FINAL DRAINAGE REPORT

March 25, 2019

PARCEL C

at Ritz Carlton Resort

Town of Paradise Valley, AZ

Prepared for:

Five Star Development

6720 N Scottsdale Road, Suite 130

Scottsdale, AZ 85253

Prepared by:

CVL Consultants, Inc.

4550 N 12th Street

Phoenix, AZ 85014

Contact: Oscar Garcia, PE

602.285.4735

Job #1.01.02689.08

Registered Professional Engineer (Civil)
CERTIFICATE NO.
66356
OSCAR E.
GARCIA
Date Signed 3-25-19
ARIZONA, U.S.A.
Expires 6-30-2021

Oscar Garcia

CVL
CONSULTANTS

FINAL DRAINAGE REPORT

THE RITZ-CARLTON RESORT - PARCEL C

TOWN OF PARADISE VALLEY, AZ

March 25, 2019

Prepared for:

Five Star Development

6720 N. Scottsdale Road, Suite 130

Scottsdale, Arizona 85253

(480) 657-7827

Prepared by:

Coe & Van Loo Consultants, Inc.

4550 N. 12th Street

Phoenix, AZ 85014

(602) 264-6831

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The Town approves these plans for concept only and accepts no liability for errors or omissions.

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TOWN OF PARADISE VALLEY, AZ

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Final Drainage Report
The Ritz-Carlton Resort - Parcel C

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CVL CONSULTANTS

1.0 Introduction

1.1 Scope

Coe & Van Loo Consultants, Inc. (CVL) has been contracted by Five Star Development, Inc. to provide engineering services in support of the proposed Ritz-Carlton Resort Parcel C, herein referred to as the site. The purpose of this report is to provide hydrologic analysis for the proposed development. In addition, this report addresses off-site drainage, on-site drainage and stormwater storage requirements.

This report is focused on providing final design information, evaluation and analysis for statistical flood events up to and including the 100-year frequency flood. The scope of this assessment does not include, neither did CVL's client request that, evaluation of storm-water runoff resulting from events exceeding the 100-year storm. Hence, it should be noted that a storm event exceeding the 100-year frequency may cause or create the risk of greater flood impact than is addressed and presented in this assessment.

The procedures used herein are derived from, and performed with, currently accepted engineering methodologies and practices. Additionally, the criteria for this evaluation are designed to conform to currently applicable ordinances, regulations and policies as set forth by the Town of Paradise Valley and Maricopa County.

1.2 Site Description

The site is currently an infill area, consisting of empty desert land surrounded by developed property. This site slopes generally to the northeast at an approximately 0.9 percent slope. The site is bordered on the north by Saint Barnabas on the Desert Episcopal Church, on the west by Mockingbird Lane, on the east by currently vacant land, and on the south by Lincoln Drive. Furthermore, the site is located in Section 10 and 3, Township 2 North, Range 4 East of the Gila and Salt River Base and Meridian, Maricopa County, Arizona., (See Figure 1 – Vicinity and Location Map).

1.3 Proposed Development

The proposed development consists of 39 single-family detached lots on approximately 17.8 acres and is part of the proposed Ritz-Carton Resort located in the Town of Paradise Valley. The site is being developed in two phases; Phase 1 includes the development of Lots 1-27 and 35-39; Phase 2 includes Lots 28-34. Each phase will include the associated local streets and drainage facilities. Phase 1 will include a temporary surface retention basin for the Phase 2 area. The site provides adequate permanent and temporary drainage measures to meet the Town of Paradise Valley drainage requirements.

1.3 Regulatory Jurisdiction

The development is designed to meet the Town of Paradise Valley (PV) drainage requirements [1], with accordance to the Maricopa County drainage requirements as stated in the Flood Control District of Maricopa County (FCDMC), Drainage Design Manuals for Maricopa County, Arizona, Volume I, Hydrology [2], Volume II, Hydraulics [3], and Drainage Policies and Standards Manual (DPSM) for Maricopa County, Arizona [4].

2.0 FEMA Floodplain Classification

The Maricopa County, Arizona and Incorporated Areas Flood Insurance Rate Map (FIRM), panel number 04013C1770L, Map Revised October 16, 2013 [5], indicate the site falls within Zone "D"

Zone "D" is defined by FEMA as:

> “The Zone D designation is used for areas where there are possible but undetermined flood hazards, as no analysis of flood hazards has been conducted. The Zone D designation is also used when a community incorporates portions of another community’s area where no map has been prepared.”

Refer to Figure 2 for a copy of the Flood Insurance Rate Map (FIRM).

3.0 Off-Site Drainage Description

3.1 Off-Site Hydrology

Off-site flows currently sheet flow across the site to the east. For the proposed conditions, all off-site flow is conveyed around the site via a channel that will extend from an existing box culvert at the northwest corner of Ocotillo Road and Mockingbird Lane to another existing box culvert at the southwest corner of Indian Bend Road and Scottsdale Road and another channel on the south along Lincoln Drive. The two off-site channels have been evaluated in a separate report, the Master Drainage

Report for the Ritz Carlton Resort [6] (see excerpts in Appendix A). Due to these channels, no offsite flows will affect the site.

4.0 MANAGEMENT OF ON-SITE RUNOFF

4.1 ON-SITE HYDROLOGY

The on-site hydrology is based on the Rational Method in accordance with PV [1] and FCDMC Hydrology Manual [2]. The drainage sub-basins and on-site delineations are based on the lot layout and final grading plans. Times of concentration and the 10-year and 100-year intensities are based on DPSM [4]. A 100-year weighted runoff coefficient of 0.77 has been calculated based on pervious and impervious areas (see Figure 3 and Appendix B for weighted runoff coefficient calculations). Rainfall data was obtained from NOAA Atlas 14 and has also been included in Appendix C.

4.2 ON-SITE RUNOFF MANAGEMENT PLAN

The site drains to three different outfall locations where existing drainage infrastructure conveys the flow to existing underground storage tanks. All existing drainage infrastructure including underground tanks was analyzed in the Infrastructure Final Drainage Report for Ritz Carlton Resort [7] and was sized adequately for the anticipated flows and retention requirements of Parcel C. Phase 1 includes the development of Lots 1-27 and Lots 35-39 and associated streets and drainage facilities which are encompassed by Subbasins SUB1 and SUB2. Phase 2 includes the development of Lots 28-34 and associated streets and drainage facilities which are encompassed by Subbasin SUB3. Subbasin SUB1 runoff is conveyed down Horseshoe Lane and intercepted by catch basinss CB-1 and CB-2. SUB1 ultimately all drains to existing drainage infrastructure on Palmeraie Boulevard then onto underground retention tank UR-2. Street runoff from Subbasin SUB2 is intercepted by slotted drain catch basins CB-4 to CB-13. SUB2 ultimately drains to an existing 48-inch stormdrain pipe at the southeast end of Parcel C via stormdrain and South Channel on Lot 5. The 48-inch stormdrain drains to underground retention tank UR-2 (see Infrastructure FDR excerpts [7] in Appendix A). Subbasin SUB3 (see Plate 1 for reference) drains to the north where slotted drain catch basin CB-3 at the Sierra Vista Drive cul-de-sac intercepts most of the street runoff. The remainder of the street runoff flows to the North Channel on Lot 30 then to underground retention tank UR-3 (for underground retention location and information see excerpts of Infrastructure Final Drainage Report (FDR) [7] in Appendix A).

Local streets are designed to convey storm water runoff to slotted drain catch basins throughout the site. Streets have been designed to convey the 10-year storm event between back of curbs and the 100-year storm between the right-of-way. Where street capacity was exceeded, slotted drain was used to intercept runoff. Slotted drains were sized with a clogging factor of 50%. Street capacity calculations can be found in Appendix D.

Slotted drain catch basins are specified as Contech Slotted Drain™ using Contech UltraFlo® corrugated metal pipe (CMP) which has a manning's n value of 0.012 for all diameters (see Appendix E). Storm drain pipes were sized for the 100-year peak flow (see Bentley StormCAD® results in Appendix D). The rectangular channels are concrete with trash racks lining the top length of the channel and are also designed to convey the 100-year peak flow with at least a foot of freeboard (see Bentley FlowMaster® calculations in Appendix D). Tailwater conditions used in the StormCAD models were matched to the existing drainage infrastructure that is being tied into.

Existing underground retention tanks built during infrastructure provide sufficient retention for Parcel C's first flush storage requirement. A temporary surface retention basin will be constructed during Phase 1 to retain the first flush volume required by Phase 2. First flush retention was calculated using a precipitation depth of 0.5 inches, a weighted runoff coefficient of 0.77 and the area (see first flush retention calculations in Appendix B). The allotted retention for Parcel C can be seen in the Infrastructure FDR [7] excerpts provided in Appendix A.

Finish floor elevations are set at a minimum 12 inches above adjacent 100-year high water elevations and a minimum of 14 inches above the low top of curb, whichever is greatest, [1] [4].

5.0 Storm Water Pollution Prevention Plan

A Storm Water Pollution Prevention Plan (SWPPP) has been prepared and submitted for approval along with this report.

6.0 Summary and Conclusions

1. The streets have been designed to convey the 100-year on-site flow within the right-of way to the underground retention tanks.
2. Retention is designed to retain first flush volume from the 100-year, 2-hour storm.

3. All finished floor elevations will be at least 14 inches above the lowest drainage outfall for the lot.
4. The finished floor elevations for the lots are at least 12 inches above the adjacent 100-year, 2-hour high water elevations and at least 14 inches above the low top of curb, whichever is greatest.
5. Off-site flows are conveyed around the site, no improvements are required.
6. According to the FIRM panel number 04013C1770L, Map Revised: October 16, 2013, the site is located within a Zone “D”.

7.0 References

[1] Town of Paradise Valley, "Storm Drainage Design Manual", January 2017.

[2] Flood Control District of Maricopa County, "Drainage Design Manual for Maricopa County, Arizona, Volume I, Hydrology," August 15, 2013.

[3] Flood Control District of Maricopa County, Arizona, "Draft Drainage Design Manual for Maricopa County, Volume II, Hydraulics," August 15, 2013.

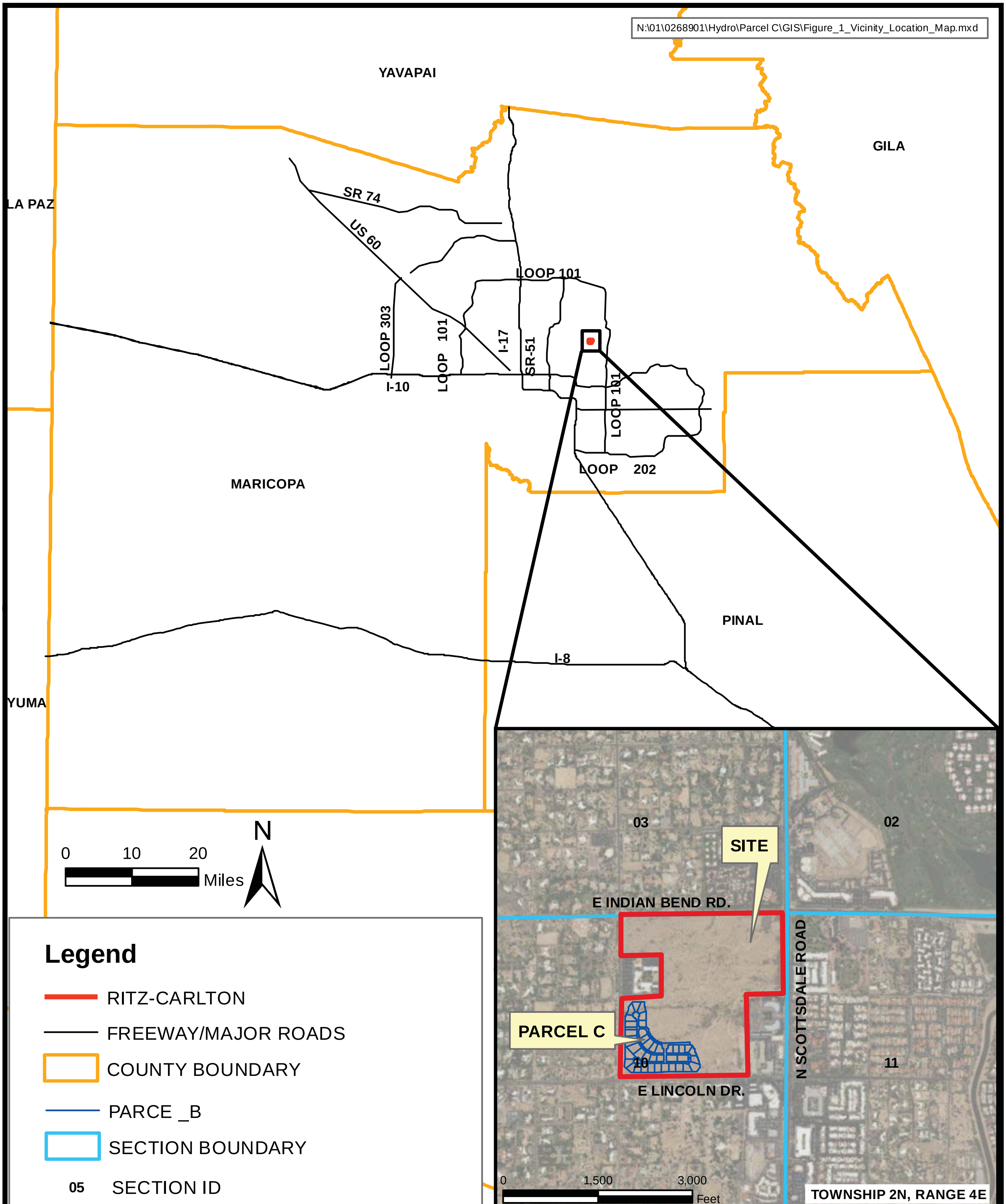
[4] Flood Control District of Maricopa County, "Drainage Policies and Standards," Revised June 1, 2016.

[5] Federal Emergency Management Agency (FEMA), "National Flood Insurance Program, Flood Insurance Rate Map, Maricopa County, Arizona and Incorporated Areas, Panel Numbers 04013C1770L," Revised October 16, 2013.

[6] Coe & Van Loo Consultants, Inc, "Master Drainage Report for Ritz Carlton Resort," June 28, 2017.

[7] Coe & Van Loo Consultants, Inc, "Infrastructure Final Drainage Report for Ritz Carlton Resort," July 20, 2017.

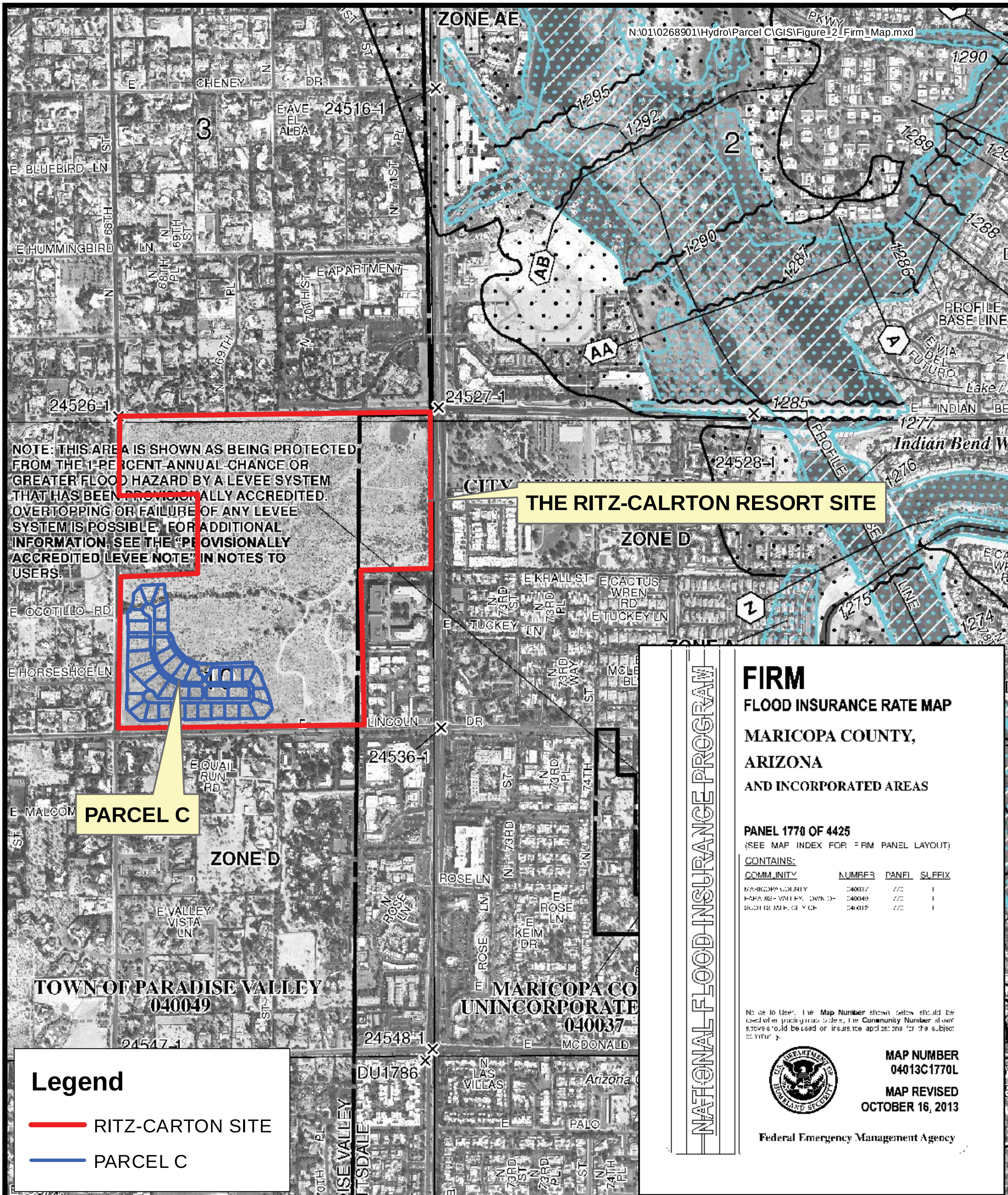
FIGURES



CVL CONSULTANTS

4550 NORTH 12TH STREET
PHOENIX, ARIZONA 85014
TELEPHONE (602) 264-6831

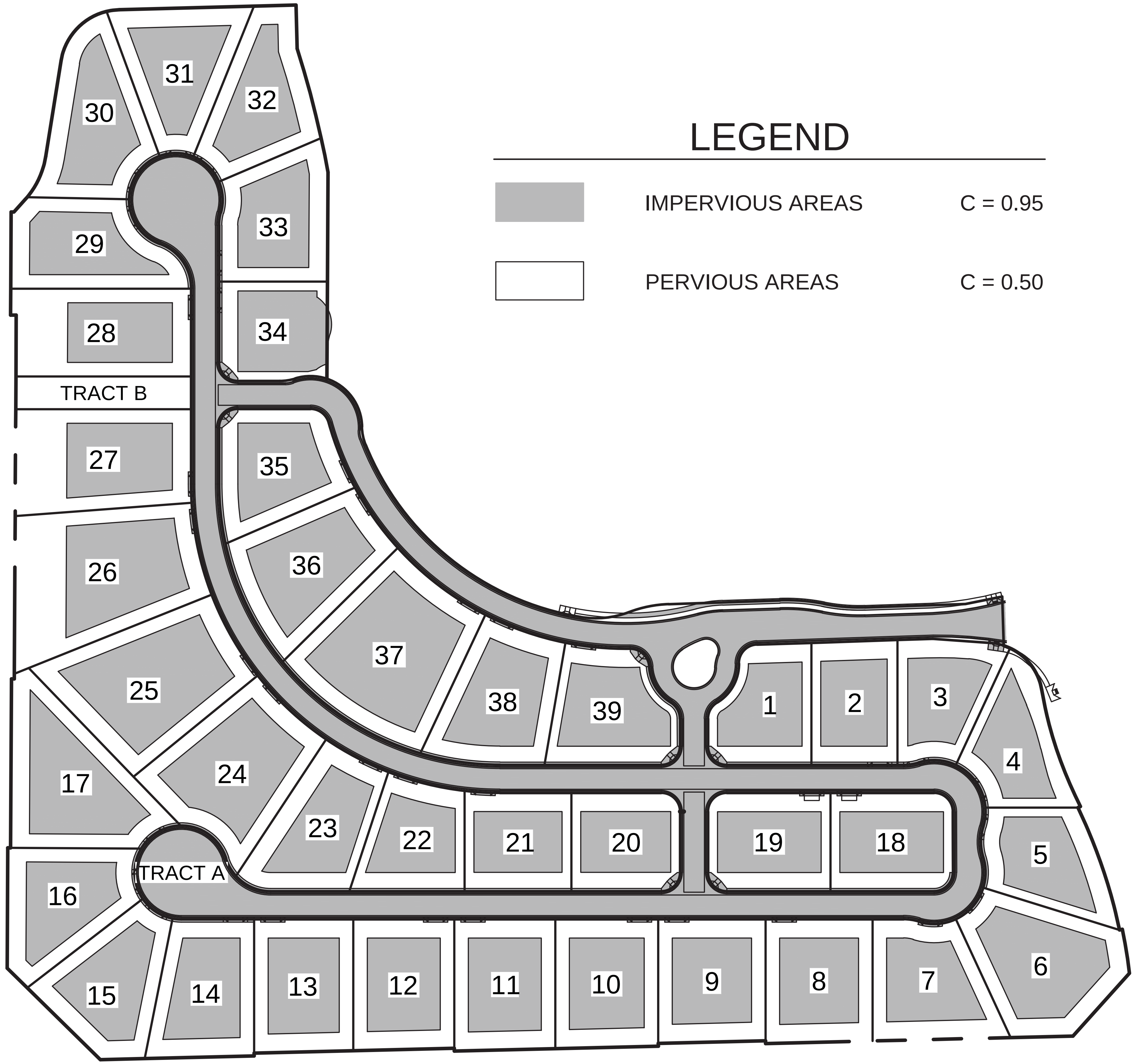
THE RITZ-CARLTON RESORT PARCEL C	JOB NO. 01-0268901
VICINITY & LOCATION MAP	FIGURE 1



CVL CONSULTANTS

4550 NORTH 12TH STREET
PHOENIX, ARIZONA 85014
TELEPHONE (602) 264-6831

THE RITZ-CARLTON RESORT	JOB NO. 01-0268901
FLOOD INSURANCE RATE MAP	FIGURE 2



LEGEND

(shaded)	IMPERVIOUS AREAS	C = 0.95
(unshaded)	PERVIOUS AREAS	C = 0.50

WEIGHTED C VALUE EXHIBIT

RITZ CARLTON RESORT - PARCEL C

SCALE 1" = 120'

FIGURE 3

CVL CONSULTANTS

4550 North 12th Street
Phoenix, Arizona 85014
Phone 602-264-6831
http://www.cvlci.com

APPENDICES

CVL

APPENDIX A

Excerpts from Existing Drainage Reports

Excerpts from Ritz Carlton Resort

Master Drainage Report

CVL

MASTER DRAINAGE REPORT

June 28, 2017

Ritz Carlton Resort

Town of Paradise Valley & City of Scottsdale

Prepared for:

Five Star Development
6720 North Scottsdale Road
Suite 130
Scottsdale, AZ 85253

Prepared by:

Coe & Van Loo Consultants, Inc.
4550 N 12th Street
Phoenix, AZ 85014
Contact: Jason Kelley
602.264.6831

Job #:1-01-0268901

Registered Professional Engineer (Civil)
CERTIFICATE NO.
37297
JASON K.
KELLEY
Date Signed 6-28-17
ARIZONA, U.S.A.
Expires 3-31-2020

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CONSULTANTS

MASTER DRAINAGE REPORT
RITZ CARLTON RESORT
TOWN OF PARADISE VALLEY & CITY OF SCOTTSDALE, AZ

June 28, 2017

Prepared for:

Five Star Development
6720 North Scottsdale Road, Suite 130
Scottsdale, AZ 85253

Prepared by:

Coe & Van Loo Consultants, Inc.
4550 N. 12th Street
Phoenix, AZ 85014
(602) 264-6831

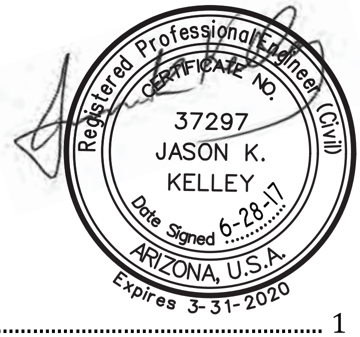
Registered Professional Engineer (Civil)
CERTIFICATE NO.
37297
JASON K.
KELLEY
Date Signed 6-28-17
ARIZONA, U.S.A.
Expires 3-31-2020

CVL Job Number: 1.01.0268901

FIVE STAR DEVELOPMENT

CVL CONSULTANTS

Master Drainage Report
Ritz Carlton Resort



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Registered Professional Engineer (Civil)
CERTIFICATE NO.
37297
JASON K.
KELLEY
Date Signed 6-28-17
ARIZONA, U.S.A.
Expires 3-31-2020

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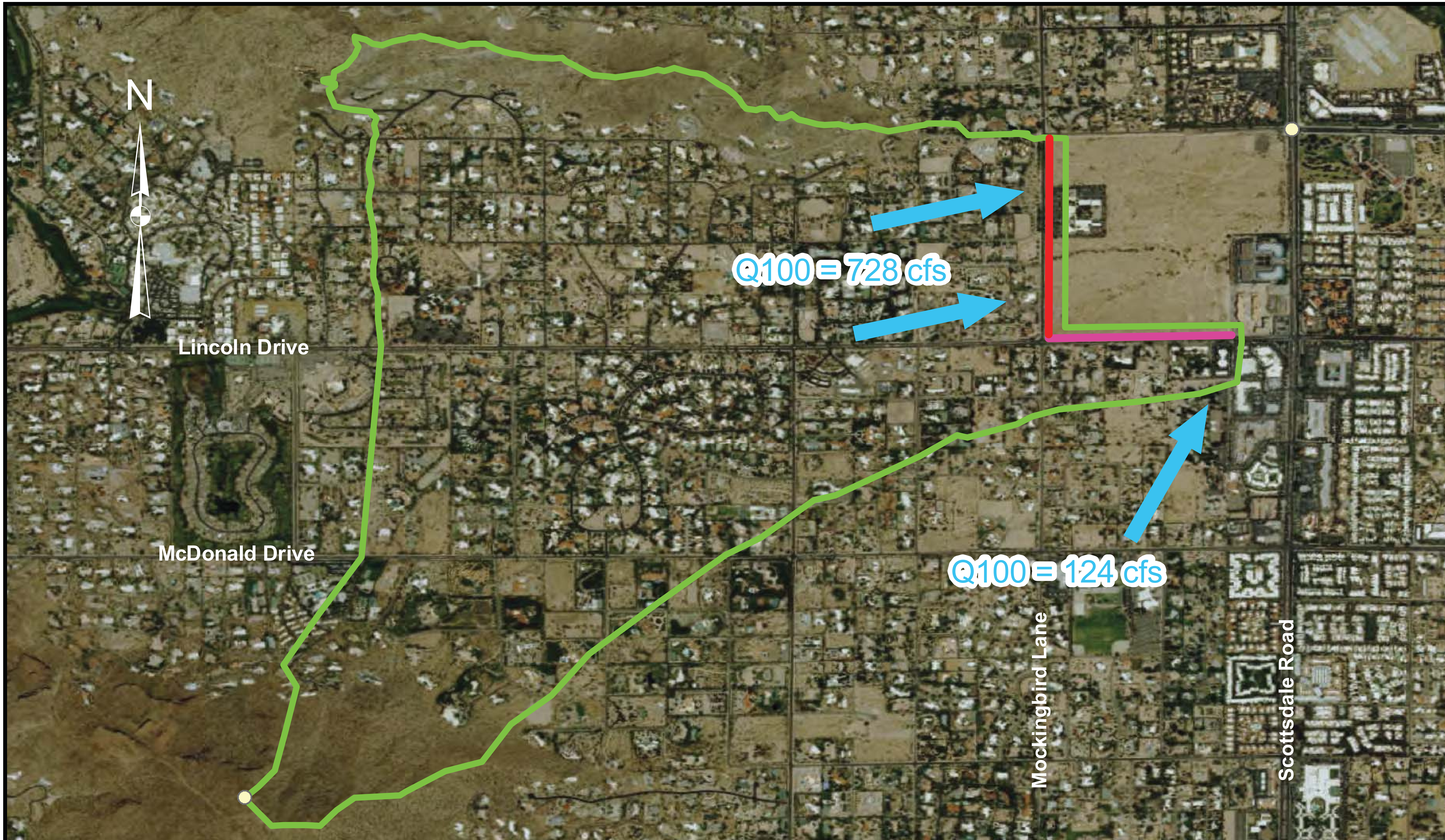
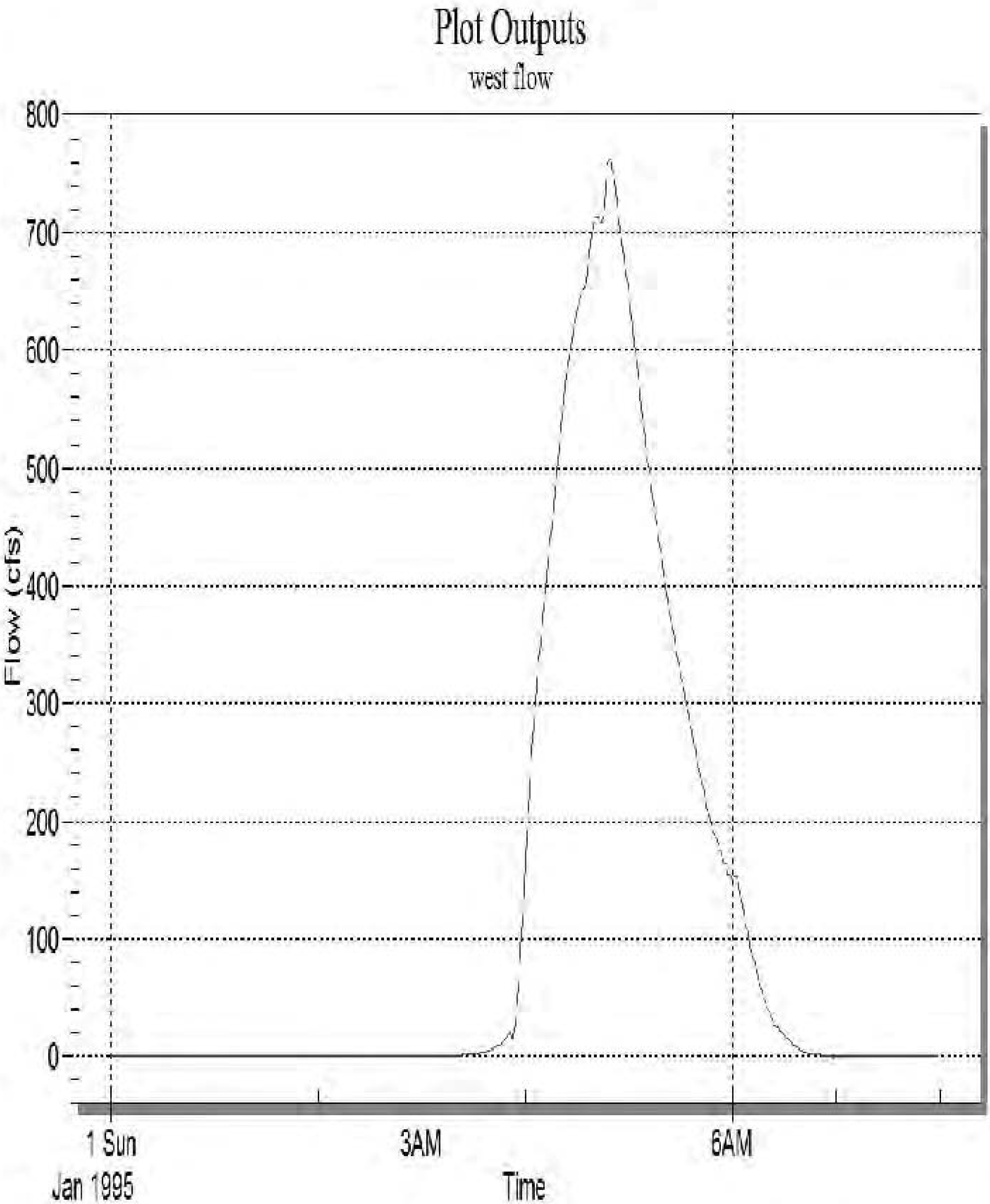
CD Electronic Files



CVL CONSULTANTS

4550 NORTH 12TH STREET
PHOENIX, ARIZONA 85014
TELEPHONE (602) 264-6831

RITZ CARLTON	JOB NO. 0268901
XPSWMM - Flow Cross Sections and 100-yr Peak Flows	Exhibit 3



4550 NORTH 12TH STREET
PHOENIX, ARIZONA 85014
TELEPHONE (602) 264-6831

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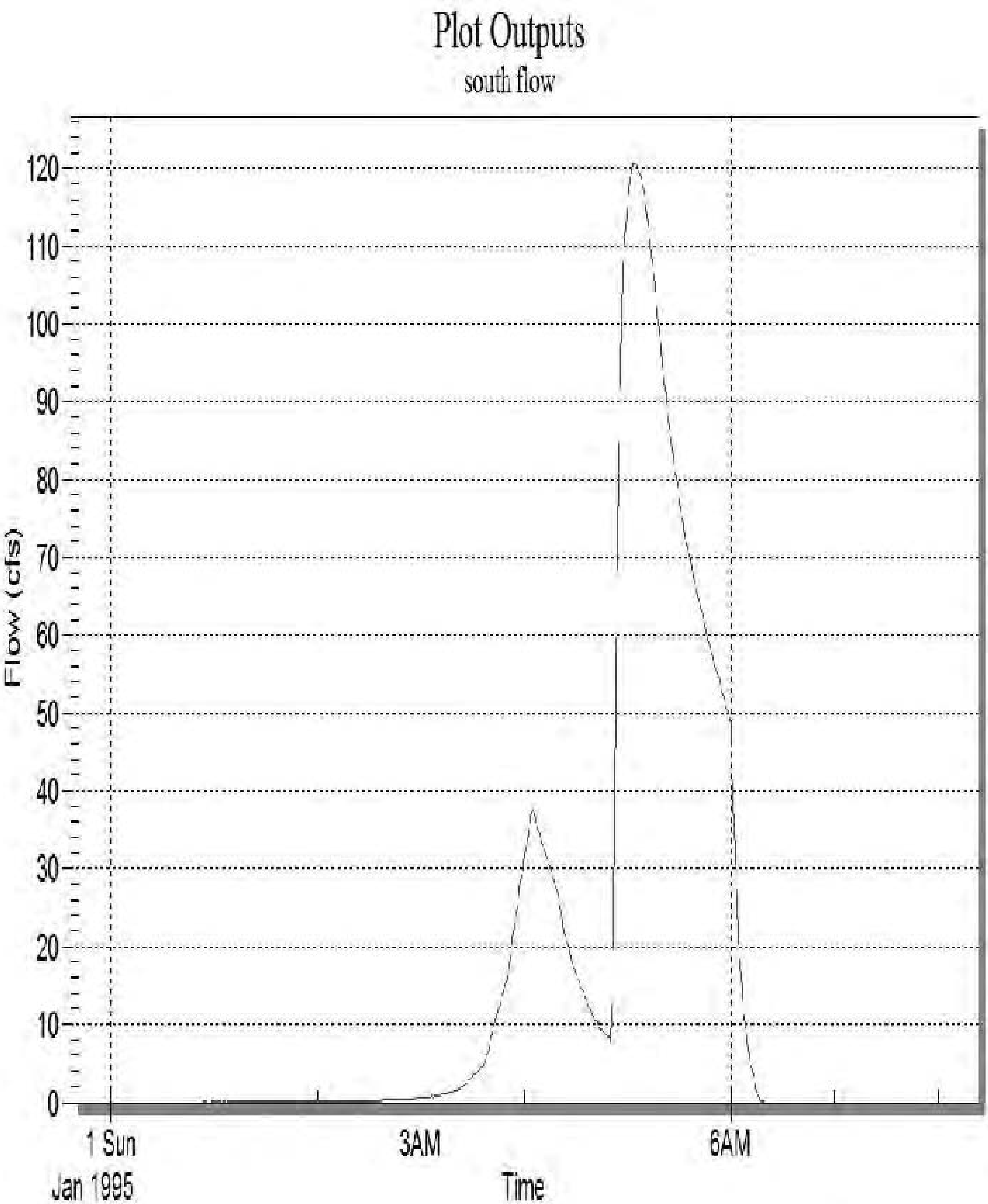
RITZ CARLTON	JOB NO. 0268901
MOCKINGBIRD LN INFLOW HYDROGRAPH - NO BLOCKAGE	EXHIBIT 6B



CVL CONSULTANTS
4550 NORTH 12TH STREET
PHOENIX, ARIZONA 85014
TELEPHONE (602) 264-6831

RITZ CARLTON

JOB NO. 0268901

LINCOLN DRIVE INFLOW HYDROGRAPH - NO BLOCKAGE

Exhibit 7B

Excerpts from Ritz Carlton Resort Infrastructure Final Drainage Report

CVL

FINAL DRAINAGE REPORT

July 20, 2017

RITZ-CARLTON INFRASTRUCTURE

Town of Paradise Valley/
City of Scottsdale, Arizona

Prepared for:

Five Star Development
6720 N Scottsdale Rd, Suite 130
Scottsdale, Arizona 85253

Prepared by:

Coe & Van Loo Consultants, L.L.C.
4550 N 12th Street
Phoenix, AZ 85014

602.264.6831

Job #:1-01-0268901

Registered Professional Engineer (Civil)
CERTIFICATE NO.
37297
JASON K.
KELLEY
Date Signed 7-20-17
ARIZONA, U.S.A.
Expires 3-31-2020

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RITZ-CARLTON INFRASTRUCTURE
TOWN OF PARADISE VALLEY

July 20, 2017

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6720 N. Scottsdale Road, Suite 130

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(480) 657-7827

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Coe & Van Loo Consultants, Inc.

4550 N. 12th Street

Phoenix, AZ 85014

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Final Drainage Report
Ritz-Carlton Infrastructure

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CERTIFICATE NO.
37297
JASON K.
KELLEY
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ARIZONA, U.S.A.
Expires 3-31-2020

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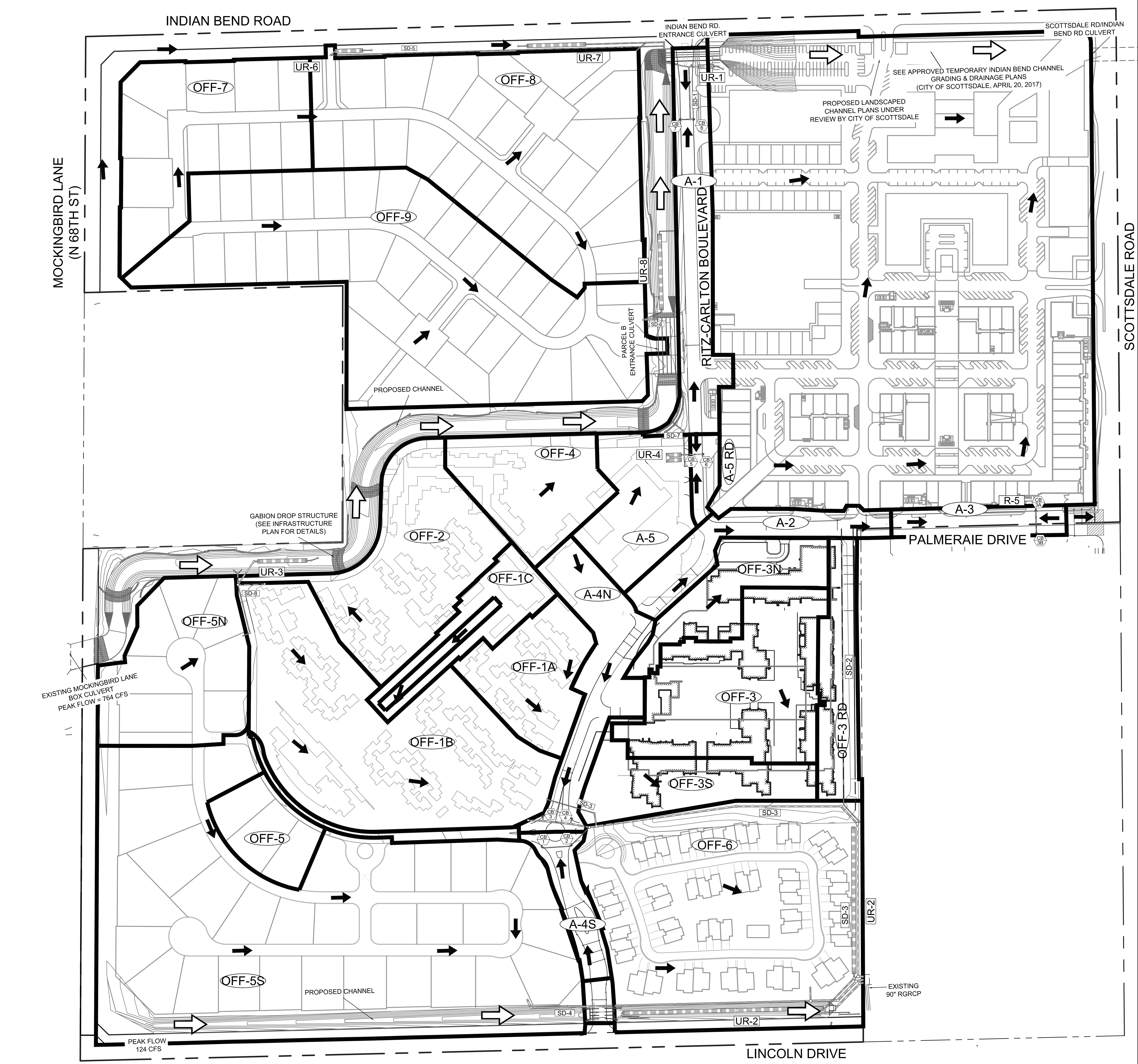
Ritz-Carlton Infrastructure
First Flush Retention Basin Volume Calculations

First Flush								
Retention [1] Sub-Watershed ID	Drainage Area A (acres)	Runoff [2] Coefficient C	Precipitation [3] P (inches)	Volume [4] Required V_{req} (acre-ft)	Retention ID	Volume per lf of 10 ft dia pipe (ft^2)	Linear feet Provided 10 ft dia pipe	Volume Provided V (acre-ft)
A-1	2.27	0.78	0.50	0.07				
SUB TOTAL	**2.27**			**0.07**	UR-1	78.54	40	**0.07**
A-4N	2.20	0.83	0.50	0.08				
A-4S	0.79	0.87	0.50	0.03				
OFF-1A	1.90	0.73	0.50	0.06				
OFF-1B	6.91	0.68	0.50	0.20				
OFF-1C	1.43	0.69	0.50	0.04				
OFF-5	1.58	0.76	0.50	0.05				
OFF-5S	15.81	0.70	0.50	0.46				
OFF-6	8.93	0.94	0.50	0.35				
OFF-3*	8.82	0.94	0.50	0.35				
SUB TOTAL	**48.39**			**1.61**	UR-2	78.54	893	**1.61**
OFF-5N	3.20	0.70	0.50	0.09				
OFF-2	3.75	0.82	0.50	0.13				
SUB TOTAL	**3.75**			**0.22**	UR-3	78.54	127	**0.23**
A-5	1.95	0.84	0.50	0.07				
A-5 RD	0.34	0.84	0.50	0.01				
OFF-4	2.18	0.73	0.50	0.07				
SUB TOTAL	**2.18**			**0.15**	UR-4	78.54	81	**0.15**
OFF-7	4.01	0.76	0.50	0.127	UR-6	78.54	71	0.128
OFF-8	8.53	0.76	0.50	0.270	UR-7	78.54	151	0.272
OFF-9	11.02	0.76	0.50	0.349	UR-8	78.54	195	0.352
SUB TOTAL	**4.01**			**0.75**			417	**0.75**
TOTAL	**60.60**			**2.79**				**2.809**

Notes:

1. Drainage sub-basin delineated per Drainage Map (Plate 1).
2. Weighted C-Value of 0.75 for residential areas, 0.95 for Infrastrucure Roads 0.30 for retention basins and 0.45 for undeveloped desert rangeland per Figure 4.1-4 *City of Scottsdale Design Standards & Policies Manual*
3. P=0.5 inches for First Flush
4. V_{req} = A x C x (P/12) = volume required for retention in acre-ft.

* OFF-3 includes drainage areas PFF-3, OFF-3N, OFF-3S, AND OFF-3 RD



LEGEND

A-1	Drainage Area
CB 1	Catch Basin
UR-1	Underground Retention
SD-1	Storm Drain
	Off-Site Flow Direction
	On-Site Flow Direction
	Drainage Area
	Property Boundary
	Existing Contours

120' 60' 0 120'
SCALE: 1" = 120'

CVL CONSULTANTS
4550 North 12th Street
Phoenix, Arizona 85014
602-264-6831
www.cvlci.com

Coe & Van Loo Consultants, Inc.

NO.	REVISION	DATE

Drainage Map

RITZ-CARLTON INFRASTRUCTURE

Paradise Valley / Scottsdale, ARIZONA

SHEET 1 OF 1

CVL Contact: JASON KELLEY
CVL Project #: 01.0268901
CVL File #:

PROJECT NO. 01.0268901

Call at least two full working days before you begin excavation.
ARIZONA 811 Arizona Blue Stake, Inc.
Dial 8-1-1 or 1-800-STAKE-IT (782-5348)
In Maricopa County: (602) 263-1100

Printed By: **MirandaB** Print Date: **July 20, 2017** Filename: N:\01\0268901\Hydro\INFRASTRUCTURE\FDR\2nd Submittal-MIRANDA\CADD\WB.DRAIN_1.dwg

APPENDIX B

Onsite Hydrology Calculations

Peak Flow Calculations

SUMMARY OF RATIONAL METHOD PEAK FLOW HYDROLOGY

The Ritz Carlton Resort - Parcel C

CP Concentration Point	Sub-basin Area (ac)	Water Course Length ft	High Elevation ft	Low Elevation ft	Roughness, Kb	C Weighted Runoff Coefficient		i Intensity (in/hr)		Tc Time of (min)		Q Peak Flow Rate (cfs)	
						Return Period		Return Period		Return Period		Return Period	
						10-Year	100-Year	10-Year	100-Year	10-Year	100-Year	10-Year	100-Year
CP1	2.43	505	1320.31	1318.65	0.0376 (A)	0.62	0.78	3.7	6.5	9.7	7.8	5.6	**12.3**
SUB1/CB-1 & CB-2	2.96	882	1320.31	1312.70	0.0371 (A)	0.62	0.78	3.8	6.6	9.3	7.5	7.0	**15.2**
CB-4	0.83	322	1321.60	1319.29	0.0405 (A)	0.62	0.78	4.6	7.6	5.8	5.0	2.4	**4.9**
CB-5	1.62	443	1321.60	1318.82	0.0387 (A)	0.62	0.78	4.3	7.3	7.1	5.8	4.3	**9.2**
CB-6	2.76	771	1321.60	1317.33	0.0372 (A)	0.62	0.78	3.6	6.4	10.2	8.2	6.2	**13.8**
CB-7	4.14	1194	1321.60	1313.29	0.0361 (A)	0.62	0.78	3.4	5.8	11.9	9.7	8.7	**18.7**
CB-8	1.30	299	1322.70	1319.76	0.0393 (A)	0.62	0.78	4.8	7.6	5.0	5.0	3.9	**7.7**
CB-9	2.39	461	1322.70	1318.87	0.0376 (A)	0.62	0.78	4.5	7.4	6.4	5.3	6.7	**13.8**
CB-10	3.52	681	1322.70	1317.13	0.0366 (A)	0.62	0.78	4.1	7.0	8.0	6.5	8.9	**19.2**
CB-11	5.09	991	1322.70	1314.30	0.0356 (A)	0.62	0.78	3.6	6.5	9.9	7.9	11.4	**25.8**
CB-12	5.46	1067	1322.70	1313.46	0.0354 (A)	0.62	0.78	3.6	6.4	10.2	8.2	12.2	**27.3**
CB-13	10.68	1346	1322.70	1312.76	0.0336 (A)	0.62	0.78	3.4	5.8	12.0	9.7	22.5	**48.3**
SUB2/SOUTH CHANNEL	11.38	1519	1321.60	1312.14	0.0334 (A)	0.62	0.78	3.2	5.5	13.7	11.1	22.6	**48.8**
LOT 5	0.30	212	1314.77	1314.10	0.0432 (A)	0.62	0.78	4.5	7.5	6.3	5.2	0.8	**1.8**
LOT 6	0.40	316	1315.12	1314.40	0.0425 (A)	0.62	0.78	3.8	6.7	9.0	7.3	0.9	**2.1**
CB-3A	1.01	326	1321.60	1319.01	0.04 (A)	0.62	0.78	4.7	7.6	5.6	5.0	2.9	**6.0**
CB-3B	2.27	420	1321.60	1318.12	0.0378 (A)	0.62	0.78	4.5	7.5	6.1	5.1	6.3	**13.3**
SUB3/NORTH CHANNEL	2.98	637	1321.60	1318.17	0.037 (A)	0.62	0.78	3.8	6.7	9.1	7.4	7.0	**15.6**
LOT 30	0.34	309	1321.47	1320.80	0.0429 (A)	0.62	0.78	3.8	6.7	9.1	7.3	0.8	**1.8**
LOT 31	0.36	333	1321.57	1320.90	0.0428 (A)	0.62	0.78	3.6	6.5	9.8	7.9	0.8	**1.8**

Reference: Drainage Design Manual for Maricopa County, Hydrology, August 2018.

Notes:

T_c = Time of concentration = $11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38}$ (Equation 3.2, Papadakis and kazan equation, 1987)

L = Length of the longest flow path, miles.

S = Watercourse slope, feet/mile.

K_b = Watershed resistance coefficient = $m\log_{10}A + b$, where A= drainage area in acres, m and b values from (Table 3.1).

Q = Peak discharge = C*I*A, cfs. (Equation 3.1)

i = Average rainfall intensity, in in/hr, lasting for a T_c. Determined using the I-D-F curve from the NOAA Atlas 14 PRECIPITATION FREQUENCY ESTIMATES

C = Runoff coefficient per Undeveloped Desert Rangeland land use category per Table 3.2.

Retention Calculations

The Ritz-Carlton Resort - Parcel C

First Flush Retention Basin Volume Calculations

Retention [1] Sub-Watershed ID	Drainage Area A (ft^2)	Drainage Area A (acres)	Runoff [2] Coefficient C	Precipitation [3] P (inches)	Volume [4] Required V_{req} (acre-ft)	Infrastructure Drainage Area ID[6]	Volume[5] Provided V (acre-ft)	Receiving Underground Detention ID[6]
SUB1	128,751	2.96	0.78	0.50	0.10	OFF-5N	0.09	**UR-3**
SUB2	495,587	11.38	0.78	0.50	0.37	OFF-5S	0.46	**UR-2**
SUB3	129,731	2.98	0.78	0.50	0.10	OFF-5	0.05	**UR-2**
TOTAL	**754,069**	**19.65**			**0.56**		**0.60**	

Reference: Drainage Policies and Standards for Maricopa County, Arizona, Draft January 2013.

Drainage Design Manual for Maricopa County, Arizona, Hydrology, August, 2013.

Design Standards & Policies Manual for City of Scottsdale - June 2014

Ritz Carlton Resort Infrastructure Final Drainage Report by CVL Consultants, Inc. - July, 2017.

Notes:

1. Drainage sub-basin delineated per Plate 1, Drainage Map
2. Estimated 100-year C-Value per Table 3.2, Design Standards & Policies Manual (Land Use: Paved Streets, Desert Landscaping (no imp. Weed barrier))

   Total drainage area C-Value calculated using a weighted average of the contributing areas and C-Values.
3. Estimated 100-year, 2-hour precipitation depth, P= 2.19 inches per NOAA 14 PRECIPITATION FREQUENCY ESTIMATES.

   For first flush basins, P= 0.5 inches.
4. V_{req} = A x C x (P/12) = volume required for retention in acre-ft.
5. Volume provided per LF of 10' diameter pipe = $\pi*(d^2/4)*LF$ where d is the diameter of the pipe.
6. See excerpts of Infrastructure Final Drainage Report prepared by CVL in Appendix A.

The Ritz-Carlton Resort - Parcel C

100-year, 2-hour Temporary Basin Volume Calculations

Retention [1] Sub-Watershed ID	Drainage Area A (ft^2)	Drainage Area A (acres)	Runoff [2] Coefficient C	Precipitation [3] P (inches)	Volume [4] Required V_{req} (ft^3)	Volume [4] Required V_{req} (acre-ft)	Temporary Drainage Basin ID	Volume[5] Provided V (ft^3)	Volume[5] Provided V (acre-ft)
PHASE 2 (SUB3)	129,731	2.98	0.50	2.19	11,838	0.27	R-TEMP	45,273	1.04
TOTAL	**129,731**	**5.32**			**11,838**	**0.27**		**45,273**	**1.04**

Reference: Drainage Policies and Standards for Maricopa County, Arizona, Draft January 2013.

Drainage Design Manual for Maricopa County, Arizona, Hydrology, August, 2013.

Design Standards & Policies Manual for City of Scottsdale - June 2014

Ritz Carlton Resort Infrastructure Final Drainage Report by CVL Consultants, Inc. - July, 2017.

Notes:

1. Drainage sub-basin delineated per Plate 1, Drainage Map
2. 100-year C-Value per Table 3.2, Design Standards & Policies Manual (Land Use: Undeveloped Desert Rangeland)
3. 100-year, 2-hour precipitation depth, P= 2.19 inches per NOAA 14 PRECIPITATION FREQUENCY ESTIMATES.
4. V_{req} = A x C x (P/12) = volume required for retention in acre-ft.
5. Volume provided per grading plan.

Weighted Runoff Calculations

CVL

The Ritz-Carlton Resort - Parcel C

Weighted Runoff Coeffcient Calculations

Type of Land	Area	Area	100-year	A*C	Weighted C Value			
	(ft^2)	(acres)	C Value		2 to 10	25	50	100
Pervious	304,003	6.98	0.50	3.49				
*Impervious	452,752	10.39	0.95	9.87				
Totals	756,755	**17.37**		**13.36**	**0.62**	**0.68**	**0.74**	**0.77**

Notes: See Figure 3 In Drainage Report for Impervious Areas.
100 year C value = Sum A*C / Sum A
25 year C value = (5 to10 year C value)*1.1
50 year C value = (5 to10 year C value)*1.2
100 year C value = (5 to 10 year C value)*1.25
The adjustment factors are extracted from the hydrology drainage manual from Maricopa County, Arizona

* Impervious includes streets, sidewalk, and houses

Refer to Figure 3 for impervious and pervious area exhibit.

APPENDIX C

NOAA Atlas 14 Rainfall Data

CVL

NOAA Atlas 14, Volume 1, Version 5
Location name: Paradise Valley, Arizona, USA*
Latitude: 33.5326°, Longitude: -111.9325°
Elevation: 1313.28 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.186** (0.156-0.228)	**0.243** (0.204-0.298)	**0.331** (0.275-0.403)	**0.397** (0.329-0.482)	**0.487** (0.397-0.589)	**0.556** (0.447-0.668)	**0.627** (0.495-0.752)	**0.700** (0.543-0.837)	**0.796** (0.602-0.954)	**0.870** (0.645-1.04)
10-min	**0.284** (0.237-0.347)	**0.371** (0.311-0.454)	**0.503** (0.419-0.613)	**0.605** (0.500-0.734)	**0.742** (0.604-0.896)	**0.847** (0.681-1.02)	**0.955** (0.754-1.15)	**1.07** (0.827-1.27)	**1.21** (0.916-1.45)	**1.32** (0.981-1.59)
15-min	**0.352** (0.294-0.430)	**0.459** (0.386-0.562)	**0.624** (0.519-0.760)	**0.750** (0.620-0.910)	**0.919** (0.749-1.11)	**1.05** (0.844-1.26)	**1.18** (0.935-1.42)	**1.32** (1.02-1.58)	**1.50** (1.14-1.80)	**1.64** (1.22-1.97)
30-min	**0.473** (0.396-0.579)	**0.619** (0.520-0.757)	**0.840** (0.699-1.02)	**1.01** (0.835-1.23)	**1.24** (1.01-1.50)	**1.41** (1.14-1.70)	**1.60** (1.26-1.91)	**1.78** (1.38-2.13)	**2.02** (1.53-2.42)	**2.21** (1.64-2.65)
60-min	**0.586** (0.490-0.717)	**0.766** (0.643-0.937)	**1.04** (0.865-1.27)	**1.25** (1.03-1.52)	**1.53** (1.25-1.85)	**1.75** (1.41-2.10)	**1.97** (1.56-2.37)	**2.20** (1.71-2.63)	**2.50** (1.89-3.00)	**2.74** (2.03-3.29)
2-hr	**0.680** (0.577-0.814)	**0.881** (0.748-1.06)	**1.18** (0.995-1.41)	**1.40** (1.17-1.67)	**1.71** (1.42-2.03)	**1.95** (1.59-2.30)	**2.19** (1.76-2.59)	**2.44** (1.92-2.88)	**2.77** (2.13-3.27)	**3.03** (2.28-3.60)
3-hr	**0.748** (0.632-0.906)	**0.959** (0.814-1.17)	**1.26** (1.06-1.52)	**1.49** (1.25-1.80)	**1.83** (1.50-2.18)	**2.09** (1.70-2.49)	**2.37** (1.89-2.82)	**2.65** (2.08-3.15)	**3.05** (2.32-3.62)	**3.37** (2.50-4.01)
6-hr	**0.900** (0.777-1.07)	**1.14** (0.985-1.35)	**1.46** (1.25-1.72)	**1.71** (1.46-2.01)	**2.06** (1.73-2.40)	**2.33** (1.93-2.71)	**2.62** (2.13-3.04)	**2.91** (2.33-3.38)	**3.30** (2.58-3.84)	**3.61** (2.75-4.21)
12-hr	**1.00** (0.875-1.17)	**1.27** (1.10-1.48)	**1.61** (1.39-1.87)	**1.87** (1.61-2.17)	**2.23** (1.90-2.58)	**2.50** (2.10-2.89)	**2.78** (2.31-3.21)	**3.07** (2.51-3.54)	**3.45** (2.75-4.01)	**3.75** (2.94-4.38)
24-hr	**1.19** (1.05-1.38)	**1.52** (1.33-1.75)	**1.96** (1.72-2.27)	**2.32** (2.02-2.68)	**2.81** (2.44-3.24)	**3.20** (2.75-3.68)	**3.60** (3.08-4.15)	**4.02** (3.41-4.63)	**4.60** (3.85-5.30)	**5.06** (4.20-5.84)
2-day	**1.29** (1.13-1.48)	**1.65** (1.45-1.90)	**2.16** (1.90-2.49)	**2.58** (2.25-2.96)	**3.15** (2.74-3.62)	**3.61** (3.11-4.14)	**4.10** (3.51-4.70)	**4.60** (3.91-5.28)	**5.31** (4.46-6.10)	**5.87** (4.88-6.77)
3-day	**1.37** (1.20-1.57)	**1.75** (1.54-2.01)	**2.31** (2.02-2.65)	**2.76** (2.40-3.16)	**3.38** (2.94-3.87)	**3.89** (3.35-4.45)	**4.43** (3.79-5.07)	**4.99** (4.24-5.72)	**5.79** (4.86-6.63)	**6.43** (5.34-7.39)
4-day	**1.45** (1.27-1.66)	**1.86** (1.63-2.13)	**2.45** (2.15-2.80)	**2.93** (2.56-3.35)	**3.62** (3.14-4.13)	**4.17** (3.59-4.76)	**4.76** (4.07-5.43)	**5.39** (4.57-6.16)	**6.27** (5.26-7.16)	**6.99** (5.80-8.01)
7-day	**1.63** (1.43-1.87)	**2.08** (1.82-2.39)	**2.76** (2.40-3.17)	**3.30** (2.87-3.79)	**4.08** (3.52-4.67)	**4.70** (4.04-5.37)	**5.36** (4.57-6.14)	**6.07** (5.13-6.96)	**7.07** (5.90-8.10)	**7.87** (6.51-9.04)
10-day	**1.76** (1.54-2.02)	**2.25** (1.98-2.58)	**2.98** (2.60-3.40)	**3.56** (3.10-4.07)	**4.38** (3.80-4.99)	**5.04** (4.34-5.72)	**5.74** (4.91-6.53)	**6.47** (5.50-7.37)	**7.50** (6.29-8.54)	**8.33** (6.92-9.50)
20-day	**2.17** (1.91-2.47)	**2.79** (2.46-3.18)	**3.69** (3.25-4.20)	**4.37** (3.83-4.96)	**5.29** (4.62-6.00)	**6.00** (5.21-6.80)	**6.72** (5.81-7.63)	**7.45** (6.41-8.47)	**8.44** (7.20-9.61)	**9.20** (7.79-10.5)
30-day	**2.54** (2.23-2.89)	**3.27** (2.87-3.72)	**4.31** (3.78-4.90)	**5.11** (4.47-5.79)	**6.17** (5.37-7.00)	**7.00** (6.07-7.92)	**7.84** (6.77-8.87)	**8.70** (7.47-9.83)	**9.86** (8.40-11.2)	**10.7** (9.10-12.2)
45-day	**2.93** (2.59-3.32)	**3.78** (3.33-4.28)	**4.98** (4.39-5.64)	**5.87** (5.17-6.64)	**7.05** (6.18-7.97)	**7.94** (6.93-8.98)	**8.84** (7.68-10.00)	**9.74** (8.43-11.0)	**10.9** (9.39-12.4)	**11.8** (10.1-13.5)
60-day	**3.23** (2.86-3.64)	**4.17** (3.70-4.71)	**5.49** (4.86-6.19)	**6.45** (5.70-7.28)	**7.71** (6.79-8.68)	**8.64** (7.57-9.73)	**9.57** (8.36-10.8)	**10.5** (9.12-11.8)	**11.7** (10.1-13.2)	**12.6** (10.8-14.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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APPENDIX D

Onsite Hydraulic Calculations

CVL

Street Capacity Calculations

CVL

Cross Section for Horseshoe Lane - STA10+66.50 to 15+87.49

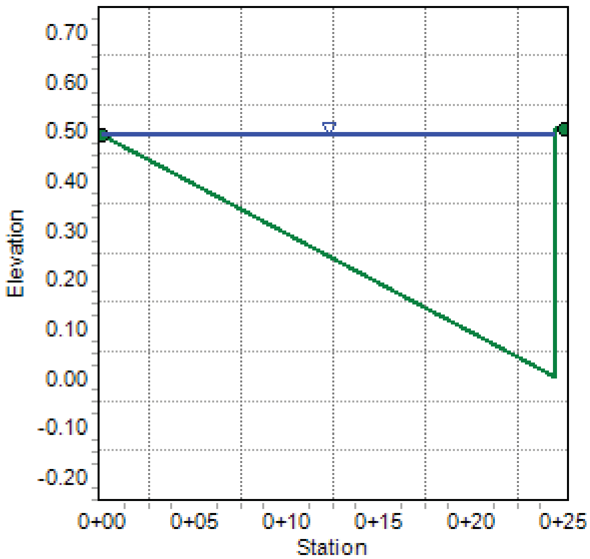
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.0084	ft/ft
Normal Depth	0.49	ft
Discharge	21.1	ft³/s

Cross Section Image



Worksheet for Horseshoe Lane - STA10+66.50 to 15+87.49

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.0084	ft/ft
Normal Depth	0.49	ft
Section Definitions		

Station (ft)	Elevation (ft)
0+00.00	0.49
0+24.50	0.00
0+24.50	0.50
0+25.00	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.00, 0.49)	(0+25.00, 0.50)	0.015

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge	21.1	ft³/s
Elevation Range	0.00 to 0.50 ft	
Flow Area	6.00	ft²
Wetted Perimeter	24.99	ft
Hydraulic Radius	0.24	ft
Top Width	24.50	ft
Normal Depth	0.49	ft
Critical Depth	0.53	ft
Critical Slope	0.00516	ft/ft
Velocity	3.51	ft/s
Velocity Head	0.19	ft
Specific Energy	0.68	ft
Froude Number	1.25	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.49	ft
Critical Depth	0.53	ft
Channel Slope	0.0084	ft/ft
Critical Slope	0.00516	ft/ft

Cross Section for Horseshoe Lane - 15+87.49 to CB-1 & CB-2

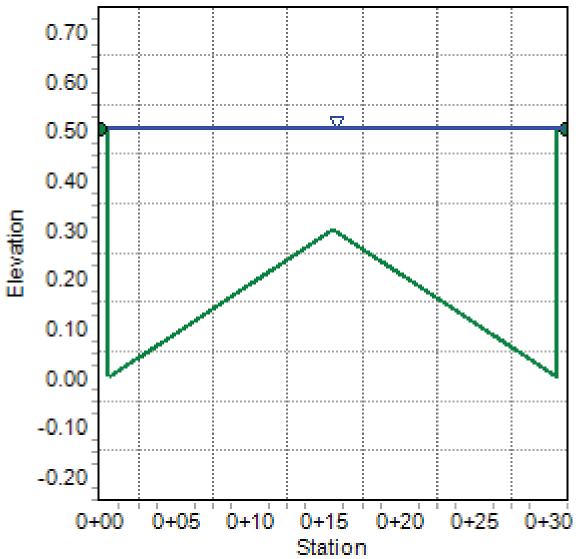
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.0075	ft/ft
Normal Depth	0.50	ft
Discharge	43.8	ft³/s

Cross Section Image



Worksheet for Horseshoe Lane - 15+87.49 to CB-1 & CB-2

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.0075	ft/ft
Normal Depth	0.50	ft

Section Definitions

Station (ft)	Elevation (ft)
0+00.00	0.50
0+00.50	0.50
0+00.50	0.00
0+15.50	0.30
0+30.50	0.00
0+30.50	0.50
0+31.00	0.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.00, 0.50)	(0+31.00, 0.50)	0.015

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge	43.8	ft³/s
Elevation Range	0.00 to 0.50 ft	
Flow Area	10.50	ft²
Wetted Perimeter	31.01	ft
Hydraulic Radius	0.34	ft
Top Width	30.00	ft
Normal Depth	0.50	ft
Critical Depth	0.56	ft
Critical Slope	0.00468	ft/ft
Velocity	4.17	ft/s
Velocity Head	0.27	ft

Cross Section for Local Street - Inverted w/ Ribbon Curb

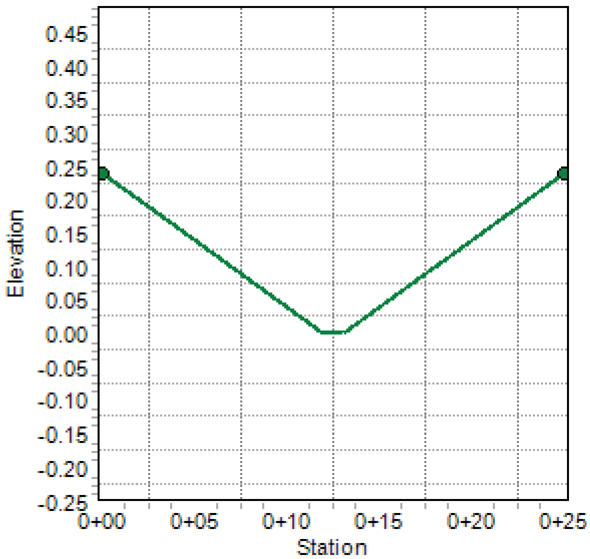
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.0157	ft/ft
Normal Depth	0.24	ft
Discharge	9.7	ft³/s

Cross Section Image



Rating Table for Local Street - Inverted w/ Ribbon Curb

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.0157	ft/ft
Normal Depth	0.24	ft

Section Definitions

Station (ft)	Elevation (ft)
0+00.00	0.24
0+12.00	0.00
0+13.00	0.00
0+25.00	0.24

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.00, 0.24)	(0+25.00, 0.24)	0.015

Channel Slope (ft/ft)	Discharge (ft³/s)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.0030	4.2	1.35	3.12	25.00	25.00
0.0032	4.4	1.40	3.12	25.00	25.00
0.0034	4.5	1.44	3.12	25.00	25.00
0.0036	4.6	1.48	3.12	25.00	25.00
0.0038	4.8	1.52	3.12	25.00	25.00
0.0040	4.9	1.56	3.12	25.00	25.00
0.0042	5.0	1.60	3.12	25.00	25.00
0.0044	5.1	1.64	3.12	25.00	25.00
0.0046	5.2	1.68	3.12	25.00	25.00
0.0048	5.3	1.71	3.12	25.00	25.00
0.0050	5.5	1.75	3.12	25.00	25.00
0.0052	5.6	1.78	3.12	25.00	25.00
0.0054	5.7	1.82	3.12	25.00	25.00
0.0056	5.8	1.85	3.12	25.00	25.00
0.0058	5.9	1.88	3.12	25.00	25.00

Rating Table for Local Street - Inverted w/ Ribbon Curb

Input Data

Channel Slope (ft/ft)	Discharge (ft^3/s)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
0.0060	6.0	1.92	3.12	25.00	25.00
0.0062	6.1	1.95	3.12	25.00	25.00
0.0064	6.2	1.98	3.12	25.00	25.00
0.0066	6.3	2.01	3.12	25.00	25.00
0.0068	6.4	2.04	3.12	25.00	25.00
0.0070	6.5	2.07	3.12	25.00	25.00
0.0072	6.5	2.10	3.12	25.00	25.00
0.0074	6.6	2.13	3.12	25.00	25.00
0.0076	6.7	2.16	3.12	25.00	25.00
0.0078	6.8	2.18	3.12	25.00	25.00
0.0080	6.9	2.21	3.12	25.00	25.00
0.0082	7.0	2.24	3.12	25.00	25.00
0.0084	7.1	2.27	3.12	25.00	25.00
0.0086	7.2	2.29	3.12	25.00	25.00
0.0088	7.2	2.32	3.12	25.00	25.00
0.0090	7.3	2.35	3.12	25.00	25.00
0.0092	7.4	2.37	3.12	25.00	25.00
0.0094	7.5	2.40	3.12	25.00	25.00
0.0096	7.6	2.42	3.12	25.00	25.00
0.0098	7.6	2.45	3.12	25.00	25.00
0.0100	7.7	2.47	3.12	25.00	25.00
0.0102	7.8	2.50	3.12	25.00	25.00
0.0104	7.9	2.52	3.12	25.00	25.00
0.0106	7.9	2.55	3.12	25.00	25.00
0.0108	8.0	2.57	3.12	25.00	25.00
0.0110	8.1	2.59	3.12	25.00	25.00

Cross Section for Section X-X_Bella Vista Street Capacity at CB-8

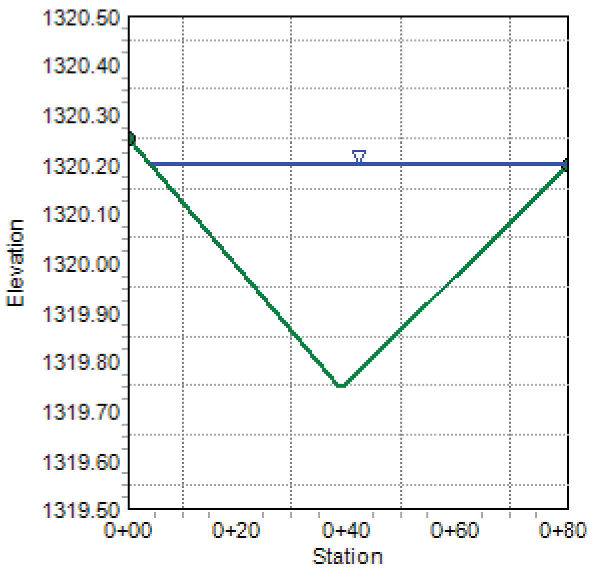
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.0030	ft/ft
Normal Depth	0.45	ft
Discharge	33.2	ft³/s

Cross Section Image



Worksheet for Section X-X_Bella Vista Street Capacity at CB-8

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.0030	ft/ft
Normal Depth	0.45	ft
Section Definitions		

Station (ft)	Elevation (ft)
0+00.00	1320.25
0+38.60	1319.75
0+39.60	1319.75
0+80.70	1320.20

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.00, 1320.25)	(0+80.70, 1320.20)	0.016

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge	33.2	ft³/s
Elevation Range	1319.75 to 1320.25 ft	
Flow Area	17.51	ft²
Wetted Perimeter	76.85	ft
Hydraulic Radius	0.23	ft
Top Width	76.84	ft
Normal Depth	0.45	ft
Critical Depth	0.39	ft
Critical Slope	0.00640	ft/ft
Velocity	1.90	ft/s
Velocity Head	0.06	ft
Specific Energy	0.51	ft
Froude Number	0.70	
Flow Type	Subcritical	

Worksheet for Section X-X_Bella Vista Street Capacity at CB-8

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.45	ft
Critical Depth	0.39	ft
Channel Slope	0.0030	ft/ft
Critical Slope	0.00640	ft/ft

Catch Basin Calculations

CVL

Worksheet for CB-1 & CB-2_Curb Inlet on Grade

Project Description

Solve For	Efficiency

Input Data

Discharge	7.6	cfs
Slope	0.00750	ft/ft
Gutter Width	1.42	ft
Gutter Cross Slope	0.12	ft/ft
Road Cross Slope	0.02	ft/ft
Roughness Coefficient	0.015	
Curb Opening Length	12.8	ft
Local Depression	2.00	in
Local Depression Width	1.42	ft

Results

Efficiency	90.25	%
Intercepted Flow	6.9	ft^3/s
Bypass Flow	0.7	ft^3/s
Spread	15.34	ft
Depth	0.45	ft
Flow Area	2.45	ft^2
Gutter Depression	0.14	ft
Total Depression	0.31	ft
Velocity	3.10	ft/s
Equivalent Cross Slope	0.08526	ft/ft
Length Factor	0.73	
Total Interception Length	17.64	ft

Messages

Notes

Curb opening length to be constructed is 16' length (10' wing + 3' box + 3' wing).
Curb opening length of 12.8' used in calculation is for a 1.25 reduction factor.

Worksheet for CB3A_Ditch Inlet On Grade

Project Description

Solve For	Efficiency

Input Data

Roughness Coefficient	0.016	
Slope	0.00500	ft/ft
Left Side Slope	2.00	%
Right Side Slope	2.00	%
Bottom Width	1.00	ft
Discharge	6.0	ft³/s
Grate Width	1.75	in
Grate Length	20.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	83.74	%
Intercepted Flow	5.0	ft³/s
Bypass Flow	1.0	ft³/s
Flow Area	3.52	ft²
Wetted Perimeter	26.54	ft
Top Width	26.54	ft
Velocity	1.71	ft/s
Splash Over Velocity	33.20	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.84	
Grate Flow Ratio	0.01	
Active Grate Length	10.00	ft
Critical Depth	0.24	ft
Critical Slope	0.00751	ft/ft
Froude Number	0.83	
Flow Type	Subcritical	
Specific Energy	0.30	ft
Velocity Head	0.05	ft
Depth	0.26	ft

Messages

Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).

Worksheet for CB3B_Ditch Inlet In Sag

Project Description

Solve For	Spread

Input Data

Discharge	8.3	ft³/s
Left Side Slope	2.00	%
Right Side Slope	2.00	%
Bottom Width	1.00	ft
Grate Width	1.75	in
Grate Length	30.00	ft
Local Depression	0.00	in
Local Depression Width	0.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Results

Spread	62.53	ft
Depth	0.62	ft
Wetted Perimeter	62.54	ft
Top Width	62.53	ft
Open Grate Area	1.97	ft²
Active Grate Weir Length	60.15	ft

Messages

Notes

Maximum ponding depth of 0.91'; calculated from low point of 1308.12 at center of cul-de-sac to back-of-curb low-point of 1319.03.

Worksheet for CB4_Ditch Inlet On Grade

Project Description

Solve For	Efficiency

Input Data

Roughness Coefficient	0.016	
Slope	0.00400	ft/ft
Left Side Slope	2.00	%
Right Side Slope	2.00	%
Bottom Width	1.00	ft
Discharge	4.9	ft³/s
Grate Width	1.75	in
Grate Length	20.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	86.76	%
Intercepted Flow	4.3	ft³/s
Bypass Flow	0.6	ft³/s
Flow Area	3.28	ft²
Wetted Perimeter	25.65	ft
Top Width	25.65	ft
Velocity	1.49	ft/s
Splash Over Velocity	33.20	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.87	
Grate Flow Ratio	0.01	
Active Grate Length	10.00	ft
Critical Depth	0.22	ft
Critical Slope	0.00771	ft/ft
Froude Number	0.74	
Flow Type	Subcritical	
Specific Energy	0.28	ft
Velocity Head	0.03	ft
Depth	0.25	ft

Messages

Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).

Worksheet for CB5_Ditch Inlet On Grade

Project Description

Solve For	Efficiency

Input Data

Roughness Coefficient	0.016	
Slope	0.00400	ft/ft
Left Side Slope	2.00	%
Right Side Slope	2.00	%
Bottom Width	1.00	ft
Discharge	4.9	ft³/s
Grate Width	1.75	in
Grate Length	20.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	86.76	%
Intercepted Flow	4.3	ft³/s
Bypass Flow	0.6	ft³/s
Flow Area	3.28	ft²
Wetted Perimeter	25.65	ft
Top Width	25.65	ft
Velocity	1.49	ft/s
Splash Over Velocity	33.20	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.87	
Grate Flow Ratio	0.01	
Active Grate Length	10.00	ft
Critical Depth	0.22	ft
Critical Slope	0.00771	ft/ft
Froude Number	0.74	
Flow Type	Subcritical	
Specific Energy	0.28	ft
Velocity Head	0.03	ft
Depth	0.25	ft

Messages

Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).

Worksheet for CB6_Ditch Inlet On Grade

Project Description

Solve For	Efficiency

Input Data

Roughness Coefficient	0.016	
Slope	0.00460	ft/ft
Left Side Slope	2.00	%
Right Side Slope	2.00	%
Bottom Width	1.00	ft
Discharge	5.2	ft³/s
Grate Width	1.75	in
Grate Length	20.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	85.31	%
Intercepted Flow	4.4	ft³/s
Bypass Flow	0.8	ft³/s
Flow Area	3.26	ft²
Wetted Perimeter	25.55	ft
Top Width	25.55	ft
Velocity	1.60	ft/s
Splash Over Velocity	33.20	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.85	
Grate Flow Ratio	0.01	
Active Grate Length	10.00	ft
Critical Depth	0.22	ft
Critical Slope	0.00765	ft/ft
Froude Number	0.79	
Flow Type	Subcritical	
Specific Energy	0.29	ft
Velocity Head	0.04	ft
Depth	0.25	ft

Messages

Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).

Worksheet for CB7_Ditch Inlet On Grade

Project Description

Solve For	Efficiency

Input Data

Roughness Coefficient	0.016	
Slope	0.01570	ft/ft
Left Side Slope	2.00	%
Right Side Slope	2.00	%
Bottom Width	1.00	ft
Discharge	5.7	ft³/s
Grate Width	1.75	in
Grate Length	30.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	86.09	%
Intercepted Flow	4.9	ft³/s
Bypass Flow	0.8	ft³/s
Flow Area	2.20	ft²
Wetted Perimeter	21.00	ft
Top Width	21.00	ft
Velocity	2.59	ft/s
Splash Over Velocity	104.25	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.86	
Grate Flow Ratio	0.01	
Active Grate Length	15.00	ft
Critical Depth	0.23	ft
Critical Slope	0.00756	ft/ft
Froude Number	1.41	
Flow Type	Supercritical	
Specific Energy	0.30	ft
Velocity Head	0.10	ft
Depth	0.20	ft

Messages

Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).

Worksheet for CB8_Ditch Inlet On Grade

Project Description

Solve For	Efficiency

Input Data

Roughness Coefficient	0.016	
Slope	0.00300	ft/ft
Left Side Slope	1.25	%
Right Side Slope	1.09	%
Bottom Width	1.00	ft
Discharge	7.7	ft³/s
Grate Width	1.75	in
Grate Length	20.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	89.17	%
Intercepted Flow	6.9	ft³/s
Bypass Flow	0.8	ft³/s
Flow Area	5.88	ft²
Wetted Perimeter	44.94	ft
Top Width	44.94	ft
Velocity	1.31	ft/s
Splash Over Velocity	33.20	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.89	
Grate Flow Ratio	0.01	
Active Grate Length	10.00	ft
Critical Depth	0.21	ft
Critical Slope	0.00780	ft/ft
Froude Number	0.64	
Flow Type	Subcritical	
Specific Energy	0.28	ft
Velocity Head	0.03	ft
Depth	0.26	ft

Messages

Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).

Worksheet for CB9_Ditch Inlet On Grade

Project Description

Solve For	Efficiency	

Input Data

Roughness Coefficient	0.016	
Slope	0.00790	ft/ft
Left Side Slope	2.00	%
Right Side Slope	2.00	%
Bottom Width	1.00	ft
Discharge	6.9	ft³/s
Grate Width	1.75	in
Grate Length	20.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Options

Grate Flow Option	Exclude None	

Results

Efficiency	78.05	%
Intercepted Flow	5.4	ft³/s
Bypass Flow	1.5	ft³/s
Flow Area	3.29	ft²
Wetted Perimeter	25.67	ft
Top Width	25.67	ft
Velocity	2.10	ft/s
Splash Over Velocity	33.20	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.78	
Grate Flow Ratio	0.01	
Active Grate Length	10.00	ft
Critical Depth	0.25	ft
Critical Slope	0.00737	ft/ft
Froude Number	1.03	
Flow Type	Supercritical	
Specific Energy	0.32	ft
Velocity Head	0.07	ft
Depth	0.25	ft

Messages

Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).

Worksheet for CB10_Ditch Inlet On Grade

Project Description

Solve For	Efficiency	

Input Data

Roughness Coefficient	0.016	
Slope	0.00790	ft/ft
Left Side Slope	2.00	%
Right Side Slope	2.00	%
Bottom Width	1.00	ft
Discharge	6.9	ft³/s
Grate Width	1.75	in
Grate Length	20.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Options

Grate Flow Option	Exclude None	

Results

Efficiency	78.05	%
Intercepted Flow	5.4	ft³/s
Bypass Flow	1.5	ft³/s
Flow Area	3.29	ft²
Wetted Perimeter	25.67	ft
Top Width	25.67	ft
Velocity	2.10	ft/s
Splash Over Velocity	33.20	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.78	
Grate Flow Ratio	0.01	
Active Grate Length	10.00	ft
Critical Depth	0.25	ft
Critical Slope	0.00737	ft/ft
Froude Number	1.03	
Flow Type	Supercritical	
Specific Energy	0.32	ft
Velocity Head	0.07	ft
Depth	0.25	ft

Messages

Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).

Worksheet for CB11_Ditch Inlet On Grade

Project Description

Solve For	Efficiency

Input Data

Roughness Coefficient	0.016	
Slope	0.01100	ft/ft
Left Side Slope	2.00	%
Right Side Slope	2.00	%
Bottom Width	1.00	ft
Discharge	8.1	ft³/s
Grate Width	1.75	in
Grate Length	20.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	72.59	%
Intercepted Flow	5.9	ft³/s
Bypass Flow	2.2	ft³/s
Flow Area	3.28	ft²
Wetted Perimeter	25.62	ft
Top Width	25.62	ft
Velocity	2.47	ft/s
Splash Over Velocity	33.20	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.72	
Grate Flow Ratio	0.01	
Active Grate Length	10.00	ft
Critical Depth	0.27	ft
Critical Slope	0.00721	ft/ft
Froude Number	1.22	
Flow Type	Supercritical	
Specific Energy	0.34	ft
Velocity Head	0.09	ft
Depth	0.25	ft

Messages

Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).

Worksheet for CB12_Ditch Inlet On Grade

Project Description

Solve For	Efficiency

Input Data

Roughness Coefficient	0.016	
Slope	0.01000	ft/ft
Left Side Slope	2.00	%
Right Side Slope	2.00	%
Bottom Width	1.00	ft
Discharge	3.7	ft³/s
Grate Width	1.75	in
Grate Length	20.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Options

Grate Flow Option	Exclude None

Results

Efficiency	80.08	%
Intercepted Flow	3.0	ft³/s
Bypass Flow	0.7	ft³/s
Flow Area	1.88	ft²
Wetted Perimeter	19.44	ft
Top Width	19.44	ft
Velocity	1.96	ft/s
Splash Over Velocity	33.20	ft/s
Frontal Flow Factor	1.00	
Side Flow Factor	0.80	
Grate Flow Ratio	0.01	
Active Grate Length	10.00	ft
Critical Depth	0.19	ft
Critical Slope	0.00801	ft/ft
Froude Number	1.11	
Flow Type	Supercritical	
Specific Energy	0.24	ft
Velocity Head	0.06	ft
Depth	0.18	ft

Messages

Messages	Grate Length should be within the defined range of HEC-22's Chart 5 (approx. 0.5-4.5 ft / 0.15-1.35 m).

Worksheet for CB-13_Ditch Inlet In Sag

Project Description

Solve For	Spread	

Input Data

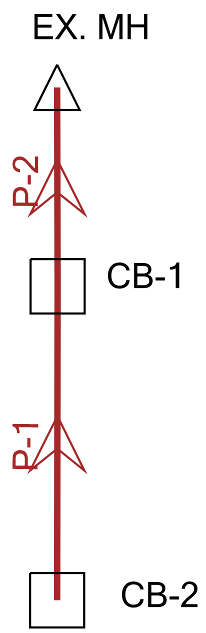
Discharge	3.8	ft³/s
Left Side Slope	2.00	%
Right Side Slope	2.00	%
Bottom Width	1.00	ft
Grate Width	1.75	in
Grate Length	20.00	ft
Local Depression	1.00	in
Local Depression Width	1.00	ft
Grate Type	P-50 mm (P-1-7/8")	
Clogging	50.00	%

Results

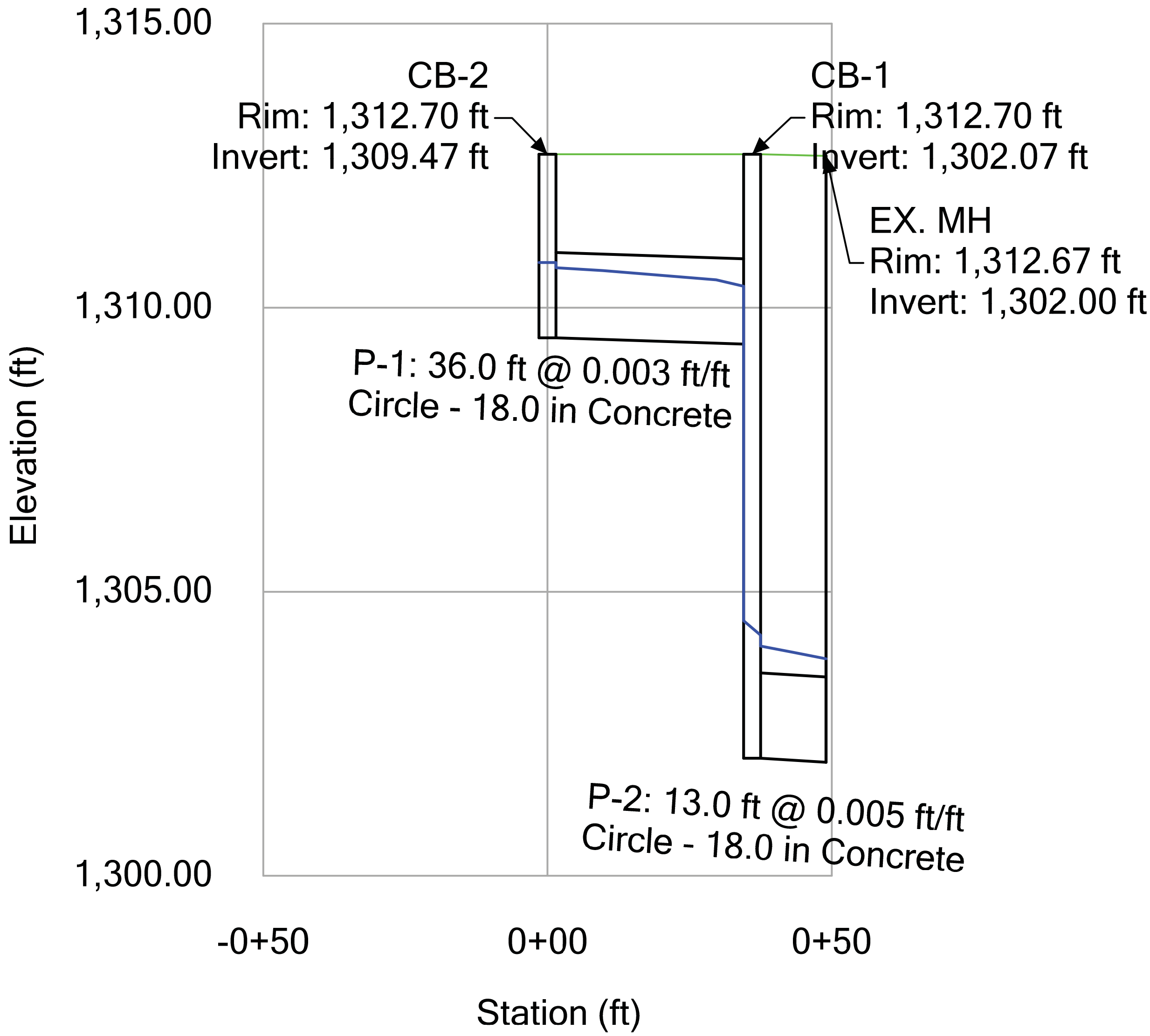
Spread	21.69	ft
Depth	0.21	ft
Wetted Perimeter	21.69	ft
Top Width	21.69	ft
Open Grate Area	1.31	ft²
Active Grate Weir Length	40.15	ft

Stormdrain Pipe Calculations

Scenario: Base



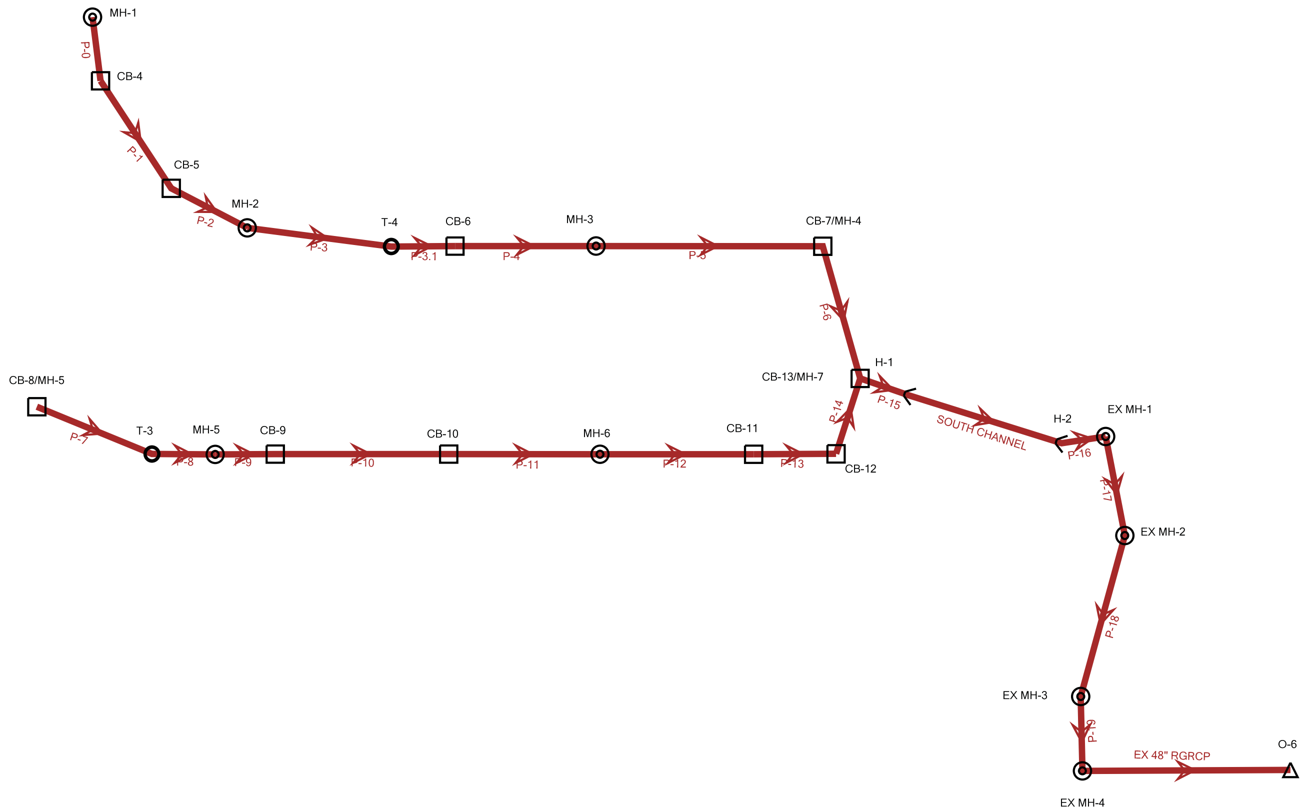
Profile Report
Engineering Profile - Profile - 1 (SUB1 System.stsw)



FlexTable: Conduit Table

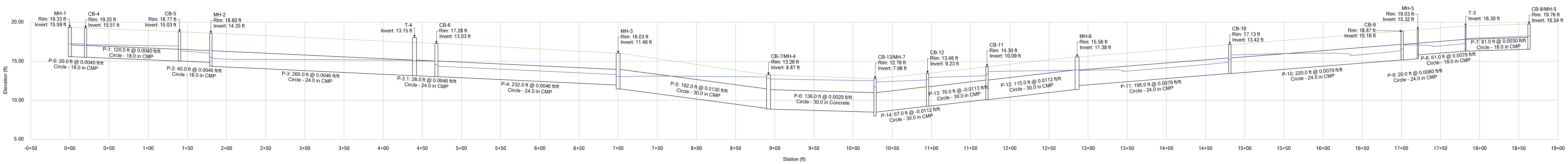
Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (User Defined) (ft)	Slope (Calculated) (ft/ft)	Section Type	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Capacity (Full Flow) (cfs)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
P-1	CB-2	1,309.47	CB-1	1,309.36	36.0	0.003		18.0	0.013	6.90	4.93	5.81	1,310.70	1,310.38
P-2	CB-1	1,302.07	EX. MH	1,302.00	13.0	0.005		18.0	0.013	13.80	7.81	7.71	1,304.04	1,303.82

Scenario: Base

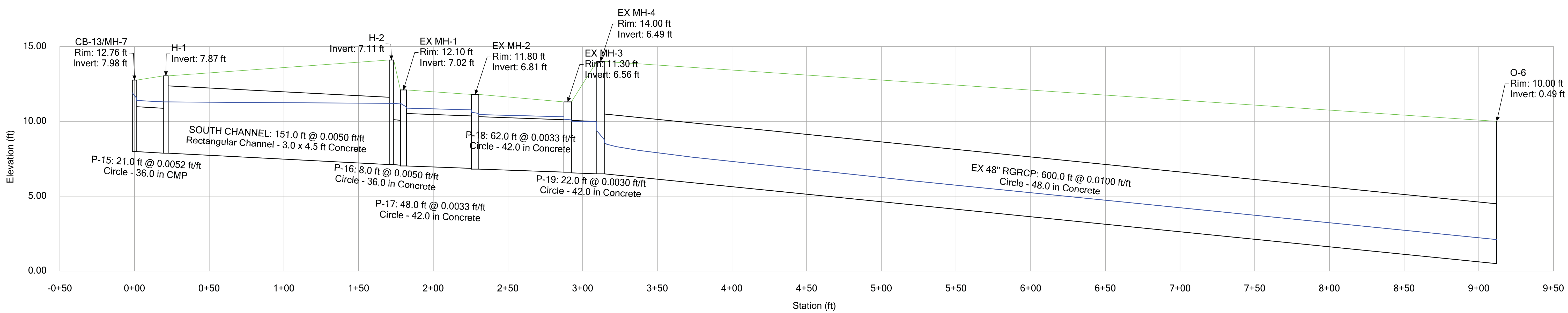


Profile Report

Engineering Profile - Profile - 1 (SUB2 System.stsw)



Profile Report
Engineering Profile - Profile - 2 (SUB2 System.stsw)



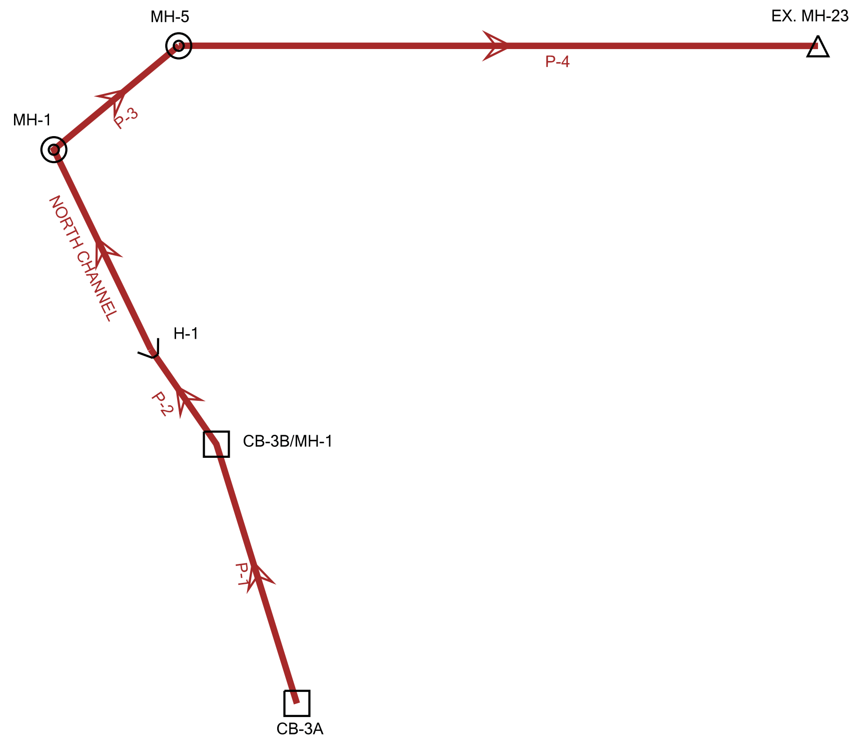
FlexTable: Conduit Table

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (User Defined) (ft)	Slope (Calculated) (ft/ft)	Section Type	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Capacity (Full Flow) (cfs)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
P-1	CB-4	15.51	CB-5	15.03	120.0	0.0040		18.0	0.012	4.30	2.43	7.20	17.12	16.95
P-2	CB-5	15.03	MH-2	14.85	40.0	0.0046		18.0	0.012	8.60	5.64	7.72	16.33	15.98
P-13	CB-12	9.23	CB-11	10.09	76.0	-0.0113		30.0	0.012	23.60	4.81	47.27	13.14	12.93
P-9	MH-5	15.32	CB-9	15.16	20.0	0.0080		24.0	0.012	6.90	2.28	21.92	17.10	17.09
P-10	CB-9	15.16	CB-10	13.42	220.0	0.0079		24.0	0.012	12.30	4.91	21.79	16.42	15.80
P-11	CB-10	13.42	MH-6	11.88	195.0	0.0079		24.0	0.012	17.70	6.31	21.78	14.94	13.81
P-4	CB-6	13.03	MH-3	11.96	232.0	0.0046		24.0	0.012	13.00	5.94	16.64	14.36	13.26
P-0	MH-1	15.59	CB-4	15.51	20.0	0.0040		18.0	0.012	0.00	0.00	7.20	17.23	17.23
P-14	CB-13/MH-7	8.48	CB-12	9.23	67.0	-0.0112		30.0	0.012	26.60	5.42	47.01	12.59	12.35
P-5	MH-3	11.46	CB-7/MH-4	8.97	192.0	0.0130		30.0	0.012	13.00	3.35	50.60	13.01	12.99
P-6	CB-7/MH-4	8.87	CB-13/MH-7	8.48	136.0	0.0029		30.0	0.012	17.90	3.65	23.79	12.72	12.50
P-15	CB-13/MH-7	7.98	H-1	7.87	21.0	0.0052		36.0	0.012	48.30	6.83	52.29	11.39	11.30
SOUTH CHANNEL	H-1	7.87	H-2	7.11	151.0	0.0050			0.013	48.30	4.31	118.41	11.30	11.20
P-16	H-2	7.11	EX MH-1	7.07	8.0	0.0050		36.0	0.013	48.80	6.90	47.16	11.20	11.16
P-7	CB-8/MH-5	16.54	T-3	16.30	81.0	0.0030		18.0	0.012	6.90	3.90	6.19	18.22	17.92

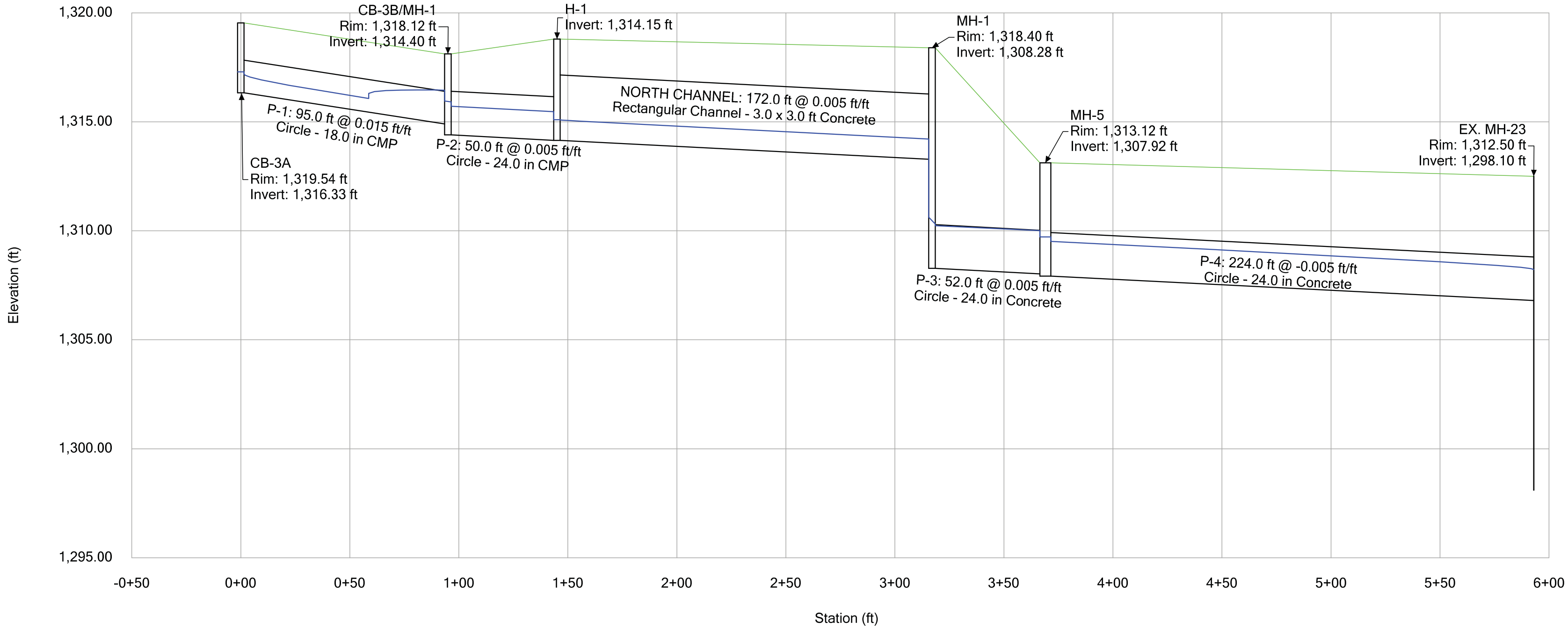
FlexTable: Conduit Table

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (User Defined) (ft)	Slope (Calculated) (ft/ft)	Section Type	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Capacity (Full Flow) (cfs)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
P-8	T-3	16.30	MH-5	15.82	61.0	0.0079		18.0	0.012	6.90	4.93	10.09	17.32	17.05
P-12	MH-6	11.38	CB-11	10.09	115.0	0.0112		30.0	0.012	17.70	3.61	47.06	13.87	13.68
P-3	MH-2	14.35	T-4	13.15	260.0	0.0046		24.0	0.012	8.60	3.96	16.59	15.39	15.12
P-3.1	T-4	13.15	CB-6	13.03	28.0	0.0046		24.0	0.012	8.60	2.77	16.63	15.04	15.01
P-17	EX MH-1	7.02	EX MH-2	6.86	48.0	0.0033		42.0	0.013	48.80	5.07	58.08	10.88	10.77
P-18	EX MH-2	6.81	EX MH-3	6.61	62.0	0.0033		42.0	0.013	48.80	5.07	57.85	10.45	10.30
P-19	EX MH-3	6.56	EX MH-4	6.49	22.0	0.0030		42.0	0.013	48.80	5.08	54.68	10.01	9.97
EX 48" RGRCP	EX MH-4	6.49	O-6	0.49	600.0	0.0100		48.0	0.013	48.80	8.83	143.64	8.58	2.10

Scenario: Base



Profile Report
Engineering Profile - Profile - 1 (SUB3 System.stsw)



FlexTable: Conduit Table

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (User Defined) (ft)	Slope (Calculated) (ft/ft)	Section Type	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Capacity (Full Flow) (cfs)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
NORTH CHANNEL	H-1	1,314.15	MH-1	1,313.28	172.0	0.005			0.013	15.60	5.56	73.16	1,315.09	1,314.21
P-3	MH-1	1,308.28	MH-5	1,308.02	52.0	0.005		24.0	0.013	15.60	4.98	16.00	1,310.23	1,310.01
P-4	EX. MH-23	1,306.80	MH-5	1,307.92	224.0	-0.005		24.0	0.013	15.60	6.16	16.00	1,309.52	1,308.22
P-1	CB-3A	1,316.33	CB-3B/MH-1	1,314.90	95.0	0.015		18.0	0.012	5.00	3.80	13.96	1,317.19	1,316.45
P-2	CB-3B/MH-1	1,314.40	H-1	1,314.15	50.0	0.005		24.0	0.012	13.30	6.08	17.33	1,315.71	1,315.46

Channel Calculations

CVL

Cross Section for North Channel

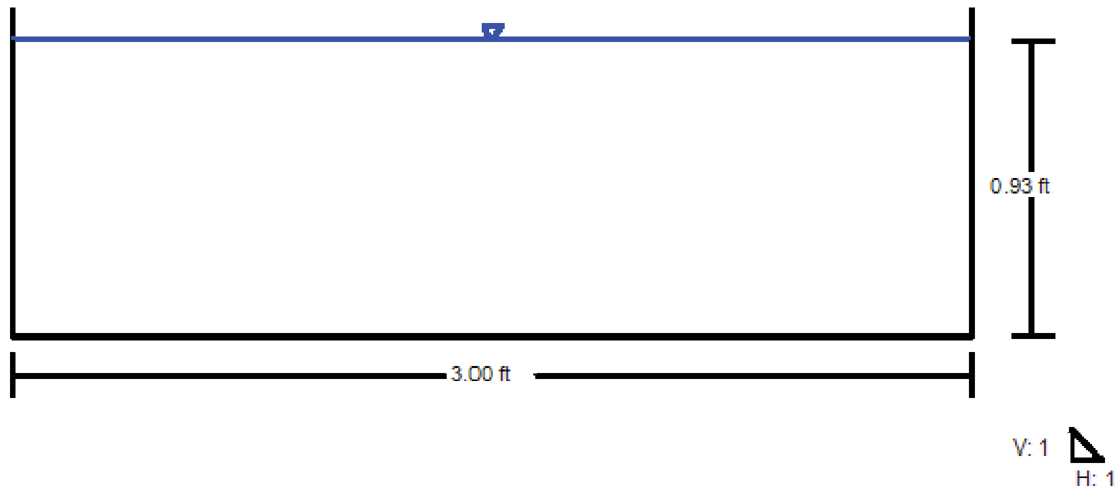
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00500	ft/ft
Normal Depth	0.93	ft
Bottom Width	3.00	ft
Discharge	15.60	ft³/s

Cross Section Image



Worksheet for North Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00500	ft/ft
Bottom Width	3.00	ft
Discharge	15.60	ft³/s

Results

Normal Depth	0.93	ft
Flow Area	2.79	ft²
Wetted Perimeter	4.86	ft
Hydraulic Radius	0.57	ft
Top Width	3.00	ft
Critical Depth	0.94	ft
Critical Slope	0.00481	ft/ft
Velocity	5.59	ft/s
Velocity Head	0.48	ft
Specific Energy	1.42	ft
Froude Number	1.02	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.93	ft
Critical Depth	0.94	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.00481	ft/ft

Cross Section for South Channel

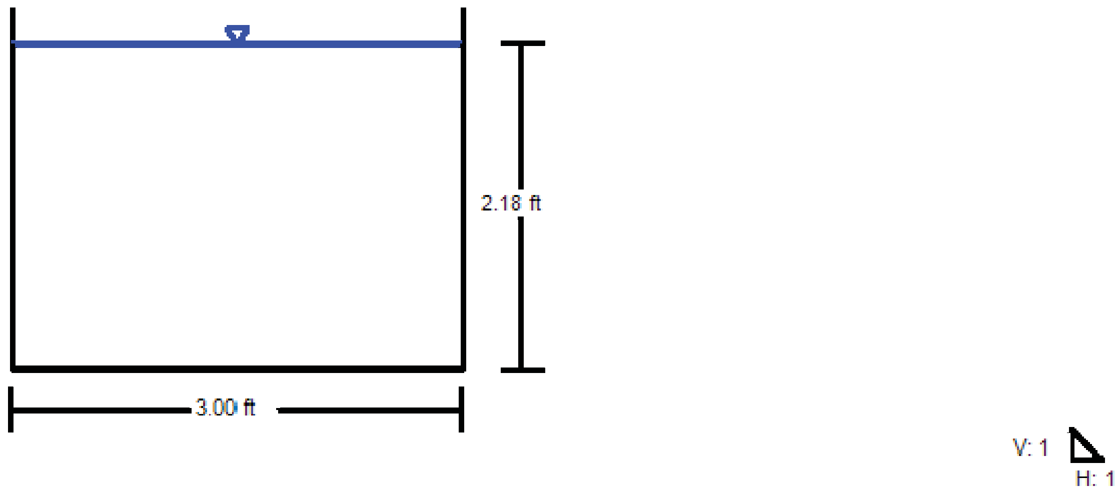
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00500	ft/ft
Normal Depth	2.18	ft
Bottom Width	3.00	ft
Discharge	48.80	ft³/s

Cross Section Image



Worksheet for South Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00500	ft/ft
Bottom Width	3.00	ft
Discharge	48.80	ft³/s

Results

Normal Depth	2.18	ft
Flow Area	6.53	ft²
Wetted Perimeter	7.36	ft
Hydraulic Radius	0.89	ft
Top Width	3.00	ft
Critical Depth	2.02	ft
Critical Slope	0.00607	ft/ft
Velocity	7.47	ft/s
Velocity Head	0.87	ft
Specific Energy	3.04	ft
Froude Number	0.89	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

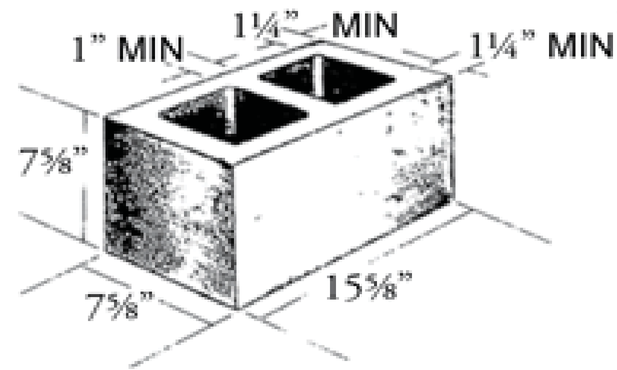
Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.18	ft
Critical Depth	2.02	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.00607	ft/ft

Turn Block Opening Calculations

Ritz Carlton - Parcel C

Summary of Intercepted Overflow Calculations

Location ID	Peak [1] Flow Q_{100} (cfs)	Height to [2] Center of Opening d_0 (ft)	Clogging Factor Cg	Orifice Coefficient C_0	Turn Block Opening Dimensions: Opening Height h (ft)	Turn Block Opening Dimensions: Opening Width L (ft)	Gravity g (ft/s^2)	Flow Capacity of Single Turned Block Qi [3] (cfs)	Turned Blocks [4] Needed to Pass Q_{100} (#)
LOT 5	1.8	0.35	0.50	0.67	0.43	1.01	32.2	0.69	3
LOT 6	2.1	0.35	0.50	0.67	0.43	1.01	32.2	0.69	3
LOT 30	1.8	0.35	0.50	0.67	0.43	1.01	32.2	0.69	3
LOT 31	1.8	0.35	0.50	0.67	0.43	1.01	32.2	0.69	3



For Design: For block dimensions, use standard 8"X8"X16" concrete block.
Actual Dimensions: 7-5/8" x 7-5/8" x 15-5/8"
Opening Dimensions: 6-1/16" x 5-1/8"

Notes:

1) See Appendix B for Off-site Peak Flow Calculations.
2) Ponding depth of 8-inches at wall assumed.
3) $\mathbf{Qi = C_g[C_0 hL(2gd_o)^{0.5}]}$ (Orifice Flow Equation 3.14, FCDMC Volume II, Hydraulics)

Where:

Qi = Amount of flow intercepted by One Turned Block, cfs.
C_0 = Orifice coefficient. 0.67 per FCDMC Equation 3.14
g = Gravity, 32.2 ft/s^2
d_0 = Ponding depth
L=Length of opening
Cg = Clogging factor=50% A Safety Clogging Factor was incorporated into formula.

4) Turned Blocks Needed = Q_{100} / Q_i

APPENDIX E

CONTECH Slotted Drain™ & UltraFlo® Pipe

CVL

Efficiently Remove Surface Water

Contech Slotted Drain is a practical, aesthetically pleasing inlet for the efficient removal of surface water on streets and highways. It also is widely used in parking lots and other similar locations, where it removes sheet flow without complex multiple grades or water channeling devices like asphalt dikes, berms and curbs.

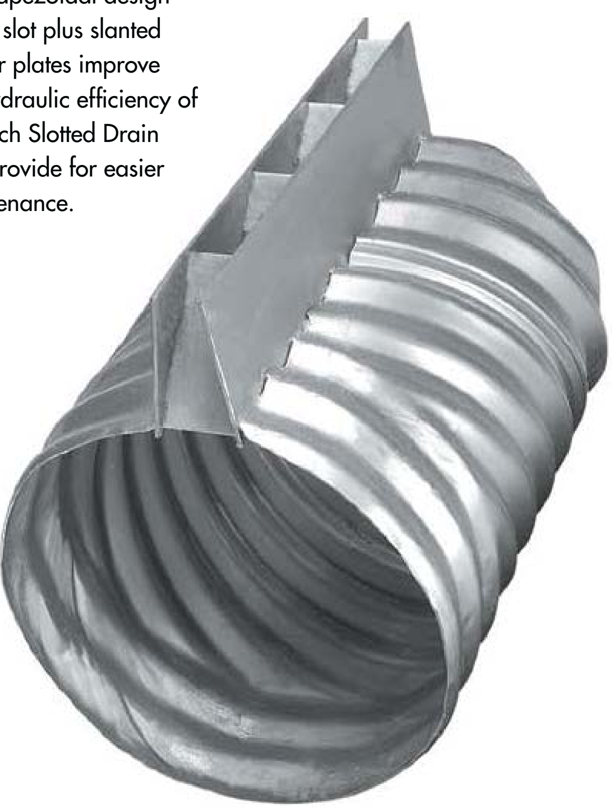
Slotted Drain is fabricated from Contech Corrugated Steel Pipe. The pipe is cut along a longitudinal axis, and a trapezoidal or straight-sided grate with reinforcing spacer plates is welded in place to form a 1 3/4-inch-wide slot opening. The slot collects runoff and channels it to the pipe below, from which it flows to the appropriate outlet.

Slotted Drain is fabricated at plants throughout the United States, allowing fast delivery no matter where your project is located.

Contech Slotted Drain has a variety of applications for removal of surface water

- Curb inlets
- Inlet system across driveway cuts
- Shoulder drains along median barriers
- Pedestrian thoroughfares, malls and bicycle paths
- Replacements for curbs and berms where those obstacles are undesirable for safety reasons
- Ground-level floors with drainage requirements
- Parking lots or other continuous paved surfaces
- Sidelines of playing fields in stadiums
- Airport aprons, taxiways, hangars, and deicing areas
- Railroad intermodel facilities with heavy wheel loads

The trapezoidal design of the slot plus slanted spacer plates improve the hydraulic efficiency of Contech Slotted Drain and provide for easier maintenance.



Parallel side grate is typically available and is used in variable-height grate applications. For variable-height grate information, see Pages 4 and 9.

Contech Slotted Drain Is Proven Superior To Other Drain Systems

Long, successful history

Contech Slotted Drain has been used at countless locations throughout the United States for more than 40 years… simply because it is the most effective solution to water removal problems.

Improved drainage efficiency

The grate on a standard 20-foot length of Slotted Drain will intercept up to 50% more runoff than most standard 2′ x 2′ grate inlets.* With solid cross plate spacers tipped at 30°, runoff is directed into the open slot for more efficient interception. (The hydraulic information on Page 7 will help determine the lengths of Slotted Drain needed to meet your hydraulic requirements.)

Structurally sound

Contech Slotted Drain is constructed of thick grate and thick spacer plates to resist deformation under heavy traffic loads and thermal expansion. The design has been tested using truck loading parallel and perpendicular to the slot.

The grate height of six inches is the most widely used height for standard AASHTO H 20 loading.

Better safety

Because Slotted Drain can be installed so that it extends only two inches from the curb, hazardous dips and ponding in grade are eliminated. Slotted Drain also minimizes hazards to two-wheel vehicles.

Fewer debris problems

FHWA testing on straight-sided grate has shown its efficiency to resist clogging to range from 73% to 86%. Slotted Drain will retain its effectiveness even when a localized blockage occurs in one area. Under similar conditions, a conventional drain would be severely restricted. Debris is less likely to block Slotted Drain's trapezoidal grate. Anything large enough to fit through the top of the slot opening will fall harmlessly through to the bottom of the drain.

Easier to maintain

There are no hardware or heavy grates to remove, and there are no protrusions that can be damaged with snow plows. It is cleaned by flushing with water from hoses.

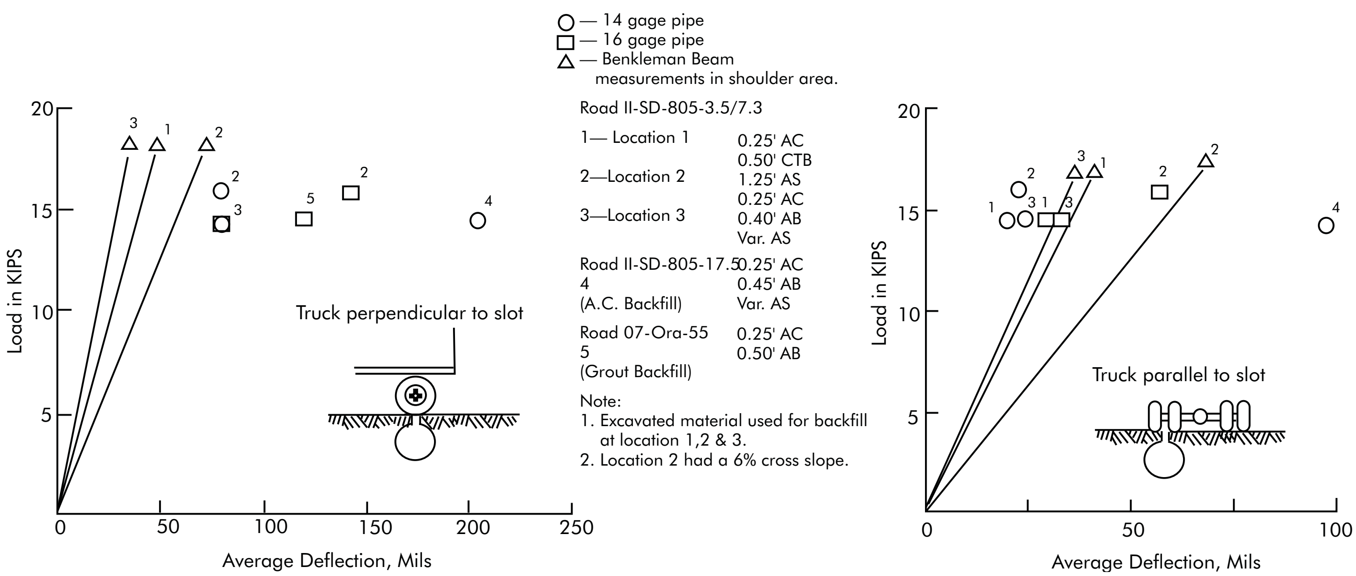
No unusual freezing

When freezing occurs, slotted drain will handle ice, snow and runoff equally as well as any conventional drainage system.

Easier to install

Field experience indicates that the installation of Slotted Drain is much easier than the installation of conventional catch basin systems.

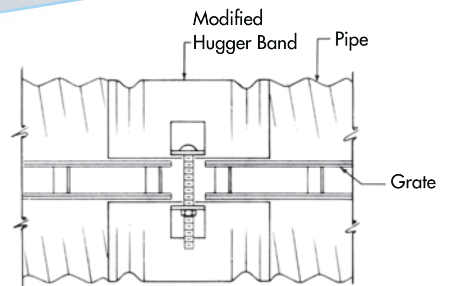
**Source: Figure 15, Hydraulic Engineering Circular No. 12, U.S. Department of Transportation, March 1984. This document is available from the National Technical Information Service, Springfield, VA 22161.*



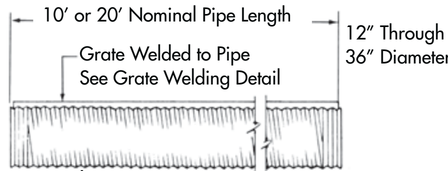
Product Details

Pipe

Slotted Drain made from Contech Corrugated Steel Pipe with HUGGER® Bands meets applicable portions of AASHTO Designation M36 and ASTM A760. Pipe is fabricated from galvanized steel for excellent durability, or from ALUMINIZED STEEL™ Type 2 when more corrosion resistance is required. Slotted Drain is available in 12-inch through 36-inch diameter HEL-COR® pipe and in 14-gage and 16-gage. Thirty and thirty-six inch diameter pipe is also available in 12-gage. Slotted Drain may also be provided in 18-inch through 36-inch diameter ULTRA FLO® pipe, and in 15-inch diameter with limited availability.



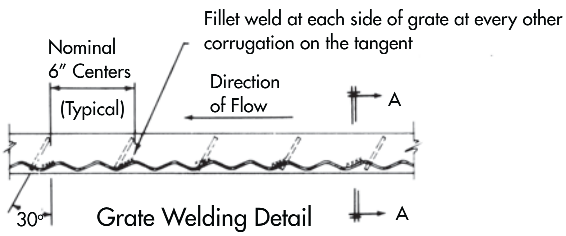
Modified Hugger Band—Top View



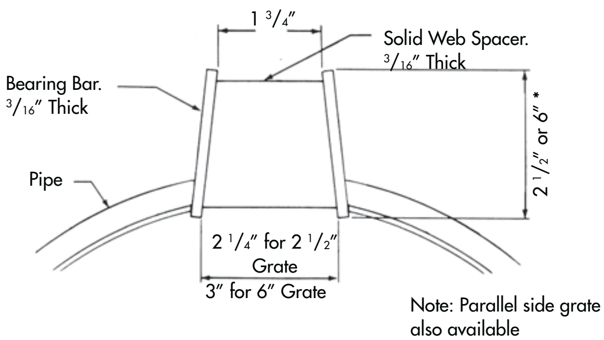
Typical Pipe Section

Grate

The Slotted Drain concept was developed in the early 1960s in California. From the beginning, a need for certain structural requirements was recognized in the grating design and in its attachment to the pipe wall. The Contech grating system and design is the result of many years of experience and is still widely used on State of California Department of Transportation projects.



Grate Welding Detail



Section A-A — Standard Grate Detail

Joints and couplers

Standard 20-foot lengths of Slotted Drain normally are joined with a modified version of the HUGGER Band. Because the grate is extended to within one inch of the end of the pipe (to provide a fully continuous slot), the band is trimmed back to accommodate the grating at the joint. A single band bolt is provided for band tensioning.

An alternate jointing system is the use of closure plates. The closure plate jointing system helps align the grates and gives a more finished appearance as desired in some applications.

Heel guard

When Slotted Drain is installed in areas of heavy pedestrian traffic, expanded wire mesh can be specified for installation across the top of the drain opening. This helps prevent shoe heels from being caught in the open slot. Standard, galvanized, expanded metal mesh (1/2″ x #13) is welded directly to the grating at the plant. As an alternative, paint wide, bright yellow warning stripes on the pavement adjacent to each side of the slot.

Fittings

A complete line of standard corrugated steel pipe fittings is available to simplify installation of slotted drain under many conditions: on a curve, through a change in elevation or through a change in pipe diameter.

Fittings include 90-degree tees, wyes and elbows with annular ends for attachment of the HUGGER Band; stubs, special junctions, angle/tee combinations and special end caps. These fittings do not have a grate.

Pipe diameters can be changed with a plate reducer.

Variable-height grate

Variable-height grates* (straight-sided grate only) can be supplied for installation on flat grades. Generally, the grade built into variable-height grates is a maximum of 1%. Ask your Contech Sales Engineer.

Tolerances (20-foot length)

The design engineer should be able to work with the manufacturing tolerances of vertical bow ± 3/8 inch, horizontal bow ± 5/8 inch and twist ± 1/2 inch on a 6-inch grate. On special requirements, the engineer should call the local Contech Sales Engineer.

**Heights up to 31 inches are available in special straight-sided grates. Call your Contech Sales Engineer for details.*

Contech Slotted Drain is a versatile and cost effective solution for surface water removal on many sites.

Wide Range of Applications

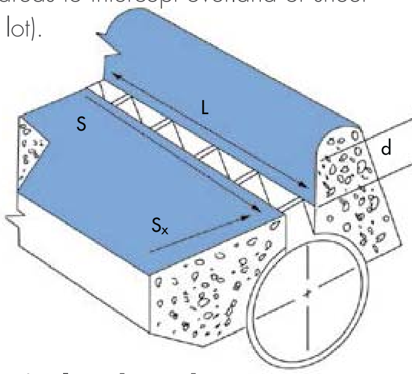
About 3,900 feet of 12-inch HEL-COR®, 16-gage Slotted Drain in the Indianapolis, Indiana, area allows water to drain between the lane barrier and the shoulder. Replacing curbs and drain basins with continuous lengths of Slotted Drain opens up an obstruction-free and single grade roadside that greatly enhances the effectiveness of the shoulder to improve the safety on the highway.

Slotted Drain is widely used in parking areas and driveways, where its ability to provide efficient drainage, without the need for hazardous dips in pavement, is a safety asset.

Grate Inlet Hydraulic FHWA Test

Slotted Drain can be used to intercept runoff in any one of the following ways:

1. Installed in a typical curb-and-gutter as a slot-on-grade to intercept flow from streets and highways.
2. Installed in a typical curb-and-gutter at a sag or low point in a grade to accommodate carryover from preceding slots on a grade and to intercept surface runoff sloped to the gutter.
3. Installed in wide, flat areas to intercept overland or sheet flow (as on a parking lot).

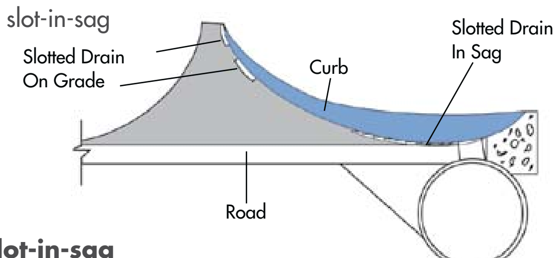


1. Slot-on-grade in typical curb-and-gutter

For any given flow into an inlet, Q, cross slope, S_x, and longitudinal gutter slope, S, the required Slotted Drain length can be determined from the nomograph (Figure A) on Page 7.

It is common practice in curb-and-gutter drainage design to carry over up to 35% of the total flow at an upstream inlet, Q, to other inlets downstream. See Figure B on Page 7 for the carryover efficiency curve. Q_i is the capacity of the grate to intercept and discharge the runoff into the CSP below it. Any bypass flow, Q_b, will flow overtop of the inlet and continue down the gutter to be intercepted by another slot-on-grade or a slot-in-sag. Because of the larger diameter pipe typically used, i.e., 15" and 18", Contech Slotted Drain has a much larger system capacity than the competitors' systems.

Typical cross section of combination slot-on-grade and a slot-in-sag



2. Slot-in-sag

When Slotted Drain is installed in a sag or at a low point in grade, the length of the slot is calculated from the formula:

$$L_r = \frac{1.4Q}{\sqrt{d}}$$

Normally a safety factor of two is used in a sag. $L_s = 2 \times L_r$.

3. Overland sheet flow

Slotted Drain is used effectively to intercept runoff from wide, flat areas such as parking lots, highway medians—even tennis courts and airport taxiways. In these installations, the drain is placed transverse to the direction of flow, so that the open slot acts as a weir intercepting all of the flow uniformly along the entire length of the drain. The water is not collected and channeled against a berm (curb), as required by slot-on-grade installations.

Slotted Drain has been tested for overland flow (sheet flow). These results are published in Report No. FHWA-RD-79-106 by the Federal Highway Administration.

The test system was designed to supply at least 0.025 cfs per foot, which corresponds to a rainstorm of 15 inches per hour over a 72-foot-wide roadway (six lanes).

At the design discharge of 0.025 cfs per foot, the total flow fell through the slot as a weir flow. The tests included flows up to 0.040 cfs per foot of slot.

Slopes ranged from a longitudinal slope of 9% and a Ƶ of 16, to a longitudinal slope of 0.5% and a Ƶ of 48.

The water ranged in depth from 0.38 inches to 0.56 inches. Velocity ranged from 1.263 ft/sec to 0.857 ft/sec.

Even at the maximum discharge of 0.04 cfs per foot and maximum slopes, nearly all the flow passed through the slot. Only some water hitting the spacer plates and splashing over was not intercepted.

Using:

$$Q = CIA, \text{ then } A = \frac{Q}{CI}$$

Where:

Q given as 0.04 ft^3/sec/ft of slotted drain

C = 0.80 to 0.95 for asphalt pavement

After the engineer selects C and I (ft/sec), A can be calculated. Since Q is per foot of slot, A is ft^2/ft of slot. Since the units for A can be reduced to feet, the value of A is also the distance parallel to the flow intercepted by one foot of slot.

Example:

C = 0.85

I = 10 in./hr or 0.0002315 ft/sec

$$A = \frac{0.04 \text{ ft}^3/\text{sec/ft}}{0.85 \times 0.0002315 \text{ ft/sec}}$$

A = 203.3 ft^2/ft

Therefore, at the selected C and I, one foot of slot will intercept flow from 203.3 linear feet upstream of the slot.

Figure A: Nomograph—Slotted Drain on Grade in Curb-and-Gutter

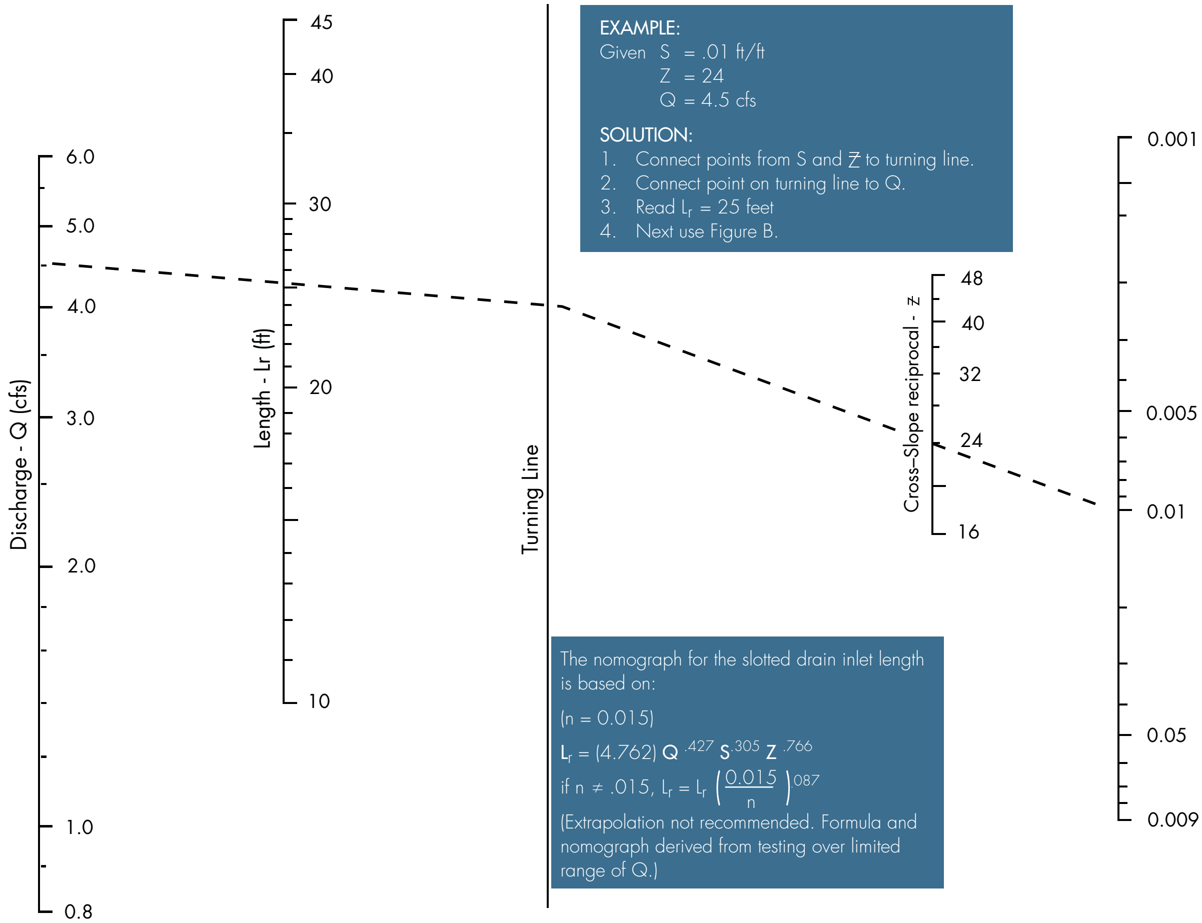
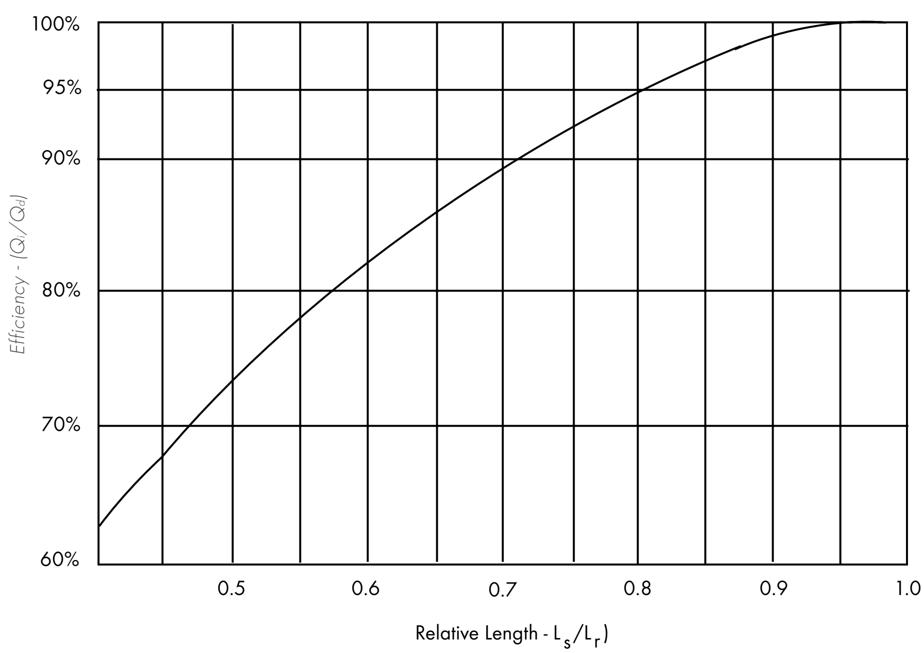


Figure B: Slotted Drain Carryover Efficiency



Definitions

- S — Longitudinal gutter or channel slope, ft/ft
- S_x — Transverse slope, ft/ft
- Z — Transverse slope reciprocal
- d — Depth of flow over the slot, ft
- L_r — Length of slot required for total interception, ft
- L_s — Selected length of slot, ft
- Q — Total flow into inlet, cfs
- Q_i — Intercepted flow at inlet, cfs
- Q_b — Bypass flow, cfs
- C — Runoff coefficient
- I — Rainfall intensity, ft/sec
- A — Area drained, ft²/ft

Example: Solution from Figure A is L_r = 25 feet. If a standard 20-foot length is used, relative length ratio L_s/L_r = 20 ft/ 25 ft = 0.8. From Figure B with a relative length ratio of 0.8, the efficiency is 95%; therefore, the intercepted flow at the inlet, Q_i = 0.94 x 4.5 cfs = 4.23 cfs. This flow is intercepted by the 20-foot length, and the remaining bypass flow runs down the gutter to be intercepted by the next slot. The bypass flow of 0.06 x 4.5 cfs = 0.27 cfs must be added to the flow downstream of the slot in this example to be intercepted by another slot or drainage structure (fixture), such as a slot-in-sag inlet.

Installation

Contech Slotted Drain's primary advantages are its economical design and ease of installation. Unlike typical parking lots that require grades to be sloped in four directions for each storm collection grate, a parking lot with slotted drain requires only one transverse and one longitudinal slope for the entire drainage area. That translates to a lower-cost installation for the contractor and owner; and less stake-out for the engineer. Because of slotted drain's efficiency in removing surface water, fewer collectors and laterals under the roadway are needed.

When properly installed, Slotted Drain provides a better-looking, more efficient drainage system at a lower cost. Photographs illustrate the basic steps for installing slotted drain as a curb inlet. The procedure is basically the same in other applications.

Experience has shown the best method for installing Slotted Drain is to place it in a contoured trench, level it to grade, backfill with high slump concrete, then pave with the desired surfacing material. The pipe must be placed so the slanted spacer plates are facing upstream, leaning against the direction of surface flow.

In long runs, construction joints should be placed perpendicular to the pipe runs.

Modified HUGGER Bands or the closure plate jointing system is used to join adjacent pipes.

Your Contech Sales Engineer can discuss various installation techniques with you.

Leveling to grade

Contractors have developed many methods for positioning Slotted Drain in the trench prior to the backfilling.

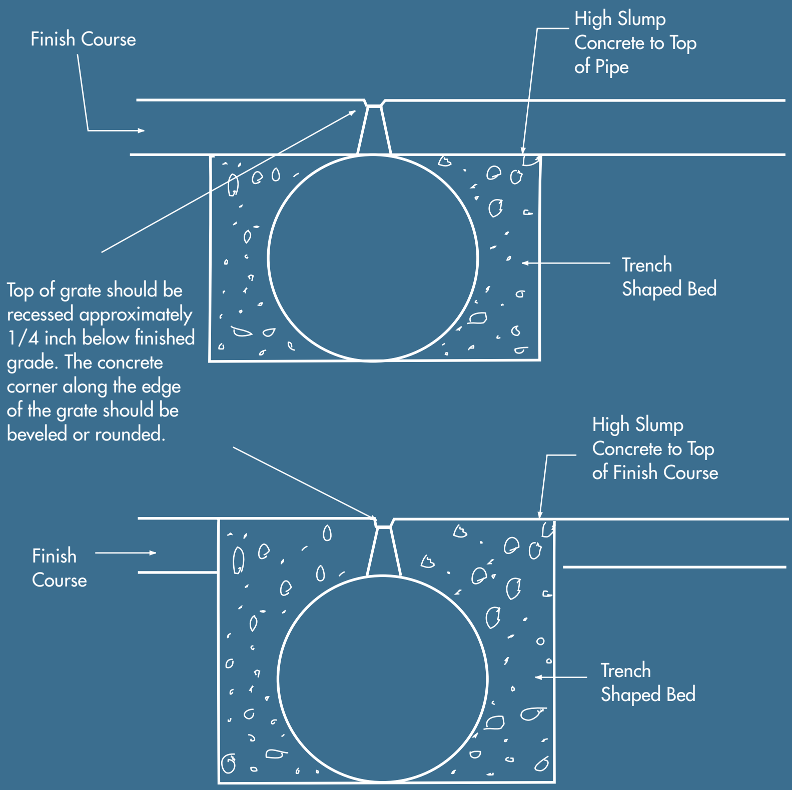
One popular method is to use positioning devices fastened through the slotted opening with a toggle bolt or similar device.

Another method involves leveling the pipe with granular material at selected points along the drain pipe. The remaining area is backfilled with high slump concrete.

Anchoring devices may be required to avoid flotation during the backfill process.

Grate extensions

Grate extensions are available if the height needs to be raised at a future time.



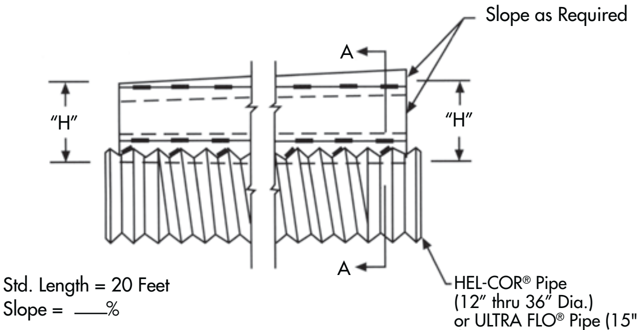
Recommended installation practices. For installation aids, call your local Contech Sales Engineer

High slump concrete

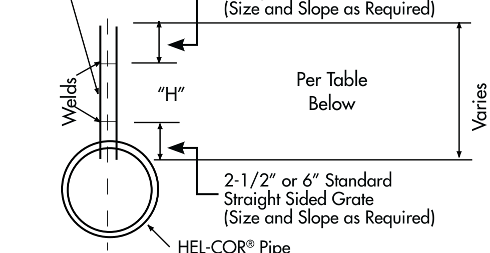
After the Slotted Drain has been leveled to grade, it is important that a high slump concrete or lean grout (minimum 750 psi compressive strength) be used as backfill. The high slump concrete helps ensure a uniform foundation and side support and transfers the live load to the surrounding earth. In non-live load areas, A-1-a AASHTO M145 backfill or cement stabilized sand is sufficient.

Surfacing

Once the Slotted Drain is backfilled with high slump concrete, cover the slotted opening before surfacing and leave it covered until the paving operation is complete. Duct tape, metal strips or lumber can be used to cover the slot.



Side View



Section A-A

Loading Condition	**Standard Maximum Extender Height—"H"**
<H10 * Granular Backfill	8"
H20/H25 * 750 PSI Concrete	19"
Airport ** 1000 PSI Concrete	12"

** 125 PSI Tire Pressure*
*** 195 PSI Tire Pressure*

Slotted Drain Specification

1.0 General

1.1 This specification covers Slotted Drain used for removal of water as shown on the plans.

1.2 The corrugated steel pipe used in the Slotted Drain shall meet the requirements of AASHTO M36/ASTM A 760. The CSP shall be made of ALUMINIZED STEEL Type 2 (AASHTO M274). The diameter and gage shall be as shown on the plans.

2. Connections

2.1 The CSP shall have a minimum of two rerolled annular ends.

2.2 The Slotted Drain bands shall be modified HUGGER Bands to secure the pipe and prevent infiltration

of backfill.

.3 When the Slotted Drain is banded together, the adjacent grates shall have a maximum 3-inch gap.

3. Grates

3.1 The grates shall be manufactured from ASTM A 1011, Grade 36 or ASTM A 36 steel. The spacers and side plates shall be $^{3}/_{16}$-inch material ±0.008 inches. The plate extenders are minimum 7 gage and made from ASTM A 761 or the above materials.

3.2 The spacer plates shall be on 6-inch centers and welded on both sides to each bearing plate (sides) with four 1 $^{1}/_{4}$-inch-long $^{3}/_{16}$-inch fillet welds on each side of the bearing plate.

3.3 The engineer may call for tensile strength test on the grate if the grate is not in compliance with 3.1 and 3.2. If tensile strength tests are called for, minimum results for an in-place spacer plate pulled perpendicular to the bearing plate shall be:

T = 12,000 pounds for 2 $^{1}/_{2}$-inch grate

T = 15,000 pounds for 6-inch grate

3.4 The grates shall be trapezoidal with a 1 $^{3}/_{4}$-inch opening in the top and 30° slanted spacer plates unless shown otherwise on the plans. The grate shall be 2 $^{1}/_{2}$ inches high or 6 inches high as shown on the plans.

Note

For Slotted Drain installations with other than 2 $^{1}/_{2}$" or 6" standard grate, i.e. variable height and for all special loading conditions, contact your Contech Sales Engineer.

4. Galvanizing

4.1 The grate shall be galvanized in accordance with ASTM A 123 except with a 2-ounce galvanized coating.

5. Grate Attached to CSP

5.1 The grate shall be fillet welded a minimum 1-inch long to the CSP on each side of the grate at every other corrugation.

6. Tolerances—Finished Slotted Drain Grates—20-foot Lengths

6.1 Vertical bow is ± $^{3}/_{8}$ inch.

6.2 Horizontal bow is ± $^{5}/_{8}$ inch.

6.3 Twist is ± $^{1}/_{2}$ inch.

Connecticut I-84 Hartford/Boston Corridor.

Corrugated Steel Pipe—Manning's "n" Value

	All Diameters	Helical* Corrugation								
		1-1/2″ x 1/4″		Helical—2-2/3″ x 1/2″						
2-2/3″ x 1/2″	Annular	8 in.	10 in.	12 in.	15 in.	18 in.	24 in.	36 in.	48 in.	60 in. and Larger
Unpaved	0.024	0.012	0.014	0.011	0.012	0.013	0.015	0.018	0.020	0.021
PAVED-INVERT	0.021						0.014	0.017	0.020	0.019
SMOOTH-FLO	0.012						0.012	0.012	0.012	0.012
HEL-COR CL	0.012						0.012	0.012	0.012	0.012
SmoothCor	N/A					0.012	0.012	0.012	0.012	0.012

		Helical*—3″ x 1″							
3″ x 1″	Annular	36 in.	42 in.	48 in.	54 in.	60 in.	66 in.	72 in.	78 in. and Larger
Unpaved	0.027	0.022	0.022	0.023	0.023	0.024	0.025	0.026	0.027
PAVED-INVERT	0.023	0.019	0.019	0.020	0.020	0.021	0.022	0.022	0.023
SMOOTH-FLO	0.012			0.012	0.012	0.012	0.012	0.012	0.012
HEL-COR CL	0.012				0.012	0.012	0.012	0.012	0.012
SmoothCor	N/A			0.012	0.012	0.012	0.012	0.012	0.012

		Helical*—5″ x 1″					
5″ x 1″		48 in.	54 in.	60 in.	66 in.	72 in.	78 in. and Larger
Unpaved	0.025	0.022	0.022	0.023	0.024	0.024	0.025
PAVED-INVERT	0.022	0.019	0.019	0.020	0.021	0.021	0.022
SMOOTH-FLO	0.012			0.012	0.012	0.012	0.012
HEL-COR CL	0.012			0.012	0.012	0.012	0.012

ULTRA-FLO		3/4″ x 3/4″ x 7-1/2″ All diameters n = 0.012

*Tests on helically corrugated pipe demonstrate a lower coefficient of roughness than for annually corrugated steel pipe. Pipe-arches approximately have the same roughness characteristics as their equivalent round pipes.

PLATE

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