

Appendix E

Hydraulic Report

**HYDRAULIC REPORT
FOR
AVENIDA ENCINAS COASTAL RAIL TRAIL AND PEDESTRIAN
IMPROVEMENTS (SEGMENT 3)

IN THE VICINITY OF
CARLSBAD**

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TABLE OF CONTENTS

ITEM

1.0 INTRODUCTION

- 1.1 PROJECT LOCATION
- 1.2 PROJECT DESCRIPTION
- 1.3 EXISTING DRAINAGE PATTERNS

2.0 METHODOLOGY

- 2.1 HYDROLOGY
 - 2.1.1 Rational Method
 - 2.1.2 Runoff Coefficient
 - 2.1.3 Rainfall Intensity
 - 2.1.4 Time of Concentration
- 2.2 HYDRAULIC DESIGN
 - 2.2.1 Inlet Capacity Design

3.0 SOFTWARE USED

4.0 SUMMARY

- 4.1 HYDROLOGIC ASSESSMENT

APPENDICES:

A: HYDROLOGY CALCULATIONS

B: HYDROLOGIC ASSESSMENT

Curb Inlet Capacity Analysis

C: DRAINAGE BASIN MAP

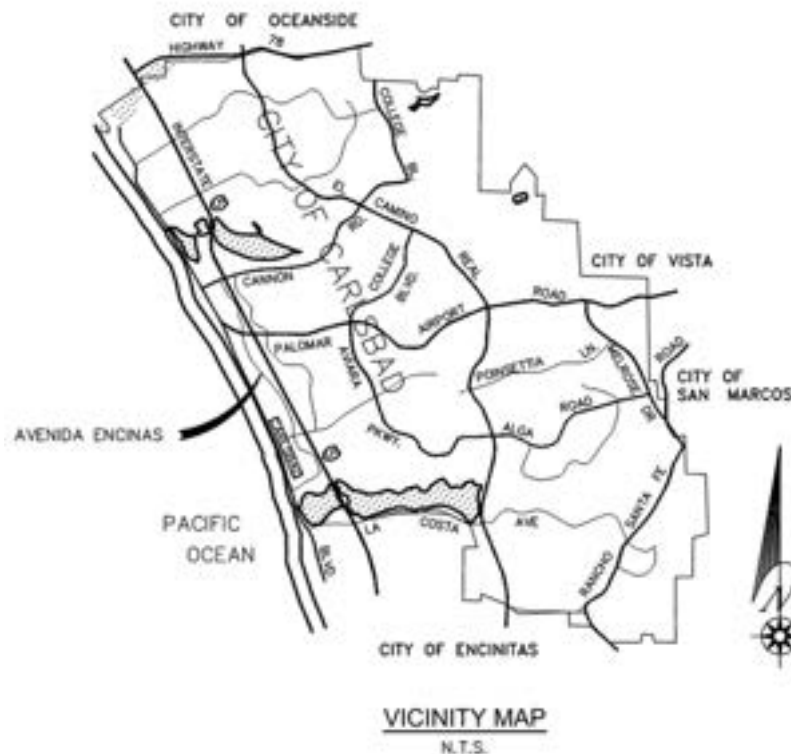
D: REFERENCE MAPS AND TABLES

1.0 INTRODUCTION

The objective of this hydraulic study is to evaluate the proposed storm water conveyance system for the improvements along Avenida Encinas. This Hydraulic Study has been prepared to comply with the methods and standards set forth by the County of San Diego's Hydrology Manual (June 2003) and the County of San Diego Hydraulic Design Manual (September 2014). This report includes an analysis of the 6 drainage basin areas that are associated with the proposed improvements along Avenida Encinas, and also the proposed curb inlets designed to capture the onsite storm water generated from drainage basins A2, B2, C1, and C2 (see *Appendix C*).

1.1 PROJECT LOCATION

The project is located along Avenida Encinas from Palomar Airport Road to Embarcadero Lane in the City of Carlsbad.



1.2 PROJECT DESCRIPTION

Avenida Encinas is scheduled to be improved along approximately a 5400-foot stretch ranging from Palomar Airport Road to approximately Embarcadero Lane. The proposed improvements include the partial roadway widening of Avenida Encinas to include a new sidewalk, medians with parkways with landscaping, biofiltration planters, and bike lanes along the road.

1.3 EXISTING DRAINAGE

The existing drainage patterns near the proposed site located on Avenida Encinas consists of roadway and commercial sheet flow. Runoff from the street is collected into the curb and gutter on the west/east sides of the street. The existing drainage is considered to be three basins. Basins A, B, and C. Basin A is the north part of Avenida Encinas, which receives sheet flow from the street into the curb and gutter and discharges to an existing metal flume on the west side and to the east to an existing curb inlet. Basin B, is considered to be the middle section of the road. This basin receives sheet flow onto curb and gutter and discharges to west and east into an existing curb inlet. Basin C is the south portion of Avenida Encinas, which receives flow from the road and sheet flows to a low point where runoff is collected via concrete headwall that connects to a 36" RCP pipe. All three basins discharge west to the Encinas Creek and ultimately discharge to the Pacific Ocean.

Run-on from the adjacent private properties is not included in the calculations for this report. Only drainage from the roadway was used for the hydrologic analysis.

1.4 PROPOSED DRAINAGE

The proposed drainage consists of roadway sheet flow that is collected into curb and gutter system and discharge directly through curb cuts in which runoff can discharge to the proposed planters or can also discharge to the proposed curb inlets. Runoff from the street is treated by the biofiltration planters per County of San Diego Green Streets Design Criteria. See Proposed Hydrology Exhibit Appendix C. The site was divided into six basins in which drain to three existing low points of Avenida Encinas. Basin 1A consists the existing north east half of the road and portion of the proposed landscape median. Runoff sheet flows directly to an existing curb inlet that connects to a storm drain pipe and discharge to the Encinas Creek. Basin 2A consists of the north west half of the road, which consists of portion of the existing road and the proposed widening of the road, new sidewalk, median, and parkway. Runoff is collected into planters and curb inlet, which discharges to Encinas Creek. Basin B1 consists of the top portion of the existing road and proposed landscaped medians. Runoff collected from this side of the road drains directly to an existing curb inlet, and connects to a 36" RCP that discharges to an existing triple box culvert that discharges to Encinas Creek. Basin B2 is the other north west side of the road that consist of portion of the existing road and the widen road with the proposed

sidewalk, parkway, and medians. Runoff discharges directly into an existing curb inlet that also connects to the triple box culvert via an 18" RCP pipe. Basin C1 consists of a portion of existing road, and the proposed widening, sidewalk, parkway, and median. Runoff sheet flows into planters and proposed curb inlet and connect to an existing 36" RCP that connects to an existing type F inlet and connects to another 36" RCP before discharging to the Encinas Creek. Lastly, Basin C2 consists of half of the south west road that includes portion of existing road, portion of the proposed widening, proposed sidewalk, parkway, and medians. Runoff discharges to a proposed curb inlet that connects a proposed 36" RCP that connects to the proposed curb inlet on the east side of the road to connect to the existing storm drain system and discharge to the Encinas Creek. All of the storm drains systems connect and eventually discharge to the Pacific Ocean.

2.0 METHODOLOGY

2.1 HYDROLOGY

Hydrologic analysis was conducted to determine the 100-year design storm peak runoff rate to the proposed Type-B inlets. All hydrologic analysis was prepared using the rational method in accordance with the San Diego County Hydrology Manual (See *Appendix A* for calculations).

2.1.1 Rational Method

The rational method formula estimates the peak rate or runoff at any location within a watershed. The rational method assumes that the peak runoff rate is generated from constant rainfall intensity over an area for a specific duration of time. The duration of time is equal to the time of concentration which is defined as the time required for a rain drop to fall at the most upstream point in the tributary drainage basin to the point in question. The rational method equation is as follows:

$$Q = CIA$$

Where

Q = Peak Discharge Rate (cfs)

C = Runoff Coefficient

I = Rainfall Intensity (in/hr)

A = Tributary Area (acres)

2.1.2 Runoff Coefficient

The runoff coefficient is the percentage of excess rainfall that will flow overland at the point of interest. The runoff coefficient is based on the surface type and the soil type. The runoff coefficient can be represented by the equation below:

$$C = 0.9 (\%imp) + C_p (\% pervious)$$

Where:

C = Runoff Coefficient

% imp = Percent of impervious surface with 90% runoff

% per = Percent of pervious surfaces (%per = 1 - %imp)

Cp = Pervious Runoff Coefficient based on soil type

For the Avenida Encinas hydrology drainage area the pervious runoff coefficient is assumed to be Type D hydrologic soils with a Cp = 0.35.

2.1.3 Rainfall Intensity

The rainfall intensity (I) is the constant rate of rainfall over the tributary area for a duration of time that is equal to the time of concentration for a selected design storm frequency. To estimate the rainfall intensity an Intensity-Duration design chart (Figure 3-1 of the Hydrology Manual) was used. The Intensity-Duration design chart is modeled after the following equation:

$$I = 7.44 P_6 D^{-.645}$$

Where

I = Rainfall intensity specific to Design storm (in/hr)

P₆ = 6-hour storm rainfall amount (in)

D = Storm Duration which equals the Time of Concentration, Tc

The 6-hour rainfall amount is determined for the storm event in question from Isopluvial Maps located in Appendix B of the Hydrology Manual. For Avenida Encinas, the 100-year design storm was analyzed for the road way drainage. The 6-hour storm rainfall amount is as follows:

100 Year Storm Event P₆ = 2.6 in

2.1.4 Time of Concentration

The time of concentrations (Tc) is the time required for the runoff to flow from the most remote part of the drainage area to the point of interest. The time of concentration is calculated as the sum of the initial time of concentration (Ti) and the travel time (Tt).

$$T_c = T_i + T_t$$

Initial Time of Concentration

The initial time of concentration is based on sheet flow conditions at the upstream portion of the drainage basin. Sheet flow conditions are analyzed using the Overland Time of Flow developed by the Federal Aviation Agency (FAA). This method is based on the following equation:

$$T_i = \frac{1.8*(1.1-C)\sqrt{D}}{\sqrt[3]{S}}$$

Where:

Ti = Initial time of concentration (min)

C = Weighted runoff coefficient

D = Distance or length of sheet flow (ft)

S = Slope of sheet flow (%)

Travel Time

The travel time is the time required for the runoff to flow in a channelized flow condition from the upper portion of the watershed to the point of interest. The channel velocity is calculated assuming the uniform flow conditions thus validating the Manning Equation. The velocity is then converted to the travel time by following equation:

$$T_t = \frac{L}{60v}$$

Where: Tt = Travel Time (min)

L = length of channel (ft)

V = Flow velocity in channel (ft/s)

2.2 HYDRAULIC DESIGN CRITERIA

The roadway widening improvements for Avenida Encinas include the installation of three new curb inlets Type-B per SDRSD D-02 and biofiltration planters that will collect onsite storm water from corresponding hydrology basins. The roadway drainage system will capture storm water runoff in the curb and gutter system and discharge into the corresponding curb inlets. The proposed curb inlet has been sized using the rational method in accordance with the San Diego County Hydrology Manual. The 100-year flow rates calculated by the rational method are used to design the length of the inlet openings that are required to capture 100% of the storm water generated by the storm event for the basin area.

2.2.1 Inlet Capacity Design

Inlet capacity is critical to intercepting roadway drainage. Inlets on a continuous grade must be designed to intercept a minimum of 85 percent of the peak discharge from the 50-year design storm. Inlets located in a sump condition must fully intercept the peak discharge from the 100-year design event.

To intercept the excess storm water from the road curb and gutter system, three Type-B curb inlets per San Diego's Regional standard drawings will be placed along the alignment of Avenida Encinas. This places the inlet into a sump condition based on the following assumption: 1) the inlet capacity is greater than the approaching excess storm water.

The inlet capacity for the Type-B curb inlets were analyzed under both weir and orifice conditions. The inlet capacity governed by the weir condition is calculated as:

$$Q = C_w L_w d^{3/2} \quad \text{For Curb Inlets}$$

Where:

Q = inlet capacity governed by weir flow (cfs)
 C_w = Weir Coefficient ($C_w = 3.00$)
 L_w = Effective Weir Length (Curb Opening) (ft)
d = flow depth (ft)

The inlet capacity governed by the orifice flow condition is calculated as:

$$Q = C_o h L (2gd)^{1/2} \quad \text{For Curb Inlets}$$

Where:

Q = inlet capacity governed by orifice flow (cfs)	L = Curb Opening Length
C_o = Orifice Coefficient ($C_o = 0.67$)	g = gravitational acceleration (32.2 ft/s ²)
h = Curb Opening Height	d = effective depth of flow at curb face (ft)

Note: See *Appendix B* for the Hydrologic Assessment and sizing of the proposed Type B curb inlets.

3.0 SOFTWARE USED

Computer aided software will be used to assist in hydraulic modeling of the storm water conveyance system. Programs used for hydraulic analysis are Autodesk Hydraflow Storm Sewers 2018.

Autodesk Hydraflow Storm Sewers 2018

Hydraflow will be used to analyze the hydraulic grade line for the underground storm drain system within the roadway. Hydraflow Storm Sewer uses the energy-based standard step method to compute the hydraulic profile. This method is an iterative procedure that applies

Bernoulli's Energy Equation between the downstream and upstream ends of each line in the system. It uses Manning's equation to determine head losses due to pipe friction. Using this method, a solution can always be found regardless of the flow regime. This method makes no assumptions as to depth of flow and is only accepted when the energy equation has balanced.

4.0 SUMMARY

The hydraulic calculations shown in this report provide a base understanding of what is required for the proposed curb inlets drainage facilities. The 100% improvements plans propose the widening of Avenida encinas that includes new sidewalks, parkways, medians, curb ramps, biofiltration planters, curb and gutter, new storm drain pipes, and curb inlets. The proposed development will create new impervious areas, thus increasing storm water runoff. The following is a summary of the Hydrology Calculations that are attached at the end of this report. For more information on the hydrology calculations and hydrologic assessment that was used for the curb inlets sizing see Appendix B.

Rainfall Precipitation Depths

	100 Year Event
$P_6 =$	2.6
$P_{24} =$	4.5
$P_6/P_{24} =$	57.77%

Basin	Tributary Area, A (acres)	Runoff Coefficient, C	Time of Concentration (min)	Rainfall Intensity, I (in/hr)	Runoff Rate, Q (cfs)
A1	1.14	0.88	6.71	5.67	5.72
A2	1.28	0.84	7.70	5.19	5.55
B1	1.95	0.87	7.91	5.09	8.61
B2	1.94	0.85	7.22	5.40	8.85
C1	1.67	0.86	12.33	3.83	5.52
C2	2.03	0.79	12.98	3.70	5.90

4.1 HYDROLOGIC ASSESSMENT

Hydrologic assessment was conducted to determine the 100-year design storm peak runoff rate to the proposed Type-B curb inlets. Basin A2 was calculated to have a runoff flow rate of 5.55 cfs flowing into the Type B inlet. The flow rate of Basin A2 was used to find the minimum length of 3 feet for the curb inlet in a sump condition. Basin C1 was determined to have a peak runoff rate of 5.52 cfs, the curb inlet was then sized to have a minimum curb opening of 3 feet. Lastly, Basin C2 was calculated to have a peak runoff rate of 5.90 cfs, the curb inlet was sized to have a minimum curb opening of 3 feet. All proposed curb inlets were designed to intercept 100% of the peak runoff generated by their respective hydrologic areas. See Appendix B for more information and calculations.

REFERENCES

County of San Diego Standard Urban Storm water Mitigation Plan Requirements for Development Applications by San Diego County, Dated January 8, 2011

Best Management Practices for Erosion and Sediment Control & Storm Water Retention/Detention by San Diego County Association of Resource Conservation Districts, San Diego County Edition

County of San Diego County Hydrology Manual prepared by the County of San Diego Department of Public Works, Flood Control Section, June 2003

San Diego County Hydraulic Design Manual by County of San Diego Department of Public Works, Flood Control Section, September 2014

APPENDIX A
HYDROLOGY CALCULATIONS

BASIN DATA: PROPOSED CONDITIONS (BASIN A1)

Runoff Coefficient

Sub Area	Area (acres)	% Impervious	% Pervious	Description	C Value
Basin A1	1.14	97.1%	2.9%	Street/Landscaping/Planter	0.88
Hydrologic Soil Type D					

Time of concentration

Sheet Flow

$$T_i = \frac{1.48(L)^{0.76}}{C^0.58}$$

Basin	Node	C Value	L (ft)	Δ Height (ft)	Slope (%)	T _i (min)
A1		0.88	51.00	0.50	0.98	2.80

Channelized Flow

$$T_f = \frac{L}{60V}$$

Basin	Channel Description	Node	Channel Length (ft)	Δ Height (ft)	Average Q (cfs)	Velocity (fps)	T _t (min)
A1	Gutter Flow		1230.00	32.40	2.86	5.24	3.91

Total Time of Concentration

Basin	T _i (min)	T _t (min)	T _c (min)
A1	2.80	3.91	6.71

100 YEAR - 6 HOUR Storm

P₆ = 2.6 in

$$i = 7.44 P_6 T_c^{-0.645}$$

Basin	C Value	T _c (mins)	Intensity (in/hr)	Area (acres)	Runoff (Q, cfs)
A1	0.88	6.71	5.67	1.14	5.72

Note: See the charts and graphs used for the hydrologic calculations at the end of this study.

BASIN SUMMARY

5.72 cfs

Runoff to existing curb inlet at low point of Basin A1.

BASIN DATA: PROPOSED CONDITIONS (BASIN A2)

Runoff Coefficient

Sub Area	Area (acres)	% Impervious	% Pervious	Description	C Value
Basin A2	1.28	88.3%	11.7%	Street/Landscaping/ Planter	0.84
Hydrologic Soil Type D					

Time of concentration

Sheet Flow

$$T_i = \frac{1.48(1.49 - C)V L}{\sqrt{S}}$$

Basin	Node	C Value	L (ft)	Δ Height (ft)	Slope (%)	T _i (min)
A2		0.84	35.00	0.17	0.49	3.58

Channelized Flow

$$T_f = \frac{L}{60V}$$

Basin	Channel Description	Node	Channel Length (ft)	Δ Height (ft)	Average Q (cfs)	Velocity (fps)	T _t (min)
A2	Gutter Flow		1300.00	34.45	2.78	5.26	4.12

Total Time of Concentration

Basin	T _i (min)	T _t (min)	T _c (min)
A2	3.58	4.12	7.70

100 YEAR - 6 HOUR Storm

$$P_6 = 2.6 \text{ in}$$

$$i = 7.44 P_6 T_c^{-0.645}$$

Basin	C Value	T _c (mins)	Intensity (in/hr)	Area (acres)	Runoff (Q, cfs)
A2	0.84	7.70	5.19	1.28	5.55

Note: See the charts and graphs used for the hydrologic calculations at the end of this study.

BASIN SUMMARY

5.55 cfs

Runoff to proposed Type B curb inlet at low point of Basin A2.

BASIN DATA: PROPOSED CONDITIONS (BASIN B1)

Runoff Coefficient

Sub Area	Area (acres)	% Impervious	% Pervious	Description	C Value
Basin B1	1.95	93.7%	6.3%	Street/Landscaping	0.87
Hydrologic Soil Type D					

Time of concentration

Sheet Flow

$$T_i = \frac{148(L)^{0.76} - C N L}{\sqrt{S}}$$

Basin	Node	C Value	L (ft)	Δ Height (ft)	Slope (%)	T _i (min)
B1		0.87	32.00	0.32	1.00	2.39

Channelized Flow

$$T_f = \frac{L}{60V}$$

Basin	Channel Description	Node	Channel Length (ft)	Δ Height (ft)	Average Q (cfs)	Velocity (fps)	T _t (min)
B1	Gutter Flow		1070.00	10.68	4.31	3.23	5.53

Total Time of Concentration

Basin	T _i (min)	T _t (min)	T _c (min)
B1	2.39	5.53	7.91

100 YEAR - 6 HOUR Storm

P₆ = 2.6 in

$$i = 7.44 P_6 T_c^{-0.645}$$

Basin	C Value	T _c (mins)	Intensity (in/hr)	Area (acres)	Runoff (Q, cfs)
B1	0.87	7.91	5.09	1.95	8.61

Note: See the charts and graphs used for the hydrologic calculations at the end of this study.

BASIN SUMMARY

8.61 cfs

Runoff to existing curb inlet at low point of Basin B1.

BASIN DATA: PROPOSED CONDITIONS (BASIN B2)

Runoff Coefficient

Sub Area	Area (acres)	% Impervious	% Pervious	Description	C Value
Basin B2	1.94	90.3%	9.7%	Street/Landscaping	0.85
Hydrologic Soil Type D					

Time of concentration

Sheet Flow

$$T_i = \frac{148(L)^{0.76} - C V_i L}{V_i}$$

Basin	Node	C Value	L (ft)	Δ Height (ft)	Slope (%)	T _i (min)
B2		0.85	50.00	0.73	1.46	2.84

Channelized Flow

$$T_t = \frac{L}{60V}$$

Basin	Channel Description	Node	Channel Length (ft)	Δ Height (ft)	Average Q (cfs)	Velocity (fps)	T _t (min)
B2	Gutter Flow		1217.00	25.03	4.43	4.63	4.38

Total Time of Concentration

Basin	T _i (min)	T _t (min)	T _c (min)
B2	2.84	4.38	7.22

100 YEAR - 6 HOUR Storm

$$P_6 = 2.6 \text{ in}$$

$$i = 7.44 P_6 T_c^{-0.645}$$

Basin	C Value	T _c (mins)	Intensity (in/hr)	Area (acres)	Runoff (Q, cfs)
B2	0.85	7.22	5.40	1.94	8.85

Note: See the charts and graphs used for the hydrologic calculations at the end of this study.

BASIN SUMMARY

8.85 cfs

Runoff to existing curb inlet at low point of Basin B2.

BASIN DATA: PROPOSED CONDITIONS (BASIN C1)

Runoff Coefficient

Sub Area	Area (acres)	% Impervious	% Pervious	Description	C Value
Basin C1	1.67	93.2%	6.8%	Street/Landscaping/Planter	0.86
Hydrologic Soil Type D					

Time of concentration

Sheet Flow

$$T_i = \frac{1.48(1.49 - C)V L}{\sqrt{S}}$$

Basin	Node	C Value	L (ft)	Δ Height (ft)	Slope (%)	T _i (min)
C1		0.86	31.00	0.73	2.00	1.89

Channelized Flow

$$T_f = \frac{L}{60V}$$

Basin	Channel Description	Node	Channel Length (ft)	Δ Height (ft)	Average Q (cfs)	Velocity (fps)	T _t (min)
C1	Gutter Flow		1485.00	7.99	2.76	2.37	10.44

Total Time of Concentration

Basin	T _i (min)	T _t (min)	T _c (min)
C1	1.89	10.44	12.33

100 YEAR - 6 HOUR Storm

P₆ = 2.6 in

$$i = 7.44 P_6 T_c^{-0.645}$$

Basin	C Value	T _c (mins)	Intensity (in/hr)	Area (acres)	Runoff (Q, cfs)
C1	0.86	12.33	3.83	1.67	5.52

Note: See the charts and graphs used for the hydrologic calculations at the end of this study.

BASIN SUMMARY

5.52 cfs

Runoff to proposed Type B curb inlet at low point of Basin C1.

BASIN DATA: PROPOSED CONDITIONS (BASIN C2)

Runoff Coefficient

Sub Area	Area (acres)	% Impervious	% Pervious	Description	C Value
Basin C2	2.03	79.3%	20.7%	Street/Landscaping/Planter	0.79
Hydrologic Soil Type D					

Time of concentration

Sheet Flow

$$T_i = \frac{148(L - C)N}{C^2}$$

Basin	Node	C Value	L (ft)	Δ Height (ft)	Slope (%)	T _i (min)
C2		0.79	48.00	0.73	2.00	3.11

Channelized Flow

$$T_f = \frac{L}{60V}$$

Basin	Channel Description	Node	Channel Length (ft)	Δ Height (ft)	Average Q (cfs)	Velocity (fps)	T _t (min)
C2	Gutter Flow		1430.00	7.99	2.95	2.41	9.87

Total Time of Concentration

Basin	T _i (min)	T _t (min)	T _c (min)
C2	3.11	9.87	12.98

100 YEAR - 6 HOUR Storm

P₆ = 2.6 in

$$i = 7.44 P_6 T_c^{-0.645}$$

Basin	C Value	T _c (mins)	Intensity (in/hr)	Area (acres)	Runoff (Q, cfs)
C2	0.79	12.98	3.70	2.03	5.90

Note: See the charts and graphs used for the hydrologic calculations at the end of this study.

BASIN SUMMARY

5.90 cfs

Runoff to proposed Type B curb inlet at low point of Basin C2.

Channelized Flow Analysis

Basin B2 - Gutter Flow

L = 1217.00 ft
H = 25.03 ft
S = 0.021 ft/ft

Gutter Flow - Manning

D	6.00 in
A	4.75 ft ²
P	25.60 ft
R	0.19 ft
n	0.015 Concrete
S	0.021 ft/ft
V	4.63 ft/s

Basin A2 - Gutter Flow

L = 1300.00 ft
H = 34.45 ft
S = 0.027 ft/ft

Gutter Flow - Manning

D	6.00 in
A	4.75 ft ²
P	25.60 ft
R	0.19 ft
n	0.015 Concrete
S	0.027 ft/ft
V	5.26 ft/s

Basin C2 - Gutter Flow

L = 1430.00 ft
H = 7.99 ft
S = 0.006 ft/ft

Gutter Flow - Manning

D	6.00 in
A	4.75 ft ²
P	25.60 ft
R	0.19 ft
n	0.015 Concrete
S	0.006 ft/ft
V	2.41 ft/s

Basin C1 - Gutter Flow

L = 1485.00 ft
H = 7.99 ft
S = 0.005 ft/ft

Gutter Flow - Manning

D	6.00 in
A	4.75 ft ²
P	25.60 ft
R	0.19 ft
n	0.015 Concrete
S	0.005 ft/ft
V	2.37 ft/s

Basin A1 - Gutter Flow

L = 1230.00 ft
H = 32.40 ft
S = 0.026 ft/ft

Gutter Flow - Manning

D	6.00 in
A	4.75 ft ²
P	25.60 ft
R	0.19 ft
n	0.015 Concrete
S	0.026 ft/ft
V	5.24 ft/s

Basin B1 - Gutter Flow

L = 1070.00 ft
H = 10.68 ft
S = 0.010 ft/ft

Gutter Flow - Manning

D	6.00 in
A	4.75 ft ²
P	25.60 ft
R	0.19 ft
n	0.015 Concrete
S	0.010 ft/ft
V	3.23 ft/s

Legend

D = depth of flow Assumed Full

A = Cross Sectional area of flow

P = Wetted perimeter

R = hydraulic radius (A/P) Assumed Full

n = Manning Coefficient of Roughness

S = slope of the channel

V = manning velocity of channelized flow

Manning Coefficients

Asphalt 0.016

Concrete 0.015

Grass 0.25

Earth

(weedy) 0.03

APPENDIX B

HYDROLOGIC ASSESSMENT

Basin A2 Curb Inlet Analysis

Typical Curb Inlet

C	I	A
0.84	5.19	1.28

Curb Inlet Analysis Weir

			Approach Flow		Inlet Geometry	
DMA ID	Station	Description	Weir Coefficient (Cw)	100 Year Storm Q _{approach} (cfs)	Flow depth (d) (ft)	Minimum Required Curb Inlet Opening, Lw (ft)
PROPOSED INLETS						
A2	23+36.39 25' RT	CURB INLET TYPE-B	3.0	5.55	0.83	2.4

Curb Inlet Analysis Orifice

			Approach Flow		Inlet Geometry	
DMA ID	Station	Description	Weir Coefficient (Cw)	100 Year Storm Q _{approach} (cfs)	Flow depth (d) (ft)	Minimum Required Curb Inlet Opening, Lw (ft)
PROPOSED INLETS						
A2	23+36.39 25' RT	CURB INLET TYPE-B	3.0	5.55	0.83	1.4

Curb Inlets in Sag

Curb inlets in sags of steep locations operate as weirs at shallow depths, and operate as orifices as water depth increases. The designer shall estimate the capacity of the inlet under each condition and adopt a design capacity equal to the smaller of the two results. When designing the size of a facility, the designer shall use the larger of the sizes obtained by solving for the two conditions.

Inlets in sumps act as weirs for shallow depths, which can be described using Equation 2-8:

$$Q = C_w L_w d^{3/2} \quad (2-8)$$

where:

- Q = inlet capacity (ft³/s);
- C_w = weir discharge coefficient (see Table 2-1);
- L_w = weir length (ft); and
- d = flow depth (ft).

Table 2-1 presents appropriate weir coefficient values and lengths for various inlet types.

At higher flow depths, curb inlets operate in a manner more typical of an orifice (Equation 2-9):

$$Q = 0.67 h L \sqrt{2 g d_e} \quad (2-9)$$

where:

- Q = inlet capacity (ft³/s);
- h = curb opening height (ft);
- L = curb opening length (ft);
- g = gravitational acceleration (ft/s²); and
- d_e = effective depth of flow at curb face (ft).

Table 2-1 Weir Coefficients for Inlets in Sag Locations

Inlet Type	Coefficient	Weir Length	Equation Valid
	C_w	L_w	
G grate inlet against curb	3.00	$L + 2d^{0.75}$	$d \leq 1.79 \{d_c / L_w\}$
G grate inlet, flow from all sides	3.00	$2(L + d^{0.75})$	$d \leq 1.79 \{d_c / L_w\}$
Curb opening inlet	3.00	L'	$d \leq h$
Depressed curb opening inlet: Less than L' = 12 ft ²	3.00	$L' \leq 1.81d'$	$d \leq h$
Skull inlet	2.48	$L^{0.75}$	$d \leq 0.2 \cdot h$

(1) Weir length shall be reduced by 50% to account for clogging; (2) "Depressed Curb Opening inlets" refers to curb inlets with depression larger than the width of the grate (for example, JCD-PSS No. 25, "Concrete Apron for Curb, Inc."); The width (W) of the curb opening depression is measured perpendicular to the face of the curb opening.

Channel Report

Curb Inlet Analysis Basin A2

Gutter

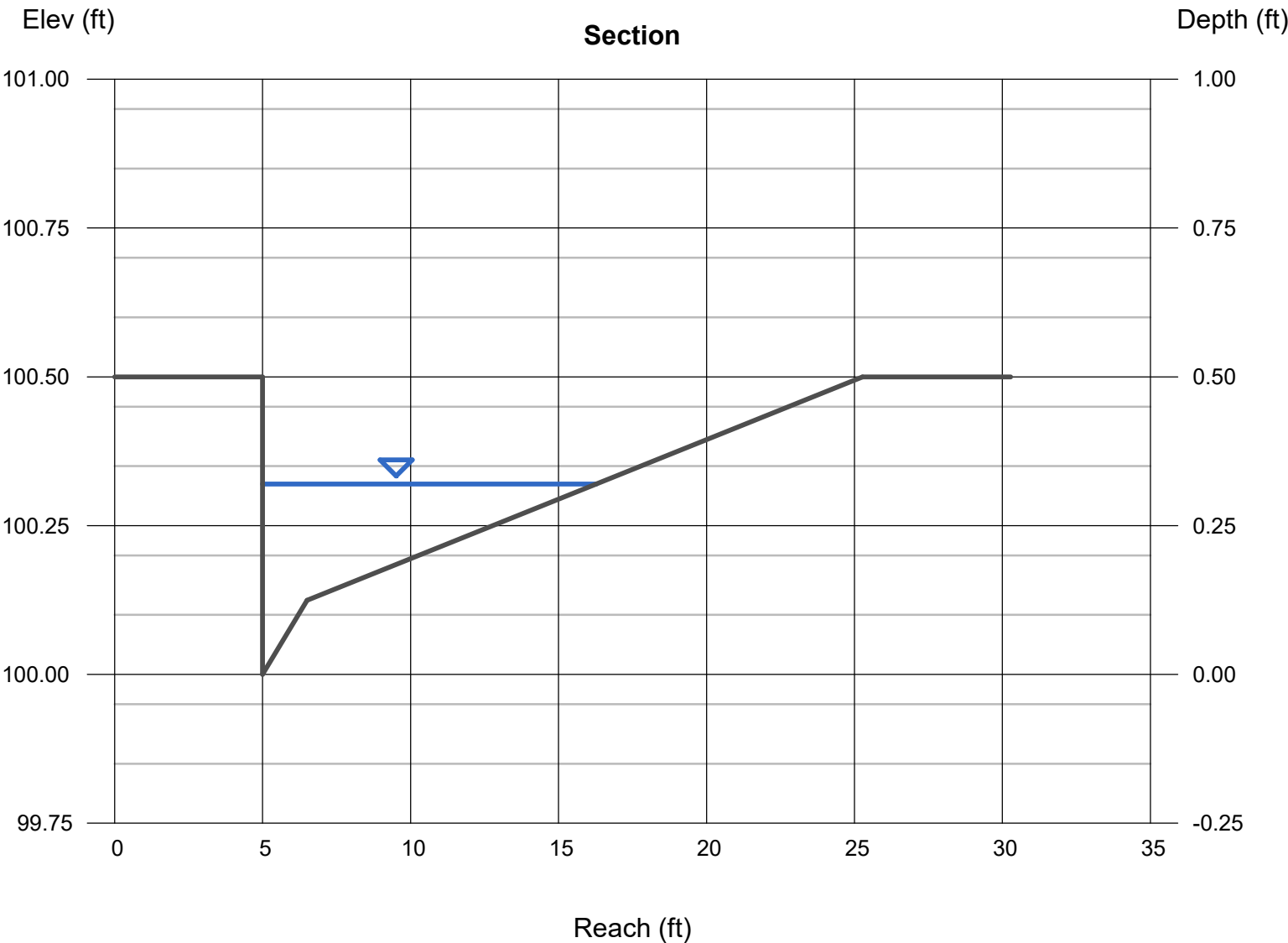
Cross SI, Sx (ft/ft)	= 0.020
Cross SI, Sw (ft/ft)	= 0.083
Gutter Width (ft)	= 1.50
Invert Elev (ft)	= 100.00
Slope (%)	= 2.00
N-Value	= 0.015

Calculations

Compute by:	Known Q
Known Q (cfs)	= 5.55

Highlighted

Depth (ft)	= 0.32
Q (cfs)	= 5.550
Area (sqft)	= 1.34
Velocity (ft/s)	= 4.14
Wetted Perim (ft)	= 11.60
Crit Depth, Yc (ft)	= 0.41
Spread Width (ft)	= 11.27
EGL (ft)	= 0.59



Basin C1 Curb Inlet Analysis

Typical Curb Inlet

C	I	A
0.86	3.83	1.67

Curb Inlet Analysis Weir

			Approach Flow		Inlet Geometry	
DMA ID	Station	Description	Weir Coefficient (Cw)	100 Year Storm Q _{approach} (cfs)	Flow depth (d) (ft)	Minimum Required Curb Inlet Opening, Lw (ft)
PROPOSED INLETS						
C1	53+79.51 25' RT	CURB INLET TYPE-B	3.0	5.52	0.83	2.4

Curb Inlet Analysis Orifice

			Approach Flow		Inlet Geometry	
DMA ID	Station	Description	Weir Coefficient (Cw)	100 Year Storm Q _{approach} (cfs)	Flow depth (d) (ft)	Minimum Required Curb Inlet Opening, Lw (ft)
PROPOSED INLETS						
C1	53+79.51 25' RT	CURB INLET TYPE-B	3.0	5.52	0.83	1.3

Curb Inlets in Sag

Curb inlets in sags or bump locations operate as weirs at shallow depths, and operate as orifices as water depth increases. The designer shall estimate the capacity of the inlet under each condition and adopt a design capacity equal to the smaller of the two results. When designing the size of a facility, the designer shall use the larger of the sizes obtained by solving for the two conditions.

Inlets in sumps act as weirs for shallow depths, which can be described using Equation 2-8:

$$Q = C_w L_w d^{1.5} \quad (2-8)$$

where:

- Q = inlet capacity (ft³/s).
- C_w = weir discharge coefficient (see Table 2-1).
- L_w = weir length (ft); and
- d = flow depth (ft).

Table 2-1 presents appropriate weir coefficient values and lengths for various inlet types.

At higher flow depths, curb inlets operate in a manner more typical of an orifice (Equation 2-9):

$$Q = 0.67hL(2gd)^{0.5} \quad (2-9)$$

where:

- Q = inlet capacity (ft³/s).
- h = curb opening height (ft).
- L = curb opening length (ft).
- g = gravitational acceleration (ft/s²); and
- d_e = effective depth of flow at curb face (ft).

Table 2-1 Weir Coefficients for Inlets in Sag Locations

Inlet Type	Coefficient	Weir Length	Equation Valid
	C_w	L_w	
Grate Inlet Against Curb	3.00	$L + 2H^{0.75}$	$d \leq 1.79 \{d_c / L_w\}$
Grate Inlet, Flow from All Sides	3.00	$2(L + H^{0.75})$	$d \leq 1.79 \{d_c / L_w\}$
Curb Opening Inlet	3.00	L	$d \leq h$
Depressed Curb Opening Inlets Less than 12 ft ²	3.00	$L + 1.8H$	$d \leq h$
Skilled Inlets	2.48	L	$d \leq 0.2 ft$

(1) Weir length shall be reduced by 50% to account for clogging. (2) "Depressed Curb Opening Inlets" refers to curb inlets with depression larger than the width of the grate (for example, JCI-PSS No. 26, "Concrete Apron for Curb Inlet"). The width (W) of the curb opening depression is measured perpendicular to the face of the curb opening.

Channel Report

Curb Inlet Analysis Basin C1

Gutter

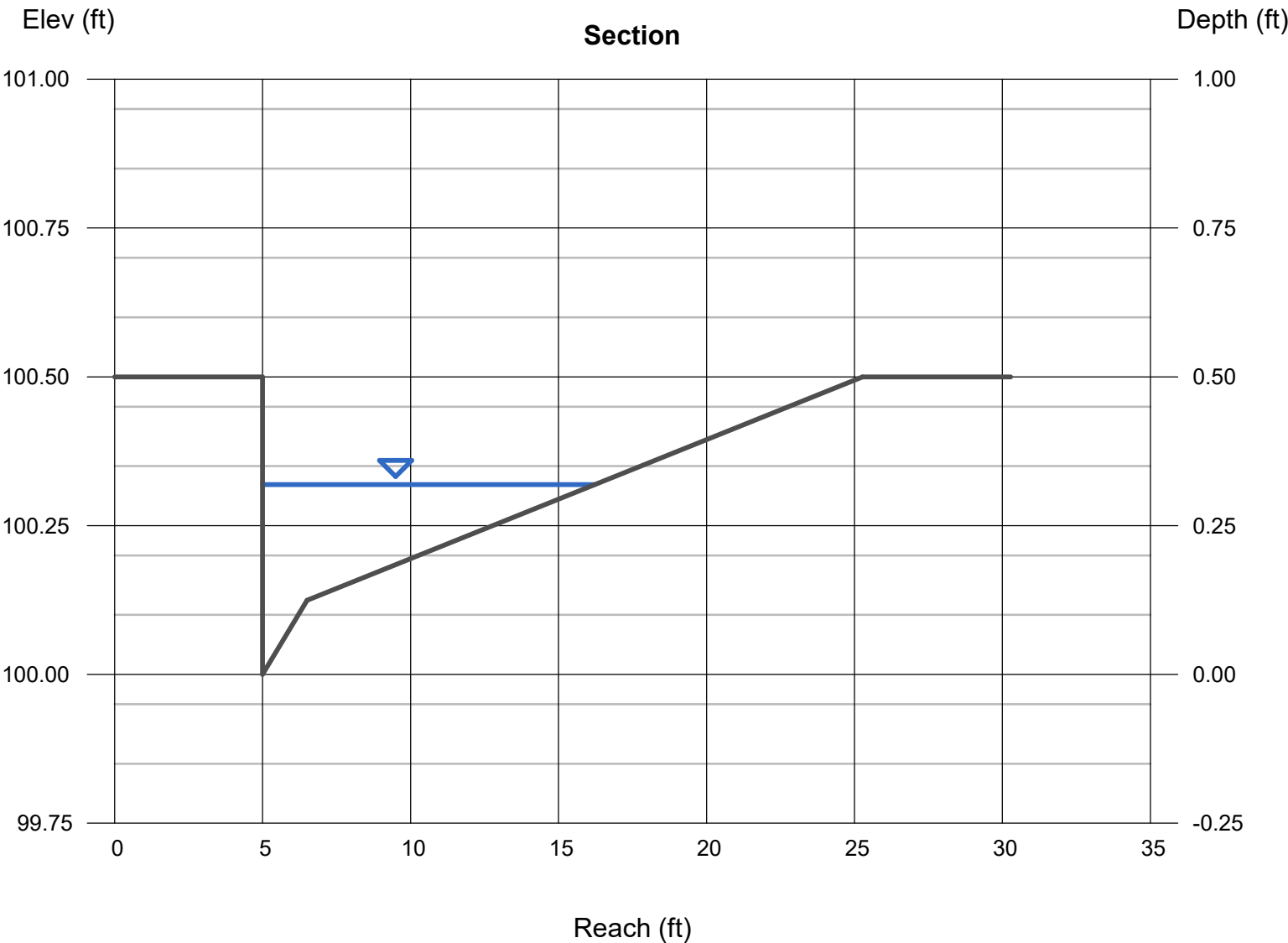
Cross Sl, Sx (ft/ft)	= 0.020
Cross Sl, Sw (ft/ft)	= 0.083
Gutter Width (ft)	= 1.50
Invert Elev (ft)	= 100.00
Slope (%)	= 2.00
N-Value	= 0.015

Calculations

Compute by:	Known Q
Known Q (cfs)	= 5.52

Highlighted

Depth (ft)	= 0.32
Q (cfs)	= 5.520
Area (sqft)	= 1.33
Velocity (ft/s)	= 4.15
Wetted Perim (ft)	= 11.55
Crit Depth, Yc (ft)	= 0.41
Spread Width (ft)	= 11.22
EGL (ft)	= 0.59



Basin C2 Curb Inlet Analysis

Typical Curb Inlet

C	I	A
0.79	3.70	2.03

Curb Inlet Analysis Weir

			Approach Flow		Inlet Geometry	
DMA ID	Station	Description	Weir Coefficient (Cw)	100 Year Storm Q _{approach} (cfs)	Flow depth (d) (ft)	Minimum Required Curb Inlet Opening, Lw (ft)
PROPOSED INLETS						
C2	53+79.51 25' LT	CURB INLET TYPE-B	3.0	5.90	0.83	2.59

Curb Inlet Analysis Orifice

			Approach Flow		Inlet Geometry	
DMA ID	Station	Description	Weir Coefficient (Cw)	100 Year Storm Q _{approach} (cfs)	Flow depth (d) (ft)	Minimum Required Curb Inlet Opening, Lw (ft)
PROPOSED INLETS						
C2	53+79.51 25' LT	CURB INLET TYPE-B	3.0	5.90	0.83	1.44

Curb Inlets in Sag

Curb inlets in sags of steep locations operate as weirs at shallow depths, and operate as orifices as water depth increases. The designer shall estimate the capacity of the inlet under each condition and adopt a design capacity equal to the smaller of the two results. When designing the trap of a facility, the designer shall use the larger of the sizes obtained by solving for the two conditions.

Inlets in sumps act as weirs for shallow depths, which can be described using Equation 2-8:

$$Q = C_w L_w d^{1.5} \quad (2-8)$$

where:

- Q = inlet capacity (ft³/s);
- C_w = weir discharge coefficient (see Table 2-1);
- L_w = weir length (ft); and
- d = flow depth (ft).

Table 2-1 presents appropriate weir coefficient values and lengths for various inlet types.

At higher flow depths, curb inlets operate in a manner more typical of an orifice (Equation 2-9):

$$Q = 0.67 h L \sqrt{2 g d_e} \quad (2-9)$$

where:

- Q = inlet capacity (ft³/s);
- h = curb opening height (ft);
- L = curb opening length (ft);
- g = gravitational acceleration (ft/s²); and
- d_e = effective depth of flow at curb face (ft).

Table 2-1 Weir Coefficients for Inlets in Sag Locations

Inlet Type	Coefficient	Weir Length	Equation Valid
	C_w	L_w	
Gate Inlet Against Curb	3.00	$L + 2H^{1/3}$	$d \leq 1.79 \{d_o / L_o\}$
Circle Inlet, Flow from All Sides	3.00	$2(L + H^{1/3})$	$d \leq 1.79 \{d_o / L_o\}$
Curb Opening Inlets	3.00	L'	$d \leq h$
Depressed Curb Opening Inlets Less than 1'-12" deep	3.00	$L' + 1.8H'$	$d < h$
Skipped Inlets	2.48	$L^{1/3}$	$d < 0.2 H$

(1) Weir length shall be reduced by 50% to account for clogging. (2) "Depressed Curb Opening inlets" refers to curb inlets with depression larger than the width of the gutter (for example, A-1, A-2, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z, AA, AB, AC, AD, AE, AF, AG, AH, AI, AJ, AK, AL, AM, AN, AO, AP, AQ, AR, AS, AT, AU, AV, AW, AX, AY, AZ, BA, BB, BC, BD, BE, BF, BG, BH, BI, BJ, BK, BL, BM, BN, BO, BP, BQ, BR, BS, BT, BU, BV, BW, BX, BY, BZ, CA, CB, CC, CD, CE, CF, CG, CH, CI, CJ, CK, CL, CM, CN, CO, CP, CQ, CR, CS, CT, CU, CV, CW, CX, CY, CZ, DA, DB, DC, DD, DE, DF, DG, DH, DI, DJ, DK, DL, DM, DN, DO, DP, DQ, DR, DS, DT, DU, DV, DW, DX, DY, DZ, EA, EB, EC, ED, EE, EF, EG, EH, EI, EJ, EK, EL, EM, EN, EO, EP, EQ, ER, ES, ET, EU, EV, EW, EX, EY, EZ, FA, FB, FC, FD, FE, FF, FG, FH, FI, FJ, FK, FL, FM, FN, FO, FP, FQ, FR, FS, FT, FU, FV, FW, FX, FY, FZ, GA, GB, GC, GD, GE, GF, GG, GH, GI, GJ, GK, GL, GM, GN, GO, GP, GQ, GR, GS, GT, GU, GV, GW, GX, GY, GZ, HA, HB, HC, HD, HE, HF, HG, HH, HI, HJ, HK, HL, HM, HN, HO, HP, HQ, HR, HS, HT, HU, HV, HW, HX, HY, HZ, IA, IB, IC, ID, IE, IF, IG, IH, II, IJ, IK, IL, IM, IN, IO, IP, IQ, IR, IS, IT, IU, IV, IW, IX, IY, IZ, JA, JB, JC, JD, JE, JF, JG, JH, JI, JJ, JK, JL, JM, JN, JO, JP, JQ, JR, JS, JT, JU, JV, JW, JX, JY, JZ, KA, KB, KC, KD, KE, KF, KG, KH, KI, KJ, KK, KL, KM, KN, KO, KP, KQ, KR, KS, KT, KU, KV, KW, KX, KY, KZ, LA, LB, LC, LD, LE, LF, LG, LH, LI, LJ, LK, LL, LM, LN, LO, LP, LQ, LR, LS, LT, LU, LV, LW, LX, LY, LZ, MA, MB, MC, MD, ME, MF, MG, MH, MI, MJ, MK, ML, MM, MN, MO, MP, MQ, MR, MS, MT, MU, MV, MW, MX, MY, MZ, NA, NB, NC, ND, NE, NF, NG, NH, NI, NJ, NK, NL, NM, NN, NO, NP, NQ, NR, NS, NT, NU, NV, NW, NX, NY, NZ, OA, OB, OC, OD, OE, OF, OG, OH, OI, OJ, OK, OL, OM, ON, OO, OP, OQ, OR, OS, OT, OU, OV, OW, OX, OY, OZ, PA, PB, PC, PD, PE, PF, PG, PH, PI, PJ, PK, PL, PM, PN, PO, PP, PQ, PR, PS, PT, PU, PV, PW, PX, PY, PZ, QA, QB, QC, QD, QE, QF, QG, QH, QI, QJ, QK, QL, QM, QN, QO, QP, QQ, QR, QS, QT, QU, QV, QW, QX, QY, QZ, RA, RB, RC, RD, RE, RF, RG, RH, RI, RJ, RK, RL, RM, RN, RO, RP, RQ, RR, RS, RT, RU, RV, RW, RX, RY, RZ, SA, SB, SC, SD, SE, SF, SG, SH, SI, SJ, SK, SL, SM, SN, SO, SP, SQ, SR, SS, ST, SU, SV, SW, SX, SY, SZ, TA, TB, TC, TD, TE, TF, TG, TH, TI, TJ, TK, TL, TM, TN, TO, TP, TQ, TR, TS, TT, TU, TV, TW, TX, TY, TZ, UA, UB, UC, UD, UE, UF, UG, UH, UI, UJ, UK, UL, UM, UN, UO, UP, UQ, UR, US, UT, UY, UZ, VA, VB, VC, VD, VE, VF, VG, VH, VI, VJ, VK, VL, VM, VN, VO, VP, VQ, VR, VS, VT, VU, VV, VW, VX, VY, VZ, WA, WB, WC, WD, WE, WF, WG, WH, WI, WJ, WK, WL, WM, WN, WO, WP, WQ, WR, WS, WT, WU, WV, WW, WX, WY, WZ, XA, XB, XC, XD, XE, XF, XG, XH, XI, XJ, XK, XL, XM, XN, XO, XP, XQ, XR, XS, XT, XU, XV, XW, XX, XY, XZ, YA, YB, YC, YD, YE, YF, YG, YH, YI, YJ, YK, YL, YM, YN, YO, YP, YQ, YR, YS, YT, YU, YV, YW, YX, YY, YZ, ZA, ZB, ZC, ZD, ZE, ZF, ZG, ZH, ZI, ZJ, ZK, ZL, ZM, ZN, ZO, ZP, ZQ, ZR, ZS, ZT, ZU, ZV, ZW, ZX, ZY, ZZ).

Channel Report

Curb Inlet Analysis C2

Gutter

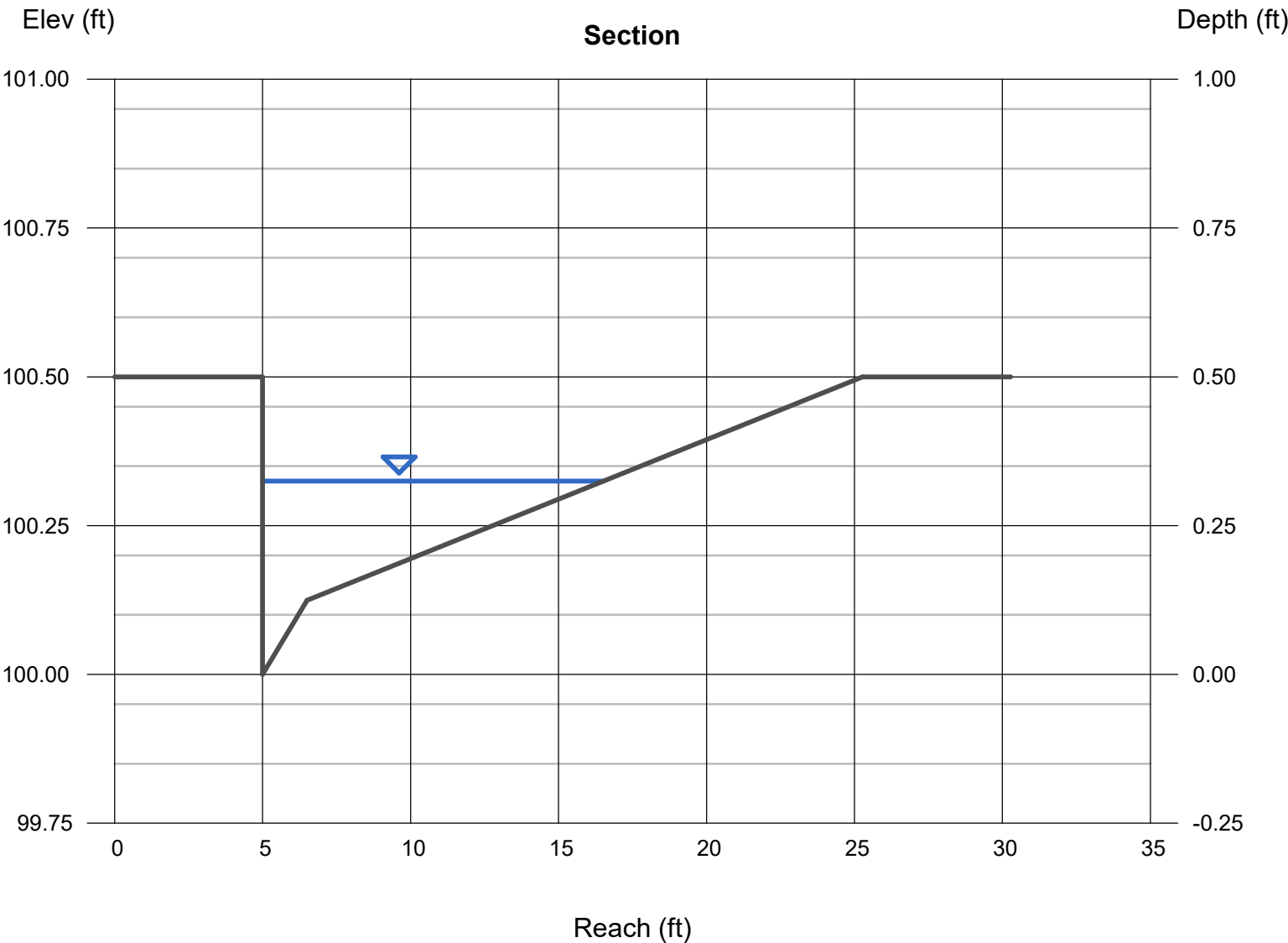
Cross SI, Sx (ft/ft)	= 0.020
Cross SI, Sw (ft/ft)	= 0.083
Gutter Width (ft)	= 1.50
Invert Elev (ft)	= 100.00
Slope (%)	= 2.00
N-Value	= 0.015

Highlighted

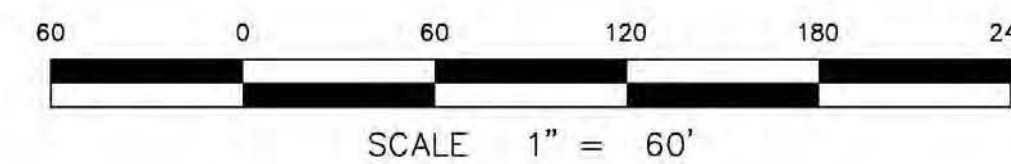
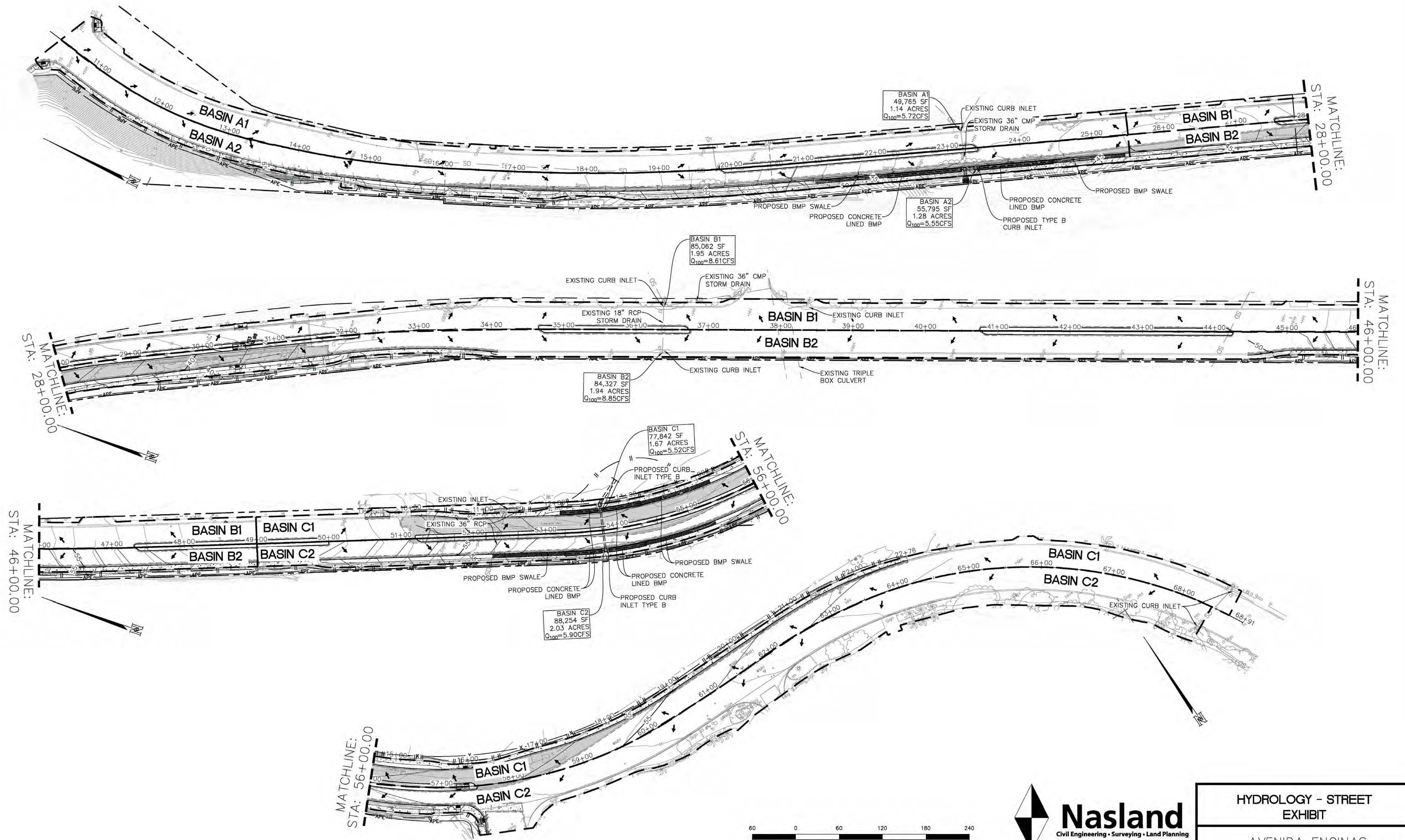
Depth (ft)	= 0.32
Q (cfs)	= 5.900
Area (sqft)	= 1.40
Velocity (ft/s)	= 4.22
Wetted Perim (ft)	= 11.86
Crit Depth, Yc (ft)	= 0.42
Spread Width (ft)	= 11.52
EGL (ft)	= 0.60

Calculations

Compute by:	Known Q
Known Q (cfs)	= 5.90



APPENDIX C
DRAINAGE BASIN MAP



HYDROLOGY - STREET
EXHIBIT

AVENIDA ENCINAS
COASTAL RAIL TRAIL AND
PEDESTRIAN IMPROVEMENTS

APPENDIX D

REFERENCE MAPS AND TABLES

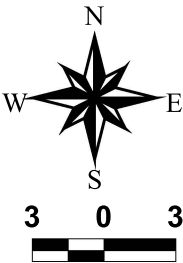
County of San Diego Hydrology Manual



Rainfall Isopluvials

100 Year Rainfall Event - 6 Hours

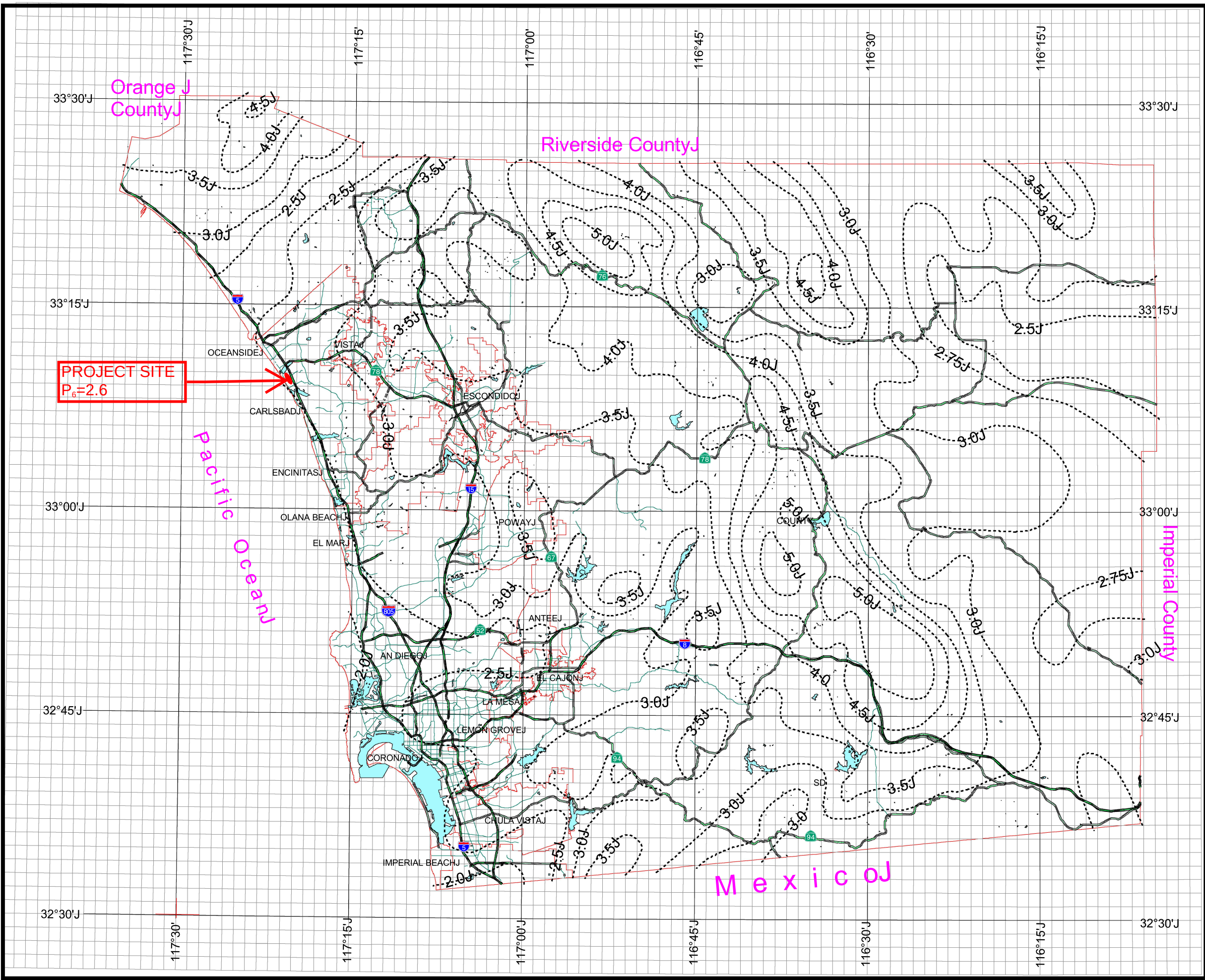
----- Isopluvial (inches)



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County of San Diego Hydrology Manual



Rainfall Isopluvials

100 Year Rainfall Event - 24 Hours

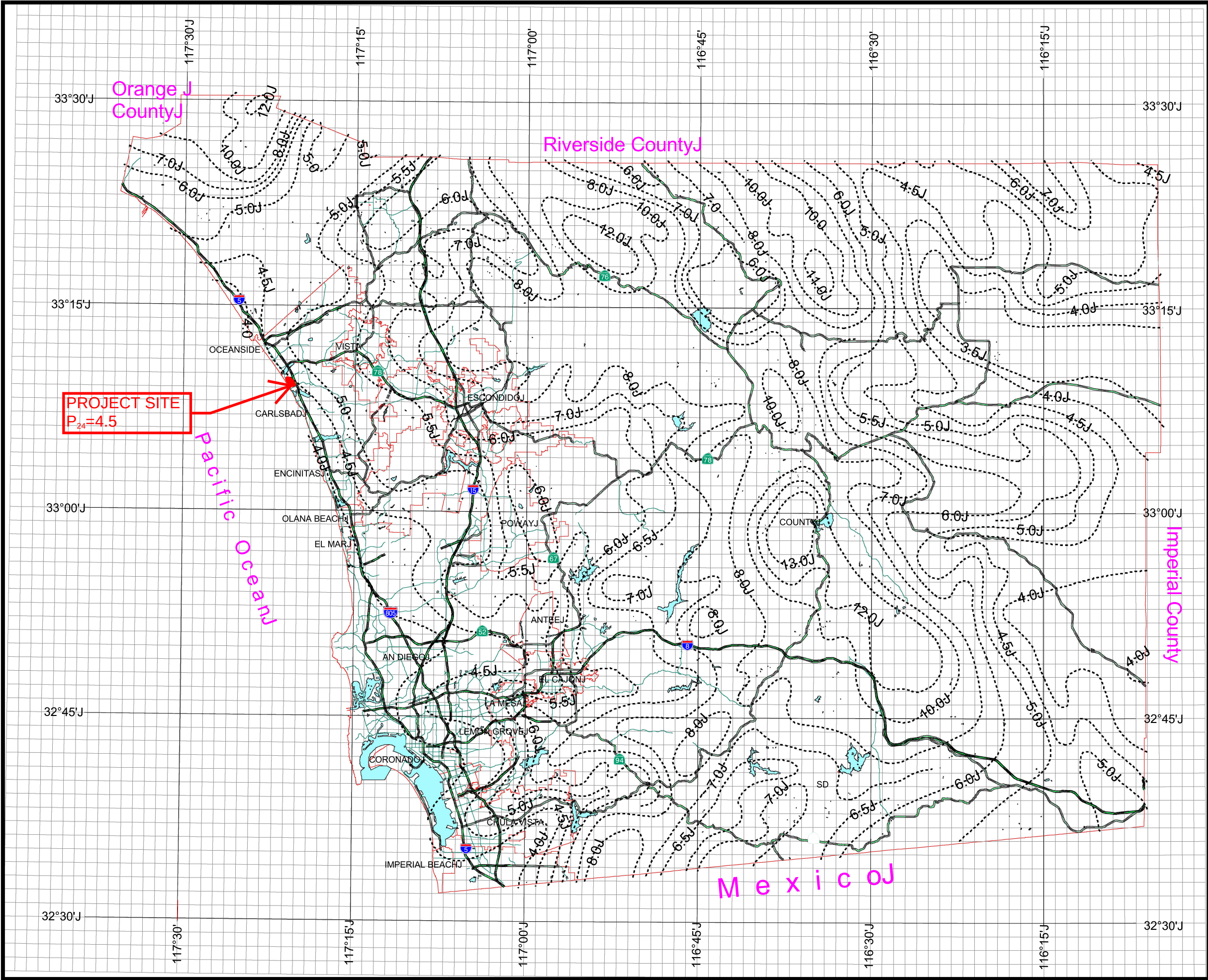
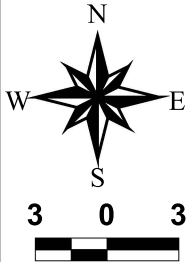
----- Isopluvial (inches)

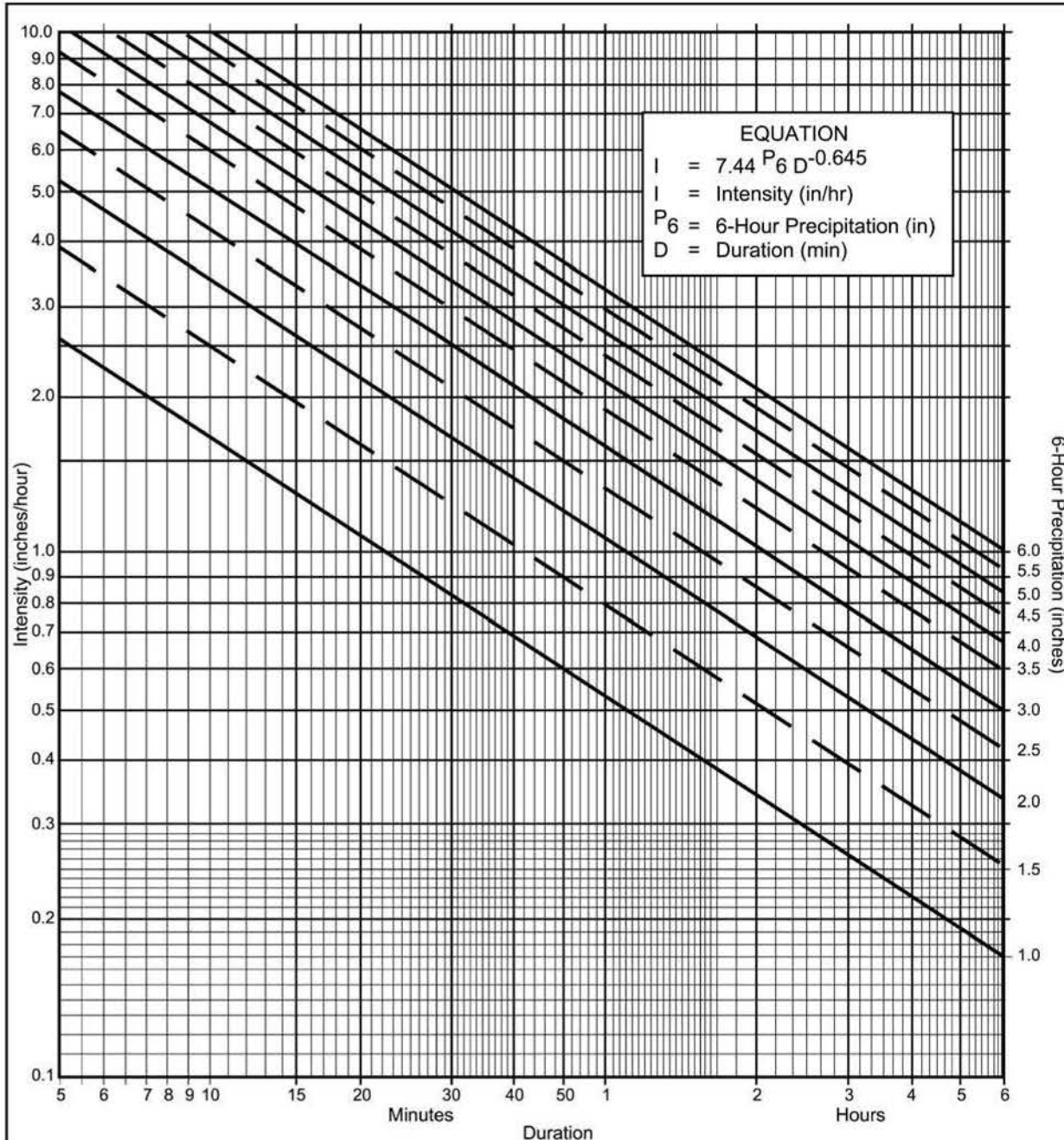


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Directions for Application:

- (1) From precipitation maps determine 6 hr and 24 hr amounts for the selected frequency. These maps are included in the County Hydrology Manual (10, 50, and 100 yr maps included in the Design and Procedure Manual).
- (2) Adjust 6 hr precipitation (if necessary) so that it is within the range of 45% to 65% of the 24 hr precipitation (not applicable to Desert).
- (3) Plot 6 hr precipitation on the right side of the chart.
- (4) Draw a line through the point parallel to the plotted lines.
- (5) This line is the intensity-duration curve for the location being analyzed.

Application Form:

- (a) Selected frequency _____ year
- (b) $P_6 =$ _____ in., $P_{24} =$ _____, $\frac{P_6}{P_{24}} =$ _____ %⁽²⁾
- (c) Adjusted $P_6^{(2)} =$ _____ in.
- (d) $t_x =$ _____ min.
- (e) $I =$ _____ in./hr.

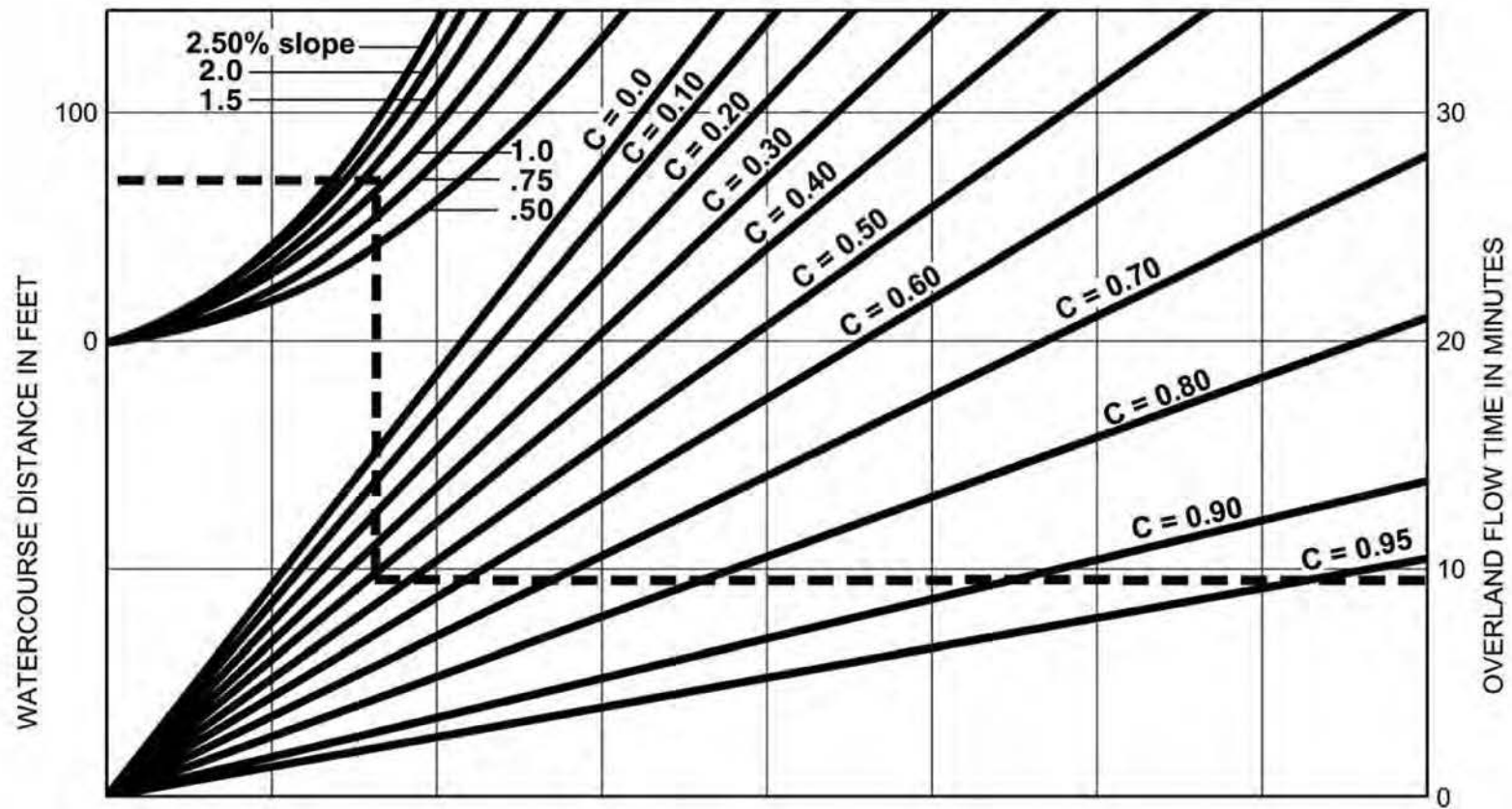
Note: This chart replaces the Intensity-Duration-Frequency curves used since 1965.

P6	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6
Duration	I	I	I	I	I	I	I	I	I	I	I
5	2.63	3.95	5.27	6.59	7.90	9.22	10.54	11.86	13.17	14.49	15.81
7	2.12	3.18	4.24	5.30	6.36	7.42	8.48	9.54	10.60	11.66	12.72
10	1.68	2.53	3.37	4.21	5.05	5.90	6.74	7.58	8.42	9.27	10.11
15	1.30	1.95	2.59	3.24	3.89	4.54	5.19	5.84	6.49	7.13	7.78
20	1.08	1.62	2.15	2.69	3.23	3.77	4.31	4.85	5.39	5.93	6.46
25	0.93	1.40	1.87	2.33	2.80	3.27	3.73	4.20	4.67	5.13	5.60
30	0.83	1.24	1.66	2.07	2.49	2.90	3.32	3.73	4.15	4.56	4.98
40	0.69	1.03	1.38	1.72	2.07	2.41	2.76	3.10	3.45	3.79	4.13
50	0.60	0.90	1.19	1.49	1.79	2.09	2.39	2.69	2.98	3.28	3.58
60	0.53	0.80	1.06	1.33	1.59	1.86	2.12	2.39	2.65	2.92	3.18
90	0.41	0.61	0.82	1.02	1.23	1.43	1.63	1.84	2.04	2.25	2.45
120	0.34	0.51	0.68	0.85	1.02	1.19	1.36	1.53	1.70	1.87	2.04
150	0.29	0.44	0.59	0.73	0.88	1.03	1.18	1.32	1.47	1.62	1.76
180	0.26	0.39	0.52	0.65	0.78	0.91	1.04	1.18	1.31	1.44	1.57
240	0.22	0.33	0.43	0.54	0.65	0.76	0.87	0.98	1.08	1.19	1.30
300	0.19	0.28	0.38	0.47	0.56	0.66	0.75	0.85	0.94	1.03	1.13
360	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.84	0.92	1.00

Intensity-Duration Design Chart - Template

FIGURE

3-1



EXAMPLE:

Given: Watercourse Distance (D) = 70 Feet
 Slope (s) = 1.3%
 Runoff Coefficient (C) = 0.41
 Overland Flow Time (T) = 9.5 Minutes

$$T = \frac{1.8 (1.1-C) \sqrt{D}}{\sqrt[3]{S}}$$

SOURCE: Airport Drainage, Federal Aviation Administration, 1965

Rational Formula - Overland Time of Flow Nomograph

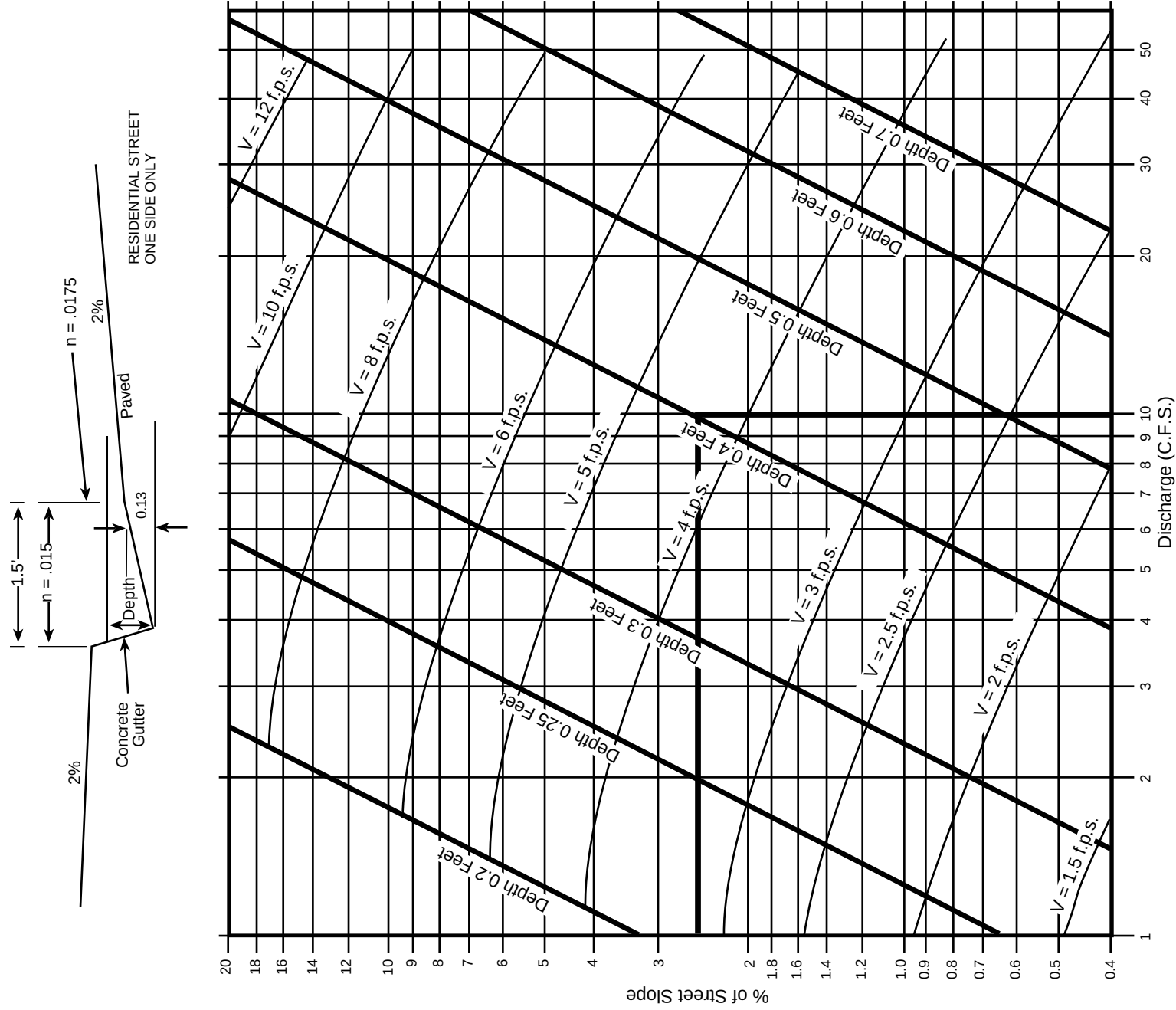
F I G U R E

3-3

$$C = 0.90 \times (\% \text{ Impervious}) + C_p \times (1 - \% \text{ Impervious})$$

Where: C_p = Pervious Coefficient Runoff Value for the soil type (shown in Table 3-1 as Undisturbed Natural Terrain/Permanent Open Space, 0% Impervious). Soil type can be determined from the soil type map provided in Appendix A.

The values in Table 3-1 are typical for most urban areas. However, if the basin contains rural or agricultural land use, parks, golf courses, or other types of nonurban land use that are expected to be permanent, the appropriate value should be selected based upon the soil and cover and approved by the local agency.

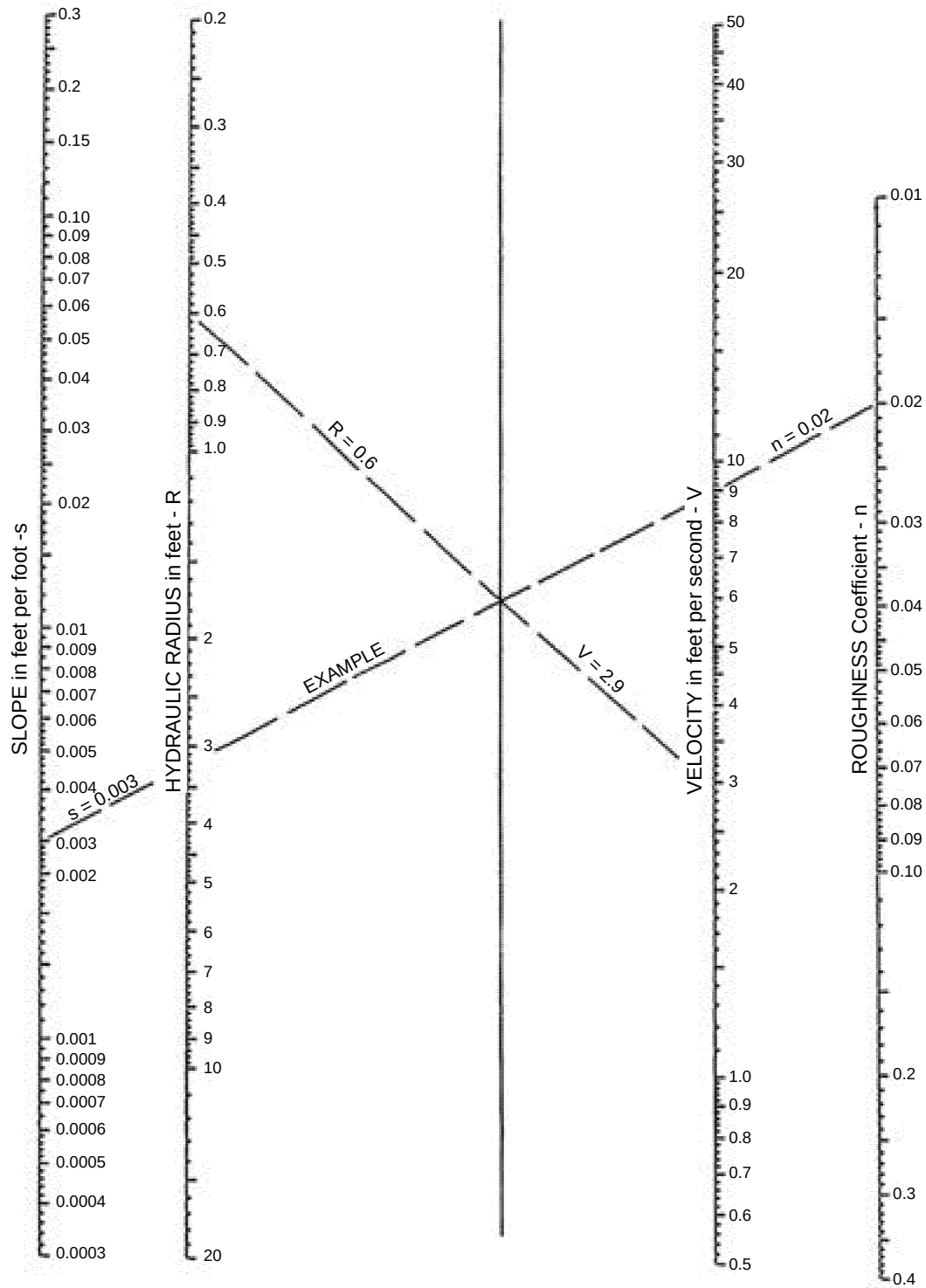


SOURCE: San Diego County Department of Special District Services Design Manual

FIGURE

Gutter and Roadway Discharge - Velocity Chart

$$\text{EQUATION: } V = \frac{1.49}{n} R^{2/3} S^{1/2}$$



GENERAL SOLUTION

SOURCE: USDOT, FHWA, HDS-3 (1961)

F I G U R E

Manning's Equation Nomograph

3-7

Table 3-1
RUNOFF COEFFICIENTS FOR URBAN AREAS

Land Use		Runoff Coefficient "C"				
NRCS Elements	County Elements	% IMPER.	Soil Type			
			A	B	C	D
Undisturbed Natural Terrain	Permanent Open Space	0*	0.20	0.25	0.30	0.35
Low	Residential, 1.0 DU/A or less	10	0.27	0.32	0.36	0.41
Low	Residential, 2.0 DU/A or less	20	0.34	0.38	0.42	0.46
Low	Residential, 2.9 DU/A or less	25	0.38	0.41	0.45	0.49
Medium Density Residential	Residential, 4.3 DU/A or less	30	0.41	0.45	0.48	0.52
Medium Density Residential	Residential, 7.3 DU/A or less	40	0.48	0.51	0.54	0.57
Medium Density Residential	Residential, 10.9 DU/A or less	45	0.52	0.54	0.57	0.60
Medium Density Residential	Residential, 14.5 DU/A or less	50	0.55	0.58	0.60	0.63
High Density Residential	Residential, 24.0 DU/A or less	65	0.66	0.67	0.69	0.71
High Density Residential	Residential, 43.0 DU/A or less	80	0.76	0.77	0.78	0.79
Commercial/Industrial	Neighborhood Commercial	80	0.76	0.77	0.78	0.79
Commercial/Industrial	General Commercial	85	0.80	0.80	0.81	0.82
Commercial/Industrial	Office Professional/Commercial	90	0.83	0.84	0.84	0.85
Commercial/Industrial	Limited Industrial	90	0.83	0.84	0.84	0.85
Commercial/Industrial	General Industrial	95	0.95	0.95	0.95	0.95

*The values associated with 0% impervious may be used for direct calculation of the runoff coefficient as described in Section 3.1.2 (representing the pervious runoff coefficient, C_p , for the soil type), or for areas that will remain undisturbed in perpetuity. Justification must be given that the area will remain natural forever (e.g., the area is located in Cleveland National Forest).

DU/A = dwelling units per acre

NRCS = National Resources Conservation Service

County of San Diego Hydrology Manual



Soil Hydrologic Groups

Legend

oil Groups

Group A

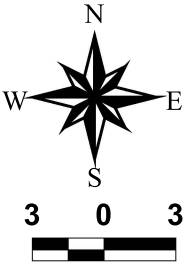
Group BJ

Group C

Group DJ

Undetermined

ata Unavailable



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