this solution sketch is not a complete memo. Students need to produce a memorandum. The sketch provides sufficient guidance to construct the relevant components for the memorandum

CE 3372 – Water Systems Design
Exercise Set XXXXX

Problem Statement and Background

Figure 1 is an older (circa 1993) aerial image of a portion of Houston, Texas. The red polygon is the drainage boundary for a storm sewer system that drains North from the part of the area near Westheimer Road to a tributary of Buffalo Bayou and East from the area. The drainage ditch is shown as the "blue" fuzzy line on the figure. Drainage in the ditch is from West to East. The two main streets in the study area are highlighted in magenta.

Figure 1: Tanglewilde Drive Study Area

Figure 2 is a map showing storm drainage alignments and inlets location.

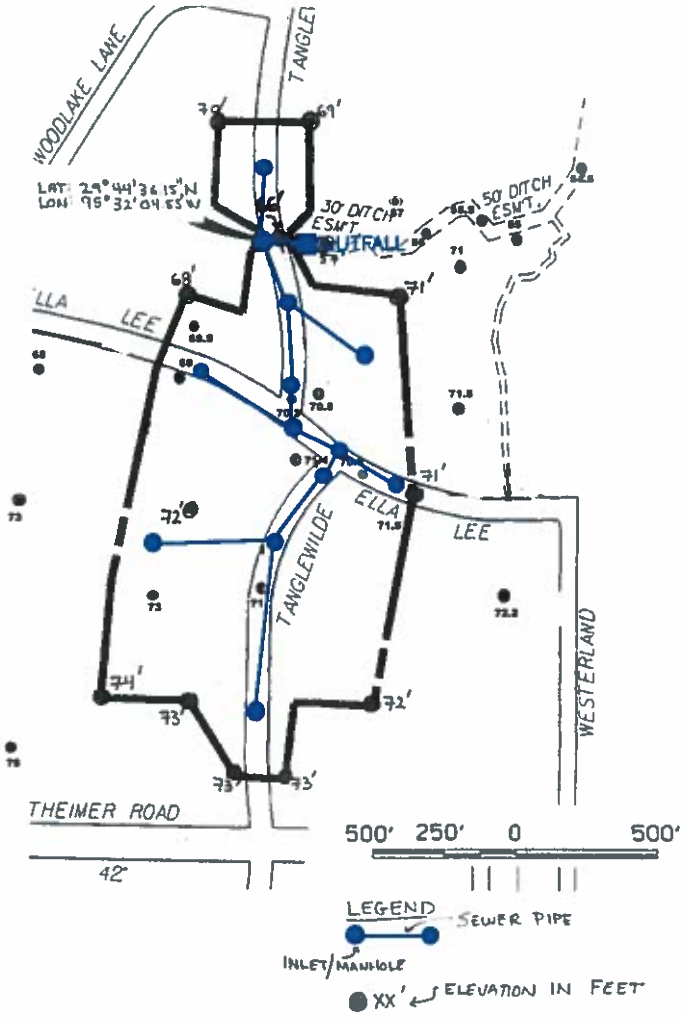


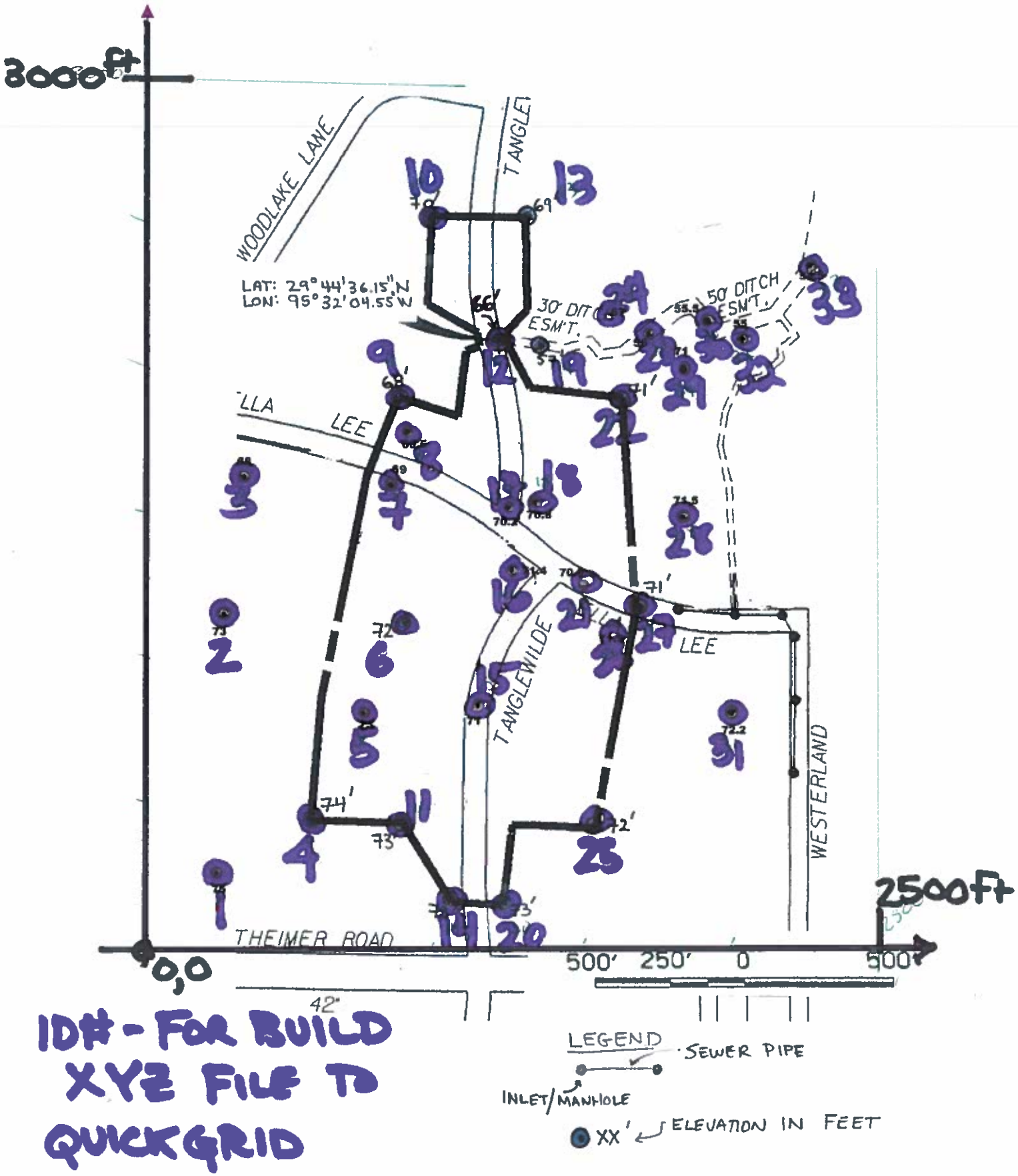
Figure 2: Tanglewilde Drive Storm Drain Inlet and Pipe Alignments

The figure shows land surface elevations in feet at the indicated locations. A linear scale is

shown in the legend. Use the map(s) and:

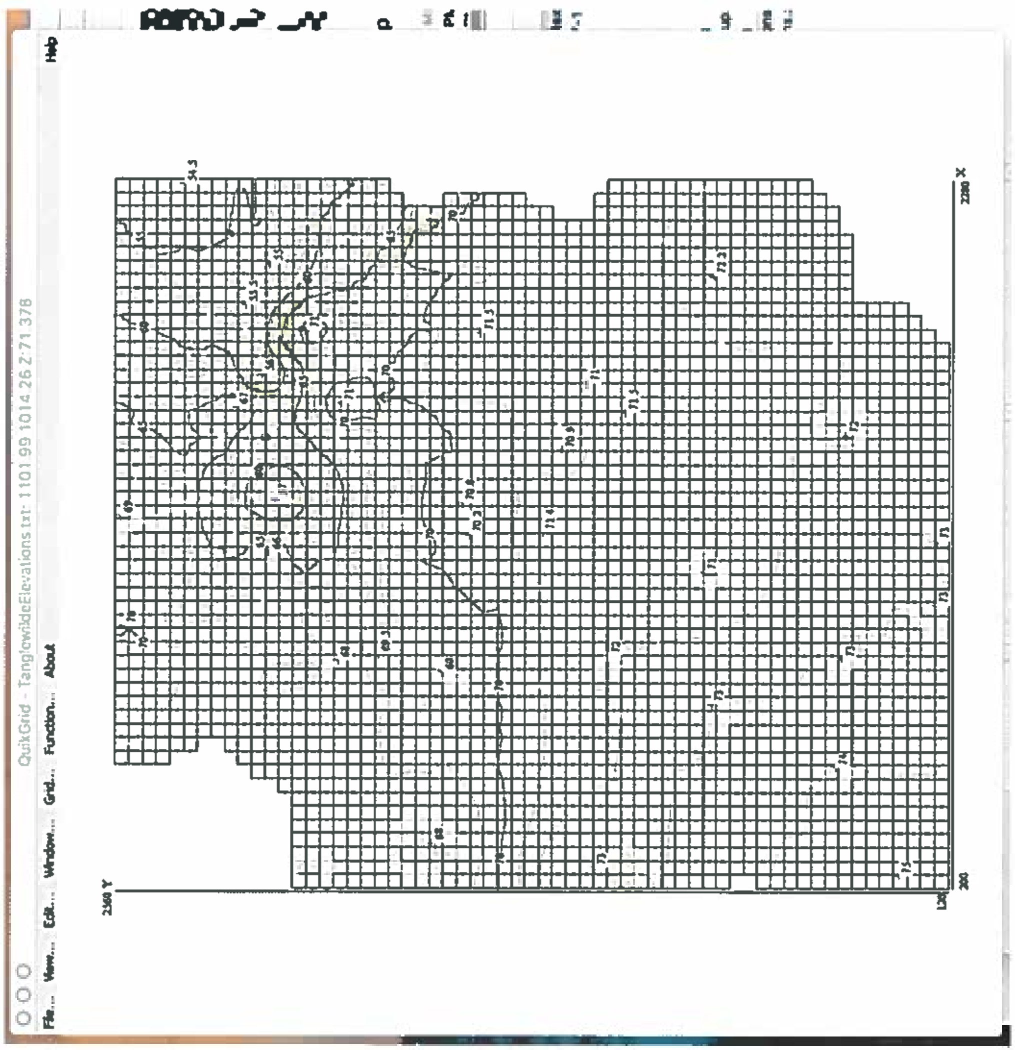
1. Construct a land surface elevation contour map using the provided elevation and locations.
2. Using your contour map determine the drainage areas to each inlet node. Indicate which nodes you do not assign drainage (junction nodes for connecting pipes).
3. Use the rational design method to size the conduits for a 5-year storm, for Harris County, Texas.
4. Specify the invert (flow line) elevations of the nodes (inlets and junction boxes).
5. Specify the soffit (crown) elevations for the pipes at each node.

Submit a memorandum with screen captures of the relevant components above. Save your work, you need it for Project 2.

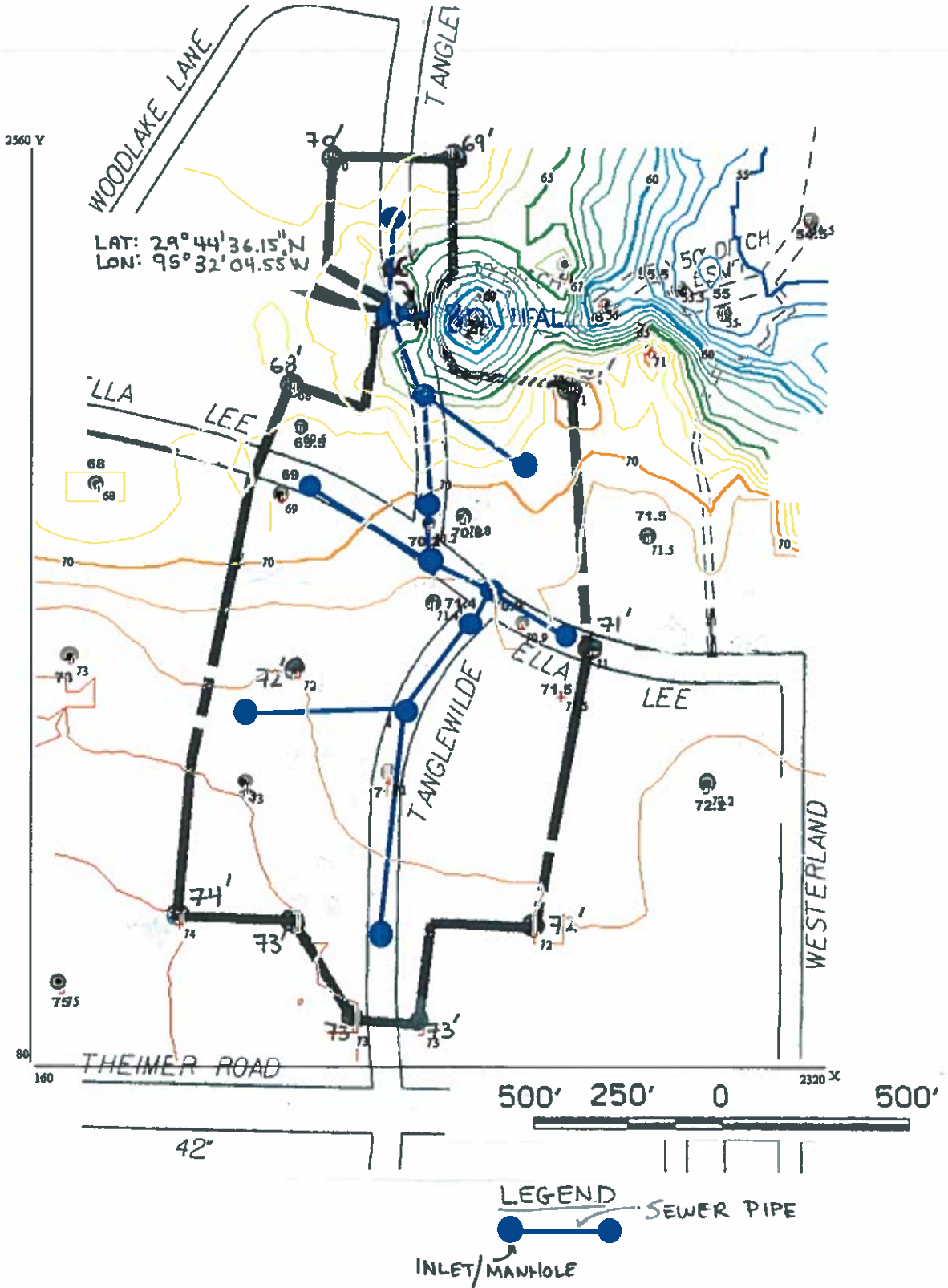

3000ft
WOODLAKE LANE
TANGLEWILDE
LAT: 29°44'36.15"N
LON: 95°32'04.55"W
30' DITCH ESM'T.
50' DITCH ESM'T.
LEE
TANGLEWILDE
WESTERLAND
THEIMER ROAD
0,0
500' 250' 0 500'
2500ft
42"
LEGEND
SEWER PIPE
INLET/MANHOLE
XX' ELEVATION IN FEET
ID# - FOR BUILD XYZ FILE TO QUICKGRID

	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,Y1				
3	332.144775	1633.90828	68		4) Locate X1, Y2				
4	554.122697	448.65323	74		5) Use G3DATA to capture x,y each point				
5	737.728288	815.072914	73		6) Manual enter z for each point based on collect order				
6	880.998109	1119.57212	72						
7	832.812956	1602.41018	69						
8	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						
30	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						

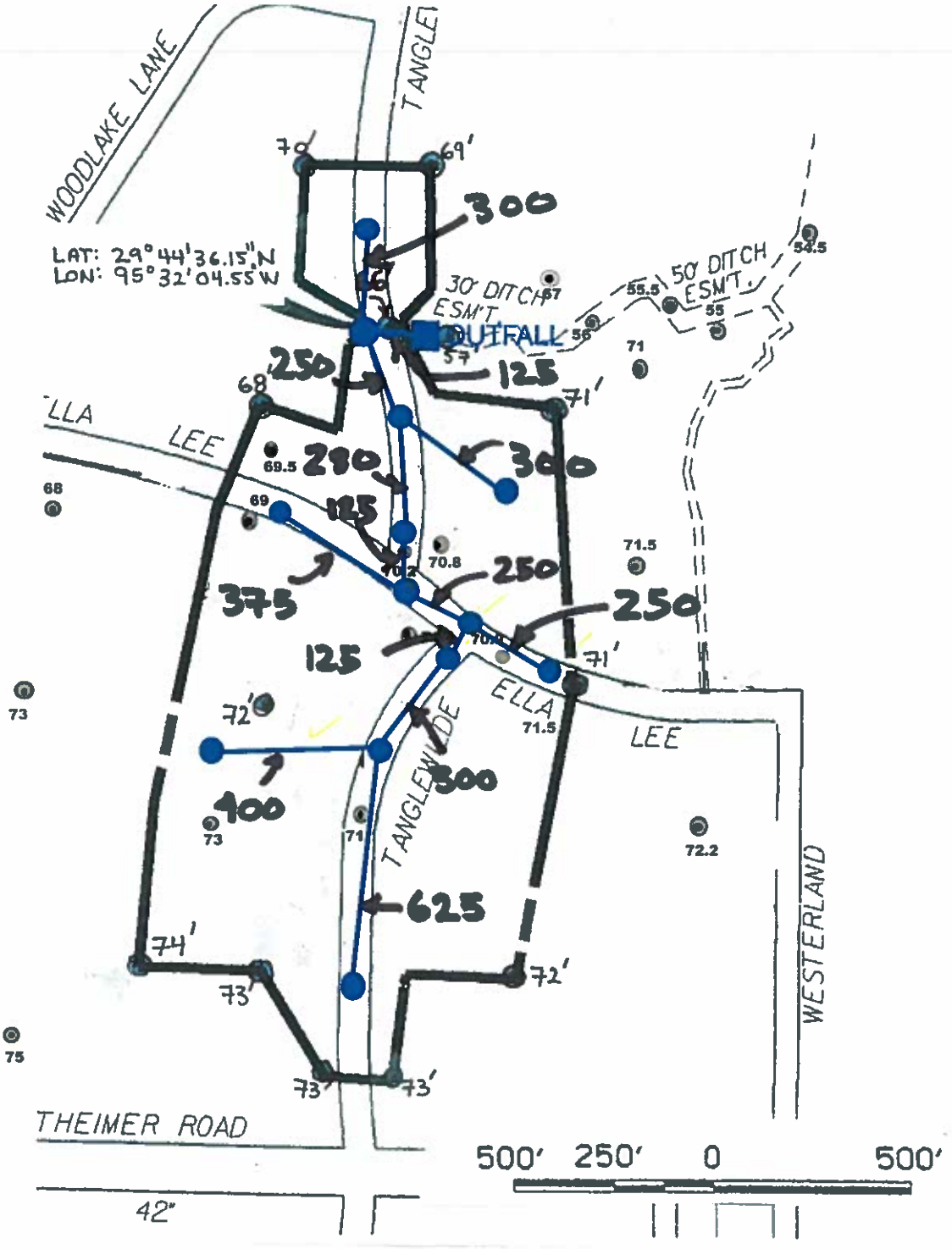
ELEVATIONS FOR INPUT TO QUICKGRID



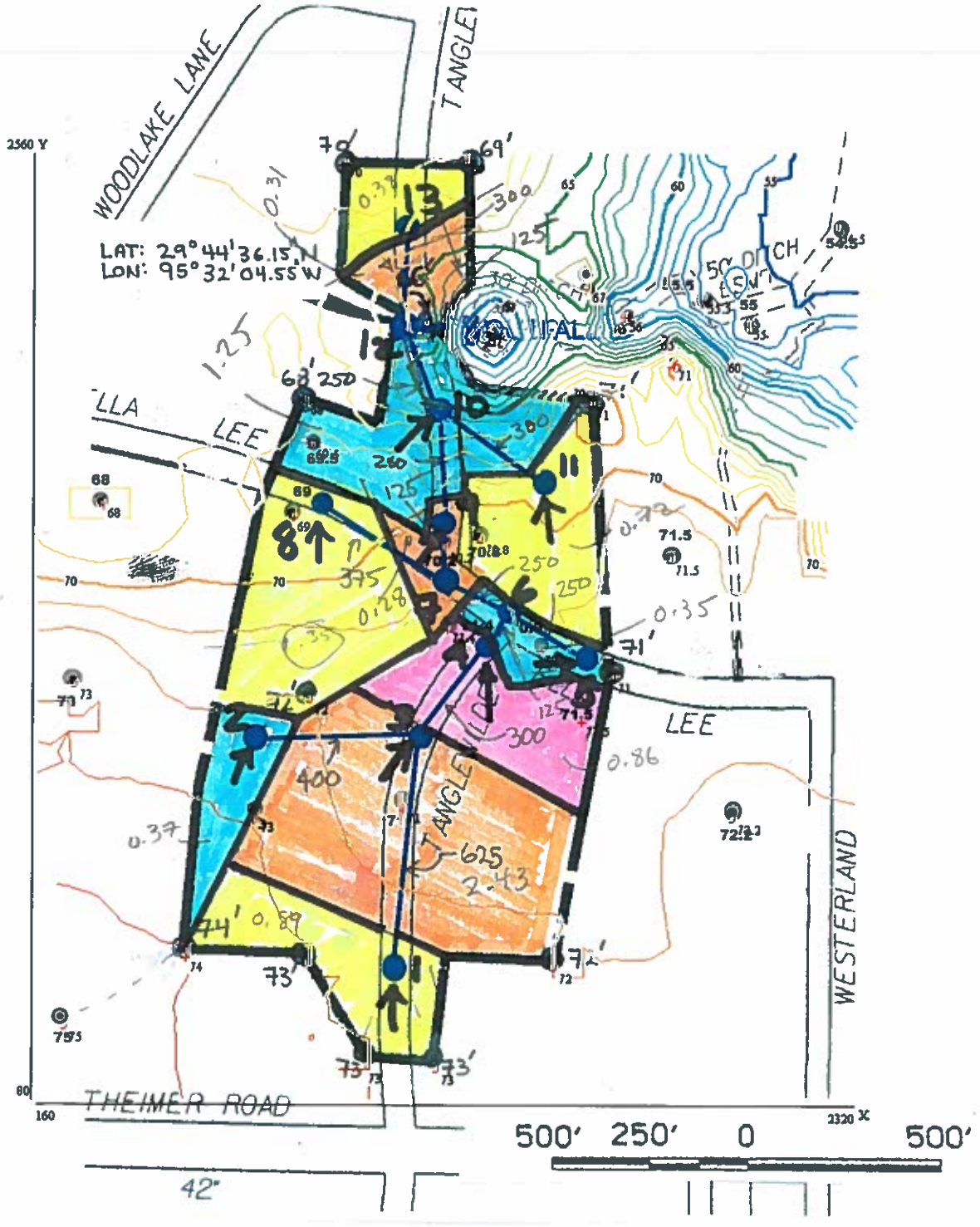
QUICKGRID INITIAL RESULT, ADJUST SETTINGS TO BUILD OVERLAY



OVERLAY CONTOUR MAP ON LAYOUT



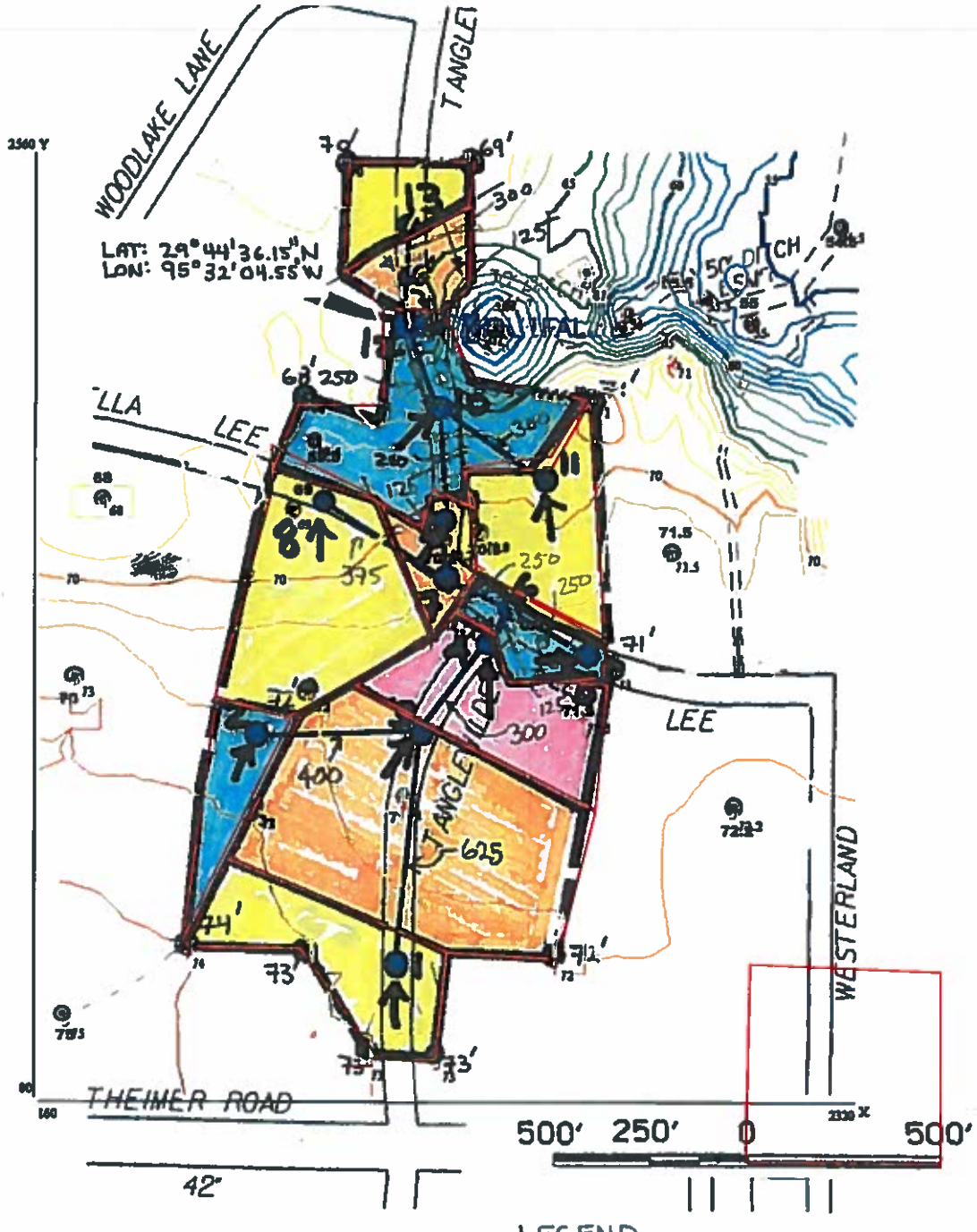
PIPE LENGTHS (DIRECT MEASURE ON MAP)



ID REASONABLE DA & NODE ID (NAMES)

USE TO FIND DRAIN AREA TO EACH NODE
PIPE LENGTH EACH PIPE – BUILD TABLE

AREAS IN ACROBAT PRO



ID REASONABLE DA & NODE ID (NAMES)

USE TO FIND DRAIN AREA TO EACH NODE
PIPE LENGTH EACH PIPE – BUILD TABLE

NODE-ARC DATA FROM ACROBAT

Node	Area (sq.in)	Area (sq. ft.)	Area (acres)		Overland Flow Distance (feet)	NRCS Upland Velocity (ft/sec)			Average Slope			
1	0.890	152920.962	3.511		391.051				Drop	2	feet	
2	0.370	63573.883	1.459		252.139				Distance	625	feet	
3	2.430	417525.773	9.585		646.162				Slope	0.0032	Dimensionless	
4	0.860	147766.323	3.392		384.404				Slope	0.32	% Slope	
5	0.350	60137.457	1.381		245.229							
6	0.000	0.000	0.000		0.000							
7	0.000	0.000	0.000		0.000							
8	1.350	231958.763	5.325		481.621							
9	0.280	48109.966	1.104		219.340							
10	1.250	214776.632	4.931		463.440							
11	0.720	123711.340	2.840		351.726							
12	0.310	53264.605	1.223		230.791							
13	0.380	65292.096	1.499		255.523							
14	--	--	36.250	Outfall								

USE UPLAND t_c ENTER NEXT SHEET

Pipe	Node_1	Node_2	Length
1	1	3	625
2	2	3	400
3	3	4	300
4	4	6	125
5	5	6	250
6	6	7	250
7	7	9	125
8	8	7	375
9	9	10	280
10	11	10	300
11	10	12	250
12	13	12	300
13	12	14	125

NRCS Upland Method Tc Estimator

Input Values

0.32	<= Watershed Slope (%)
Nearly Bare Ground	<= Select Watershed Surface Type (Pull Down Menu)
255	<= Path Length (ft)

Reference: NEH 630 Chapter 15
http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=27002.wba

Computed Values

0.565685425	<= Flow Velocity (ft/s)
451	<= Time (seconds)
7.5	<= Time (minutes)
0.13	<= Time (hours)

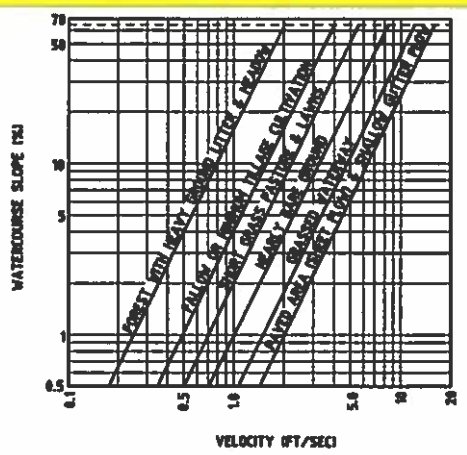
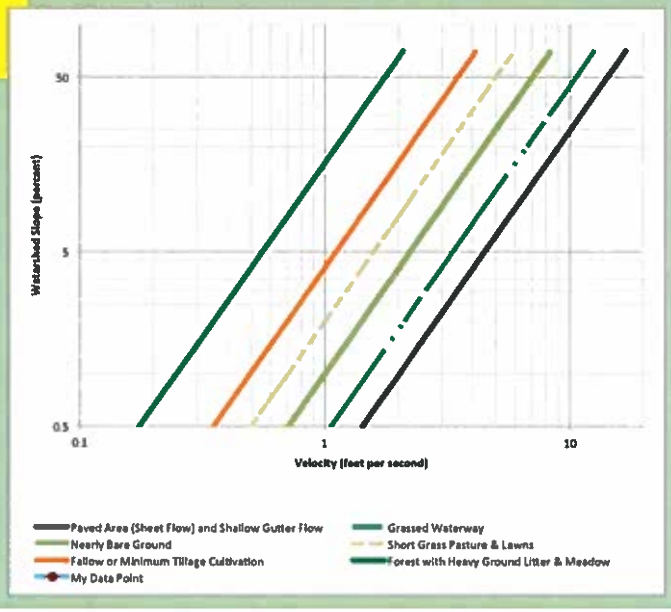


Figure 5-4. Velocities for Upland Method of Estimating Time of Concentration--English (Adapted from the National Engineering Handbook Volume 4)



Rainfall Intensity-Duration-Frequency Coefficients for Texas

Based on United States Geological Survey (USGS) Scientific Investigations Report 2004–5041
"Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas"

1. Select English or SI Units

English

2. Select or Enter a County

Harris

3. Enter a Time of Conc. Select Units

22.66 min

Coefficient	50% (2-year)	20% (5-year)	10% (10-year)	4% (25-year)	2% (50-year)	1% (100-year)
e	0.7939	0.7855	0.7829	0.7774	0.7727	0.772
b (in.)	57.73	73.87	86.47	102.23	116.88	136.33
d (min)	9.48	10.46	11.27	12.32	12.95	14.08
Intensity (in./hr)	3.67	4.73	5.48	6.45	7.39	8.44

(Spreadsheet Release Date: August 31, 2015; data table reshuffle by Asquith July 14, 2016)

From NRCS

From EBOLKUP

Tangiewilde Storm Sewer

Drainage Area ID	Drainage Area (acres)	Runoff Coefficient	Inlet ID	Inlet Time (min)		PipeID	NodeID-NodeID	Pipe Length (ft)	Pipe Slope
DA-1	3.51058224	0.85	1	11.5		1	DA1-DA3	625	0.0050
DA-2	1.45945554	0.85	2	7.4		2	DA2-DA3	400	0.0050
DA-3	9.58507285	0.85	3	19		3	DA3-DA4	300	0.0050
DA-4	3.392248	0.85	4	11.3		4	DA4-DA6	125	0.0050
DA-5	1.38056605	0.85	5	7.2		5	DA5-DA6	250	0.0050
DA-6	0	0.85	6			6	DA6-DA7	250	0.0050
DA-7	0	0.85	7			7	DA7-DA9	125	0.0050
DA-8	5.32504047	0.85	8	14.2		8	DA8-DA7	375	0.0050
DA-9	1.10445284	0.85	9	6.5		9	DA9-DA10	280	0.0050
DA-10	4.930593O3	0.85	10	13.6		10	DA11-DA10	300	0.0050
DA-11	2.84002158	0.85	11	10.3		11	DA10-DA12	250	0.0050
DA-12	1.22278707	0.85	12	6.8		12	DA13-DA12	300	0.0050
DA-13	1.49890028	0.85	13	7.5		13	DA12-OF14	125	0.0050
OF14	0	0.85							
Total	36.2497199								

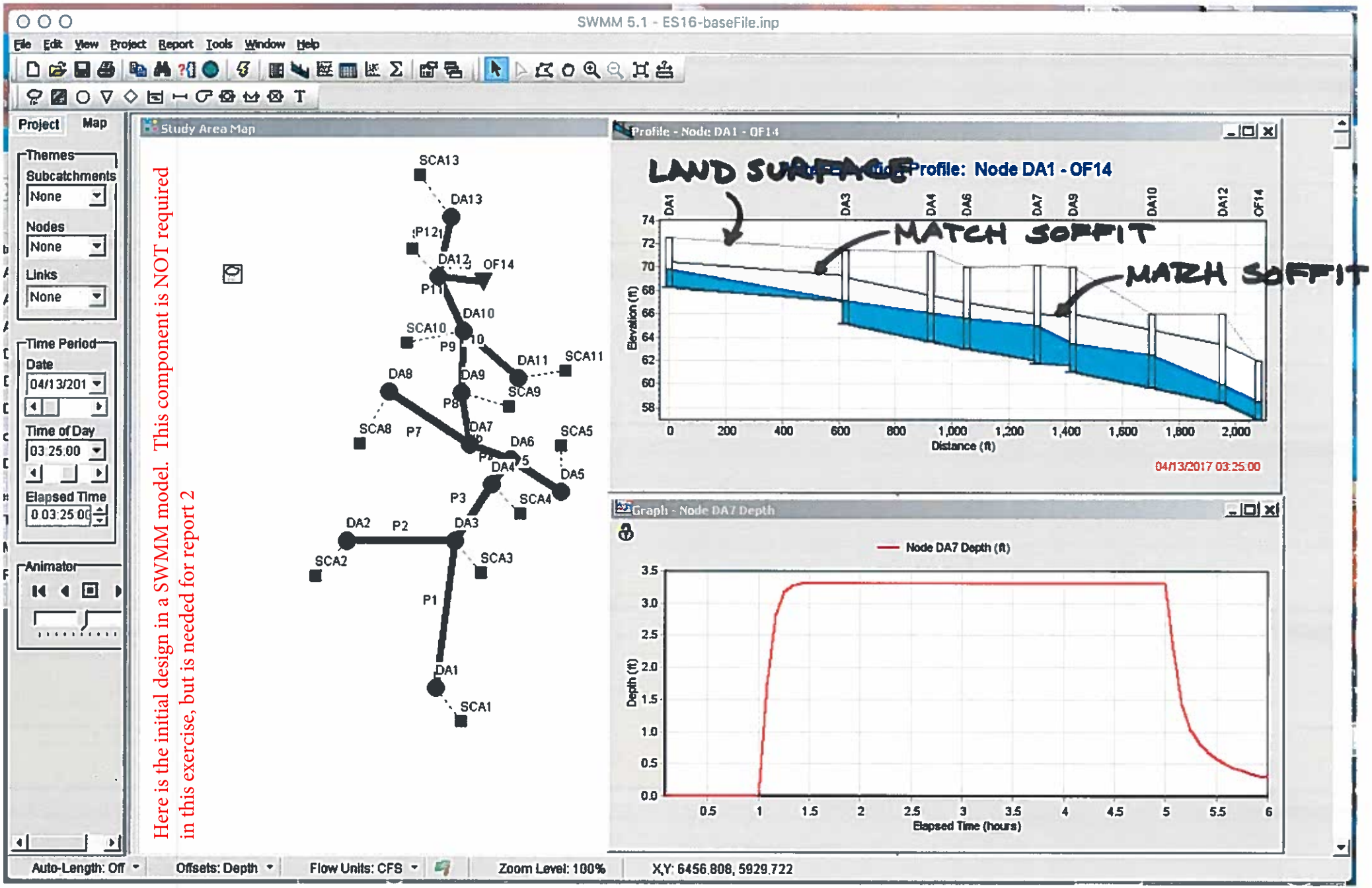
Rational Calculations

Pipe ID					DA-ID	DA	C	Cum Area	CA	SumCA	Inlet Time	Upstream Sewer Time	t_c	I	Qp	D-computed	D-used	V-used (ft/sec)	Sewer Time (min)
1	DA1-DA3	625	0.0050	DA-1		3.51	0.85	3.51	2.9835	2.9835	11.5	0	11.5	6.53	19.482255	2.20651806	2.25	4.89986716	2.12590797
2	DA2-DA3	400	0.0050	DA-2		1.46	0.85	1.46	1.241	1.241	7.4	0	10	6.9	8.5629	1.62115898	2	2.72365572	2.44589462
3	DA3-DA4	300	0.0050	DA-3		9.58	0.85	9.58	8.143	8.143	19	0	19						
				DA-1							11	2.12590797	13.125908						
				DA-2							9.2	2.44589462	11.6458946						
3	DA3-DA4					14.55				12.3675			19	5.18	64.06365	3.44803891	4	5.09802329	0.9807723
4	DA4-DA6	125	0.0050	DA4		3.39	0.85	3.39	2.8815	2.8815	11.3	0	11.3	6.6	19.0179	2.1866473	0.83333333	34.868653	0.05974803
3	DA3-DA4	125	0.0050	DA3-DA2-DA1							19	0.9807723	19.9807723						
4	DA4-DA6					17.94				15.249			19.9807723	5.05	77.00745	3.69438844	4	6.12805816	0.33996631
5	DA4-DA6	250	0.0050	DA5		1.38	0.85	1.38	1.173	1.173	7.2	0	10	6.9	8.0937	1.58725953	2	2.57630473	1.61730351
5	DA4-DA6					1.38				1.173			10	6.9	8.0937	1.58725953	2	2.57630473	1.61730351
					3.1														
6	DA6	250	0.0050	DA6		0	0.85	0	0	0	7.2	0	10		0	0	2	0	#DIV/0!
5	DA5										10	1.61730351	11.6173035						
4	DA4-3-2-1										19.9	0.33996631	20.2399663						
6	DA4-DA6					19.32				16.422			20.2399663	5.02	82.41844	3.79001946	4	6.56024261	0.63513911
					4.1														
7	DA7	250	0.0050	DA7		0	0.85	0	0	0	7.2	0	10		0	0	2	0	#DIV/0!
6	DA6-5-4-3-2-1										20.2399663	0.63513911	20.8751054						
8	DA8										14.2	1.138	15.338						
7	DA7-DA9					24.64				20.944			20.8751054	4.94	103.46596	4.12703114	4.25	7.29321198	0.5713075
					5.2														
8	DA8	375	0.0050	DA8		5.32	0.85	5.32	4.522	4.522	7.2	0	14.2	5.96	26.95112	2.49206339	2.5	5.49043708	1.13834289
8	DA8-DA7					5.32				4.522			14.2	5.96	26.95112	2.49206339	2.5	5.49043708	1.13834289
9	DA9	250	0.0050	DA7		1.1	0.85	1.1	0.935	0.935	7.2	0	10	6.9	6.4515	1.45785906	2	2.05357623	2.02898076
7	DA8-7-6-5-4-3-2-1										20.8751054	0.5713075	21.4464129						
9	DA9-DA10					25.74				21.879			21.4464129	4.94	108.08229	4.19518083	5	5.5045843	0.75694484
10	DA11	300	0.0050	DA11		2.84	0.85	2.84	2.414	2.414	10.3	0	10.3	6.8	16.4152	2.06923633	2.5	3.34407708	1.49518084
10	DA11-DA10					2.84				2.414			10.3	6.8	16.4152	2.06923633	2.5	3.34407708	1.49518084
11	DA10	250	0.0050	DA10		4.93	0.85	4.93	4.1905	4.1905	7.2	0	10	6.9	28.91445	2.55864998	3	4.09055791	1.01860596
10	DA11-DA10										10.3	1.49518084	11.7951808						
9	DA9-DA10										21.44	0.63	22.07						
11	DA10-DA12					33.51				28.4835			22.07	4.79	136.435965	4.57816145	5	6.94862664	0.59963888
12	DA13	300	0.0050	DA13		1.49	0.85	1.49	1.2665	1.2665	7.5	0	10.3	6.9	8.73885	1.63357145	2	2.78166235	1.79748631
12	DA13-DA12					1.49				1.2665			10.3	6.9	8.73885	1.63357145	2	2.78166235	1.79748631
13	DA12	125	0.0036	DA12		1.22	0.85	1.22	1.037	1.037	6.8	0	10	6.9	7.1553	1.61186393	2	2.27760273	0.91470444
12	DA13-DA12										10.3	1.79748631	12.0974863						
11	DA10-DA12										22.07	0.599	22.669						
13	DA12-OF14					36.22				30.787			22.669	4.73	145.62251	4.98946095	5	7.41649353	0.28090543

PRELIM. DESIGN

SUMMARY							Preliminary Design Inverts				Estimated Land Surface Elev			
PipeID	NodeID-NodeID	Pipe Length (ft)	Pipe Slope	Diameter (ft)	Flow (CFS)	Velocity (ft/s)	DA-IN	ELEV	DA-OUT	ELEV	DA-IN	ELEV	DA-OUT	ELEV
1	DA1-DA3	625	0.0050	2.25	19.482255	4.89986716	DA1	68.225	DA3	65.1	DA1	72.5	DA3	71.5
2	DA2-DA3	400	0.0050	2	8.5629	2.72565572	DA2	67.1	DA3	65.1	DA2	72.2	DA3	71.5
3	DA3-DA4	300	0.0050	4	64.06365	5.09802329	DA3	65.1	DA4	63.6	DA3	71.5	DA4	71.4
4	DA4-DA6	125	0.0050	4	77.00745	6.12805816	DA4	63.6	DA6	62.975	DA4	71.4	DA6	70
5	DA5-DA6	250	0.0050	2	8.09937	2.57630473	DA5	64.225	DA6	62.975	DA5	70.5	DA6	70
6	DA6-DA7	250	0.0050	4	82.43844	6.56024261	DA6	62.975	DA7	61.725	DA6	70	DA7	70.2
7	DA7-DA9	125	0.0050	4.25	103.46336	7.29321198	DA7	61.725	DA9	61.1	DA7	70.2	DA9	70
8	DA8-DA7	375	0.0050	2.5	26.95112	5.49043708	DA8	63.6	DA7	61.725	DA8	69	DA7	70.2
9	DA9-DA10	280	0.0050	5	108.08226	5.5045843	DA9	61.1	DA10	59.7	DA9	70	DA10	66
10	DA11-DA10	300	0.0050	2.5	16.4152	3.34407708	DA11	61.2	DA10	59.7	DA11	69.5	DA10	66
11	DA10-DA12	250	0.0050	5	136.435965	6.94862664	DA10	59.7	DA12	58.45	DA10	66	DA12	66
12	DA13-DA12	300	0.0050	2	8.73885	2.78166235	DA13	59.95	DA12	58.45	DA13	68	DA12	66
13	DA12-OF14	125	0.0036	5	145.62251	7.41649353	DA12	58.45	OF14	58	DA12	66	OF14	58
									One foot above bottom[4]					

	Checks			Preliminary Design Soffits				Distance Below Grade			
	Yes	Are Soffits Below Grade?		DA-IN	ELEV	DA-OUT	ELEV				
	Yes	Are Velocity < 10		DA1	70.475	DA3	67.35	DA1	2.025		
	Yes	Are Velocity > 2		DA2	69.1	DA3	67.1	DA2	3.1		
	Yes	Commercial Sized Pipes ?		DA3	69.1	DA4	67.6	DA3	2.4		
				DA4	67.6	DA6	66.975	DA4	3.8		
				DA5	66.225	DA6	64.975	DA5	4.275		
				DA6	66.975	DA7	65.725	DA6	3.025		
				DA7	65.975	DA9	65.35	DA7	4.225		
				DA8	66.1	DA7	64.225	DA8	2.9		
				DA9	66.1	DA10	64.7	DA9	3.9		
				DA11	63.7	DA10	62.2	DA11	5.8		
				DA10	64.7	DA12	63.45	DA10	1.3		
				DA13	61.95	DA12	60.45	DA13	6.05		
				DA12	63.45	OF14	63	DA12	2.55		



INITIAL DESIGN IN SWMM 5yr 30min intensity for 4 hrs