Introduction

The Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA) was created in 1990 by the New Mexico State Legislature to address flooding problems in the southern portion of Sandoval County. SSCAFCA initially applied the City of Albuquerque drainage guidance. In 2009, SSCAFCA and the City of Rio Rancho 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 over the past 12 years has been used to calibrate hydrologic models and refine methods for estimating stormwater runoff. Figure 1 illustrates the importance of model calibration for obtaining realistic model results¹.

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

¹ SSCAFCA (2015)
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 mi² urban basin located in the City of Rio Rancho²;
- Rainfall simulator test carried out on different soils throughout SSCAFCA’s jurisdictional area to quantify infiltration and runoff under controlled conditions³;
- A calibrated hydrologic model of the 1.1 mi² 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 Survey³;
- A detailed hydrologic study of the 61 mi² 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 District⁴.

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 areas⁵ show that the differences in peak discharge and runoff volume from a typical urban subdivision using the new methods are expected to be small.

---

² Schoener (2017)
³ Schoener and Stone (2019)
⁴ See Appendix B
⁵ See Appendix C
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;
4. support delineation of lateral erosion envelopes and other management strategies for the preservation of natural arroyos.

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;
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 jurisdiction. 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.

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:

**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?bk_mrk=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.

---

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

**Rainfall – 90th Percentile Storm**

According to the NPDES General Permit (USEPA, 2014) governing SSCAFCA’s jurisdictional area, runoff from the 90th percentile storm has to be managed on-site for all new development “through stormwater controls that infiltrate [or] evapotranspire the discharge volume, ...” (see NPDES Permit No. NMR04A000, pg. 28). EPA publication 832-R-15-009 (2015) referenced in the NPDES permit defines cumulative precipitation from the 90th percentile storm in the Albuquerque metropolitan area as 0.65 inches based on the rain gauge located at the Albuquerque International Airport. The value is consistent with an analysis by SSCAFCA using rain gauge data from stations in the Rio Rancho area (see Appendix A).

The 90th percentile cumulative precipitation is also equivalent to the annual 2-hour storm in the SSCAFCA jurisdiction. The following frequency storm parameters should therefore be used when modeling the 90th percentile storm:

<table>
<thead>
<tr>
<th><strong>HEC-HMS model parameters, water quality storm</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Probability:</strong> Other</td>
</tr>
<tr>
<td><strong>Input Type:</strong> Partial Duration</td>
</tr>
<tr>
<td><strong>Intensity Duration:</strong> 5 Minutes</td>
</tr>
<tr>
<td><strong>Storm Duration:</strong> 2 Hours</td>
</tr>
<tr>
<td><strong>Intensity Position:</strong> 25%</td>
</tr>
<tr>
<td><strong>Storm Area:</strong> Blank</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Partial-Duration Depth:</strong></th>
<th><strong>Duration</strong></th>
<th><strong>Partial-Duration Depth (in)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Minutes</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>15 Minutes</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>1 Hour</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>2 Hours</td>
<td>0.65</td>
<td></td>
</tr>
</tbody>
</table>
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.

Initial Abstraction

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

\[ I_a = 0.2 \times S \]

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

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.

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.

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

<table>
<thead>
<tr>
<th>Major Land Use Categories</th>
<th>CN</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directly Connected Impervious Areas (DCIA) ³</td>
<td>See note ⁴</td>
<td>Impervious areas that are directly connected to the drainage system. See urban land uses below for examples</td>
</tr>
<tr>
<td>Unconnected Impervious Areas (UIA) ²</td>
<td>98</td>
<td>Impervious areas that are not directly connected to the drainage system. See urban land uses below for examples</td>
</tr>
<tr>
<td>Graded/Compacted Areas ²</td>
<td>86</td>
<td>Soils graded and/or compacted by driving or construction activity</td>
</tr>
<tr>
<td>Open Space ¹</td>
<td>70 – 80</td>
<td>Natural areas undisturbed by human activity; see text for explanation of CN range; use CN=80 if no justification is provided (see Table 4)</td>
</tr>
<tr>
<td>Undisturbed Residential Yards ¹</td>
<td>70 – 80</td>
<td>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)</td>
</tr>
<tr>
<td>Residential yard in mass-graded subdivision</td>
<td>80</td>
<td>Minimal vegetation and landscaping</td>
</tr>
<tr>
<td>Natural Desert Landscaping ²</td>
<td>77</td>
<td>Only landscaping without impervious weed barrier, gravel mulch</td>
</tr>
<tr>
<td>Artificial Desert Landscaping ²</td>
<td>96</td>
<td>Impervious weed barrier, gravel mulch</td>
</tr>
<tr>
<td>Unpaved Roads (including right-of-way) ²</td>
<td>82</td>
<td>Graded dirt and gravel roads</td>
</tr>
<tr>
<td>Park, Lawn ²</td>
<td>68</td>
<td>Areas covered by irrigated turf</td>
</tr>
</tbody>
</table>

Urban Land Uses

<table>
<thead>
<tr>
<th>Land Use Category</th>
<th>DCIA</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family Residential</td>
<td>See note ⁴</td>
<td>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.</td>
</tr>
<tr>
<td>DCIA</td>
<td>e.g. streets, driveways, 50% of roof area draining directly onto driveway or paved street</td>
<td></td>
</tr>
<tr>
<td>UIA</td>
<td>e.g. 50% of roof area draining onto pervious landscaping, paved backyard patio or shed</td>
<td></td>
</tr>
<tr>
<td>Commercial, Office, Multi-Family Residential, Industrial</td>
<td>DCIA</td>
<td>DCIA should be delineated with care, as it is a major contributor to developed runoff.</td>
</tr>
<tr>
<td>DCIA</td>
<td>See note ⁴</td>
<td>Paved parking and roof areas draining to storm drain inlet or paved street</td>
</tr>
<tr>
<td>UIA</td>
<td>Sidewalk with pervious buffer, paved parking draining to depressed landscaping</td>
<td></td>
</tr>
<tr>
<td>Other Urban Land Uses (School, Church, etc.)</td>
<td>Perform site-specific evaluation; distinguish site-specific DCIA, UIA, and pervious areas.</td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Ground cover</th>
<th>Curve Numbers for Soil Textures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sand</td>
</tr>
<tr>
<td>&lt; 30%</td>
<td>72</td>
</tr>
<tr>
<td>30-70%</td>
<td>70</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Land use</th>
<th>Area (mi²)</th>
<th>Curve Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directly connected impervious areas (DCIA)</td>
<td>1.2</td>
<td>Accounted for as % Impervious</td>
</tr>
<tr>
<td>Unconnected impervious areas (UIA)</td>
<td>0.7</td>
<td>98</td>
</tr>
<tr>
<td>Compacted areas</td>
<td>0.8</td>
<td>86</td>
</tr>
<tr>
<td>Open space¹</td>
<td>2.3</td>
<td>76</td>
</tr>
<tr>
<td><strong>Total Area</strong></td>
<td><strong>5</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Pervious + UIA</strong></td>
<td><strong>3.8</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Land use</th>
<th>Area (mi²)</th>
<th>Curve Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directly connected impervious areas (DCIA)</td>
<td>1.2</td>
<td>Accounted for as % Impervious</td>
</tr>
<tr>
<td>Unconnected impervious areas (UIA)</td>
<td>0.7</td>
<td>98</td>
</tr>
<tr>
<td>Compacted areas</td>
<td>0.8</td>
<td>86</td>
</tr>
<tr>
<td>Open space¹</td>
<td>2.3</td>
<td>76</td>
</tr>
<tr>
<td><strong>Total Area</strong></td>
<td><strong>5</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Pervious + UIA</strong></td>
<td><strong>3.8</strong></td>
<td></td>
</tr>
</tbody>
</table>

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:

\[
CN_{COMP} = \frac{0.7}{3.8} \times 98 + \frac{0.8}{3.8} \times 86 + \frac{2.3}{3.8} \times 76 = 82
\]

Only pervious areas and UIA (3.8 mi²) are used in the calculation because DCIA is already accounted for.

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

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 methods described in National Engineering Handbook chapter 15 (USDA 2010). SCAFCA may choose a different transform method for regional models, for example in cases where measured rainfall/runoff data is available for model calibration.
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:

<table>
<thead>
<tr>
<th>HEC-HMS model parameters, Muskingum-Cunge routing method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time Step Method:</strong></td>
</tr>
<tr>
<td><strong>Length (ft):</strong></td>
</tr>
<tr>
<td><strong>Slope (ft/ft):</strong></td>
</tr>
<tr>
<td><strong>Manning’s n:</strong></td>
</tr>
<tr>
<td><strong>Invert:</strong></td>
</tr>
<tr>
<td><strong>Shape:</strong></td>
</tr>
</tbody>
</table>

\[
\text{Average Slope} = \frac{z_1 + z_2 + z_3}{L_1 + L_2 + L_3}
\]

Figure 3: Slope calculation in channels with drop structures.
Table 5: Recommended base values of Manning’s n.

<table>
<thead>
<tr>
<th>Channel Type</th>
<th>Manning’s n value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand channel/arroyo¹</td>
<td>0.020 - 0.035</td>
</tr>
<tr>
<td>Troweled concrete</td>
<td>0.013</td>
</tr>
<tr>
<td>Tined concrete</td>
<td>0.018</td>
</tr>
<tr>
<td>Shotcrete</td>
<td>0.025</td>
</tr>
<tr>
<td>Streets (asphalt)</td>
<td>0.017</td>
</tr>
<tr>
<td>Reinforced concrete pipe</td>
<td>0.013</td>
</tr>
<tr>
<td>Corrugated metal pipe</td>
<td>0.025</td>
</tr>
</tbody>
</table>

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.

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.
**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.

**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:

<table>
<thead>
<tr>
<th><strong>Method:</strong></th>
<th><strong>Outflow Curve</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage Method:</strong></td>
<td><strong>Elevation-Storage-Discharge</strong></td>
</tr>
<tr>
<td><strong>Stor-Dis Function or Elev-Area Function:</strong></td>
<td><strong>Select appropriate table</strong></td>
</tr>
<tr>
<td><strong>Elev-Stor Function or Elev-Dis Function:</strong></td>
<td><strong>Select appropriate table</strong></td>
</tr>
<tr>
<td><strong>Primary:</strong></td>
<td><strong>Storage-Discharge</strong></td>
</tr>
<tr>
<td><strong>Initial Condition:</strong></td>
<td><strong>Storage</strong></td>
</tr>
<tr>
<td><strong>Initial Storage (AC-FT):</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>
Documentation

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);
- 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.

<table>
<thead>
<tr>
<th>Location</th>
<th>Lat</th>
<th>Long</th>
<th>Soil texture</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW quadrant of Southern Blvd. and User Blvd.</td>
<td>35.239848</td>
<td>-106.701032</td>
<td>Sand</td>
<td>Estimate using NRCS field guide (^1)</td>
</tr>
<tr>
<td></td>
<td>35.240704</td>
<td>-106.701481</td>
<td>Loamy sand</td>
<td>Laboratory analysis (^2)</td>
</tr>
</tbody>
</table>

\(^1\) 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.

<table>
<thead>
<tr>
<th>Subbasin ID</th>
<th>Basin 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario</td>
<td>Existing Conditions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impervious (DCIA)</th>
<th>Area (mi²)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area</td>
<td>0.5000</td>
<td>100%</td>
</tr>
<tr>
<td>DCIA</td>
<td>0.0625</td>
<td>12.5%</td>
</tr>
<tr>
<td>Pervious and UIA</td>
<td>0.4375</td>
<td>87.5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Composite CN calculation</th>
<th>Area (mi²)</th>
<th>CN</th>
</tr>
</thead>
<tbody>
<tr>
<td>UIA</td>
<td>0.0075</td>
<td>98</td>
</tr>
<tr>
<td>Compacted</td>
<td>0.0300</td>
<td>86</td>
</tr>
<tr>
<td>Open space (sand, &gt;30% ground cover)</td>
<td>0.2000</td>
<td>72</td>
</tr>
<tr>
<td>Natural Desert landscaping</td>
<td>0.2000</td>
<td>77</td>
</tr>
<tr>
<td>Composite CN</td>
<td></td>
<td>76</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transform parameters</th>
<th>min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag time</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design storm parameters</th>
<th>Cumulative precipitation (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-yr 24-hr</td>
<td>2.90</td>
</tr>
<tr>
<td>500-yr 24-hr *</td>
<td>3.61</td>
</tr>
<tr>
<td>Water quality storm *</td>
<td>0.66</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model results</th>
<th>Peak discharge (cfs)</th>
<th>Runoff volume (ac-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-yr 24-hr</td>
<td>260</td>
<td>31.8</td>
</tr>
<tr>
<td>500-yr 24-hr *</td>
<td>405</td>
<td>45.7</td>
</tr>
<tr>
<td>Water quality storm *</td>
<td>26</td>
<td>2.2</td>
</tr>
</tbody>
</table>

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

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

1 or area (ac) if using elevation-area-discharge method
References


