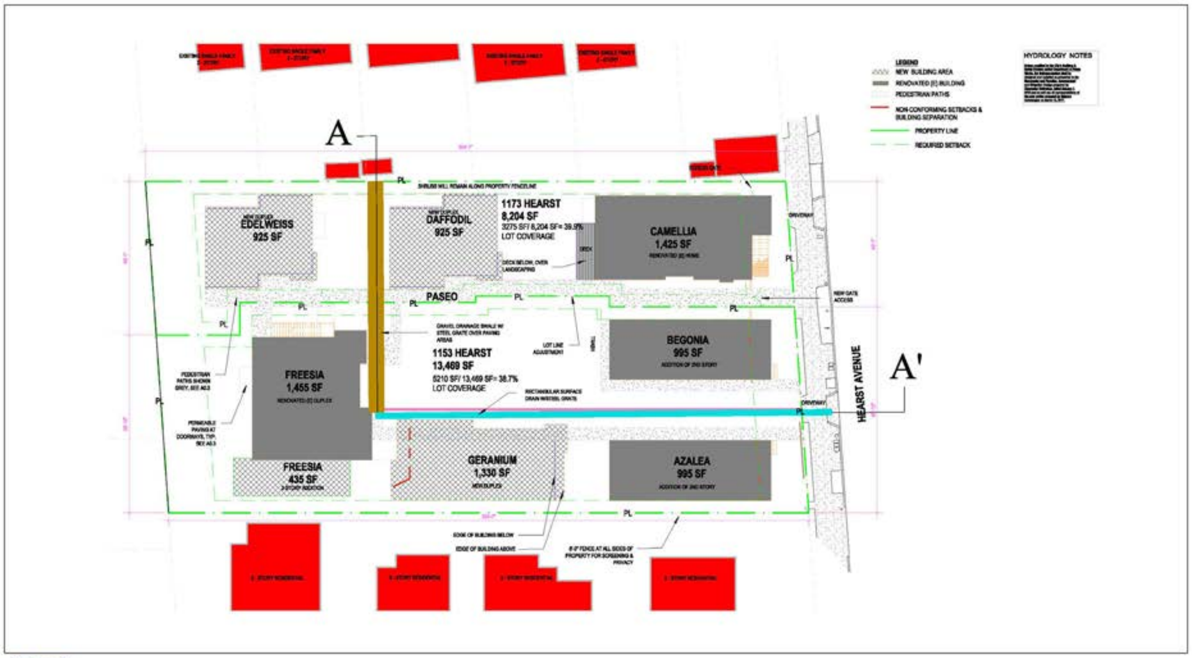
Issue 3: Elimination of the Existing "Rain Garden"

In its initial Draft Technical Memorandum (Oct. 2015), Terraphase proposes a baseline analytical scenario that the topographic depression existing on the central portion of the site acts as a rain garden. Rain gardens are usually constructed on sites to retain and pond stormwater runoff which can then prolong the opportunity for infiltration into the soil profile, rather than run-off into a storm drain system. These features only work where surface and near surface soils are relatively permeable and soil rather than concrete forms the "garden" depression. This is not the case at the project site, where the existing depression largely encompasses a settled concrete parking/driveway area, underlain by a low permeability clay substrate. Thus, while stormwater may pond, before it breaks out and flows toward Hearst Avenue, the clayey nature of the subsoil does not provide the infiltration opportunities that a true rain garden would. Evaporation is more likely to dissipate the majority of the ponded stormwater.

Issue 4: The Proposed Stormwater Design Fails to Improve Nuisance Flooding Conditions

The CH Stormwater and Flooding Assessment and Mitigation Design report (July 2017) detailed the hydrologic and hydraulic analyses that were conducted for the Hearst Avenue corridor, including the relevant block of Curtis Street, and the project site. The hydraulic analysis used the most conservative estimates of peak flows generated over the project site and the west side Curtis Street properties, including modeled overflow from the Curtis Street gutter down the residential driveways and into the low lying backyards immediately east of the site. CH conducted a supplemental total station survey of Curtis Street between Delaware St. and Hearst Avenue. Based on the integrated and expanded site topography, we determined that the lowest backyard elevations at the western Curtis Street property lines were 1.0 ft. lower than the elevations along the eastern 1161-1173 site property line. In other words, the backyard at 1173 Hearst Ave. was 1.0 ft. higher than the Curtis Street backyards. This existing physical condition creates the likelihood of backyard flooding due wholly to runoff from portions of the Curtis Street buildings, driveways and concrete patios/backyard areas.

The CH design recognized this existing impediment to more efficient drainage along the Curtis Street backyard areas and developed a solution that would provide for construction of a surface drainage channel to capture and drain-off roughly 50% of the ponded water during higher recurrence interval (i.e. more intense) rainstorms. The layout of the new drainage channel is below in Figure 2. While this feature will not completely eliminate the existing backyard nuisance flooding for those properties, it will improve the existing drainage from those lots and reduce the depth of flooding experienced by the west side Curtis Street properties.



CLEARWATER HYDROLOGY

Figure 2: Drainage Outlet Channel with June 2018 Project Design and Adjusted Daffodil Building Location

Project: 1155-1173 Hearst Avenue Project
Date: 10-09-2019

In addition to the surface swale and outlet drainage channel within the new project driveway- the alignments of which are also shown in the Figure 2, CH evaluated the volumetric increase in site stormwater runoff for the post-project condition. The estimated increase of 5.6 cubic feet, or 119 gallons could be mitigated by incorporating a rain barrel (cistern) into the project design. To add a safety factor, we recommend that both of the new buildings along the eastern portion of the site be fitted with 150-200 gal. rain cisterns.

I believe that the above responses address the concerns identified by Terraphase and Dr. Paz in its memoranda and testimony regarding the project. I can also be available to offer testimony at the next City hearing on the project should you deem it helpful.

Yours truly,

William Vandivere, M.S., P.E.
Principal

APPENDIX A
LOG OF BORINGS

SOIL CLASSIFICATION CHART

PRIMARY DIVISIONS			SECONDARY DIVISIONS: CRITERIA *	GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS MORE THAN 50% RETAINED ON NO.200 SIEVE	GRAVELS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO.4 SIEVE	CLEAN GRAVELS LESS THAN 5% FINES	$C_u \geq 4$ AND $1 \leq C_c \leq 3$ ^{A}	GW	Well-graded gravel
			$C_u < 4$ AND/OR $1 > C_c > 3$	GP	Poorly-graded gravel
		GRAVELS WITH FINES - MORE THAN 12% FINES	FINES CLASSIFY AS ML OR MH	GM	Silty gravel
			FINES CLASSIFY AS CL OR CH	GC	Clayey gravel
	SANDS 50% OR MORE OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SANDS LESS THAN 5% FINES	$C_u \geq 6$ AND $1 \leq C_c \leq 3$	SW	Well-graded sand
			$C_u < 6$ AND/OR $1 > C_c > 3$	SP	Poorly-graded sand
		SANDS WITH FINES - MORE THAN 12% FINES	FINES CLASSIFY AS ML OR MH	SM	Silty sand
			FINES CLASSIFY AS CL OR CH	SC	Clayey sand
FINE-GRAINED SOILS 50% OR MORE PASSES THE NO.200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50%	INORGANIC	PI > 7 AND PLOTS ON OR ABOVE "A" LINE	CL	Lean clay
			PI < 4 OR PLOTS BELOW "A" LINE	ML	Silt
		ORGANIC	$\frac{\text{LIQUID LIMIT - OVEN DRIED}}{\text{LIQUID LIMIT - NOT DRIED}} < 0.75$	OL	Organic Clay & Organic Silt
	SILTS AND CLAYS LIQUID LIMIT 50% OR MORE	INORGANIC	PI PLOTS ON OR ABOVE "A" LINE	CH	Fat clay
			PI PLOTS BELOW "A" LINE	MH	Elastic silt
		ORGANIC	$\frac{\text{LIQUID LIMIT - OVEN DRIED}}{\text{LIQUID LIMIT - NOT DRIED}} < 0.75$	OH	Organic Clay & Organic Silt
	HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR	PT	Peat

REFERENCE: Unified Soil Classification System (ASTM D2487-11)

* Criteria may be done on visual basis, not necessarily based on lab testing

A – $C_u = D_{60}/D_{100}$ & $C_c = (D_{30})^2 / (D_{10} \times D_{60})$

GRAIN SIZES

	U. S. STANDARD SERIES SIEVE: 200	40	10	4	CLEAR SQUARE SIEVE OPENINGS: 3/4"	3"	12"
SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

ABBREVIATIONS

<u>INDEX TESTS</u>

LL - Liquid Limit (%) (ASTM D4318-17)
PI - Plasticity Index (%) (ASTM D4318-17)
-200 - Passing No. 200 Sieve (%) (ASTM D1140-17)

<u>STRENGTH TESTS</u>

PP - Field Pocket Penetrometer test of unconfined compressive strength (tsf)
TV - Field Torvane test of shear strength (psf)
UC - Laboratory unconfined compressive strength (psf) (ASTM D2166/2166M-16)
TXUU - Laboratory unconsolidated, undrained triaxial test of undrained shear strength (psf) (ASTM D2850-15)

<u>MISCELLANEOUS</u>

ATOD - At time of drilling
psf/tsf - pounds per square foot / tons per square foot
psi - pounds per square inch (indicates relative force required to advance Shelby tube sampler)

SYMBOLS

- Standard Penetration Test Split Spoon (2-inch O.D.)
- Modified California Sampler (3-inch O.D.)
- Thin-walled Sampler Tube (either Pitcher or Shelby) (3-inch O.D.)
- Rock Core
- Bag Sample
- Groundwater Level during drilling
- Groundwater Level after drilling

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

KEY TO EXPLORATORY BORING LOGS

HEARST GARDENS
Berkeley, California

PROJECT NO.	DATE	FIGURE
2744-2	**August 2018**	**A-1**

DRILL RIG: 89: ;<=>2Ā ?;@A6	**SURFACE ELEVATION:** Ā1BCĀ Ā+ D&	**LOGGED BY:** +,-
DEPTH TO GROUNDWATER:)"%Ā66@Ā766Ā3?@7G	**BORING DIAMETER:** *%1Ā23456	**DATE DRILLED:** ./ 0/).

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
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SAND, Silty Ā ĀY?2 7@	M;<9Ā+ ?@Ā:ĀU2@ J ;<3V6	+6 : 2=Y ĀR6376	D+	)!)*					
GRAVEL, Silty ĀĀU2@Ā7=3:XĀY?2 7@Ā@ĀU6@	M;<9 ... +6 : 2=YĀI ;?U3	+6 : 2=Y ĀR6376	M+	)0)1)$)H).)Ä		Ā0)]			

(Continued on Next Page)

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

EXPLORATORY BORING LOG

HEARST GARDENS
Berkeley, California

PROJECT NO.	DATE	SHEET	
2744-2	August 2018	1 of 2	I J K(LMĀLJ % **1**

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
(Continued from Previous Page)									
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CLAY, Lean ĀĀU2@ĀV;<6>Y ?27@	I; ?U3	- 6;9Ā@E2	T&	!! !* !0		Ā!"			
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ALAN KROPP & ASSOCIATES
Geotechnical Consultants

EXPLORATORY BORING LOG
HEARST GARDENS
Berkeley, California

PROJECT NO.	DATE	SHEET	
2744-2	**August 2018**	**2 of 2**	I J K(LMĀJ % **1**

DRILL RIG: 89: ;<=>24Ā ?;@A6	**SURFACE ELEVATION:** Ā$BCĀ Ā+ D&	**LOGGED BY:** +,-
DEPTH TO GROUNDWATER: F76Ā3?@76G	**BORING DIAMETER:** *%1Ā23456	**DATE DRILLED:** ./ 0/).

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
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SAND, Clayey, Lean Ā ĀY27@	&25@ĀI;?U3	+6 : 2=Y ĀR6376	DT	. Ä)"					
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*%ĀĀ636@<@23Ā6727<346ĀW=67ĀA>?UĀ4?=3@ĀY <;[6: ĀU25Ā<3Ā7@67[ĀFGĀ6Ā3?@7Ā@3: <;: ĀZ636@;@23Ā;627@346ĀW=67%

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ALAN KROPP & ASSOCIATES Geotechnical Consultants	**EXPLORATORY BORING LOG** HEARST GARDENS Berkeley, California	
PROJECT NO. **2744-2**	DATE **August 2018**	SHEET **1 of 1**

I J K(LMĀJ % **2**

DRILL RIG: 89: ;<=>4Ā ?;@A6	**SURFACE ELEVATION:** Ā$BCĀ Ā+ D&	**LOGGED BY:** +,-
DEPTH TO GROUNDWATER: F76Ā?@7G	**BORING DIAMETER:** *%1Ā23456	**DATE DRILLED:** ./ 0/).

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
SAND, Silty, Clayey Ā Ā@5?Y 6Ā\<V6X Y?27@ [Topsoil]	I; ?U3	+6 : 2=Y ĀR6376	DT	) ! *					
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GRAVEL, Clayey, Lean ĀĀ<3V=×;XĀY?27@	+ 6:2=Y Ā@ĀR<;[I; ?U3	+6 : 2=Y ĀR6376	MT	)"))		Ā'$]			

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*%ĀĀ636@<@23Ā6727<346ĀV=67Ā>?UĀ4?=3@ĀY <;[6: ĀU25Ā<3Ā<7@67[ĀFGĀ6Ā?@Ā3: <;: Ā636@;@23Ā;6727@346ĀV=67%

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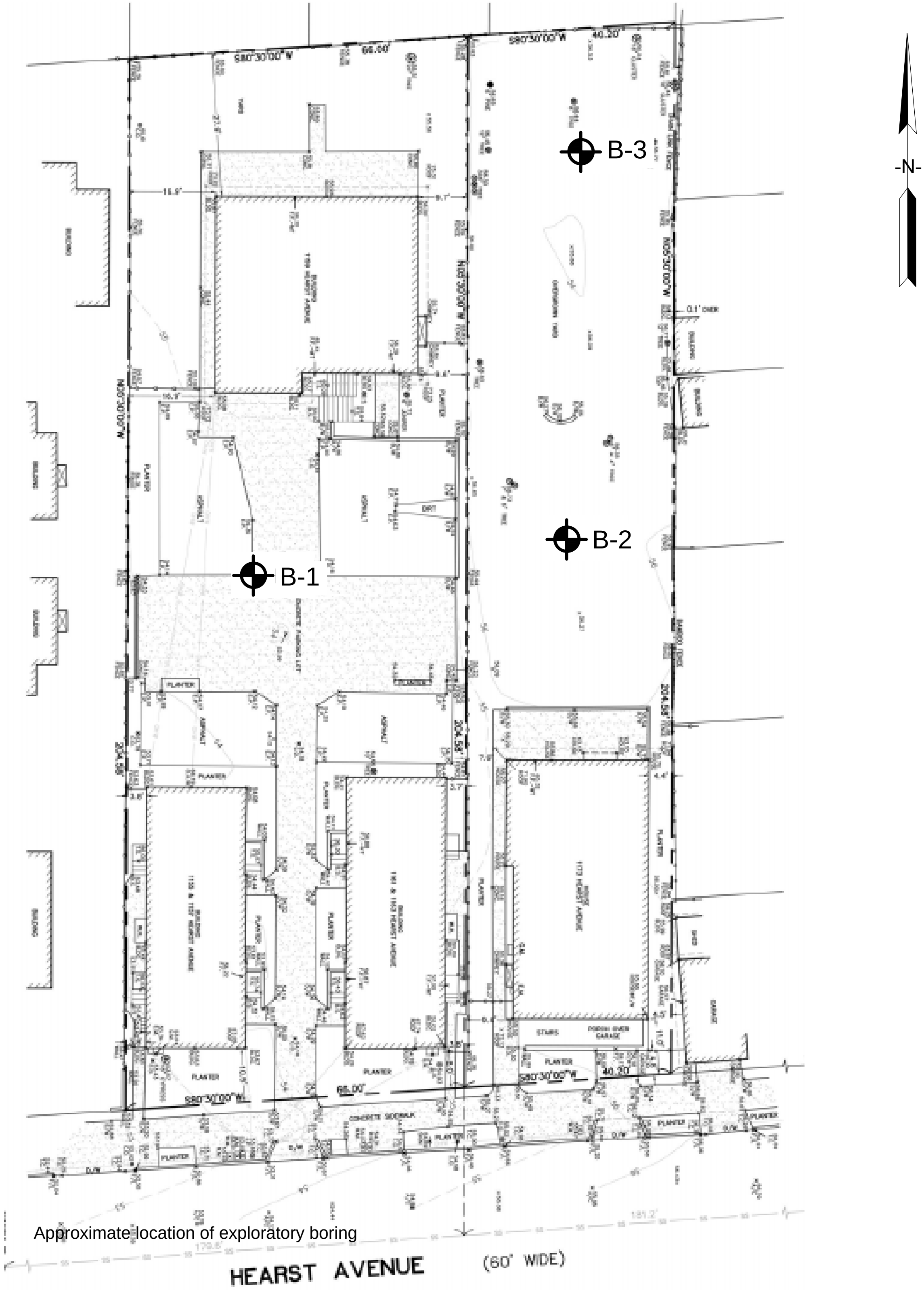
ALAN KROPP & ASSOCIATES Geotechnical Consultants	**EXPLORATORY BORING LOG** HEARST GARDENS Berkeley, California			
	PROJECT NO. **2744-2**	DATE **August 2018**	SHEET **1 of 1**	I J K(LMĀJ % **3**



LEGEND

B–1 Approximate location of exploratory boring

10 0 20 40
APPROXIMATE SCALE FEET

Source: "Boundary and Topographic Survey, Located at 1155-1173 Hearst Avenue."; by Moran Engineering. Inc.; dated June 8, 2015

ALAN KROPP & ASSOCIATES *Geotechnical Consultants*	**SITE PLAN**		
	HEARST GARDENS Berkeley, California		
	PROJECT NO.	DATE	FIGURE **4**
	2744-2	**August 2018**	

December 2, 2019
Z5059B

TO: Leslie Mendez
Senior Planner
CITY OF BERKELEY
1947 Center Street, 2nd Floor
Berkeley, California 94704

SUBJECT: **Supplemental Geotechnical Peer Review**
RE: Rhoades Planning Group, Six Home Development, Renovations, Remodels and Additions on Two Lots
ZP2016-0028; APN 57-2086-14 and 57-2086-13
1155, 1157, 1159, 1161, 1163 and 1173 Hearst Avenue

At your request, we have completed a supplemental geotechnical peer review of the proposed land use permit application using:

- Response to Hydrologic Concerns raised by Terraphase Engineering (letter), prepared by Clearwater Hydrology, Inc., dated October 9, 2019;

- Supplemental Geotechnical Engineering Comments (letter), prepared by Alan Kropp & Associates, Inc., dated August 30, 2019;

In addition, we have reviewed pertinent technical maps and reports from our office files, and reviewed project reports, letters, correspondences, and plans through the project website.

DISCUSSION

We understand the applicant proposes to construct three additional duplex buildings resulting in a total of six new dwelling units on the two subject parcels (APN -14 and -13). The project will also consist of renovating and remodeling four existing buildings (consisting of seven existing dwelling units) located on the subject parcels. Remodeling will consist of second story additions within the existing footprint of two, one-story buildings and a two-story addition increasing the footprint of one existing building. New site impervious flatwork and paving, along with other drainage improvements associated with the proposed site construction are also anticipated.

In a previous geotechnical peer review dated March 14, 2019, we recommended the Project Geotechnical Consultant clarify geotechnical aspects of the site subsurface investigation and address concerns related to potential settlement and consolidation of existing site earth materials encountered. We also recommended the Project Geotechnical Consultant evaluate the condition of existing structures and impacts from new addition loads and discuss potential constraints to new construction (i.e. adverse seismic affects, differential settlement, etc.). The applicant's Geotechnical Consultant has responded to these concerns as noted in our geotechnical peer review dated April 29, 2019. In those peer reviews we did not explicitly review site flooding or drainage concerns beyond those directly impacting the geotechnical aspects of the project. Ultimately, we understand that potential site flooding issues will be addressed to the satisfaction of the City Engineer; however, the scope of this peer review is to further comment on the site drainage considerations from a geotechnical perspective, including surface runoff and subsurface flows. We understand that design level civil grading and drainage plans have not been submitted to the City; however, hydrologic studies and conceptual drainage plans have been prepared and submitted for peer review.

We understand the City would like us to specifically address four items: **1)** Will the development impact subsurface flows and act as a "dam"?; **2)** Will the loads of the proposed structures displace subsurface water and result in adverse impacts to neighboring properties?; **3)** Will the proposed development result in significantly increased surface runoff and into City maintained drainage infrastructure?; and **4)** are additional geologic or geotechnical investigative methods necessary to evaluate these concerns?

SITE CONDITIONS

The Project Geotechnical Consultant has previously advanced 3 site exploratory borings to depths of 10 to 25 feet. Groundwater was encountered at a depth of 15.5 feet below the ground surface in Boring B-1 and was measured at a depth of 10 feet below the ground surface an hour after drilling. Earth materials encountered in site borings include undocumented sandy fill (SC), as well as shallow soft native clays (CL), and alluvial deposits reported to be consistent with the Temescal Formation. The Project Geotechnical Consultant clarifies that all fill underlying and within three feet of proposed building footprints will be excavated and replaced as engineered fill during site construction. Based on site subsurface exploration, the Project Geotechnical Consultant concludes that the site is underlain by a confining layer of relatively impermeable clay (approximately 6 feet thick where undisturbed in B-2 and B-3). This layer of near surface clay overlies medium dense sands and gravels at depth that may transmit groundwater. The Project Design Team finds that this near surface clay would both impede the ground water table from intersecting the ground surface as well as impede surface water from percolating or infiltrating to recharge groundwater at the site.

Geologic mapping (CGS – SHZR081) indicates that the project site is located on Pleistocene-aged alluvial fan deposits (Qpf). The proposed project is not located within a liquefaction hazard zone as mapped by the California Geological Survey and we note that mapped liquefaction zones in this vicinity typically include areas proximal to known creek alignments where shallow groundwater or young depositional environments may impact site earth materials. The Geotechnical Consultant has concluded that liquefaction of site earth materials during a probable earthquake is low. The California Geological Survey has mapped the historic high groundwater at approximately 5 feet below the ground surface, and groundwater may be locally perched and variable as noted by the Project Geotechnical Consultant. The Project Geotechnical Consultant recommends that a groundwater height of 5 feet below the ground surface be used in project design.

Regional topographic data indicates the site is located within a broad and subdued swale approximately 800 feet wide, potentially associated with a relic subparallel tributary alignment of Strawberry Creek. This relic alignment is approximately mapped trending through the property, and we understand that the relic tributary was filled during development of the site vicinity. We note that mapping of the relic creek alignment is considered accurate to within 200 feet (Sowers and Richard, 2009) and some maps do not include this tributary of Strawberry Creek as a historic drainage feature (e.g., Radbruch, 1957). The currently mapped alignment of Strawberry Creek is located approximately 800 feet south of the site. The project site is located within an area of minimal flood hazard (Zone X) as delineated in flood hazard mapping by FEMA, effective December 21, 2018. Zone X corresponds to areas that have either a 0.2% annual chance of flood hazard or a 1 percent annual chance of flooding with average depths of less than 1 foot of water. The Project Hydrologist concludes, based on collected topographic data and field observations, that a depression along the northern property boundary currently allows for local flooding up to 1 foot in depth, and further recommends extending a drainage swale to the property boundary as part of proposed site improvements to better service the site vicinity.

To address geotechnical concerns presented in our peer review letter dated March 14, 2019, the Project Geotechnical Consultant completed supplemental settlement calculations using correlations of soil index properties, anticipated building loads, and previously completed subsurface investigation data. They provided an estimate of approximately two inches of total consolidation settlement with one inch of differential settlement across the length of the proposed buildings. These settlement calculations were based on an anticipated structural load of 300 pounds-per-square-foot (psf). During our previous site reconnaissance, we observed numerous hairline width, vertical and oblique cracks to existing stucco exteriors. These cracks typically stemmed from the corners of windows, doorways, or brick staircases. Doorways appeared slightly out of level, potentially due to previous settlement of the existing structures and foundations.

CONCLUSIONS AND RECOMMENDED ACTION

The subject property is potentially constrained by relatively shallow groundwater, reported seasonal flooding, undocumented fill of variable depth (up to five feet thick), soft surficial earth materials prone to settlement and consolidation, and strong seismic ground shaking. The three conditions presented in our previous letter dated April 29, 2019, for land use permit geotechnical approval still apply to the subject permit application.

Based on the evaluations provided by the Project Design Team along with the documents available for our review, we conclude the following regarding the four geotechnical and hydrologic items we were asked to address:

1) Will the development preclude subsurface water and act as a 'dam'?

We concur with the Project Geotechnical Consultant and the Project Hydrologist that the proposed shallow foundations for new structures would not constitute a literal or functionally effective dam that could significantly impede subsurface flow or greatly hinder surface runoff given adequate surface drainage design.

2) Will the structural loads of the proposed structures displace subsurface water and result in adverse impacts to neighboring properties?

We find the anticipated structural loads presented by the Project Geotechnical Consultant are reasonable for the proposed construction. We concur with the evaluations presented by the Project Geotechnical Consultant that the buildings should not significantly displace subsurface water thereby impacting adjacent properties.

3) Will the proposed development result in significantly increased runoff conditions or flow into City maintained drainage infrastructure?

Based on evaluations by the Project Hydrologist, it appears that the proposed site improvements would result in an increase of impervious area of approximately 1.8 percent. This increase in impervious area is substantially mitigated by replacement of existing impervious driveway and parking areas with pervious pavers. Pervious pavers typically require routine maintenance to ensure consistent permeability, they also may require subsurface drainage improvements to direct infiltrating water to proper discharge outlets given the impermeable clay described by the Project Design Team. We concur with item 6 presented by Balance Hydrologics, Inc., in their peer review letter dated March 16, 2017.

Site conceptual drainage design also considers the use of rain barrels or cisterns to collect roof runoff water for later discharge. With an understanding that current site drainage is generally characterized by sheet flow of water off of the property, and an understanding that rain barrels or cisterns are recommended and would be used to intermittently intercept run off that would then be discharged after rain events, we find it reasonable to assume that the proposed site improvements will not significantly increase flow into City maintained drainage infrastructure. We note that detailed civil grading and drainage plans have not been submitted for peer review.

4) Are additional geologic or geotechnical investigative methods necessary to evaluate these concerns?

We find that the geotechnical evaluations provided by the Project Geotechnical Consultant are consistent with the prevailing standard of geotechnical practice. It appears that a concern has been presented to the City that the groundwater table seasonally intercepts the ground surface in the vicinity of the project site resulting in ponded water conditions. Alternatively, the applicant's Consultants have investigated the site subsurface conditions and concluded that ponded water conditions are a result of local topography and poor infiltration due to encountered subsurface clay soils (i.e., a perched groundwater condition). Given the completed investigations and published historic high groundwater for this area, we find that the latter explanation is geologically and geotechnically of greater merit. We find it less feasible for the groundwater table in this vicinity to seasonally intersect the ground surface and create local adverse ponding conditions. We understand that the historic high groundwater level is documented or projected to rise to potentially 5 feet below the ground surface. We find the Project Geotechnical Consultant's recommendation to use this groundwater elevation in project design to be conservative and based on representative data from the project vicinity. Based on our experience we find it unlikely that unconfined groundwater would rise to a level that would intersect the ground surface in the vicinity of the site.

To evaluate the annual groundwater variations across the site, a percolation testing program along with groundwater monitoring wells and piezometers could be designed, installed, and regularly monitored by a qualified professional. We note that hydrogeologic investigation design would need to consider the influence of potential perched groundwater conditions as this appears to be a dominant factor influencing site conditions, rather than a simpler unconfined condition. Ultimately, we do not find this supplemental investigation necessary as it appears that the Project Design Team have considered and provided conservative design recommendations based on site specific and proximal published data.

In conclusion, we find that the applicant's Geotechnical Consultant and Project Design Team have provided recommendations and evaluations consistent with the standard of geotechnical practice in the area. We also find that site drainage design should incorporate recommendations provided by the City's Hydrologic peer reviewer, as necessary. We concur that rain barrels and/or cisterns along with site grading, surface and subsurface drainage improvements could result in improved drainage conditions for the site and site vicinity. We also concur that pervious paver design should consider the benefits of additional subsurface drainage or storage to mitigate the potential perched groundwater conditions. We recommend geotechnical approval of subject land use permit applications with the 3 conditions presented in our peer review letter dated April 29, 2019, and the following condition attached:

1. **Design Level Civil Plans and Plan Review** – The Project Civil Engineer should review the completed geotechnical and hydrologic studies and subsequent peer review letters by professionals contracted by the City and incorporate the pertinent design recommendations into the design level grading and drainage plans. As part of the Civil Plans, we recommend consideration of rain barrels and/or cisterns to collect storm water as discussed in the hydrologic studies completed for the project. We also recommend that the Project Civil Engineer design site pervious drainage features considering the benefits of additional run off collection and discharge (e.g. additional subgrade preparation or storage beneath areas to receive pervious pavers, etc.), and with the understanding that pervious pavements/sidewalks may percolate at the flows stated by the manufacturer.

   Civil Plans should include detailed cross sections of all proposed swales and artificial pervious areas including the design thickness of the proposed concrete, subgrade, swale dimensions, and grass seed or planting recommendations as appropriate for the grass-lined swale.

   A maintenance and monitoring program should be included for site drainage improvements that, as applicable, details the regular procedure for discharging rain barrels and/or cisterns, the clearing of constructed concrete swales, and the mowing or landscaping of grass swales and other bio-drainage improvements. We recommend the Project Design Team consider incorporating site topographic surveying into the monitoring program to, at minimum, document the final as-built site drainage conditions.

   The final plans should be reviewed, analyzed, and approved from a surface hydrologic perspective by the applicant's registered/licensed Project Hydrologist to ensure the proposed design is adequate to improve site drainage conditions and to ensure the plans incorporate their hydrologic recommendations. Project civil grading and drainage plans and hydrologic evaluations should also be reviewed by the City's register/licensed peer reviewer (Balance Hydrologics, Inc.,). This plan review condition does not exclude the plans from review by the Project

Geotechnical Consultant as recommended in our previous peer review letter.

These plans and evaluations should be completed, submitted and then reviewed and approved by appropriate City Staff or their designee prior to building permit approval.

LIMITATIONS

This supplemental geotechnical peer review has been performed to provide technical advice to assist the City with its discretionary permit decisions. Our services have been limited to review of the documents previously identified. Our opinions and conclusions are made in accordance with generally accepted principles and practices of the geotechnical profession. This warranty is in lieu of all other warranties, either expressed or implied.

Respectfully submitted,

COTTON, SHIRES AND ASSOCIATES, INC.
CITY GEOTECHNICAL CONSULTANT

Ted Sayre
Engineering Geologist
CEG 1795

David T. Schrier
Principal Geotechnical Engineer
GE 2334

DTS:CS:TS

RhoadesPlanningGroup

Memorandum

To: Leslie Mendez, City of Berkeley Planning & Development Department
From: Mark Rhoades, Rhoades Planning Group
Date: February 6, 2020
Re: 1155-1173 Hearst Avenue/ZP2016-0028

Dear Ms. Mendez,

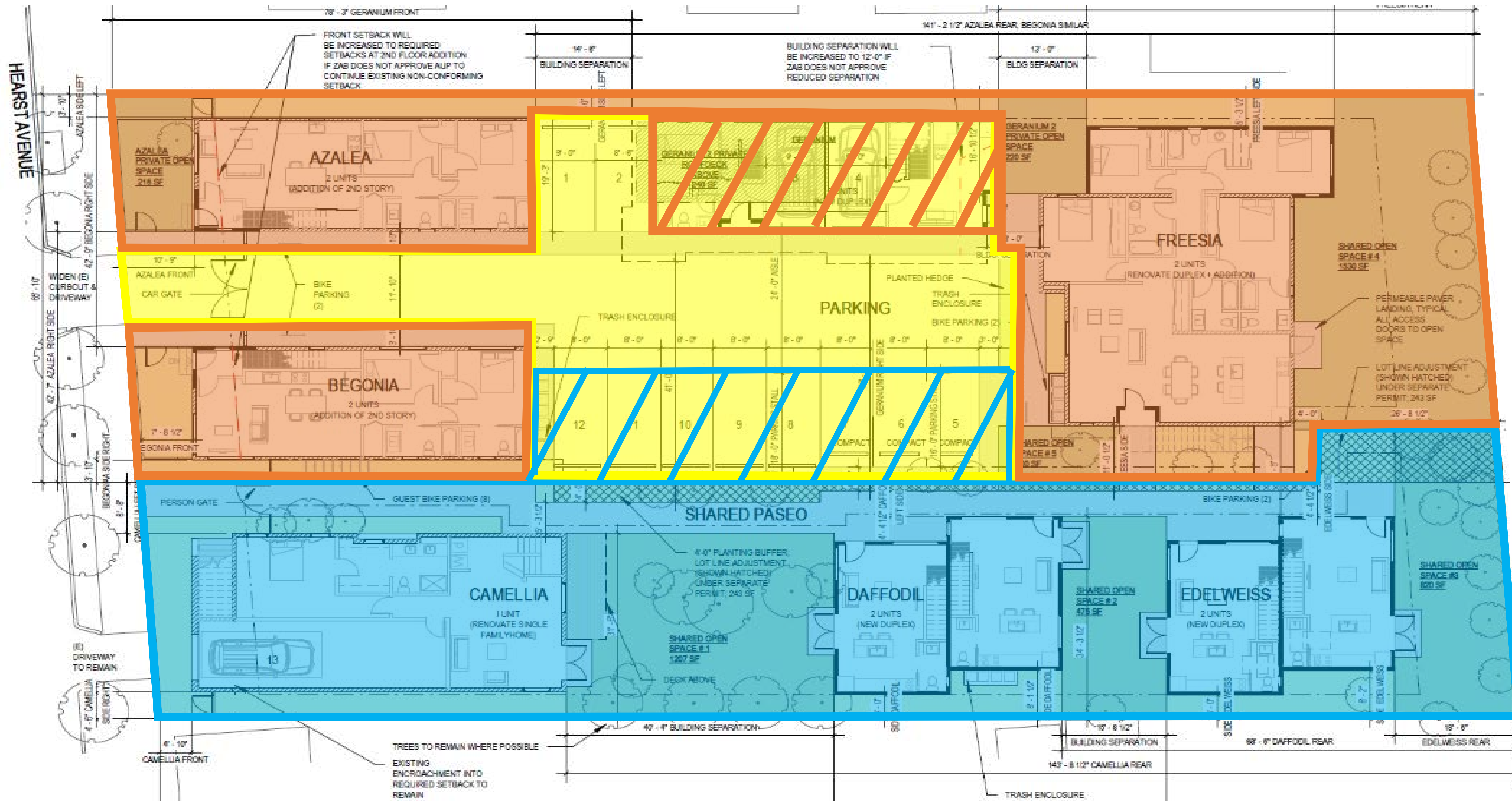
This memo serves to memorialize the owners' commitment to:

- Preserve the six-existing rent-controlled units in the project in perpetuity.
- The six-existing rent-controlled units will not be converted to condominiums, and no work proposed in this Use Permit, other than routine maintenance, will be performed on any building that is occupied by a resident.
- The owners are prepared to have staff recommend the above commitments as Conditions of Approval.
- These commitments were also discussed at the meeting that was held on February 26, 2019 at the Berkeley Rent Board offices with Rent Board staff, Rhoades Planning Group, and the existing residents of 1155-1173 Hearst Avenue. The meeting was noticed by Rent Board staff well in advance of the meeting date, both by USPS and email. One resident attended the meeting and had the opportunity to have her questions answered by Rent Board staff, including a staff attorney.

Please also find attached proposed construction phasing plan which will benefit the current residents by maintaining some of the parking onsite during construction.

Sincerely,

Mark Rhoades, AICP
510-545-4341



Hearst Gardens- Project Phasing and Implementation

Phase I
4 new units, renovate ex. SFR, install drainage facility, maintain up to 8 resident parking spaces during construction along west property line

Phase II
Fully improve parking area, landscape, and walkway treatments, paint existing apartments

Phase I
Construction staging, 8' screen fence for dust and view control

Phase III – At voluntary vacancy of at least one of the existing duplexes
2 new units (pay AHMF for full project – triggered by 5th unit), duplex additions