HMS-PrePro
TR-55 Background & User's Guide

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A common approach for determining the runoff time over a watershed is the TR-55 method. According to the Urban Hydrology for Small Watersheds TR-55 Manual, the time of concentration may be calculated as the sum of travel times along the longest flow path (USDA, 1986[1]). The longest flow path is split into three segments that are differentiated by sheet flow (t_{sh}), shallow concentrated flow (t_{sc}), and channelized flow (t_{ch}).

$$t_c = t_{sh} + t_{sc} + t_{ch}$$

$$t_{sh} = \frac{0.007(n_{ol}L_{sh})^{0.8}}{{P_2}^{0.5}{S_{sh}}^{0.4}} \qquad t_{sc} = \frac{L_{sc}}{3600\,K\,{S_{sc}}^{0.5}} \qquad t_{ch} = \frac{L_{ch}}{\left(3600\,\frac{1.49}{n}R^{2/3}{S_{ch}}^{1/2}\right)}$$

Where:

- P_2 = 2-yr, 24-hr rainfall depth (in)
- n_{ol} = overland flow roughness coefficient
- L = length of longest flow path (ft)
- S = slope of longest flow path (ft/ft)
- K = 16.13 for unpaved surfaces, 20.32 for paved surfaces
- n = Manning's roughness coefficient for channel
- R = channel hydraulic radius (ft)
- t_c = time of concentration (hr)

Sheet flow represents the planar flow that occurs at the headwater of a stream near the most hydraulically-remote point. Typically, sheet flow occurs for 100 feet or less before transitioning into shallow-concentrated flow. The TR-55 sheet flow approximation is a simplified version of the kinematic wave Manning's equation, developed by Welle and Woodward (1986[2]). Shallow-concentrated flow is then collected in small swales and gullies. Shallow-concentrated flow is considered to be between 0.1 and 0.5 feet in depth. When flow is collected in a well-defined stream, channel flow is assumed to occur. The transition between shallow-concentrated and channelized flow is typically assumed to begin where channels are visible on aerial photography or where surveyed cross-sections establish bankfull conditions (USDA, 2010[3]). Since detailed channel geometry is unlikely from a DEM, GIS-preprocessors require user-input for certain channel properties. Field observations, as-built drawings, aerial imagery, and survey datasets are used to specify channel parameters such as the roughness coefficient and the hydraulic radius (USACE, 2009[4]).

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[1] USDA (1986). Urban Hydrology for Small Watersheds: TR-55. 210-VI-TR-55, Second Ed., June 1986. Washington, D.C.

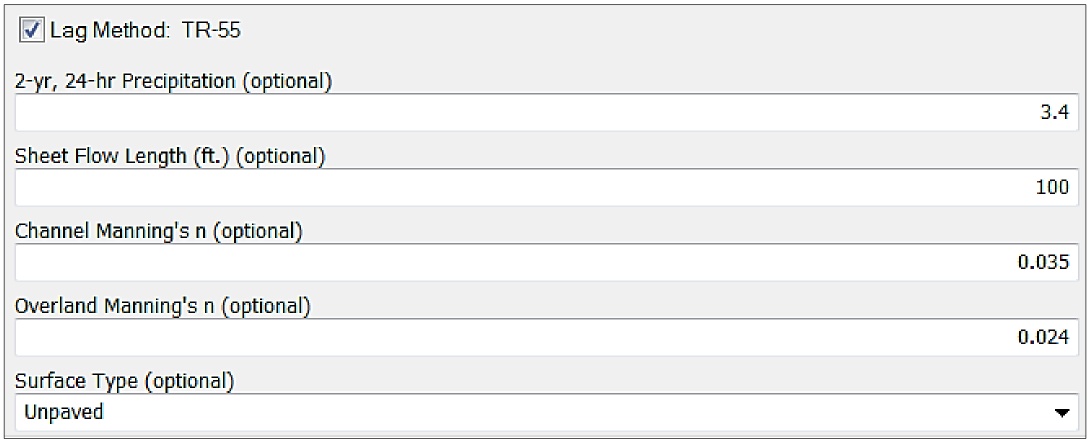
[2] Welle, P.J., and D.E. Woodward (1986). Time of concentration. Hydrology, Technical Note No. N4. U.S. Department of Agriculture, Soil Conservation Service, NENTC, Chester, PA.

[3] USACE (2010). Hydrologic Modeling System HEC-HMS: User's Manual, Version 3.5. August 2010. US Army Corps of Engineers, Hydrologic Engineering Center.

[4] USACE (2009). HEC-GeoHMS Geospatial Hydrologic Modeling Extension: User's Manual, Version 4.2. May 2009. US Army Corps of Engineers, Hydrologic Engineering Center.

TR-55 User's Guide

The following figure shows the user-defined parameters required in HMS-PrePro for the TR-55 lag method. These values should be modified by the user according to local observations.



<u>Instructions:</u>

In HMS-PrePro, the TR-55 method uses two separate scripts to allow user-input regarding the flowpath properties. In the *Preprocess Basin* script tool, fields are automatically added to the longest flowpath layer and populated according to a uniform value from user-input. For a given location, the 2-year, 24-hour precipitation may be obtained from a depth-duration-frequency atlas. The length of sheetflow is specified by the user for values up to 300 feet. Average Manning's roughness coefficients are provided for channel and overland flow. The surface type may be selected as paved or unpaved, which is used to determine the *K* value for shallow-concentrated flow.

Segmented flowpaths are created from the longest flowpath layer according to a defined percentage downstream. The user may choose this value to be any reasonable percentage, and subsequent steps will manually update the flowpath lengths. A GIS point feature class is created to represent the transition between sheet, shallow-concentrated, and channel flow. These point locations are then modified by the user according to observed data. When the point locations are updated, the user may modify Manning's n-values for individual subbasins. The user supplies the hydraulic radius value (*R*) for each channel reach, which may be obtained using spatial tools such as 3D-Analyst.

The *TR-55* script may be run once the flowpath transition points have been modified and the hydraulic radius values have been supplied. In the second script, the user-defined point locations are used to update the flowpath segments. The flowpath is interpolated onto the DEM where elevations are extracted for each upstream and downstream endpoint. The elevation points are used with the length of each flowpath segment to determine the slope. The three TR-55 flowpath equations are solved and summed to determine the time of concentration in each subbasin.

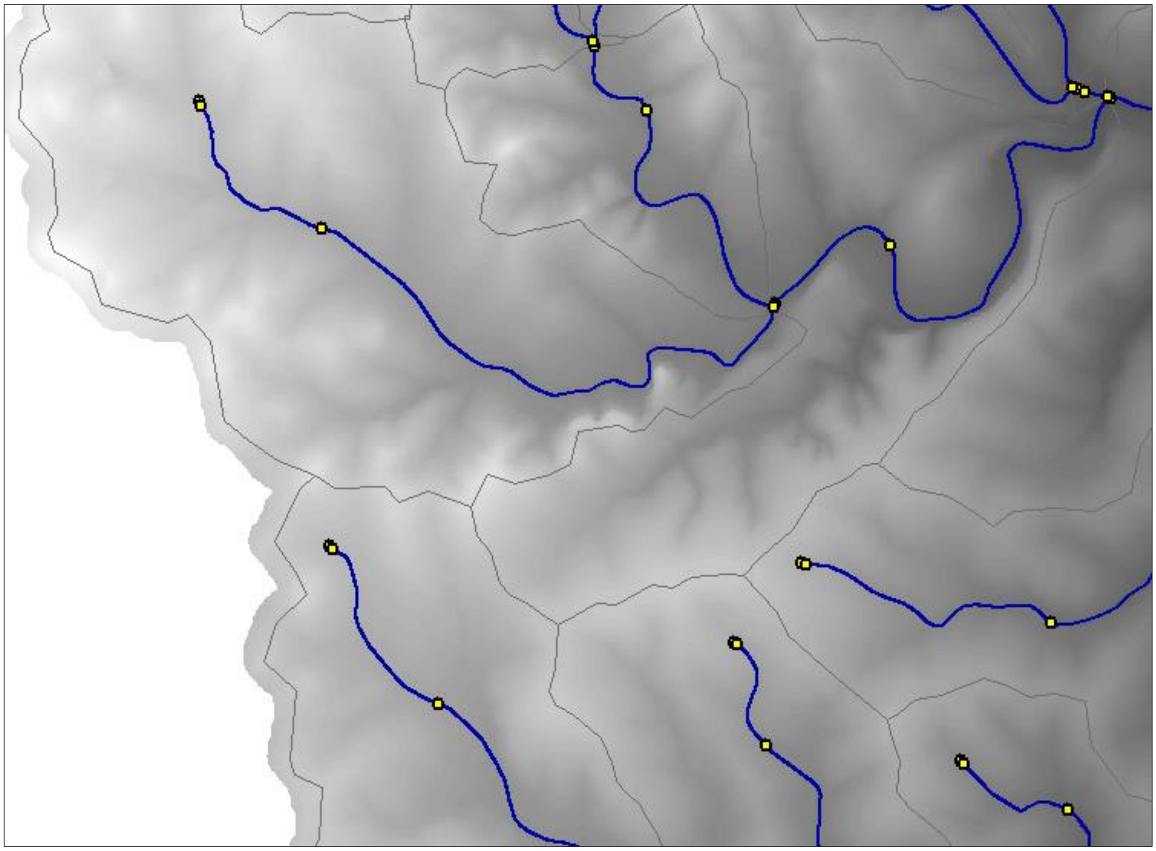


Figure 1: Longest flowpath and point output, used to define transition from sheet flow to shallow-concentrated flow to channelized flow. Points are initially created by the Preprocess Basin script and should be modified per the user. The Manning's roughness and Hydraulic Radius (R) attribute values should also be manually updated by the user. Then, the TR-55 script is run for updated calculations and a new .BASIN output file.