

## WMS 11.0 Tutorial

# Time of Concentration Calculations and Composite CN with TR-55

Compute hydrologic parameters such as sub-basin time of concentration and curve number



### Objectives

Learn how to compute coverage overlay percentages, time of concentration, and curve numbers for sub-basins and how to apply these parameters to a TR-55 model.

### Prerequisite Tutorials

- DEM Delineation

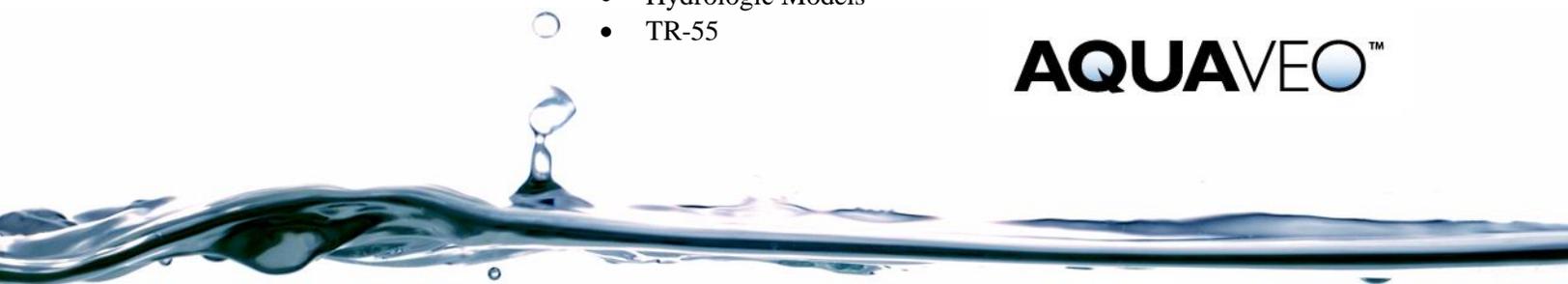
### Required Components

- Data
- Drainage
- Map
- Hydrology
- Hydrologic Models
- TR-55

### Time

- 15–20 minutes

**AQUAVEO™**



1	Introduction .....	2
2	Getting Started .....	2
3	Importing a TR-55 Project .....	3
4	Assigning Equations to Time Computation Arcs .....	3
5	Computing Time of Concentration for a TR-55 Simulation .....	5
6	Computing a Composite Curve Number .....	6
6.1	Land Use Table .....	6
6.2	Computing Composite Curve Numbers .....	7
7	TR-55 Hydrographs .....	8
8	Conclusion.....	9

## 1 Introduction

---

This tutorial discusses tools that are helpful in calculating the time of concentration ( $T_c$ ) and in computing a composite curve number (CN). In particular, the Natural Resources Conservation Service's (NRCS) TR-55 model will be discussed.

Travel times (time of concentration, lag time, and travel time along a routing reach) are critical to performing analyses with any of the hydrologic models. There are two different ways WMS can be used to compute time of concentration for a TR-55 simulation:

- Runoff distances and slopes for each basin are automatically computed whenever watershed models are created from TINs, DEMs, or computed basin data. These values can then be used in one of several available equations in WMS to compute lag time or time of concentration
- In order to have more control over the lag time or time of concentration, use a time computation coverage to define critical flow paths. This allows for better documentation of data. Time computation coverages contain flow path arcs for each sub-basin. An equation to estimate travel time is assigned to each arc. The time of concentration is the sum of the travel times of all arcs within a basin. Lengths are taken from the length of the arc and slopes derived if a TIN or DEM are present.

Lag times are computed in the same ways. In the next portion of this tutorial, the time of concentration will be calculated for the two sub-basins and the travel time between outlet points in the given watershed. Use the TR-55 library of equations, one of the other pre-defined equations, or enter a new equation.

## 2 Getting Started

---

Starting with a new WMS project at the beginning of each tutorial is recommended. This resets the data, display options, and other WMS settings to their defaults. To do this:

1. If necessary, launch WMS.
2. If WMS is already running, press *Ctrl-N* or select *File | New...* to ensure that the program settings are restored to their default state.
3. A dialog may appear asking to save changes. Click **Don't Save** to clear all data.

The graphics window of WMS should refresh to show an empty space.

### 3 Importing a TR-55 Project

---

First, import a project file of an urban area that has been processed and delineated as a single basin. The project includes a drainage coverage, a time computation coverage, and two shapefiles for the land use and soil type data.

1. Switch to the **Map**  module.
2. Select *File* / **Open**  to bring up the *Open* dialog.
3. Select “WMS XMDF Project File (\*.wms)” from the *Files of type* drop-down.
4. Browse to the *tr-55\tr-55\* folder and select “suburbtr55.wms”.
5. Click **Open** to import the project and exit the *Open* dialog.

The project should appear similar to Figure 1.

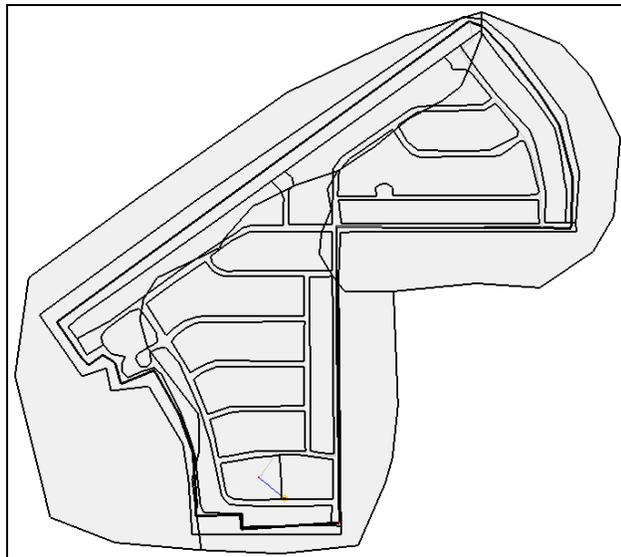


Figure 1 Initial TR-55 project

### 4 Assigning Equations to Time Computation Arcs

---

A flow path arc has already been defined for the basin. This arc represents the longest flow path for the urban area, starting from a sandy area at the top of the basin, following along the streets and down towards a detention pond at the bottom of the basin.

The arc has been split into four different segments to assign different equations for determining the travel time for the arc. The different equations assigned to the different arc segments represent different runoff flow types such as sheet flow, shallow concentrated flow, and channel flow. Use Figure 2 as a guide while defining the equations.

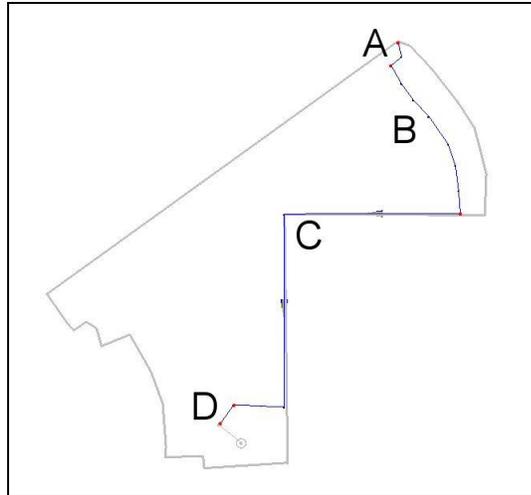


Figure 2 Time computation arcs

1. Turn off “ landuse\_poly.shp” and “ soils\_poly.shp” in the Project Explorer. These shapefiles will be used at a later step to calculate the CN.
2. Select “ Time Computation” to make it active.
3. Using the **Select Feature Arc** tool, double-click on the arc labeled “A” in Figure 2 to bring up the *Time Computation Arc Attributes* dialog.

Notice that, in the *Instructions / Results* section, there are two items which still need to be defined.

By default, “TR-55 sheet flow eqn” will be selected in the Equation Type drop-down. Therefore, only define the overland Manning’s roughness coefficient and the 2yr–24hr rainfall. Length and slope were already defined for the selected arc.

4. In the *Variables* section, select the “n Mannings” line.
5. Enter “0.03” as the *Variable value* below the *Variables* section.
6. In the *Variables* section, select the “P 2yr–24hr. rainfall” line.
7. Enter “1.1” as the *Variables value* below the *Variables* section.
8. In the *Variables* section, select the “S Slope” line.

Notice that the *Instructions / Results* section now gives a travel time for the selected arc.

9. Click **OK** to close the *Time Computation Arc Attributes* dialog.

An equation has now been defined for the overland sheet flow segment in the basin. Segments B and D need to be defined as having shallow concentrated flow.

10. Using the **Select Feature Arc** tool, double-click on arc B (see Figure 2) to bring up the *Time Computation Arc Attributes* dialog.
11. Select “TR-55 shallow conc eqn” from the *Equation Type* drop-down.
12. In the *Variables* section, select the “Paved” line.
13. Enter “YES” as the *Variable value* and click **OK** to close the *Time Computation Arc Attribute* dialog.

14. Repeat steps 10-13 for arc D (see Figure 2), but enter “NO” as the *Variable value* for the “Paved” line in the *Variables* section.

The remaining arc, segment C, will be defined as an open channel flow arc.

15. Using the **Select Feature Arc**  tool, double-click on arc C (see Figure 2) to bring up the *Time Computation Arc Attributes* dialog.
16. Select “TR-55 open channel eqn” from the *Equation Type* drop-down.
17. In the *Variables* section, select the “n Manning’s” line.
18. Enter “0.017” as the *Variable value*.
19. In the *Variables* section, select the “r hydraulic radius” line.
20. Click **Hydraulic Radius** to the right of the *Variables* section, to bring up the *Channel Calculations* dialog.

The hydraulic radius will be computed from estimates of the curb in the subdivision.

21. Click **Launch Channel Calculator** to bring up the *Channel Analysis* dialog.
22. In the upper left section, select “Triangular” from the *Type* drop-down.
23. Enter “10.0” as the *Side slope 1 (Z1)*.
24. Enter “0.01” for both the *Side slope 2 (Z2)* and the *Longitudinal Slope*.
25. In the lower left section, select *Enter depth* and enter “0.5” in the field to the right of the option.

This is an approximated depth since the flow is unknown at this point.

26. Click **Calculate**.
27. Click **OK** to close the *Channel Analysis* window
28. Click **OK** to close the *Channel Calculations* window

The necessary parameters for computing travel time have now been computed using the TR-55 open channel flow (Manning’s) equation. Notice the “r hydraulic radius” value in the *Variables* section has been updated with the calculated value.

29. In the *Variables* section, select “S Slope”.

Notice that the *Instructions / Results* section updates with a travel time for the arc.

30. Click **OK** to close the *Time Computation Arc Attributes* dialog.
31. Click anywhere outside of the arcs to deselect arc C.

The equations and variable values for each flow path segment have also been defined. Changing the equations and variables, adding new flow path segments, etc., can help to determine the best flow paths and most appropriate equations for each basin. In other words, the process is subjective and may take a few iterations to get the best value.

## 5 Computing Time of Concentration for a TR-55 Simulation

---

Before assigning a time of concentration to each basin, decide which model to use. TR-55 will be used for this tutorial, but the computation tools and methods learned in this tutorial could be used for any of the supported WMS models (such as in the *TR-20 basin*

data dialog, the *HEC-1 Unit Hydrograph method* dialog, and the *Rational Method* dialog).

1. Switch to the **Hydrologic Modeling**  module.
2. Select “TR-55” from the Model selector drop-down at the top of the WMS window.
3. Using the **Select Basin**  tool, select the basin by single-clicking on it.
4. Select *TR-55 / Run Simulation...* to bring up the *TR-55* dialog.

In the *TR-55* dialog, notice the two drop-downs at the top. These allow the changing TR-55 information for basins and outlets individually (“Selected”) or collectively (“All”). Leave these drop-downs at their default selections.

5. Enter “1.5” as the *Rainfall (P) (in)*.
6. Select “Type II” from the *Rainfall Distribution* drop-down.
7. On the *Compute Tc – Map Data* row, click **Compute...** to bring up the *Travel Time Computation* dialog.

Notice the four time computation arcs that are in the basin. A detailed report of the time computation arcs could be created as a text file by clicking the **Export Data File...** or **Copy to Clipboard** buttons.

Note that the time computation attributes dialog can be brought up and the equation or equation variables can be changed by selecting the desired arc and clicking the **Edit Arcs...** button.

8. Click **Done** to close the *Travel Time Computation* window.

As shown in the *Time of Concentration (TC) (hr)* row, the sum of the travel times for these four arcs will be used as the time of concentration for this basin.

9. Click **OK** to close the *TR-55* window.

## 6 Computing a Composite Curve Number

---

This section discusses and demonstrates how to overlay land use and soil coverages on the delineated watershed in order to derive a curve number (CN).

### 6.1 Land Use Table

---

Create a land use table with IDs and CNs for each type of land used on the map. An incomplete table has been provided. To finish the table with all of the IDs and CNs for the shapefiles in the project—or to edit the table in general—complete the following steps:

1. Select *File / Edit File...* to bring up the *Open* dialog.
2. Select “landuse.txt” and click **Open** to bring up the *View Data File* dialog. If the *Never ask this again* option has been previously turned on, this dialog will not appear. In that case, skip to step 4.

3. Select the desired text editor from the *Open With* drop-down and click **OK** to open the text file in the selected text editor.

In the text editor, each of the three lines shows values for ID, the name of the land use ID in quotation marks, and individual CN values for soil types A, B, C, and D, respectively. Each value is separated from the next on the line by a comma followed by a space. This file includes CN values for land use types: “Transportation, Communications”, “Other Urban or Built-Up Land”, and “Bare Ground”. The land use shapefile in this project also contains land use polygons for residential areas, with an ID for 11.

Complete the land use table by editing the file to include ID 11 above the existing three lines:

4. Add the following line to the file: 11, "Residential", 61, 75, 83, 87
5. Select *File / Save* and close the editor by clicking  at the top of window.
6. Return to WMS.
7. Turn on  “landuse\_poly.shp” and  “soils\_poly.shp” in the Project Explorer.

The graphics window should appear similar to Figure 3.

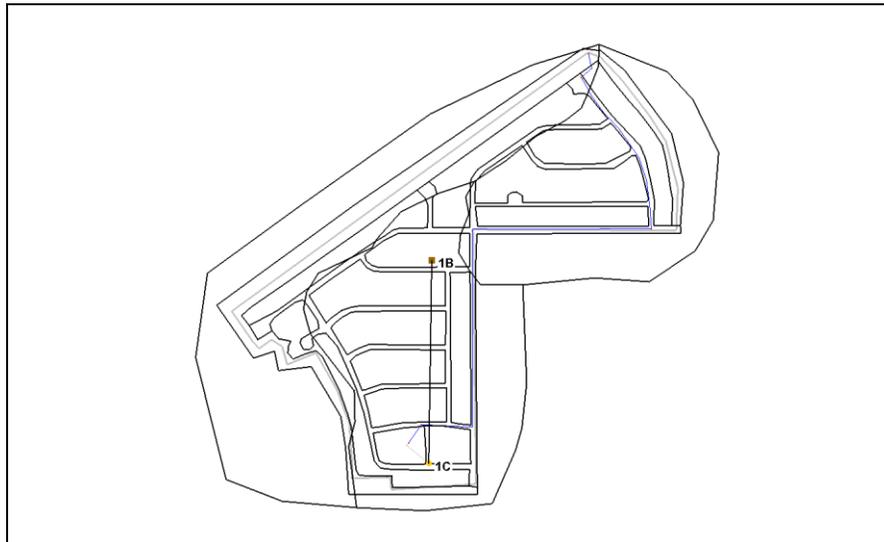


Figure 3 Land use and soil polygons after adjusting the land use table

## 6.2 Computing Composite Curve Numbers

In order to compute composite curve numbers, WMS needs to know which type of soil underlies each area of land. This requires either a land use and soil type coverage, or a land use and soil type shapefile with the appropriate fields. For this tutorial, land use and soil type shapefiles are used.

1. Select *Calculators / Compute GIS Attributes...* to bring up the *Compute GIS Attributes* dialog.
2. In the *Computation* section, select “SCS Curve Numbers” from the drop-down.
3. In the *Using* section, select *GIS Layers*.
4. Select “soils\_poly.shp” from the *Soil Layer Name* drop-down.

5. Select “HYDGRP” from the *Soil Group Field* drop-down.
6. Select “landuse\_poly.shp” from the *Land Use Layer Name* drop-down.
7. Select “LU\_CODE” from the *Land Use ID Field* drop-down.

Land use and soil type tables may be stored in data files, such as the one previously edited. Instead of manually assigning the data as done here, just import the tables using the **Import** button.

Whether the tables are manually created or imported from files, the land use IDs and CNs for each soil type should be visible, and land use descriptions should also be visible in the *Mapping* section.

8. In the *Mapping* section, click **Import** to bring up the *Open* dialog.
9. Select “Land/Soil Table File (\*.txt)” from the *Files of type* drop-down.
10. Select “landuse.txt” and click **Open** to exit the *Open* dialog and import the text file.

The assignment of CN values from the previously-edited land use table should now be visible in the *Mapping* section.

11. Click **OK** to compute the composite CNs, close the *Compute GIS Attributes* dialog, and bring up the *View Data File* dialog. If the *Never ask this again* option in this dialog has been previously turned on, this dialog will not appear. In that case, skip to step 13.
12. Select the desired text editor from the *Open With* drop-down. Click **OK** to open the text file in the selected text editor to view the “cn\_report.txt” file listed as the *File To Open*. If not wanting to view the report at this time, skip to step 14.

This is a Runoff Curve Number Report. The composite curve number appears at the bottom of the report.

13. When done reviewing the report, it can be saved if desired. Close the editor by clicking  at the top of window and skip to step 15.
14. Using the **Select Basin**  tool, double-click on the basin to bring up the *TR-55* dialog.

Notice that the *Runoff Curve Number (CN)* has been updated with the calculated value from the *Compute GIS Attributes* dialog.

## 7 TR-55 Hydrographs

---

While entering the data for the basin, instructions are given in the TR-55 data window to advise what must be entered before a peak Q can be determined. Once all of the data is entered, the peak Q is computed and displayed in the same window.

Notice that the TR-55 reference equation for computing peak flow is displayed next to *Peak Discharge*.

1. Click **Compute** to the right of *Compute Hydrograph*.
2. Click **OK** to close the *TR-55* dialog.

3. Using the **Select Hydrograph**  tool, double-click on the hydrograph icon next to the basin icon to bring up the *Hydrograph* dialog.
4. After reviewing the hydrograph, click  to close the *Hydrograph* dialog.

## 8 Conclusion

---

This completes the “Tc Calculations and Composite CN with TR-55” tutorial. The following key topics were discussed and demonstrated:

- Importing a TR-55 project
- Assigning equations to time computation calculations
- Computing time of concentration
- Using the land use and soil coverage to compute a composite CN value
- TR-55 hydrographs

If desired, continue to experiment with the tools discussed in this tutorial. Otherwise, exit the program.