VOL.1

Hydrology

SSCAFCA CRITERIA MANUAL

SSCAFCA

SSCAFCA Criteria Manual

Volume 1

Hydrology

Table of Contents

Tables

Figures

1 Document Revision History

SSCAFCA Board of Directors Approval Date: April 16, 2020

Revisions:

Version	Date	Description
v1.0	April 2020	Adoption of *SSCAFCA Hydrology Manual*;
v1.1	March 2021	Specified the velocity method as the recommended procedure for estimating time of concentration (see *Transform*, page 14);
v1.2	May 2024	• Changed document formatting to correspond to new Criteria Manual format. Changed document title from "Hydrology Manual" to "SSCAFCA Criteria Manual – Volume 1 – Hydrology" • Removed 90th Percentile Rainfall section

2 Introduction

Volume 1 – Hydrology provides SSCAFCA's requirements for hydrologic analyses within their jurisdiction. There may be other requirements by local, state, and federal agencies in addition to the criteria provided herein.

In general, the criteria set forth in this Chapter must be met for SSCAFCA to consider ownership and/or maintenance responsibility of flood control infrastructure.

SSCAFCA was created in 1990 and initially adopted the City of Albuquerque's drainage guidance. In 2009, SSCAFCA adopted a revised manual outlining procedures for hydrologic analysis and design of flood control structures.

As the agency in charge of planning large scale flood control infrastructure, SSCAFCA continually strives to improve the accuracy of hydrologic analysis within its jurisdiction. In 2007, SSCAFCA began collecting rainfall and runoff data in all its major watersheds. Data collected between 2007 and 2020 was used to calibrate hydrologic models and refine methods for estimating stormwater runoff. Figure 1 illustrates the importance of model calibration for obtaining realistic model results[1].

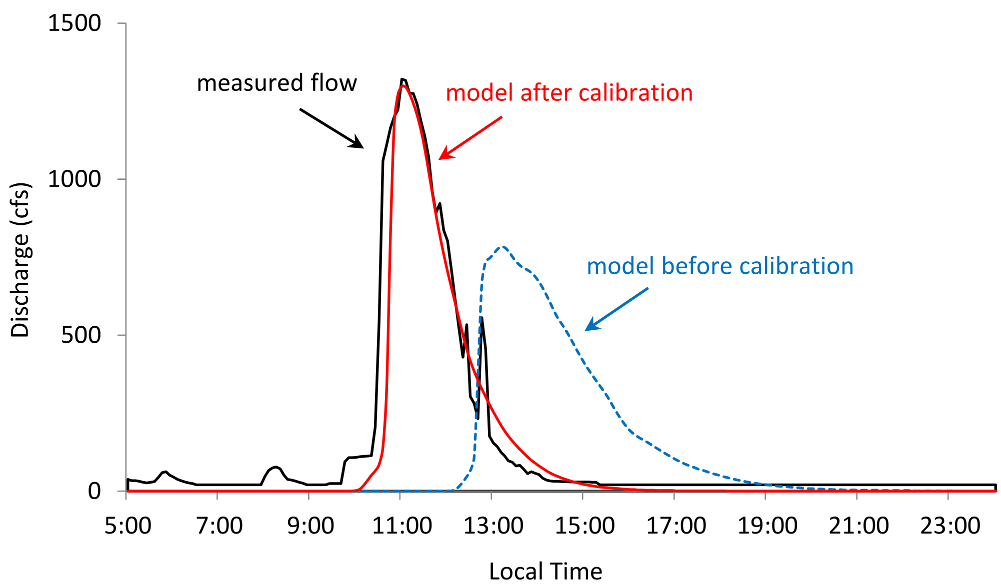

Figure 1: Simulated and measured flow in the Calabacillas Arroyo following the storm of Sep. 13, 2013.

The revised guidelines for hydrologic analysis contained in this document are based on a number of studies conducted by SSCAFCA:

- A paper assessing the impact of different modeling approaches for impervious surfaces in a 0.6 mi^2 urban basin located in the City of Rio Rancho[2];

[1] SSCAFCA (2015)
[2] Schoener (2017)

- Rainfall simulator test carried out on different soils throughout SSCAFCA's jurisdictional area to quantify infiltration and runoff under controlled conditions[3];
- A calibrated hydrologic model of the 1.1 mi^2 Arroyo 19A watershed on Albuquerque's west side; the entire basin is in its natural state. Hydrologic analysis was based on 20 years of rainfall-runoff data (1992-2013) collected by the U.S. Geological Survey[3];
- A detailed hydrologic study of the 61 mi^2 Montoyas watershed; the underlying model was calibrated and validated using 13 storm events that occurred between 2008 and 2018. Both the model and associated documentation were reviewed by the U.S. Army Corps of Engineers Albuquerque District[4].

The main changes to SSCAFCA's drainage guidelines are:

- HEC-HMS is the recommended software for rainfall-runoff modeling;
- The curve number method should be used to simulate rainfall loss and excess;
- The design storm temporal distribution to be used is the frequency storm available in HEC-HMS.

Two case studies for subdivision-scale areas[5] show that the differences in peak discharge and runoff volume from a typical urban subdivision using the new methods are expected to be small.

This is a working document. SSCAFCA welcomes feedback, suggestions, and corrections to the information within. SSCAFCA may periodically update the document, and the most current version will be available on SSCAFCA's website (https://www.sscafca.org).

3 Hydrology

The objective of the hydrology section of this manual is to provide technical guidance for estimating runoff from hypothetical storms of varying magnitudes to:

(1) assess the impact of land use changes on runoff hydrographs;
(2) appropriately size stormwater infrastructure to avoid flooding;
(3) evaluate water quality implications of urban development; and
(4) support delineation of lateral erosion envelopes and other management strategies for the preservation of natural arroyos.

Hydrologic analyses are conducted using rainfall-runoff modeling.

[3] Schoener and Stone (2019)
[4] See Appendix B
[5] See Appendix C

3.1 Rainfall-Runoff Modeling

Rainfall-runoff modeling should be conducted using the latest version of the U.S. Army Corps of Engineers HEC-HMS software. The HEC-HMS program and documentation is available free of charge from the Hydrologic Engineering Center website http://www.hec.usace.army.mil/software/hec-hms/ .

Rainfall-runoff models consist of four major components:

(1) Rainfall – the real or hypothetical storm of interest;
(2) Rainfall Loss – that portion of precipitation that does not become runoff due to processes such as infiltration, interception or depression storage;
(3) Transform – a method that converts excess precipitation from the area of interest into a runoff hydrograph; and
(4) Flood Routing – simulating the movement of a flood wave through a channel, pipe or pond.

For each of the four model components, a multitude of methods exist within the HEC-HMS software. The following section of this document describes the recommended methods for hydrologic analysis in the SSCAFCA area. Other methods and /or other rainfall-runoff models may be acceptable to SSCAFCA and other reviewing agencies, but need to be justified and should be discussed with the reviewing agency early-on in the project before proceeding.

3.1.1 Rainfall - Flood Control Design Storm

The flood control design storm is a hypothetical storm used to determine a design runoff volume and peak discharge. The design storm for peak discharge estimation and design of ponds and dams is the 100-year 24-hour storm. The 500-year 24-hour storm is used for sizing emergency spillways. If a proposed structure falls under the jurisdiction of the New Mexico Office of the State Engineer, guidelines set forth by the Dam Safety Bureau shall be followed (http://www.ose.state.nm.us/DS/dsIndex.php).

The design storm should be simulated in the latest version of HEC-HMS using the frequency storm option. The following input parameters are required[6]:

[6] This guidance was developed based on HEC-HMS version 4.2.1. Parameters may vary in other versions of the software.

HEC-HMS model parameters, flood control design storm	
Probability:	*This is the inverse of the return period and indicates the probability of a storm occurring in any given year; choices are 50% (2-year storm), 20% (5-year storm), 10% (10-year storm), and "Other" for all other probabilities such as the 1% (100-year) storm and 0.2% (500-year) storm for pond emergency spillway design*
Input Type:	*Select Partial Duration*
Intensity Duration:	*Select 5 Minutes*
Storm Duration:	*1 Day*
Intensity Position:	*Select 25%; this determines the period of peak rainfall intensity*
Storm Area:	*This field is used to calculate the depth-area reduction factor and should be left blank in most cases, except for sizing large regional flood control infrastructure with a contributing drainage area exceeding ten square miles*
Partial-Duration Depth:	*This data is obtained from the NOAA Precipitation Frequency Data Server (PFDS):* *https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nm* *The location should be selected at the centroid of contributing drainage basins; please submit the project specific point precipitation frequency estimate table obtained from PFDS as part of any drainage submittal.*

Depth-area reduction can be used to adjust point precipitation estimates for large basins. This is accomplished by entering the watershed size under "*Storm Area*" (see above). This adjustment, however, should only be used for very large basins with a contributing drainage area exceeding ten square miles (USACE 2000; WMO 1994). Moreover, caution is necessary when using depth-area reduction: when a storm area is entered, the program adjusts rainfall depths for the entire model. Results for smaller subbasins may therefore be underestimated.

The HEC-HMS should be run with a time step equal to or smaller than the intensity duration (i.e. 5 minutes or less).

3.1.2 Rainfall Loss

The recommended rainfall loss methodology is the curve number method (USDA, 2004a). The curve number equation is:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}$$

where Q (in) is the direct runoff, P (in) is the cumulative precipitation, I_a (in) is the initial abstraction, and S (in) is the maximum potential retention after runoff begins. The curve number (CN) is a transformation of S, whereby:

$$CN = \frac{1000}{10 + S}$$

As implemented in HEC-HMS, the curve number method allows specification of three parameters: initial abstraction, curve number, and percent impervious area.

3.1.2.1 Initial Abstraction

While the initial abstraction can be user specified, it is often calculated as:

$$I_a = 0.2\,S$$

This is the default in HEC-HMS and should be used for hydrologic analysis in the SSCAFCA area (initial abstraction field is left blank).

3.1.2.2 Urban Imperviousness

Impervious surfaces are one of the critical factors influencing the rainfall runoff relationship in urban areas, particularly for small frequent storms such as the water quality storm (Schoener, 2017). Impervious surfaces can be divided into two categories: directly connected and unconnected (Figure 2). Directly Connected Impervious Areas (DCIA) comprise all surfaces with a direct connection to the drainage system. Impervious areas that drain onto pervious surfaces, e.g. rooftop areas that drain onto landscaping, are considered Unconnected Impervious Areas (UIA). This distinction is important during small storm events because some or all of the runoff from UIA may spread over pervious surfaces, where it is subject to losses due to depression storage and infiltration, before it reaches the drainage system.

Directly Connected Impervious Areas (DCIA) comprise all surfaces with a direct connection to the drainage system, e.g. paved roads, driveways, parking lots, and rooftop areas that drain onto paved areas.

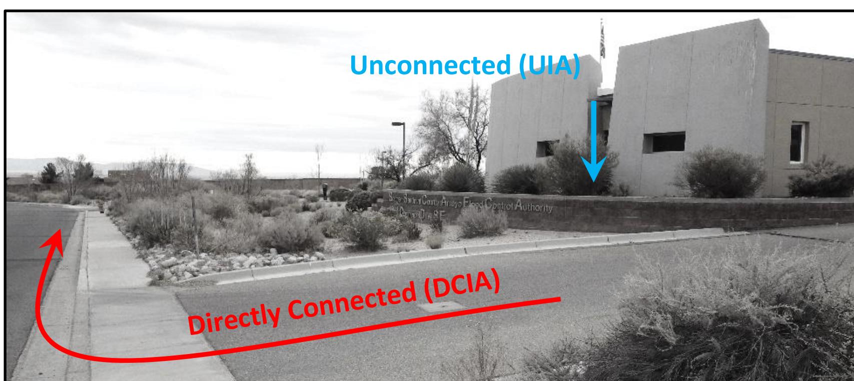

Figure 2: Example of DCIA (red arrow, driveway) and UIA (blue arrow, roof downspout into pervious planter) at the SSCAFCA office building.

DCIA include paved roads, driveways, parking lots, and rooftop areas that drain onto paved areas. Special emphasis should be placed on delineating DCIA in the area to be modeled. In HEC-HMS, DCIA for each subbasin must be specified as *percent impervious area.* All precipitation falling on that portion of the subbasin becomes direct runoff. Unconnected impervious areas are included in the composite curve number calculation (see below). This approach is commonly referred to as the split hydrograph method because a runoff hydrograph for DCIA is computed separately from pervious areas and UIA. The two hydrographs are then added together to obtain a composite hydrograph for the subbasin.

Table 1 lists major sources of urban imperviousness and recommended proportion of DCIA and UIA. For master-planned residential developments, DCIA and UIA do not have to be delineated on a lot-by-lot basis. For example, average roof and driveway areas can be estimated using a representative sub-set of lots from an existing subdivision within SSCAFCA's jurisdiction with similar land use densities. This can be accomplished using orthophotography available from SSCAFCA or with the aid of free services such as Google Earth. Imperviousness associated with roadways should be estimated based on approved platting. Commercial areas should be assessed on a case-by-case basis.

The drainage report should include a short description of the method used to determine DCIA and UIA percentages accompanied by figures where appropriate. Values in Table 1 can be adjusted based on site-specific conditions with appropriate justification.

Table 1: Major sources of urban imperviousness.

Land Cover	DCIA	UIA
Residential roof	50%	50%
Backyard impervious (paved patio, shed roof, etc.)	0%	100%
Residential driveway	100%	0%
Commercial parking lot	100%	0%
Commercial roof	100%	0%
Road (with curb and gutter, storm drain)	100%	0%
Sidewalk (separated from road by pervious buffer)	0%	100%
Rural road (without curb and gutter, storm drain)	0%	100%

3.1.2.3 Composite Curve Number

One curve number must be specified for each subbasin within the model. Curve numbers theoretically range from 0 to 100 and depend on soil type and condition, vegetation, and moisture conditions, among other factors. Curve numbers are often estimated based on hydrologic soil group and cover type (USDA 2004a). Hydrologic soil groups in turn are obtained from NRCS soils maps. However, evidence from the published literature suggests that mapped hydrologic soil groups are not good predictors for curve numbers for the area covered by this manual (Heggen 1987, Ward and Bolton 2010, Schoener and Stone 2019). This can be attributed – at least in part – to the level of detail underlying the mapping effort. According to the NRCS Soil Survey of Sandoval County "most of the survey area is used as rangeland, and mapping was performed at a less detailed level. The mapping units in this area are broadly defined. Soil boundaries were plotted and verified at widely spaced intervals. In general, these mapping units are less homogeneous and contain more minor soil component areas than the more detailed mapping units. These units are designed primarily for planning the

> Mapped hydrologic soil groups are not good predictors for curve numbers for the area covered by this manual. Onsite investigation is essential to provide the detail needed for planning intensive land uses.

management of large tracts of land as rangeland. They provide general information for development, but the information should be used with caution. Onsite investigation is essential to provide the detail needed for planning intensive land uses." (Hacker and Banet, 2008, pg. 20-21).

Until more detailed soils maps become available and a correlation between mapped soils and curve numbers can be established, Table 2 and Table 3 should be used as guidance for estimating curve numbers in the area covered by this manual.

Table 2: Runoff curve numbers.

Major Land Use Categories	CN	Description
Directly Connected Impervious Areas (DCIA) [3]	See note [4]	Impervious areas that <u>are</u> directly connected to the drainage system. See urban land uses below for examples
Unconnected Impervious Areas (UIA) [2]	98	Impervious areas that <u>are not</u> directly connected to the drainage system. See urban land uses below for examples
Graded/Compacted Areas [2]	86	Soils graded and/or compacted by driving or construction activity
Open Space [1]	70 – 80	Natural areas undisturbed by human activity; see text for explanation of CN range; use CN=80 if no justification is provided (see Table 4)
Undisturbed Residential Yards [1]	70 – 80	Yards in residential subdivisions that are undisturbed or minimally impacted by construction activity can be considered equivalent to open space; use CN=80 if no justification is provided (see Table 4)
Residential yard in mass-graded subdivision	80	Minimal vegetation and landscaping
Natural Desert Landscaping [2]	77	Only landscaping without impervious weed barrier, gravel mulch
Artificial Desert Landscaping [2]	96	Impervious weed barrier, gravel mulch
Unpaved Roads (including right-of-way) [2]	82	Graded dirt and gravel roads
Park, Lawn [2]	68	Areas covered by irrigated turf
Urban Land Uses		
Single-Family Residential	Land use categories for master-planned residential developments do not have to be delineated on a lot-by-lot basis; it is acceptable to estimate major land use types from a representative sub-set of lots.	
DCIA	See note [4]	e.g. streets, driveways, 50% of roof area draining directly onto driveway or paved street
UIA	98	e.g. 50% of roof area draining onto pervious landscaping, paved backyard patio or shed
Commercial, Office, Multi-Family Residential, Industrial	DCIA should be delineated with care, as it is a major contributor to developed runoff.	
DCIA	See note [4]	Paved parking and roof areas draining to storm drain inlet or paved street
UIA	98	Sidewalk with pervious buffer, paved parking draining to depressed landscaping
Other Urban Land Uses (School, Church, etc.)	Perform site-specific evaluation; distinguish site-specific DCIA, UIA, and pervious areas.	

[1] SSCAFCA 2019; [2] USDA 2004b; [3] Schoener 2017;

[4] All DCIA shall be modeled in HEC-HMS as *Percent Impervious*.

A range of curve numbers is provided for open space areas and undisturbed residential yards. This range is based on several studies conducted by SSCAFCA: rainfall simulator testing carried out on area soils (Schoener and Stone 2019), and hydrologic models for two watersheds calibrated based on measured rainfall/runoff data (SSCAFCA 2019, Schoener and Stone 2019). Curve number variability is due to rainfall intensity and duration, cumulative precipitation, soil moisture conditions, and local variations in soil and cover type (USDA, 2004b). Ultimate selection of pervious area curve numbers requires some judgement by the modeler and should be justified.

Table 3 can be used to estimate curve numbers for open space and undisturbed residential yards based on ground cover and soil texture or percent fines. Both methods (using soil texture or using percent fines) are acceptable, and only one has to be used.

Percent fines can be determined from particle size analysis; as an alternative to laboratory testing, use of the NRCS field guide to estimate soil texture by feel is acceptable (see Appendix D). At least 10 samples per square mile, but no less than 3 samples for any proposed development should be analyzed. Soil samples should be retrieved from the top 6 inches of the soil profile. Ground cover should also be estimated in the field. Soils with fines content >50% or clay content >20% are not common in SSCAFCA's jurisdiction with the exception of the Rio Grande valley. Should such soils be encountered, higher curve numbers should be used (see Table 3, right hand column).

Table 3: Guidelines for CN selection – open space and undisturbed residential yards.

	Curve Numbers for Soil Textures			
	Sand	Loamy Sand	Sandy Loam	Sandy Clay Loam, Sandy Clay, Loam
Ground cover	(0-15% Fines)	(15-30% Fines)	(30-50% Fines)	(>50% Fines or >20% Clay)
< 30%	72	76	80	88
30-70%	70	74	78	86

NRCS field guide

or

Particle size analysis

Estimated texture classes should be included in the drainage report as a justification for curve number selection (see section *Documentation*, page 17). CN=80 should be used for open space and undisturbed residential yards if no soil texture and ground cover-based justification is provided.

Subbasins should be delineated as homogeneously as possible with respect to soil texture, land use characteristics, subbasin size, basin shape and predominant land slope. In areas where multiple land use types exist within one subbasin, a composite curve number representative of the entire subbasin should be calculated as the area-weighted average of individual land use categories (see example calculation below). If a large discrepancy between pervious area curve numbers exist, subbasins should be split to achieve more uniform land use categories.

Unconnected impervious areas are included in this weighted average using a curve number value of 98.

Example:

A 5 square mile subbasin has the following land cover characteristics and associated curve numbers:

Table 4: Sample composite curve number calculation.

Land use	Area (mi^2)	Curve Number
Directly connected impervious areas (DCIA)	1.2	Accounted for as % Impervious
Unconnected impervious areas (UIA)	0.7	98
Compacted areas	0.8	86
Open space[1]	2.3	76
Total Area	5	
Pervious + UIA	3.8	

[1] Open space CN for loamy sand, <30% ground cover (see Table 3)

The percent impervious area is the fraction of the subbasin covered by DCIA:

$$DCIA = \frac{1.2}{5.0} = 24\%$$

The composite curve number is calculated as the area weighted average of the pervious land use types and unconnected impervious areas:

$$CN_{COMP} = \frac{0.7}{3.8} * 98 + \frac{0.8}{3.8} * 86 + \frac{2.3}{3.8} * 76 = 82$$

Only pervious areas and UIA (3.8 mi^2) are used in the calculation because DCIA is already accounted for.

The following loss parameters must be specified in HEC-HMS:

HEC-HMS model parameters, curve number loss method

Initial Abstraction (in): *Blank (by leaving this field blank, the model uses the default of $I_a = 0.2\, S$)*

Curve Number: *Enter the composite subbasin curve number*

Impervious (%): *% DCIA*

3.1.2.4 Antecedent Moisture Conditions

Antecedent soil moisture is an important factor in the generation of runoff. High initial moisture content leads to substantially higher runoff from a given storm event. In the context of the curve number loss methodology, this means that an area with a given soil and cover type will have a lower curve number (= less runoff) if soils are dry at the onset of the storm. Curve numbers reported in Table 2 and Table 3 can be interpreted as intermediate conditions and are appropriate for most analyses.

Sensitivity analysis including wet conditions runoff may be requested at the discretion of the Executive Engineer for regional flood control infrastructure (i.e. regional stormwater detention facilities, road crossings of major arroyos, major flood control conveyances).

3.1.3 Transform

The Soil Conservation Service (SCS) unit hydrograph is the recommended transform method for the area covered by this manual. Typically, it should be used with the standard graph type (PRF 484). The lag time – defined as the length of time between the centroid of precipitation mass and peak flow – is estimated as 60% of the time of concentration (T_c). T_c is the time required for runoff to travel from the hydraulically most distant point of the subbasin to the basin outlet or concentration point. T_c is estimated based on the velocity method described in National Engineering Handbook chapter 15 (USDA 2010). SSCAFCA may choose a different transform method for regional models, for example in cases where measured rainfall/runoff data is available for model calibration.

HEC-HMS model parameters, SCS Unit Hydrograph transform	
Graph Type:	*Standard (PRF 484)*
Lag Time (min):	*Enter subbasin-specific lag time*

3.1.4 Flood Routing

In analyses where the area of interest is subdivided into multiple subbasins, and runoff from upper subbasins moves through channels or storm drain pipes to the outlet, flood routing must be used to account for the travel time and peak flow attenuation as the flood wave moves downstream. In HEC-HMS, the Muskingum-Cunge routing method should be used. The following parameters must be specified:

HEC-HMS model parameters, Muskingum-Cunge routing method	
Time Step Method:	*Automatic fixed interval*
Length (ft):	*Total length of the reach*
Slope (ft/ft):	*Average bed slope; if the reach contains drop structures, the slope should be calculated as the average channel bed slope between drop structures and not account for the height of the drop (see Figure 3)*
Manning's n:	*Average roughness coefficient for the entire reach; common roughness coefficients are listed in Table 5.*
Invert:	*Blank*
Shape:	*Circle, Eight Point, Rectangle, Trapezoid or Triangle*

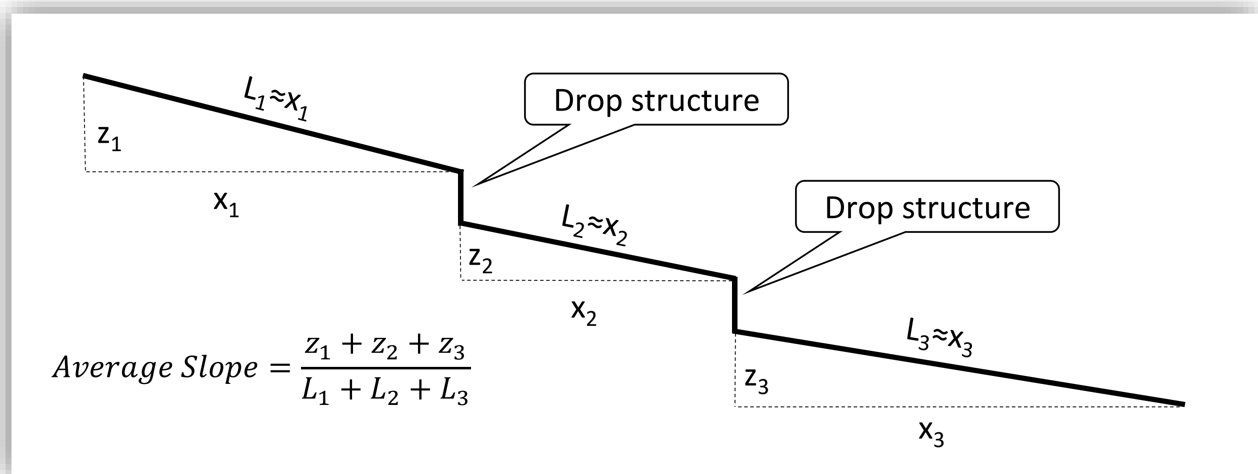

Figure 3: Slope calculation in channels with drop structures.

Table 5: Recommended base values of Manning's n.

Channel Type	Manning's n value
Sand channel/arroyo[1]	0.020 - 0.035
Troweled concrete	0.013
Tined concrete	0.018
Shotcrete	0.025
Streets (asphalt)	0.017
Reinforced concrete pipe	0.013
Corrugated metal pipe	0.025

[1] *depending on bed material and flow regime*

Flow resistance is affected by many factors including bed material size, bedforms, flow depth, vegetation, channel irregularities and obstructions. Adjustment of n-values listed in Table 5 may be necessary in some cases. For more information and values for materials not listed in Table 5, please refer to SSCAFCA's Sediment and Erosion Design Guide (2008) and other appropriate publications (e.g. Brater et al. 1996).

Routing reaches should be fairly uniform with respect to slope and cross-section; if either varies considerably, the reach should be subdivided.

3.2 Transmission Losses

Arroyo sediments often have much higher infiltration rates than soils of the surrounding land surface. As runoff flows through an arroyo, a portion of the stormwater infiltrates into the alluvial sediments. These so-called transmission losses can have a substantial impact on peak discharge and runoff volume, particularly during frequent, low intensity storm events (Schoener, 2016). Only catchment-scale models should account for transmission losses in the main stem of major arroyos. Typically, models of that scale will be maintained by SSCAFCA. Approval by SSCAFCA is required before accounting for transmission losses in models of smaller spatial scale.

3.3 Sediment Bulking

Stormwater runoff within SSCAFCA's jurisdictional area typically carries large amounts of sediment. A bulking factor is therefore added to clearwater discharges to account for increased runoff volumes. Bulking factors are 18% for open space and 6% for urbanized areas with paved roads and curb and gutter. For subbasins counting both open space and urbanized land uses, an area-averaged bulking factor should be used. Bulking factors can be modeled in HEC-HMS by assigning an appropriate flow ratio (e.g. 1.06 and 1.18 for bulking factors of 6% and 18%, respectively) to each subbasin element. Please note that flow ratios must first be enabled for a basin model before they are available for subbasins within the basin model. .

3.4 Pond Routing

Flow through stormwater detention ponds should be routed using the elevation-storage-discharge or elevation-area-discharge method. The following parameters are required:

Method:	*Outflow Curve*
Storage Method:	*Elevation-Storage-Discharge*
Stor-Dis Function or Elev-Area Function:	*Select appropriate table*
Elev-Stor Function or Elev-Dis Function:	*Select appropriate table*
Primary:	*Storage-Discharge*
Initial Condition:	*Storage*
Initial Storage (AC-FT):	*0*

4 Reporting & Submittal Requirements

Documentation accompanying each submittal should include the following information:

- Version of HEC-HMS used to compute runoff;
- Design storm precipitation frequency estimate table for the centroid of all contributing drainage basins;
- Basin boundary map;
- Description of existing conditions model;
- Existing conditions model parameters and results for each subbasin (see Table 7);
- Description of developed conditions model with proposed infrastructure in place;
- Developed conditions model parameters and results for each subbasin (see Table 7); this should include a brief discussion of how imperviousness (DCIA and UIA) was estimated;
- Table of soil samples results to justify curve number selection for open space/undisturbed residential yards (see Table 6); and
- Detailed table for each proposed pond (see Table 8), along with a description of the principal and emergency spillways. Incremental elevations should be no more than one foot. If a ported riser is used, information describing the structure (number of ports, top elevation) should be included in the notes section of the table.

Table 6: Sample table for estimation of soil textures.

Location	Lat	Long	Soil texture	Source
SW quadrant of Southern Blvd. and User Blvd.	35.239848	-106.701032	Sand	Estimate using NRCS field guide [1]
	35.240704	-106.701481	Loamy sand	Laboratory analysis [2]

[1] *see Appendix D*
[2] *if laboratory analysis was performed, please include results as an attachment to the report*

Table 7: Sample table to be included in the drainage submittal specifying model parameters and results for each subbasin.

Subbasin ID	Basin 1	
Scenario	Existing Conditions	
Impervious (DCIA)	**Area (mi^2)**	**%**
Total area	0.5000	100%
DCIA	0.0625	12.5%
Pervious and UIA	0.4375	87.5%
Composite CN calculation	**Area (mi^2)**	**CN**
UIA	0.0075	98
Compacted	0.0300	86
Open space (sand, >30% ground cover)	0.2000	72
Natural Desert landscaping	0.2000	77
Composite CN		76

Transform parameters	min
Lag time	30

Design storm parameters	Cumulative precipitation (in)
100-yr 24-hr	2.90
500-yr 24-hr *	3.61
Water quality storm *	0.66

Model results	Peak discharge (cfs)	Runoff volume (ac-ft)
100-yr 24-hr	260	31.8
500-yr 24-hr *	405	45.7
Water quality storm *	26	2.2

* *if applicable*

Table 8: Sample table to be included in the drainage submittal for each stormwater detention pond.

		Discharge			
Elevation	**Cumulative Storage[1]**	**Principal Spillway**	**Emergency Spillway**	**Total**	**Notes**
ft)	(ac-ft)	(cfs)	(cfs)	(cfs)	
5492	0.00	0.0	0.0	0.0	Pond and principal spillway invert
5493	0.10	4.0	0.0	4.0	
5494	0.36	13.3	0.0	13.3	
5495	0.81	18.7	0.0	18.7	
5496	1.47	21.6	0.0	21.6	100-year WSE (5496.4 ft)
5497	2.34	24.2	0.0	24.2	Emergency spillway invert
5498	3.40	26.5	260.0	286.5	
5499	4.63	28.6	735.4	764.0	
5500	5.98	30.6	1351.0	1381.6	

[1] *or area (ac) if using elevation-area-discharge method*

5 References

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