CE 3372 WATER SYSTEMS DESIGN

LESSON 19: STORM SEWER DESIGN EXAMPLE (TANGLEWILDE STORM SEWER)

DESIGN STORM SEWER FOR TANGLEWILDE

- Method: Rational Equation Design Method to make initial design for subsequent hydraulics analysis
- Identical study area as ES-13



PREPARATION STEPS

- Apply (make) topographic map principles to identify drainage pattern(s)
- Identify the individual drainage areas based on the topographic map and sewer system layout.
- Determine the area of each contributing area, in acres. (ENGAUGE, PLANIMETER, etc)
- Determine the rational runoff coefficient for each area (TABLE LOOKUP)



PREPARATION STEPS

- Determine inlet time for surface portion of drainage system.
- Determine rainfall intensity equation for Harris County.



ANALYSIS STEPS

- Apply the intensity equation to the various surface drainage areas, and the accumulating area to size the conduits.
- Check invert elevations to fit into the useable vertical drop for the location
- Size the inlets using appropriate inlet hydraulics equations.



• Locate the elevations and construct an XY coordinate system.



 Use the XY-coordinate system and build an XYZ input file for topographic rendering.

	Tanglewilde Elevations							
ELEVATION SURVEY VALUES			METHOD(S)				·	
ID	X (FEET) Y (FEET)		Z (FEET)	1) Use drawing and impose axes				
1	237.484279	263.09382	75	 2) Locate X1,	Y1			
2	260.879376	1158.93885	73	3) Locate X2,	¥1			
3	332.144775	1633.90828	68	4) Locate X1,	Y2			
4	554.122697	448.65323	74	 5) Use G3DA1	TA to capture	x,y each poir	nt	
5	737.728288	815.072914	73	 6) Manual en	ter z for each	point based	on collect or	ler
6	880.998109	1119.57212	72					
7	832.812956	1602.41018	69					
	882.668563	1790.82685	69.5	_				
9	866.834237	1907.0222	68					
10	967.813595	2534.28453	70					
11	871.797496	430.252877	73					
12	1183.38082	2110.654	66					
13	1290.42541	2544.27839	69					
14	1028.15545	159.007068	73					
15	1126.33177	837.907403	71					
16	1240.80157	1310.25046	71.4					
17	1234.64451	1521.96078	70.2				_	
18	1328.54412	1542.51785	70.8				_	
19	1340.99381	2092.41894	57					
20	1218.73147	153.646749	73					
21	1484.9939	1253.19966	70.9					
22	1621.45072	1898.49764	71					
23	1706.6526	2130.76766	56					
24	1609.72694	2205.73866	67					
25	1527.34122	419.248873	72					
26	1595.18699	1067.19946	71.5					
27	1680.99234	1180.7081	71					
28	1829.31725	1490.36559	71.5					
29	1834.34173	2001.54801	71					
	1912.21023	2177.02698	55.5					
31	1995.38308	808.61062	72.2					
32	2031.97563	2107.19589	55			_		
33	2266.97172	2359.96526	54.5					

- Render a topographic map using appropriate tools
 - By-hand; Excel, R-script
 - QuickGrid, Surfer, etc.
 - Arc GIS, qGIS, etc.
- Adjust settings to build an overlay



 Overlay the map – use known data locations (in XY) to reference the overlay to the sewer drawing



DETERMINE DRAINAGE AREAS

- Identify the individual drainage areas using the topographic rendering and the project layout drawing.
- We will assume that drainage from outside the project area is collected elsewhere
 - The figure to the right is intended as a guide to the method – the areas listed are not topographically justified; that is left as an exercise!



DETERMINE PIPE DISTANCES

- Identify the pipes to be sized in the drainage network
- Measure the pipe lengths





NODE-ARC DATA FROM ACROBAT Overland NRCS Upland Flow Distance Velocity Average Area (sq.in) Area (sq. ft.) Area (acres) (ft/sec) Slope Node (feet) 0.890 152920.962 1 3.511 391.051 Drop 2 feet 0.370 63573.883 1.459 2 252.139 625 feet Distance 2.430 417525.773 9.585 646.162 3 Slope 0.0032 Dimensionless 3.392 0.860 147766.323 384.404 4 9 Slope 0.32 % Slope 60137.457 1.381 245.229 5 0.350 Y 0.000 6 0.000 0.000 0.000 7 0.000 0.000 0.000 0.000 1.350 231958,763 5.325 8 481.621 0.280 48109.966 1.104 219.340 9 1.250 214776.632 4.931 463.440 10 11 0.720 123711.340 351.726 2.840 12 0.310 53264.605 1.223 230.791 13 0.380 65292.096 1.499 255.523 36.250 Outfall 14 ---Pipe Node 1 Node 2 Length 3 625 400 300 4 125 4 4 6 250 5 5 6 250 6 7 7 7 9 125 375 8 8 7 280 9 9 10 300 10 11 10 250 11 10 12 12 13 300 12 13 12 14 125

DETERMINE INLET TIMES

- Declare a travel distance on a drainage area to an inlet
- Determine slope along that path
- Apply a Tc estimation method
- Repeat for each inlet



DEVELOP AN INTENSITY EQUATION

- Locate the region on NOAA Atlas 14, Vol. 11 PFDS.
- Download the .CSV table
- Use solver to fit

$$I = \frac{B}{(T_c + D)^E}$$

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Jat	ta descrip	otion											
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	c) By address Search Q												
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	PF Duration 5-min 10-min 10-min 30-min 60-min 2-hr	30km 20mi 20mi 5.95 (4.51-7.87) 4.71 (3.04-5.30) 2.88 (2.18-3.80) 1.89 (1.43-2.50) 1.14 (0.870-1.50)	WITH 94 PF graphic PDS-basec 2 7.02 (5.35-9.16) 5.56 (4.24-7.25) 4.70 (3.59-6.14) 3.36 (2.57-4.39) 2.23 (1.70-2.91) 1.40 (1.06-1.78)	Angelen POINT PR 0% CONFIDE M al Sup a precipitation 5 8.72 (6.65-11.5) 6.94 (5.28-9.10) 5 8.72 (6.44-7.66) 4.14 (3.16-5.44) 2.77 (2.11-3.64) 1.78 (1.36-2.31)	ECIPITATION NCE INTERVAI IOAA Atlas 14 optementary Int 10.2 (7.63-13.5) 8.09 (6.07-10.8) 6.78 (5.09-9.03) 4.80 (3.60-6.39) 3.23 (2.42-4.31) 2.13 (1.61-2.82)	FREQUENCY LS AND SUPP , Volume 11, V formation 25 12.2 (8.83-16.7) 9.70 (7.06-13.3) (5.88-11.1) 5.70 (4.13-7.80) 3.87 (2.80-5.29) 2.64 (1.93-3.59)	+ (PF) ESTIM LEMENTAR (ersion 2 90% confide ce interval (y 50 13.7 (9.70-19.3) 11.0 (7.77-15.5) (6.44-12.8) 6.38 (4.50-8.98) (3.07-6.12) (3.05 (2.17-4.27)	* Source: ESRI N ** Source: USGS IATES IY INFORMATION Information (III) (IIII) (III)	Aps n inches/hour 200 17.1 (11.5-25.4) 13.6 (9.11-20.2) 11.3 (7.58-16.8) 7.92 (5.33-11.8) 5.49 (3.69-8.18) 4.06 (2.74-6.00)	 Print pa 500 19.5 (12.6-30.0) 15.3 (9.94-23.6) 12.8 (8.34-19.8) 9.11 (5.92-14.1) 6.42 (4.17-9.91) 4.90 (3.20-7.52) 	1000 21.4 (13.5-33.8) 16.7 (10.5-26.3) 10.1 (6.39-15.9) 7.20 (4.56-11.4) 5.63 (3.57-8.83)		
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	PF Duration 5-min 10-min 15-min 30-min 60-min 2-hr 3-hr 6-hr	30km 20mi 20mi 5.95 (4.51-7.87) (4.51-7.87) (4.51-7.87) (4.51-7.87) (4.51-7.87) (4.51-7.87) (4.51-7.87) (4.51-7.87) (4.51-7.87) (4.51-7.87) (3.04-5.30) (2.18-3.80) (1.43-2.50) (1.43-2.50) (1.43-2.50) (1.43-2.50) (1.635-1.08) (0.635-1.08) (0.370-0.621) (0	WITH 94 PF graphic PDS-based 2 7.02 (5.35-9.16) 5.56 (4.24-7.25) (3.59-6.14) 3.36 (2.57-4.39) 2.23 (1.70-2.91) 1.40 (1.06-1.78) 1.04 (0.787-1.31) 0.6526	Angelen POINT PR D% CONFIDE b% CONFIDE	ECIPITATION NCE INTERVA IOAA Atlas 14 optementary int n frequency es Ave 10 10.2 (7.63-13.5) 8.09 (6.07-10.8) 5.78 (5.09-9.03) 4.80 (3.60-6.39) 3.23 (2.42-4.31) 2.13 (1.61-2.82) 1.65 (1.25-2.17) (0.786-1.34)	FREQUENCY LS AND SUPP , Volume 11, V formation 25 12.2 (8.83-16.7) 9.70 (7.06-13.3) 8.09 (5.88-11.1) 5.70 (4.13-7.80) 3.87 (2.80-5.29) 2.64 (1.93-3.59) 2.08 (1.53-2.83) (0.988-1.80) (0.988-1.80)	+ (PF) ESTIM LEMENTAR fersion 2 90% confide ce interval (y 50 13.7 (9.70-19.3) 11.0 (7.77-15.5) 9.10 (6.44-12.8) 6.38 (3.07-6.12) 3.05 (2.17-4.27) 2.45 (1.75-3.42) (1.75-3.42) (1.15-0.22) (1.1	* Source: ESRI N ** Source: USGS IATES IV INFORMATION ence intervals (ii rears) 100 15.3 10.6-22.2) (8.45-17.8) (10.6-22.2) (8.45-17.8) (10.6-22.2) (8.45-17.8) (10.6-22.2) (1.6-22.2)	Asps 200 17.1 (11.5-25.4) 13.6 (9.11-20.2) 11.3 (7.58-16.8) 7.92 (5.33-11.8) 5.49 (3.69-8.18) 4.06 (2.74-6.00) 3.37 (2.28-4.96) (2.28-4.96) (1.55-3.32)	 Print pe 500 19.5 (12.6-30.0) 15.3 (9.94-23.6) 12.8 (8.34-19.8) 9.11 (5.92-14.1) (6.42 (4.17-9.91) (4.90 (3.20-7.52) 4.14 (2.71-6.33) (2.74-6.331) (1.86-4.31) 	1000 21.4 (13.5-33.6) 16.7 (10.5-26.3) 10.1 (6.39-15.9) 7.20 (4.56-11.4) 5.63 (3.57-8.83) 4.81 (3.06-7.52) 3.33 (2.13.65.17)		
	PF Duration 5-min 10-min 15-min 30-min 60-min 2-hr 3-hr 6-hr 12-br	30km 20mi 20mi 595 (4.51-7.87) 4.71 (3.04-5.30) 2.88 (1.43-2.50) 1.49 (1.43-2.50) 1.14 (0.870-1.50) 0.635-1.08) 0.635-1.08) 0.635-1.08) 0.6370-0.621)	WITH 94 PF graphic PDS-based 2 7.02 (5.35-9.16) 5.56 (4.247.25) 4.70 (3.59-6.14) 3.36 (2.574.39) 2.23 (1.70-2.91) 1.40 (1.06-1.78) 1.04 (0.787-1.31) 0.626 (0.470-0.766) 0.386	Angreen POINT PR D% CONFIDE b% CONFIDE	ECIPITATION NCE INTERVA IOAA Atlas 14 optementary inf 10.2 (7.63-13.5) 8.09 (6.07-10.8) 8.78 (5.09-9.03) 4.80 (3.60-6.39) 3.23 (2.42-4.31) 2.13 (1.61-2.82) 1.65 (1.25-2.17) 1.03 (0.785-1.34) 0.5614	FREQUENCY LS AND SUPP Volume 11, V formation 25 12.2 (8.83-16.7) 9.70 (7.06-13.3) 8.09 (5.88-11.1) 5.70 (4.13-7.80) 3.87 (2.80-5.29) 2.64 (1.93-3.59) 2.64 (1.53-2.83) 1.53-2.83) (0.988-1.80) 0.9806	+ (PF) ESTIM LEMENTAR Version 2 90% confide ce interval (y 50 13.7 (9.70-19.3) (7.77-15.5) 9.10 (6.44-12.8) 6.38 (4.50-8.98) 4.35 (2.174-27) 2.45 (1.75-3.42) 1.152-23 0.974	* Source: ESRI N ** Source: USGS ATES EY INFORMATION I	Asps n inches/hour 200 17.1 (11.5-25.4) 13.6 (9.11-20.2) 11.3 (7.58-16.8) 7.92 (5.33-11.8) 5.49 (3.69-8.18) (2.28-4.96) 2.28 (1.55-3.33) 1.41 1.41	 Print pa 500 19.5 (12.6-30.0) 15.3 (9.94-23.6) 12.8 (8.34-19.8) 9.11 (5.92-14.1) (6.42 (4.17-9.91) (4.271-6.33) 2.84 (1.86-4.31) 1.77 	1000 21.4 (13.5-33.8) 16.7 (10.5-22.3) 10.1 (6.39-15.9) 7.20 (4.56-11.4) 5.63 (3.57-8.83) 4.81 (3.06-7.52) 3.33 (2.13-5.17) 2.07		
	PF Duration 5-min 10-min 15-min 30-min 60-min 2-hr 3-hr 6-hr 12-hr	30km 20mi 20mi 5.95 (4.51-7.87) 4.71 (3.57-6.22) 4.01 (3.04-5.30) 2.88 (2.18-3.80) 1.43-2.50) 1.43-2.50) 1.43-2.50) 1.43-2.50) 0.830 (0.635-1.08) 0.635-1.08) 0.370-0.621) 0.275 (0.213-0.353) 0.159	WITH 94 PF graphic PDS-based PDS-based (5.356 (4.24-7.25) 4.70 (3.59-6.14) 3.36 (2.57-4.39) 2.23 (1.70-2.91) 1.40 (1.06-1.78) 1.04 (0.787-1.31) 0.626 (0.275-0.441) 0.214	Angeten POINT PR % CONFIDE: % CONFIDE: % al Sup d precipitation 5 8.72 (6.65-11.5) 6.94 (5.28-9.10) 5.83 (4.44-7.66) 4.14 (3.16-5.44) 2.173.64) 1.36 (1.04-1.75) 0.830 (0.639-1.06) 0.491 (0.380-0.620) 0.290	EECIPITATION NCE INTERVAI (OAA Atlas 14 oplementary Inf 10 (7.63-13.5) (6.07-10.8) (5.09-9.03) (3.60-6.39) (3.60-6.39) (3.213 (1.61-2.82) (1.25-2.17) (1.25-2.17) (1.25-2.17) (0.785-1.34) (0.614 (0.472-0.795) 0.365	FREQUENCY LS AND SUPP , Volume 11, V formation 25 12.2 (8.83-16.7) 9.70 (7.06-13.3) 8.09 (5.88-11.1) 5.70 (4.13-7.80) 3.87 (2.80-5.29) 2.64 (1.93-3.59) 2.08 (1.53-2.83) 1.33 (0.986-1.80) 0.986-1.80) 0.986-1.80	+ (PF) ESTIM LEMENTAR /ersion 2 90% confide co interval (y 50 13.7 (9.70-19.3) (7.77-15.5) 9.10 (6.44-12.8) 6.38 (4.50-8.98) (4.50-8.98) (3.07-6.12) (2.17-6.3.42) 1.15-2.3.42 1.15-2.5.42 1.15-2.5.5 1	* Source: ESRI N ** Source: USGS ATES EXPINFORMATION I	Asps n inches/hour 200 17.1 (11.5-25.4) 13.6 (9.11-20.2) 11.3 (7.58-16.8) 7.92 (5.33-11.8) 5.49 (3.69-8.16) (2.74-6.00) 3.37 (2.28-4.96) 2.28 (1.55-3.33) 1.41 (0.959-2.04) 0.850	■ Print ps 1 500 19.5 (12.6-30.0) 15.3 (9.94-23.6) 12.8 (8.34-19.8) 9.11 (5.92-14.1) 6.42 (4.17-9.1) 4.14 (2.71-6.33) 2.84 (1.86-4.31) 1.16-2.66) 1.06	1000 21.4 (13.5-33.8) 16.7 (10.5-26.3) 14.1 (6.39-15.9) 7.20 (4.56-11.4) 5.63 (3.57-8.83) 4.81 (3.06-7.52) 3.33 (2.13-5.17) 2.07 (1.33-3.20) 1.25		
	PF Duration 5-min 10-min 15-min 30-min 60-min 2-hr 3-hr 6-hr 12-hr 12-hr	30km 20mi 20mi 595 (4.51-7.87) 4.71 (3.04-5.30) 2.88 (1.43-2.50) (1.43-2.50) (1.43-2.50) (1.43-2.50) (0.635-1.08) (0.635-1.08) (0.635-1.08) (0.635-1.08) (0.635-1.08) (0.635-1.08) (0.124-0.202) (0.124-0.202)	WITH 94 PF graphic PDS-based 2 7.02 (5.35-9.16) 5.56 (4.247.25) 4.70 (3.59-6.14) 3.36 (2.57-4.39) 2.23 (1.70-2.91) 1.40 (1.06-1.78) 1.04 (0.787-1.31) 0.626 (0.470-0.766) 0.366 (0.275-0.441) 0.214 (0.161-0.254)	Angeten POINT PR % CONFIDE: % CONFIDE: % CONFIDE: % 4 Sup 4 precipitation 5 8.72 (6.65-11.5) 6.94 (5.28-9.10) 5.83 (4.44-7.66) 4.14 (3.16-5.44) 2.173.64) 1.36 (1.04-1.75) 0.830 (0.639-1.06) 0.491 (0.380-0.620) 0.226-0.362)	ECIPITATION NCE INTERVA IOAA Atlas 14 optementary Int n frequency es Ave 10 10.2 (7.63-13.5) 8.09 (6.07-10.8) 6.78 (5.09-9.03) (3.60-6.39) 3.23 (2.42-4.31) (1.61-2.82) 1.65 (1.25-2.17) 1.03 (0.785-1.34) 0.614 (0.472-0.795) 0.385 (0.282-0.469)	FREQUENCY LS AND SUPP , Volume 11, V formation 25 12.2 (8.83-16.7) 9.70 (7.06-13.3) 8.09 (5.88-11.1) 5.70 (4.13-7.80) 3.87 (2.80-5.29) 2.64 (1.93-3.59) 2.08 (1.53-2.83) 1.33 (0.988-1.80) 0.988-1.80) 0.988-1.80 0.988-1.988-1.80 0.988-1.80 0.988-1.80 0.988-1.80 0.988-1.80 0.988-1.80 0.988-1.988-1.80 0.988-1.80 0.988-1.80 0.988-1.80 0.988-1.80 0.988-1.80 0.988-1.	+ (PF) ESTIM LEMENTAR /ersion 2 30% confide co interval (y 50 13.7 (9.70-19.3) (7.77-15.5) 9.10 (6.44-12.8) 6.38 (4.50-8.98) (4.50-8.98) (3.07-6.12) 3.05 (2.17-8.342) (1.15-2.342) 1.15-2.342	* Source: ESRI N ** Source: USGS ATES EY INFORMATION I	Asps n inches/hour 200 17.1 (11.5-25.4) 13.6 (9.11-20.2) 11.3 (7.58-16.8) 7.92 (5.33-11.8) 5.49 (3.69-8.16) (2.74-6.00) 3.37 (2.28-4.96) 2.28 (1.55-3.33) 1.41 (0.959-2.04) 0.850 (0.582-1.22)		1000 21.4 (13.5-33.8) 16.7 (10.5-26.3) 14.1 (8.92-22.3) 10.1 (6.39-15.9) 7.20 (4.56-11.4) 5.63 (3.57-8.83) 4.81 (3.06-7.52) 3.33 (2.13-5.17) 2.07 (1.33-3.20) 1.25 (0.801-1.91)		

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DEVELOP AN INTENSITY EQUATION

• Solver results for (2-yr ARI) $I = \frac{48.01}{(T_c + 9.06)^{0.73}}$

- Use the above equation in the subsequent analysis
- Note: The exercise requests a design for 5-yr ARI, so readers will have to conduct the fitting exercise on the 5-yr column from NOAA Atlas 14!

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1						e	0.7287615					
2						b	48.0144527					
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7	15	4.7		1.17609126	0.67209786		4,72790749	0.00077883			5.55761-157	
8	30	3.36		1.47712125	0.52633928		3.32152065	0.00148066				
9	60	2.23		1.77815125	0.34830486		2.19275845	0.00138693				
10	120	1.4		2.07918125	0.14612804		1.39025869	9.4893E-05				
11	180	1.04		2.25527251	0.01703334		1.05260434	0.00015887				
12	360	0.626		2.5563025	-0.2034257		0.6464964	0.0004201				
13	720	0.366		2.8573325	-0.4365189		0.39363897	0.00076391				
14	1440	0.214		3.15836249	-0.6695862		0.23861229	0.00060576				
15								0.00823866	<= SSE			
16												
18		10					-	-				
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-	► F	'F_Intensity	_English_P[DS.csv	EBD-Versi	on +		_				
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ANALYSIS

• Apply the intensity equation as needed