Watershed Analysis

Overview

In this lesson, you learn about how AutoCAD® Civil 3D® software is used to analyze surface water runoff in a watershed. Hydrologic analysis begins with a close inspection of the terrain surface. A watershed is the total area of land that contributes surface runoff to a particular point of interest. A defined surface in Civil 3D may or may not entirely contain a watershed. Using the Watershed Analysis and Water Drop tools can help determine where surface water flows on the surface. Along with other factors such as soil type, slope, and land cover, the area of a watershed is necessary to calculate surface runoff flow rate.

Objectives

After completing this lesson, you will be able to:

- Describe the different types of watersheds delineated by Civil 3D.
- Use watershed analysis to delineate watershed boundaries.
- Create surface water runoff paths.

Exercises

The following exercises are provided in a step-by-step format in this lesson:

1. Delineate Watersheds
2. Visualize Runoff Paths

About the Hydrologic Cycle

The *hydrologic cycle* is the ongoing process in which water is evaporated from oceans, lakes, streams, and rivers and then redistributed to the surface of the earth in the form of precipitation. When precipitation, such as rain or snow, falls on the land surface, it encounters a number of different fates. A portion of the precipitation returns to the atmosphere as water vapor, or *evaporates*. Some of this water vapor is consumed by trees and other plant matter, and is eventually passed back to the atmosphere through their leaves in a process is called *transpiration*. Some precipitation *infiltrates* into the earth's soil and may be stored there as groundwater or it may continue flowing through the soil until it reaches a stream or river. Finally, some precipitation becomes *surface runoff* and enters our streams, rivers, and lakes. Civil and environmental engineers study the behavior of surface runoff to learn more about floods, droughts, and water pollution. Humans can greatly impact surface runoff patterns by altering the way land is used. When studying surface runoff, the basic hydrologic unit is the *watershed*.

About Watersheds

A *watershed* is an area that contributes surface water runoff to a particular point of interest, also called an *outlet point*. Any precipitation that falls within this area, and does not evaporate, transpire, or infiltrate, will run overland and eventually pass this outlet point. Because any point may be designated as a point of interest, the number of possible watersheds is infinite. However, logical points are typically designated as outlet points, such as the confluence of a tributary with a main stream or, in a developed area, where two storm sewers join.

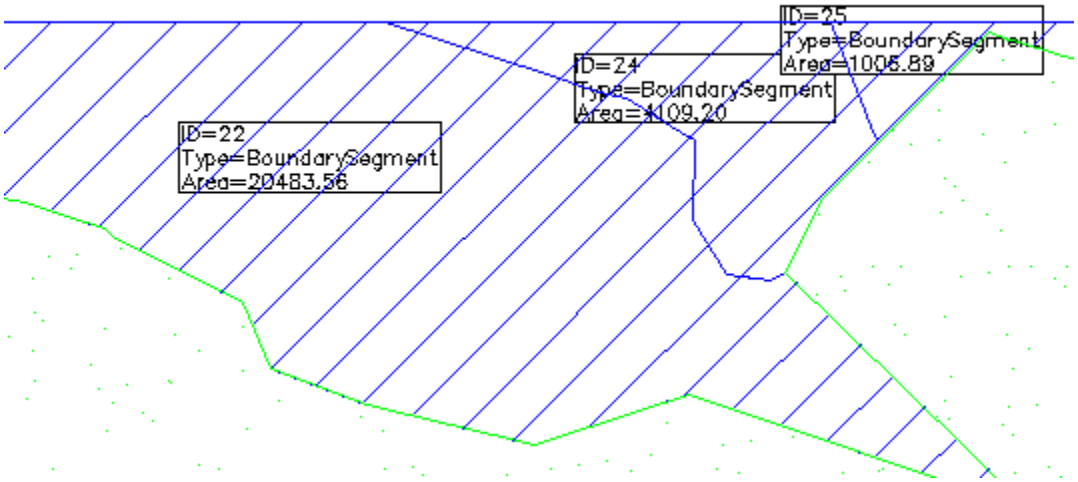
Delineation, or outlining, of the area which drains to a particular outlet point is of particular importance, because the volume of surface runoff is directly proportional to the drainage area. Civil 3D automatically analyzes a surface based on the triangles of the TIN to determine the outline of watersheds on the surface. This analysis is performed using the Analysis tab of the Surface Properties of any surface.

There can be several different types of watersheds present on a surface based on the type of drain target of the watershed. A drain target is the location where the water flow either stops or leaves the surface. Water that flows along an area or across a surface triangle eventually flows off the surface, or it reaches a point from which there is no downhill direction. For each drain target in a surface, Civil 3D determines the region of the surface that drains to that target. This region is called the watershed for that drain target.

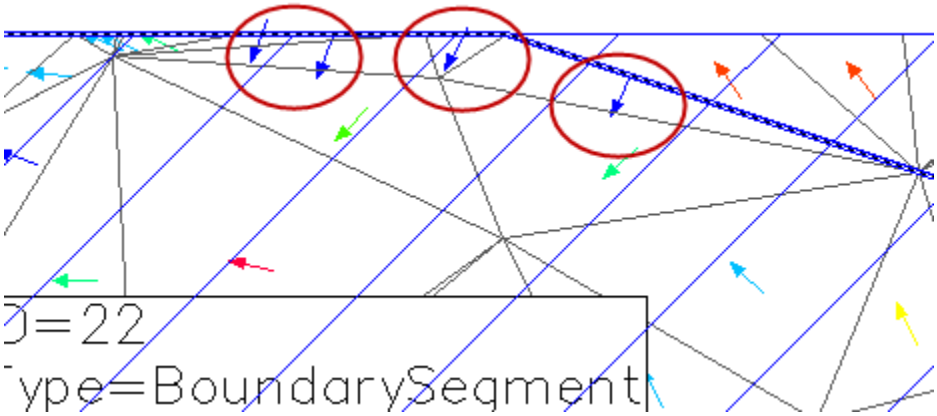
The types of watersheds analyzed by Civil 3D include those listed in the following table.

Watershed	Description
Boundary Point	If the downhill end of a channel edge is on the surface boundary, then water flowing through that channel continues off the surface. The boundary point is the lowest end of the channel.
Boundary Segment	If an edge on the surface boundary belongs to a triangle that slopes down toward that edge, then water flows off the surface all along that edge. A boundary segment is a connected sequence of such edges.
Depression	If a point is at a lower elevation than all its neighboring TIN points, then when water flows to it, it has no downhill place to go. Similarly, a connected set of points that are at the same elevation and all of whose neighbors are at a higher elevation, is a single drain target. A depression is any such set of points.
Flat Area	A flat area watershed is a flat area, from which water could flow down to more than one drain target. It also includes the parts of the surface that drain to that flat area. A flat area is a connected set of triangles all of whose vertices have the same elevation. Flat areas abut parts of the surface that slope downhill.
Multi-Drain	One type of ambiguous watershed is called a multi-drain or split channel watershed.
Multi-Drain Notch	A multi-drain notch watershed occurs where there is a flat edge between two points on a surface.

The following illustration displays several boundary segment watersheds.



These watersheds are segregated because some of the edge triangles are sloped in towards the surface and not towards the edge. Turning on the triangles of the surfaces along with the slope arrows clarifies this in the following illustration along the border between watershed ID 22 and 24. Note that the slope arrows are drawn along the line of the slope of the face of the TIN triangle.



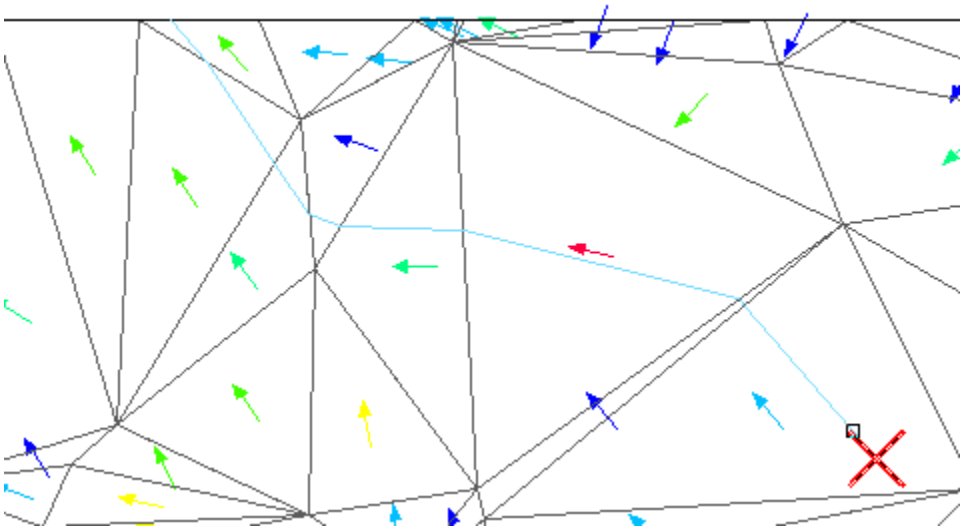
About Flow Paths

A particular path that a water drop takes for surface runoff is determined by the slope of the individual faces of the surface. Analyzing either an existing surface or a design surface for runoff flow paths is an important step in determining how to handle stormwater at the site.

In general, you click a location on the surface as the start of the travel path for a drop of water. The algorithm traces a line parallel to the slope of the 3D face of the TIN triangle where you clicked until the line intersects another triangle. At that point, the path is turned to parallel the

slope of the intersected triangle. This process continues until an endpoint is reached, which can be the edge of the surface, or a low point or depression.

The following illustration displays the original starting point for the water drop as a red X marker, with the subsequent path as a blue polyline until it reaches the edge of the surface. Notice the changes in slope as the path intersects the next triangle.



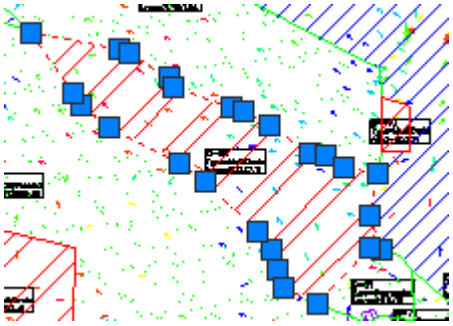
Key Terms

Hydrologic Cycle	The ongoing process in which water is cycled through precipitation, runoff, infiltration, evaporation, and transpiration.
Watershed	A watershed is the total area of land that contributes surface runoff to a particular point of interest.
Drain Target	A drain target is the location where the water flow either stops or leaves the surface
Runoff Water Path	The particular path that a water drop takes for surface runoff. The path is determined by the slope of the individual faces of the surface.

Exercise 1: Delineate Watersheds

In this exercise, you modify a surface style and perform a watershed analysis in order to delineate watersheds and visualize drainage patterns.

At the end of this exercise, the drawing displays as shown.

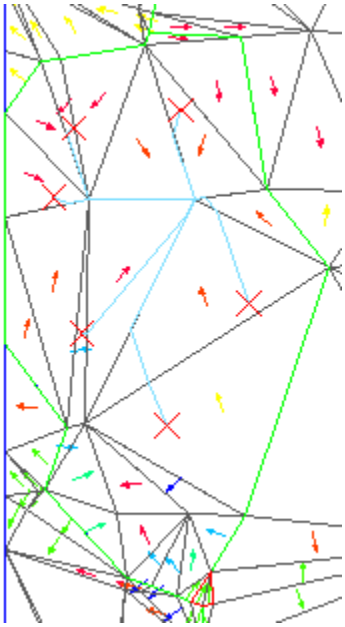


For this exercise open *…\I_Watersheds-EX1.dwg (M_Watersheds-EX1.dwg)*.

Exercise 2: Visualize Runoff Paths

In this exercise, you use the Water Drop tool to visualize runoff paths in the watersheds.

At the end of this exercise, the drawing displays as shown.



For this exercise, open *…\I_Watersheds-EX2.dwg* (*M_Watersheds-EX2.dwg*).

Assessment

Challenge Exercise

Instructors provide a master or challenge exercise for students to do based on this lesson.

Questions

1. What is a watershed?
2. Define a depression-type of watershed.
3. What is a flow path, also known as runoff water path?
4. What are some major factors that are related to surface runoff flow rate?

Answers

1. A *watershed* is an area that contributes surface water runoff to a particular point of interest, also called an *outlet point*.
2. If a point is at a lower elevation than all its neighboring TIN points, then when water flows to it, it has no downhill place to go. Similarly, a connected set of points that are at the same elevation and all of whose neighbors are at a higher elevation, is a single drain target. A depression is any such set of points.
3. A flow path is the particular path that a water drop takes for surface runoff. The path is determined by the slope of the individual 3D triangle faces of the surface.
4. Watershed area, land cover, slope, and soil type are all important when calculating surface runoff rate.

Lesson Summary

In this lesson, students learned about the concepts of watershed analysis and how to use AutoCAD Civil 3D to perform basic analysis. They used the Watershed Analysis tool for an existing surface to delineate watersheds, extracted the boundaries as closed polygons, and inserted a watershed legend table. Students used the Water Drop tool along with slope arrows and triangles to visualize the surface water runoff patterns on a surface.