PRE-PROJECT
HYDROLOGY STUDY

FOR

PROJECT ZEUS DEVELOPMENT

Mare Island
Vallejo, CA

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TABLE OF CONTENTS

1. Introduction 1

2. Pre-Project Conditions 1

3. Hydrology Calculations 2
    3.1 Hydrology Standards and Methodology
    3.2 Runoff Coefficient
    3.3 Rainfall Intensity
    3.4 Area Calculation
    3.5 Pump Stations

4. Results 4

5. Appendices
    5.1 Convert Design Rainfall to Intensity
    5.2 Weighted Runoff Coefficients
    5.3 Time of Concentration
    5.4 15-Year Storm Event Peak Runoff Calculations
    5.5 Outfall Pipe Capacity Calculations
    5.6 Pre-Project Hydrology Maps, Sheets H1A, H1B, H1C & H1D

1. INTRODUCTION

The purpose of this report is to present the results of the Pre-Project Hydrology Study for four north Mare Island storm drain systems which will be partially retained to intercept and convey runoff from the proposed Project Zeus Development project. Based on aerial topographic information prepared by 360 Aerial Surveys dated August 17, 2016, Vallejo Sanitation and Flood Control District (VSFCD) record information for the existing storm drain systems and hydrology criteria in the Solano County Water Agency Hydrology Manual, this Study analyzed pre-project hydrology and found the peak storm runoff flow rates for four discharge locations along the east shore of the Mare Island Strait between Ernest D. Wichels Memorial Causeway and Highway 37.

2. PRE-PROJECT CONDITIONS

The area of Mare Island in Vallejo, CA undergoing planning for the development of the Project Zeus Development project is bounded by the Ernest D. Wichels Memorial Causeway (Causeway) and G Street to the south, Highway 37 to the north, the Mare Island Strait to the east and Azuar Drive to the west. This area was previously developed with buildings, streets, parking lots and utility infrastructure to service the needs of the United States Navy in their activities on Mare Island. Currently, most of the streets, parking lots and utility infrastructure remain in place. Some of the pavement is partially demolished and broken. The remainder of the pavement throughout the area is in fair condition and is maintained to provide access to existing industrial businesses on the west side of Azuar Drive, and to provide passage from the Causeway and G Street to Highway 37. A number of abandoned buildings also remain throughout the project site. The buildings range in condition from highly deteriorated and partially demolished to mostly intact.

The area studied for this analysis encompasses approximately 169 acres and is flat with slopes on the order of zero to 5% which generally drain from the west along Azuar Drive eastward to the Mare Island Strait. Outside of the existing streets and buildings the land is vegetated with grasses, low shrubs and a few trees.

According to the VSFCD record drawings, there are five storm drain systems which collect runoff from the area of study and discharge it to the Mare Island Strait at 5 separate outfall locations. The outfall locations are identified on Sheets H1A through H1D in the appendices of this report. The naming convention for the storm drain systems and areas tributary to them is based on the name of the outfall (1, 2, 3A, 3B and 4).

The storm drain systems are comprised of a combination of corrugated metal pipe (CMP), reinforced concrete pipe (RCP), reinforced concrete box, vitrified clay pipe (VCP) and transite pipe. The age of the systems are unknown and they are speculated to have been modified throughout the years to suit changes in the development needs of the U.S. Navy. It is also speculated that due to the notations in the record drawings evidencing inaccessibility and sag conditions that the storm drain systems are generally in poor condition. Also based on notation in the record drawings there appears to be a connection between System 1 and System 2 at L Street near Walnut Avenue.

At the north end of the project site, between Azuar Drive, Walnut Avenue, L Street and Independence Street, the land is lower in elevation than the bounding street system and requires a pump station to intercept runoff and discharge it to the north toward the Mare Island Strait. Identified as "SDPS-15" on Sheet H1C of this report, this pump station is located at the north end of Independence Street near the eastbound off-ramp of Highway 37 and discharges to the Mare Island Strait through the pipe system tied to Outfall 1, seen on Sheet H1A. A second pump station, "SDPS-14" on Sheet H1C, intercepts runoff from a low area behind an existing building located at the corner of L Street and Walnut Avenue.

3. HYDROLOGY CALCULATIONS

3.1 Hydrology Methodology and Standards, Rational Method

The Study was based on the Solano County Water Agency (SCWA) Hydrology Manual (Hydrology Manual). The study was performed using the 15-year design storm and the Rational Method.

The Rational Method was used to calculate the pre-project peak flow of runoff from the site. Drainage areas were calculated using AutoCAD. Weighted runoff coefficients were calculated based on amounts of roof and pavement versus vegetated land within the drainage areas. Rainfall intensities were based on the criteria specified by the Hydrology Manual for time of concentration and rainfall.

The terms of the Rational Method are defined as follows:

$$Q=CIA$$

Where:

Q = Flow Rate (cubic feet per second, cfs)
C = Runoff Coefficients
I = Rainfall Intensity (inches per hour, in/hr)
A = Tributary Area (acres, ac)

3.2 Runoff Coefficient

The runoff coefficients used in this report come from the standards issued by the SCWA Hydrology Manual. From Table 3-2, $C=0.85$ was used for impervious (roof and pavement) areas and $C=0.30$ was used for vegetated areas. A weighted runoff coefficient was calculated using the terms below:

Weighted Runoff Coefficients are defined as follows:

$$C_{\text{weighted}} = \frac{C_1A_1 + C_2A_2 + C_3A_3 \; ...}{A_1 \; + A_2 \; + \; A_3 \; ...}$$

3.3 Rainfall Intensity

Intensities for a 15-year frequency storm event come from the mean annual precipitation (MAP) from Figure 2-2, and the time of concentration.

Time of Concentration was calculated as follows:

$T_c = T_0$ (overland flow) + T_c (channelized flow) + T_p (pipe flow)

Where:

T_c = total time (minutes)
T_0 (overland flow) = initial time of concentration (minutes)
T_c (channelized flow) = channelized flow travel time (minutes)
T_p (pipe flow) = pipe flow travel time (minutes)

The initial time of concentration was calculated using Equation3-2 from the Hydrology Manual, or 5 minutes, whichever was greater. Equation 3-2 is defined as follows:

$$T_c = \sqrt{\frac{D}{(80 \; x \; S^{1/2})}} * (18.5 - 16.5 * C) \qquad \text{(Equation 3 − 2)}$$

Channelized flow travel time and pipe flow travel time were calculated from Manning's Equation in conjunction with hand calculations, Express software, and Excel.

3.4 Pipe Capacity

Pipe Capacities were calculated using a computer program, AutoCAD Express Tools (Express). Pipe parameters (diameter, slope, manning's roughness coefficient, etc.), were input into Express and the program calculated pipe capacity based on Manning's Formula.

The pipe parameters were based upon existing data for the storm drain systems including pipe type, diameter, and invert elevations where they were available. If data was unavailable for the pipe systems, it was assumed they were reinforced concrete pipe at a minimum slope of 0.5%.

3.5 Pump Stations

For the purposes of this study, it was assumed that the peak flow of runoff from the area tributary to the pump stations was automatically discharged, at the rate at which it arrived, into the storm drain systems downstream of the pump stations.

4. RESULTS

The following are the results of the hydrologic calculations for the Pre-Project conditions of the Project Zeus Development site:

Peak Runoff, 15-Year Storm Event

Point of Concentration (P.O.C.)	Peak Runoff 15-Year Storm Event (cubic feet per second; cfs)
Outfall 1	52.07
Outfall 2	63.74
Outfall 3A	2.74
Outfall 3B	23.20
P.O.C. 4-1*	4.00
P.O.C. 4-2*	6.39
P.O.C. 4-3*	1.88

*Because System 4 primarily serves property outside of the project site, peak flow rates were calculated at the 3 potential locations of connection to System 4 rather than determining the peak runoff for the entire system at Outfall 4 or the capacity of the pipe at Outfall 4.

Outfall Pipe Capacity

Outfall*	Pipe Size and Type	Pipe Capacity (cubic feet per second; cfs)
Outfall 1	30" Reinforced Concrete Pipe	14.65
Outfall 2	36" Reinforced Concrete Pipe	20.02
Outfall 3A	18" Corrugated Metal Pipe	2.10
Outfall 3B	30" Reinforced Concrete Pipe	13.77

*Because System 4 primarily serves property outside of the project site, peak flow rates were calculated at the 3 potential locations of connection to System 4 rather than determining the peak runoff for the entire system at Outfall 4 or the capacity of the pipe at Outfall 4.

As seen in the results for Peak Runoff and Outfall Pipe Capacity, each of the outfalls is under capacity to convey peak flows from a 15-year storm event. In the event that a 15-year storm event occurs, it is anticipated that runoff will back up and be detained within in each of the storm drain systems and as inundation in the surrounding land, until such time that storm intensities decrease and runoff is allowed to be released at or below the capacity of the outfall pipe.

APPENDIX 5.1

CSW | ST2

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SHEET NO. 1/4

JOB NO. 5148300

BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology

CHK'D DATE

Convert Design Rainfall to Intensity

Interpolation of Values in Table 3-4A "Solano County Design Rainfall for San Francisco Bay Drainage Region"

15-Year Return Period

MAP	5 min	10min	15 min	30min	1 hr
Given → 20	0.34	0.46	0.55	0.74	0.99
Interpolated → 20.5	0.35	0.47	0.56	0.76	1.02
Given → 22	0.38	0.51	0.60	0.81	1.09

5 min

$$\frac{X - 0.34}{0.38 - 0.34} = \frac{20.5 - 20}{22 - 20}$$

$$X = \left(\frac{0.5}{2}\right)(0.04) + 0.34 = 0.35$$

10min

$$\frac{X - 0.46}{0.51 - 0.46} = \frac{20.5 - 20}{22 - 20}$$

$$X = \left(\frac{0.5}{2}\right)(0.05) + 0.46 = 0.47$$

15 min

$$\frac{X - 0.55}{0.60 - 0.55} = \frac{20.5 - 20}{22 - 20}$$

$$X = \left(\frac{0.5}{2}\right)(0.05) + 0.55 = 0.56$$

30min

$$\frac{X - 0.74}{0.81 - 0.74} = \frac{20.5 - 20}{22 - 20}$$

$$X = \left(\frac{0.5}{2}\right)(0.07) + 0.74 = 0.76$$

1 hr

$$\frac{X - 0.99}{1.09 - 0.99} = \frac{20.5 - 20}{22 - 20}$$

$$X = \left(\frac{0.5}{2}\right)(0.1) + 0.99$$

$$X = 1.02$$

SHEET NO. 2/4

JOB NO. 5148300 J

BY KNP

DATE

CLIENT

SUBJECT Pre-Project Hydrology

CHK'D

DATE

Convert Design Rainfall to Intensity:

15-year return period Duration vs. Intensity

Time of Concentration	5 min	10 min	15 min	30 min	60 min
Intensity: I_{15}	4.2 in/hr	2.82 in/hr	2.24 in/hr	1.52 in/hr	1.02 in/hr

I_{15} = Design Rainfall depth ÷ Duration in hours

Example: for 5 min 15-year return period frequency

$$I_{15} = \frac{0.35}{(5\,\text{min})\left(\frac{1\,\text{hr}}{60\,\text{min}}\right)} = 4.2\ \text{in/hr}$$

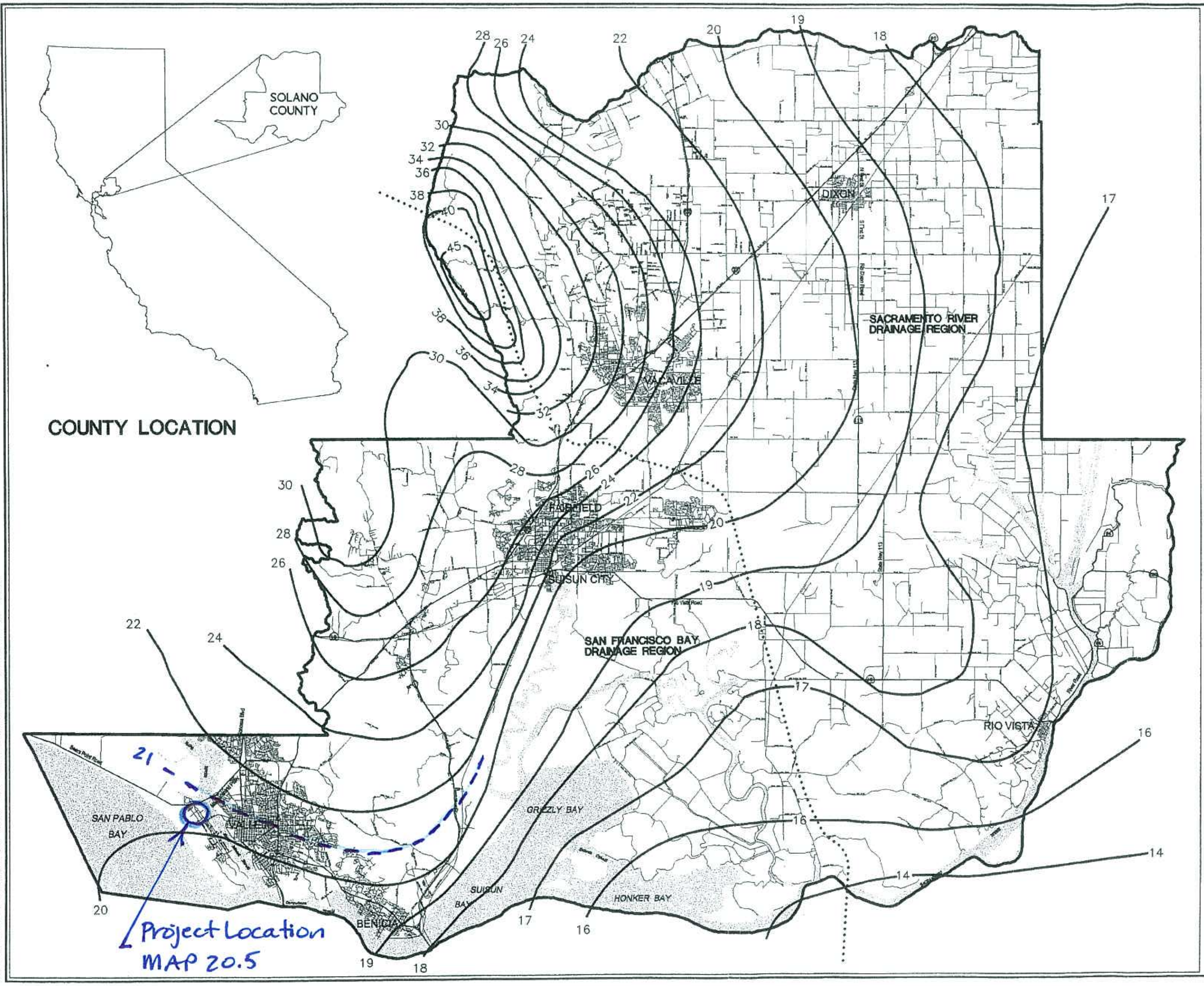


Figure 2-2

Solano County Water Agency
Hydrology Manual

ISOHYETAL MAP OF SOLANO COUNTY MEAN ANNUAL PRECIPITATION

N

0 10,000 20,000
SCALE IN FEET

NOTES:

1. SOURCE OF UNDERLYING MAPPING SHOWN HEREON IS DIGITIZED USGS QUAD MAPS AS SUPPLIED BY AMERICAN DIGITAL CARTOGRAPHY.
2. BOUNDARIES ARE APPROXIMATE AND HAVE BEEN ADJUSTED TO FIT USGS QUAD MAPS.
3. BASED ON OR CORRECTED TO THE 1951 TO 1980 BASE PERIOD.
4. ISOHYETAL LINES ARE FROM DESIGN RAINFALL FOR SOLANO COUNTY. PREPARED BY JAMES D. GOODRIDGE, SEPTEMBER 5, 1998.

LEGEND:

──	ROADS & MINOR HIGHWAYS
──	MAJOR HIGHWAYS
─22─	ISOHYETAL LINES
⋯⋯	DRAINAGE REGION BOUNDARY

WEST YOST & ASSOCIATES

CAD FILE: I:/074/98-04/04/074Fig-2-2.dwg CFG FILE: WYA2500.PCP_MRG DATE: 04-30-99 9:30am

3/4

4/4

Table 3-4A. Solano County Design Rainfall for San Francisco Bay Drainage Region

2-Year Return Period

MAP	5 Min	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	12 Hr	1 Day	2 Day	3 Day	4 Day	5 Day	6 Day	8 Day	10 day	15 Day	20 Day	30 Day	60 Day	Year
14	0.13	0.18	0.21	0.28	0.38	0.51	0.61	0.82	1.11	1.49	1.95	2.04	2.30	2.48	2.67	2.98	3.31	3.87	4.65	5.13	7.54	13.61
15	0.14	0.19	0.22	0.30	0.41	0.55	0.65	0.88	1.18	1.59	2.07	2.19	2.47	2.67	2.87	3.21	3.57	4.16	4.97	5.50	8.11	14.58
16	0.15	0.20	0.24	0.32	0.43	0.59	0.70	0.94	1.26	1.70	2.20	2.34	2.64	2.86	3.07	3.44	3.82	4.45	5.29	5.87	8.68	15.55
17	0.16	0.21	0.25	0.34	0.46	0.62	0.74	1.00	1.34	1.81	2.32	2.49	2.81	3.05	3.27	3.67	4.07	4.74	5.61	6.24	9.25	16.53
18	0.17	0.23	0.27	0.36	0.49	0.66	0.78	1.06	1.42	1.91	2.45	2.64	2.97	3.24	3.47	3.91	4.33	5.03	5.93	6.61	9.82	17.50
19	0.18	0.24	0.28	0.38	0.52	0.70	0.83	1.11	1.50	2.02	2.57	2.79	3.14	3.43	3.67	4.14	4.58	5.33	6.25	6.98	10.39	18.47
20	0.19	0.25	0.30	0.40	0.54	0.73	0.87	1.17	1.58	2.13	2.70	2.94	3.31	3.62	3.87	4.37	4.83	5.62	6.57	7.35	10.96	19.44
22	0.21	0.28	0.33	0.44	0.60	0.81	0.96	1.29	1.74	2.34	2.94	3.24	3.65	4.00	4.27	4.83	5.34	6.20	7.21	8.09	12.10	21.39
24	0.22	0.30	0.36	0.48	0.65	0.88	1.05	1.41	1.90	2.55	3.19	3.54	3.99	4.38	4.67	5.30	5.84	6.79	7.85	8.84	13.24	23.33
26	0.24	0.33	0.39	0.52	0.71	0.95	1.13	1.52	2.05	2.76	3.44	3.84	4.33	4.76	5.07	5.76	6.35	7.37	8.49	9.58	14.38	25.27
28	0.26	0.35	0.42	0.57	0.76	1.02	1.22	1.64	2.21	2.98	3.69	4.14	4.67	5.13	5.47	6.22	6.85	7.96	9.13	10.32	15.52	27.22
30	0.28	0.38	0.45	0.61	0.82	1.10	1.31	1.76	2.37	3.19	3.94	4.44	5.01	5.51	5.87	6.69	7.36	8.54	9.78	11.06	16.66	29.16
32	0.30	0.40	0.48	0.65	0.87	1.17	1.39	1.88	2.53	3.40	4.19	4.74	5.34	5.89	6.28	7.15	7.86	9.13	10.42	11.80	17.80	31.11
34	0.32	0.43	0.51	0.69	0.92	1.24	1.48	1.99	2.68	3.61	4.44	5.04	5.68	6.27	6.68	7.61	8.37	9.71	11.06	12.54	18.94	33.05
36	0.34	0.45	0.54	0.73	0.98	1.32	1.57	2.11	2.84	3.83	4.69	5.34	6.02	6.65	7.08	8.08	8.88	10.30	11.70	13.28	20.08	35.00
38	0.36	0.48	0.57	0.77	1.03	1.39	1.66	2.23	3.00	4.04	4.94	5.64	6.36	7.03	7.48	8.54	9.38	10.88	12.34	14.02	21.22	36.94
40	0.37	0.50	0.60	0.81	1.09	1.46	1.74	2.35	3.16	4.25	5.19	5.94	6.70	7.41	7.88	9.00	9.89	11.47	12.98	14.76	22.36	38.88
45	0.42	0.57	0.67	0.91	1.22	1.65	1.96	2.64	3.55	4.78	5.82	6.69	7.55	8.36	8.88	10.16	11.15	12.93	14.58	16.62	25.21	43.75

5-Year Return Period

MAP	5 Min	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	12 Hr	1 Day	2 Day	3 Day	4 Day	5 Day	6 Day	8 Day	10 day	15 Day	20 Day	30 Day	60 Day	Year
14	0.18	0.25	0.29	0.40	0.53	0.72	0.85	1.15	1.55	2.08	2.81	2.93	3.27	3.54	3.81	4.22	4.62	5.33	6.39	7.06	10.25	17.80
15	0.20	0.26	0.32	0.42	0.57	0.77	0.92	1.23	1.66	2.23	2.99	3.15	3.51	3.81	4.10	4.55	4.97	5.74	6.83	7.57	11.02	19.07
16	0.21	0.28	0.34	0.45	0.61	0.82	0.98	1.31	1.77	2.38	3.17	3.36	3.75	4.08	4.38	4.88	5.32	6.14	7.27	8.08	11.80	20.34
17	0.22	0.30	0.36	0.48	0.65	0.87	1.04	1.40	1.88	2.53	3.35	3.58	3.99	4.35	4.67	5.20	5.67	6.54	7.71	8.59	12.57	21.62
18	0.24	0.32	0.38	0.51	0.69	0.92	1.10	1.48	1.99	2.68	3.53	3.80	4.23	4.62	4.95	5.53	6.02	6.95	8.15	9.10	13.35	22.89
19	0.25	0.34	0.40	0.54	0.72	0.97	1.16	1.56	2.10	2.83	3.71	4.01	4.47	4.89	5.24	5.86	6.38	7.35	8.59	9.60	14.12	24.16
20	0.26	0.35	0.42	0.57	0.76	1.03	1.22	1.64	2.21	2.98	3.89	4.23	4.71	5.17	5.53	6.19	6.73	7.75	9.03	10.11	14.90	25.43
22	0.29	0.39	0.46	0.62	0.84	1.13	1.34	1.81	2.43	3.28	4.25	4.66	5.19	5.71	6.10	6.84	7.43	8.56	9.92	11.13	16.45	27.97
24	0.31	0.42	0.50	0.68	0.91	1.23	1.46	1.97	2.65	3.57	4.61	5.09	5.68	6.25	6.67	7.50	8.14	9.37	10.80	12.15	18.00	30.52
26	0.34	0.46	0.55	0.74	0.99	1.33	1.59	2.14	2.88	3.87	4.97	5.52	6.16	6.79	7.24	8.16	8.84	10.18	11.68	13.17	19.55	33.06
28	0.37	0.49	0.59	0.79	1.07	1.44	1.71	2.30	3.10	4.17	5.33	5.95	6.64	7.33	7.81	8.81	9.54	10.98	12.56	14.19	21.10	35.60
30	0.39	0.53	0.63	0.85	1.14	1.54	1.83	2.46	3.32	4.47	5.69	6.39	7.12	7.87	8.39	9.47	10.25	11.79	13.44	15.21	22.65	38.14
32	0.42	0.56	0.67	0.91	1.22	1.64	1.95	2.63	3.54	4.77	6.05	6.82	7.60	8.41	8.96	10.13	10.95	12.60	14.32	16.23	24.20	40.69
34	0.45	0.60	0.71	0.96	1.29	1.74	2.07	2.79	3.76	5.06	6.41	7.25	8.08	8.95	9.53	10.78	11.66	13.40	15.20	17.25	25.75	43.23
36	0.47	0.64	0.76	1.02	1.37	1.85	2.20	2.96	3.98	5.36	6.78	7.68	8.57	9.50	10.10	11.44	12.36	14.21	16.09	18.27	27.30	45.77
38	0.50	0.67	0.80	1.07	1.45	1.95	2.32	3.12	4.20	5.66	7.14	8.11	9.05	10.04	10.68	12.10	13.06	15.02	16.97	19.29	28.85	48.32
40	0.52	0.71	0.84	1.13	1.52	2.05	2.44	3.29	4.42	5.96	7.50	8.55	9.53	10.58	11.25	12.75	13.77	15.82	17.85	20.31	30.40	50.86
45	0.59	0.79	0.95	1.27	1.71	2.31	2.75	3.70	4.98	6.70	8.40	9.62	10.73	11.93	12.68	14.39	15.53	17.84	20.05	22.85	34.27	57.22

10-Year Return Period

MAP	5 Min	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	12 Hr	1 Day	2 Day	3 Day	4 Day	5 Day	6 Day	8 Day	10 day	15 Day	20 Day	30 Day	60 Day	Year
14	0.22	0.30	0.35	0.47	0.64	0.86	1.02	1.37	1.85	2.49	3.40	3.54	3.93	4.11	4.42	4.89	5.44	6.23	7.45	8.25	11.85	20.22
15	0.23	0.32	0.38	0.51	0.68	0.92	1.09	1.47	1.98	2.67	3.62	3.80	4.22	4.43	4.76	5.27	5.85	6.70	7.97	8.85	12.74	21.67
16	0.25	0.34	0.40	0.54	0.73	0.98	1.17	1.57	2.11	2.85	3.83	4.06	4.50	4.74	5.09	5.65	6.27	7.17	8.48	9.45	13.64	23.11
17	0.27	0.36	0.43	0.57	0.77	1.04	1.24	1.67	2.25	3.02	4.05	4.32	4.79	5.05	5.42	6.03	6.68	7.64	9.00	10.04	14.53	24.56
18	0.28	0.38	0.45	0.61	0.82	1.10	1.31	1.77	2.38	3.20	4.27	4.58	5.08	5.37	5.75	6.41	7.10	8.11	9.51	10.64	15.43	26.00
19	0.30	0.40	0.48	0.64	0.86	1.16	1.38	1.86	2.51	3.38	4.49	4.84	5.37	5.68	6.08	6.79	7.51	8.59	10.02	11.23	16.33	27.45
20	0.31	0.42	0.50	0.68	0.91	1.22	1.46	1.96	2.64	3.56	4.70	5.10	5.66	6.00	6.42	7.17	7.93	9.06	10.54	11.83	17.22	28.89
22	0.34	0.46	0.55	0.74	1.00	1.35	1.60	2.16	2.91	3.91	5.14	5.62	6.24	6.63	7.08	7.93	8.75	10.00	11.57	13.02	19.01	31.78
24	0.38	0.51	0.60	0.81	1.09	1.47	1.75	2.35	3.17	4.27	5.58	6.14	6.82	7.25	7.74	8.69	9.58	10.94	12.59	14.21	20.81	34.67
26	0.41	0.55	0.65	0.88	1.18	1.59	1.89	2.55	3.43	4.62	6.01	6.67	7.40	7.88	8.41	9.45	10.41	11.88	13.62	15.41	22.60	37.56
28	0.44	0.59	0.70	0.95	1.27	1.71	2.04	2.75	3.70	4.98	6.45	7.19	7.98	8.51	9.07	10.21	11.24	12.83	14.65	16.60	24.39	40.45
30	0.47	0.63	0.75	1.01	1.36	1.84	2.19	2.94	3.96	5.33	6.88	7.71	8.56	9.14	9.74	10.97	12.07	13.77	15.68	17.79	26.18	43.34
32	0.50	0.67	0.80	1.08	1.46	1.96	2.33	3.14	4.23	5.69	7.32	8.23	9.13	9.77	10.40	11.73	12.90	14.71	16.70	18.98	27.97	46.22
34	0.53	0.72	0.85	1.15	1.55	2.08	2.48	3.34	4.49	6.05	7.75	8.75	9.71	10.40	11.07	12.49	13.73	15.65	17.73	20.18	29.76	49.11
36	0.56	0.76	0.90	1.22	1.64	2.20	2.62	3.53	4.75	6.40	8.19	9.27	10.29	11.02	11.73	13.25	14.56	16.60	18.76	21.37	31.56	52.00
38	0.59	0.80	0.95	1.28	1.73	2.33	2.77	3.73	5.02	6.76	8.63	9.79	10.87	11.65	12.39	14.01	15.39	17.54	19.79	22.56	33.35	54.89
40	0.63	0.84	1.00	1.35	1.82	2.45	2.91	3.92	5.28	7.11	9.06	10.31	11.45	12.28	13.06	14.77	16.22	18.48	20.82	23.75	35.14	57.78
45	0.70	0.95	1.13	1.52	2.05	2.75	3.28	4.41	5.94	8.00	10.15	11.62	12.90	13.85	14.72	16.67	18.29	20.84	23.39	26.73	39.62	65.00

15-Year Return Period

Interpolate between these values for MAP = 20.5"

MAP	5 Min	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	12 Hr	1 Day	2 Day	3 Day	4 Day	5 Day	6 Day	8 Day	10 day	15 Day	20 Day	30 Day	60 Day	Year
14	0.24	0.32	0.38	0.52	0.69	0.93	1.11	1.50	2.02	2.71	3.73	3.88	4.29	4.60	4.95	5.46	5.89	6.71	8.03	8.90	12.69	21.50
15	0.26	0.34	0.41	0.55	0.74	1.00	1.19	1.60	2.16	2.91	3.97	4.17	4.61	4.96	5.33	5.89	6.34	7.22	8.58	9.55	13.65	23.04
16	0.27	0.37	0.44	0.59	0.79	1.07	1.27	1.71	2.30	3.10	4.20	4.45	4.92	5.31	5.70	6.31	6.79	7.73	9.14	10.19	14.61	24.57
17	0.29	0.39	0.47	0.63	0.84	1.13	1.35	1.82	2.45	3.30	4.44	4.74	5.24	5.66	6.07	6.74	7.24	8.24	9.69	10.83	15.57	26.11
18	0.31	0.41	0.49	0.66	0.89	1.20	1.43	1.93	2.59	3.49	4.68	5.02	5.56	6.01	6.44	7.16	7.69	8.75	10.24	11.48	16.53	27.65
19	0.32	0.44	0.52	0.70	0.94	1.27	1.51	2.03	2.74	3.68	4.92	5.31	5.87	6.36	6.81	7.59	8.13	9.25	10.80	12.12	17.49	29.18
20	0.34	0.46	0.55	0.74	0.99	1.34	1.59	2.14	2.88	3.88	5.16	5.59	6.19	6.72	7.18	8.01	8.58	9.76	11.35	12.76	18.45	30.72
22	0.38	0.51	0.60	0.81	1.09	1.47	1.75	2.35	3.17	4.27	5.64	6.17	6.82	7.42	7.93	8.86	9.48	10.78	12.46	14.05	20.37	33.79
24	0.41	0.55	0.66	0.88	1.19	1.60	1.91	2.57	3.46	4.65	6.12	6.74	7.46	8.12	8.67	9.71	10.38	11.79	13.56	15.34	22.29	36.86
26	0.44	0.60	0.71	0.96	1.29	1.74	2.07	2.78	3.74	5.04	6.60	7.31	8.09	8.83	9.42	10.56	11.28	12.81	14.67	16.62	24.21	39.93
28	0.48	0.64	0.77	1.03	1.39	1.87	2.22	3.00	4.03	5.43	7.07	7.88	8.72	9.53	10.16	11.41	12.18	13.82	15.78	17.91	26.13	43.01
30	0.51	0.69	0.82	1.10	1.49	2.00	2.38	3.21	4.32	5.82	7.55	8.45	9.35	10.23	10.90	12.26	13.07	14.84	16.89	19.19	28.05	46.08
32	0.55	0.74	0.88	1.18	1.59	2.14	2.54	3.42	4.61	6.21	8.03	9.02	9.99	10.94	11.65	13.11	13.97	15.86	17.99	20.48	29.98	49.15
34	0.58	0.78	0.93	1.25	1.69	2.27	2.70	3.64	4.90	6.59	8.51	9.59	10.62	11.64	12.39	13.96	14.87	16.87	19.10	21.77	31.90	52.22
36	0.61	0.83	0.98	1.33	1.79	2.40	2.86	3.85	5.18	6.98	8.99	10.17	11.25	12.35	13.14	14.81	15.77	17.89	20.21	23.05	33.82	55.29
38	0.65	0.87	1.04	1.40	1.88	2.54	3.02	4.06	5.47	7.37	9.46	10.74	11.89	13.05	13.88	15.66	16.67	18.90	21.32	24.34	35.74	58.36
40	0.68	0.92	1.09	1.47	1.98	2.67	3.18	4.28	5.76	7.76	9.94	11.31	12.52	13.75	14.62	16.51	17.57	19.92	22.42	25.63	37.66	61.44
45	0.77	1.03	1.23	1.66	2.23	3.00	3.58	4.81	6.48	8.73	11.14	12.74	14.10	15.51	16.48	18.63	19.81	22.46	25.19	28.84	42.46	69.12

APPENDIX 5.2

SHEET NO. 1/7

JOB NO. 5148300

BY KNP

DATE

CLIENT

SUBJECT Pre-Project Hydrology

CHK'D

DATE

Weighted Runoff Coefficients

1-3 274588.74 sf = 6.30 Ac

1-2 464904.77 sf = 10.67 Ac

1-1 1508688.59 sf = 34.63 Ac

2 3350464.47 sf = 76.92 Ac

3A-1 134758.97 sf = 3.09 Ac

3A-2 76959.97 sf = 1.77 Ac

3B 1293757.01 sf = 29.70 Ac

4-1 78290.34 sf = 1.80 Ac

4-2 145824.31 sf = 3.35 Ac

4-3 22506.77 sf = 0.52 Ac

Acreage of Drainage Areas

SHEET NO. 2/7

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Weighted Runoff Coefficients

Note: Use C = 0.85 for pavement and roofs. Use C = 0.30 for vegetated areas. These are consistent with values for C in Table 3-2 of the Solano County Hydrology Manual for AC/concrete & Roofs and Pasture.

For design storm of 15-year frequency:

$C_{impen} = (0.85)(1.04) = 0.88$

$C_{veg} = (0.30)(1.04) = 0.31$

Drainage Area 1-3 :

Total Area = 6.30 Ac

Pavement/Building Area = 95820.05 sf = 2.20 Ac

Vegetated Area = 6.30 Ac − 2.20 Ac = 4.10 Ac

$$Cw_{1-3} = \frac{(2.20\,Ac)(0.88) + (4.10\,Ac)(0.31)}{6.30\,Ac}$$

$$\boxed{Cw_{1-3} = 0.51 \;//\; \text{Drainage Area 1-3}}$$

Drainage Area 1-2 :

Total Area = 10.67 Ac

Pavement/Building Area = 131215.67 sf + 98195.11 sf = 229410.78 = 5.27 Ac

Vegetated Area = 10.67 Ac − 5.27 Ac = 5.40 Ac

$$Cw_{1-2} = \frac{(5.27\,Ac)(0.88) + (5.40\,Ac)(0.31)}{10.67\,Ac}$$

$$\boxed{Cw_{1-2} = 0.59 \;//\; \text{Drainage Area 1-2}}$$

Drainage Area 1-1 :

Total Area = 34.63 Ac

Pavement/Building Area = 302167.32 sf + 271446.54 sf = 573613.86 sf = 13.17 Ac

Vegetated Area = 34.63 Ac − 13.17 Ac = 21.46 Ac

$$Cw_{1-1} = \frac{(13.17\,Ac)(0.88) + (21.46\,Ac)(0.31)}{34.63\,Ac} = \boxed{0.53 = Cw_{1-1} \;//\; \text{Drainage Area 1-1}}$$

SHEET NO. 3/7

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Weighted Runoff Coefficients cont'd

Drainage Area 2 :

Total Area = 76.92 Ac

Pavement / Building Area = 220 1508.60 sf = 50.54 Ac

Vegetated Area = 76.92 Ac − 50.54 Ac = 26.38 Ac

$$Cw_2 = \frac{(50.54\text{ Ac})(0.88) + (26.38\text{ Ac})(0.31)}{76.92\text{ Ac}} = 0.68$$

$$\boxed{Cw_2 = 0.68 \;//\; \text{Drainage Area } 2}$$

Drainage Area 3A-1 :

Total Area = 3.09 Ac

Pavement / Building Area = 36690.67 sf = 0.84 Ac

Vegetated Area = 3.09 Ac − 0.84 Ac = 2.25 Ac

$$Cw_{3A-1} = \frac{(0.84\text{ Ac})(0.88) + (2.25\text{ Ac})(0.31)}{3.09\text{ Ac}} = 0.46$$

$$\boxed{Cw_{3A-1} = 0.46 \;//\; \text{Drainage Area 3A-1}}$$

Drainage Area 3A-2 :

Total Area = 1.77 Ac

Pavement / Building Area = 8207.76 sf = 0.19 Ac

Vegetated Area = 1.77 Ac − 0.19 Ac = 1.58 Ac

$$Cw_{3A-2} = \frac{(0.19\text{ Ac})(0.88) + (1.58\text{ Ac})(0.31)}{1.77\text{ Ac}} = 0.37$$

$$\boxed{Cw_{3A-2} = 0.37 \;//\; \text{Drainage Area 3A-2}}$$

SHEET NO. 4/7

JOB NO. 5148300 JOB KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Weighted Runoff Coefficients cont'd

Drainage Area 3B

Total Area = 29.70 Ac

Pavement/Building Area = 534122.89 sf = 12.26 Ac

Vegetated Area = 29.70 Ac − 12.26 Ac = 17.44 Ac

$$Cw_{3B} = \frac{(12.26\,Ac)(0.88) + (17.44\,Ac)(0.31)}{29.70\,Ac} = 0.55$$

$$\boxed{Cw_{3B} = 0.55 \ // \ \text{Drainage Area 3B}}$$

Drainage Area 4-1

Total Area = 1.80 Ac

Pavement/Building Area = 50216.04 sf = 1.15 Ac

Vegetated Area = 1.80 Ac − 1.15 Ac = 0.65 Ac

$$Cw_{4-1} = \frac{(1.15\,Ac)(0.88) + (0.65\,Ac)(0.31)}{1.80\,Ac} = 0.67$$

$$\boxed{Cw_{4-1} = 0.67 \ // \ \text{Drainage Area 4-1}}$$

Drainage Area 4-2

Total Area = 3.35 Ac

Pavement/Building Area = 115567.72 sf = 2.65 Ac

Vegetated Area = 3.35 Ac − 2.65 Ac = 0.70 Ac

$$Cw_{4-2} = \frac{(2.65\,Ac)(0.88) + (0.70\,Ac)(0.31)}{3.35\,Ac} = 0.76$$

$$\boxed{Cw_{4-2} = 0.76 \ // \ \text{Drainage Area 4-2}}$$

SHEET NO. 5/7

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Weighted Runoff Coefficients cont'd

Drainage Area 4-3

Total Area = 0.52 Ac

Pavement/Building Area = 21985.16 sf = 0.50 Ac

Vegetated Area = 0.52 Ac − 0.50 Ac = 0.02 Ac

$$C_{W_{4-3}} = \frac{(0.50 \text{Ac})(0.88) + (0.02 \text{Ac})(0.31)}{0.52 \text{Ac}} = 0.86$$

$$\boxed{C_{W_{4-3}} = 0.86 \quad // \text{ Drainage Area } 4\text{-}3}$$

6/7

Table 3-2. Runoff Coefficient for 10-Year Return Frequency[(a)]

Land Use	C[(b)]
Residential	
Apartments/condominiums	0.50 to 0.70
Single family (6 - 8 units per acre)	0.50 to 0.60
Single family (4 - 6 units per acre)	0.40 to 0.50
Single family (2 - 4 units per acre)	0.30 to 0.40
Single family (1 - 2 units per acre)	0.25 to 0.35
Commercial	
Downtown	0.70 to 0.95
Neighborhood	0.50 to 0.70
Industrial	
Light	0.50 to 0.80
Heavy	0.60 to 0.90
Parks, cemeteries	0.10 to 0.25
Playgrounds	0.20 to 0.35
Railroad yard	0.20 to 0.35
Unimproved urban areas	0.10 to 0.30
Agricultural/Open Space	
Cultivated	0.20 to 0.50
Pasture	0.15 to 0.45
Oak Timber & Brush	0.10 to 0.40
Surface Types	
Asphaltic and Concrete	0.70 to 0.95
Brick	0.70 to 0.85
Roofs	0.75 to 0.95
Lawns	0.15 to 0.35

Vegetated Areas C=0.30

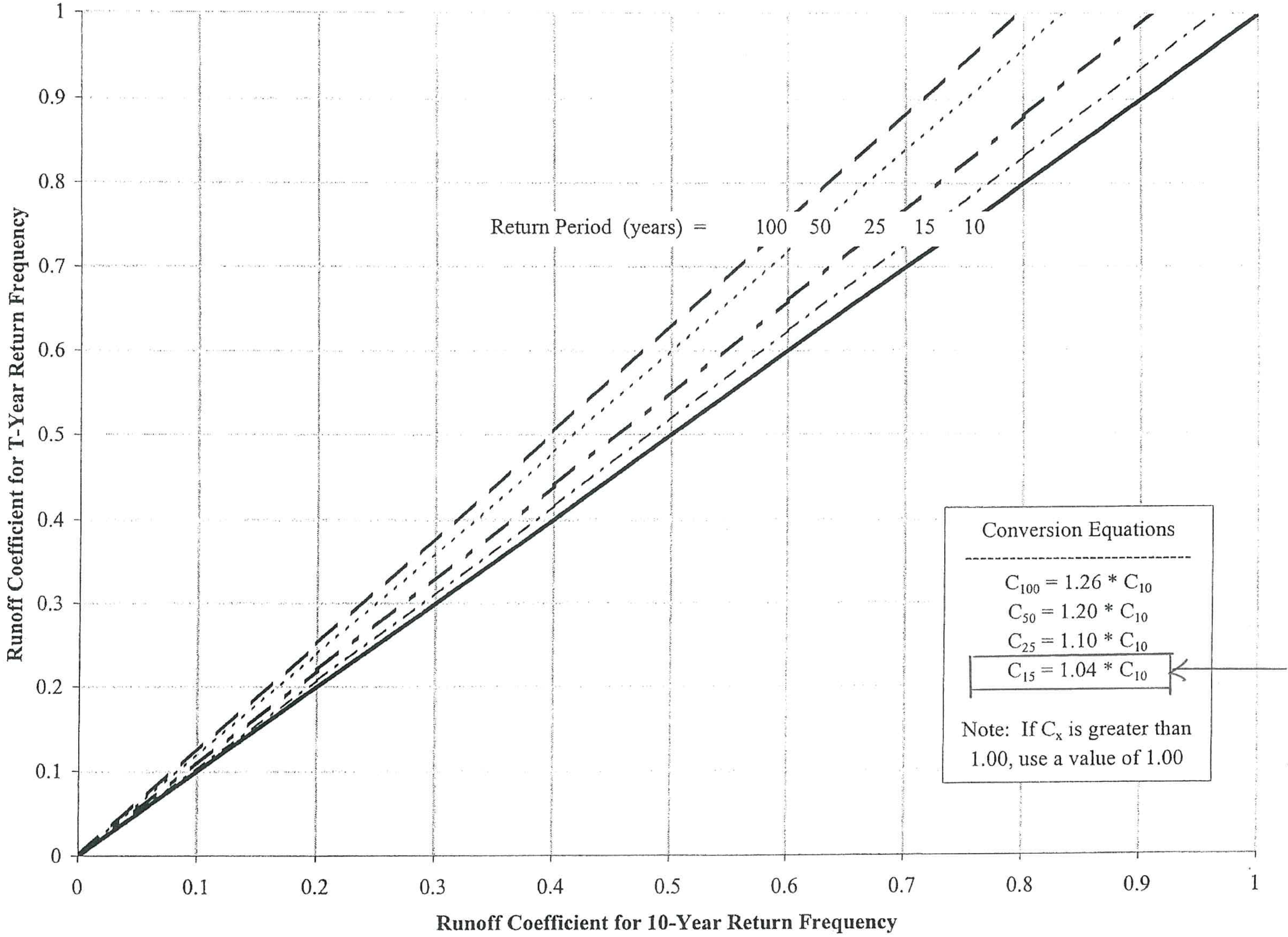
Pavement, broken C=0.88

Buildings, abandoned C=0.88

(a) For other return periods, adjust C coefficient based on Figure 3-1.

(b) For areas with slopes of 1 percent or less, use values in the low end of the given range; for areas with slopes greater than 1 percent and up to 5 percent, use values in the middle of the given range; for areas with slopes greater than 5 percent, use values in the high end of the given range.

Figure 3-1. Runoff Coefficient Correction for Design Frequency



Runoff Coefficient Conversion for 10-year to 15-year event.

APPENDIX 5.3

SHEET NO. 1/16

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration T_c

Area 1-3

Overland Flow t_o :

$$t_o = \sqrt{\frac{D}{80\sqrt{S}}}\,(18.5 - 16.5C)$$

$$t_o = \sqrt{\frac{585\text{ ft}}{80\sqrt{0.4}}}\,(18.5 - 16.5(0.51))$$

$$t_o = (3.40)(10.09)$$

$$t_o = 34.3 \text{ min}$$

Path Length = 585 ft = D

Upstream Elev = 9.4

Downstream Elev = 7.2

$$S = \frac{9.4 - 7.2}{585}(100) = 0.4\%$$

$$C_{W_{1-3}} = 0.51$$

$$\boxed{T_{c_{1-3}} = t_o = 34.3 \text{ min} \quad \text{Time of Concentration, Area 1-3}}$$

Area 1-2

Overland Flow t_o :

$$t_o = \sqrt{\frac{D}{80\sqrt{S}}}\,(18.5 - 16.5C)$$

$$t_o = \sqrt{\frac{407}{80\sqrt{0.4}}}\,(18.5 - 16.5(0.59))$$

$$t_o = 24.9 \text{ min}$$

Path Length = 407 ft = D

Upstream Elev = 11.7

Dowstream Elev = 10

$$S = \frac{11.7 - 10}{407}(100) = 0.4\%$$

$$C_{W_{1-2}} = 0.59$$

Pipe Flow t_{p_1} : first segment of pipe flow

10" CMP

$n = 0.026$ (Table 3-3
Solano County
Water Agency
Hydrology Manual)

Pipe length = 611 ft

Uses datum on record drawings { Upstream Elev = 107.62 } for slope calculation only

Uses datum on record drawings { Downstream Elev = 104.62 } for slope calculation only

$$S = \frac{107.62 - 104.62}{611} = 0.005 \text{ ft/ft}$$

SHEET NO. 2/16
JOB NO. 5148300
BY KNP
DATE
CLIENT
SUBJECT Pre-Project Hydrology
CHK'D
DATE

Time of Concentration cont'd

Area 1-2 cont'd

t_{p_1}, first segment of pipe flow:

Assume pipe is flowing at 100% of pipe depth during 15-year storm event

for 10" cmp at slope 0.005 ft/ft, the velocity of flow in pipe is:

$v = 1.42$ ft/s (calculated using Manning's Formula through Hydraflow Express computer program)

$$t_{p_1} = 611\text{ ft}\left(\frac{1\text{sec}}{1.42\text{ ft}}\right)\left(\frac{1\text{min}}{60\text{ sec}}\right) = 7.2\text{ min}$$

Pipe Flow t_{p_2}: second segment of pipe flow

15" cmp
$n = 0.026$ (Table 3-3, Solano County Water Agency Hydrology Manual)

uses datum on record drawings

Pipe Length = 434 LF
Upstream Elev = 104.62
Downstream Elev = 102.53

$$S = \frac{104.62 - 102.53}{434\text{ LF}} = 0.005\text{ ft/ft}$$

Assume pipe is flowing at 100% of pipe depth during 15-year storm event

for 15" cmp at slope 0.005 ft/ft, the velocity of flow in pipe is:

$v = 1.86$ ft/s (Hydraflow Express)

$$t_{p_2} = 434\text{ ft}\left(\frac{1\text{sec}}{1.86\text{ ft}}\right)\left(\frac{1\text{min}}{60\text{sec}}\right) = 3.9\text{ min}$$

SHEET NO. 3/16

JOB NO. 51483.00

BY KNP DATE

CLIENT

SUBJECT Pre-Project Hydrology

CHK'D

DATE

Time of Concentration cont'd

Area 1-2 cont'd:

$$Tc_{1-2} = t_o + t_{p_1} + t_{p_2} = 24.9\text{ min} + 7.2\text{ min} + 3.9\text{ min} = 36.0\text{ min}$$

$$\boxed{Tc_{1-2} = 36.0\text{ min} \quad \text{Time of Concentration, Area 1-2}}$$

Area 1-1:

Overland Flow t_o:

$$t_o = \sqrt{\frac{D}{80\sqrt{S}}}\,(18.5-16.5C)$$

$$t_o = \sqrt{\frac{97}{80\sqrt{1.34}}}\,(18.5-16.5(0.53))$$

$$t_o = 10.0\text{ min}$$

Path Length = 97 LF = D

Upstream Elev = 8.5

Downstream Elev = 7.2

$$S = \frac{8.5-7.2}{97}(100) = 1.34\%$$

$$Cw_{1-1} = 0.53$$

Pipe Flow t_{p_1}: 1st segment of pipe flow

10" CMP

n = 0.026 (Table 3-3; SCWA Hydrology manual)

Assume pipe is flowing at 100% of pipe depth during 15-year storm event

For 10" CMP at slope 0.3% the velocity in the pipe is:

v = 1.10 ft/s (Hydraflow Express)

$$t_{p_1} = 687\text{ ft}\left(\frac{1\text{ sec}}{1.10\text{ ft}}\right)\left(\frac{1\text{ min}}{60\text{ sec}}\right) = 10.4\text{ min}$$

Pipe Length = 687 LF

Upstream Elev = 102.61

Downstream Elev = 102.10

Length for slope calc: 192

$$S = \frac{102.61-102.10}{192} = 0.003\text{ ft/ft}$$

SHEET NO. 4/16

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration
Area 1-1 cont'd:

Pipe Flow t_{p_2}: 2nd segment of pipe flow

12" CMP
n = 0.0026 (Table 3-3, SCWA Hydrology Manual)

Assume pipe is flowing at 100% of pipe depth during 15-year storm event

For 12" CMP at slope 0.3% the velocity in the pipe is:

$v = 1.24$ ft/s (Hydraflow Express)

$$t_{p_2} = 304\text{ LF}\left(\frac{1\text{ sec}}{1.24\text{ ft}}\right)\left(\frac{1\text{ min}}{60\text{ sec}}\right) = 4.1\text{ min}$$

Pipe length = 304 LF

Upstream Elev = 102.05

Downstream Elev = 101.14

$$S = \frac{102.05 - 101.14}{304\text{ LF}} = 0.003\text{ ft/ft}$$

Pipe Flow t_{p_3}: 3rd segment of pipe flow

15" x 15" BOX (assume concrete)
n = 0.015 (Table 3-3, SCWA Hydrology Manual)

Assume conduit is flowing full during a 15-year storm event

For 15" x 15" conc box at slope 0.8% the velocity in the pipe is:

$v = 4.94$ ft/s (Hydraflow Express)

$$t_{p_3} = 206\text{ LF}\left(\frac{1\text{ sec}}{4.94\text{ ft}}\right)\left(\frac{1\text{ min}}{60\text{ sec}}\right) = 0.7\text{ min}$$

Pipe length = 206 LF

Upstream Elev = 100.94

Downstream Elev = 99.34

$$S = \frac{100.94 - 99.34}{206} = 0.008\text{ ft/ft}$$

SHEET NO. 5/16

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration
Area 1-1 cont'd:

Pipe Flow t_{p4} : 4th segment of pipe flow

21" cmp
$n = 0.026$ (Table 3-3, SCWA Hydrology Manual)

Assume conduit is flowing full during a 15-year storm event

For a 21" cmp at slope 0.4% the velocity in the pipe is:

$v = 2.08$ ft/s (Hydraflow Express)

$$t_{p4} = 260\,LF\left(\frac{1\,sec}{2.08\,ft}\right)\left(\frac{1\,min}{60\,sec}\right) = 2.1\,min$$

Pipe length 260 LF

Upstream Elev = 99.29

Downstream Elev = 97.69

Length for slope calculation
358 LF

$$S = \frac{99.29 - 97.69}{358\,LF} = 0.004\,ft/ft$$

Pipe Flow t_{p5}

24" cmp
$n = 0.026$ (Table 3-3, SCWA Hydrology Manual)

Assume conduit is flowing full during a 15-year storm event

For a 24" cmp at slope 0.4%, the velocity in the pipe is:

$v = 2.28$ ft/s (Hydraflow Express)

$$t_{p5} = 134\,LF\left(\frac{1\,sec}{2.28\,ft}\right)\left(\frac{1\,min}{60\,sec}\right) = 1.0\,min$$

Pipe length = 134 LF

Use slope calculation from t_{p4}.

$S = 0.004$ ft/ft

SHEET NO. 6/16

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration
Area 1-1 cont'd

Pipe Flow t_{p_6}

21" RCP
n = 0.015 (Table 3-3, SCWA Hydrology Manual)

Assume conduit is flowing full during a 15-year storm event

For a 21" RCP at slope 0.4%, the velocity in the pipe is:

$v = 3.61$ ft/s (Hydraflow Express)

$$t_{p_6} = 255\,LF\left(\frac{1\,sec}{3.61\,ft}\right)\left(\frac{1\,min}{60\,sec}\right) = 1.2\,min$$

Pipe length = 255 LF

Assume pipe slope is similar to the slope of the pipes just upstream.

S = 0.004 ft/ft.

Pipe Flow t_{p_7}

24"x24" BOX (assume concrete)
n = 0.015 (Table 3-3, SCWA Hydrology Manual)

Assume conduit is flowing full during a 15-year storm event

For a 24"x24" box culvert at slope 0.4%, the velocity in the conduit is:

$v = 4.78$ ft/s (Hydraflow Express)

$$t_{p_7} = 158\,LF\left(\frac{1\,sec}{4.78\,ft}\right)\left(\frac{1\,min}{60\,sec}\right) = 0.6\,min$$

Conduit Length = 158 LF

Assume conduit slope is similar to the slope of the pipes just upstream

S = 0.004 ft/ft.

SHEET NO. 7/16

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration cont'd

Area 1-1 cont'd

$$T_{C_{1-1}} = t_o + t_{p_1} + t_{p_2} + t_{p_3} + t_{p_4} + t_{p_5} + t_{p_6} + t_{p_7}$$

$$T_{C_{1-1}} = 10.0\,min + 10.4\,min + 4.1\,min + 0.7\,min + 2.1\,min + 1.0\,min + 1.2\,min + 0.6\,min$$

$$\boxed{T_{C_{1-1}} = 30.1\,min \quad \text{Time of Concentration, Area 1-1}}$$

SHEET NO. 8/16

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-project Hydrology CHK'D DATE

Time of Concentration, Tc

Area 2

Overland Flow, t_o:

$$t_o = \sqrt{\frac{D}{80\sqrt{S}}}\,(18.5-16.5C)$$

$$t_o = \sqrt{\frac{178\ \text{LF}}{80\sqrt{1}}}\,(18.5-16.5(0.68))$$

$$t_o = 10.9\ \text{min}$$

Assume land slope is on the order of 1%.

$C_{w_2} = 0.68$

$D = 178$ LF

$S = 1\%$

Pipe Flow t_{p_1}:

10" CMP
$n = 0.026$ (Table 3-3, SCWA Hydrology Manual)

Assume pipe is flowing at 100% of pipe depth during 15-year storm event.

The velocity of flow in pipe is:

$v = 1.42$ ft/s

$$t_{p_1} = (297\ \text{LF})\left(\frac{1\ \text{sec}}{1.42\ \text{ft}}\right)\left(\frac{1\ \text{min}}{60\ \text{sec}}\right) = 3.5\ \text{min}$$

Pipe length = 297 LF

As pipes are generally sloped on the order of 0.5%, use this slope for t_{p_1}. No data on inverts.

SHEET NO. 9/16

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration cont'd

Area 2, cont'd

Pipe Flow, t_{p2}:

12" CMP
$n = 0.026$ (Table 3-3, SCWA Hydrology Manual)

Assume pipe is flowing at full depth during a 15-year storm event

The velocity of flow in pipe is:

$v = 0.56$ ft/s (Hydraflow Express)

$$t_{p2} = (100 \text{ LF})\left(\frac{1\text{sec}}{0.56 \text{ ft}}\right)\left(\frac{1\text{min}}{60\text{sec}}\right) = 3.0 \text{ min}$$

Pipe length = 100 LF

upstream elev = 105.95

downstream elev = 105.89

$$\text{Slope} = \frac{105.95 - 105.89}{100} = 0.06\%$$

$v = 3.22$ ft/s

$$t_{p_3} = 334 \text{ ft}\left(\frac{1\text{sec}}{3.22 \text{ ft}}\right)\left(\frac{1\text{min}}{60\text{sec}}\right) = 1.7 \text{ min}$$

t_{p3} 18" RCP
$n = 0.015$

$$S = \frac{106.14 - 104.83}{334} = 0.39$$

~~ft/ft~~

Pipe Flow, t_{p4}:

24" RCP
$n = 0.015$ (Table 3-3, SCWA Hydrology Manual)

Assume pipe is flowing full during 15-year event

The velocity of flow in pipe is:

$v = 2.16$ ft/s (Hydraflow Express)

$$t_{p4} = 1004 \text{ LF}\left(\frac{1\text{sec}}{2.16 \text{ ft}}\right)\left(\frac{1\text{min}}{60\text{ sec}}\right) = 7.7 \text{ min}$$

Pipe length = 1004 LF

upstream inv. = 104.98

downstream inv = 103.76

$$\text{Slope} = \frac{104.98 - 103.76}{1004} = 0.12\%$$

— offsite —

SHEET NO. 10/16
JOB NO. 5148300
BY KNP DATE
CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration cont'd

Area 2, cont'd

Pipe Flow t_{p_5}

24" RCP
$n = 0.015$

Assume pipe is flowing full during the 15-year storm event

$v = 2.5$ ft/s

$$t_{p_5} = 586\ LF\left(\frac{1\ sec}{2.5\ ft}\right)\left(\frac{1\ min}{60\ sec}\right) = 3.9\ min$$

Pipe length = 586 LF
upstream invert = 103.61
downstream invert = 102.69
length for slope calc = 422

$$S = \frac{103.61 - 102.69}{586} = 0.16\%$$

Pipe Flow t_{p_6}

24" RCP
$n = 0.015$

Pipe flowing full

$v = 2.4$ ft/s

$$t_{p_6} = 94'\left(\frac{1\ sec}{2.4\ ft}\right)\left(\frac{1\ min}{60\ sec}\right) = 0.6\ min$$

Pipe length = 94'
for slope calculation
L = 253'
upstream inv = 104.27
downstream inv = 103.90

$$slope = \frac{104.27 - 103.90}{253} = 0.15\%$$

Pipe Flow t_{p_7}

36" RCP
$n = 0.015$

$v = 3.75$ ft/s

$$t_{p_7} = 1580\ ft\left(\frac{1\ sec}{3.75\ ft}\right)\left(\frac{1\ min}{60\ sec}\right) = 7.0\ min$$

Pipe length = 1580
upstream inv = 103.85
downstream inv = 100.85
Length for slope calc = 1422
$S = 0.21\%$

SHEET NO. 11/16

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration cont'd

Area 2, cont'd

Time of concentration for upstream, offsite flow = Tc_{2off}

$Tc_{2off} = t_o + t_{p_1} + t_{p_2} + t_{p_3} + t_{p_4} = 10.9 + 3.5 + 3.0 + 1.7 + 7.7 = 26.8$ min

$Tc_{2off} = 26.8$ min

Time of Concentration at Diversion location = $Tc_{2\,Divert}$

$Tc_{2DIVERT} = Tc_{2off} + t_{p_5} = 26.8$ min $+ 3.9$ min $= 30.7$ min

$Tc_{2DIVERT} = 30.7$ min

Time of Concentration at Outfall = $Tc_{2\,outfall}$

$Tc_{2outfall} = Tc_{2DIVERT} + t_{p_6} + t_{p_7} = 30.7$ min $+ 0.6$ min $+ 7.0$ min $= 38.3$ min

$\boxed{Tc_{2outfall} = 38.3 \text{ min} \quad \text{Area 2}}$

SHEET NO. 12/16

JOB NO. 5148300

BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration

Area 3A-1

Overland Flow to:

D = 630
upstream elev = 10.89
downstream elev = 9.2

$$S = \frac{10.89-9.2}{630} = 0.27\%$$

$$Cw_{3A-1} = 0.46$$

$$t_o = \sqrt{\frac{D}{80\sqrt{S}}}\ (18.5-16.5C)$$

$$t_o = \sqrt{\frac{630}{80\sqrt{0.27}}}\ (18.5-16.5(0.46))$$

$$t_o = 42.5 \text{ min}$$

$$\boxed{Tc_{3A-1} = t_o = 42.5 \text{ min} \qquad \text{Area } 3A-1}$$

Area 3A-2

Overland Flow, to:

D = 240 ft
upstream elev = 12
downstream elev = 11

$$S = 0.42\%$$

$$Cw_{3A-2} = 0.37$$

$$t_o = \sqrt{\frac{D}{80\sqrt{S}}}\ (18.5-16.5C)$$

$$= \sqrt{\frac{240}{80\sqrt{0.42}}}\ \overset{12.395}{(18.5-16.5(0.37))}$$

$$\boxed{Tc_{3A-2} = t_o = 24.7 \text{ min} \qquad \text{Area } 3A-2}$$

SHEET NO. 13/16

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration cont'd

Area 3B

Overland Flow, t_o

$$t_o = \sqrt{\frac{D}{80\sqrt{S}}}\ (18.5 - 16.5C)$$

$$t_o = \sqrt{\frac{575}{80\sqrt{0.9}}}\ (18.5 - 16.5(0.55))$$

$$t_o = 25.9 \text{ min}$$

Path length = 575 LF

upstream elev = 14
downstream elev = 8.8

S = 0.9%

$C_{W_{3B}} = 0.55$

t_{p_1} Pipe Flow

8" cast iron
$n = 0.015$

$v = 2.76$ ft/s

$$t_{p_1} = 153 \text{ LF}\left(\frac{1 \text{ sec}}{2.76 \text{ ft}}\right)\left(\frac{1 \text{ min}}{60 \text{ sec}}\right) = 0.9 \text{ min}$$

Pipe length = 153 LF

up inv = 105.52
down inv = 103.17
length for slope = 280
S = 0.84%

t_{p_2} pipe flow

12" CMP
$n = 0.026$

$v = 1.11$ ft/s

$$t_{p_2} = 558 \text{ LF}\left(\frac{1 \text{ sec}}{1.11 \text{ ft}}\right)\left(\frac{1 \text{ min}}{60 \text{ sec}}\right) = 8.4 \text{ min}$$

Pipe length = 558 LF

up inv = 103.17
down inv = 102.13
length for slope = 431
S = 0.24%

SHEET NO. 14/16

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration cont'd

Area 3B

t_{P3} pipe flow

24" RCP
$n = 0.015$

Pipe length = 297 LF
up elev = 102.13
down elev = 100.53
length for slope = 208
$S = 0.77\%$

$v = 5.48$ ft/s

$$t_{P_3} = 297\text{ LF}\left(\frac{1\text{ sec}}{5.48\text{ ft}}\right)\left(\frac{1\text{ min}}{60\text{ sec}}\right) = 0.9\text{ min}$$

$$T_c = t_o + t_{P_1} + t_{P_2} + t_{P_3} = 25.9\text{ min} + 0.9\text{ min} + 8.4\text{ min} + 0.9\text{ min}$$

$T_c = 36.1$ min

$\boxed{T_c = 36.1 \text{ minutes} \quad \text{Area 3B}}$

SHEET NO. 15/16

JOB NO. 5148300 BY KWP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration

Area 4-1

t_o = Assume 5 minutes for t_o (roof to bottom of downspout)

8" RCP

$v = 2.13$ ft/s

Length = 406 LF

$t_{p_1} = 406\,\text{LF}\left(\frac{1\,\text{sec}}{2.13\,\text{ft}}\right)\left(\frac{1\,\text{min}}{60\,\text{sec}}\right) = 3.2\,\text{min}$

assume slope = 0.5%

$n = 0.015$

$T_c = t_o + t_{p_1} = 5\,\text{min} + 3.2\,\text{min} = 8.2\,\text{min}$

$\boxed{T_c = 8.2\text{ minutes Area 4-1}}$

Area 4-2

$t_o = \sqrt{\frac{D}{80\sqrt{S}}}\,(18.5 - 16.5C)$

D = 186'
upst elev = 14.9
down elev = 14

$t_o = \overset{1.813297}{\sqrt{\frac{186'}{80\sqrt{0.5}}}}\,\overset{5.96}{(18.5 - 16.5(0.76))}$

$S = \frac{14.9 - 14}{186}(100) = 0.5\,\%$

$t_o = 10.8$ min

$C_{W_{4\text{-}2}} = 0.76$

assume 8" RCP n=0.015

t_{p_1}

$v = 4.66$ ft/s

Length = 527'
upst elev = 111.90
down elev = 109.01 length = 122
slope = 2.4%

$t_{p_1} = 527\,\text{ft}\left(\frac{1\,\text{sec}}{4.66\,\text{ft}}\right)\left(\frac{1\,\text{min}}{60\,\text{sec}}\right) = 1.9\,\text{min}$

$T_c = 10.8\,\text{min} + 1.9\,\text{min} = 12.7\,\text{min}$

$\boxed{T_c = 12.7\text{ minutes, Area 4-2}}$

SHEET NO. 16/16

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Time of Concentration, Tc, cont'd:

Area 4-3

8" RCP
slope = 1% (assumed)
n = 0.015

Length = 242'

v = 3.01 ft/s (Hydraflow Express)

$$T_c = 242' \left(\frac{1 \text{sec}}{3.01 \text{ft}}\right)\left(\frac{1 \text{min}}{60 \text{sec}}\right) = 1.3 \text{ min}$$

$$\boxed{\text{Use } T_c = 5 \text{min} \qquad \text{Area } 4\text{-}3}$$

APPENDIX 5.4

CSW | ST2
CSW/Stuber-Stroeh Engineering Group, Inc.
45 Leveroni Court, Novato, CA 94949 Tel 415.883.9850 Fax 415.883.9835
1310 Redwood Way, Suite 220, Petaluma, CA 94954 Tel 707.795.4764 www.cswst2.com

SHEET NO. 1/14

JOB NO. 5148300

BY KNP DATE

CLIENT

SUBJECT Pre-Project Hydrology

CHK'D

DATE

PEAK FLOW, 15-YEAR STORM EVENT

AREA 2 – Intersection of L Street and Walnut Avenue

Tributary Area = 1424890.17 sf = 32.71 Ac = $A_{2_{LSTREET}}$

$C_{W_2} = 0.68$

$T_{C_{2DIVERT}} = 30.7$ min

Intensity: $\dfrac{I_{15} - 1.52}{1.02 - 1.52} = \dfrac{30.7 - 30}{60 - 30}$

$I_{15} = \left(\dfrac{0.7}{30}\right)(-0.50) + 1.52 = 1.51$ in/hr

Rational Method: $Q = CIA$

$Q_{2_{LSTREET}} = (C_{W_2})(I_{15})(A_{2_{LSTREET}}) = (0.68)(1.51 \text{ in/hr})(32.71 \text{ Ac})$

$Q_{2_{LSTREET}} = 33.59$ cfs

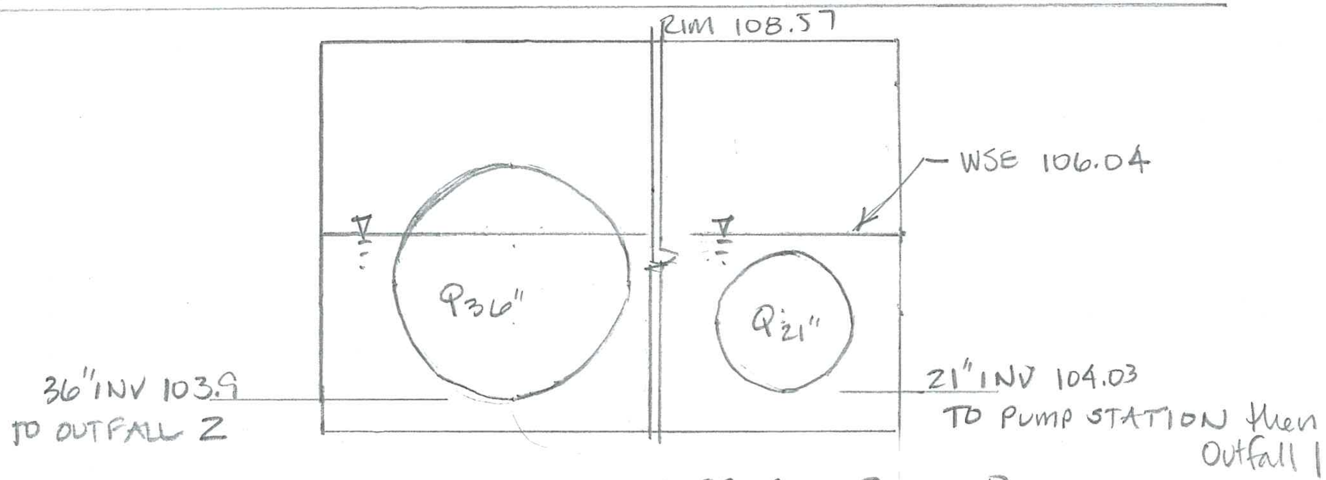
SHEET NO. 2/14

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

PEAK FLOW, 15-YEAR STORM EVENT

AREA 2 – FLOW SPLIT AT INTERSECTION OF L STREET AND WALNUT AVENUE



$$Q_{2_{LSTREET}} = 33.59 \text{ cfs} = Q_{36''} + Q_{21''}$$

BY INLET CONTROL, HOW IS THE FLOW DIVIDED BETWEEN THE 36" RCP AND THE 21" CMP ($Q_{2_{LSTREET}} = 33.59$ cfs)

From Hydraflow Express computer program, for the flow to split to the two directions, the 36" RCP will intercept 22.25 cfs and the 21" cmp will intercept 11.34 cfs.

$Q_{36''} = 22.25$ cfs (toward Outfall 2)

$Q_{21''} = 11.34$ cfs (toward Pump Station, then Outfall 1)

Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Monday, Nov 7 2016

36in RCP

Invert Elev Dn (ft) = 101.40
Pipe Length (ft) = 50.00
Slope (%) = 5.00
Invert Elev Up (ft) = 103.90
Rise (in) = 36.0
Shape = Circular
Span (in) = 36.0
No. Barrels = 1
n-Value = 0.015
Culvert Type = Circular Concrete
Culvert Entrance = Square edge w/headwall (C)
Coeff. K,M,c,Y,k = 0.0098, 2, 0.0398, 0.67, 0.5

Input to generate inlet control condition.

Embankment

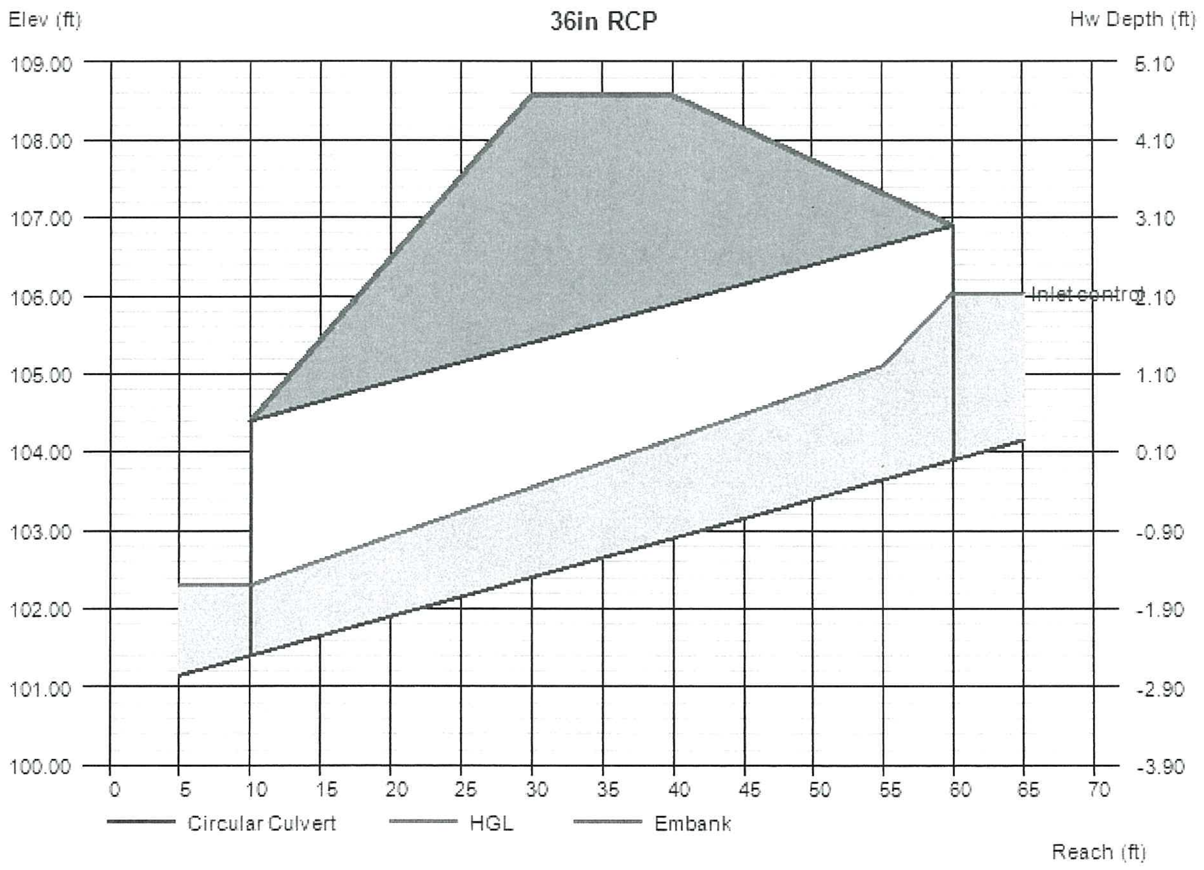
Top Elevation (ft) = 108.57
Top Width (ft) = 10.00
Crest Width (ft) = 10.00

Calculations

Qmin (cfs) = 22.25
Qmax (cfs) = 22.25
Tailwater Elev (ft) = Critical

Highlighted

Qtotal (cfs) = 22.25
Qpipe (cfs) = 22.25
Qovertop (cfs) = 0.00
Veloc Dn (ft/s) = 12.46
Veloc Up (ft/s) = 6.21
HGL Dn (ft) = 102.30
HGL Up (ft) = 105.42
Hw Elev (ft) = 106.04
Hw/D (ft) = 0.71
Flow Regime = Inlet Control



4/14

Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc.

Monday, Nov 7 2016

21in CMP

Invert Elev Dn (ft) = 101.53
Pipe Length (ft) = 50.00
Slope (%) = 5.00
Invert Elev Up (ft) = 104.03
Rise (in) = 21.0
Shape = Circular
Span (in) = 21.0
No. Barrels = 1
n-Value = 0.024
Culvert Type = Circular Corrugate Metal Pipe
Culvert Entrance = Headwall
Coeff. K,M,c,Y,k = 0.0078, 2, 0.0379, 0.69, 0.5

Input to generate inlet control condition.

Embankment

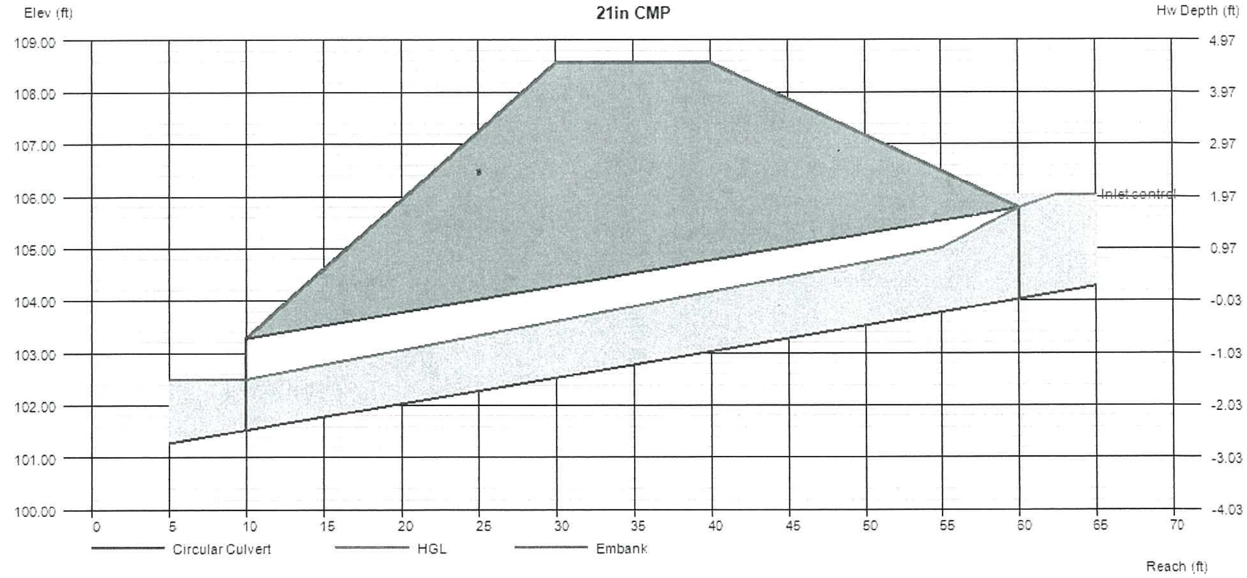
Top Elevation (ft) = 108.57
Top Width (ft) = 10.00
Crest Width (ft) = 10.00

Calculations

Qmin (cfs) = 11.34
Qmax (cfs) = 11.34
Tailwater Elev (ft) = Critical

Highlighted

Qtotal (cfs) = 11.34
Qpipe (cfs) = 11.34
Qovertop (cfs) = 0.00
Veloc Dn (ft/s) = 8.28
Veloc Up (ft/s) = 6.15
HGL Dn (ft) = 102.50
HGL Up (ft) = 105.28
Hw Elev (ft) = 106.04
Hw/D (ft) = 1.15
Flow Regime = Inlet Control



SHEET NO. 5/14

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

PEAK FLOW, 15-YEAR STORM EVENT

AREA 2 – PEAK FLOW AT OUTFALL 2

STARTING AFTER FLOW SPLIT AT INTERSECTION OF L STREET AND WALNUT AVE:

$Q_{36''} = 22.25$ cfs $\qquad Tc_{2_{DIVERT}} = 30.7$ min

Tributary area downstream of L Street and Walnut Avenue

$A_{2'} = A_2 - A_{2_{LSTREET}} = 76.92 \text{ Ac} - 32.71 \text{ Ac} = 44.21 \text{ Ac}$

$C_{w_2} = 0.68$

$T_{c_2} = 38.3$ min

Intensity: $\dfrac{I_{15} - 1.52}{1.02 - 1.52} = \dfrac{38.3 - 30}{60 - 30}$

$I_{15} = \left(\dfrac{8.3}{30}\right)(-0.5) + 1.52 = 1.38 \text{ in/hr}$

Rational Method: $Q = CIA$

$$Q_2 = Q_{36''} + (C_{w_2})(I_{15})(A_{2'})$$
$$= 22.25 \text{ cfs} + (0.68)(1.38 \text{ in/hr})(44.21 \text{ Ac})$$
$$= 22.25 \text{ cfs} + 41.49 \text{ cfs}$$

$\boxed{Q_2 = 63.74 \text{ cfs} \qquad \text{Peak Flow, 15-year event, Outfall 2}}$

SHEET NO. 6/14

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

PEAK FLOW, 15-YEAR STORM EVENT

AREA 1-1: STORM DRAIN PUMP STATION 15

Area = 34.63 Ac = A_{1-1} $Q_{21''} = 11.34$ cfs (from Area 2)

$C_{W_{1-1}} = 0.53$

$T_{C_{1-1}} = 30.1$ min

Intensity: $\frac{I_{15} - 1.52}{1.02 - 1.52} = \frac{30.1 - 30}{60 - 30}$

$$I_{15} = \left(\frac{0.1}{30}\right)(-0.5) + 1.52 = 1.52 \text{ in/hr}$$

Rational Method $Q = CIA$

$$Q_{1-1} = (C_{W_{1-1}})(I_{15})(\text{Area}) + Q_{21''}$$
$$= (0.53)(1.52 \text{ in/hr})(34.63 \text{ Ac}) + 11.34 \text{ cfs}$$

$Q_{1-1} = 39.24$ cfs Peak Flow, 15 year event
Pump Station 15

SHEET NO. 7/14

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Peak Flow, 15-YEAR STORM EVENT

OUTFALL 1

From Area 1-1 and Q21":
$Q_{1-1} = 39.24\text{ cfs}$ at $T_{C_{1-1}} = 30.1\text{ min}$

$$\text{Area} = A_{1-2} + A_{1-3}$$
$$= 10.67\text{ Ac} + 6.30\text{ Ac}$$
$$\text{Area} = 16.97\text{ Ac}$$

$C_{W_{1-2}} = 0.59$; $C_{W_{1-3}} = 0.51$

$$C_W = \frac{(0.59)(10.67) + (0.51)(6.30)}{16.97\text{ Ac}} = 0.56$$

Time of Concentration:

By inspection, time of concentration is governed by Area 1-2

$T_{C_{1-2}} = 36.0\text{ min}$

Additionally, the time of travel to the location where the runoff flow from Area 1-1 and Area 1-2 join with the flow of runoff from Area 1-3 is: $t_{P_{30''RCP}}$

30" RCP, $n = 0.015$
pipe length $= L = 760$ LF

upstream invert = 102.86
downstream invert = 101.68

$$\text{slope} = \frac{102.86 - 101.68}{760\text{ LF}}$$
$$= 0.0016\text{ ft/ft}$$
$$= 0.16\%$$

From HydraflowExpress, the velocity of water in the pipe, flowing full is: $v = 2.9\text{ ft/s}$

$$t_{P_{30''RCP}} = 760\text{ LF}\left(\frac{1\text{ sec}}{2.9\text{ ft}}\right)\left(\frac{1\text{ min}}{60\text{ sec}}\right) = 4.4\text{ min}$$

$$T_{C_{OUTFALL\,1}} = T_{C_{1-2}} + t_{P_{30''RCP}} = 36.0\text{ min} + 4.4\text{ min} = \boxed{40.4\text{ min} = T_{C_{OUTFALL\,1}}}$$

OUTFALL 1
TIME OF CONCENTRATION

SHEET NO. 8/14

JOB NO. 5148300

BY KNP DATE

CLIENT

SUBJECT Pre-Project Hydrology

CHK'D

DATE

Peak Flow, 15-YEAR STORM EVENT

OUTFALL 1, cont'd

Intensity: $\frac{I_{15} - 1.52}{1.02 - 1.52} = \frac{40.4 - 30}{60 - 30}$

$$I_{15} = \left(\frac{10.4}{30}\right)(-0.50) + 1.52 = 1.35 \text{ in/hr}$$

Rational Method $Q = CIA$

$$Q_{OUTFALL 1} = (C_W)(I_{15})(A_{1-2} + A_{1-3}) + Q_{1-1}$$

$$= (0.56)(1.35 \text{ in/hr})(16.97 \text{ Ac}) + 39.24 \text{ cfs}$$

$$= 12.83 \text{ cfs} + 39.24 \text{ cfs}$$

$$\boxed{Q_{OUTFALL 1} = 52.07 \text{ cfs} \quad \text{Peak Flow, 15-year event Outfall 1}}$$

9/14

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Monday, Nov 7 2016

30in RCP

Circular

Diameter (ft) = 2.50

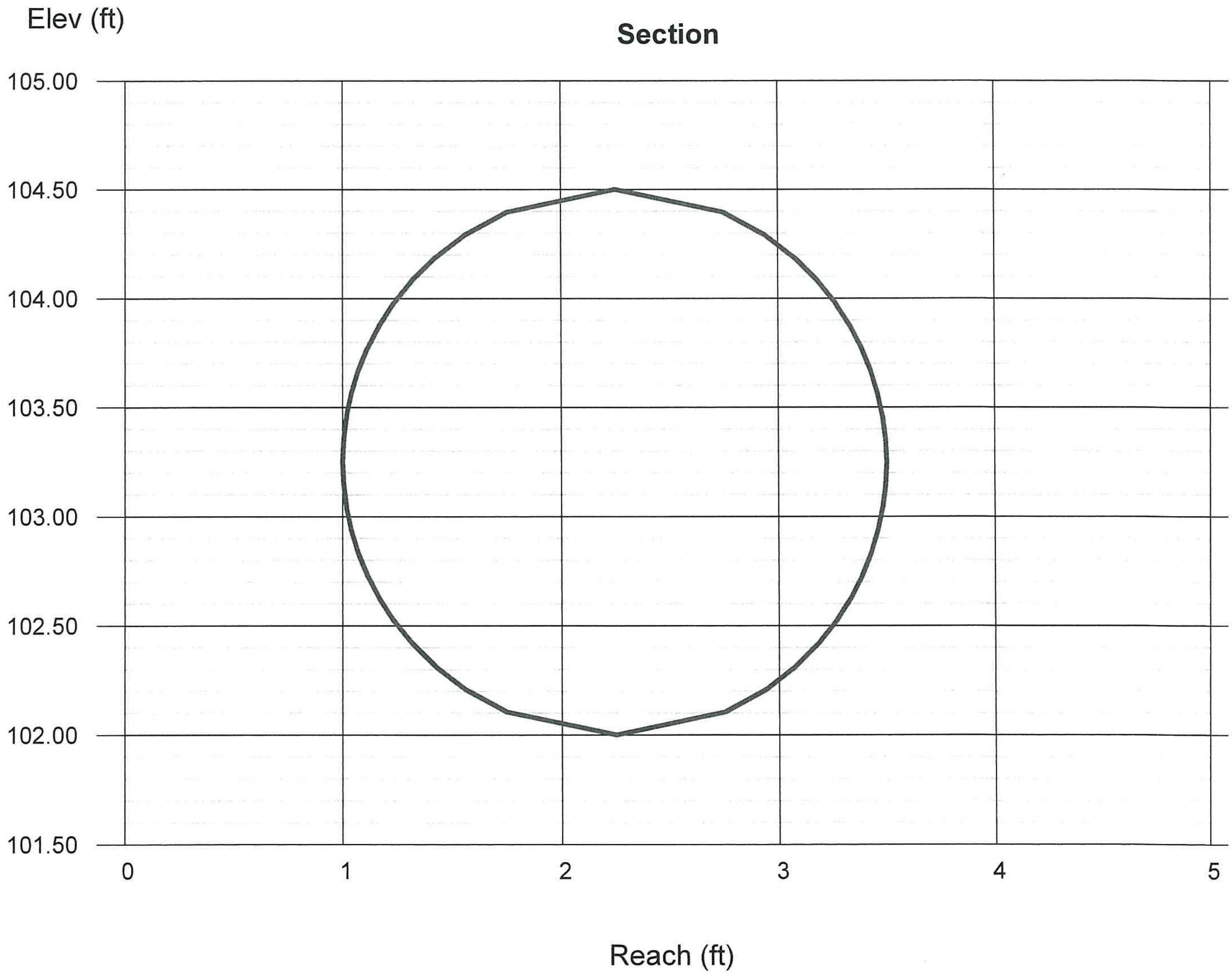
Invert Elev (ft) = 102.00
Slope (%) = 0.16
N-Value = 0.015

Calculations

Compute by: Known Depth
Known Depth (ft) = 2.50

Highlighted

Depth (ft) = 2.50
Q (cfs) = 14.22
Area (sqft) = 4.91
Velocity (ft/s) = 2.90
Wetted Perim (ft) = 7.85
Crit Depth, Yc (ft) = 1.27
Top Width (ft) = 0.00
EGL (ft) = 2.63



SHEET NO. 10/14

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

PEAK FLOW, 15-YEAR STORM EVENT

AREA 3A-1

$\text{Area} = 3.09\ \text{Ac}$

$C_{W_{3A-1}} = 0.46$

$T_{C_{3A-1}} = 42.5\ \text{min}$

Intensity: $\frac{I_{15} - 1.52}{1.02 - 1.52} = \frac{42.5 - 30}{60 - 30}$

$$I_{15} = \left(\frac{12.5}{30}\right)(-0.5) + 1.52 = 1.31\ \text{in/hr}$$

Rational Method: $Q = CIA$

$$Q_{3A-1} = (C_{W_{3A-1}})(I_{15})(\text{Area}) = (0.46)(1.31\ \text{in/hr})(3.09\ \text{Ac}) = 1.86\ \text{cfs}$$

Peak Flow to Outfall 3A is comprised of runoff from Area 3A-1 and Area 3A-2.

By inspection the governing time of concentration is from Area 3A-1.

The peak flow to outfall 3A is: Q_{3A}

$$\text{Area} = A_{3A-1} + A_{3A-2} = 3.09\ \text{Ac} + 1.77\ \text{Ac} = 4.86\ \text{Ac} = A_{3A}$$

$$C_{W_{3A}} = \frac{(C_{W_{3A-1}})(3.09\ \text{Ac}) + (C_{W_{3A-2}})(1.77\ \text{Ac})}{4.86\ \text{Ac}} = \frac{(0.46)(3.09) + (0.37)(1.77)}{4.86} = 0.43$$

$T_{C_{3A}} = T_{C_{3A-1}} = 42.5\ \text{min}$; $I_{15} = 1.31\ \text{in/hr}$

$$Q_{3A} = (C_{W_{3A}})(I_{15})(A_{3A}) = (0.43)(1.31\ \text{in/hr})(4.86\ \text{Ac}) = 2.74\ \text{cfs}$$

$Q_{3A} = 2.74$ cfs Peak Flow, 15-year event, Outfall 3A

SHEET NO. 11/14

JOB NO. 514830 0

BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

Peak Flow, 15-Year storm EVENT

AREA 3B

Area = 29.70 Ac

$C_{W_{3B}} = 0.55$

$T_{C_{3B}} = 36.1$ min

Intensity : $\frac{I_{15} - 1.52}{1.02 - 1.52} = \frac{36.1 - 30}{60 - 30}$

$$I_{15} = \left(\frac{6.1}{30}\right)(-0.5) + 1.52 = 1.42 \text{ in/hr}$$

Rational Method: $Q = CIA$

$Q_{3B} = (C_{W_{3B}})(I_{15})(\text{Area}) = (0.55)(1.42 \text{ in/hr})(29.70 \text{ Ac}) = 23.20$ cfs

$Q_{3B} = 23.20$ cfs Peak Flow, 15-year event, Outfall 3B

SHEET NO. 12/14

JOB NO. 5148300

BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

PEAK FLOW, 15-YEAR STORM EVENT

AREA 4-1

Area = 1.80 Ac

$C_{W_{4-1}} = 0.67$

$Tc_{4-1} = 8.2 \text{min}$

Intensity : $\frac{I_{15} - 4.2 \text{ in/hr}}{2.82 - 4.2} = \frac{8.2 - 5}{10 - 5}$

$I_{15} = \left(\frac{3.2}{5}\right)(-1.38) + 4.2 \text{ in/hr} = 3.32 \text{ in/hr}$

Rational Method : $Q = CIA$

$Q_{4-1} = (C_{W_{4-1}})(I_{15})(\text{Area}) = (0.67)(3.32 \text{ in/hr})(1.80 \text{Ac}) : 4.00 \text{ cfs}$

$Q_{4-1} = 4.00 \text{ cfs}$ Peak Flow, 15-year event, Point of Concentration 4-1

JOB NO. 51A8300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

PEAK FLOW, 15-YEAR STORM EVENT

AREA 4-2

Area = 3.35 Ac

$C_{W4-2} = 0.76$

$T_{C4-2} = 12.7 \text{ min}$

Intensity: $\frac{I_{15} - 2.82 \text{ in/hr}}{2.24 \text{ in/hr} - 2.82 \text{ in/hr}} = \frac{12.7 - 10}{15 - 10}$

$$I_{15} = \left(\frac{2.7}{5}\right)(-0.58) + 2.82 \text{ in/hr} = 2.51 \text{ in/hr}$$

Rational Method: $Q = CIA$

$$Q_{4-2} = (C_{W4-2})(I_{15})(\text{Area}) = (0.76)(2.51 \text{ in/hr})(3.35 \text{ Ac}) = 6.39 \text{ cfs}$$

$\boxed{Q_{4-2} = 6.39 \text{ cfs} \quad \text{Peak Flow, 15-Year event, Point of Concentration 4-2}}$

SHEET NO. 14/14

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

PEAK FLOW, 15-YEAR STORM EVENT

AREA 4-3

Area = 0.52 Ac

$C_{W_{4-3}} = 0.86$

$T_{C_{4-3}} = 5$ min

Intensity : $I_{15} = 4.2$ in/hr

Rational Method : $Q = CIA$

$Q_{4-3} = (C_{W_{4-3}})(I_{15})(\text{Area} = (0.86)(4.2\ \text{in/hr})(0.52\ \text{Ac}) = 1.88$ cfs

$Q_{4-3} = 1.88$ cfs Peak Flow, 15-Year event, Point of Concentration 4-3

APPENDIX 5.5

SHEET NO. 1/8

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

CAPACITY OF OUTFALL PIPES

Outfall 1 30" RCP

$n = 0.015$ (Table 3-3, Solano County Water Agency Hydrology Manual)

slope:

Length = 490.5'

upstream invert = 101.68

downstream invert = 100.83

$$\text{Slope} = \frac{101.68 - 100.83}{490.5'} = 0.0017 \text{ ft/ft}$$

slope = 0.17%

From Vallejo Sanitation & Flood Control District
Mare Island Storm Drain record drawings

From the Hydraflow Express computer program which calculates capacity through the use of Manning's Equation:

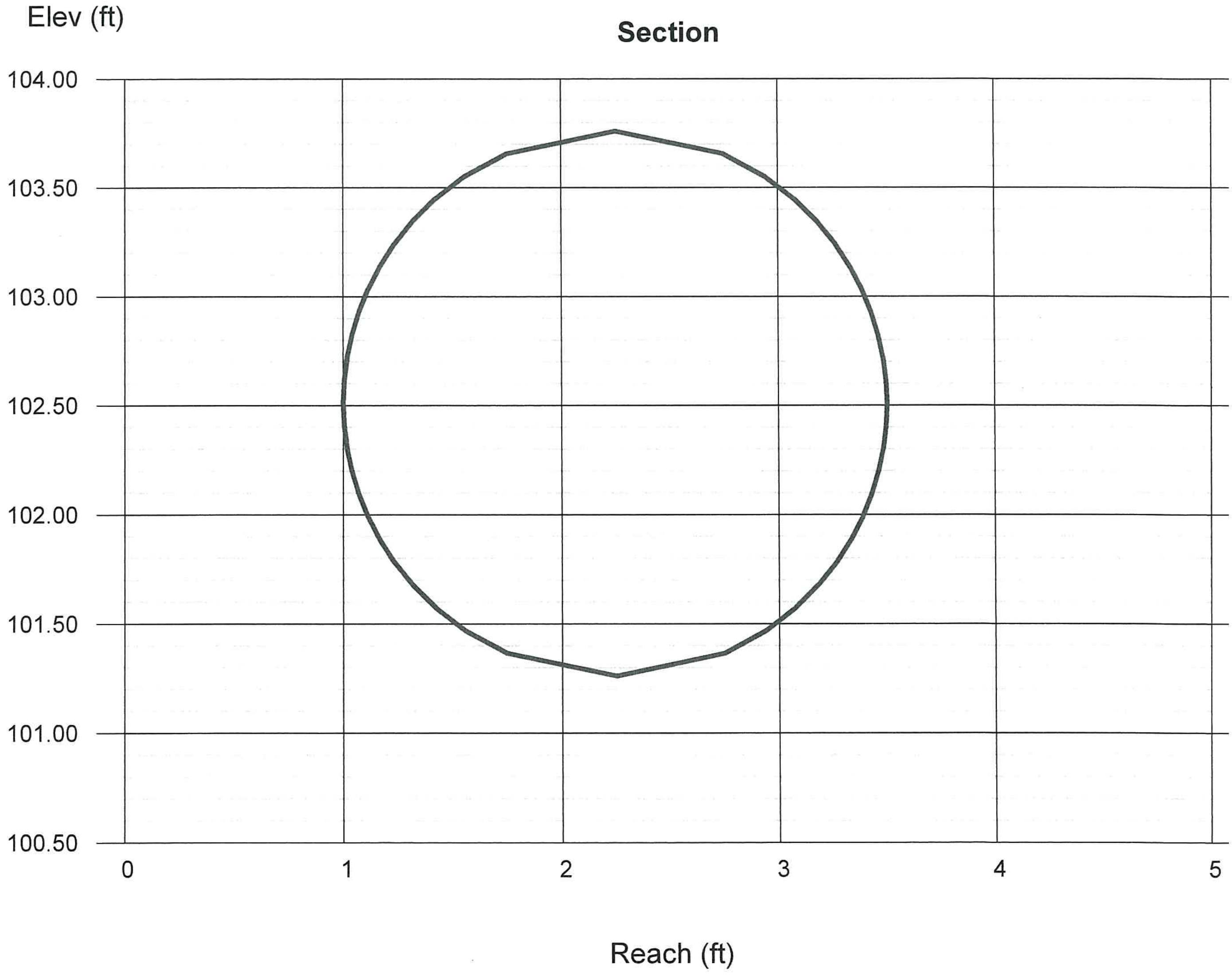
Capacity of 30" RCP (Outfall 1):
Q_{CAP_1} = 14.65 cfs

2/8

Channel Report

Outfall 1 Capacity

Circular		**Highlighted**	
Diameter (ft)	= 2.50	Depth (ft)	= 2.50
		Q (cfs)	= 14.65
		Area (sqft)	= 4.91
Invert Elev (ft)	= 101.26	Velocity (ft/s)	= 2.99
Slope (%)	= 0.17	Wetted Perim (ft)	= 7.85
N-Value	= 0.015	Crit Depth, Yc (ft)	= 1.29
		Top Width (ft)	= 0.00
Calculations		EGL (ft)	= 2.64
Compute by:	Known Depth		
Known Depth (ft)	= 2.50		



SHEET NO. 3/8

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

CAPACITY OF OUTFALL PIPES, CONT'D

Outfall 2 36" RCP

$n = 0.015$ (Table 3-3, Solano County Water Agency) Hydrology Manual

slope:

Length = 518

upstream invert = 101.49

downstream invert = 100.85

$$\text{Slope} = \frac{101.49-100.85}{518} = 0.0012 \text{ ft/ft}$$

Slope = 0.12%

From VS&FCD Mare Island storm drain record drawings

From the Hydraflow Express computer program:

Capacity of 36" RCP (outfall 2):

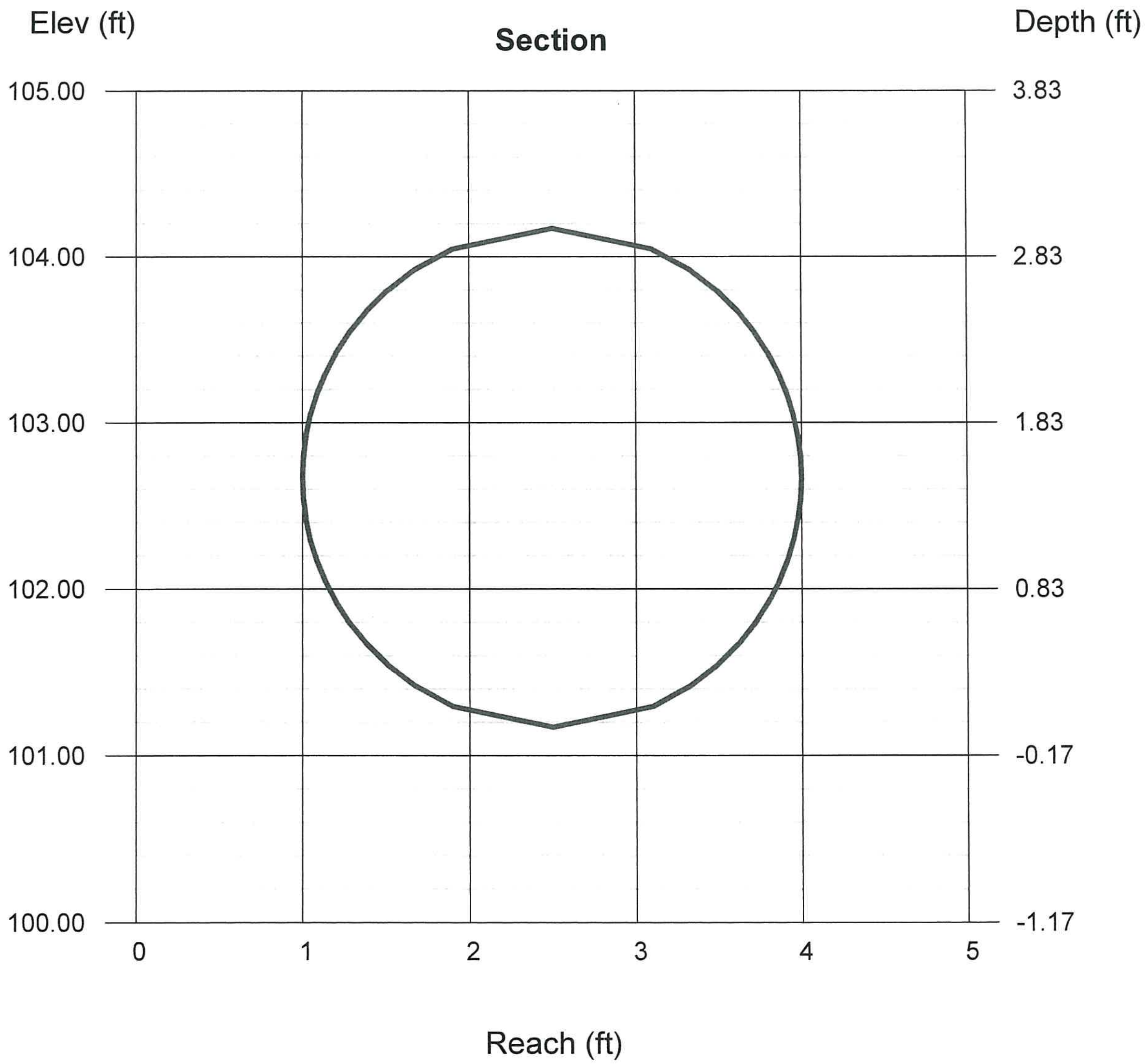
$$Q_{CAP_2} = 20.02 \text{ cfs}$$

4/8

Channel Report

Outfall 2 Capacity

Circular		**Highlighted**	
Diameter (ft)	= 3.00	Depth (ft)	= 3.00
		Q (cfs)	= 20.02
		Area (sqft)	= 7.07
Invert Elev (ft)	= 101.17	Velocity (ft/s)	= 2.83
Slope (%)	= 0.12	Wetted Perim (ft)	= 9.42
N-Value	= 0.015	Crit Depth, Yc (ft)	= 1.44
		Top Width (ft)	= 0.00
Calculations		EGL (ft)	= 3.12
Compute by:	Known Depth		
Known Depth (ft)	= 3.00		



SHEET NO. 5/8

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

CAPACITY OF OUTFALL PIPES CONT'D

Outfall 3A 18" CMP

$n = 0.026$ (Table 3-3, Solano County Water Agency Hydrology Manual)

slope:

Length = 974'

upstream invert = 107.42

downstream invert = 105.85

$$\text{Slope} = \frac{107.42 - 105.85}{974'} = 0.0016 \text{ ft/ft}$$

Slope = 0.16%

Inverts from VS & FCD Mare Island storm drain record drawings.

From the Hydraflow Express computer program:

Capacity of 18" cmp (outfall 3A):

$Q_{CAP_{3A}} = 2.1$ cfs

6/8

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Nov 3 2016

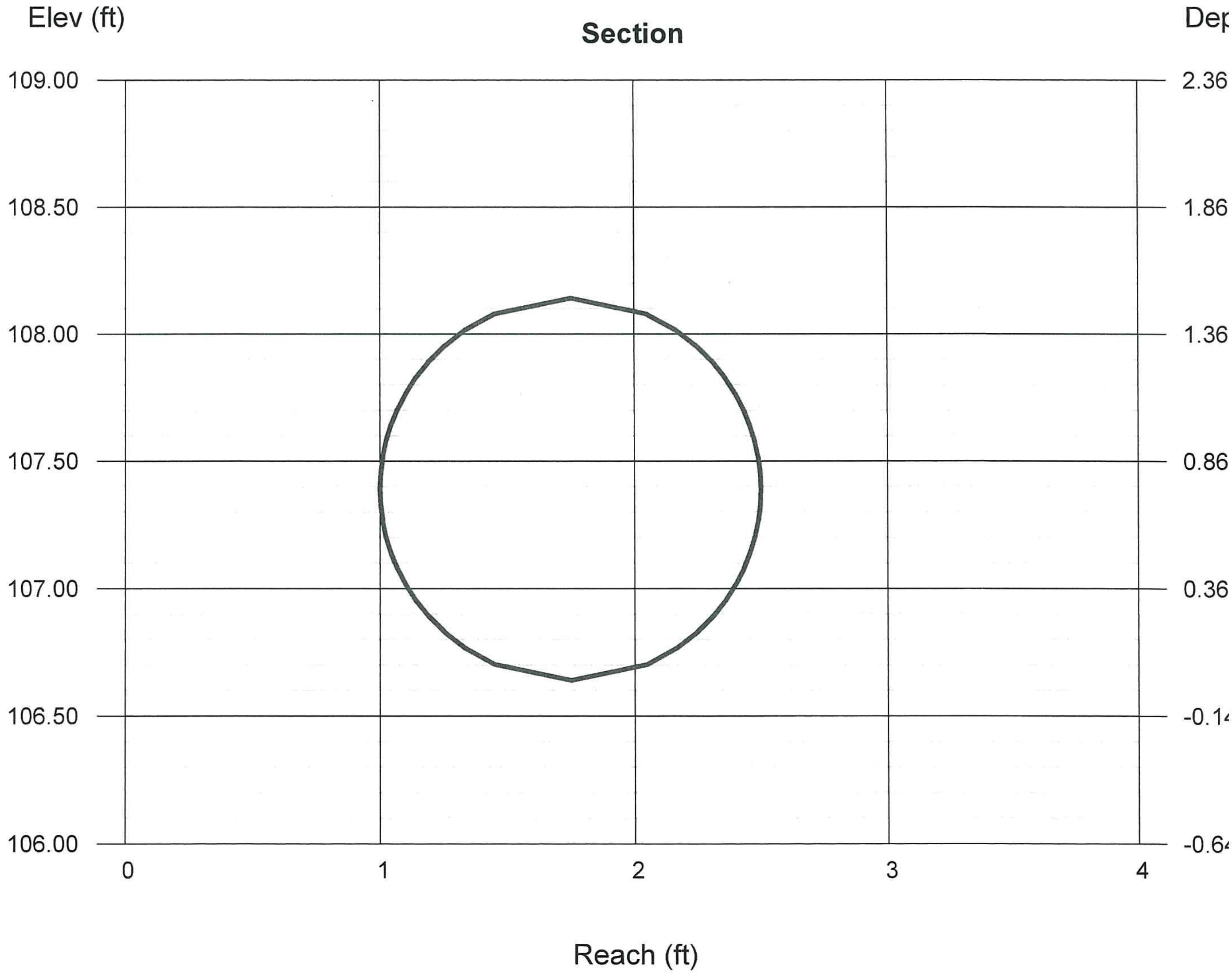
Outfall 3A Capacity

Circular
Diameter (ft) = 1.50

Invert Elev (ft) = 106.64
Slope (%) = 0.16
N-Value = 0.026

Calculations
Compute by: Known Depth
Known Depth (ft) = 1.50

Highlighted
Depth (ft) = 1.50
Q (cfs) = 2.100
Area (sqft) = 1.77
Velocity (ft/s) = 1.19
Wetted Perim (ft) = 4.71
Crit Depth, Yc (ft) = 0.55
Top Width (ft) = 0.00
EGL (ft) = 1.52



SHEET NO. 7/8

JOB NO. 5148300 BY KNP DATE

CLIENT SUBJECT Pre-Project Hydrology CHK'D DATE

CAPACITY OF OUTFALL PIPES CONT'D

OUTFALL 3B 30" RCP

n = 0.015 (Table 3-3, Solano County Water Agency Hydrology Manual)

slope:

Length = approximately 400' (AutoCAD)

upstream invert = unknown

downstream invert = unknown

Assume slope is consistent with other outfalls in vicinity.

∴ slope is on the order of 0.15%

From the Hydraflow Express computer program:

Capacity of 30" RCP (outfall 3B)

$Q_{CAP_{3B}}$ = 13.77 cfs

8/8

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc.

Thursday, Nov 3 2016

Outfall 3B Capacity

Circular

Diameter (ft) = 2.50

Invert Elev (ft) = 101.00

Slope (%) = 0.15

N-Value = 0.015

Calculations

Compute by:	Known Depth
Known Depth (ft)	= 2.50

Highlighted

Depth (ft) = 2.50

Q (cfs) = 13.77

Area (sqft) = 4.91

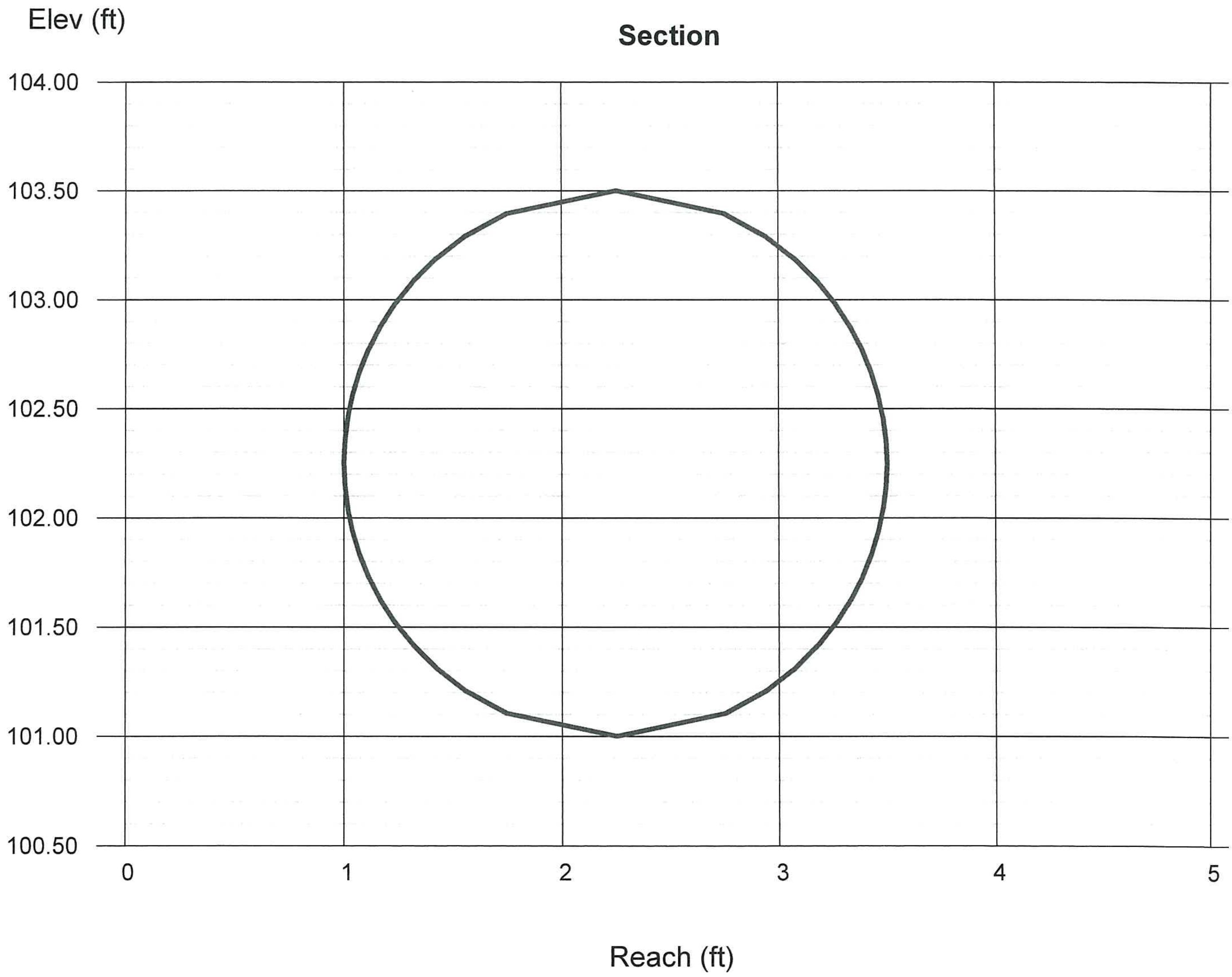
Velocity (ft/s) = 2.80

Wetted Perim (ft) = 7.85

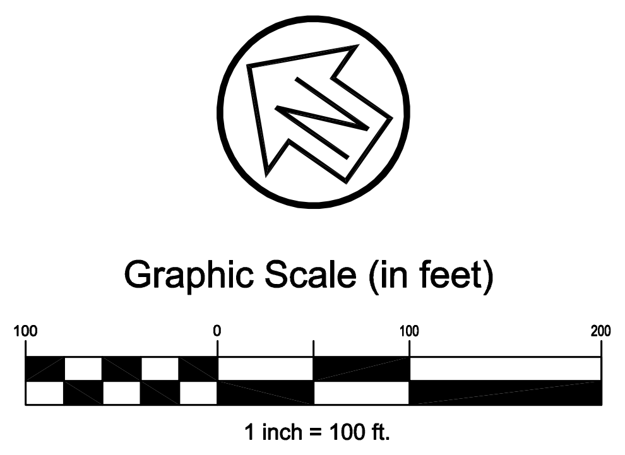
Crit Depth, Yc (ft) = 1.25

Top Width (ft) = 0.00

EGL (ft) = 2.62

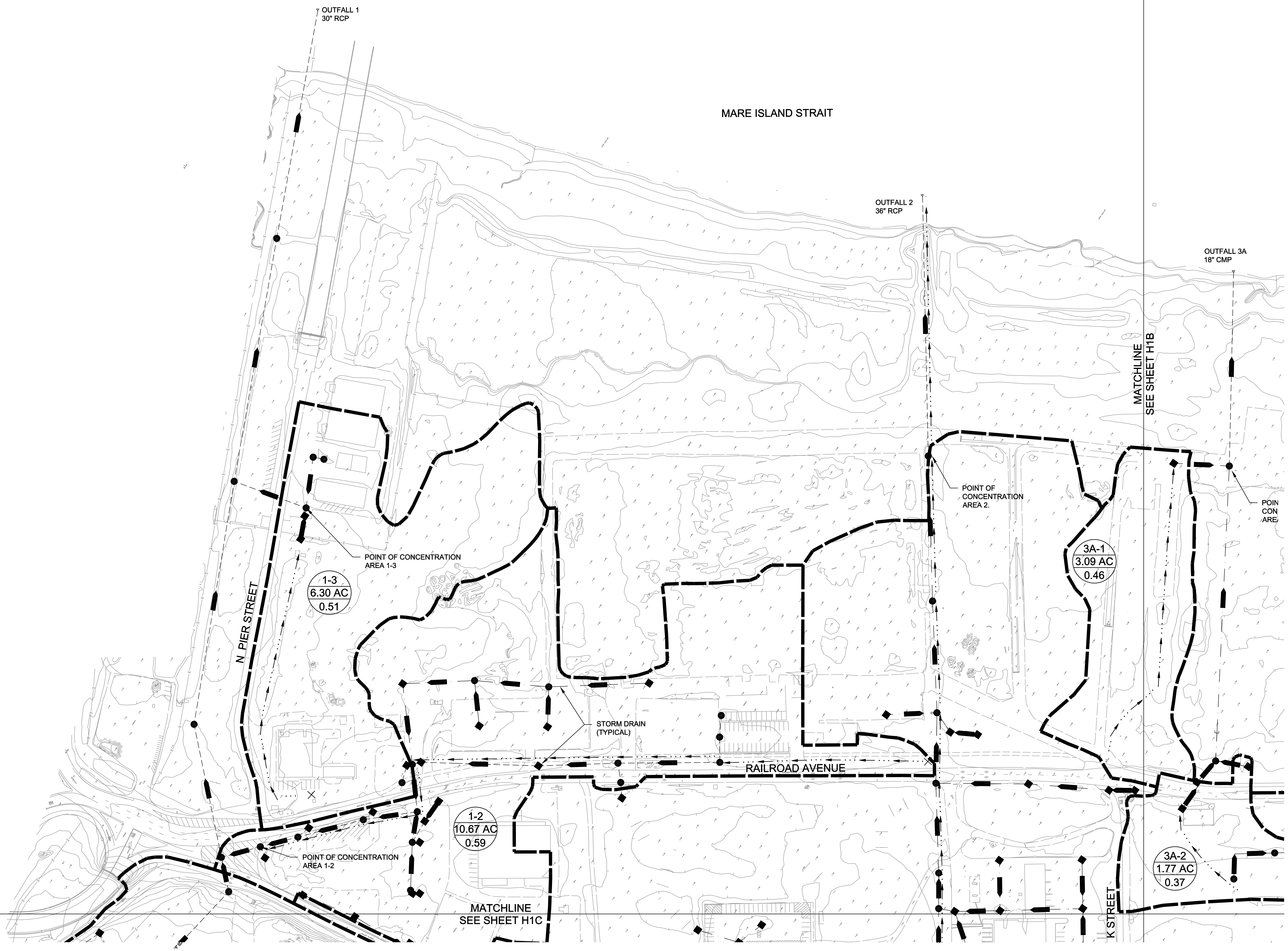


APPENDIX 5.6



HYDROLOGY LEGEND

1-1 34.63 AC 0.53	DRAINAGE AREA DESIGNATION
	AREA IN ACRES
	RUNOFF COEFFICIENT
➡	OVERLAND FLOW DIRECTION
▬ ▬ ▬ ▬	DRAINAGE AREA BOUNDARY
— — — —	DRAINAGE SUB-AREA BOUNDRY
· · ·→· · ·→· · ·→	STREAM FLOWLINE



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PRE-PROJECT
HYDROLOGY MAP
AMEC FOSTER WHEELER

City Of
Vallejo

County Of
Solano

State Of
California

Prepared Under the Direction of:

Kristine N. Pillsbury, RCE 61685

Sheet
H1A

Scale:	1" = 100'
Date:	10/28/2016
Project Number:	5.1483.00
Plan File:	D-

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PRE-PROJECT
HYDROLOGY MAP
AMEC FOSTER WHEELER

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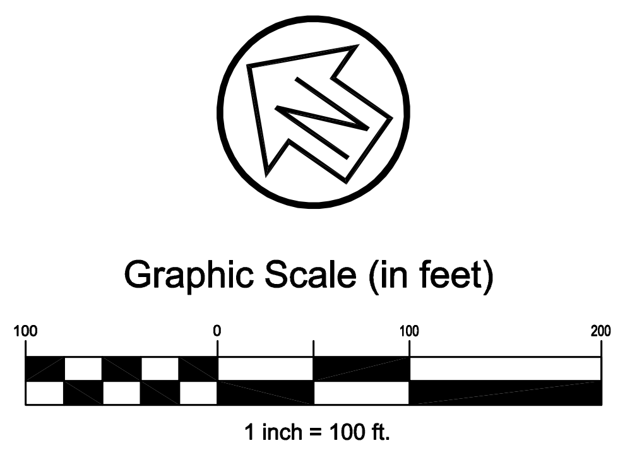
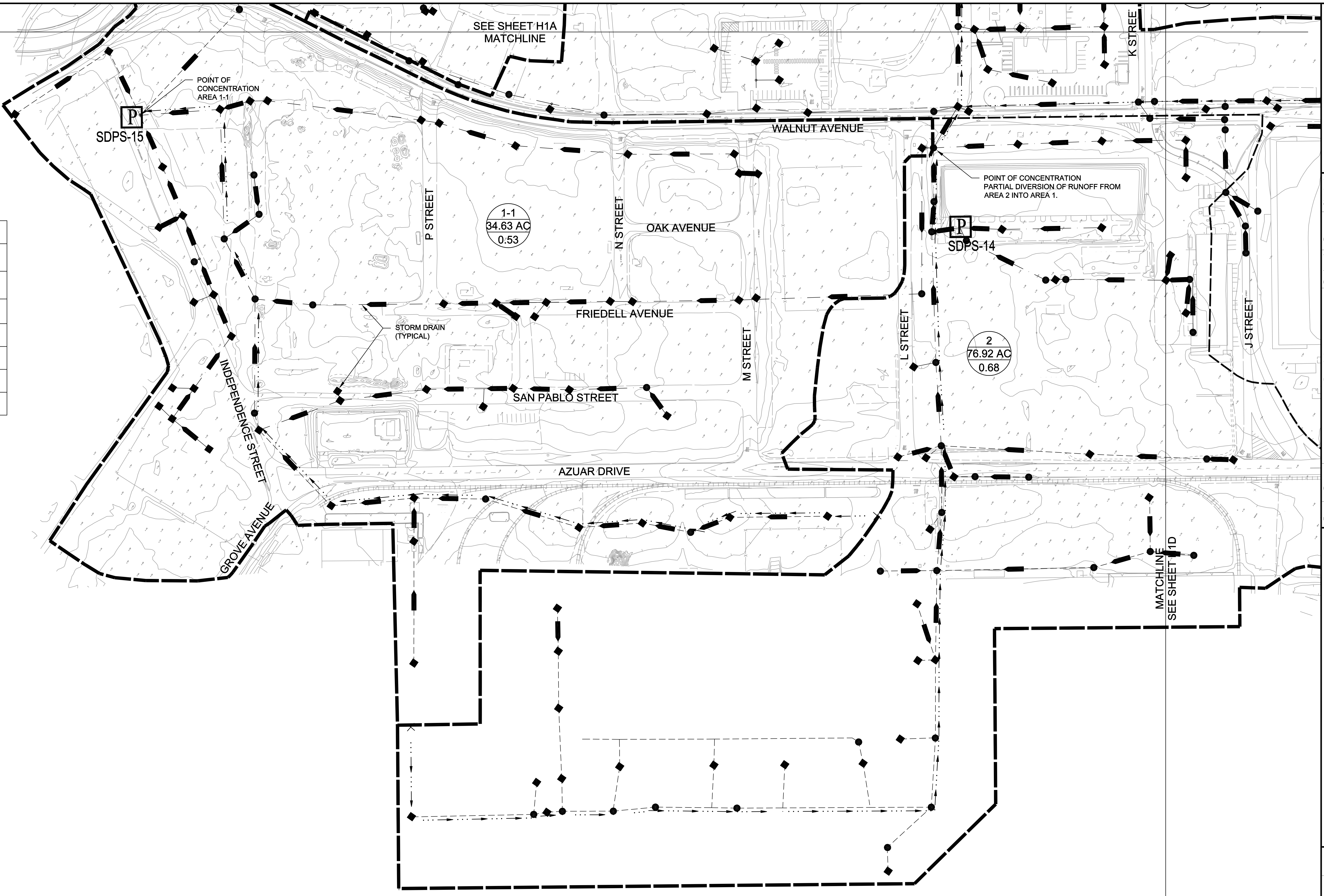


HYDROLOGY LEGEND

1-1	DRAINAGE AREA DESIGNATION
34.63 AC	AREA IN ACRES
0.53	RUNOFF COEFFICIENT
➡	OVERLAND FLOW DIRECTION
▬ ▬ ▬ ▬	DRAINAGE AREA BOUNDARY
— — — —	DRAINAGE SUB-AREA BOUNDRY
·· ➝ ·· ➝ ··	STREAM FLOWLINE



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PRE-PROJECT HYDROLOGY MAP

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City Of
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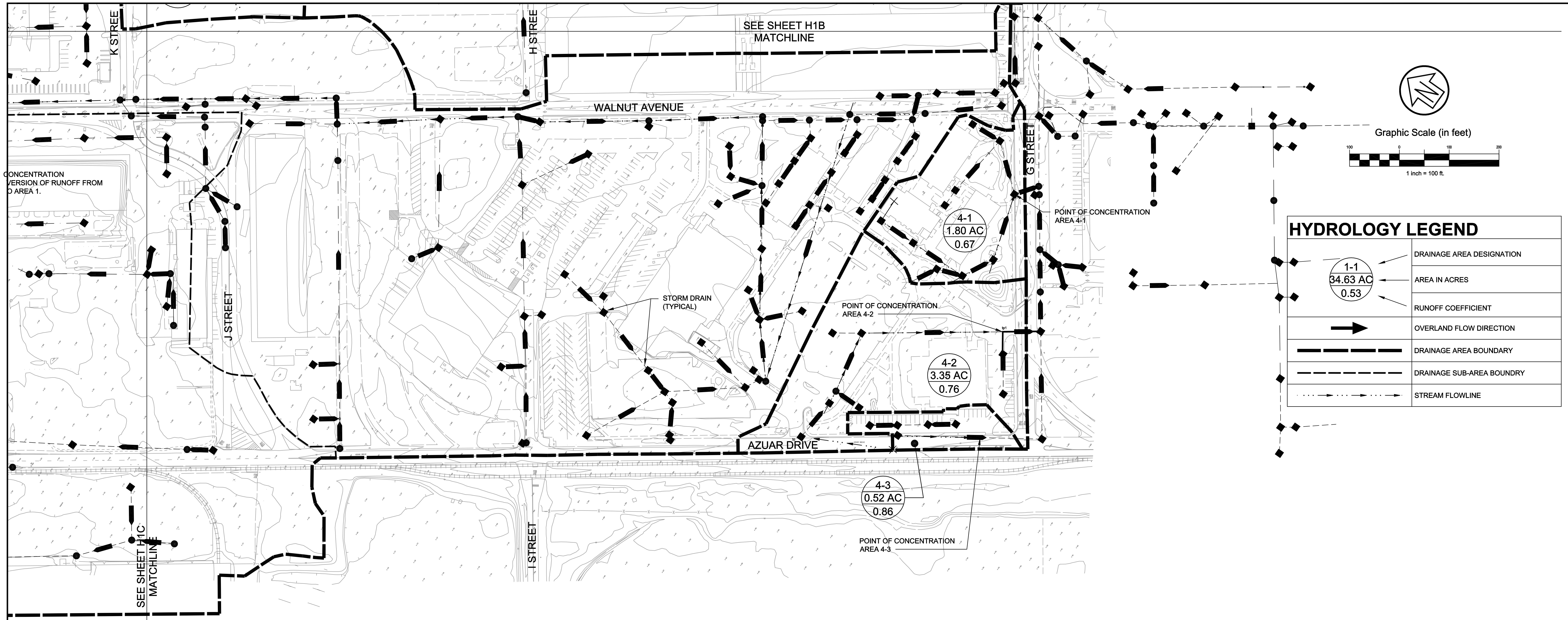

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