



# AUTODESK UNIVERSITY 2015

CI11309-L

## Intelligent Hydrology with AutoCAD Civil 3D - Lab

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### Learning Objectives

- Learn how to utilize AutoCAD Civil 3D software Parcels to perform hydrology analyses and prepare drainage maps
- Learn how to utilize label expressions to perform automated hydrology calculations integrated with your drainage map production
- Learn how to create dynamic drainage tables to summarize the hydrology model information
- Learn how to export your drainage maps to Storm and Sanitary Analysis (SSA) for more detailed calculations

### Description

AutoCAD Civil 3D software gives civil engineers some great tools out of the box to perform hydraulics and hydrology studies; but if you dig a little deeper, you can truly bring out the "I" in Building Information Modeling (BIM) for civil engineers. This is a lab session in which we will utilize AutoCAD Civil 3D software parcels for an integrated solution for watershed area delineation, hydrologic analysis calculations, and drainage map production. We will work in a highly customized hydrology workflows template that includes parcel object and label styles setup, specifically to produce drainage maps with dynamic hydrology calculations updating as the watersheds are edited. We will finish by exporting our drainage map out for more complex analyses in Storm and Sanitary Analysis (SSA).

### Your AU Experts

**Curtis Smith** is registered professional engineer (FL, TN) and BIM for civil engineering specialist at Innerlight Engineering Corporation in Miramar Beach, Florida. His engineering expertise is extremely diverse ranging from small scale residential site designs, commercial and industrial site development, and even large-scale municipal and airport stormwater infrastructure redevelopment projects. Curtis brings over 8 years of Civil 3D experience, Civil 3D Certified Professional status, prior AU Speaker status (AU 2013 – CI2170), and 2015 Autodesk Gunslinger status. He provides professional online training courses for Digital-Tutors/Plurasight for both AutoCAD and AutoCAD Civil 3D. He also is heavily involved in the Autodesk Customer Council providing ideas, development feedback, and product beta testing for AutoCAD, AutoCAD Civil 3D, and InRoads 360.

## Background and Summary

### Prior to AU 2015

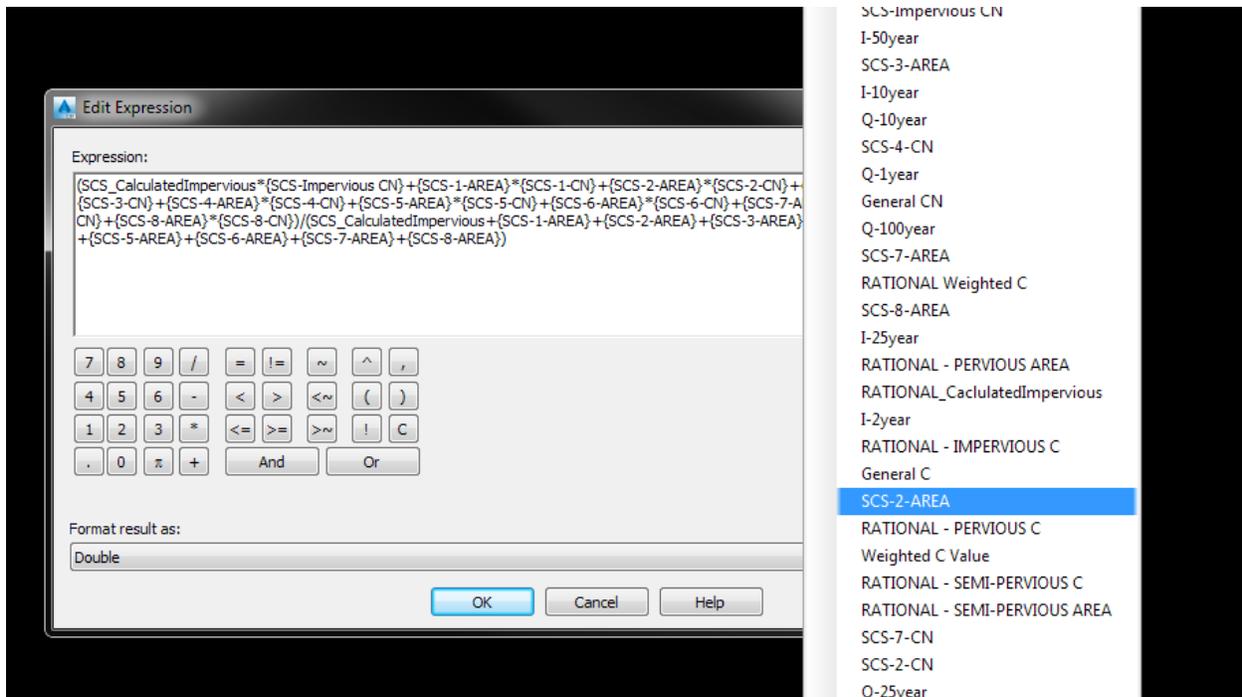
It is recommended that you view the AU 2013 lesson CI2170 prior to coming to this lab session. In this previous AU2013 lesson we learned how the styles and settings were produced for the Hydraulics and Hydrology template that we will be using. Course materials and the video of this lesson may be found at the link below. Hydrology Information Modeling is covered in Task 3 of the course outline.

<http://au.autodesk.com/au-online/classes-on-demand/class-catalog/2013/infrastructure-design-suite/ci2170#chapter=0>

### Data Sets and Template

Data Sets will be available on the day of the lab session. Feel free to utilize the styles and settings for production of your own Hydraulics and Hydrology templates.

If you are going to copy these styles into your templates it is recommended that you utilize the Civil 3D Import Styles tool to copy over all of the H&H parcel styles, label styles, and table styles at once. When copying styles over double check the Expressions to be sure they copied correctly, as they have been known to create errors in the Expression equation during the style importing or copy process. Typically when an error occurs you will see a lengthy alphanumeric string in the equation where one of the custom User Defined Properties is supposed to be. To repair the Expression just delete the errant string and reinsert the correct variable.



The screenshot shows the 'Edit Expression' dialog box with the following content:

Expression:

$$\frac{(\text{SCS\_CalculatedImpervious} * \{\text{SCS-Impervious CN}\} + \{\text{SCS-1-AREA}\} * \{\text{SCS-1-CN}\} + \{\text{SCS-2-AREA}\} * \{\text{SCS-2-CN}\} + \{\text{SCS-3-CN}\} + \{\text{SCS-4-AREA}\} * \{\text{SCS-4-CN}\} + \{\text{SCS-5-AREA}\} * \{\text{SCS-5-CN}\} + \{\text{SCS-6-AREA}\} * \{\text{SCS-6-CN}\} + \{\text{SCS-7-AREA}\} * \{\text{SCS-7-CN}\} + \{\text{SCS-8-AREA}\} * \{\text{SCS-8-CN}\})}{(\text{SCS\_CalculatedImpervious} + \{\text{SCS-1-AREA}\} + \{\text{SCS-2-AREA}\} + \{\text{SCS-3-AREA}\} + \{\text{SCS-5-AREA}\} + \{\text{SCS-6-AREA}\} + \{\text{SCS-7-AREA}\} + \{\text{SCS-8-AREA}\})}$$

Format result as:  
Double

OK Cancel Help

SCS-Impervious CN  
I-50year  
SCS-3-AREA  
I-10year  
Q-10year  
SCS-4-CN  
Q-1year  
General CN  
Q-100year  
SCS-7-AREA  
RATIONAL Weighted C  
SCS-8-AREA  
I-25year  
RATIONAL - PERVIOUS AREA  
RATIONAL\_CaclulatedImpervious  
I-2year  
RATIONAL - IMPERVIOUS C  
General C  
**SCS-2-AREA**  
RATIONAL - PERVIOUS C  
Weighted C Value  
RATIONAL - SEMI-PERVIOUS C  
RATIONAL - SEMI-PERVIOUS AREA  
SCS-7-CN  
SCS-2-CN  
Q-25year



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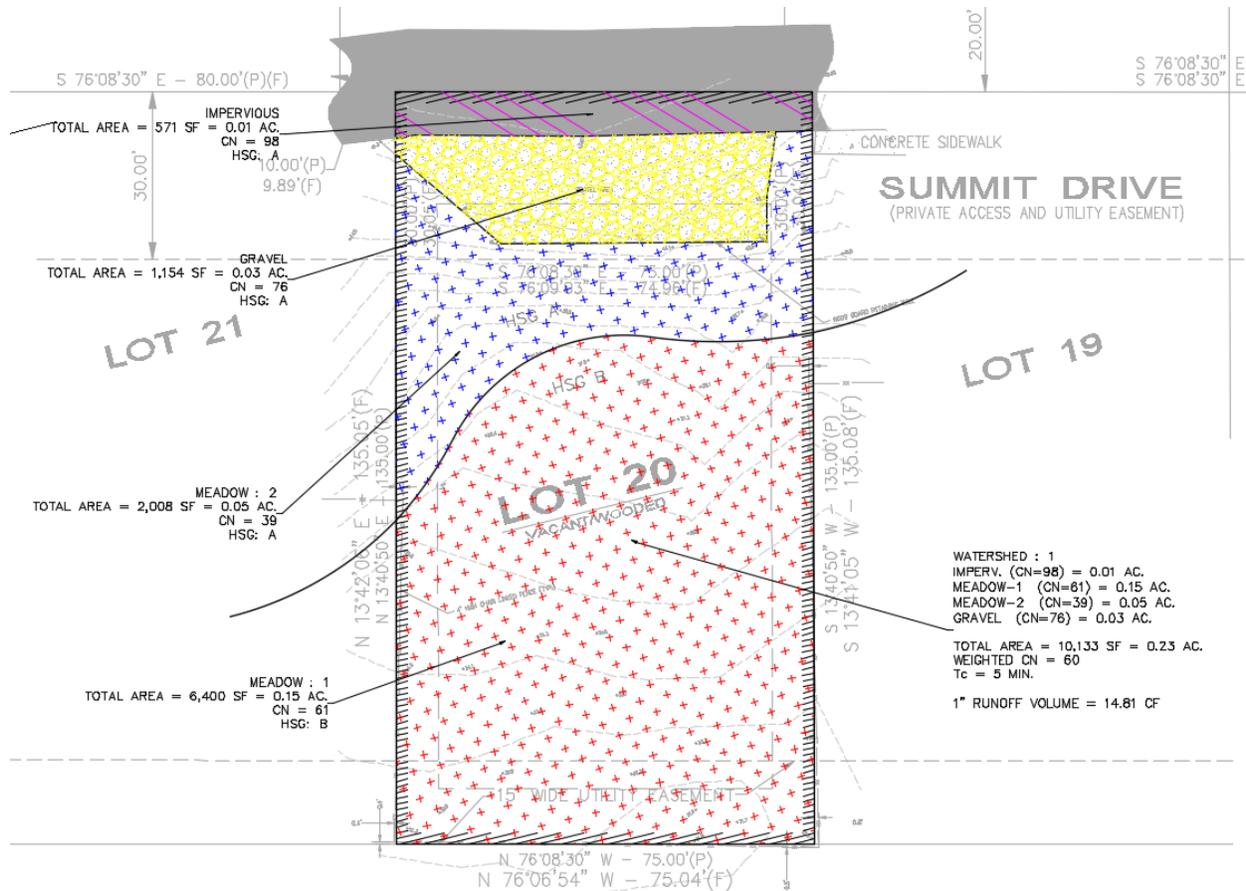
## Task 1 – Generate an Existing Conditions Hydrology Map Using SCS Methodology

1. Create a new file from the H&H Template. Call it “Ex-Hydrology.dwg”
2. Reference the “Ex-Base.dwg” file and “SoilMap.dwg” file
3. Use NCOPY to pull in the parcel boundary and soil boundary
4. Create Parcel from the boundary line
  - a. Place it on a new site called Overall Watersheds
  - b. Use the Parcel style SCS Watersheds
  - c. Use the area label style SCS Watersheds – Full Area Label
  - d. Modify the Parcel style to decrease the hatch fill distance and scale
5. Copy the watershed to a new site called “SCS Subsheds”
  - a. Change the Parcel area label style to “SCS Watersheds - Small Subshed Area Label”
  - b. Change the Parcel style to “SCS Subsheds – Meadow”
6. Use Create Parcels from Objects to split the subshed between the Hydrologic Soil Group line.
  - a. Modify the HSG and General CN values of the subsheds in the Parcel User Defined Properties (UDP) menu. Use open space, good condition for the land cover. Refer to FIGURE 1 : SCS CURVE NUMBERS for values.
  - b. Change the colors of the Parcels to help differentiate between the two.
7. Draw a polyline to delineate the gravel area.
  - a. Note: you do not need to close the line. Stop at the intersection of an existing parcel boundary.
8. Create a parcel from the polyline.
  - a. Copy the SCS Subsheds – Meadow style to create a new style called SCS Subsheds – Gravel
  - b. Note that the new parcel may have been placed in the area you did not intend on changing. This is a limitation of these workflows but can easily be modified using the AutoCAD Properties palette to change the style or by utilizing the Match Properties command.
  - c. Update the UDPs as needed.
9. Trace a polyline to close split the impervious and open space area, and create a parcel from the line.
  - a. Apply the SCS Subsheds – Impervious style to the impervious area
  - b. Update the UDPs as needed.
10. Modify the subshed Parcel names as needed to be Meadow-1, Meadow-2, Gravel, and Impervious
11. Input the Area, CN, and HSG values for each subshed into the UDPs of the overall watershed.

**Do not** enter the impervious surface as a subshed area, as this is automatically calculated.

  - a. Note that the UDPs are not organized alphabetically. Be careful to select the correct line item when inputting values.
  - b. After exiting the Parcel Properties, notice the impervious area and weighted CN are calculated and update in the label.
12. Use copy label style on the overall watershed area label to create a label called SCS Watersheds - Overall Area Label.
  - a. Remove Areas 4 – 8 from the label style. Rename Area 1 – 3 to Meadow-1, Meadow-2, and Gravel

13. Change to the Paper Space layout tab, drag rotate the viewport as desired, drag labels, and apply plot styles any way you like to finalize your plan. Here's mine!



14. Before we move on, go back into the Area Selection label style editor to explore other parameters provided in the H&H template that may be labeled on your plan.
15. In a situation with many watersheds on a small scale plan you may wish to label only the watershed names and provide tables for the watershed properties. We'll generate a quick table parcel area table together during the session.

Cover description	Average percent impervious area <sup>1</sup>	Curve numbers for hydrologic soil group			
		A	B	C	D
<i>Fully developed urban areas (vegetation established)</i>					
Open space (lawns, parks, golf courses, cemeteries, etc.) <sup>2</sup> :					
Poor condition (grass cover < 50%) .....		68	79	86	89
Fair condition (grass cover 50% to 75%) .....		49	69	79	84
Good condition (grass cover > 75%) .....		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way) .....					
		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way) .....					
		98	98	98	98
Paved; open ditches (including right-of-way) .....					
		83	89	92	93
Gravel (including right-of-way) .....					
		76	85	89	91
Dirt (including right-of-way) .....					
		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) <sup>4</sup> .....					
		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders) .....					
		96	96	96	96
Urban districts:					
Commercial and business .....					
	85	89	92	94	95
Industrial .....					
	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses) .....					
	65	77	85	90	92
1/4 acre .....					
	38	61	75	83	87
1/3 acre .....					
	30	57	72	81	86
1/2 acre .....					
	25	54	70	80	85
1 acre .....					
	20	51	68	79	84
2 acres .....					
	12	46	65	77	82
<i>Developing urban areas</i>					
Newly graded areas (pervious areas only, no vegetation) <sup>5</sup> .....					
		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

<sup>1</sup> Average runoff condition, and  $I_p = 0.2S$

<sup>2</sup> The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

<sup>3</sup> CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

<sup>4</sup> Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

<sup>5</sup> Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

FIGURE 1 : SCS CURVE NUMBERS

### Task 1.5 – The Parcel Properties Manager in Civil 3D 2016 Transportation Extension

The Civil 3D 2016 Transportation Extension released in October, 2015 introduced a new way to work with User Defined Properties in Parcels. This allows us to bulk edit UDPs in a table. The Parcels in the drawing file are linked to the table but the updates must be pushed back and forth using the buttons in the Panorama-like menu. You can also export a .csv file if you would like to take your Hydrology Map and Catchment Map data in to MS Excel spreadsheets.



For those that have not seen this new tool, it is expected to be available on the CI11309-Lab workstations at AU 2015. We will take a brief look at it, but we won't go into much detail. FIGURE 2 below shows a snippet of what this tool looks like in action.

Select	Name	Number	Description	Area (sq.ft.)	Perimeter (ft)	Site	Style	Area Label Style	P-5year	P-10year	P	P-25year	P-50year	P-1year	P-100year
<input type="checkbox"/>	DS-1	7		605.43	98.44	Catchments	Rational Catchments	Rational - Catchments - Full Area Label	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<input type="checkbox"/>	DS-2	6		644.64	101.57	Catchments	Rational Catchments	Rational - Catchments - Full Area Label	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<input type="checkbox"/>	DS-3	2		283.89	72.00	Catchments	Rational Catchments	Rational - Catchments - Full Area Label	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<input type="checkbox"/>	DS-4	5		283.89	72.00	Catchments	Rational Catchments	Rational - Catchments - Full Area Label	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<input type="checkbox"/>	DS-5	3		644.64	101.57	Catchments	Rational Catchments	Rational - Catchments - Full Area Label	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<input type="checkbox"/>	DS-6	1		605.41	98.43	Catchments	Rational Catchments	Rational - Catchments - Full Area Label	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<input type="checkbox"/>	IMPERV. EAST	3		180.62	63.52	Catchment Surface Types	Rational SubCatchments - Impervious	Rational - Catchments - Small SubArea Label	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<input type="checkbox"/>	IMPERV. WEST	2		164.75	57.74	Catchment Surface Types	Rational SubCatchments - Impervious	Rational - Catchments - Small SubArea Label	0.000	0.000	0.000	0.000	0.000	0.000	0.000

FIGURE 2 : PARCEL PROPERTIES MANAGER (NEW TO CIVIL 3D 2016 SUBSCRIPTION CUSTOMERS)

## Task 2 – Generate a Proposed Catchment Area Map with Rational Method Calculations

There are two slotted drain pipes on the north side of the proposed home. These are piped through 8” lines running south around each side of the home. Downspout connections connect to the HDPE lines at 3 locations on each side of the home. We need to generate a catchment area map to show the contributing drainage area, weighted runoff coefficient, and calculated flow rate for each of the slotted drain inlets and downspout connectors.

1. Create a new file from the H&H Template. Call it “Prop-Catchments.dwg”
2. Reference “Ex-Base.dwg” and “Prop-Base.dwg”
3. NCOPY the home exterior into the current file.
4. Use Create Parcel from objects to on the main home area and the rear porch area.
  - a. Use a new site called Catchments
  - b. Use the Rational Catchments parcel style
  - c. Use the Rational Catchments Full Area Label style
5. Divide the two catchments into smaller catchments for each downspout connector by drawing polylines and repeating the Create Parcels from Objects command.
6. Use the Rename/Renumber Parcels tool to name each of the 6 downspout catchments using the name template “DS-(Next Counter)”
7. Draw polylines to delineate the catchment area for the slotted drain pipes.
  - a. You may wish to create a Data Shortcut for the Lot Grading surface in Prop-Base file to help delineate catchment areas.
8. Create parcel from the polylines and rename them Slot Drain West and Slot Drain East
9. Use Copy to Site for each of the two slot drain catchments. We will use this to further break up the area into pervious pavers, open space, and impervious area.
  - a. Name the new site Catchment Surface Types
  - b. Depending on how you originally made the slot drain parcels (a closed region or a region connected to the home roof) you may be left with another parcel that you do not need on this site. You may wish to delete this catchment by moving it to a temporary Site or you may create a “NoDisplay” style to hide it.
10. Use polylines to further divide the Surface Type catchments into the pervious paver, open space, and impervious asphalt areas.
11. Use the Properties palette and/or Match Properties to change the parcel styles to the appropriate surface type.



- a. Apply a color to each different surface type if you would like to differentiate them.
- 12. Use Properties palette to change the name of surface type area to Impervious West, Pavers West, Open Space West, etc.
- 13. For the overall catchment area parcels, enter the surface type areas into the UDPs under the Rational Method Properties UDP classification
  - a. **Do not** enter impervious area, as this is automatically calculated. Check to see that the calculated impervious area in the overall catchments match the surface type area label when complete.
- 14. Note that default values of 0.95 (Imperv.), 0.65 (semi-pervious), and 0.3 (Pervious) are used for the runoff coefficients. We want to use 0.70 for the pavers. You may change these on individual parcels independent of others, or if you want to make a global change you can change the default value in the Settings tab of Toolspace.
  - a. Go to Settings > Parcel > User-Defined Property Classifications > Rational Method Properties. On the bottom list in Toolspace, scroll over to the default values. Changing these values will modify the UDP value for any parcels which have not received an individual override.
    - i. Use REGENALL to update the labels and weighted C calculations
- 15. Edit the Rational Catchments Full Area Label style to contain the design flow rate of the contributing drainage area.
  - a. Add to the bottom of the text “Q10 = <[Q-10year(P2|RN|AP|GC|UN|Sn|OF)]> CFS”
  - b. All the Q10 values should now be 0.00 cfs. We need to Rainfall Intensity data (IDF curve data) to our UDPs.
  - c. In Settings tab of Toolspace > Parcel > User-Defined Property Classifications > Rainfall Intensities, add the 5-min duration IDF data to the default values from FIGURE 3 below. Remember, this will apply the values to all parcels that have not received individual overrides.
    - i. Note: Civil 3D will likely do something strange here and change the currently selected UDP Classification as you are entering values... It wouldn't be a Civil 3D lesson without some wonky programmatic issue.

**PF tabular**

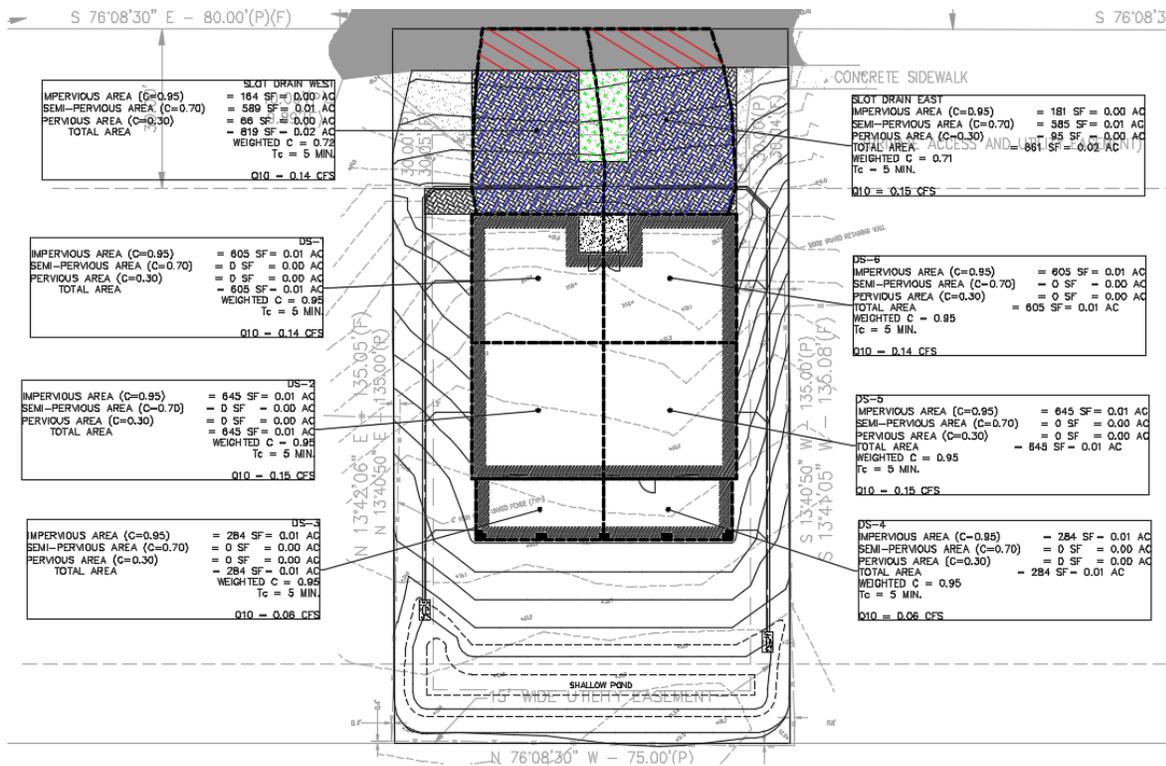
PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour) <sup>1</sup>										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	6.46 (5.46-7.80)	7.46 (6.31-9.04)	9.07 (7.63-11.0)	10.4 (8.66-12.6)	12.1 (9.62-15.1)	13.3 (10.4-16.9)	14.5 (10.8-19.0)	15.7 (11.1-21.1)	17.1 (11.7-23.8)	18.2 (12.0-25.8)
10-min	4.73 (4.00-5.71)	5.47 (4.62-6.61)	6.64 (5.59-8.08)	7.58 (6.34-9.24)	8.83 (7.05-11.0)	9.74 (7.58-12.4)	10.6 (7.94-13.9)	11.5 (8.17-15.5)	12.6 (8.53-17.4)	13.3 (8.81-18.9)

FIGURE 3: NOAA RAINFALL IDF DATA

- d. After entering the Intensity values, run REGEN to update the Q10 calculation in the labels.
- 16. Add a Parcel Area Table using the style Rational – Catchment Area Table with Qs
  - a. Apply the table to the Rational Catchments Full Area Label style, using Existing and New for the selection rule. Now if you need to add new inlets with new catchment parcels, they'll automatically go into the table.



17. Go to the Paper Space layout and print your masterpiece catchment map. Mine looks like this!



CATCHMENT AREA TABLE											
CATCHMENT	IMPERVIOUS	SEMI-PERVIOUS	PVIOUS	TOTAL	Q - 1 YEAR	Q - 2 YEAR	Q - 5 YEAR	Q - 10 YEAR	Q - 25 YEAR	Q - 50 YEAR	Q - 100 YEAR
DS-1	AREA = 0.01 AC. C = 0.95	AREA = 0.00 AC. C = 0.70	AREA = 0.00 AC. C = 0.30	AREA = 0.01 AC. Cv = 0.95	0.09 CFS	0.10 CFS	0.12 CFS	0.14 CFS	0.16 CFS	0.18 CFS	0.19 CFS
DS-2	AREA = 0.01 AC. C = 0.95	AREA = 0.00 AC. C = 0.70	AREA = 0.00 AC. C = 0.30	AREA = 0.01 AC. Cv = 0.95	0.09 CFS	0.10 CFS	0.13 CFS	0.15 CFS	0.17 CFS	0.19 CFS	0.20 CFS
DS-3	AREA = 0.01 AC. C = 0.95	AREA = 0.00 AC. C = 0.70	AREA = 0.00 AC. C = 0.30	AREA = 0.01 AC. Cv = 0.95	0.04 CFS	0.05 CFS	0.06 CFS	0.06 CFS	0.07 CFS	0.08 CFS	0.09 CFS
DS-4	AREA = 0.01 AC. C = 0.95	AREA = 0.00 AC. C = 0.70	AREA = 0.00 AC. C = 0.30	AREA = 0.01 AC. Cv = 0.95	0.04 CFS	0.05 CFS	0.06 CFS	0.06 CFS	0.07 CFS	0.08 CFS	0.09 CFS
DS-5	AREA = 0.01 AC. C = 0.95	AREA = 0.00 AC. C = 0.70	AREA = 0.00 AC. C = 0.30	AREA = 0.01 AC. Cv = 0.95	0.09 CFS	0.10 CFS	0.13 CFS	0.15 CFS	0.17 CFS	0.19 CFS	0.20 CFS
DS-6	AREA = 0.01 AC. C = 0.95	AREA = 0.00 AC. C = 0.70	AREA = 0.00 AC. C = 0.30	AREA = 0.01 AC. Cv = 0.95	0.09 CFS	0.10 CFS	0.12 CFS	0.14 CFS	0.16 CFS	0.18 CFS	0.19 CFS
SLOT DRAIN EAST	AREA = 0.00 AC. C = 0.95	AREA = 0.01 AC. C = 0.70	AREA = 0.00 AC. C = 0.30	AREA = 0.02 AC. Cv = 0.71	0.09 CFS	0.10 CFS	0.13 CFS	0.15 CFS	0.17 CFS	0.19 CFS	0.20 CFS
SLOT DRAIN WEST	AREA = 0.00 AC. C = 0.95	AREA = 0.01 AC. C = 0.70	AREA = 0.00 AC. C = 0.30	AREA = 0.02 AC. Cv = 0.72	0.09 CFS	0.10 CFS	0.12 CFS	0.14 CFS	0.16 CFS	0.18 CFS	0.20 CFS

### Task 3 – Take Your Parcel Watersheds and Catchments into SSA

Using Parcels to create our watershed maps instead of using Catchment objects gives us much more flexibility with custom properties, expressions, and annotation. However, we lose the ability to link the catchment area to a pipe network structure and then carry it into Hydraflow Storm Sewers or Storm and Sanitary Analysis (SSA) for more detailed analytics. There is a workflow to generate Catchment objects from these parcels that I covered in the AU 2013 CI2170 course referenced at the beginning of this handout (begins on page 55 of the CI2170 handout). However, I have found it too tedious of a task to setup and manage edits to the Catchment Maps with both Parcels and Catchment objects in the file. But thanks to ability of SSA to import LandXML files as watersheds we can bypass this workflow all together and still get our catchment areas into SSA efficiently without reproducing the data input. Here's how:

1. From Civil 3D, use the Export to LandXML tool.
  - a. Select all of your parcels from the Catchments site. If you have erroneous parcels living in the file that you've simply turned to a "NoDisplay" style, these can be unchecked to omit from the export.
2. Open SSA 2016
  - a. Note: A typical workflow may include having Pipe Networks living in or data referenced into your Catchment Map file. In this case you can export straight to SSA from your working file with your pipe networks ready to go.
3. Use File > Import > LandXML file to bring in your parcels. Note that if you exported your pipe networks with the XML file they will also come in.
  - a. If you already brought in pipe networks or done some work in the SSA file, SSA will want to create a new file for the XML import and will ask you to save. If this happens, save your current file, import the XML file, and then use File > Merge to bring everything back in from the first file.
4. Use File > Import > Layer Manager to bring in your Prop-Catchments CAD file. Check Watermark Image to fade it. We will use this as a background reference.
5. Unfortunately your intelligent UDPs in the Civil 3D file do not carry through XML files, so you will have to key in the Curve Numbers to each watershed. This area easily done by referencing the CAD background image we just imported.
6. The final step is to link your watersheds to the appropriate notes. Since this is not intended to be an SSA session, we will not go into further detail with this.
7. You can merge more XML files to combine your add in both your Rational catchment areas and your SCS watersheds. You may have many files that all need to be combined for a large EPA SWMM model to be ran in SSA.
8. Check out past and present AU courses for more information on working with SSA.

Be sure to check out the example drainage maps that have been provided with the handouts for more ideas. Put down those calculators and spreadsheets, and take advantage of the simultaneous, dynamic plan production and analytics that Civil 3D offers.

If you have questions, need the services of a Civil Engineer/Land Planner/Hydrologist, or would just like to provide some general feedback you can reach me at [curtis@innerlighteng.com](mailto:curtis@innerlighteng.com).

Thanks for joining!

