SUDAS Revision Submittal Form

Status Date:	As of 5/18/2023	**Topic:**	Storm distribution for hydrograph routing
Manual:	Design	**Location:**	Sections 2A-4, 2B-4, and 2B-5

Requested Revision:

From Section 2A-4 (Project Drainage Report), C (Contents), 1 (Site Characteristics)

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e. Pre-development Runoff Analysis:

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3) Precipitation Model: Describe the precipitation model and rainfall duration used for the design storm. Typical models may include one or more of the following:

a) NRCS ~~Type II~~ MSE3 or MSE4 Rainfall Distribution.
b) Huff Rainfall Distribution. Select the appropriate distribution based on rainfall duration.
c) Frequency-Based Hypothetical Storm.
d) Rainfall Intensity Duration Frequency (IDF) Curve.
e) User-defined model based on collected precipitation data, subject to the Jurisdictional Engineer's approval. Total rainfall amounts for given frequency and duration should be obtained from Bulletin 71, "Rainfall Frequency Atlas of the Midwest" (see Section 2B-2). Bulletin 71 supersedes Technical Paper Number 40, "Rainfall Frequency Atlas of the United States."

From Section 2B-4 (Runoff and Peak Flow), C (SCS Methods)

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3. SCS Peak Runoff: ~~After the total runoff is determined, the SCS Peak Discharge Method may be utilized to determine the peak rate of discharge from the watershed. The equation for the peak discharge is given as:~~ TR-55 presents a Graphical Peak Discharge Method for manually calculating peak runoff using the SCS Depth of Runoff values calculated above with the NRCS Standard Type II Rainfall distribution. SUDAS has adopted the NRCS Updated Rainfall Distributions (MSE3 and MSE4) based on the Atlas 14 rainfall (see Section 2B-5); however, graphical representations of these distributions are not provided within the TR-55 documentation or other NRCS National Engineering Handbook documentation. For these reasons, manual calculation using the SCS Peak Runoff method is not allowed.

The designer should utilize Win-TR-55 or other software that can incorporate the MSE distributions for calculating peak runoff.

~~$q_p = q_u A_m Q F_p$~~ **~~Equation 2B-4.08~~**

~~where:~~

~~q_p = peak discharge, cfs~~
~~q_u = unit peak discharge, $ft^3/s/mi^2/in$ (csm)~~
~~A_m = drainage area, mi^2~~
~~Q = runoff, in (from Equation 2B-4.04 above)~~
~~F_p = pond and swamp adjustment factor (Table 2B-4.07)~~

~~The unit peak flow is calculated with the following equation (graphical depictions are presented in TR-55):~~

~~$q_u = 10^{[C_0+(C_1)(\log t_c)+(C_2)(\log t_c)^2]}$~~ **~~Equation 2B-4.09~~**

~~where:~~

C_0, C_1, C_2 = Coefficients, listed in Table 2B-4.06. These are a function of the 24 hour rainfall
distribution type and Ia/P.
t_c = time of concentration (refer to Section 2B-3)
I_a = Initial abstraction (refer to Equation 2B-4.05), in

Source: HEC-22, FHWA

Table 2B-4.06: Coefficients for SCS Peak Discharge Method

I_a/P	C_0	C_1	C_2
0.10	2.55323	-0.61512	-0.16403
0.30	2.46532	-0.62257	-0.11657
0.35	2.41896	-0.61594	-0.08820
0.40	2.36409	-0.59857	-0.05621
0.45	2.29238	-0.57005	-0.02281
0.50	2.20282	-0.51599	-0.01259

Note: Values are for Type II rain distribution, which applies to all of Iowa.

Source: TR-55, USDA

Table 2B-4.07: Adjustment Factor (F_p) for Pond and Swamp Areas that are Spread Throughout the Watershed

Percentage of pond and swamp area	F_p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

Source: HEC-22, FHWA

From Section 2B-5 [Watershed Routing (Hydrograph Determination)]

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C. Tabular Hydrograph Method

The TR-55 Tabular Hydrograph Method is used for computing discharges from rural and urban areas, using the time of concentration (T_c) and travel time (T_t) from a subarea as inputs. The SCS TR-55 methodology can determine peak flows from areas of up to 2,000 acres, provide a hydrograph for times of concentration between 0.1 to 2 hours, and estimate the required storage for a specified outflow.

This method can develop composite flood hydrographs at any point in a watershed by dividing the watershed into homogeneous subareas. In this manner, the method can estimate runoff from non-homogeneous watersheds; a common occurrence in developed urban areas. The method is especially applicable for estimating the effects of land use change in a portion of a watershed.

1. **Method Description:** The Tabular Hydrograph method is based on a series of unit discharge hydrographs developed by the SCS. The tabular data was developed by computing hydrographs for one-square mile of drainage area for selected T_c's and routing them through stream reaches with a range of T_t's. The resulting values, expressed in cubic feet per second per square mile of watershed per inch of runoff, are summarized in ten tables provided in the SCS TR-55 manual.

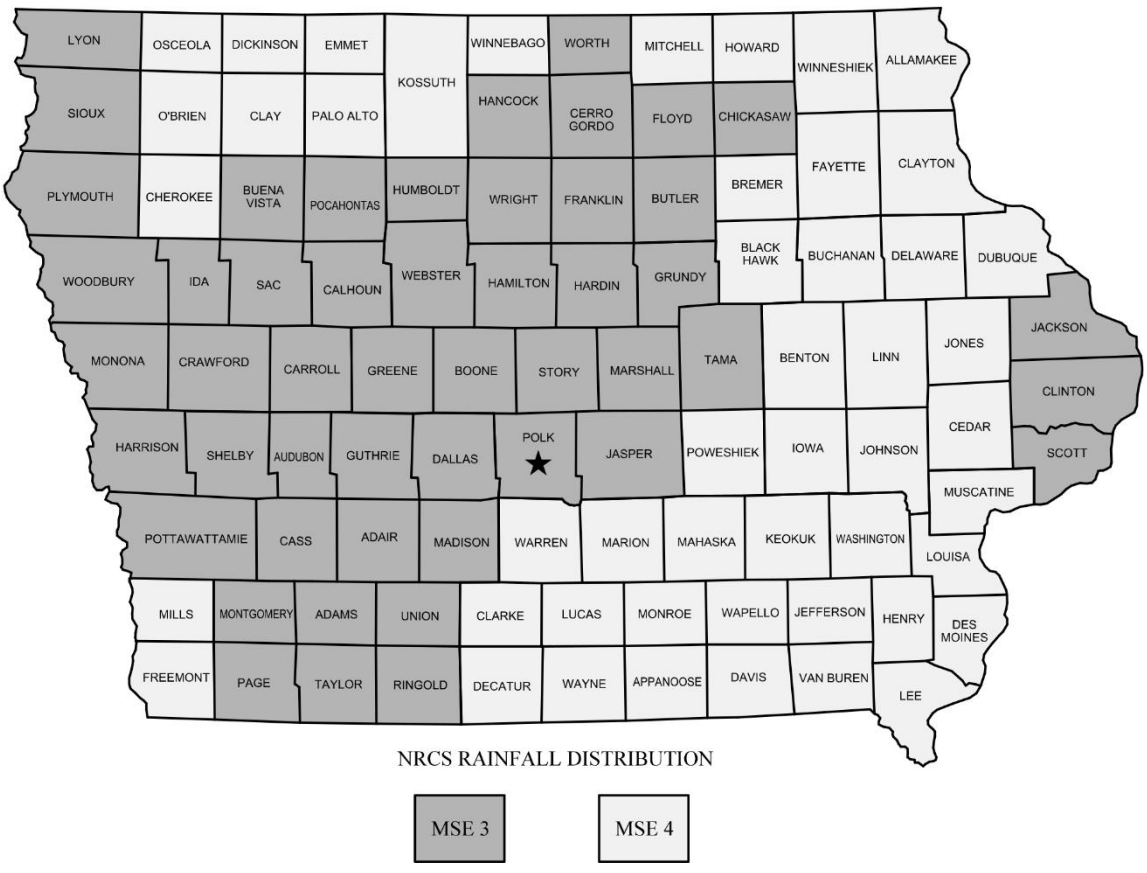
Chapter 5 of TR-55 provides a detailed description for manual calculation with the tabular hydrograph method, in addition to the tables necessary to complete the calculation. The input data required to develop a flood hydrograph by the SCS TR-55 method includes:

- 24 hour rainfall, in
- Appropriate rainfall distribution, (~~I, IA, II, or III~~ MSE Types 1-6) (Iowa is Type ~~II~~ 3 and 4)
- Curve Number (Refer to Section 2B-4)
- Time of Concentration, T_c, hr.
- Travel Time, T_t, hr.
- Drainage Area, sq. mi.

Using the Weather Bureau's TP-40 (1961) data, SCS developed four 24 hour synthetic storm distributions (Type I, IA, II, and III) associated with broad climatic regions across the United States. The Type II rainfall distribution applied to a vast majority of the continental United States (including Iowa), even though typical storm events can vary widely between regions. With the release of NOAA's Atlas 14 database (2013), more than 50 years of new rainfall data became available. NRCS's analysis of this data led to the development of new synthetic rainfall distributions, including distributions specifically intended for Midwest and Southeast (MSE) regions. These MSE distributions reflect regional variation, consider recent changes in weather patterns, and prevent the over/under estimation of peak discharges. The new MSE distributions also better account for shorter rainfall durations within the 24 hour rainfall distribution (e.g. 24 hour, 2 hour, 10 minute, 5 minute, etc.) (Merkel and Moody, 2015).

Six MSE distributions were developed for regions in the Midwest and Southeast. Most of Iowa falls within two of the MSE distributions: MSE3 and MSE4. Several outlier areas of the state fall into the MSE2 and MSE5 regions; however, the areas are small enough that the Iowa NRCS has assigned all counties in the state to either the MSE3 or MSE4 distribution. The following figure identifies which distribution is applied within each county.

Figure 2B-5.03: NRCS MSE Rainfall Distributions



The 24 hour rainfall amount, rainfall distribution, and the runoff curve number are used in Equations 2B-4.06 and 2B-4.07 to determine the runoff depth in each subarea. The product of the runoff depth times drainage is multiplied times each tabular hydrograph value to determine the final hydrograph ordinate for a particular subarea. Subarea hydrographs are then added to determine the final hydrograph at a particular point in the watershed.

Calculating runoff hydrographs manually utilizing the tabular method is time consuming, tedious, and rarely done. This calculation is typically completed utilizing user-created spreadsheets, WinTR-55, or other software that utilizes the TR-55 methodology. The NRCS has incorporated the MSE storm distributions into WinTR-55.

2. **Limitation:** The tabular method is used to determine peak flows and hydrographs within a watershed. However, the accuracy of the Tabular Method decreases as the complexity of the watershed increases. The Tabular Method should not be used if any of the following conditions exist:
   - The drainage area of the watershed is greater than 2,000 acres.
   - T_t is greater than 3 hours (largest T_t in tabular hydrograph data)
   - T_c is greater than 2 hours (largest T_c in tabular hydrograph data)
   - Drainage areas of individual subareas differ by a factor of 5 or more

   If any of the above situations exist, NRCS TR-20, or another applicable methodology should be utilized.

D. References

U.S. Department of Agriculture. *Urban Hydrology for Small Watersheds*. Technical Release No. 55. 1975.

U.S. Department of Transportation. *Urban Drainage Design Manual*. Hydraulic Engineering Circular, No. 22. Third Ed. 2009.

NRCS. *NOAA Atlas 14 Rainfall for Midwest and Southeast States.* Merkel and Moody. 2015

Reason for Revision:	Updated hydrograph routing to reflect the new region specific storm distributions.
Comments:	Should we post the new distributions on the SUDAS website (they are available online, but a little tricky to find)?

District:	☒ 1	☒ 2	☒ 3	☒ 4	☒ 5	☒ 6	**2/22/2023 Webinar**
Comments:	None.						
District:	☒ 1	☒ 2	☒ 3	☒ 4	☒ 5	☒ 6	**4/2023 Meetings**
Comments:	None.						
Action:	☐ Deferred			☐ Not Approved			☒ Approved

Final District Action Summary:	All 6 districts approved.
Board of Directors Action:	Approved.