Town of Florence

1st Street Improvements

Drainage Report

April 26, 2017

Prepared for:

Town of Florence, Arizona

Prepared by:

Wilson & Company, Inc.,
Engineers & Architects

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX

1. Introduction

1.1 Authorization

The Town of Florence authorized Wilson & Company, Inc., Engineers & Architects (Wilson & Company) to prepare a drainage report for the roadway improvements project along 1st St from Don Mattingly Way (Main Street) to Hwy 79 (Pinal Parkway Ave.).

1.2 Study Area Location

The primary area of focus for this study is a region bounded by 1st St and Ruggles St from north to south and Main Street to Hwy 79 from east to west. Refer to Figure 1 (Location Map) for the location of the site.

1.3 Purpose and Goals

The purpose of this drainage report is to recommend improvements for the proposed 1st St Reconstruction. The primary goals of this report are as follows:

- Identify drainage patterns and flooding issues through research of existing documents, field visits with local agency personnel, and hydrologic analysis.
- Quantify Runoff (Hydrology) for the existing and proposed conditions throughout the watershed for the 10-year and 100-year events to provide a basis for analyzing existing facilities.
- Recommend a Drainage Solution to convey runoff without adverse impact to the traveling public.
- Obtain Approvals and Implement a Design with the Town of Florence personnel to form a drainage solution and complete a final design for construction.

Figure 1: Location Map

WILSON
&COMPANY

2. Hydrology

2.1 Methodology

2.1.1 Drainage Basin Delineation

Resources used to define sub-basins included topographic survey conducted by Wilson & Company and associated Digital Elevation Model's (DEM). The existing drainage basins were delineated through the analysis of existing storm drain infrastructure, as well as determining roadway runoffs from the placement of curb and gutter and roadway crowns.

2.1.2 Hydrological Method

Hydrologic procedures presented in the *Drainage Design Manual for Maricopa County, Arizona* and the *Drainage Policies and Standards for Maricopa County, Arizona* were used to calculate peak flow rates. Although Florence is located in Pinal County, in discussions with Town Staff, it was agreed to use Maricopa County standards as the basis for this drainage report. The Rational Method was the selected hydrological method. The Rational Method utilizes runoff coefficients, rainfall intensities and area to determine peak flow rates. In accordance with the *Drainage Manual*, the time of concentration was calculated to select the appropriate storm intensities that would be applied to the Rational Method equation. The Rational Method Equation used is described as the following:

$$Q = CiA$$

Where:

Q = the peak discharge, in cfs, from a given area

C = a coefficient relating the runoff to rainfall

i = average rainfall intensity, in inches/hour, lasting for a T_c

T_c = the time of concentration, in hours

A = drainage area, in acres

1st St is a minor collector/local street, so according to Table 6.7 found in the *Drainage Policies and Standards,* the project area is designed with peak frequencies consisting of a 10-year storm event with flow depths not to exceed the curb height and a 100-year storm event with the maximum depth for the vehicular travel lane not to exceed 8 inches.

The Bentley FlowMaster computer program was utilized to complete the analysis on the grass-lined ditches, allowable flow rates along 1st St, the sidewalk scupper and storm drain capacities. This software reviewed the existing conditions and was analyzed for the proposed improvements.

2.2 Hydrological Characteristics

2.2.1 Precipitation

The National Oceanographic and Atmospheric Administration's (NOAA) Precipitation Frequency Data Server (PFDS) was used to obtain precipitation depths for various storm frequencies over the study area. Precipitation depths are based on NOAA Atlas 14, Volume 1, Version 5 found in Appendix A. The PFDS requires a location to be entered and Google Earth was used to obtain the site location in latitude and longitude. The location entered into the PFDS is latitude 33.0311 N and longitude 111.3942 W. Precipitation intensities (inches/hr) for various durations were found for the 2-, 5-, 10-, 25-, 50-, and 100-yr average recurrence intervals. Table 1 below lists the precipitation intensities used to determine the rainfall distribution.

Table 1: NOAA Precipitation Intensities (in/hr)

Duration	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
5-min	2.51	4.44	5.30	6.50	7.40	8.33
10-min	1.91	3.37	4.04	4.94	5.63	6.34
15-min	1.58	2.79	3.34	4.09	4.66	5.24
30-min	1.06	1.88	2.25	2.75	3.14	3.53
1-hr	0.658	1.16	1.39	1.70	1.94	2.18
2-hr	0.376	0.650	0.772	0.940	1.07	1.20
3-hr	0.271	0.455	0.540	0.660	0.754	0.853
6-hr	0.164	0.265	0.311	0.374	0.424	0.475
12-hr	0.094	0.150	0.174	0.208	0.234	0.260
24-hr	0.054	0.088	0.105	0.127	0.144	0.162

2.2.2 Land Use Parameters/Runoff Coefficient

Land cover for the study area was determined based on aerial photography. The drainage area has five land uses which include commercial 1, low density residential, pavement and rooftops, gravel roadways, and undeveloped desert rangeland. The Design Drainage Manual for Maricopa County, Table 3.2, lists cover types with respective runoff coefficients (C), these values are unitless. The flows for the project site were a result of four separate basins. These individual basins included multiple land uses with their respective runoff coefficients. To calculate the discharge from each basin, a weighted runoff coefficient was calculated as follows:

$$C_W = \frac{C_1 A_1 + C_2 A_2 \ldots . + C_n A_n}{\sum A_n}$$

Where C is equal to the runoff coefficient of a respective land type

Where A is equal to the area (in acres) of a respective land type

In the *Drainage Manual,* the land types have a minimum and maximum value. This drainage assessment utilized the maximum values to ensure more conservative results. The larger the value of runoff coefficient, the more impervious it is. This allows for the land types with larger runoff coefficients to produce larger discharges than those land types that are able to absorb more runoff. Refer to Table 2 for the land cover types and runoff coefficients used in this drainage analysis.

Table 2: Runoff Coefficients for Maricopa County		
Land Cover Type	**Runoff Coefficients**	
	10 Yr Max	**100 Yr Max**
Low Density Residential	0.48	0.70
Commercial 1	0.65	0.81
Pavement and Rooftops	0.85	0.95
Gravel Roadways and Shoulders	0.70	0.88
Undeveloped Desert Rangeland	0.40	0.50

2.2.3 Time of Concentration Calculations

In accordance to the *Drainage Manual,* the time of concentration must be solved for to use the correct storm intensity. The equation for T_c is as follows:

$$T_c = 11.4\, L^{0.5} K_b^{0.52} S^{-0.31} i^{-.038}$$

Where:

T_c = time of concentration, in hours

L = length of the longest flow path, in miles

K_b = watershed resistance coefficient

S = watercourse slope, in feet/mile.

i = rainfall intensity, in inches/hour

To determine the watershed resistance coefficient, K_b, Figure 3.1 of the *Drainage Manual* was used. The time of concentration equation was then simplified and expressed in terms of intensity. The intensity for the 15 minute duration of the desired storm event is then used to estimate the T_c. After a log interpolation is performed to solve for a more precise T_c, then the duration for the respective storm event is selected. Another log interpolation may be needed to determine the intensity using the data from Table 1. Refer to Appendix C for the determination of the T_c for each sub-basin and thus the corresponding intensities used for the 10-year and 100-year storm events.

2.3 Existing Condition

The project area is composed of mostly residential land with exception of a few commercial lots along 1st St. from Hwy 79 to Main St. A 4-inch rolled curb and gutter is utilized throughout the entire length of 1st St. A grass-lined channel begins at the intersection of 1st St. and Main St. and runs south along Main St. before veering west. There are currently two curb drop inlets along Main St. north of Ruggles St. These inlets capture run off from a portion of Ruggles St.

Under current conditions, 1st St. experiences flooding at its western end near Main St. Storm runoff currently sits in the roadway prism until it can make its way to a channel at the northeast corner of 1st St. and Main St. through the implementation of sidewalk culverts and rundowns. The water in this channel is then directed underneath Main St. through the use of 6-2'X3' elliptical corrugated metal pipe structures. 1st St. also ponds at the Phoenix St. intersection until the water makes its way north. As a result of the storm runoff described above, 1st St. is experiencing significant pavement deterioration and alligator cracking in these areas likely due to the subgrade being saturated during storm events. Refer to Figure 2 for the sub-basin delineations.

Figure 2: Existing Basin Map

The slope of the study area is from south to north and is very gradual. The profile of 1st St. is highest at Hwy 79 and slopes approximately 0.50% toward Main St. The study area was found to have three discharge locations. The basins were delineated based on the discharge locations.

As shown above, basin 2 was delineated further into sub-basins. Basin 1 represents flows that will be discharged into the channel under 1st St. by an 18 inch culvert. The existing property lines, profile of Ruggles St., and the crowns along Pinal St. and 1st St. delineate this basin further.

Basin 2 is divided into multiple sub-basins along all of the streets that intersect 1st St. This was done in order to know the peak discharges at each cross street so that we could evaluate the need for 6-inch curb and gutter or inlets. The boundaries of Basin 2 consist of the crowns of Ruggles St., Pinal St., King St., and 1st St.

Basin 3 represents all of the runoff from Pinal Parkway Ave. to just west of King St. There is a high point along 1st St. just west of King St. shown by the boundaries in Figure 2: Existing Basin Map. This high point allows for runoff to retreat back to the east and discharge off of 1st St. to the north of the intersection with Phoenix St. This runoff then makes its way through the parking lot of the Baptist church located on the northwest corner of the 1st St. and Phoenix St. intersection.

Basin 4 is shown as the north side of 1st St. starting at the high point that delineates Basin 3 and follows the existing crown along 1st St. to the intersection of Main St. This basin consists of the surface flow from the north side of 1st St. The properties north of 1st St. are lower in elevation than the road.

Tables 3 and 4 below summarize the peak discharges calculated for the respective basins and sub-basins described. The complete computations can be found in Appendix B.

Table 3: Existing Sub-Basin Peak Discharges, 10-YR Storm Event					
Sub-Basin	Area (ac)	C-Weighted	T_c (min)	Intensity (in/hr)	$Q_{10\text{-}Yr}$ (cfs)
1	5.43	0.53	12	3.62	**10.33**
2a	6.45	0.55	14	3.55	**12.54**
2b	6.42	0.56	14	3.55	**12.66**
2c	3.19	0.59	14	3.55	**6.69**
2d	6.47	0.57	14	3.55	**13.16**
2e	6.26	0.56	14	3.55	**11.76**
3	9.38	0.61	10	4.04	**24.07**
4	0.74	0.85	17	3.31	**2.08**
Total	**44.96**	**N/A**	**N/A**	**N/A**	**93.29**

Table 4: Existing Sub-Basin Peak Discharges, 100-YR Storm Event					
Sub-Basin	Area (ac)	C-Weighted	T_c (min)	Intensity (in/hr)	$Q_{100\text{-}Yr}$ (cfs)
1	5.43	0.67	9	6.70	**24.52**
2a	6.45	0.71	11	6.10	**27.93**
2b	6.42	0.73	11	6.10	**28.71**
2c	3.19	0.75	11	6.10	**14.68**
2d	6.47	0.75	11	6.10	**29.75**
2e	6.26	0.71	11	6.10	**25.88**
3	9.38	0.77	8	7.07	**52.77**
4	0.74	0.95	14	5.44	**3.81**
Total	**44.96**	**N/A**	**N/A**	**N/A**	**180.12**

The existing curb and gutter was analyzed through the use of Bentley FlowMaster. With the roadway cross-slope set at 2%, the profile set at 0.81% and a 4-inch curb, the allowable flow 1st St. was found to be 8.32 cfs. This is based on the 10-year design criteria of a minor collector/local street with flow depth not to exceed the curb height.

During our field review, Wilson & Company was asked by the Town Engineer to determine the current capacity of the existing channel that provides a significant amount of drainage from the Town of Florence to the nearby Gila River. The existing channel follows a trapezoidal shape with varying dimensions throughout the entire length. Wilson & Company surveyors picked up longitudinal elevations along the channel with intermediate cross section elevations at the locations shown below in Figure 3. With the assistance of Bentley FlowMaster, approximate capacities of the grass-lined channel were developed. Refer to Table 5 for the summary. Complete FlowMaster worksheets can be found in Appendix D.

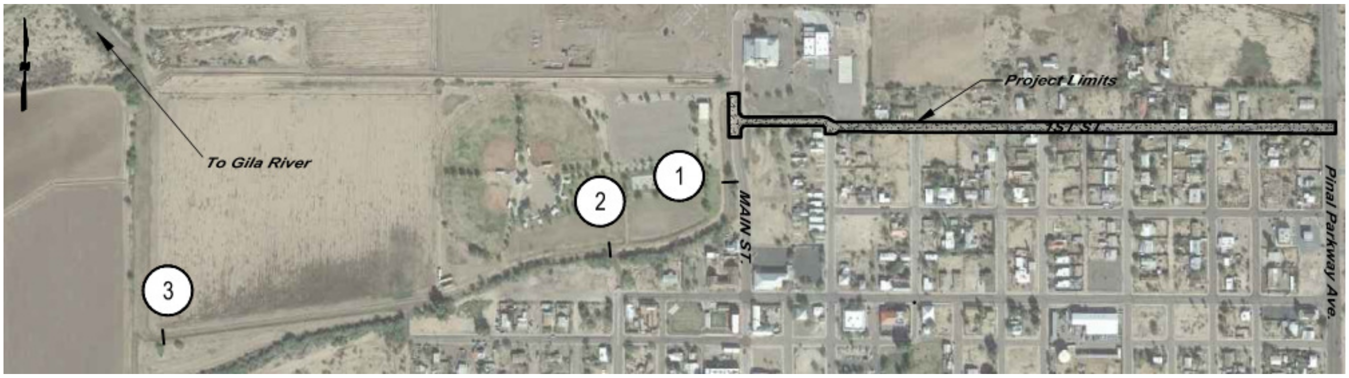


Figure 3: Grass-Lined Ditch Analysis Locations

Table 5: Existing Grass-Lined Channel Capacity				
Location	Normal Depth (ft)	Approximate Longitudinal Slope	Roughness Coefficient	Discharge (cfs)
1	1.87	0.440%	0.035	194.85
2	2.58	0.310%	0.035	179.36
3	2.05	0.302%	0.035	86.96

2.4 Recommendations

Our recommendations presented below are based on the assumption that only curb and gutter improvements will be made to the existing roadway. No changes in the existing typical section and minor corrections to the roadway profile are anticipated.

Table 6 below demonstrates the cumulative peak discharges along Basin 2 for the 10-yr storm event.

Table 6: Cumulative Peak Discharges for Basin 2			
Sub-Basin	Individual Sub-Basin Q_{10} (cfs)	Cumulative Q_{10} (cfs)	Treatment
2e	11.76	11.76	None
2d	13.16	24.92	None
2c	6.69	31.61	None
2b	12.66	44.27	Begin 6” Curb
2a	12.54	56.81	6” Curb

The cumulative peak discharge at 1st St. and Florence St. is 31.61 cfs during a 10-yr storm event. It is recommended to begin replacing the existing 4-inch rolled curb and gutter at approx. Station 11+22 and continue west toward N. Pinal Street (Sta. 4+35) in order to maximize the capacity of storm water that can be conveyed in the roadway prism. The capacity in the roadway prism will be increased from 8.32 cfs to 25.19 cfs using a 6-inch curb. See FlowMaster report in Appendix D. However during the 10-yr storm event there will be drainage that overtops the 6-inch curb and gutter to the north. During the design process, a storm drain system was reviewed in order to contain the drainage and covey it to the detention pond on the north east side of 1st St. and Don Mattingly Way. However due to utility constraints, the existing sanitary sewer services from residences that were shallow and crossed the proposed storm drain, it was eliminated. With the installation of the 6-inch curb and gutter, additional drainage will remain within the roadway prism until it reaches Pinal St. where it will be drop into the existing detention pond by two concrete scuppers in succession.

The north side of 1st St will be able to convey the Basin 4 discharge. For the 10-year event, Basin 4 discharges 2.08 cfs. This minimal discharge can be retained by the existing 4-inch rolled curb and gutter along with the 6-inch curb and gutter recommended above. These flows will collect the length of 1st St. until they drop into the channel through the recommended concrete scuppers and spillways. It is also recommended to increase the capacity of the detention basin in the northeast corner of 1st St. and Main St. by lowering the grade approximately one foot. This will increase the detention pond capacity and direct the runoff out of the roadway prism prior to Main St. We recommend a future study to determine the capacity needs of the drainage channel to the Gila River. Our report only provides a rough estimate at three isolated locations.

Basin 1, for the 10-year event, has a discharge of 10.33 cfs. This flow can continue on its existing pattern beneath 1st St. See culvert analysis in Appendix D.

It is recommended to pave the parking lot of the Baptist Church located on the north side of 1st St. and Phoenix St. The parking lot shall have a constant cross-slope to its east end and it is recommended to construct a valley gutter to convey the flows discharged by Basin 3 into the existing vacant field. The Town of Florence has right-of-way through this area. Basin 3 produces 23.26 cfs in the 10-year storm event. A concrete valley gutter with 33:1 side slopes, a 0.56% grade (existing conditions), and normal depth of 0.6 feet can convey 24.63 cfs. See Appendix D for FlowMaster computation. Below Figure 4 summaries all recommended improvements.

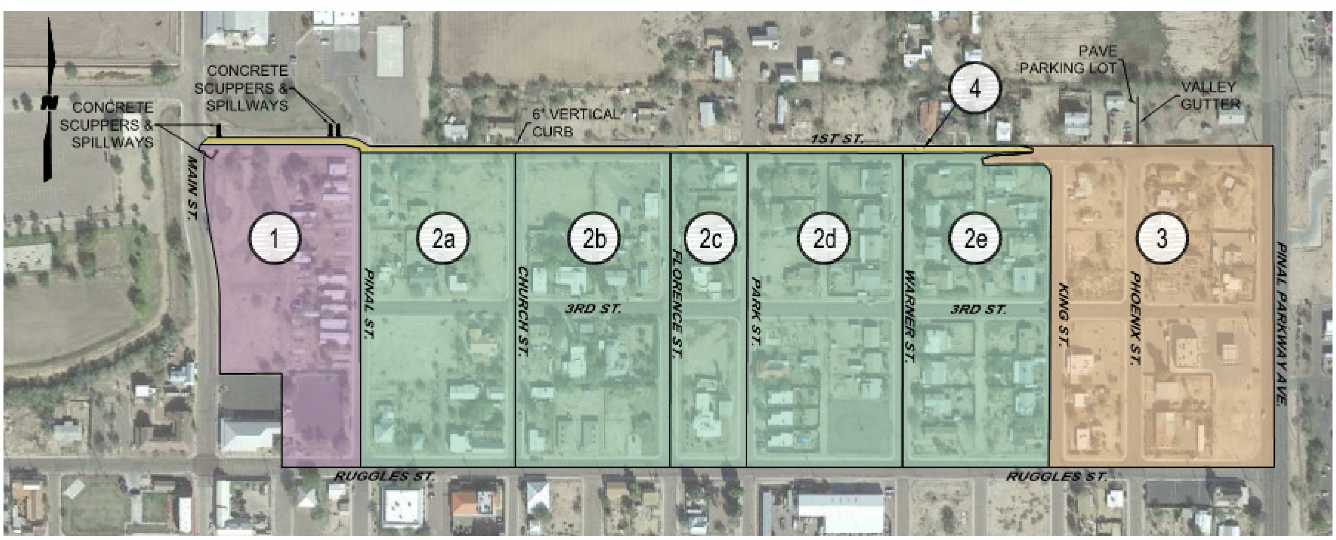


Figure 4: Recommended Improvements

3. Conclusion

The Town of Florence experiences flooding along 1st St. from Pinal Parkway Ave to Main St. This is a result of a relatively flat profile along 1st St., the existing 4-inch curb and gutter, and the lack of storm drain infrastructure to carry flows to the channel that eventually outlets to the Gila River. The Rational Method was used to analyze these flows under the design criteria expressed in the *Drainage Policies and Standards for Maricopa County, Arizona*.

After analyzing the project limits for 10-year and 100-year storm events, it is recommended to construct a 6-inch curb and gutter along a portion of the north side of 1st St. to increase the capacity of runoff held within the roadway prism. A concrete valley gutter is also recommended to be constructed north of the 1st St and Phoenix St intersection to convey flows off of the roadway.

It is important to note that these recommendations will improve the existing conditions but will not accommodate the entire 10-year event. In the case of a 100-year event, flooding will occur as the design criteria allows for a maximum flow depth of 8 inches within the roadway prism. This depth is greater than the height of the adjacent curb and gutter. Our proposed improvements will help alleviate this flooding but will not prevent it.

Appendix A

NOAA Atlas 14, Volume 1, Version 5
Location name: Florence, Arizona, USA*
Latitude: 33.0311°, Longitude: -111.3942°
Elevation: 1486.37 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/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	2.51 (2.14–3.00)	3.28 (2.82–3.92)	4.44 (3.78–5.28)	5.30 (4.50–6.30)	6.50 (5.44–7.67)	7.40 (6.11–8.72)	8.33 (6.76–9.79)	9.26 (7.39–10.9)	10.5 (8.17–12.4)	11.5 (8.72–13.6)
10-min	1.91 (1.63–2.29)	2.50 (2.14–2.99)	3.37 (2.87–4.02)	4.04 (3.43–4.80)	4.94 (4.13–5.84)	5.63 (4.64–6.64)	6.34 (5.14–7.45)	7.05 (5.62–8.30)	8.00 (6.21–9.44)	8.73 (6.64–10.4)
15-min	1.58 (1.35–1.89)	2.06 (1.77–2.47)	2.79 (2.38–3.32)	3.34 (2.83–3.96)	4.09 (3.42–4.83)	4.66 (3.84–5.48)	5.24 (4.25–6.16)	5.83 (4.64–6.86)	6.61 (5.14–7.80)	7.22 (5.48–8.56)
30-min	1.06 (0.906–1.27)	1.39 (1.19–1.66)	1.88 (1.60–2.24)	2.25 (1.91–2.67)	2.75 (2.30–3.25)	3.14 (2.58–3.69)	3.53 (2.86–4.15)	3.92 (3.13–4.62)	4.45 (3.46–5.25)	4.86 (3.69–5.76)
60-min	0.658 (0.561–0.787)	0.859 (0.738–1.03)	1.16 (0.989–1.39)	1.39 (1.18–1.65)	1.70 (1.42–2.01)	1.94 (1.60–2.29)	2.18 (1.77–2.57)	2.43 (1.94–2.86)	2.75 (2.14–3.25)	3.01 (2.29–3.57)
2-hr	0.376 (0.323–0.444)	0.487 (0.420–0.576)	0.650 (0.555–0.767)	0.772 (0.656–0.910)	0.940 (0.787–1.10)	1.07 (0.884–1.25)	1.20 (0.979–1.41)	1.34 (1.07–1.56)	1.52 (1.18–1.78)	1.66 (1.27–1.96)
3-hr	0.271 (0.233–0.321)	0.347 (0.299–0.412)	0.455 (0.390–0.541)	0.540 (0.459–0.639)	0.660 (0.552–0.775)	0.754 (0.621–0.883)	0.853 (0.690–0.999)	0.955 (0.760–1.12)	1.10 (0.847–1.29)	1.21 (0.913–1.43)
6-hr	0.164 (0.144–0.191)	0.207 (0.182–0.241)	0.265 (0.231–0.308)	0.311 (0.270–0.360)	0.374 (0.320–0.430)	0.424 (0.357–0.486)	0.475 (0.393–0.546)	0.527 (0.430–0.607)	0.600 (0.475–0.690)	0.656 (0.508–0.758)
12-hr	0.094 (0.083–0.107)	0.118 (0.105–0.135)	0.150 (0.132–0.170)	0.174 (0.153–0.198)	0.208 (0.180–0.235)	0.234 (0.200–0.263)	0.260 (0.220–0.294)	0.287 (0.239–0.325)	0.323 (0.262–0.368)	0.351 (0.280–0.402)
24-hr	0.054 (0.049–0.058)	0.068 (0.063–0.074)	0.088 (0.081–0.096)	0.105 (0.096–0.113)	0.127 (0.115–0.136)	0.144 (0.130–0.155)	0.162 (0.146–0.175)	0.181 (0.161–0.195)	0.207 (0.182–0.224)	0.228 (0.198–0.246)
2-day	0.029 (0.027–0.032)	0.037 (0.034–0.041)	0.049 (0.045–0.053)	0.058 (0.053–0.063)	0.071 (0.065–0.077)	0.082 (0.074–0.088)	0.092 (0.083–0.100)	0.104 (0.092–0.113)	0.120 (0.105–0.130)	0.132 (0.115–0.145)
3-day	0.021 (0.019–0.023)	0.027 (0.024–0.029)	0.035 (0.032–0.038)	0.042 (0.038–0.045)	0.051 (0.046–0.055)	0.059 (0.053–0.064)	0.067 (0.060–0.072)	0.075 (0.067–0.082)	0.087 (0.076–0.095)	0.096 (0.084–0.106)
4-day	0.017 (0.015–0.018)	0.021 (0.019–0.023)	0.028 (0.026–0.030)	0.033 (0.030–0.036)	0.041 (0.037–0.044)	0.047 (0.042–0.051)	0.054 (0.048–0.058)	0.061 (0.054–0.066)	0.070 (0.062–0.077)	0.078 (0.068–0.086)
7-day	0.011 (0.010–0.012)	0.013 (0.012–0.015)	0.018 (0.016–0.019)	0.021 (0.019–0.023)	0.026 (0.024–0.029)	0.030 (0.027–0.033)	0.034 (0.031–0.038)	0.039 (0.034–0.043)	0.045 (0.039–0.050)	0.050 (0.043–0.055)
10-day	0.008 (0.007–0.009)	0.010 (0.009–0.011)	0.013 (0.012–0.015)	0.016 (0.015–0.018)	0.020 (0.018–0.022)	0.023 (0.021–0.025)	0.026 (0.023–0.028)	0.029 (0.026–0.032)	0.034 (0.030–0.037)	0.037 (0.033–0.041)
20-day	0.005 (0.005–0.005)	0.006 (0.006–0.007)	0.008 (0.008–0.009)	0.010 (0.009–0.011)	0.012 (0.011–0.013)	0.014 (0.012–0.015)	0.015 (0.014–0.017)	0.017 (0.015–0.018)	0.019 (0.017–0.021)	0.021 (0.018–0.023)
30-day	0.004 (0.004–0.004)	0.005 (0.005–0.005)	0.007 (0.006–0.007)	0.008 (0.007–0.008)	0.009 (0.009–0.010)	0.011 (0.010–0.011)	0.012 (0.011–0.013)	0.013 (0.012–0.014)	0.015 (0.013–0.016)	0.016 (0.014–0.018)
45-day	0.003 (0.003–0.003)	0.004 (0.004–0.004)	0.005 (0.005–0.006)	0.006 (0.006–0.007)	0.007 (0.007–0.008)	0.008 (0.007–0.009)	0.009 (0.008–0.010)	0.010 (0.009–0.011)	0.011 (0.010–0.012)	0.012 (0.011–0.013)
60-day	0.003 (0.002–0.003)	0.003 (0.003–0.004)	0.004 (0.004–0.005)	0.005 (0.005–0.005)	0.006 (0.006–0.007)	0.007 (0.006–0.007)	0.008 (0.007–0.008)	0.008 (0.007–0.009)	0.009 (0.008–0.010)	0.010 (0.009–0.011)

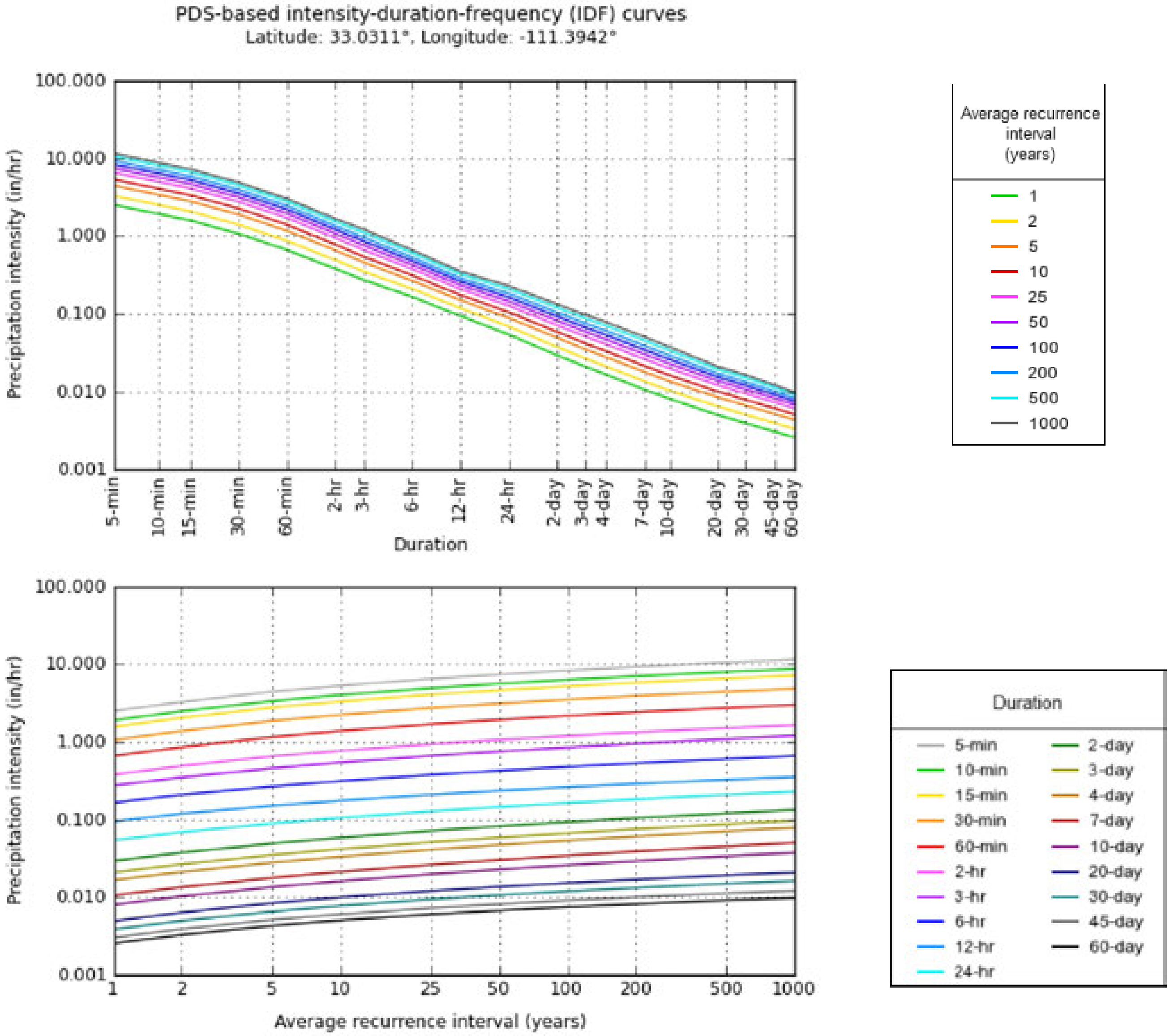
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

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.

Back to Top

PF graphical



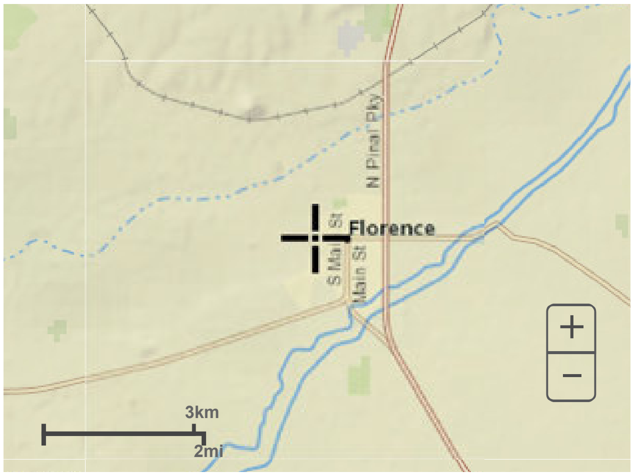
NOAA Atlas 14, Volume 1, Version 5

Created (GMT): Mon Dec 5 22:54:29 2016

Back to Top

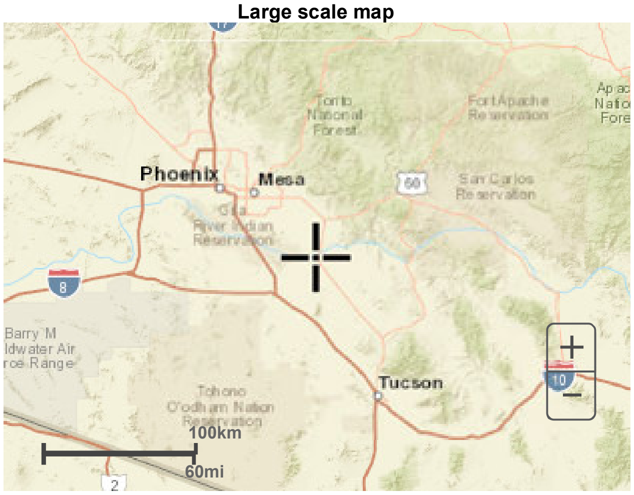
Maps & aerials

Small scale terrain

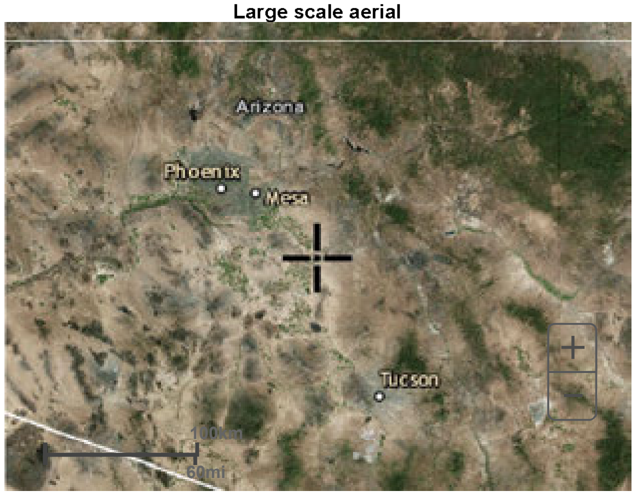


Large scale terrain

Large scale map



Large scale aerial



Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Appendix B

WCI Project: 16-100-112-01
Calculated by: SML 12-31-16
Checked by: EC 01-01-17

Town of Florence
1st Street Improvements - Existing Sub Basin Peak Discharges, 10-YR Storm Event
Rational Method
Q=CiA

Existing Conditions					
Basin 1					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
1 - Undeveloped	83,976	1.93	0.40	0.77	0.53
2 - Gravel Alley	10,348	0.24	0.70	0.17	**Intensity (in/hr)***
3 - Residential	72,476	1.66	0.48	0.80	3.62
4 - Undeveloped	9,087	0.21	0.40	0.08	
5 - Commercial	33,330	0.77	0.65	0.50	
Roadway	27,443	0.63	0.85	0.54	
Basin 1b Area	**236,660**	**5.43**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		10.33	0.53	3.62	5.43
Basin 2a					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
6 - Residential	65,404	1.50	0.48	0.72	0.55
7 - Undeveloped	41,919	0.96	0.40	0.38	**Intensity (in/hr)***
8 - Undeveloped	27,310	0.63	0.40	0.25	3.55
9 - Residential	79,998	1.84	0.48	0.88	
Roadway	66,407	1.52	0.85	1.30	
Basin 1a Area	**281,038**	**6.45**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		12.54	0.55	3.55	6.45
Basin 2b					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
10 - Undeveloped	34,178	0.78	0.40	0.31	0.56
11 - Residential	73,704	1.69	0.48	0.81	**Intensity (in/hr)***
12 - Residential	107,382	2.47	0.48	1.18	3.55
Roadway	64,399	1.48	0.85	1.26	
Basin 2b Area	**279,663**	**6.42**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		12.66	0.56	3.55	6.42
Basin 2c					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
13 - Residential	46,569	1.07	0.48	0.51	0.59
14 - Undeveloped	19,564	0.45	0.40	0.18	**Intensity (in/hr)***
15 - Residential	26,768	0.61	0.48	0.29	3.55
Roadway	46,009	1.06	0.85	0.90	
Basin 2c Area	**138,910**	**3.19**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		6.69	0.59	3.55	3.19

*See time of concentration calculations in Appendix B

WILSON & COMPANY

WCI Project: 16-100-112-01
Calculated by: SML 12-31-16
Checked by: EC 01-01-17

Town of Florence
1st Street Improvements - Existing Sub Basin Peak Discharges, 10-YR Storm Event
Rational Method
Existing Conditions

Basin 2d					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
16 - Residential	48,417	1.11	0.48	0.53	0.57
17 - Gravel Alley	8,218	0.19	0.70	0.13	**Intensity (in/hr)***
18 - Residential	51,389	1.18	0.48	0.57	3.55
19 - Residential	49,227	1.13	0.48	0.54	
20 - Gravel Alley	8,077	0.19	0.70	0.13	
21 - Residential	29,845	0.69	0.48	0.33	
22 - Gravel Yard	21,067	0.48	0.40	0.19	
Roadway	65,662	1.51	0.85	1.28	
Basin 2d Area	**281,902**	**6.47**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		13.16	0.57	3.55	6.47
Basin 2e					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
23 - Residential	49,552	1.14	0.48	0.48	0.55
24 - Gravel Alley	6,544	0.15	0.70	0.11	**Intensity (in/hr)***
25 - Residential	50,149	1.15	0.48	0.55	3.55
26 - Residential	50,591	1.16	0.48	0.56	
27 - Gravel Alley	6,929	0.16	0.70	0.11	
28 - Residential	49,761	1.14	0.48	0.55	
Roadway	49,122	1.13	0.85	0.96	
Basin 2e Area	**262,648**	**6.03**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		11.76	0.55	3.55	6.03
Basin 3 Area					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
29 - Residential	22,781	0.52	0.48	0.25	0.62
30 - Undeveloped	23,044	0.53	0.40	0.21	**Intensity (in/hr)***
31 - Residential	46,795	1.07	0.48	0.52	4.04
32 - Residential	90,428	2.08	0.48	1.00	
33 - Commericial	42,535	0.98	0.65	0.63	
34 - Residential	32,125	0.74	0.48	0.35	
35 - Undeveloped	18,679	0.43	0.50	0.21	
Roadway	142,415	3.27	0.85	2.78	
Basin 3 Area	**418,802**	**9.61**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		24.07	0.62	4.04	9.61
Basin 4 Area					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Intensity (in/hr)***
32 - Roadway	32,133	0.74	0.85	N/A	3.31
Basin 4 Area	**32,133**	**0.74**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		2.08	0.85	3.31	0.74
Total Flow (Basin 1, Basin 2, Basin 3)					
		Q(cfs)	**Total Area (Acres)**		
		93.29	**44.35**		

*See time of concentration calculations in Appendix B

WILSON & COMPANY

WCI Project: 16-100-112-01
Calculated by: SML 12-31-16
Checked by: EC 01-04-17

Town of Florence
1st Street Improvements - Existing Sub Basin Peak Discharges, 100-YR Storm Event
Rational Method
Q=CiA

Existing Conditions					
Basin 1					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
1 - Undeveloped	83,976	1.93	0.50	0.96	0.67
2 - Gravel Alley	10,348	0.24	0.88	0.21	**Intensity (in/hr)***
3 - Residential	72,476	1.66	0.70	1.16	6.70
4 - Undeveloped	9,087	0.21	0.50	0.10	
5 - Commercial	33,330	0.77	0.81	0.62	
Roadway	27,443	0.63	0.95	0.60	
Basin 1b Area	**236,660**	**5.43**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		24.52	0.67	6.70	5.43
Basin 2a					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
6 - Residential	65,404	1.50	0.70	1.05	0.71
7 - Undeveloped	41,919	0.96	0.50	0.48	**Intensity (in/hr)***
8 - Undeveloped	27,310	0.63	0.50	0.31	6.10
9 - Residential	79,998	1.84	0.70	1.29	
Roadway	66,407	1.52	0.95	1.45	
Basin 1a Area	**281,038**	**6.45**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		27.93	0.71	6.10	6.45
Basin 2b					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
10 - Undeveloped	34,178	0.78	0.50	0.39	0.73
11 - Residential	73,704	1.69	0.70	1.18	**Intensity (in/hr)***
12 - Residential	107,382	2.47	0.70	1.73	6.10
Roadway	64,399	1.48	0.95	1.40	
Basin 2b Area	**279,663**	**6.42**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		28.71	0.73	6.10	6.42
Basin 2c					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
13 - Residential	46,569	1.07	0.70	0.75	0.75
14 - Undeveloped	19,564	0.45	0.50	0.22	**Intensity (in/hr)***
15 - Residential	26,768	0.61	0.70	0.43	6.10
Roadway	46,009	1.06	0.95	1.00	
Basin 2c Area	**138,910**	**3.19**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		14.68	0.75	6.10	3.19

*See time of concentration calculations in Appendix B

WILSON & COMPANY

WCI Project: 16-100-112-01
Calculated by: SML 12-31-16
Checked by: EC 01-04-17

Town of Florence
1st Street Improvements - Existing Sub Basin Peak Discharges, 100-YR Storm Event
Rational Method

Existing Conditions					
Basin 2d					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
16 - Residential	48,417	1.11	0.70	0.78	0.75
17 - Gravel Alley	8,218	0.19	0.88	0.17	**Intensity (in/hr)***
18 - Residential	51,389	1.18	0.70	0.83	6.10
19 - Residential	49,227	1.13	0.70	0.79	
20 - Gravel Alley	8,077	0.19	0.88	0.16	
21 - Residential	29,845	0.69	0.70	0.48	
22 - Gravel Yard	21,067	0.48	0.50	0.24	
Roadway	65,662	1.51	0.95	1.43	
Basin 2d Area	**281,902**	**6.47**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		29.75	0.75	6.10	6.47
Basin 2e					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
23 - Residential	49,552	1.14	0.70	0.48	0.70
24 - Gravel Alley	6,544	0.15	0.88	0.13	**Intensity (in/hr)***
25 - Residential	50,149	1.15	0.70	0.81	6.10
26 - Residential	50,591	1.16	0.70	0.81	
27 - Gravel Alley	6,929	0.16	0.88	0.14	
28 - Residential	49,761	1.14	0.70	0.80	
Roadway	49,122	1.13	0.95	1.07	
Basin 2e Area	**262,648**	**6.03**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		25.88	0.70	6.10	6.03
Basin 3 Area					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Weighted C**
29 - Residential	22,781	0.52	0.70	0.37	0.78
30 - Undeveloped	23,044	0.53	0.50	0.26	**Intensity (in/hr)***
31 - Residential	46,795	1.07	0.70	0.75	7.07
32 - Residential	90,428	2.08	0.70	1.45	
33 - Commericial	42,535	0.98	0.81	0.79	
34 - Residential	32,125	0.74	0.70	0.52	
35 - Undeveloped	18,679	0.43	0.50	0.21	
Roadway	142,415	3.27	0.95	3.11	
Basin 3 Area	**418,802**	**9.61**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		52.77	0.78	7.07	9.61
Basin 4 Area					
Sub-Areas	**SF**	**Acres**	**Individual C**	**Ax*Cx**	**Intensity (in/hr)***
32 - Roadway	32,133	0.74	0.95	N/A	5.44
Basin 4 Area	**32,133**	**0.74**			
		Q(cfs)	**C**	**i (in/hr)**	**A (acres)**
		3.81	0.95	5.44	0.74
Total Flow (Basin 1, Basin 2, Basin 3)					
		Q(cfs)	**Total Area (Acres)**		
		180.12	**44.35**		

*See time of concentration calculations in Appendix B

Appendix C

Basin 1 Time of Concentration Calculations, 10-YR Storm Event

TC=11.4L^0.5 * Kb^0.52 * S ^-0.31 * i^-0.38

TC	Time of concentration, hours	0.21	12.49 min	Length of Watercourse Slope
L	Length of longest flowpath, in miles	0.21		0.0595 mi
Kb	Watershed Resistance coefficient	0.034	*Figure 3.1	
S	watercourse slope in, feet/mile	25.22		
i	inches/hour	3.34	*Estimated for 15 minute duration 10 yr event	

L^0.5	0.46		
Kb^0.52	0.17	0.329	Tc=0.27*i^-0.38
S^-0.31	0.37		
i^-0.38	0.63		

Log Interpolation

	10 Minute Intensity	15 Minute Intensity	
	4.04	3.44	
A	0.50		
B	0.54	i = 10 ^ (AD+C)	
C	0.61		
D	-0.07		
	i		3.73 in/hr
	Tc	0.20	11.98 min

Log Interpolation

	5 Minute Intensity	10 Minute Intensity	
	5.3	4.04	
A	1.40		
B	0.61	i = 10 ^ (AD+C)	
C	0.72		
D	-0.12		
	i		3.63 in/hr
	Tc	0.20	12.11 min

Log Interpolation

	5 Minute Intensity	10 Minute Intensity	
	5.3	4.04	
A	1.42		
B	0.61	i = 10 ^ (AD+C)	
C	0.72		
D	-0.12		
	i		3.60 in/hr
	Tc	0.20	12.14 min

Difference between interpolations is less than 2%. Use Tc = 12 min and interpolate for intensity

Log Interpolation

	5 Minute Intensity	10 Minute Intensity	
	5.3	4.04	
A	1.40		
B	0.61	i = 10 ^ (AD+C)	
C	0.72		
D	-0.12		
	i		**3.62 in/hr**

Basin 2 Time of Concentration Calculations, 10-YR Storm Event

TC=11.4L^0.5 * Kb^0.52 * S ^-0.31 * i^-0.38

TC	Time of concentration, hours	0.24	14.61 min	Length of Watercourse Slope
L	Length of longest flowpath, in miles	0.42		0.2813 mi
Kb	Watershed Resistance coefficient	0.030	*Figure 3.1	
S	watercourse slope in, feet/mile	39.11		
i	inches/hour	3.34	*Estimated for 15 minute duration 10 yr event	

L^0.5	0.65		
Kb^0.52	0.16	0.385	Tc=0.32*i^-0.38
S^-0.31	0.32		
i^-0.38	0.63		

Log Interpolation

	10 Minute Intensity	15 Minute Intensity	
	4.04	3.44	
A	0.92		
B	0.54	i = 10 ^ (AD+C)	
C	0.61		
D	-0.07		
	i		3.48 in/hr
	Tc	0.24	14.38 min

Log Interpolation

	10 Minute Intensity	15 Minute Intensity	
	4.04	3.44	
A	0.88		
B	0.54	i = 10 ^ (AD+C)	
C	0.61		
D	-0.07		
	i		3.51 in/hr
	Tc	0.24	14.34 min

Difference between interpolations is less than 2%. Use Tc = 14 min and interpolate for intensity

Log Interpolation

	10 Minute Intensity	15 Minute Intensity	
	4.04	3.44	
A	0.80		
B	0.54	i = 10 ^ (AD+C)	
C	0.61		
D	-0.07		
	i		**3.55 in/hr**

Basin 3 Time of Concentration Calculations, 10-YR Storm Event

TC=11.4L^0.5 * Kb^0.52 * S ^-0.31 * i^-0.38

TC	Time of concentration, hours	0.18	11.02 min		Length of Watercourse Slope
L	Length of longest flowpath, in miles	0.21			0.0564 mi
Kb	Watershed Resistance coefficient	0.033	*Figure 3.1		
S	watercourse slope in, feet/mile	35.44			
i	inches/hour	3.34	*Estimated for 15 minute duration 10 yr event		

L^0.5	0.45		
Kb^0.52	0.17	0.291	Tc=0.32*i^-0.38
S^-0.31	0.33		
i^-0.38	0.63		

Log Interpolation

	10 Minute Intensity		15 Minute Intensity	
	4.04		3.44	
A	0.20			
B	0.54		i = 10 ^ (AD+C)	
C	0.61			
D	-0.07			
		i		3.91 in/hr
		Tc	0.17	10.38 min

Log Interpolation

	10 Minute Intensity		15 Minute Intensity	
	4.04		3.44	
A	0.08			
B	0.54		i = 10 ^ (AD+C)	
C	0.61			
D	-0.07			
		i		3.99 in/hr
		Tc	0.17	10.30 min

Difference between interpolations is less than 4%. Use Tc = 10 min and interpolate for intensity

Log Interpolation

	5 Minute Intensity		10 Minute Intensity	
	5.30		4.04	
A	1.00			
B	0.61		i = 10 ^ (AD+C)	
C	0.72			
D	-0.12			
		i		**4.04 in/hr**

Basin 4 Time of Concentration Calculations, 10-YR Storm Event

TC=11.4L^0.5 * Kb^0.52 * S ^-0.31 * i^-0.38

TC	Time of concentration, hours	0.28	16.98 min
L	Length of longest flowpath, in miles	0.38	
Kb	Watershed Resistance coefficient	0.040	*Figure 3.1
S	watercourse slope in, feet/mile	31.95	
i	inches/hour	3.34	*Estimated for 15 minute duration 10 yr event

Length of Watercourse Slope=
Length of Longest Flowpath for Basin 4
0.38 mi

L^0.5	0.61
Kb^0.52	0.19
S^-0.31	0.34
i^-0.38	0.63

0.448 Tc=0.32*i^-0.38

Log Interpolation

	15 Minute Intensity	30 Minute Intensity	
	3.44	2.55	
A	0.13		
B	0.41	i = 10 ^ (AD+C)	
C	0.54		
D	-0.13		
i			3.31 in/hr
Tc		0.28	17.05 min

Log Interpolation

	15 Minute Intensity	30 Minute Intensity	
	3.44	2.55	
A	0.14		
B	0.41	i = 10 ^ (AD+C)	
C	0.54		
D	-0.13		
i			3.30 in/hr
Tc		0.28	17.06 min

Difference between interpolations is less than 4%. Use Tc = 17 min and interpolate for intensity

Log Interpolation

	15 Minute Intensity	30 Minute Intensity	
	3.44	2.55	
A	0.13		
B	0.41	i = 10 ^ (AD+C)	
C	0.54		
D	-0.13		
i			**3.31 in/hr**

Basin 1 Time of Concentration Calculations, 100-YR Storm Event

TC=11.4L^0.5 * Kb^0.52 * S ^-0.31 * i^-0.38

TC	Time of concentration, hours	0.18	10.53 min		Length of Watercourse Slope
L	Length of longest flowpath, in miles	0.21			0.0595 mi
Kb	Watershed Resistance coefficient	0.034	*Figure 3.1		
S	watercourse slope in, feet/mile	25.22			
i	inches/hour	5.24	*Estimated for 15 minute duration 10 yr event		

L^0.5	0.46		
Kb^0.52	0.17	0.329	Tc=0.27*i^-0.38
S^-0.31	0.37		
i^-0.38	0.53		

Log Interpolation

	10 Minute Intensity	15 Minute Intensity	
	6.34	5.24	
A	0.11		
B	0.72	i = 10 ^ (AD+C)	
C	0.80		
D	-0.08		
	i		6.21 in/hr
	Tc	0.16	9.87 min

Log Interpolation

	5 Minute Intensity	10 Minute Intensity	
	8.33	6.34	
A	0.97		
B	0.80	i = 10 ^ (AD+C)	
C	0.92		
D	-0.12		
	i		6.39 in/hr
	Tc	0.16	9.76 min

Log Interpolation

	5 Minute Intensity	10 Minute Intensity	
	8.33	6.34	
A	0.95		
B	0.80	i = 10 ^ (AD+C)	
C	0.92		
D	-0.12		
	i		6.42 in/hr
	Tc	0.16	9.74 min

Difference between interpolations is less than 2%. Use Tc = 9 min and interpolate for intensity

Log Interpolation

	5 Minute Intensity	10 Minute Intensity	
	8.33	6.34	
A	0.80		
B	0.80	i = 10 ^ (AD+C)	
C	0.92		
D	-0.12		
	i		**6.70 in/hr**

Basin 2 Time of Concentration Calculations, 100-YR Storm Event

TC=11.4L^0.5 * Kb^0.52 * S ^-0.31 * i^-0.38

TC	Time of concentration, hours	0.21	12.31 min	Length of Watercourse Slope	
L	Length of longest flowpath, in miles	0.42		0.2813	mi
Kb	Watershed Resistance coefficient	0.030	*Figure 3.1		
S	watercourse slope in, feet/mile	39.11			
i	inches/hour	5.24	*Estimated for 15 minute duration 10 yr event		

L^0.5	0.65		
Kb^0.52	0.16	0.385	Tc=0.32*i^-0.38
S^-0.31	0.32		
i^-0.38	0.53		

Log Interpolation

	10 Minute Intensity	15 Minute Intensity		
	6.34	5.24		
A	0.46			
B	0.72	i = 10 ^ (AD+C)		
C	0.80			
D	-0.08			
	i		5.81	in/hr
	Tc	0.20	11.84	min

Log Interpolation

	10 Minute Intensity	15 Minute Intensity		
	6.34	5.24		
A	0.37			
B	0.72	i = 10 ^ (AD+C)		
C	0.80			
D	-0.08			
	i		5.91	in/hr
	Tc	0.20	11.76	min

Difference between interpolations is less than 2%. Use Tc = 11 min and interpolate for intensity

Log Interpolation

	10 Minute Intensity	15 Minute Intensity		
	6.34	5.24		
A	0.20			
B	0.72	i = 10 ^ (AD+C)		
C	0.80			
D	-0.08			
	i		**6.10**	**in/hr**

Basin 3 Time of Concentration Calculations, 100-YR Storm Event

TC=11.4L^0.5 * Kb^0.52 * S ^-0.31 * i^-0.38

TC	Time of concentration, hours	0.15	9.29 min		Length of Watercourse Slope
L	Length of longest flowpath, in miles	0.21			0.0564 mi
Kb	Watershed Resistance coefficient	0.033	*Figure 3.1		
S	watercourse slope in, feet/mile	35.44			
i	inches/hour	5.24	*Estimated for 15 minute duration 10 yr event		

L^0.5	0.45		
Kb^0.52	0.17	0.291	Tc=0.32*i^-0.38
S^-0.31	0.33		
i^-0.38	0.53		

Log Interpolation

	5 Minute Intensity	10 Minute Intensity		
	8.33	6.34		
A	0.86			
B	0.80	i = 10 ^ (AD+C)		
C	0.92			
D	-0.12			
	i		6.59	in/hr
	Tc	0.14	8.51	min

Log Interpolation

	5 Minute Intensity	10 Minute Intensity		
	8.33	6.34		
A	0.70			
B	0.80	i = 10 ^ (AD+C)		
C	0.92			
D	-0.12			
	i		6.88	in/hr
	Tc	0.14	8.38	min

Difference between interpolations is less than 4%. Use Tc = 8 min and interpolate for intensity

Log Interpolation

	5 Minute Intensity	10 Minute Intensity		
	8.33	6.34		
A	0.60			
B	0.80	i = 10 ^ (AD+C)		
C	0.92			
D	-0.12			
	i		**7.07**	**in/hr**

Basin 4 Time of Concentration Calculations, 100-YR Storm Event

TC=11.4L^0.5 * Kb^0.52 * S ^-0.31 * i^-0.38

TC	Time of concentration, hours	0.24	14.31 min
L	Length of longest flowpath, in miles	0.38	
Kb	Watershed Resistance coefficient	0.040	*Figure 3.1
S	watercourse slope in, feet/mile	31.95	
i	inches/hour	5.24	*Estimated for 15 minute duration 10 yr event

Length of Watercourse Slope=
Length of Longest Flowpath for Basin 4
0.38 mi

L^0.5	0.61		
Kb^0.52	0.19	0.448	Tc=0.32*i^-0.38
S^-0.31	0.34		
i^-0.38	0.53		

Log Interpolation

	10 Minute Intensity	15 Minute Intensity		
	6.34	5.24		
A	0.86			
B	0.72	i = 10 ^ (AD+C)		
C	0.80			
D	-0.08			
	i		5.38	in/hr
	Tc	0.24	14.17	min

Log Interpolation

	10 Minute Intensity	15 Minute Intensity		
	6.34	5.24		
A	0.83			
B	0.72	i = 10 ^ (AD+C)		
C	0.80			
D	-0.08			
	i		5.41	in/hr
	Tc	0.24	14.14	min

Difference between interpolations is less than 4%. Use Tc = 14 min and interpolate for intensity

Log Interpolation

	10 Minute Intensity	15 Minute Intensity		
	6.34	5.24		
A	0.80			
B	0.72	i = 10 ^ (AD+C)		
C	0.80			
D	-0.08			
	i		**5.44**	**in/hr**

Appendix D

Worksheet for Grass-Lined Channel Location 1

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00440	ft/ft
Normal Depth	1.87	ft
Left Side Slope	10.54	ft/ft (H:V)
Right Side Slope	6.93	ft/ft (H:V)
Bottom Width	15.82	ft

Results

Discharge	194.85	ft³/s
Flow Area	60.13	ft²
Wetted Perimeter	48.71	ft
Hydraulic Radius	1.23	ft
Top Width	48.49	ft
Critical Depth	1.31	ft
Critical Slope	0.01843	ft/ft
Velocity	3.24	ft/s
Velocity Head	0.16	ft
Specific Energy	2.03	ft
Froude Number	0.51	
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	1.87	ft
Critical Depth	1.31	ft
Channel Slope	0.00440	ft/ft

Worksheet for Grass-Lined Channel Location 1

GVF Output Data

Critical Slope	0.01843	ft/ft

Worksheet for Grass-Lined Channel Location 2

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00310	ft/ft
Normal Depth	2.58	ft
Left Side Slope	8.66	ft/ft (H:V)
Right Side Slope	4.50	ft/ft (H:V)
Bottom Width	5.84	ft

Results

Discharge	179.36	ft^3/s
Flow Area	58.87	ft^2
Wetted Perimeter	40.22	ft
Hydraulic Radius	1.46	ft
Top Width	39.79	ft
Critical Depth	1.76	ft
Critical Slope	0.01775	ft/ft
Velocity	3.05	ft/s
Velocity Head	0.14	ft
Specific Energy	2.72	ft
Froude Number	0.44	
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	2.58	ft
Critical Depth	1.76	ft
Channel Slope	0.00310	ft/ft

Worksheet for Grass-Lined Channel Location 2

GVF Output Data

Critical Slope	0.01775	ft/ft

Worksheet for Grass-Lined Channel Location 3

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00302	ft/ft
Normal Depth	2.05	ft
Left Side Slope	4.98	ft/ft (H:V)
Right Side Slope	4.71	ft/ft (H:V)
Bottom Width	5.84	ft

Results

Discharge	86.96	ft³/s
Flow Area	32.33	ft²
Wetted Perimeter	26.12	ft
Hydraulic Radius	1.24	ft
Top Width	25.70	ft
Critical Depth	1.33	ft
Critical Slope	0.01903	ft/ft
Velocity	2.69	ft/s
Velocity Head	0.11	ft
Specific Energy	2.16	ft
Froude Number	0.42	
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	2.05	ft
Critical Depth	1.33	ft
Channel Slope	0.00302	ft/ft

Worksheet for Grass-Lined Channel Location 3

GVF Output Data

Critical Slope	0.01903	ft/ft

Worksheet for Allowable cfs for 4" curb - Basin 2

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00811	ft/ft
Normal Depth	0.33	ft
Left Side Slope	50.00	ft/ft (H:V)
Right Side Slope	0.00	ft/ft (H:V)

Results

Discharge	8.32	ft³/s
Flow Area	2.72	ft²
Wetted Perimeter	16.83	ft
Hydraulic Radius	0.16	ft
Top Width	16.50	ft
Critical Depth	0.37	ft
Critical Slope	0.00444	ft/ft
Velocity	3.06	ft/s
Velocity Head	0.15	ft
Specific Energy	0.48	ft
Froude Number	1.33	
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	0.33	ft
Critical Depth	0.37	ft
Channel Slope	0.00811	ft/ft
Critical Slope	0.00444	ft/ft

Worksheet for Allowable cfs for 6" curb - Basin 2

Project Description

Friction Method	Manning Formula	
Solve For	Discharge	

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00811	ft/ft
Normal Depth	0.50	ft
Left Side Slope	50.00	ft/ft (H:V)
Right Side Slope	0.00	ft/ft (H:V)

Results

Discharge	25.19	ft^3/s
Flow Area	6.25	ft^2
Wetted Perimeter	25.50	ft
Hydraulic Radius	0.25	ft
Top Width	25.00	ft
Critical Depth	0.58	ft
Critical Slope	0.00383	ft/ft
Velocity	4.03	ft/s
Velocity Head	0.25	ft
Specific Energy	0.75	ft
Froude Number	1.42	
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	0.50	ft
Critical Depth	0.58	ft
Channel Slope	0.00811	ft/ft
Critical Slope	0.00383	ft/ft

Worksheet for Valley Gutter at Church - Basin 3

Project Description

Friction Method	Manning Formula		
Solve For	Discharge		

Input Data

Roughness Coefficient		0.013	
Channel Slope		0.00560	ft/ft
Normal Depth		0.60	ft
Left Side Slope		33.33	ft/ft (H:V)
Right Side Slope		2.50	ft/ft (H:V)

Results

Discharge		24.63	ft³/s
Flow Area		6.45	ft²
Wetted Perimeter		21.62	ft
Hydraulic Radius		0.30	ft
Top Width		21.50	ft
Critical Depth		0.65	ft
Critical Slope		0.00361	ft/ft
Velocity		3.82	ft/s
Velocity Head		0.23	ft
Specific Energy		0.83	ft
Froude Number		1.23	
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		0.60	ft
Critical Depth		0.65	ft
Channel Slope		0.00560	ft/ft
Critical Slope		0.00361	ft/ft

Worksheet for 18" Storm Drain

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Capacity

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.00720	ft/ft
Normal Depth	1.50	ft
Diameter	1.50	ft
Discharge	8.91	ft³/s

Results

Discharge	8.91	ft³/s
Normal Depth	1.50	ft
Flow Area	1.77	ft²
Wetted Perimeter	4.71	ft
Hydraulic Radius	0.38	ft
Top Width	0.00	ft
Critical Depth	1.16	ft
Percent Full	100.0	%
Critical Slope	0.00815	ft/ft
Velocity	5.04	ft/s
Velocity Head	0.40	ft
Specific Energy	1.90	ft
Froude Number	0.00	
Maximum Discharge	9.59	ft³/s
Discharge Full	8.91	ft³/s
Slope Full	0.00720	ft/ft
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
Average End Depth Over Rise	0.00	%

Worksheet for 18" Storm Drain

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.50	ft
Critical Depth	1.16	ft
Channel Slope	0.00720	ft/ft
Critical Slope	0.00815	ft/ft

Worksheet for Concrete Scupper

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.016	
Channel Slope	0.03400	ft/ft
Normal Depth	0.50	ft
Bottom Width	4.00	ft

Results

Discharge	18.59	ft^3/s
Flow Area	2.00	ft^2
Wetted Perimeter	5.00	ft
Hydraulic Radius	0.40	ft
Top Width	4.00	ft
Critical Depth	0.88	ft
Critical Slope	0.00633	ft/ft
Velocity	9.30	ft/s
Velocity Head	1.34	ft
Specific Energy	1.84	ft
Froude Number	2.32	
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	0.50	ft
Critical Depth	0.88	ft
Channel Slope	0.03400	ft/ft
Critical Slope	0.00633	ft/ft