Appendix L –
Proposed Alternative 1
East Bouldin Creek HEC-HMS Model

Exhibit L.1

Map of Proposed Alternative 1 HEC-HMS Basins

Exhibit L.2

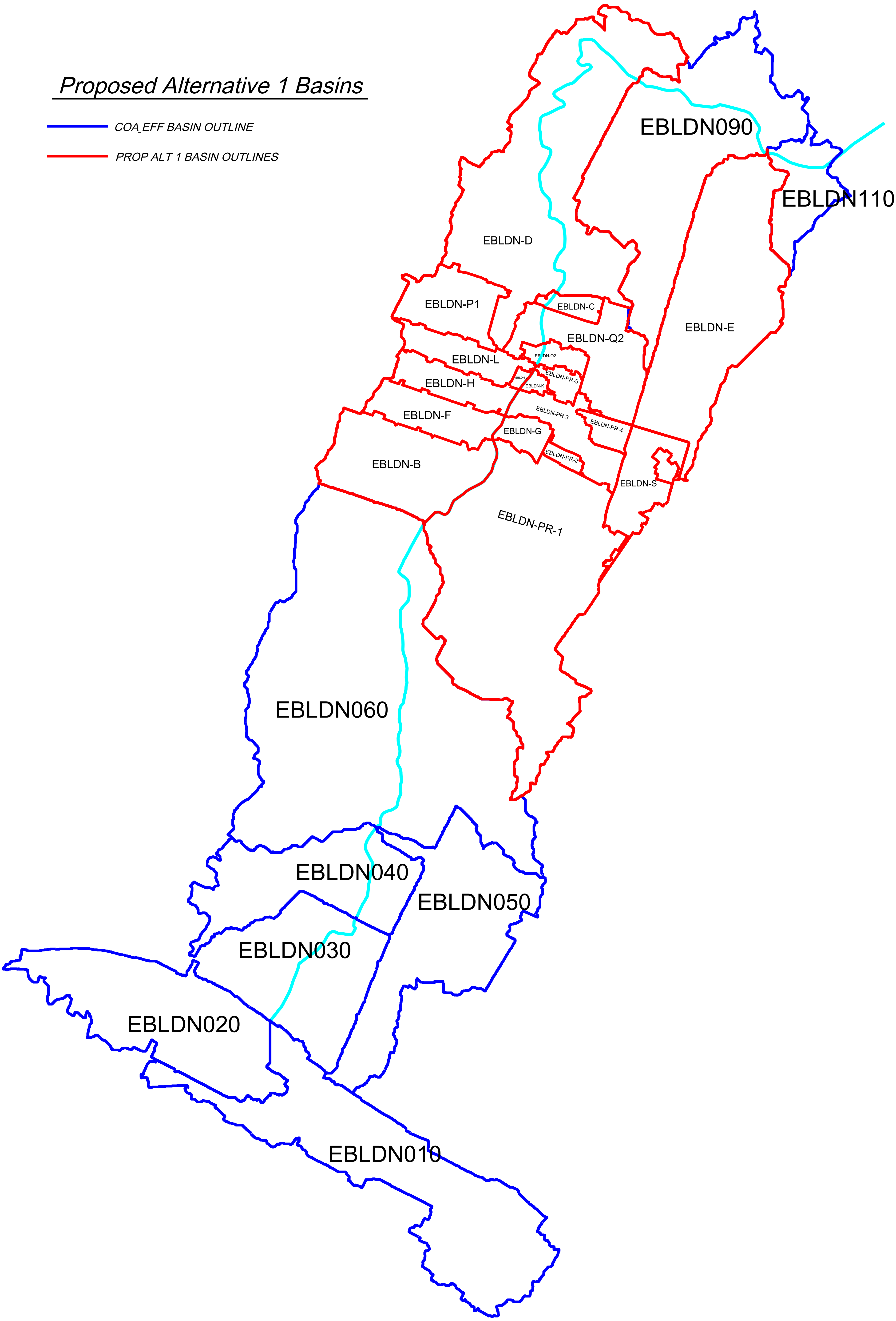
Map of Revised Pre-Project and Proposed Alternative 1 Basins

Exhibit L.3

Map of Proposed Alternative 1 Basins, Storm Drains and Contours

Exhibit L.4

Map of Proposed Alternative 1 HEC-HMS Elements


Proposed Alternative 1 Basins
COA_EFF BASIN OUTLINE
PROP ALT 1 BASIN OUTLINES
EBLDN090
EBLDN110
EBLDN-D
EBLDN-P1
EBLDN-C
EBLDN-Q2
EBLDN-E
EBLDN-O2
EBLDN-L
EBLDN-PR-5
EBLDN-K
EBLDN-H
EBLDN-PR-3
EBLDN-F
EBLDN-PR-4
EBLDN-G
EBLDN-PR-2
EBLDN-B
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EBLDN-PR-1
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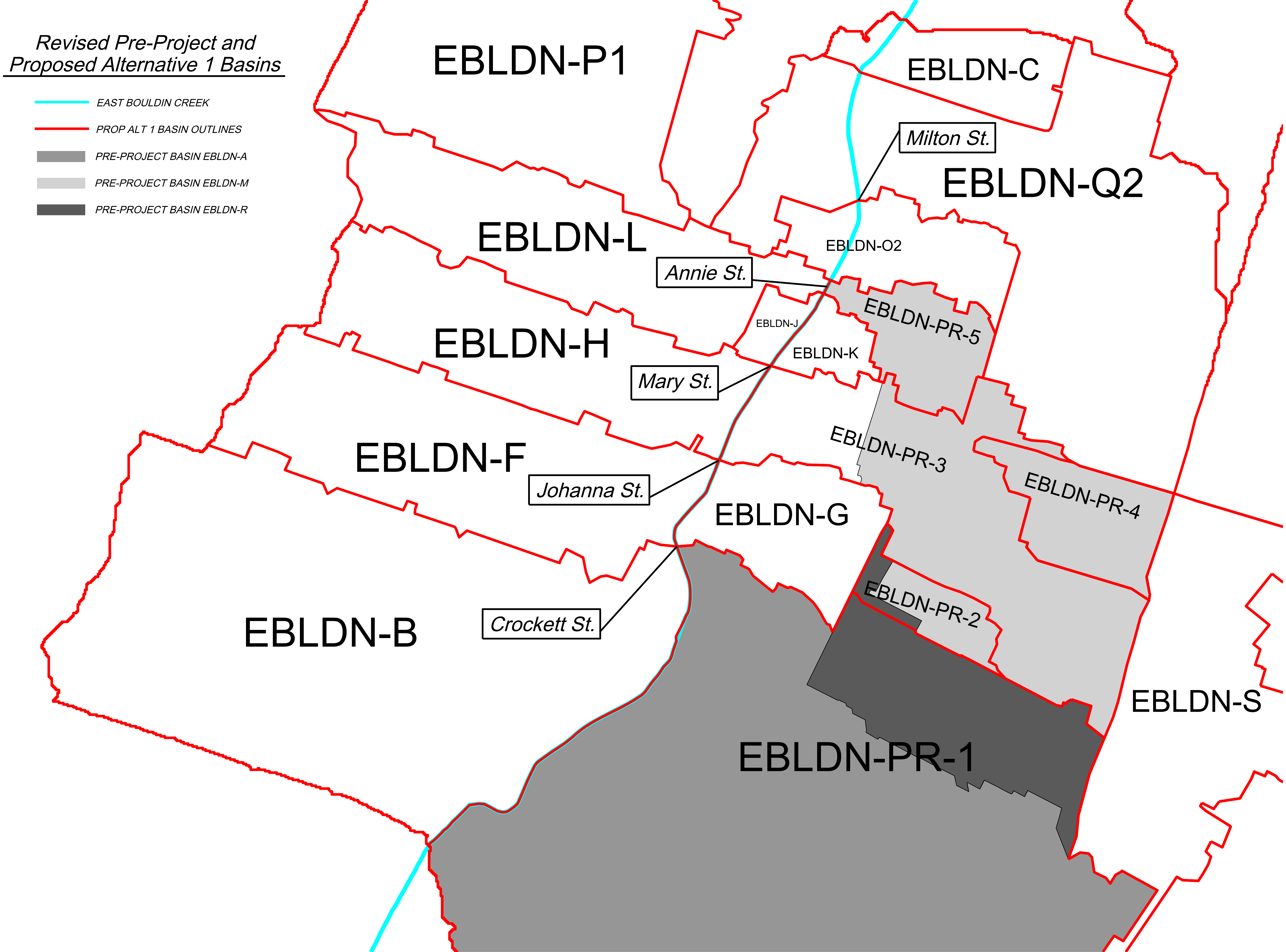
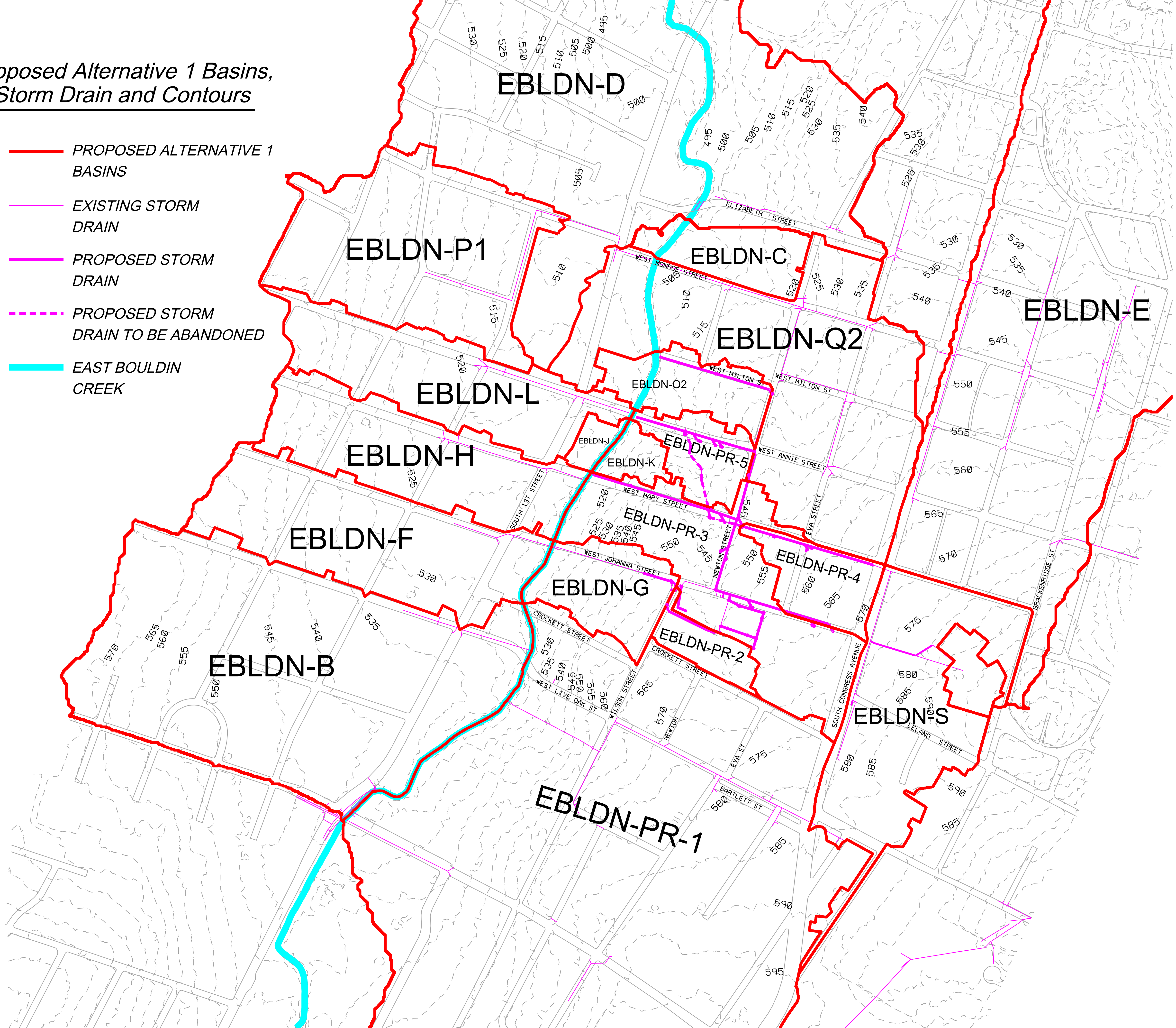
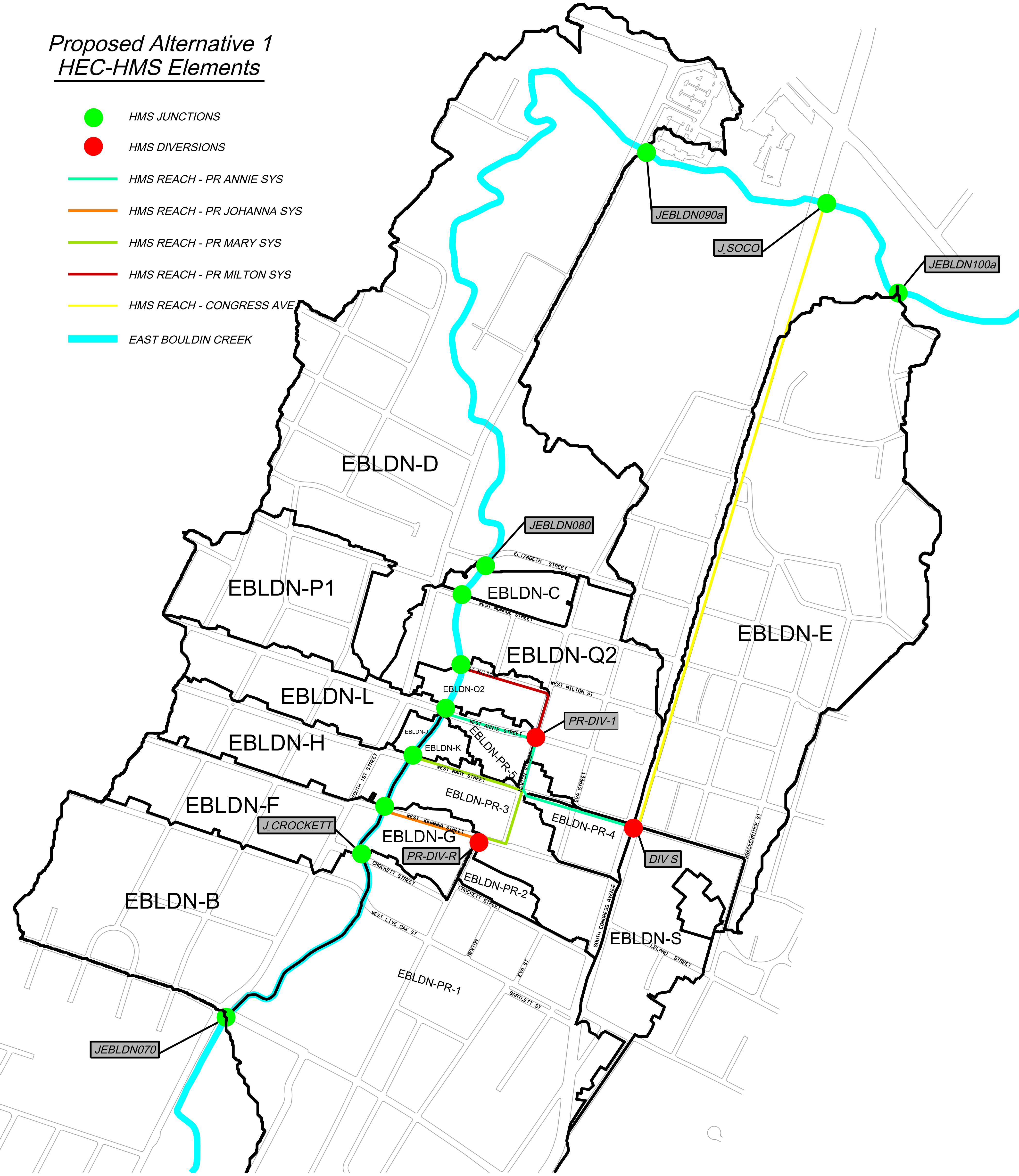
EBLDN020
EBLDN010

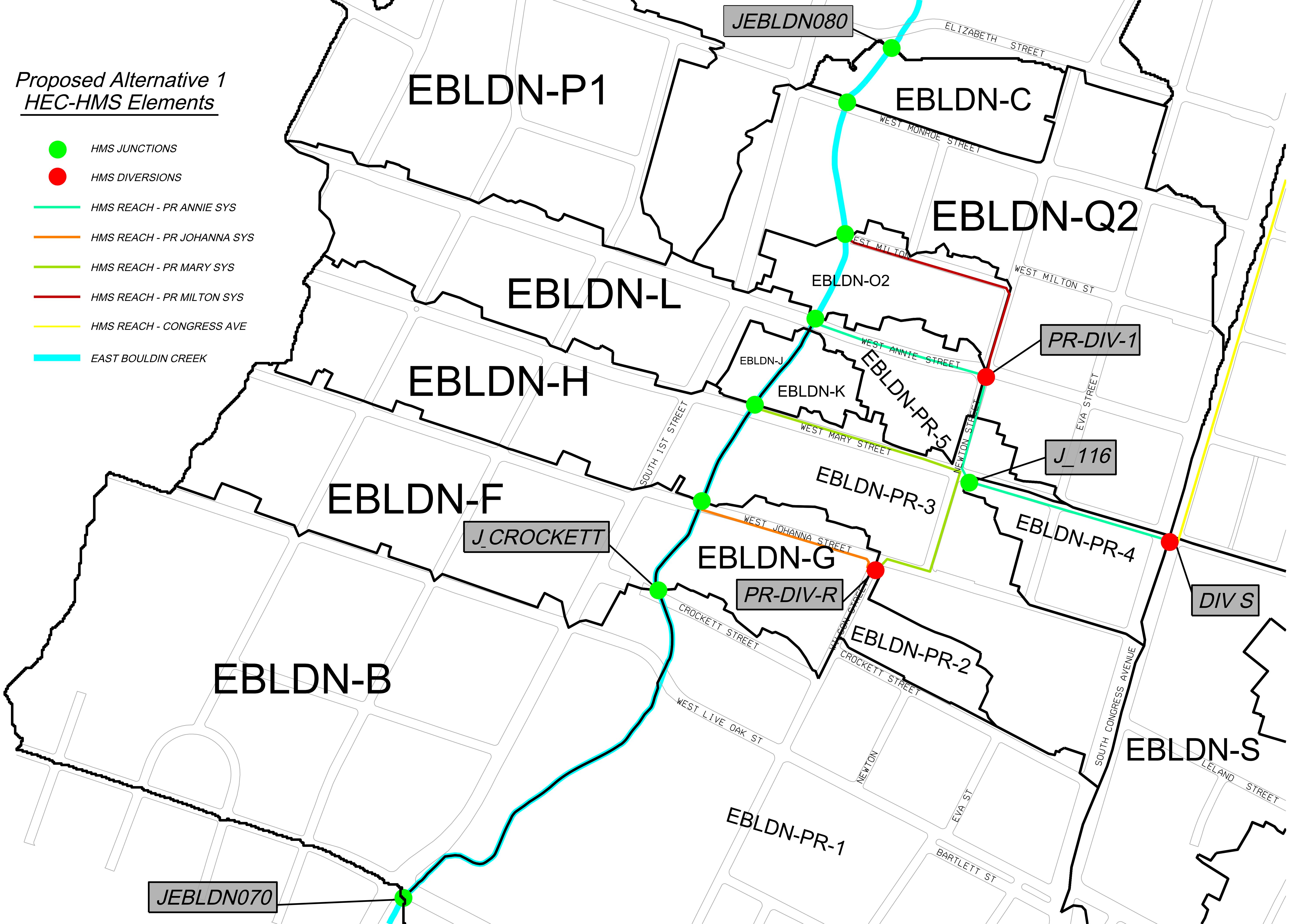

Revised Pre-Project and Proposed Alternative 1 Basins
EAST BOULDIN CREEK
PROP ALT 1 BASIN OUTLINES
PRE-PROJECT BASIN EBLDN-A
PRE-PROJECT BASIN EBLDN-M
PRE-PROJECT BASIN EBLDN-R
EBLDN-P1
EBLDN-C
Milton St.
EBLDN-Q2
EBLDN-L
EBLDN-O2
Annie St.
EBLDN-PR-5
EBLDN-J
EBLDN-H
EBLDN-K
Mary St.
EBLDN-PR-3
EBLDN-F
Johanna St.
EBLDN-PR-4
EBLDN-G
EBLDN-PR-2
Crockett St.
EBLDN-B
EBLDN-S
EBLDN-PR-1



Proposed Alternative 1 Basins, Storm Drain and Contours

Proposed Alternative 1 HEC-HMS Elements

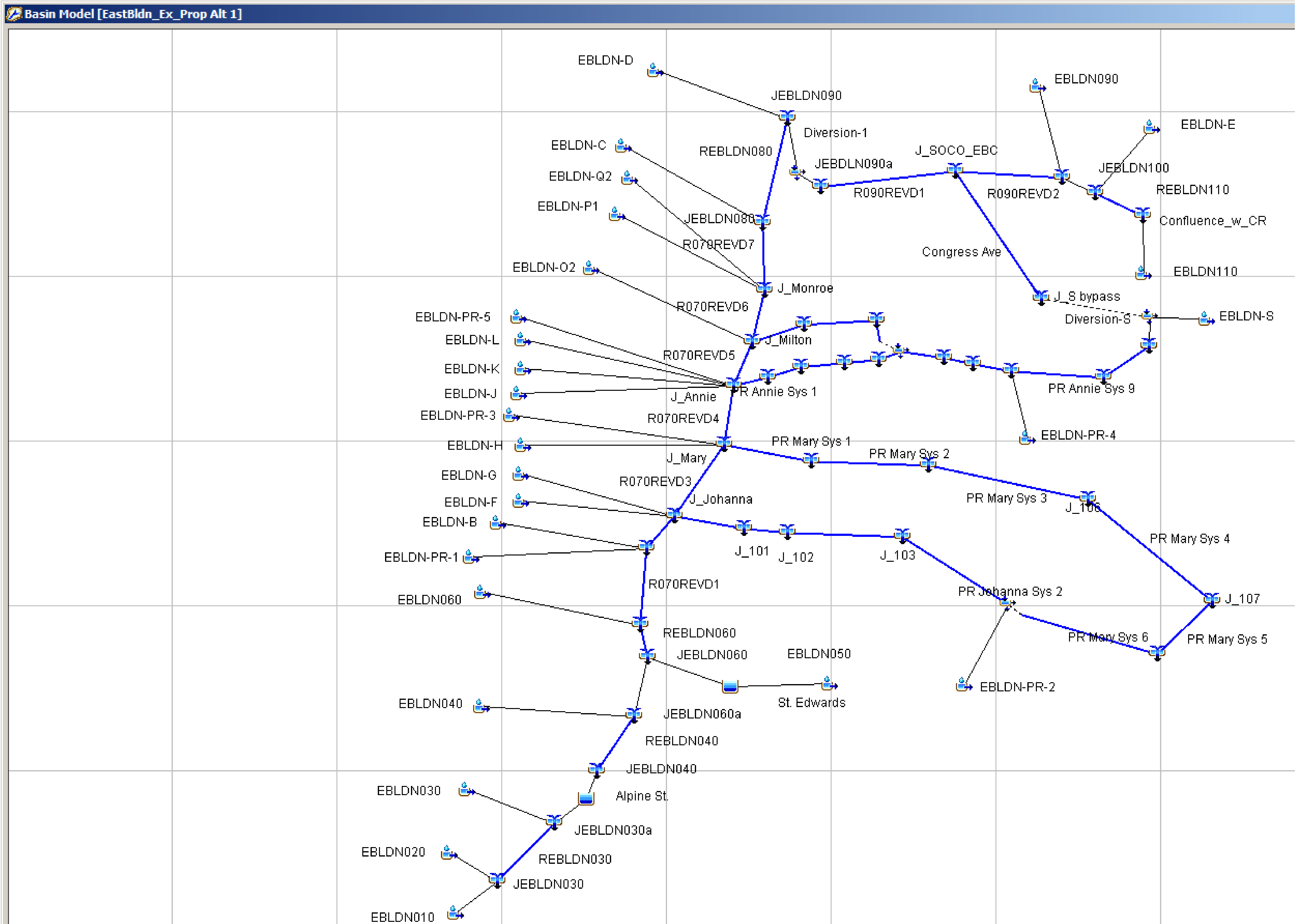




Proposed Alternative 1
HEC-HMS Elements
HMS JUNCTIONS
HMS DIVERSIONS
HMS REACH - PR ANNIE SYS
HMS REACH - PR JOHANNA SYS
HMS REACH - PR MARY SYS
HMS REACH - PR MILTON SYS
HMS REACH - CONGRESS AVE
EAST BOULDIN CREEK
JEBLDN080
EBLDN-P1
EBLDN-C
EBLDN-Q2
EBLDN-O2
EBLDN-L
EBLDN-J
EBLDN-K
EBLDN-PR-5
EBLDN-H
PR-DIV-1
J_116
EBLDN-F
EBLDN-PR-3
EBLDN-PR-4
J_CROCKETT
EBLDN-G
PR-DIV-R
DIV S
EBLDN-PR-2
EBLDN-B
EBLDN-S
EBLDN-PR-1
JEBLDN070
ELIZABETH STREET
WEST MONROE STREET
WEST MILTON ST
WEST ANNIE STREET
WEST MARY STREET
WEST JOHANNA STREET
CROCKETT STREET
WEST LIVE OAK ST
SOUTH 1ST STREET
NEWTON STREET
EVA STREET
EVA ST
NEWTON
BARTLETT ST
SOUTH CONGRESS AVENUE
LELAND STREET

Exhibit L.5

Proposed Alternative 1 Model Schematic



Basin Model [EastBldn_Ex_Prop Alt 1]
EBLDN-D
JEBLDN090
EBLDN090
EBLDN-E
Diversion-1
EBLDN-C
REBLDN080
J_SOCO_EBC
JEBDLN090a
JEBLDN100
EBLDN-Q2
R090REVD1
R090REVD2
REBLDN110
EBLDN-P1
JEBLDN080
Confluence_w_CR
R070REVD7
Congress Ave
EBLDN-O2
EBLDN110
J_Monroe
J_S bypass
R070REVD6
Diversion-S
EBLDN-S
EBLDN-PR-5
EBLDN-L
J_Milton
R070REVD5
EBLDN-K
EBLDN-J
J_Annie
PR Annie Sys 1
PR Annie Sys 9
EBLDN-PR-3
R070REVD4
EBLDN-PR-4
EBLDN-H
PR Mary Sys 1
J_Mary
PR Mary Sys 2
EBLDN-G
R070REVD3
EBLDN-F
J_Johanna
PR Mary Sys 3
J_106
EBLDN-B
EBLDN-PR-1
J_101
J_102
J_103
PR Mary Sys 4
R070REVD1
EBLDN060
PR Johanna Sys 2
J_107
REBLDN060
PR Mary Sys 6
PR Mary Sys 5
JEBLDN060
EBLDN050
EBLDN-PR-2
St. Edwards
EBLDN040
JEBLDN060a
REBLDN040
JEBLDN040
EBLDN030
Alpine St.
JEBLDN030a
EBLDN020
REBLDN030
JEBLDN030
EBLDN010

Exhibit L.6

Proposed Area, Impervious Cover and Curve Number

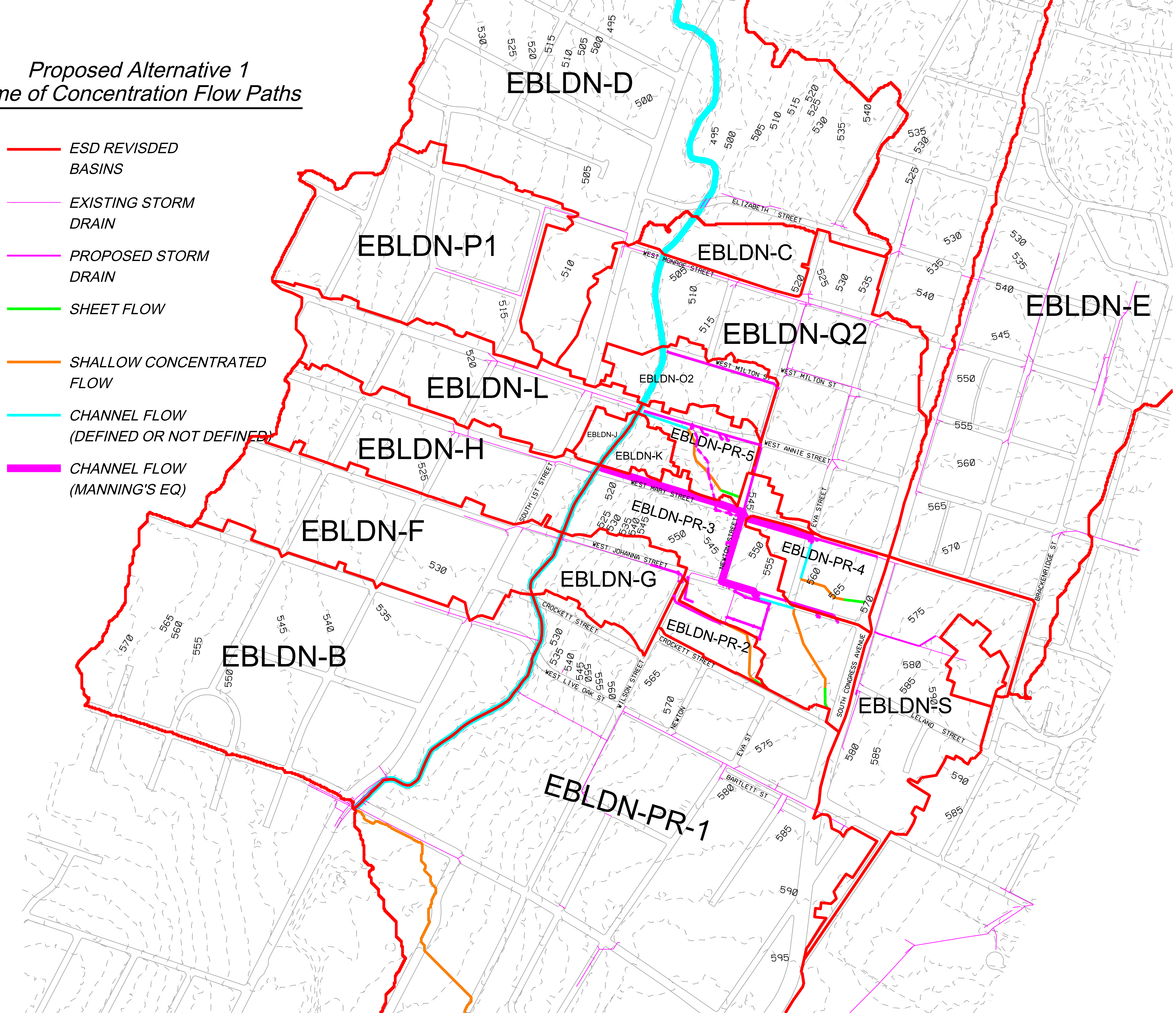
Name	Area	Area	Area	Ex_%IC	Area 700	Area 800	Area not 700 or 800	Area Pervious 700	Area Pervious 800	%IC 700	%IC 800	Ult_%IC not 700 or 800	Ult_%IC	CN for Pervious Soil Type D
	SF	AC	sq mi		SF	SF	SF	SF	SF					
Calc Notes -->	(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
EBLDN-PR-1	5910166	135.68	0.2120	60.8%	84482	1263477	4562207	57521	290321	32%	77%	79%	77.9%	80
EBLDN-PR-2	98342	2.26	0.0035	85.4%	0	20947	77395	0	3014	0%	86%	86%	86.3%	80
EBLDN-PR-3	662876	15.22	0.0238	55.7%	0	195533	467343	0	39450	0%	80%	74%	75.5%	80
EBLDN-PR-4	189224	4.34	0.0068	69.9%	0	81077	108147	0	15929	0%	80%	76%	77.9%	80
EBLDN-PR-5	161210	3.70	0.0058	43.8%	0	40875	120335	0	8932	0%	78%	65%	68.3%	80

(1) Drainage Area
(2) Area (sq mi) = Area / 27,878,400
(3) Ex_%IC = 1 - (sum(remaining pervious area)) / Area
(4) Area 700 = area that is LU category 700
(5) Area 800 = area that is LU category 800
(6) Area not 700 or 800 = (Area) - (Area 700) - (Area 800)
(7) Area Pervious 700 = remaining pervious area within LU category 700
(8) Area Pervious 800 = remaining pervious area within LU category 800
(9) %IC 700 = 1 - (Area Pervious 700)/(Area 700)
(10) %IC 800 = 1 - (Area Pervious 800)/(Area 800)
(11) Ult_%IC not 700 or 800 = weighted average for area not within LU categories 700 or 800; see GIS Join Table for Impervious Cover percentages by Land Use Category
(12) Ult_%IC = weighted average of (9) , (10) and (11)
(13) Reference TR-55 Table 2-2a, Open Space Good Condition

Exhibit L.7

Proposed Lag Times

Proposed Alternative 1
Time of Concentration Flow Paths



Lag Time Calculations for the East Bouldin Creek Watershed (Existing Conditions)

HMS Program Basin Name	Longest Flowpath (ft) (1)	Sheet Flow: Length (ft) (2)	IC% (3)	Land Use (4)	Surface Description (5)	Manning's roughness n (6)	Slope (ft/ft) (7)	Tt1 (min.) (8)
EBLDN-PR-1	6,592	100	61	Single Family	Short Grass	0.15	0.015	10.60
EBLDN-PR-2	414	82	N/A	Multi Family	Pavement	0.02	0.031	1.35
EBLDN-PR-3	1,930	100	56	Single Family	Pavement	0.02	0.005	3.28
EBLDN-PR-4	874	100	70	Commercial and Single Family	Pavement	0.02	0.028	1.65
EBLDN-PR-5	675	100	44	Single Family	Short Grass	0.15	0.047	6.71

HMS Program Basin Name	Shallow Concentrated Flow: Length 2 (ft) (9)	L2 paved (ft) (10)	L2 unpaved (ft) (11)	Slope 2 (ft/ft) (12)	Assumption for Tt2 (13)	Tt2 (paved) (min.) (13)	Tt2 (unpaved) (min.) (14)	Tt2 (min.) (15)
EBLDN-PR-1	4,941	3,014	1,927	0.025	Paved & Unpaved	15.76	12.69	28.45
EBLDN-PR-2	332	332	0	0.032	Paved	1.52	0.00	1.52
EBLDN-PR-3	420	234	186	0.033	Paved & Unpaved	1.05	1.05	2.10
EBLDN-PR-4	239	167	72	0.035	Paved & Unpaved	0.73	0.40	1.13
EBLDN-PR-5	347	152	195	0.050	Paved & Unpaved	0.56	0.90	1.46

HMS Program Basin Name	Channel Flow: Length 3 (ft) (16)	Slope 3 (ft/ft) (17)	V (ft/s) (18)	Assumption for V (19)	Tt3 (sec) (20)	Tt3 (min.) (21)	**Tc (min) (22)**	**Final Tc (min) (23)**	**Tlag (min) (24)**	**Final Tlag (min) (25)**	**Total Flowpath Lenth (ft)**	Sub-basin
EBLDN-PR-1	1,551	0.015	3.53	Defined Channel	439	7.32	46.37	46.37	27.82	**27.8**	6592	EBLDN-PR-1
EBLDN-PR-2	0	0.000	0.00	no channel	0	0.00	2.87	5.00	3.00	**3.5**	414	EBLDN-PR-2
EBLDN-PR-3	1411			see Channel Flow calculation sheet		1.64	7.02	7.02	4.21	**4.2**	1930	EBLDN-PR-3
EBLDN-PR-4	536			see Channel Flow calculation sheet		0.78	3.56	5.00	3.00	**3.5**	874	EBLDN-PR-4
EBLDN-PR-5	228			see Channel Flow calculation sheet		0.51	8.68	8.68	5.21	**5.2**	675	EBLDN-PR-5

Notes:

For flow paths, please refer to level PR_Drainage_LN_EBLDN_Tc on DGN file: N:\Team3\WPD_EBC_Annie\DGN\Annie_PROP_Alt1_KD.dgr

(1) Longest flow path equals sum of sheet, shallow concentrated and channel flow lengths.
(2) Sheet flow was considered to occur at short distances with a maximum of 100 feet for both natural (undeveloped) and developed conditions;
(3) Percent impervious cover calculations presented as part of HEC-HMS input data.
(4) Land use determined from 2012 aerial photography.
(5) Surface description (DCM Table 2-2)
(6) Manning's roughness n (DCM Table 2-2)
(7) Sheet flow slope = (US elevation - DS elevation) / overland flow length
(8) Sheet Flow Time of concentration (Tt1) = 0.42(nL)^08/((P2)^0.5 S^0.4) (DCM Eq. 2-3)
(9) Shallow concentrated flow length
(10) paved length = shallow concentrated paved length x IC% / 100; for EBLDN-PR-2, the entire shallow concentrated flow length is paved
(11) unpaved length = shallow concentrated flow length - paved length
(12) slope = (US elevation - DS elevation) / shallow concentrated flow length
(13) Tt2 (Paved) = L/60(20.3282)(S)^0.5 DCM Eq. 2-5
(14) Tt2 (Unpaved) = L/60(16.1345)(S)^0.5 DCM Eq. 2-4
(15) = (13) + (14)
(16) Total Channel flow length
(17) Channel length slope
(18) Channel velocity equations were determined by statistical analysis on the existing HEC-RAS models for East Bouldin Creek
East Bouldin Main Channel Velocity Equation (Halff Associates, July 2005) = 178.89 *(slope 2/100)+3.5055 (For "no defined channel" flow paths, velocity is assumed 2.5 - 4.0 fps based on channel slope)
Manning's equation is used for storm drain system velocity calculations assuming pipe flowing full (V=Vfull/Area). See Channel Flow calculation sheet.
For gutter flow lengths, $V = k * S^{0.5}$, where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
(19) Channel flow assumptions
(20) T = L / V in seconds
(21) Channel Time of Concentration = time in seconds / 60
(22) Tc = Sheet Flow Time of Concentration (Tt1) + Shallow Concentrated Flow (Tt2)+Channel Flow Time of Concentration (Tt3)
(23) If Tc > 5 minutes, Tc = Final Tc, else Final Tc = 5 minutes
(24) Lag Time (T lag) = 0.6* Final Tc (Soil Conservation Service)
(25) A minimum lag time of 3.5 minutes is required by HMS so that lag*0.29 is greater than the minimum time step of 1 min

Storm Drain data is from Prop Alt 1 StormCAD model: ..\StormCAD\Prop_Annie\Annie_PROP_Alt1

Channel Flow Calculations (Existing Conditions)

EBLDN_PR_3

Gutter Length =	184.11	ft	measured on dgn file
Gutter Slope =	0.034	ft/ft	slope = (US elev - DS elev) / length
k =	46.3		
Gutter Velociy =	8.6	ft/sec	Ref: V = k * S0.5 , where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	0.36	min	time = length / velocity / 60

Storm Drain Flow Calculations n = 0.013

Storm CAD ID	Pipe Dia. (in)	Pipe Dia. (ft)	Length (ft)	Slope (ft/ft)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Time (min)
PR-CO-165	18	1.5	35.9	0.1390	39.16	1.77	22.16	0.03
PR-CO-97	36	3.0	79.90	0.0130	76.04	7.07	10.76	0.12
PR-SS-A32	36	3.0	30.30	0.0200	94.32	7.07	13.34	0.04
PR-SS-A31	36	3.0	19.10	0.0210	96.65	7.07	13.67	0.02
PR-SS-A30	36	3.0	22.90	0.1500	258.31	7.07	36.54	0.01
PR-CO-118	42	3.5	154.60	0.0320	179.97	9.62	18.71	0.14
PR-CO-119	42	3.5	54.20	0.0320	179.97	9.62	18.71	0.05
PR-CO-116	42	3.5	113.90	0.0270	165.31	9.62	17.18	0.11
PR-CO-184	42	3.5	7.30	0.0270	165.31	9.62	17.18	0.01
PR-CO-185	42	3.5	77.20	0.0260	162.22	9.62	16.86	0.08
PR-CO-101	42	3.5	48.10	0.0450	213.41	9.62	22.18	0.04
PR-SS-M7	42	3.5	8.00	0.0170	131.17	9.62	13.63	0.01
PR-SS-M6	42	3.5	11.00	0.0190	138.67	9.62	14.41	0.01
PR-SS-M4	42	3.5	305.00	0.0170	131.17	9.62	13.63	0.37
PR-SS-M3	42	3.5	70.90	0.0760	277.35	9.62	28.83	0.04
PR-SS-M2	42	3.5	89.10	0.0870	296.74	9.62	30.84	0.05
PR-SS-M1	42	3.5	99.00	0.0100	100.6	9.62	10.46	0.16
		Total Length =	1226.4			Total Storm Drian Time =		1.28

Note: Storm Drain pipe data is from Prop Alt 1 StormCAD model. Flow data is calculated using FlowMaster. The Full Flow Capacity is calculated in FlowMaster using the Manning Equation.

Channel Flow Time = 1.64 min Channel flow time = gutter flow time + total storm drain time

EBLDN_PR_4

Gutter Length =	192	ft	measured on dgn file
Gutter Slope =	0.020	ft/ft	slope = (US elev - DS elev) / length
k =	46.3		
Gutter Velociy =	6.6	ft/sec	Ref: V = k * S0.5 , where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	0.48	min	time = length / velocity / 60

Storm Drain Flow Calculations n = 0.013

Storm CAD ID	Pipe Dia. (in)	Pipe Dia. (ft)	Length (ft)	Slope (ft/ft)	Flow (cfs)	Flow Area (s.f.)	Vfull (fps)	Time (min)
PR-SS-A40	18	1.5	23.9	0.2440	51.88	1.77	29.36	0.01
PR-SS-A13	48	4	153.20	0.0230	217.83	12.57	17.33	0.15
PR-CO-160	48	4	25.80	0.0080	128.47	12.57	10.22	0.04
PR-CO-162	48	4	140.60	0.0520	327.54	12.57	26.06	0.09
		Total Length =	343.5				Total Storm Drian Time =	0.29

Note: Storm Drain pipe data is from Prop Alt 1 StormCAD model. Flow data is calculated using FlowMaster. The Full Flow Capacity is calculated in FlowMaster using the Manning Equation.

Channel Flow Time = 0.78 min Channel flow time = gutter flow time + total storm drain time

EBLDN_PR_5

Gutter Length =	227.8	ft	measured on dgn file
Gutter Slope =	0.026	ft/ft	slope = (US elev - DS elev) / length
k =	46.3		
Gutter Velociy =	7.5	ft/sec	Ref: V = k * S0.5 , where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet

Channel Flow time = 0.51 min time = length / velocity / 60 = gutter flow time = channel flow time

Lag Time Calculations for the East Bouldin Creek Watershed Ultimate Development Conditions)

HMS Program Basin Name	Longest Flowpath (ft) (1)	Sheet Flow Length (ft) (2)	IC% (3)	Land Use (4)	Surface Description (5)	Manning's roughness n (6)	Slope (ft/ft) (7)	Tt1 (min.) (8)	Shallow Concentrated Flow Length 2 (ft) (9)	L2 paved (ft) (10)	L2 unpaved (ft) (11)	Slope 2 (ft/ft) (12)	Assumption for Tt2 (13)	Tt2 (paved) (min.) (13)	Tt2 (unpaved) (min.) (14)	Tt2 (min.) (15)
EBLDN-PR-1	6,592	100	78	Single Family	Short Grass	0.15	0.015	10.60	4,941	3,849	1,092	0.025	Paved & Unpaved	20.12	7.19	27.32
EBLDN-PR-2	414	82	N/A	Multi Family	Pavement	0.02	0.031	1.35	332	332	0	0.032	Paved	1.52	0.00	1.52
EBLDN-PR-3	1,930	100	76	Single Family	Pavement	0.02	0.005	3.28	420	317	103	0.033	Paved & Unpaved	1.42	0.58	2.01
EBLDN-PR-4	874	100	78	Commercial and Single Family	Pavement	0.02	0.028	1.65	239	186	53	0.035	Paved & Unpaved	0.82	0.29	1.11
EBLDN-PR-5	675	100	68	Single Family	Pavement	0.02	0.047	1.34	347	237	110	0.050	Paved & Unpaved	0.87	0.51	1.38

HMS Program Basin Name	Channel Flow Length 3 (ft) (16)	Slope 3 (ft/ft) (17)	V (ft/s) (18)	Assumption for V (19)	Tt3 (sec) (20)	Tt3 (min.) (21)	**Tc (min) (22)**	**Final Tc (min) (23)**	**Tlag (min) (24)**	**Final Tlag (min) (25)**	**Total Flowpath Lenth (ft)**	Sub-basin
EBLDN-PR-1	1,551	0.015	3.53	Defined Channel	439	7.32	45.24	45.24	27.14	**27.1**	6592	EBLDN-PR-1
EBLDN-PR-2	0	0.000	0.00	no channel	0	0.00	2.87	5.00	3.00	**3.5**	414	EBLDN-PR-2
EBLDN-PR-3	1411		see Channel Flow calculation sheet			1.64	6.93	6.93	4.16	**4.2**	1930	EBLDN-PR-3
EBLDN-PR-4	536		see Channel Flow calculation sheet			0.78	3.53	5.00	3.00	**3.5**	874	EBLDN-PR-4
EBLDN-PR-5	228		see Channel Flow calculation sheet			0.51	3.22	5.00	3.00	**3.5**	675	EBLDN-PR-5

Notes:
For flow paths, please refer to level PR_Drainage_LN_EBLDN_Tc on DGN file: N:\Team3\WPD_EBC_Annie\DGN\Annie_PROP_Alt1_KD.dgr
(1) Longest flow path equals sum of sheet, shallow concentrated and channel flow lengths.
(2) Sheet flow was considered to occur at short distances with a maximum of 100 feet for both natural (undeveloped) and developed conditions;
(3) Percent impervious cover calculations presented as part of HEC-HMS input data.
(4) Land use determined from 2012 aerial photography.
(5) Surface description (DCM Table 2-2)
(6) Manning's roughness n (DCM Table 2-2)
(7) Sheet flow slope = (US elevation - DS elevation) / overland flow length
(8) Sheet Flow Time of concentration (Tt1) = 0.42(nL)^08/((P2)^0.5 S^0.4) (DCM Eq. 2-3)
(9) Shallow concentrated flow length
(10) paved length = shallow concentrated paved length x IC% / 100; for EBLDN-PR-2, the entire shallow concentrated flow length is paved
(11) unpaved length = shallow concentrated flow length - paved length
(12) slope = (US elevation - DS elevation) / shallow concentrated flow length
(13) Tt2 (Paved) = L/60(20.3282)(S)^0.5 DCM Eq. 2-5
(14) Tt2 (Unpaved) = L/60(16.1345)(S)^0.5 DCM Eq. 2-4
(15) = (13) + (14)
(16) Total Channel flow length
(17) Channel length slope
(18) Channel velocity equations were determined by statistical analysis on the existing HEC-RAS models for East Bouldin Creek
East Bouldin Main Channel Velocity Equation (Halff Associates, July 2005) = 178.89 *(slope 2/100)+3.5055 (For "no defined channel" flow paths, velocity is assumed 2.5 - 4.0 fps based on channel slope)
Manning's equation is used for storm drain system velocity calculations assuming pipe flowing full (V=Vfull/Area). See Channel Flow calculation sheet.
For gutter flow lengths, $V = k * S^{0.5}$, where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
(19) Channel flow assumptions
(20) T = L / V in seconds
(21) Channel Time of Concentration = time in seconds / 60
(22) Tc = Sheet Flow Time of Concentration (Tt1) + Shallow Concentrated Flow (Tt2)+Channel Flow Time of Concentration (Tt3)
(23) If Tc > 5 minutes, Tc = Final Tc, else Final Tc = 5 minutes
(24) Lag Time (T lag) = 0.6* Final Tc (Soil Conservation Service)
(25) A minimum lag time of 3.5 minutes is required by HMS so that lag*0.29 is greater than the minimum time step of 1 min

Storm Drain data is from Prop Alt 1 StormCAD model: ..\StormCAD\Prop_Annie\Annie_PROP_Alt1

Channel Flow Calculations (Ultimate Development Conditions)

EBLDN_PR_3

Gutter Length =	184.11	ft	measured on dgn file
Gutter Slope =	0.034	ft/ft	slope = (US elev - DS elev) / length
k =	46.3		
Gutter Velociy =	8.6	ft/sec	Ref: V = k * S0.5 , where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	0.36	min	time = length / velocity / 60

Storm Drain Flow Calculations n = 0.013

Storm CAD ID	Pipe Dia. (in)	Pipe Dia. (ft)	Length (ft)	Slope (ft/ft)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Time (min)
PR-CO-165	18	1.5	35.9	0.1390	39.16	1.77	22.16	0.03
CO-97	36	3.0	79.90	0.0130	76.04	7.07	10.76	0.12
PR-SS-A32	36	3.0	30.30	0.0200	94.32	7.07	13.34	0.04
PR-SS-A31	36	3.0	19.10	0.0210	96.65	7.07	13.67	0.02
PR-SS-A30	36	3.0	22.90	0.1500	258.31	7.07	36.54	0.01
PR-CO-118	42	3.5	154.60	0.0320	179.97	9.62	18.71	0.14
PR-CO-119	42	3.5	54.20	0.0320	179.97	9.62	18.71	0.05
PR-CO-116	42	3.5	113.90	0.0270	165.31	9.62	17.18	0.11
PR-CO-184	42	3.5	7.30	0.0270	165.31	9.62	17.18	0.01
PR-CO-185	42	3.5	77.20	0.0260	162.22	9.62	16.86	0.08
PR-CO-101	42	3.5	48.10	0.0450	213.41	9.62	22.18	0.04
PR-SS-M7	42	3.5	8.00	0.0170	131.17	9.62	13.63	0.01
PR-SS-M6	42	3.5	11.00	0.0190	138.67	9.62	14.41	0.01
PR-SS-M4	42	3.5	305.00	0.0170	131.17	9.62	13.63	0.37
PR-SS-M3	42	3.5	70.90	0.0760	277.35	9.62	28.83	0.04
PR-SS-M2	42	3.5	89.10	0.0870	296.74	9.62	30.84	0.05
PR-SS-M1	42	3.5	99.00	0.0100	100.6	9.62	10.46	0.16
		Total Length =	1226.4			Total Storm Drian Time =		1.28

Note: Storm Drain pipe data is from Prop Alt 1 StormCAD model. Flow data is calculated using FlowMaster. The Full Flow Capacity is calculated in FlowMaster using the Manning Equation.

Channel Flow Time = 1.64 min Channel flow time = gutter flow time + total storm drain time

EBLDN_PR_4

Gutter Length =	192	ft	measured on dgn file
Gutter Slope =	0.020	ft/ft	slope = (US elev - DS elev) / length
k =	46.3		
Gutter Velociy =	6.6	ft/sec	Ref: V = k * S0.5 , where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	0.48	min	time = length / velocity / 60

Storm Drain Flow Calculations n = 0.013

Storm CAD ID	Pipe Dia. (in)	Pipe Dia. (ft)	Length (ft)	Slope (ft/ft)	Flow (cfs)	Flow Area (s.f.)	Vfull (fps)	Time (min)
PR-SS-A40	18	1.5	23.9	0.2440	51.88	1.77	29.36	0.01
PR-SS-A13	48	4	153.20	0.0230	217.83	12.57	17.33	0.15
PR-CO-160	48	4	25.80	0.0080	128.47	12.57	10.22	0.04
PR-CO-162	48	4	140.60	0.0520	327.54	12.57	26.06	0.09
		Total Length =	343.5				Total Storm Drian Time =	0.29

Note: Storm Drain pipe data is from Prop Alt 1 StormCAD model. Flow data is calculated using FlowMaster. The Full Flow Capacity is calculated in FlowMaster using the Manning Equation.

Channel Flow Time = 0.78 min Channel flow time = gutter flow time + total storm drain time

EBLDN_PR_5

Gutter Length = 227.8 ft measured on dgn file

Gutter Slope = 0.026 ft/ft slope = (US elev - DS elev) / length

k = 46.3

Gutter Velocity = 7.5 ft/sec Ref: V = k * S0.5 , where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet

Channel Flow time = 0.51 min time = length / velocity / 60 = gutter flow time = channel flow time

Exhibit L.8

Proposed Johanna Street Storm Drain System Data

Proposed Johanna Street Storm Drain System - from Wilson to EBC

Existing Pipe Data from As-builts: Street and Drainage Improvements Community Development District No. 18, Phase II (PPC-1-A-7673)
Proposed Pipe Data: ..\StormCAD\Prop_Johanna\Johanna_PROP_Alt1.stsw.sqlite

StormCAD ID	Diameter	DS Station	US Station	Length	Slope	HMS Reach Name	Sum of Pipe Segment Lengths	HMS Slope	As-built Sheet Name	Notes
N/A	27	220	320	100	2.30%	Johanna Sys 1	100	2.30%	1A-7673 (W)	slope noted on plans
N/A	24	320	575	255	8.08%	Johanna Sys 2	255	8.08%	1A-7673 (W)	slope noted on plans
N/A	24	575	660	85	3.96%	PR Johanna Sys 1	92	3.92%	1A-7673 (X)	slope from as-built note on plans
N/A	24	660	667	7	3.45%				1A-7673 (Y)	slope and length noted on plans
PR-402387	24			81.5	0.50%	PR Johanna Sys 2	137	0.55%		
PR-CO-21	24			40.7	0.50%					
PR-CO-20	24			15	1.00%					

Data used in HMS

Reach name	Length	Slope	Manning n	Diameter	Location Notes
Johanna Sys 1	100	0.023	0.013	27	starts at Johanna/EBC
Johanna Sys 2	255	0.081	0.013	24	
PR Johanna Sys 1	92	0.039	0.013	24	
PR Johanna Sys 2	137	0.006	0.013	24	ends at junction joining inlets on east and west side of Wilson just south of Johanna

Exhibit L.9

Proposed Mary Street Storm Drain System Data

Proposed Mary System Reaches

Ref: ..\StormCAD\Prop_Annie\Annie_PROP_Alt1\Annie_PROP_Alt1.stsw.sqlite

StormCAD ID	Street	Diameter inches	Length feet	Pipe Segment Slope	Manning n	HMS Reache Name	Sum of Pipe Segment Lengths	HMS Slope
PR-SS-M1	Mary	42	99.0	1.00%	0.013	PR Mary Sys 1	99.00	1.00%
PR-SS-M2	Mary	42	89.1	8.70%	0.013	PR Mary Sys 2		
PR-SS-M3	Mary	42	70.9	7.40%	0.013		160.00	8.05%
PR-SS-M4	Mary	42	305.0	1.80%	0.013			
PR-SS-M6	Mary	42	11.0	1.90%	0.013	PR Mary Sys 3	324.00	1.80%
PR-SS-M7	Mary	42	8.0	1.70%	0.013			
PR-CO-101	Mary	42	48.1	4.50%	0.013	PR Mary Sys 4	48.10	4.50%
PR-CO-185	Mary	42	77.2	2.60%	0.013			
PR-CO-184	Mary	42	7.3	2.70%	0.013			
PR-CO-116	Newton	42	139.1	2.70%	0.013	PR Mary Sys 5	433.90	2.92%
PR-CO-119	Newton	42	54.4	3.20%	0.013			
PR-CO-118	Newton	42	155.9	3.20%	0.013			
PR-CO-149	Johanna	18	172.5	3.70%	0.013	PR Mary Sys 6	172.50	3.70%

Data used in HMS

Reach name	Length	Slope	Manning n	Diameter	Location Notes
PR Mary Sys 1	99.00	0.010	0.013	42	Starts at Mary/EBC
PR Mary Sys 2	160.00	0.081	0.013	42	
PR Mary Sys 3	324.00	0.018	0.013	42	
PR Mary Sys 4	48.10	0.045	0.013	42	
PR Mary Sys 5	433.90	0.029	0.013	42	
PR Mary Sys 6	172.50	0.037	0.013	42	Ends at Johanna/Wilson

Exhibit L.10

Proposed Annie Street Storm Drain System Data

Proposed Annie System Reaches

Ref: ..\StormCAD\Prop_Annie\Annie_PROP_Alt1\Annie_PROP_Alt1.stsw.sqlite

StormCAD ID	Street	Diameter inches	Length feet	Pipe Segment Slope	HMS Reache Name	Sum of Pipe Segment Lengths	HMS Slope
PR-SS-A1	Annie	42	100.1	2.10%	PR Annie Sys 1	150.20	2.40%
PR-SS-A2	Annie	42	50.1	2.70%			
PR-SS-A3	Annie	42	88.8	5.20%	PR Annie Sys 2	132.30	5.76%
PR-CO-108	Annie	42	43.5	6.90%			
PR-CO-107	Annie	36	92.4	4.00%	PR Annie Sys 3	92.40	4.00%
PR-CO-106	Annie	36	31.7	9.60%	PR Annie Sys 4	31.70	9.60%
PR-CO-197	Annie	36	191.7	5.00%	PR Annie Sys 5	191.70	5.00%
PR-CO-196	Newton	48	95.5	2.10%	PR Annie Sys 6	299.60	1.35%
PR-CO-136	Newton	48	204.1	1.00%			
PR-CO-163	Mary	48	36.5	5.00%	PR Annie Sys 7	177.10	5.16%
PR-CO-162	Mary	48	140.6	5.20%			
PR-CO-160	Mary	48	25.8	0.80%	PR Annie Sys 8	179.00	2.08%
PR-SS-A13	Mary	48	153.2	2.30%			
PR-SS-A14	Mary	42	29.50	2.10%	PR Annie Sys 9	29.50	2.10%
PR-CO-159	Mary	36	146.4	3.00%	PR Annie Sys 10	307.40	4.10%
PR-CO-158	Mary	36	161	5.10%			

Data used in HMS

Reach name	Length	Slope	Manning n	Diameter	Location Notes
PR Annie Sys 1	150.20	0.024	0.013	42	Starts at Annie/EBC
PR Annie Sys 2	132.30	0.058	0.013	42	
PR Annie Sys 3	92.40	0.040	0.013	36	
PR Annie Sys 4	31.70	0.096	0.013	36	
PR Annie Sys 5	191.70	0.050	0.013	36	
PR Annie Sys 6	299.60	0.014	0.013	48	
PR Annie Sys 7	177.10	0.052	0.013	48	
PR Annie Sys 8	179.00	0.021	0.013	48	
PR Annie Sys 9	29.50	0.021	0.013	42	
PR Annie Sys 10	307.40	0.041	0.013	36	Ends at Mary/Congress

Exhibit L.11

Proposed Milton Storm Drain System Data

Proposed Milton System Reaches

Ref: ..\StormCAD\Prop_Annie\Annie_PROP_Alt1\Annie_PROP_Alt1.stsw.sqlite

StormCAD ID	Street	Diameter inches	Length feet	Pipe Segment Slope	Manning n	HMS Reache Name	Sum of Pipe Segment Lengths	HMS Slope
PR-CO-200	Milton	36	276.5	5.80%	0.013	PR Milton Sys 1	276.50	5.80%
PR-CO-199	Milton	36	289.3	2.80%	0.013	PR Milton Sys 2	375.40	2.98%
PR-CO-202	Newton	36	86.1	3.60%	0.013			
PR-CO-201	Newton	36	219.7	1.30%	0.013	PR Milton Sys 3	219.70	1.30%

Data used in HMS

Reach name	Length	Slope	Manning n	Diameter	Location Notes
PR Milton Sys 1	276.50	0.058	0.013	36	Starts at Milton/EBC
PR Milton Sys 2	375.40	0.030	0.013	36	
PR Milton Sys 3	219.70	0.013	0.013	36	Ends at Diversion

Exhibit L.12

Proposed Diversion R Inflow-Diversion Table

PR-Diversion R Inflow-Diversion Function - Existing and Ultimate Conditions

Ref for Q and inlet calcs: Inlet Calcs_Ultimate Conditions_PR-Div R.xls
..\StormCAD\Prop_Crockett\Crockett_PROP_Inlet Calcs_ULT.xls

Note: For Prop Alt 1, PR-Diversion R's "diversion flow" goes to Mary Sys. In the Pre-project model, Diversion-R's "diversion flow" goes to Johanna Sys. In the Pre-project model, EBLDN-R flows overland to the corner of Johanna/Wilson and splits at that point depending on which inlet at that corner intercepts the flow. But, in Proposed Alt 1, the area flowing to Wilson/Johanna (EBLDN-PR-2) has an additional sump inlet in the ally.

In the Proposed Alternative 1 scenario, the only flow that does not go to the storm drain system on Johanna street is the flow that bypasses Curb Inlet 21823 (curb inlet downstream of grate inlet DA-A22).

This diversion is modeled by relating HMS peak outflow for different return periods to the bypass flow for corresponding return periods

	Inflow to PR-Diversion-R = Peak HMS outflow for EBLDN-PR-2	Inlet 21823 Bypass Flow = Diversion to Mary Sys	
	Inflow	**Diversion**	
	CFS	**CFS**	
	0	0	
2 year	6.5	0.00	2 year
10 year	11.8	0.19	10 year
25-year	14.9	0.47	25-year
100-year	20.1	1.18	100-year

Exhibit L.13

Proposed Diversion 1 Inflow-Diversion Table

Ref: CivilStorm_diversion
Note: same as Milton split rating curve in StormCAD, developed from CivilStorm

PR-Diversion-1 Inflow-Diversion Function - Existing and Ultimate Conditions

Inflow	Diversion
0.0	0.0
12.5	4.0
25.0	8.2
37.5	12.5
50.0	16.7
62.5	20.9
75.0	25.1
87.5	29.4
100.0	33.6
112.5	37.8
125.0	42.1
137.5	46.3
150.0	50.5

Exhibit L.14

Proposed Alternative 1 Model Results

and

Comparison to Revised Pre-Project Model

Comparison of ESD Revised Pre-Project Model and Proposed Alternative 1 Model

Model Descriptions:

ESD Revisded Pre-Project - Existing Conditions is the effective COA HEC-HMS model that has been revised by ESD and is based on existing land use conditions.
ESD Revisded Pre-Project - Ultimate Development Conditions is the effective COA HEC-HMS model that has been revised by ESD and is based on future land use conditions.
ESD Revised Pre-Project time interval: 1 min

Proposed Alternative 1 - Existing Conditions is the proposed conditions that has been modified from the ESD Revised Pre-Project model and is based on existing land use conditions.
Proposed Alternative 1 - Ultimate Development Conditions is the proposed conditions that has been modified from the ESD Revised Pre-Project model and is based on future land use conditions.
ESD Revised Pre-Project time interval: 1 min

Simulation start time: 01Jan2001, 00:00

Junction Name	ESD Revised Pre-Project - Existing Conditions								Proposed Alternative 1 - Existing Conditions								Peak Flow Change from Pre-Project				% Change from Pre-Project				
	Peak Flow (cfs) and Time to Peak (hour)								Peak Flow (cfs) and Time to Peak (hour)																
	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year										
	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	
JEBLDN070	571	01Jan2001, 12:18	1185	01Jan2001, 12:23	1670	01Jan2001, 12:22	2515	01Jan2001, 12:20	571	01Jan2001, 12:18	1185	01Jan2001, 12:23	1670	01Jan2001, 12:22	2515	01Jan2001, 12:20	0	0	0	0	0.00%	0.00%	0.00%	0.00%	JEBLDN070
J_Crockett	788	01Jan2001, 12:21	1620	01Jan2001, 12:28	2212	01Jan2001, 12:28	3234	01Jan2001, 12:26	798	01Jan2001, 12:21	1642	01Jan2001, 12:28	2241	01Jan2001, 12:28	3273	01Jan2001, 12:26	10	22	28	39	0.62%	1.36%	1.28%	1.19%	J_Crockett
J_Johanna	826	01Jan2001, 12:21	1677	01Jan2001, 12:27	2282	01Jan2001, 12:28	3337	01Jan2001, 12:26	830	01Jan2001, 12:22	1689	01Jan2001, 12:28	2298	01Jan2001, 12:28	3357	01Jan2001, 12:26	4	12	16	20	0.21%	0.73%	0.70%	0.60%	J_Johanna
J_Mary	851	01Jan2001, 12:22	1718	01Jan2001, 12:28	2334	01Jan2001, 12:29	3413	01Jan2001, 12:27	865	01Jan2001, 12:22	1744	01Jan2001, 12:28	2367	01Jan2001, 12:29	3459	01Jan2001, 12:27	14	26	33	47	0.83%	1.51%	1.41%	1.37%	J_Mary
J_Annie	923	01Jan2001, 12:22	1821	01Jan2001, 12:27	2454	01Jan2001, 12:29	3581	01Jan2001, 12:27	908	01Jan2001, 12:22	1807	01Jan2001, 12:28	2440	01Jan2001, 12:29	3561	01Jan2001, 12:27	-15	-14	-14	-20	-0.81%	-0.77%	-0.58%	-0.55%	J_Annie
J_Milton	927	01Jan2001, 12:22	1826	01Jan2001, 12:28	2460	01Jan2001, 12:29	3589	01Jan2001, 12:28	923	01Jan2001, 12:22	1827	01Jan2001, 12:28	2462	01Jan2001, 12:30	3591	01Jan2001, 12:28	-4	0	3	2	-0.24%	0.01%	0.12%	0.06%	J_Milton
J_Monroe	981	01Jan2001, 12:23	1907	01Jan2001, 12:28	2554	01Jan2001, 12:29	3715	01Jan2001, 12:29	976	01Jan2001, 12:23	1906	01Jan2001, 12:28	2556	01Jan2001, 12:30	3717	01Jan2001, 12:29	-5	-1	2	1	-0.26%	-0.06%	0.06%	0.03%	J_Monroe
JEBLDN080	985	01Jan2001, 12:23	1914	01Jan2001, 12:28	2562	01Jan2001, 12:30	3723	01Jan2001, 12:30	979	01Jan2001, 12:24	1912	01Jan2001, 12:28	2563	01Jan2001, 12:30	3724	01Jan2001, 12:30	-6	-2	1	1	-0.31%	-0.10%	0.04%	0.03%	JEBLDN080
JEBLDN090	1071	01Jan2001, 12:41	2147	01Jan2001, 12:40	2649	01Jan2001, 12:54	3759	01Jan2001, 12:55	1065	01Jan2001, 12:41	2140	01Jan2001, 12:41	2645	01Jan2001, 12:55	3754	01Jan2001, 12:55	-6	-7	-4	-5	-0.26%	-0.31%	-0.14%	-0.14%	JEBLDN090
JEBLDN090a	590	01Jan2001, 12:41	1201	01Jan2001, 12:40	1481	01Jan2001, 12:54	2081	01Jan2001, 12:55	587	01Jan2001, 12:41	1197	01Jan2001, 12:41	1479	01Jan2001, 12:55	2078	01Jan2001, 12:55	-3	-4	-2	-3	-0.26%	-0.32%	-0.13%	-0.14%	JEBLDN090a
JEBLDN100a	644	01Jan2001, 12:47	1294	01Jan2001, 12:47	1552	01Jan2001, 13:03	2096	01Jan2001, 13:11	640	01Jan2001, 12:47	1287	01Jan2001, 12:48	1549	01Jan2001, 13:04	2092	01Jan2001, 13:12	-4	-6	-3	-4	-0.28%	-0.49%	-0.22%	-0.18%	JEBLDN100a
JEBLDN100	708	01Jan2001, 12:45	1427	01Jan2001, 12:41	1765	01Jan2001, 12:34	2261	01Jan2001, 12:28	704	01Jan2001, 12:45	1417	01Jan2001, 12:42	1759	01Jan2001, 12:35	2257	01Jan2001, 12:28	-4	-10	-7	-4	-0.31%	-0.67%	-0.39%	-0.18%	JEBLDN100
Confluence w/ CR	712	01Jan2001, 12:50	1438	01Jan2001, 12:47	1781	01Jan2001, 12:41	2305	01Jan2001, 12:32	708	01Jan2001, 12:50	1429	01Jan2001, 12:47	1775	01Jan2001, 12:41	2301	01Jan2001, 12:32	-4	-9	-7	-4	-0.29%	-0.64%	-0.37%	-0.17%	Confluence w/ CR

Junction Name	ESD Revised Pre-Project - Ultimate Development Conditions								Proposed Alternative 1 - Ultimate Development Conditions								Peak Flow Change from Pre-Project				Peak Flow Change from Pre-Project				
	Peak Flow (cfs) and Time to Peak (hour)								Peak Flow (cfs) and Time to Peak (hour)																
	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year										
	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	
JEBLDN070	571	01Jan2001, 12:18	1185	01Jan2001, 12:23	1670	01Jan2001, 12:22	2515	01Jan2001, 12:20	571	01Jan2001, 12:18	1185	01Jan2001, 12:23	1670	01Jan2001, 12:22	2515	01Jan2001, 12:20	0	0	0	0	0.00%	0.00%	0.00%	0.00%	JEBLDN070
J_Crockett	820	01Jan2001, 12:21	1649	01Jan2001, 12:27	2239	01Jan2001, 12:28	3264	01Jan2001, 12:26	831	01Jan2001, 12:21	1672	01Jan2001, 12:27	2269	01Jan2001, 12:28	3304	01Jan2001, 12:26	11	23	30	40	0.69%	1.41%	1.34%	1.23%	J_Crockett
J_Johanna	862	01Jan2001, 12:21	1708	01Jan2001, 12:27	2312	01Jan2001, 12:28	3368	01Jan2001, 12:26	866	01Jan2001, 12:21	1721	01Jan2001, 12:27	2329	01Jan2001, 12:28	3390	01Jan2001, 12:26	4	13	17	21	0.23%	0.74%	0.74%	0.64%	J_Johanna
J_Mary	889	01Jan2001, 12:22	1752	01Jan2001, 12:28	2365	01Jan2001, 12:29	3445	01Jan2001, 12:27	905	01Jan2001, 12:22	1780	01Jan2001, 12:27	2399	01Jan2001, 12:29	3494	01Jan2001, 12:27	16	28	34	49	0.90%	1.59%	1.45%	1.41%	J_Mary
J_Annie	967	01Jan2001, 12:21	1859	01Jan2001, 12:27	2488	01Jan2001, 12:29	3618	01Jan2001, 12:27	951	01Jan2001, 12:22	1844	01Jan2001, 12:27	2474	01Jan2001, 12:29	3596	01Jan2001, 12:27	-16	-16	-14	-23	-0.87%	-0.83%	-0.56%	-0.62%	J_Annie
J_Milton	972	01Jan2001, 12:22	1865	01Jan2001, 12:27	2495	01Jan2001, 12:29	3626	01Jan2001, 12:28	967	01Jan2001, 12:22	1865	01Jan2001, 12:28	2497	01Jan2001, 12:29	3626	01Jan2001, 12:28	-5	0	2	1	-0.27%	0.02%	0.09%	0.02%	J_Milton
J_Monroe	1031	01Jan2001, 12:22	1950	01Jan2001, 12:27	2592	01Jan2001, 12:29	3753	01Jan2001, 12:29	1025	01Jan2001, 12:22	1948	01Jan2001, 12:28	2593	01Jan2001, 12:29	3754	01Jan2001, 12:29	-6	-2	1	1	-0.32%	-0.11%	0.03%	0.02%	J_Monroe
JEBLDN080	1036	01Jan2001, 12:23	1958	01Jan2001, 12:28	2600	01Jan2001, 12:30	3760	01Jan2001, 12:30	1030	01Jan2001, 12:23	1956	01Jan2001, 12:28	2601	01Jan2001, 12:30	3761	01Jan2001, 12:30	-6	-2	1	1	-0.29%	-0.09%	0.05%	0.03%	JEBLDN080
JEBLDN090	1137	01Jan2001, 12:40	2208	01Jan2001, 12:39	2695	01Jan2001, 12:54	3802	01Jan2001, 12:54	1130	01Jan2001, 12:40	2201	01Jan2001, 12:40	2690	01Jan2001, 12:54	3795	01Jan2001, 12:55	-7	-8	-5	-7	-0.31%	-0.35%	-0.19%	-0.19%	JEBLDN090
JEBLDN090a	628	01Jan2001, 12:40	1235	01Jan2001, 12:39	1506	01Jan2001, 12:54	2104	01Jan2001, 12:54	624	01Jan2001, 12:40	1231	01Jan2001, 12:40	1503	01Jan2001, 12:54	2101	01Jan2001, 12:55	-4	-4	-3	-4	-0.32%	-0.36%	-0.19%	-0.18%	JEBLDN090a
JEBLDN100a	683	01Jan2001, 12:46	1332	01Jan2001, 12:46	1578	01Jan2001, 13:03	2119	01Jan2001, 13:11	679	01Jan2001, 12:46	1325	01Jan2001, 12:47	1574	01Jan2001, 13:03	2114	01Jan2001, 13:12	-5	-7	-4	-5	-0.34%	-0.56%	-0.25%	-0.21%	JEBLDN100a
JEBLDN100	754	01Jan2001, 12:44	1472	01Jan2001, 12:40	1801	01Jan2001, 12:35	2297	01Jan2001, 12:27	748	01Jan2001, 12:44	1461	01Jan2001, 12:40	1795	01Jan2001, 12:33	2294	01Jan2001, 12:28	-6	-11	-5	-3	-0.37%	-0.71%	-0.29%	-0.14%	JEBLDN100
Confluence w/ CR	757	01Jan2001, 12:49	1483	01Jan2001, 12:46	1819	01Jan2001, 12:40	2343	01Jan2001, 12:31	752	01Jan2001, 12:49	1473	01Jan2001, 12:46	1813	01Jan2001, 12:40	2340	01Jan2001, 12:31	-5	-10	-6	-3	-0.36%	-0.67%	-0.31%	-0.15%	Confluence w/ CR

Exhibit L.15

Pre-Project Versus Proposed Alternative 1

Flow Data for 12:27

Peak Flow Comparison

100-year Storm

Existing Land Use Conditions

	Pre-Project		Prop Alt 1		
	Peak Flow	Time	Peak Flow	Time	
EBLDN-A	589.6	01Jan2001, 12:30	628.9	01Jan2001, 12:30	EBLDN-PR-1
EBLDN-B	250	01Jan2001, 12:17	250	01Jan2001, 12:17	EBLDN-B
R070REVD1	2448.7	01Jan2001, 12:26	2448.7	01Jan2001, 12:26	R070REVD1
J_Crockett	**3234.2**	**01Jan2001, 12:26**	**3272.8**	**01Jan2001, 12:26**	**J_Crockett**
EBLDN-F	114	01Jan2001, 12:12	114	01Jan2001, 12:12	EBLDN-F
EBLDN-G	44.4	01Jan2001, 12:07	44.4	01Jan2001, 12:07	EBLDN-G
Johana Sys 1	42.5	01Jan2001, 12:12	18.8	01Jan2001, 12:05	Johana Sys 1
R070REVD2	3229.2	01Jan2001, 12:27	3267.9	01Jan2001, 12:27	R070REVD2
J_Johanna	**3336.9**	**01Jan2001, 12:26**	**3356.9**	**01Jan2001, 12:26**	**J_Johanna**
EBLDN-H	74.2	01Jan2001, 12:20	74.2	01Jan2001, 12:20	EBLDN-H
EBLDN-I	24.4	01Jan2001, 12:09	128.7	01Jan2001, 12:05	EBLDN-PR-3
			1.2	01Jan2001, 12:06	PR Mary Sys 1
R070REVD3	3335	01Jan2001, 12:27	3355.2	01Jan2001, 12:27	R070REVD3
J_Mary	**3412.5**	**01Jan2001, 12:27**	**3459.2**	**01Jan2001, 12:27**	**J_Mary**
EBLDN-J	8.2	01Jan2001, 12:05	8.2	01Jan2001, 12:05	EBLDN-J
EBLDN-K	12.2	01Jan2001, 12:05	12.2	01Jan2001, 12:05	EBLDN-K
EBLDN-L	92.1	01Jan2001, 12:11	92.1	01Jan2001, 12:11	EBLDN-L
EBLDN-M	182.1	01Jan2001, 12:06	29.9	01Jan2001, 12:06	EBLDN-PR-5
Annie Sys 1	94	01Jan2001, 12:13	68.4	01Jan2001, 12:08	PR Annie Sys 1
R070REVD4	3410.3	01Jan2001, 12:28	3456.1	01Jan2001, 12:28	R070REVD4
J_Annie	**3580.5**	**01Jan2001, 12:27**	**3560.9**	**01Jan2001, 12:27**	**J_Annie**
EBLDN-O2	42	01Jan2001, 12:05	42	01Jan2001, 12:05	EBLDN-O2
			34.6	01Jan2001, 12:08	PR Milton Sys 1
R070REVD5	3578.2	01Jan2001, 12:28	3558.3	01Jan2001, 12:28	R070REVD5
J_Milton	**3588.6**	**01Jan2001, 12:28**	**3590.8**	**01Jan2001, 12:28**	**J_Milton**
EBLDN-P1	139.1	01Jan2001, 12:11	139.1	01Jan2001, 12:11	EBLDN-P1
EBLDN-Q2	241	01Jan2001, 12:07	241	01Jan2001, 12:07	EBLDN-Q2
R070REVD6	3579.3	01Jan2001, 12:30	3581.3	01Jan2001, 12:30	R070REVD6
J_Monroe	**3715.4**	**01Jan2001, 12:29**	**3716.6**	**01Jan2001, 12:29**	**J_Monroe**

Red arrows indicate how flow is re-distributed for proposed conditions

Flow Comparison at 12:27 - Time of Peak Flow for Annie and Mary Street Junctions

100-year Storm

Existing Land Use Conditions

	Pre-Project		Prop Alt 1		
	Flow	**Time**	**Flow**	**Time**	
EBLDN-A	583.5	01Jan2001, 12:27	622.4	01Jan2001, 12:27	EBLDN-PR-1
EBLDN-B	199.8	01Jan2001, 12:27	199.8	01Jan2001, 12:27	EBLDN-B
R070REVD1	2441.6	01Jan2001, 12:27	2441.6	01Jan2001, 12:27	R070REVD1
J_Crockett	**3224.9**	01Jan2001, 12:27	**3263.8**	01Jan2001, 12:27	**J_Crockett**
EBLDN-F	66.5	01Jan2001, 12:27	66.5	01Jan2001, 12:27	EBLDN-F
EBLDN-G	16	01Jan2001, 12:27	16	01Jan2001, 12:27	EBLDN-G
Johana Sys 1	23.1	01Jan2001, 12:27	5.4	01Jan2001, 12:27	Johana Sys 1
R070REVD2	3229.2	01Jan2001, 12:27	3267.9	01Jan2001, 12:27	R070REVD2
J_Johanna	**3334.8**	01Jan2001, 12:27	**3355.9**	01Jan2001, 12:27	**J_Johanna**
EBLDN-H	67.3	01Jan2001, 12:27	67.3	01Jan2001, 12:27	EBLDN-H
EBLDN-I	10.2	01Jan2001, 12:27	36.7	01Jan2001, 12:27	EBLDN-PR-3
		01Jan2001, 12:27	0	01Jan2001, 12:27	PR Mary Sys 1
R070REVD3	3335	01Jan2001, 12:27	3355.2	01Jan2001, 12:27	R070REVD3
J_Mary	**3412.5**	01Jan2001, 12:27	**3459.2**	01Jan2001, 12:27	**J_Mary**
EBLDN-J	2.2	01Jan2001, 12:27	2.2	01Jan2001, 12:27	EBLDN-J
EBLDN-K	3.3	01Jan2001, 12:27	3.3	01Jan2001, 12:27	EBLDN-K
EBLDN-L	48.3	01Jan2001, 12:27	48.3	01Jan2001, 12:27	EBLDN-L
EBLDN-M	55.5	01Jan2001, 12:27	9.6	01Jan2001, 12:27	EBLDN-PR-5
Annie Sys 1	68.4	01Jan2001, 12:27	44.9	01Jan2001, 12:27	PR Annie Sys 1
R070REVD4	3403	01Jan2001, 12:27	3452.6	01Jan2001, 12:27	R070REVD4
J_Annie	**3580.5**	01Jan2001, 12:27	**3560.9**	01Jan2001, 12:27	**J_Annie**
EBLDN-O2	11.1	01Jan2001, 12:27	11.1	01Jan2001, 12:27	EBLDN-O2
		01Jan2001, 12:27	22.8	01Jan2001, 12:27	PR Milton Sys 1
R070REVD5	3563.6	01Jan2001, 12:27	3541.6	01Jan2001, 12:27	R070REVD5
J_Milton	**3574.7**	01Jan2001, 12:27	**3575.5**	01Jan2001, 12:27	**J_Milton**
EBLDN-P1	72.4	01Jan2001, 12:27	72.4	01Jan2001, 12:27	EBLDN-P1
EBLDN-Q2	81.4	01Jan2001, 12:27	81.4	01Jan2001, 12:27	EBLDN-Q2
R070REVD6	3528	01Jan2001, 12:27	3524.3	01Jan2001, 12:27	R070REVD6
J_Monroe	**3681.9**	01Jan2001, 12:27	**3678.2**	01Jan2001, 12:27	**J_Monroe**

Red arrows indicate how flow is re-distributed for proposed conditions

Appendix M –
Proposed Alternative 1
East Bouldin Creek
HEC-RAS Models

Exhibit M.1

Proposed Flow Change Locations

HEC_RAS Flow Change Locations for Proposed Alternative 1 - Existing Land Use Conditions

HMS Model:

RAS Model:

HMS Flow Data Source Element	RAS Flow Change Location		Existing Land Use Conditions			
	Reach	RS	2-Year peak cfs	10-year peak cfs	25-year peak cfs	100-year peak cfs
JEBLDN030	Reach 1	19568	200	377	482	656
JEBLDN040	Reach 1	17716	205	444	572	783
JEBLDN060a	Reach 1	17192	224	552	771	1100
JEBLDN060	Reach 1	16447	256	617	842	1189
JEBLDN070	Reach 1	12071	571.2	1184.8	1670.4	2515
N/A	Culvert Split	12685	571	1135	1230	1195
N/A	Reach 2	12685	0.00001	50	440	1320
JEBLDN070	Reach 3	12071	571	1185	1670	2515
J_Crockett	Reach 3	10809	798	1642	2241	3273
J_Johanna	Reach 3	10559	830	1689	2298	3357
J_Mary	Reach 3	10203	865	1744	2367	3459
J_Annie	Reach 3	9840	908	1807	2440	3561
J_Milton	Reach 3	9537	923	1827	2462	3591
J_Monroe	Reach 3	9081	976	1906	2556	3717
JEBLDN090	Reach 3	6915	1065	2140	2645	3754
JEBLDN090a	Reach 3	4415	587	1197	1479	2078
JEBLDN100a	Reach 3	2447	640	1287	1549	2092
JEBLDN100	Reach 3	1534	704	1417	1759	2257
confluence w CR	Reach 3	1116	708	1429	1775	2301

HEC_RAS Flow Change Locations for Proposed Alternative 1 - Ultimate Development Land Use Conditions

HMS Model:

RAS Model:

HEC-HMS Flow Data Source Element	RAS Flow Change Location		Ultimate Development Land Use Conditions			
	Reach	RS	2-Year peak cfs	10-year peak cfs	25-year peak cfs	100-year peak cfs
JEBLDN030	Reach 1	19568	200	377	482	656
JEBLDN040	Reach 1	17716	205	444	572	783
JEBLDN060a	Reach 1	17192	224	552	771	1100
JEBLDN060	Reach 1	16447	256	617	842	1189
JEBLDN070	Reach 1	14096	571	1185	1670	2515
N/A	Culvert Split	12685	571	1135	1230	1195
N/A	Reach 2	12685	0.00001	50	440	1320
JEBLDN070	Reach 3	12071	571	1185	1670	2515
J_Crockett	Reach 3	10809	831	1672	2269	3304
J_Johanna	Reach 3	10559	866	1721	2329	3390
J_Mary	Reach 3	10203	905	1780	2399	3494
J_Annie	Reach 3	9840	951	1844	2474	3596
J_Milton	Reach 3	9537	967	1865	2497	3626
J_Monroe	Reach 3	9081	1025	1948	2593	3754
JEBLDN090	Reach 3	6915	1130	2201	2690	3795
JEBLDN090a	Reach 3	4415	624	1231	1503	2101
JEBLDN100a	Reach 3	2447	679	1325	1574	2114
JEBLDN100	Reach 3	1534	748	1461	1795	2294
confluence w CR	Reach 3	1116	752	1473	1813	2340

Exhibit M.2

Proposed Alternative 1 Water Surface Elevations

and Comparison to

Revised Pre-Project Water Surface Elevations

Reach	River Sta	ESD Revised Pre-Project - Existing Land Use								ESD Proposed Alternative 1 - Existing Land Use								Change in WS Elev from Pre-Project			
		2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 1	19568	654.44	108.86	654.73	129.39	654.87	138.83	655.08	152.57	654.44	108.86	654.73	129.39	654.87	138.83	655.08	152.57	0.00	0.00	0.00	0.00
Reach 1	19532	653.47	104.79	653.75	123.12	653.89	132.2	654.1	144.77	653.47	104.79	653.75	123.12	653.89	132.2	654.1	144.77	0.00	0.00	0.00	0.00
Reach 1	19488	651.72	85.42	652.07	111.23	652.24	121.09	652.48	131.96	651.72	85.42	652.07	111.23	652.24	121.09	652.48	131.96	0.00	0.00	0.00	0.00
Reach 1	19445	650.17	76.74	650.57	115.44	650.75	130.35	651.04	159.96	650.17	76.74	650.57	115.44	650.75	130.35	651.04	159.96	0.00	0.00	0.00	0.00
Reach 1	19401	648.13	75.56	648.47	97.2	648.64	109	648.86	122.13	648.13	75.56	648.47	97.20	648.64	109	648.86	122.13	0.00	0.00	0.00	0.00
Reach 1	19334	642.94	180.03	643.28	196.37	643.44	201.69	643.68	210.34	642.94	180.03	643.28	196.37	643.44	201.69	643.68	210.34	0.00	0.00	0.00	0.00
Reach 1	19312 FORT MCGRUDER	Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct					
Reach 1	19291	639.39	37.54	639.94	48.13	640.19	52.56	640.54	63.29	639.39	37.54	639.94	48.13	640.19	52.56	640.54	63.29	0.00	0.00	0.00	0.00
Reach 1	19219	635.94	25.45	636.65	34.89	636.98	40.64	637.4	49.56	635.94	25.45	636.65	34.89	636.98	40.64	637.4	49.56	0.00	0.00	0.00	0.00
Reach 1	19146	634.29	24.08	635.04	32.23	635.39	36.54	635.85	42.49	634.29	24.08	635.04	32.23	635.39	36.54	635.85	42.49	0.00	0.00	0.00	0.00
Reach 1	19001	629.42	24.46	630.1	30.65	630.41	33.5	630.91	38.44	629.42	24.46	630.10	30.65	630.41	33.5	630.91	38.44	0.00	0.00	0.00	0.00
Reach 1	18835	625.67	25.47	626.38	33.47	626.71	37.41	627.17	43.06	625.67	25.47	626.38	33.47	626.71	37.41	627.17	43.06	0.00	0.00	0.00	0.00
Reach 1	18655	619.69	32.44	620.33	38.92	620.56	41.37	620.9	45.38	619.69	32.44	620.33	38.92	620.56	41.37	620.9	45.38	0.00	0.00	0.00	0.00
Reach 1	18497	617.59	31.68	618.59	49.66	618.99	56.39	619.5	64.43	617.59	31.68	618.59	49.66	618.99	56.39	619.5	64.43	0.00	0.00	0.00	0.00
Reach 1	18372	616.69	34.28	617.85	49.15	618.31	55.01	618.89	64.75	616.69	34.28	617.85	49.15	618.31	55.01	618.89	64.75	0.00	0.00	0.00	0.00
Reach 1	18235	616.68	97.59	617.83	122.53	618.28	136.27	618.86	167.17	616.68	97.59	617.83	122.53	618.28	136.27	618.86	167.17	0.00	0.00	0.00	0.00
Reach 1	18206	616.68	145.66	617.83	173.44	618.28	187.35	618.86	217.25	616.68	145.66	617.83	173.44	618.28	187.35	618.86	217.25	0.00	0.00	0.00	0.00
Reach 1	18167	616.61	224.83	617.7	269.19	618.1	290.65	618.61	317.15	616.61	224.83	617.70	269.19	618.1	290.65	618.61	317.15	0.00	0.00	0.00	0.00
Reach 1	18096	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	18025	613.74	185.48	614.42	316.96	614.71	324.32	615.17	365.39	613.74	185.48	614.42	316.96	614.71	324.32	615.17	365.39	0.00	0.00	0.00	0.00
Reach 1	17964	613.76	472.28	614.44	529.03	614.74	536.09	615.21	548.98	613.76	472.28	614.44	529.03	614.74	536.09	615.21	548.98	0.00	0.00	0.00	0.00
Reach 1	17923	613.76	510.43	614.44	528.84	614.74	537.53	615.21	550.75	613.76	510.43	614.44	528.84	614.74	537.53	615.21	550.75	0.00	0.00	0.00	0.00
Reach 1	17827	613.76	506.6	614.44	529.39	614.74	538.64	615.21	552.11	613.76	506.6	614.44	529.39	614.74	538.64	615.21	552.11	0.00	0.00	0.00	0.00
Reach 1	17814 DETENTION BASIN	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	17796	608.1	20.25	609.47	23.27	609.84	24.07	610.22	26.46	608.1	20.25	609.47	23.27	609.84	24.07	610.22	26.46	0.00	0.00	0.00	0.00
Reach 1	17781	607.92	20.69	609.41	27.07	609.79	32.27	610.16	42.7	607.92	20.69	609.41	27.07	609.79	32.27	610.16	42.7	0.00	0.00	0.00	0.00
Reach 1	17771	608	23.37	609.47	44.99	609.87	68.07	610.28	116.9	608	23.37	609.47	44.99	609.87	68.07	610.28	116.9	0.00	0.00	0.00	0.00
Reach 1	17744 ALPINE	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	17716	607.22	19.96	608.26	33.08	608.75	41.25	609.35	107.68	607.22	19.96	608.26	33.08	608.75	41.25	609.35	107.68	0.00	0.00	0.00	0.00
Reach 1	17646	604.82	26.71	605.84	34.23	606.26	36.26	606.78	46.45	604.82	26.71	605.84	34.23	606.26	36.26	606.78	46.45	0.00	0.00	0.00	0.00
Reach 1	17501	602.44	21.39	603.47	29.2	603.86	32.25	604.45	40.1	602.44	21.39	603.47	29.20	603.86	32.25	604.45	40.1	0.00	0.00	0.00	0.00
Reach 1	17305	599.72	53.78	601.14	82.54	601.77	114.89	602.4	150.13	599.72	53.78	601.14	82.54	601.77	114.89	602.4	150.13	0.00	0.00	0.00	0.00
Reach 1	17192	598.17	20.98	599.56	33.39	600.18	55.35	601.12	138.17	598.17	20.98	599.56	33.39	600.18	55.35	601.12	138.17	0.00	0.00	0.00	0.00
Reach 1	17106	596.87	24.15	599.02	98.2	599.26	107.98	599.83	126.27	596.87	24.15	599.02	98.20	599.26	107.98	599.83	126.27	0.00	0.00	0.00	0.00
Reach 1	17070 LIGHTSEY	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	17034	594.16	12.99	596.01	23.87	596.77	28.08	597.68	33.65	594.16	12.99	596.01	23.87	596.77	28.08	597.68	33.65	0.00	0.00	0.00	0.00
Reach 1	17014	592.94	16.67	594.43	18.6	595.23	19.63	596.27	20.75	592.94	16.67	594.43	18.60	595.23	19.63	596.27	20.75	0.00	0.00	0.00	0.00
Reach 1	17010	591.9	15	593.85	17.46	594.82	18.66	596.07	20.39	591.9	15	593.85	17.46	594.82	18.66	596.07	20.39	0.00	0.00	0.00	0.00
Reach 1	16967	591.44	15.26	593.24	17.87	594.12	19.15	595.33	24.21	591.44	15.26	593.24	17.87	594.12	19.15	595.33	24.21	0.00	0.00	0.00	0.00
Reach 1	16797	588.95	18.42	590.75	23.47	591.59	25.78	592.62	28.59	588.95	18.42	590.75	23.47	591.59	25.78	592.62	28.59	0.00	0.00	0.00	0.00
Reach 1	16639	587.66	22.3	589.39	27.94	590.02	29.99	590.74	32.32	587.66	22.3	589.39	27.94	590.02	29.99	590.74	32.32	0.00	0.00	0.00	0.00
Reach 1	16447	585.34	23.65	586.82	43.05	587.48	53.29	588.34	66.06	585.34	23.65	586.82	43.05	587.48	53.29	588.34	66.06	0.00	0.00	0.00	0.00
Reach 1	16323	583.55	27.66	585.22	38.52	585.98	43.77	586.79	51.49	583.55	27.66	585.22	38.52	585.98	43.77	586.79	51.49	0.00	0.00	0.00	0.00
Reach 1	16124	582.1	32.95	584.15	50.58	585.08	70.57	586.04	105.86	582.1	32.95	584.15	50.58	585.08	70.57	586.04	105.86	0.00	0.00	0.00	0.00
Reach 1	16056	581.28	22.97	583.46	33.12	584.39	63.77	585.37	121.51	581.28	22.97	583.46	33.12	584.39	63.77	585.37	121.51	0.00	0.00	0.00	0.00
Reach 1	16030 HAVANA	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	16003	580.66	17.56	582.29	25.26	583.02	29.66	583.84	35.84	580.66	17.56	582.29	25.26	583.02	29.66	583.84	35.84	0.00	0.00	0.00	0.00
Reach 1	15893	578.22	25.81	579.71	33.43	580.41	36.89	581.3	41.37	578.22	25.81	579.71	33.43	580.41	36.89	581.3	41.37	0.00	0.00	0.00	0.00
Reach 1	15734	576.62	25.87	578.14	32.76	578.81	35.75	579.64	39.48	576.62	25.87	578.14	32.76	578.81	35.75	579.64	39.48	0.00	0.00	0.00	0.00
Reach 1	15547	574.59	26.66	575.94	35.43	576.56	39.49	577.34	44.57	574.59	26.66	575.94	35.43	576.56	39.49	577.34	44.57	0.00	0.00	0.00	0.00
Reach 1	15330	572.19	29.63	573.84	40.19	574.72	46	575.69	60.83	572.19	29.63	573.84	40.19	574.72	46	575.69	60.83	0.00	0.00	0.00	0.00
Reach 1	15107	569.28	19.6	571.21	25.01	572.47	32.8	573.13	47.21	569.28	19.6	571.21	25.01	572.47	32.8	573.13	47.21	0.00	0.00	0.00	0.00
Reach 1	15022	568.45	30.15	571.09	46.39	572.46	74.64	573.24	97.53	568.45	30.15	571.09	46.39	572.46	74.64	573.24	97.53	0.00	0.00	0.00	0.00
Reach 1	14950	568.15	25.63	570.87	38.21	572.23	64.03	572.98	106.66	568.15	25.63	570.87	38.21	572.23	64.03	572.98	106.66	0.00	0.00	0.00	0.00
Reach 1	14918 EL PASO	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	14885	566.29	20.81	567.68	25.79	568.34	28.19	569.17	31.22	566.29	20.81	567.68	25.79	568.34	28.19	569.17	31.22	0.00	0.00	0.00	0.00
Reach 1	14794	564.81	23.85	566.44	31.81	567.18	35.47	568.13	40	564.81	23.85	566.44	31.81	567.18	35.47	568.13	40	0.00	0.00	0.00	0.00
Reach 1	14628	562.57	23.25	564.02	29.96	564.67	32.96	565.42	37.24	562.57	23.25	564.02	29.96	564.67	32.96	565.42	37.24	0.00	0.00	0.00	0.00
Reach 1	14471	560.92	28.16	563.1	42.59	563.46	44.95	564.12	54.36	560.92	28.16	563.10	42.59	563.46	44.95	564.12	54.36	0.00	0.00	0.00	0.00
Reach 1	14363	559.62	26.54	562.87	64.54	563.11	73.39	563.75	109.41	559.62	26.54	562.87	64.54	563.11	73.39	563.75	109.41	0.00	0.00	0.00	0.00
Reach 1	14298	559.38	27.14	562.78	84.73	562.96	110.7	563.59	143.14	559.38	27.14	562.78	84.73	562.96	110.7	563.59	143.14	0.00	0.00	0.00	0.00
Reach 1	14252 CUMBERLAND	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	14206	555.44	35.62	557.23	43.3	558.51	48.71	560.23	55.93	555.44	35.62	557.23	43.30	558.51	48.71	560.23	55.93	0.00	0.00	0.00	0.00

Reach	River Sta	ESD Revised Pre-Project - Existing Land Use								ESD Proposed Alternative 1 - Existing Land Use								Change in WS Elev from Pre-Project			
Reach	River Sta	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 1	14096	554.29	38.79	556.25	50.68	557.45	58	559.14	68.46	554.29	38.79	556.25	50.68	557.45	58.01	559.14	68.46	0.00	0.00	0.00	0.00
Reach 1	13965	553.13	36.28	555.2	46.79	556.45	53.08	558.17	61.87	553.13	36.28	555.20	46.78	556.45	53.09	558.17	61.87	0.00	0.00	0.00	0.00
Reach 1	13818	551.89	33.54	554	41.91	555.26	46.81	556.98	70.93	551.89	33.54	554.00	41.90	555.26	46.82	556.98	70.93	0.00	0.00	0.00	0.00
Reach 1	13624	550.22	31.47	552.38	40.07	553.65	45.03	555.52	111.69	550.22	31.47	552.37	40.06	553.65	45.03	555.52	111.69	0.00	-0.01	0.00	0.00
Reach 1	13539	548.93	25.88	550.93	32.43	552.07	36.18	554.01	42.69	548.93	25.89	550.93	32.43	552.07	36.19	554.01	42.69	0.00	0.00	0.00	0.00
Reach 1	13477	548.37	27.86	550.27	32.49	551.33	35.08	553.2	55.51	548.37	27.86	550.27	32.49	551.33	35.08	553.2	55.51	0.00	0.00	0.00	0.00
Reach 1	13462 PEDESTRIAN BRID	Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge					
Reach 1	13447	547.8	27.11	549.54	32.97	550.48	36.29	551.76	41.03	547.81	27.11	549.53	32.97	550.48	36.29	551.76	41.03	0.01	-0.01	0.00	0.00
Reach 1	13393	547.45	36.39	549.25	47.2	550.25	53.07	551.65	63.58	547.45	36.39	549.25	47.20	550.25	53.07	551.65	63.58	0.00	0.00	0.00	0.00
Reach 1	13268	546.33	35.27	548.11	47.42	549.05	53.99	550.37	64.32	546.33	35.27	548.10	47.42	549.05	54	550.37	64.32	0.00	-0.01	0.00	0.00
Reach 1	13058	545.13	33.05	546.46	77.02	546.95	79.83	547.68	107.08	545.13	33.05	546.46	77.02	546.95	79.83	547.68	107.08	0.00	0.00	0.00	0.00
Reach 1	13056 LOW WATER CROSS	Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct					
Reach 1	12945	543.21	30.18	545.06	42.29	545.52	57.4	546.73	119.19	543.21	30.18	545.06	42.22	545.52	57.41	546.73	119.19	0.00	0.00	0.00	0.00
Reach 1	12812	540.99	25.1	542.72	34.29	544.19	147.75	545.21	223.59	540.99	25.1	542.72	34.29	544.19	147.82	545.21	223.59	0.00	0.00	0.00	0.00
Culvert Split	12685	538.18	20	539.88	20	540.9		542.26		538.18	20	539.88	20.00	540.9		542.26		0.00	0.00	0.00	0.00
Culvert Split	12636	537.54	20	539.24	20	540.05		541.52		537.54	20	539.24	20.00	540.05		541.52		0.00	0.00	0.00	0.00
Culvert Split	12587.1	536.91	20	538.61	20	539.67		541.19		536.91	20	538.61	20.00	539.67		541.19		0.00	0.00	0.00	0.00
Culvert Split	12538.2	536.27	20	537.97	20	539.29		540.86		536.27	20	537.97	20.00	539.29		540.86		0.00	0.00	0.00	0.00
Culvert Split	12489.3	535.63	20	537.33	20	538.91		540.53		535.63	20	537.33	20.00	538.91		540.53		0.00	0.00	0.00	0.00
Culvert Split	12440.4	534.99	20	537.07		538.53		540.2		534.99	20	537.07		538.53		540.2		0.00	0.00	0.00	0.00
Culvert Split	12391.5	534.36	20	536.74		538.15		539.88		534.36	20	536.74		538.15		539.88		0.00	0.00	0.00	0.00
Culvert Split	12342.6	533.96	20	536.42		537.77		539.55		533.96	20	536.42		537.77		539.55		0.00	0.00	0.00	0.00
Culvert Split	12293.7	534.17	20	536.09		537.39		539.22		534.17	20	536.09		537.39		539.22		0.00	0.00	0.00	0.00
Culvert Split	12244.8	534.25	20	535.77		537.01		538.89		534.25	20	535.77		537.01		538.89		0.00	0.00	0.00	0.00
Culvert Split	12195.9	534.23		535.45		536.63		538.56		534.23		535.45		536.63		538.56		0.00	0.00	0.00	0.00
Culvert Split	12147	534.04		534.71		535.77		537.82		534.04		534.71		535.77		537.82		0.00	0.00	0.00	0.00
Reach 2	12685	541	0.43	542.15	61.29	543.2	173.63	543.96	275.38	541	0.43	542.15	61.29	543.2	173.63	543.96	275.38	0.00	0.00	0.00	0.00
Reach 2	12636.0*	540.71	125.51	541.8	214.19	542.78	366.46	543.67	410.15	540.71	125.51	541.80	214.18	542.78	366.46	543.67	410.15	0.00	0.00	0.00	0.00
Reach 2	12587.1*	540.01	36.64	541.21	102.91	542.3	255.65	543.25	290.16	540.01	36.64	541.21	102.91	542.3	255.65	543.25	290.16	0.00	0.00	0.00	0.00
Reach 2	12538.2*	539.29	0.47	540.6	69.89	541.72	228.15	542.87	296.28	539.29	0.47	540.60	69.90	541.72	228.15	542.87	296.28	0.00	0.00	0.00	0.00
Reach 2	12489.3*	538.69	0.43	539.56	60.84	540.7	88.61	542.18	260.11	538.69	0.43	539.56	60.83	540.7	88.61	542.18	260.11	0.00	0.00	0.00	0.00
Reach 2	12440.4*	537.97	3.64	539.04	80.01	540.3	100.68	541.55	184.82	537.97	3.64	539.04	80.01	540.3	100.68	541.55	184.82	0.00	0.00	0.00	0.00
Reach 2	12391.5*	537.97	3.18	538.86	95.37	540.2	190.28	541.49	293.8	537.97	3.18	538.86	95.37	540.2	190.28	541.49	293.8	0.00	0.00	0.00	0.00
Reach 2	12342.6*	537.75	0.48	538.71	126.49	540.12	252.99	541.4	346.41	537.75	0.48	538.71	126.49	540.12	252.99	541.4	346.41	0.00	0.00	0.00	0.00
Reach 2	12293.7*	536.75	0.39	538.52	66.52	539.96	209.31	541.21	267.85	536.75	0.39	538.52	66.53	539.96	209.31	541.21	267.85	0.00	0.00	0.00	0.00
Reach 2	12244.8*	536.59	2.78	538.39	94.92	539.77	201.43	540.85	282.9	536.59	2.78	538.39	94.92	539.77	201.43	540.85	282.9	0.00	0.00	0.00	0.00
Reach 2	12195.9*	536.59	16.8	538.36	103.05	539.64	186.5	540.56	298.03	536.59	16.8	538.36	103.05	539.64	186.5	540.56	298.03	0.00	0.00	0.00	0.00
Reach 2	12147	536.59	18.5	538.34	142.66	539.53	223.3	540.41	278.18	536.59	18.5	538.34	142.66	539.53	223.3	540.41	278.18	0.00	0.00	0.00	0.00
Reach 3	12071	532.85	21.19	534.76	28.38	535.84	32.87	538.13	239.12	532.85	21.19	534.76	28.38	535.84	32.87	538.13	239.12	0.00	0.00	0.00	0.00
Reach 3	11925	530.56	25.31	532.44	30.96	533.34	43.07	534.42	61.27	530.56	25.31	532.44	30.97	533.34	43.07	534.42	61.27	0.00	0.00	0.00	0.00
Reach 3	11657	526.98	31.79	528.44	42.76	529.35	53.16	530.54	69.28	526.98	31.79	528.44	42.73	529.35	53.16	530.54	69.28	0.00	0.00	0.00	0.00
Reach 3	11444	524.68	42.82	526.92	55.3	528.38	63.38	529.61	70.47	524.68	42.82	526.92	55.30	528.38	63.38	529.61	70.47	0.00	0.00	0.00	0.00
Reach 3	11338	523.94	38.86	526.43	59.12	528.03	74.46	529.25	116.45	523.94	38.86	526.43	59.12	528.03	74.46	529.25	116.45	0.00	0.00	0.00	0.00
Reach 3	11211	523.75	41.94	526.18	74.37	527.84	126.62	529.07	169	523.75	41.94	526.18	74.37	527.84	126.62	529.07	169	0.00	0.00	0.00	0.00
Reach 3	11160 LIVE OAK	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	11110	522.53	28.14	524.14	41.25	525.05	50.19	526.39	101.72	522.53	28.14	524.14	41.25	525.05	50.19	526.39	101.72	0.00	0.00	0.00	0.00
Reach 3	11001	520.93	43.47	522.64	54.32	523.54	60.1	524.79	68.36	520.95	43.62	522.68	54.57	523.58	60.38	524.84	68.69	0.02	0.04	0.04	0.05
Reach 3	10809	519.71	81.29	521.77	122.49	522.76	131.01	524.08	140.6	519.74	82.52	521.81	122.89	522.8	131.36	524.13	140.93	0.03	0.04	0.04	0.05
Reach 3	10618	517.28	26.3	519.56	78.56	520.49	100.07	521.53	119.26	517.29	26.33	519.57	78.74	520.5	100.17	521.53	119.36	0.01	0.01	0.01	0.00
Reach 3	10559	517.25	39.75	519.64	106.28	520.57	146.81	521.63	181.93	517.26	39.81	519.65	106.77	520.59	147.36	521.65	182.53	0.01	0.01	0.02	0.02
Reach 3	10530 JOHANNA	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	10502	516.34	32.88	518.65	88.72	519.99	150.19	521.43	191.11	516.36	32.94	518.66	89.06	520.01	151.02	521.45	191.82	0.02	0.01	0.02	0.02
Reach 3	10412	513.72	23.05	516.66	54.05	517.61	87.22	519.03	113.92	513.74	23.09	516.72	56.93	517.65	88.05	519.05	114.27	0.02	0.06	0.04	0.02
Reach 3	10284	513.35	33.64	516.85	72.99	517.8	107.55	518.67	122.22	513.43	33.87	516.90	75.83	517.84	108.08	518.7	123.62	0.08	0.05	0.04	0.03
Reach 3	10203	513.16	39.4	516.73	49.88	517.65	107.81	518.43	144.41	513.23	39.62	516.78	50.04	517.68	109.72	518.45	146.14	0.07	0.05	0.03	0.02
Reach 3	10171 MARY	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	10139	510.45	32.84	513.06	53.14	514.11	70	515.51	88.76	510.46	32.88	513.06	53.04	514.09	69.8	515.49	88.41	0.01	0.00	-0.02	-0.02
Reach 3	10067	509.87	36.23	512.8	72.36	513.91	94.47	515.25	111.4	509.86	36.1	512.78	71.88	513.89	94.16	515.22	111.05	-0.01	-0.02	-0.02	-0.03
Reach 3	9925	509.21	39.66	512.39	76.34	513.46	95.31	514.66	113.28	509.15	39.45	512.35	75.68	513.42	94.54	514.59	112.29	-0.06	-0.04	-0.04	-0.07
Reach 3	9840	508.58	34.13	511.89	83.93	512.92	102.47	513.78	161.92	508.54	34.02	511.87	83.88	512.9	101.69	513.76	160.65	-0.04	-0.02	-0.02	-0.02
Reach 3	9807 ANNIE	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	9774	507.55	30.82	509.7	45.94	510.77	60.67	512.28	147.57	507.52	30.7	509.69	45.82	510.77	60.57	512.28	147.38	-0.03	-0.01	0.00	0.00
Reach 3	9673	506.8	44.2	508.93	53.65	510.04	58.54	511.66	119.04	506.79	44.14	508.93	53.67	510.05	58.56	511.66	119.36	-0.01	0.00	0.01	0.00

Reach	River Sta	ESD Revised Pre-Project - Existing Land Use								ESD Proposed Alternative 1 - Existing Land Use								Change in WS Elev from Pre-Project			
		2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 3	9537	506.36	46.06	508.33	55.17	509.37	60.1	510.95	99.24	506.35	46	508.33	55.18	509.37	60.11	510.96	99.4	-0.01	0.00	0.00	0.01
Reach 3	9348	505.9	59.82	507.69	91.15	508.69	105.32	510.36	176.36	505.89	59.66	507.70	91.17	508.7	105.37	510.36	176.78	-0.01	0.01	0.01	0.00
Reach 3	9156	505.15	48.49	506.2	131.79	506.58	149.35	507.26	171.95	505.14	48.22	506.20	131.89	506.58	149.38	507.26	171.99	-0.01	0.00	0.00	0.00
Reach 3	9081	505.16	158.18	506.31	224.96	506.81	254.23	507.71	299.31	505.15	157.76	506.31	225.10	506.81	254.3	507.71	299.39	-0.01	0.00	0.00	0.00
Reach 3	9052 MONROE	Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge					
Reach 3	9024	501.66	39.28	504.14	126.02	505.25	180.76	506.71	277.05	501.65	39.13	504.14	125.94	505.25	180.91	506.71	277.27	-0.01	0.00	0.00	0.00
Reach 3	8942	499.93	30.35	501.92	44.47	502.97	69.75	504	122.24	499.92	30.31	501.92	44.45	502.97	69.86	504	122.3	-0.01	0.00	0.00	0.00
Reach 3	8857	498.11	34.52	500.69	64.3	501.77	129.9	503.28	210.99	498.1	34.43	500.69	64.27	501.78	130.14	503.28	211.11	-0.01	0.00	0.01	0.00
Reach 3	8764	497.9	47.75	500.5	94.28	501.62	139.95	503.06	175.14	497.88	47.66	500.50	94.21	501.63	140.06	503.07	175.29	-0.02	0.00	0.01	0.01
Reach 3	8722 ELIZABETH	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	8679	496.54	34.83	498.35	47.74	499.25	55.24	501.32	122.94	496.52	34.75	498.35	47.73	499.26	55.26	501.32	122.97	-0.02	0.00	0.01	0.00
Reach 3	8591	494.86	35.44	497	45.15	497.74	48.36	498.83	53.51	494.84	35.38	496.99	45.15	497.74	48.37	498.83	53.52	-0.02	-0.01	0.00	0.00
Reach 3	8373	492.76	44.61	494.44	61.51	495.65	90.94	496.97	114.96	492.75	44.54	494.43	61.48	495.66	90.97	496.97	114.98	-0.01	-0.01	0.01	0.00
Reach 3	8244	490.2	41.84	493.05	59.47	494.88	68.17	496.12	115.14	490.19	41.76	493.04	59.45	494.88	68.17	496.12	115.16	-0.01	-0.01	0.00	0.00
Reach 3	8022	488.67	43.53	492.51	64.6	494.53	94.31	495.67	112.54	488.65	43.44	492.51	64.55	494.52	94.29	495.67	112.55	-0.02	0.00	-0.01	0.00
Reach 3	7832	488.02	38.03	492.14	70.57	494.33	197.68	495.47	221.08	488	37.95	492.13	69.48	494.33	197.64	495.47	221.09	-0.02	-0.01	0.00	0.00
Reach 3	7780	488.06	41.95	492.16	82.03	494.34	240.75	495.48	294.39	488.04	41.91	492.16	81.98	494.34	240.68	495.48	294.4	-0.02	0.00	0.00	0.00
Reach 3	7742 SOUTH FIRST STR	Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge					
Reach 3	7704	484.89	34.49	486.76	46.3	487.71	52.53	489.11	63.74	484.87	34.4	486.74	46.19	487.71	52.54	489.11	63.74	-0.02	-0.02	0.00	0.00
Reach 3	7609	482.53	45.15	483.94	60.5	484.65	70.33	485.66	90.69	482.52	45.07	483.93	60.49	484.65	70.36	485.66	90.72	-0.01	-0.01	0.00	0.00
Reach 3	7393	479.44	48.6	480.85	60.72	481.62	67.53	482.76	77.96	479.42	48.48	480.85	60.71	481.62	67.55	482.76	77.97	-0.02	0.00	0.00	0.00
Reach 3	7126	464.85	49.55	467.06	57.12	467.9	60.03	469.48	65.25	464.83	49.5	467.05	57.08	467.89	60.01	469.47	65.23	-0.02	-0.01	-0.01	-0.01
Reach 3	6915	463.1	42.64	464.98	49.75	465.73	52.55	467.22	58.39	463.09	42.59	464.97	49.71	465.72	52.53	467.22	58.36	-0.01	-0.01	-0.01	0.00
Reach 3	6735	461.98	100.22	464.3	116.21	465.2	122.19	466.95	135.08	461.96	100.11	464.29	116.13	465.19	122.14	466.94	135.02	-0.02	-0.01	-0.01	-0.01
Reach 3	6568	460.93	55.31	463.19	67.36	464.03	71.97	465.64	81.55	460.92	55.23	463.17	67.30	464.02	71.94	465.63	81.51	-0.01	-0.02	-0.01	-0.01
Reach 3	6418	459.95	54.91	461.97	67.72	462.75	72.34	464.3	81.64	459.94	54.82	461.96	67.65	462.75	72.3	464.29	81.61	-0.01	-0.01	0.00	-0.01
Reach 3	6253	457.93	49.66	459.42	60.81	459.88	64.53	460.72	71.83	457.92	49.58	459.41	60.75	459.88	64.51	460.72	71.79	-0.01	-0.01	0.00	0.00
Reach 3	6124	457.19	88.8	458.68	115.16	459.15	117.94	460.05	121.87	457.17	88.43	458.67	115.05	459.14	117.92	460.04	121.85	-0.02	-0.01	-0.01	-0.01
Reach 3	5916	454.94	72.6	456.51	134.42	457.11	145.18	458.27	160.48	454.93	72.21	456.50	134.25	457.1	145.1	458.27	160.42	-0.01	-0.01	-0.01	0.00
Reach 3	5717	454.14	122.8	455.9	171.39	456.56	178.2	457.79	188.89	454.13	121.97	455.90	171.29	456.55	178.14	457.78	188.85	-0.01	0.00	-0.01	-0.01
Reach 3	5591	453.23	95.5	454.92	123.43	455.56	132.45	456.77	148.71	453.22	95.26	454.91	123.29	455.56	132.38	456.77	148.65	-0.01	-0.01	0.00	0.00
Reach 3	5415	452.49	102.05	454.2	115.21	454.85	125.22	456.11	146.76	452.48	102	454.19	115.07	454.85	125.14	456.1	146.66	-0.01	-0.01	0.00	-0.01
Reach 3	5247	451.93	117.05	453.64	153.24	454.33	165.84	455.63	189.12	451.92	116.78	453.63	153.05	454.32	165.75	455.63	189.02	-0.01	-0.01	-0.01	0.00
Reach 3	5129	451.41	124.96	453.32	151.69	454.04	162.8	455.38	183	451.4	124.76	453.31	151.52	454.04	162.72	455.38	182.92	-0.01	-0.01	0.00	0.00
Reach 3	4941	450.84	88.36	452.87	109.34	453.61	123.45	455	155.01	450.83	88.23	452.85	109.20	453.6	123.32	455	154.88	-0.01	-0.02	-0.01	0.00
Reach 3	4822	450.23	57.67	452.03	66.3	452.66	69.09	453.83	79.74	450.22	57.6	452.02	66.26	452.66	69.07	453.83	79.66	-0.01	-0.01	0.00	0.00
Reach 3	4781	449.86	52.31	451.45	59.72	451.98	62.33	452.92	67.74	449.85	52.24	451.44	59.68	451.98	62.31	452.92	67.68	-0.01	-0.01	0.00	0.00
Reach 3	4735	449.72	59.47	451.31	70	451.86	73.42	452.84	79.82	449.7	59.4	451.31	69.95	451.85	73.4	452.84	79.79	-0.02	0.00	-0.01	0.00
Reach 3	4655	449.67	85.77	451.33	99.45	451.9	105.42	452.96	121.58	449.65	85.67	451.32	99.38	451.9	105.36	452.95	121.51	-0.02	-0.01	0.00	-0.01
Reach 3	4625	449.4	76.09	451	209.15	451.54	217.34	452.53	239.07	449.39	75.96	450.99	209.05	451.54	217.28	452.52	238.96	-0.01	-0.01	0.00	-0.01
Reach 3	4608	449.09	68.39	450.6	227.5	451.11	245.91	451.99	255.07	449.08	68.28	450.59	226.99	451.11	245.87	451.99	255.03	-0.01	-0.01	0.00	0.00
Reach 3	4593	448.83	67.27	450.35	207.92	450.86	227.34	451.72	235.63	448.82	67.14	450.35	207.42	450.86	227.31	451.72	235.59	-0.01	0.00	0.00	0.00
Reach 3	4571	448.71	75.68	450.3	183.55	450.84	286.8	451.75	325.83	448.7	75.56	450.30	182.87	450.83	286.76	451.75	325.63	-0.01	0.00	-0.01	0.00
Reach 3	4545	448.65	91.91	450.31	168.86	450.87	266.98	451.84	344.51	448.64	91.81	450.30	167.66	450.86	266.77	451.83	344.45	-0.01	-0.01	-0.01	-0.01
Reach 3	4477	447.35	84.08	449.93	117.93	450.47	138.51	451.34	175.75	447.35	84.06	449.92	117.66	450.47	138.39	451.34	175.57	0.00	-0.01	0.00	0.00
Reach 3	4476	Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct					
Reach 3	4415	447.28	88.08	450.1	109.14	450.69	113.45	451.67	141.25	447.27	87.99	450.09	109.08	450.68	113.42	451.66	140.98	-0.01	-0.01	-0.01	-0.01
Reach 3	4220	447.01	72.14	449.98	82.06	450.54	83.9	451.47	86.93	447	72.09	449.97	82.03	450.54	83.89	451.47	86.91	-0.01	-0.01	0.00	0.00
Reach 3	4022	446.7	48.13	449.74	63.06	450.25	65.58	451.04	84.15	446.69	48.06	449.73	63.03	450.24	65.57	451.04	83.97	-0.01	-0.01	-0.01	0.00
Reach 3	3855	446.58	43.77	449.65	88.91	450.16	92.06	450.96	97.96	446.57	43.71	449.65	88.89	450.16	92.04	450.96	97.94	-0.01	0.00	0.00	0.00
Reach 3	3817 SOUTH FIRST STR	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	3779	445.29	29.15	448.07	81.48	448.33	89.5	448.8	125.16	445.28	29.14	448.07	81.48	448.33	89.5	448.8	124.91	-0.01	0.00	0.00	0.00
Reach 3	3778	Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct					
Reach 3	3631	444.45	48.06	445.97	55.57	446.78	59.63	448.52	68.63	444.44	48	445.96	55.51	446.77	59.6	448.51	68.56	-0.01	-0.01	-0.01	-0.01
Reach 3	3454	444.2	57.5	445.68	62.99	446.56	66.36	448.41	73.41	444.19	57.46	445.67	62.94	446.55	66.33	448.39	73.37	-0.01	-0.01	-0.01	-0.02
Reach 3	3231	442.74	49.37	445.2	123.53	446.29	127.06	448.3	133.56	442.73	47.75	445.18	123.47	446.29	127.04	448.29	133.52	-0.01	-0.02	0.00	-0.01
Reach 3	2977	442.22	47.53	444.86	68.03	446.02	76.38	448.09	90.9	442.21	47.39	444.84	67.89	446.02	76.33	448.08	90.81	-0.01	-0.02	0.00	-0.01
Reach 3	2773	441.71	72.24	444.7	123.68	445.93	128.11	448.05	135.99	441.69	71.74	444.67	123.61	445.92	128.08	448.04	135.94	-0.02	-0.03	-0.01	-0.01
Reach 3	2707	441.72	115.48	444.7	166.2	445.93	184.32	448.04	210.91	441.7	115.06	444.68	165.89	445.92	184.19	448.03	210.74	-0.02	-0.02	-0.01	-0.01
Reach 3	2629	441.54	60.06	444.42	100.75	445.63	121.47	447.71	188.54	441.52	59.77	444.40	100.42	445.62	121.34	447.7	188.18	-0.02	-0.02	-0.01	-0.01
Reach 3	2539 CONGRESS AVENUE	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	2447	441.1	30.37	443	34.94	443.49	36.1	444.31	38	441.08	30.33	442.98	34.89	443.48	36.09	444.3	37.99	-0.02	-0.02	-0.01	-0.01
Reach 3	2362	440.4	30.56	442.24	35.44	442.73	36.78	443.49	38.92	440.39	30.52	442.22	35.39	442.72	36.76	443.49	38.9	-0.01	-0.02	-0.01	0.00

		ESD Revised Pre-Project - Existing Land Use								ESD Proposed Alternative 1 - Existing Land Use								Change in WS Elev from Pre-Project			
Reach	River Sta	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 3	2257	439.41	29.58	441.41	34.69	441.94	36.06	442.73	38.08	439.4	29.54	441.39	34.64	441.93	36.04	442.72	38.06	-0.01	-0.02	-0.01	-0.01
Reach 3	2001	437.66	30.36	439.81	57.12	440.55	81.28	441.4	96.59	437.64	30.32	439.79	55.84	440.54	81.03	441.4	96.45	-0.02	-0.02	-0.01	0.00
Reach 3	1823	436.85	32.4	439.03	38.78	439.9	297.71	440.77	306.54	436.83	32.37	439.00	38.70	439.89	292.42	440.77	306.51	-0.02	-0.03	-0.01	0.00
Reach 3	1534	435.97	46.5	438.34	52.3	439.33	54.68	440.29	57	435.96	46.44	438.31	52.22	439.31	54.64	440.29	56.98	-0.01	-0.03	-0.02	0.00
Reach 3	1327	433.42	27.57	437.18	40.91	438.39	45.39	439.48	49.44	433.39	27.48	437.14	40.77	438.37	45.32	439.47	49.4	-0.03	-0.04	-0.02	-0.01
Reach 3	1116	433.08	33.96	435.97		437.03	40.38	438.22	42.31	433.06	33.93	435.94		437.01	40.35	438.21	42.3	-0.02	-0.03	-0.02	-0.01
Reach 3	1036 RIVERSIDE	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	956	432.33	51.74	434.19	54.88	434.8	55.18	435.41	55.49	432.32	51.71	434.17	54.87	434.79	55.18	435.41	55.49	-0.01	-0.02	-0.01	0.00
Reach 3	682	431.74	62.33	433.57	66.8	434.18	68.3	434.81	69.84	431.72	62.3	433.55	66.76	434.17	68.27	434.81	69.83	-0.02	-0.02	-0.01	0.00

		ESD Revised Pre-Project - Ultimate Land Use								ESD Proposed Alternative 1 - Ultimate Land Use								Change in WS Elev from Pre-Project			
Reach	River Sta	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 1	19568	654.44	108.86	654.73	129.39	654.87	138.83	655.08	152.57	654.44	108.86	654.73	129.39	654.87	138.83	655.08	152.57	0	0	0	0
Reach 1	19532	653.47	104.79	653.75	123.12	653.89	132.2	654.1	144.77	653.47	104.79	653.75	123.12	653.89	132.2	654.1	144.77	0	0	0	0
Reach 1	19488	651.72	85.42	652.07	111.23	652.24	121.09	652.48	131.96	651.72	85.42	652.07	111.23	652.24	121.09	652.48	131.96	0	0	0	0
Reach 1	19445	650.17	76.74	650.57	115.44	650.75	130.35	651.04	159.96	650.17	76.74	650.57	115.44	650.75	130.35	651.04	159.96	0	0	0	0
Reach 1	19401	648.13	75.56	648.47	97.2	648.64	109	648.86	122.13	648.13	75.56	648.47	97.20	648.64	109	648.86	122.13	0	0	0	0
Reach 1	19334	642.94	180.03	643.28	196.37	643.44	201.69	643.68	210.34	642.94	180.03	643.28	196.37	643.44	201.69	643.68	210.34	0	0	0	0
Reach 1	19312 FORT MCGRUDER	Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct					
Reach 1	19291	639.39	37.54	639.94	48.13	640.19	52.56	640.54	63.29	639.39	37.54	639.94	48.13	640.19	52.56	640.54	63.29	0	0	0	0
Reach 1	19219	635.94	25.45	636.65	34.89	636.98	40.64	637.4	49.56	635.94	25.45	636.65	34.89	636.98	40.64	637.4	49.56	0	0	0	0
Reach 1	19146	634.29	24.08	635.04	32.23	635.39	36.54	635.85	42.49	634.29	24.08	635.04	32.23	635.39	36.54	635.85	42.49	0	0	0	0
Reach 1	19001	629.42	24.46	630.1	30.65	630.41	33.5	630.91	38.44	629.42	24.46	630.10	30.65	630.41	33.5	630.91	38.44	0	0	0	0
Reach 1	18835	625.67	25.47	626.38	33.47	626.71	37.41	627.17	43.06	625.67	25.47	626.38	33.47	626.71	37.41	627.17	43.06	0	0	0	0
Reach 1	18655	619.69	32.44	620.33	38.92	620.56	41.37	620.9	45.38	619.69	32.44	620.33	38.92	620.56	41.37	620.9	45.38	0	0	0	0
Reach 1	18497	617.59	31.68	618.59	49.66	618.99	56.39	619.5	64.43	617.59	31.68	618.59	49.66	618.99	56.39	619.5	64.43	0	0	0	0
Reach 1	18372	616.69	34.28	617.85	49.15	618.31	55.01	618.89	64.75	616.69	34.28	617.85	49.15	618.31	55.01	618.89	64.75	0	0	0	0
Reach 1	18235	616.68	97.59	617.83	122.53	618.28	136.27	618.86	167.17	616.68	97.59	617.83	122.53	618.28	136.27	618.86	167.17	0	0	0	0
Reach 1	18206	616.68	145.66	617.83	173.44	618.28	187.35	618.86	217.25	616.68	145.66	617.83	173.44	618.28	187.35	618.86	217.25	0	0	0	0
Reach 1	18167	616.61	224.83	617.7	269.19	618.1	290.65	618.61	317.15	616.61	224.83	617.70	269.19	618.1	290.65	618.61	317.15	0	0	0	0
Reach 1	18096	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	18025	613.74	185.48	614.42	316.96	614.71	324.32	615.17	365.39	613.74	185.48	614.42	316.96	614.71	324.32	615.17	365.39	0	0	0	0
Reach 1	17964	613.76	472.28	614.44	529.03	614.74	536.09	615.21	548.98	613.76	472.28	614.44	529.03	614.74	536.09	615.21	548.98	0	0	0	0
Reach 1	17923	613.76	510.43	614.44	528.84	614.74	537.53	615.21	550.75	613.76	510.43	614.44	528.84	614.74	537.53	615.21	550.75	0	0	0	0
Reach 1	17827	613.76	506.6	614.44	529.39	614.74	538.64	615.21	552.11	613.76	506.6	614.44	529.39	614.74	538.64	615.21	552.11	0	0	0	0
Reach 1	17814 DETENTION BASIN	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	17796	608.1	20.25	609.47	23.27	609.84	24.07	610.22	26.46	608.1	20.25	609.47	23.27	609.84	24.07	610.22	26.46	0	0	0	0
Reach 1	17781	607.92	20.69	609.41	27.07	609.79	32.27	610.16	42.7	607.92	20.69	609.41	27.07	609.79	32.27	610.16	42.7	0	0	0	0
Reach 1	17771	608	23.37	609.47	44.99	609.87	68.07	610.28	116.9	608	23.37	609.47	44.99	609.87	68.07	610.28	116.9	0	0	0	0
Reach 1	17744 ALPINE	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	17716	607.22	19.96	608.26	33.08	608.75	41.25	609.35	107.68	607.22	19.96	608.26	33.08	608.75	41.25	609.35	107.68	0	0	0	0
Reach 1	17646	604.82	26.71	605.84	34.23	606.26	36.26	606.78	46.45	604.82	26.71	605.84	34.23	606.26	36.26	606.78	46.45	0	0	0	0
Reach 1	17501	602.44	21.39	603.47	29.2	603.86	32.25	604.45	40.1	602.44	21.39	603.47	29.20	603.86	32.25	604.45	40.1	0	0	0	0
Reach 1	17305	599.72	53.78	601.14	82.54	601.77	114.89	602.4	150.13	599.72	53.78	601.14	82.54	601.77	114.89	602.4	150.13	0	0	0	0
Reach 1	17192	598.17	20.98	599.56	33.39	600.18	55.35	601.12	138.17	598.17	20.98	599.56	33.39	600.18	55.35	601.12	138.17	0	0	0	0
Reach 1	17106	596.87	24.15	599.02	98.2	599.26	107.98	599.83	126.27	596.87	24.15	599.02	98.20	599.26	107.98	599.83	126.27	0	0	0	0
Reach 1	17070 LIGHTSEY	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	17034	594.16	12.99	596.01	23.87	596.77	28.08	597.68	33.65	594.16	12.99	596.01	23.87	596.77	28.08	597.68	33.65	0	0	0	0
Reach 1	17014	592.94	16.67	594.43	18.6	595.23	19.63	596.27	20.75	592.94	16.67	594.43	18.60	595.23	19.63	596.27	20.75	0	0	0	0
Reach 1	17010	591.9	15	593.85	17.46	594.82	18.66	596.07	20.39	591.9	15	593.85	17.46	594.82	18.66	596.07	20.39	0	0	0	0
Reach 1	16967	591.44	15.26	593.24	17.87	594.12	19.15	595.33	24.21	591.44	15.26	593.24	17.87	594.12	19.15	595.33	24.21	0	0	0	0
Reach 1	16797	588.95	18.42	590.75	23.47	591.59	25.78	592.62	28.59	588.95	18.42	590.75	23.47	591.59	25.78	592.62	28.59	0	0	0	0
Reach 1	16639	587.66	22.3	589.39	27.94	590.02	29.99	590.74	32.32	587.66	22.3	589.39	27.94	590.02	29.99	590.74	32.32	0	0	0	0
Reach 1	16447	585.34	23.65	586.82	43.05	587.48	53.29	588.34	66.06	585.34	23.65	586.82	43.05	587.48	53.29	588.34	66.06	0	0	0	0
Reach 1	16323	583.55	27.66	585.22	38.52	585.98	43.77	586.79	51.49	583.55	27.66	585.22	38.52	585.98	43.77	586.79	51.49	0	0	0	0
Reach 1	16124	582.1	32.95	584.15	50.58	585.08	70.57	586.04	105.86	582.1	32.95	584.15	50.58	585.08	70.57	586.04	105.86	0	0	0	0
Reach 1	16056	581.28	22.97	583.46	33.12	584.39	63.77	585.37	121.51	581.28	22.97	583.46	33.12	584.39	63.77	585.37	121.51	0	0	0	0
Reach 1	16030 HAVANA	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	16003	580.66	17.56	582.29	25.26	583.02	29.66	583.84	35.84	580.66	17.56	582.29	25.26	583.02	29.66	583.84	35.84	0	0	0	0
Reach 1	15893	578.22	25.81	579.71	33.43	580.41	36.89	581.3	41.37	578.22	25.81	579.71	33.43	580.41	36.89	581.3	41.37	0	0	0	0
Reach 1	15734	576.62	25.87	578.14	32.76	578.81	35.75	579.64	39.48	576.62	25.87	578.14	32.76	578.81	35.75	579.64	39.48	0	0	0	0
Reach 1	15547	574.59	26.66	575.94	35.43	576.56	39.49	577.34	44.57	574.59	26.66	575.94	35.43	576.56	39.49	577.34	44.57	0	0	0	0
Reach 1	15330	572.19	29.63	573.84	40.19	574.72	46	575.69	60.83	572.19	29.63	573.84	40.19	574.72	46	575.69	60.83	0	0	0	0
Reach 1	15107	569.28	19.6	571.21	25.01	572.47	32.8	573.13	47.21	569.28	19.6	571.21	25.01	572.47	32.8	573.13	47.21	0	0	0	0
Reach 1	15022	568.45	30.15	571.09	46.39	572.46	74.64	573.24	97.53	568.45	30.15	571.09	46.39	572.46	74.64	573.24	97.53	0	0	0	0
Reach 1	14950	568.15	25.63	570.87	38.21	572.23	64.03	572.98	106.66	568.15	25.63	570.87	38.21	572.23	64.03	572.98	106.66	0	0	0	0
Reach 1	14918 EL PASO	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	14885	566.29	20.81	567.68	25.79	568.34	28.19	569.17	31.22	566.29	20.81	567.68	25.79	568.34	28.19	569.17	31.22	0	0	0	0
Reach 1	14794	564.81	23.85	566.44	31.81	567.18	35.47	568.13	40	564.81	23.85	566.44	31.81	567.18	35.47	568.13	40	0	0	0	0
Reach 1	14628	562.57	23.25	564.02	29.96	564.67	32.96	565.42	37.24	562.57	23.25	564.02	29.96	564.67	32.96	565.42	37.24	0	0	0	0
Reach 1	14471	560.92	28.16	563.1	42.59	563.46	44.95	564.12	54.36	560.92	28.16	563.10	42.59	563.46	44.95	564.12	54.36	0	0	0	0
Reach 1	14363	559.62	26.54	562.87	64.54	563.11	73.39	563.75	109.41	559.62	26.54	562.87	64.54	563.11	73.39	563.75	109.41	0	0	0	0
Reach 1	14298	559.38	27.14	562.78	84.73	562.96	110.7	563.59	143.14	559.38	27.14	562.78	84.73	562.96	110.7	563.59	143.14	0	0	0	0
Reach 1	14252 CUMBERLAND	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 1	14206	555.44	35.62	557.23	43.3	558.51	48.71	560.23	55.93	555.44	35.62	557.23	43.30	558.51	48.71	560.23	55.93	0	0	0	0

		ESD Revised Pre-Project - Ultimate Land Use								ESD Proposed Alternative 1 - Ultimate Land Use								Change in WS Elev from Pre-Project			
Reach	River Sta	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 1	14096	554.29	38.79	556.25	50.68	557.45	58	559.14	68.46	554.29	38.79	556.25	50.68	557.45	58	559.14	68.46	0	0	0	0
Reach 1	13965	553.13	36.28	555.2	46.79	556.45	53.08	558.17	61.87	553.13	36.28	555.20	46.79	556.45	53.08	558.17	61.87	0	0	0	0
Reach 1	13818	551.89	33.54	554	41.91	555.26	46.81	556.98	70.93	551.89	33.54	554.00	41.91	555.26	46.81	556.98	70.93	0	0	0	0
Reach 1	13624	550.22	31.47	552.38	40.07	553.65	45.03	555.52	111.69	550.22	31.47	552.38	40.07	553.65	45.03	555.52	111.69	0	0	0	0
Reach 1	13539	548.93	25.88	550.93	32.43	552.07	36.18	554.01	42.69	548.93	25.88	550.93	32.43	552.07	36.18	554.01	42.69	0	0	0	0
Reach 1	13477	548.37	27.86	550.27	32.49	551.33	35.08	553.2	55.51	548.37	27.86	550.27	32.49	551.33	35.08	553.2	55.51	0	0	0	0
Reach 1	13462 PEDESTRIAN BRID	Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge					
Reach 1	13447	547.8	27.11	549.54	32.97	550.48	36.29	551.76	41.03	547.8	27.11	549.54	32.97	550.48	36.29	551.76	41.03	0	0	0	0
Reach 1	13393	547.45	36.39	549.25	47.2	550.25	53.07	551.65	63.58	547.45	36.39	549.25	47.20	550.25	53.07	551.65	63.58	0	0	0	0
Reach 1	13268	546.33	35.27	548.11	47.42	549.05	53.99	550.37	64.32	546.33	35.27	548.11	47.42	549.05	53.99	550.37	64.32	0	0	0	0
Reach 1	13058	545.13	33.05	546.46	77.02	546.95	79.83	547.68	107.08	545.13	33.05	546.46	77.02	546.95	79.83	547.68	107.08	0	0	0	0
Reach 1	13056 LOW WATER CROSS	Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct		Inl Struct					
Reach 1	12945	543.21	30.18	545.06	42.29	545.52	57.4	546.73	119.19	543.21	30.18	545.06	42.29	545.52	57.4	546.73	119.19	0	0	0	0
Reach 1	12812	540.99	25.1	542.72	34.29	544.19	147.75	545.21	223.59	540.99	25.1	542.72	34.29	544.19	147.75	545.21	223.59	0	0	0	0
Culvert Split	12685	538.18	20	539.88	20	540.9		542.26		538.18	20	539.88	20.00	540.9		542.26		0	0	0	0
Culvert Split	12636	537.54	20	539.24	20	540.05		541.52		537.54	20	539.24	20.00	540.05		541.52		0	0	0	0
Culvert Split	12587.1	536.91	20	538.61	20	539.67		541.19		536.91	20	538.61	20.00	539.67		541.19		0	0	0	0
Culvert Split	12538.2	536.27	20	537.97	20	539.29		540.86		536.27	20	537.97	20.00	539.29		540.86		0	0	0	0
Culvert Split	12489.3	535.63	20	537.33	20	538.91		540.53		535.63	20	537.33	20.00	538.91		540.53		0	0	0	0
Culvert Split	12440.4	534.99	20	537.07		538.53		540.2		534.99	20	537.07		538.53		540.2		0	0	0	0
Culvert Split	12391.5	534.36	20	536.74		538.15		539.88		534.36	20	536.74		538.15		539.88		0	0	0	0
Culvert Split	12342.6	533.96	20	536.42		537.77		539.55		533.96	20	536.42		537.77		539.55		0	0	0	0
Culvert Split	12293.7	534.17	20	536.09		537.39		539.22		534.17	20	536.09		537.39		539.22		0	0	0	0
Culvert Split	12244.8	534.25	20	535.77		537.01		538.89		534.25	20	535.77		537.01		538.89		0	0	0	0
Culvert Split	12195.9	534.23		535.45		536.63		538.56		534.23		535.44		536.63		538.56		0	-0.01	0	0
Culvert Split	12147	534.04		534.71		535.77		537.82		534.04		534.71		535.77		537.82		0	0	0	0
Reach 2	12685	541	0.43	542.15	61.3	543.2	173.63	543.96	275.38	541	0.43	542.15	61.29	543.2	173.63	543.96	275.38	0	0	0	0
Reach 2	12636.0*	540.71	125.51	541.8	214.21	542.78	366.46	543.67	410.15	540.71	125.51	541.80	214.18	542.78	366.46	543.67	410.15	0	0	0	0
Reach 2	12587.1*	540.01	36.64	541.21	102.92	542.3	255.65	543.25	290.16	540.01	36.64	541.21	102.91	542.3	255.65	543.25	290.16	0	0	0	0
Reach 2	12538.2*	539.29	0.47	540.6	69.91	541.72	228.15	542.87	296.28	539.29	0.47	540.60	69.90	541.72	228.15	542.87	296.28	0	0	0	0
Reach 2	12489.3*	538.69	0.43	539.56	60.85	540.7	88.61	542.18	260.11	538.69	0.43	539.56	60.83	540.7	88.61	542.18	260.11	0	0	0	0
Reach 2	12440.4*	537.97	3.64	539.04	80.01	540.3	100.68	541.55	184.82	537.97	3.64	539.04	80.01	540.3	100.68	541.55	184.82	0	0	0	0
Reach 2	12391.5*	537.97	3.18	538.86	95.4	540.2	190.28	541.49	293.8	537.97	3.18	538.86	95.37	540.2	190.28	541.49	293.8	0	0	0	0
Reach 2	12342.6*	537.75	0.48	538.71	126.5	540.12	252.99	541.4	346.41	537.75	0.48	538.71	126.49	540.12	252.99	541.4	346.41	0	0	0	0
Reach 2	12293.7*	536.75	0.39	538.52	66.56	539.96	209.31	541.21	267.85	536.75	0.39	538.52	66.53	539.96	209.31	541.21	267.85	0	0	0	0
Reach 2	12244.8*	536.59	2.78	538.39	94.93	539.77	201.43	540.85	282.9	536.59	2.78	538.39	94.93	539.77	201.43	540.85	282.9	0	0	0	0
Reach 2	12195.9*	536.59	16.8	538.36	103.06	539.64	186.5	540.56	298.03	536.59	16.8	538.36	103.06	539.64	186.5	540.56	298.03	0	0	0	0
Reach 2	12147	536.59	18.5	538.34	142.66	539.53	223.3	540.41	278.18	536.59	18.5	538.34	142.66	539.53	223.3	540.41	278.18	0	0	0	0
Reach 3	12071	532.85	21.19	534.76	28.38	535.84	32.87	538.13	239.12	532.85	21.19	534.76	28.38	535.84	32.87	538.13	239.12	0	0	0	0
Reach 3	11925	530.56	25.31	532.44	30.97	533.34	43.07	534.42	61.27	530.56	25.31	532.45	31.00	533.34	43.07	534.42	61.27	0	0.01	0	0
Reach 3	11657	526.98	31.79	528.44	42.72	529.35	53.16	530.54	69.28	526.98	31.79	528.42	42.60	529.35	53.16	530.54	69.28	0	-0.02	0	0
Reach 3	11444	524.68	42.82	526.92	55.3	528.38	63.38	529.61	70.47	524.68	42.82	526.92	55.30	528.38	63.38	529.61	70.47	0	0	0	0
Reach 3	11338	523.94	38.86	526.43	59.12	528.03	74.46	529.25	116.45	523.94	38.86	526.43	59.12	528.03	74.46	529.25	116.45	0	0	0	0
Reach 3	11211	523.75	41.94	526.18	74.37	527.84	126.62	529.07	169	523.75	41.94	526.18	74.37	527.84	126.62	529.07	169	0	0	0	0
Reach 3	11160 LIVE OAK	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	11110	522.53	28.14	524.14	41.25	525.05	50.19	526.39	101.72	522.53	28.14	524.14	41.25	525.05	50.19	526.39	101.72	0	0	0	0
Reach 3	11001	521	43.96	522.69	54.64	523.58	60.35	524.83	68.6	521.03	44.13	522.73	54.90	523.62	60.64	524.88	68.94	0.03	0.04	0.04	0.05
Reach 3	10809	519.81	84.46	521.82	122.99	522.8	131.31	524.11	140.82	519.85	85.39	521.87	123.40	522.85	131.67	524.16	141.17	0.04	0.05	0.05	0.05
Reach 3	10618	517.41	26.71	519.62	80.16	520.52	100.68	521.55	119.71	517.42	26.76	519.63	80.37	520.53	100.83	521.56	119.73	0.01	0.01	0.01	0.01
Reach 3	10559	517.38	40.25	519.69	108.09	520.6	147.88	521.65	182.77	517.39	40.3	519.71	108.65	520.62	148.51	521.67	183.22	0.01	0.02	0.02	0.02
Reach 3	10530 JOHANNA	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	10502	516.45	33.42	518.72	92.39	520.03	151.76	521.47	192.21	516.46	33.48	518.73	92.80	520.05	152.66	521.48	192.71	0.01	0.01	0.02	0.01
Reach 3	10412	513.84	23.43	516.73	57.35	517.68	88.76	519.06	114.45	513.86	23.47	516.80	60.52	517.71	89.61	519.1	115.06	0.02	0.07	0.03	0.04
Reach 3	10284	513.54	34.27	516.92	76.63	517.84	108.05	518.7	123.58	513.63	34.55	516.98	80.17	517.88	108.76	518.74	125	0.09	0.06	0.04	0.04
Reach 3	10203	513.36	39.98	516.8	50.08	517.68	109.82	518.46	146.72	513.44	40.22	516.86	50.25	517.73	112.52	518.49	148.43	0.08	0.06	0.05	0.03
Reach 3	10171 MARY	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	10139	511.39	37.3	513.14	54.34	514.14	70.63	515.55	89.56	510.62	33.61	513.13	54.18	514.14	70.53	515.53	89.19	-0.77	-0.01	0	-0.02
Reach 3	10067	511.12	47.21	512.88	74.28	513.95	95.04	515.29	111.82	510.03	37.55	512.85	73.70	513.94	94.83	515.26	111.49	-1.09	-0.03	-0.01	-0.03
Reach 3	9925	510.86	55.98	512.47	77.62	513.5	95.9	514.69	113.82	509.33	40.11	512.42	76.85	513.46	95.29	514.62	112.79	-1.53	-0.05	-0.04	-0.07
Reach 3	9840	510.62	40.09	511.97	84.19	512.94	103.6	513.81	162.96	508.73	34.57	511.95	84.12	512.94	103.57	513.8	162.59	-1.89	-0.02	0	-0.01
Reach 3	9807 ANNIE	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	9774	507.68	31.41	509.78	46.79	510.83	61.61	512.33	149.97	507.65	31.26	509.77	46.63	510.82	61.51	512.32	149.63	-0.03	-0.01	-0.01	-0.01
Reach 3	9673	506.94	44.8	509.01	53.98	510.1	58.78	511.71	121.44	506.92	44.74	509.01	53.99	510.1	58.8	511.71	121.6	-0.02	0	0	0

		ESD Revised Pre-Project - Ultimate Land Use								ESD Proposed Alternative 1 - Ultimate Land Use								Change in WS Elev from Pre-Project			
Reach	River Sta	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 3	9537	506.5	46.65	508.4	55.51	509.42	60.35	511	102.18	506.48	46.58	508.40	55.51	509.42	60.36	511	102.18	-0.02	0	0	0
Reach 3	9348	506.03	61.5	507.76	91.92	508.75	106.37	510.41	183.77	506.01	61.33	507.76	91.91	508.75	106.43	510.41	183.76	-0.02	0	0	0
Reach 3	9156	505.24	51.19	506.23	133.59	506.6	150.03	507.28	172.56	505.23	50.95	506.23	133.50	506.6	150.02	507.29	172.6	-0.01	0	0	0.01
Reach 3	9081	505.26	165.72	506.35	227.48	506.83	255.33	507.74	300.76	505.25	165.23	506.35	227.40	506.83	255.35	507.74	300.8	-0.01	0	0	0
Reach 3	9052 MONROE	Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge					
Reach 3	9024	501.78	40.69	504.23	129.38	505.3	183.97	506.76	281.18	501.77	40.6	504.23	129.15	505.3	184.06	506.76	281.29	-0.01	0	0	0
Reach 3	8942	500.08	30.8	502	45.63	503.01	72.01	504.02	123.32	500.07	30.75	502.00	45.58	503.01	72.09	504.02	123.36	-0.01	0	0	0
Reach 3	8857	498.31	36.65	500.78	65.32	501.83	132.8	503.32	212.74	498.28	36.39	500.78	65.27	501.83	132.85	503.32	212.78	-0.03	0	0	0
Reach 3	8764	498.07	48.62	500.59	97.42	501.68	141.3	503.1	176.97	498.05	48.52	500.59	97.27	501.68	141.34	503.1	177.02	-0.02	0	0	0
Reach 3	8722 ELIZABETH	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	8679	496.65	35.6	498.42	48.29	499.3	55.69	501.32	123.07	496.63	35.51	498.41	48.26	499.3	55.7	501.33	123.2	-0.02	-0.01	0	0.01
Reach 3	8591	495.01	36.12	497.05	45.39	497.77	48.53	498.86	53.66	494.99	36.04	497.05	45.38	497.77	48.53	498.86	53.67	-0.02	0	0	0
Reach 3	8373	492.9	45.76	494.51	62.51	495.73	92.98	497	115.41	492.88	45.61	494.50	62.46	495.73	93.04	497	115.37	-0.02	-0.01	0	0
Reach 3	8244	490.3	42.62	493.19	60.15	494.97	68.6	496.15	115.83	490.29	42.53	493.18	60.11	494.97	68.61	496.14	115.67	-0.01	-0.01	0	-0.01
Reach 3	8022	488.89	44.5	492.68	66.52	494.62	96.03	495.69	112.86	488.86	44.38	492.67	66.41	494.63	96.08	495.68	112.74	-0.03	-0.01	0.01	-0.01
Reach 3	7832	488.25	38.86	492.31	104.81	494.43	200.36	495.5	221.4	488.22	38.76	492.30	103.23	494.43	200.44	495.48	221.25	-0.03	-0.01	0	-0.02
Reach 3	7780	488.29	42.34	492.34	112.55	494.44	246.05	495.5	295.25	488.26	42.29	492.33	110.89	494.44	246.23	495.49	294.85	-0.03	-0.01	0	-0.01
Reach 3	7742 SOUTH FIRST STR	Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge		Bridge					
Reach 3	7704	485.01	35.12	486.82	46.74	487.76	52.86	489.17	64.38	484.99	35.03	486.83	46.76	487.76	52.85	489.17	64.39	-0.02	0.01	0	0
Reach 3	7609	482.61	46.05	483.99	61.1	484.69	71.12	485.69	91.23	482.6	45.91	483.99	61.07	484.69	71.16	485.69	91.25	-0.01	0	0	0
Reach 3	7393	479.54	49.5	480.9	61.19	481.66	67.91	482.79	78.28	479.54	49.42	480.90	61.17	481.66	67.92	482.79	78.29	0	0	0	0
Reach 3	7126	465	50.07	467.17	57.49	467.97	60.28	469.54	65.43	464.98	50.02	467.16	57.45	467.96	60.26	469.52	65.4	-0.02	-0.01	-0.01	-0.02
Reach 3	6915	463.24	43.16	465.08	50.1	465.79	52.79	467.28	58.6	463.22	43.11	465.07	50.06	465.79	52.77	467.27	58.56	-0.02	-0.01	0	-0.01
Reach 3	6735	462.14	101.37	464.41	116.97	465.28	122.7	467.01	135.57	462.12	101.25	464.40	116.88	465.27	122.65	467	135.49	-0.02	-0.01	-0.01	-0.01
Reach 3	6568	461.1	56.19	463.29	67.95	464.1	72.37	465.7	81.87	461.08	56.09	463.28	67.88	464.09	72.33	465.69	81.82	-0.02	-0.01	-0.01	-0.01
Reach 3	6418	460.1	55.87	462.07	68.3	462.82	72.74	464.34	81.94	460.08	55.77	462.06	68.23	462.81	72.7	464.34	81.89	-0.02	-0.01	-0.01	0
Reach 3	6253	458.05	50.55	459.48	61.31	459.92	64.84	460.76	72.23	458.04	50.46	459.47	61.25	459.92	64.81	460.76	72.17	-0.01	-0.01	0	0
Reach 3	6124	457.31	92.69	458.74	116.09	459.19	118.12	460.08	122.01	457.3	92.43	458.73	116.06	459.18	118.1	460.07	121.98	-0.01	-0.01	-0.01	-0.01
Reach 3	5916	455.05	76.65	456.58	135.87	457.16	146.14	458.32	160.97	455.04	76.22	456.57	135.70	457.15	146.04	458.31	160.89	-0.01	-0.01	-0.01	-0.01
Reach 3	5717	454.27	132.07	455.99	172.25	456.61	178.8	457.83	189.23	454.26	130.77	455.98	172.15	456.61	178.74	457.82	189.18	-0.01	-0.01	0	-0.01
Reach 3	5591	453.36	97.98	455	124.6	455.62	133.2	456.82	149.3	453.34	97.75	454.99	124.47	455.61	133.12	456.81	149.2	-0.02	-0.01	-0.01	-0.01
Reach 3	5415	452.61	102.59	454.28	116.44	454.91	126.11	456.15	147.62	452.6	102.54	454.27	116.30	454.9	126.01	456.15	147.48	-0.01	-0.01	-0.01	0
Reach 3	5247	452.05	119.97	453.73	154.93	454.39	166.89	455.68	190	452.04	119.66	453.72	154.74	454.38	166.77	455.67	189.86	-0.01	-0.01	-0.01	-0.01
Reach 3	5129	451.55	127.03	453.42	153.13	454.1	163.73	455.43	183.75	451.53	126.82	453.40	152.97	454.1	163.63	455.42	183.65	-0.02	-0.02	0	-0.01
Reach 3	4941	450.99	89.71	452.96	110.49	453.67	124.97	455.05	156.08	450.98	89.57	452.95	110.36	453.67	124.8	455.05	155.91	-0.01	-0.01	0	0
Reach 3	4822	450.36	58.42	452.11	66.65	452.72	69.33	453.88	80.42	450.35	58.34	452.10	66.61	452.71	69.3	453.87	80.31	-0.01	-0.01	-0.01	-0.01
Reach 3	4781	449.98	52.9	451.52	60.07	452.03	62.55	452.95	68.24	449.96	52.84	451.51	60.03	452.02	62.52	452.95	68.16	-0.02	-0.01	-0.01	0
Reach 3	4735	449.83	60.24	451.39	70.45	451.9	73.7	452.87	80.06	449.82	60.16	451.38	70.40	451.9	73.67	452.87	80.02	-0.01	-0.01	0	0
Reach 3	4655	449.79	86.81	451.4	100.06	451.95	106.13	453	122.15	449.77	86.71	451.39	99.99	451.94	106.06	452.99	122.06	-0.02	-0.01	-0.01	-0.01
Reach 3	4625	449.51	77.47	451.07	210.02	451.59	218.2	452.56	239.99	449.5	77.33	451.06	209.91	451.58	218.11	452.56	239.84	-0.01	-0.01	-0.01	0
Reach 3	4608	449.19	69.48	450.67	231.68	451.16	246.36	452.02	255.43	449.18	69.37	450.66	231.21	451.15	246.32	452.02	255.37	-0.01	-0.01	-0.01	0
Reach 3	4593	448.92	68.41	450.42	211.58	450.9	227.72	451.75	235.92	448.91	68.31	450.41	211.22	450.9	227.68	451.75	235.88	-0.01	-0.01	0	0
Reach 3	4571	448.8	76.76	450.38	190.13	450.88	287.32	451.78	327.37	448.79	76.66	450.37	189.15	450.88	287.27	451.78	327.14	-0.01	-0.01	0	0
Reach 3	4545	448.74	92.82	450.38	198.22	450.91	270.71	451.87	345	448.73	92.73	450.37	190.06	450.91	270.26	451.86	344.92	-0.01	-0.01	0	-0.01
Reach 3	4477	447.43	84.72	450.01	120.96	450.52	140.36	451.37	177.03	447.42	84.64	449.99	120.38	450.51	140.17	451.36	176.85	-0.01	-0.02	-0.01	-0.01
Reach 3	4476	Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct					
Reach 3	4415	447.44	89.25	450.18	109.73	450.73	113.8	451.7	143.23	447.43	89.13	450.17	109.64	450.73	113.76	451.7	142.94	-0.01	-0.01	0	0
Reach 3	4220	447.18	72.71	450.05	82.31	450.58	84.05	451.5	87.03	447.16	72.65	450.04	82.27	450.58	84.03	451.5	87.01	-0.02	-0.01	0	0
Reach 3	4022	446.88	48.95	449.81	63.42	450.29	65.79	451.06	85.93	446.86	48.86	449.80	63.35	450.28	65.77	451.06	85.68	-0.02	-0.01	-0.01	0
Reach 3	3855	446.75	44.49	449.73	89.24	450.2	92.36	450.99	98.15	446.74	44.41	449.71	89.18	450.2	92.33	450.98	98.12	-0.01	-0.02	0	-0.01
Reach 3	3817 SOUTH FIRST STR	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	3779	445.42	30.31	448.11	82.42	448.36	90.44	448.82	126.08	445.41	30.2	448.10	82.14	448.35	90.33	448.81	125.62	-0.01	-0.01	-0.01	-0.01
Reach 3	3778	Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct					
Reach 3	3631	444.59	48.72	446.07	56.05	446.85	59.99	448.6	69.1	444.57	48.65	446.06	56.01	446.84	59.96	448.59	69.04	-0.02	-0.01	-0.01	-0.01
Reach 3	3454	444.33	58	445.79	63.38	446.64	66.66	448.49	73.74	444.32	57.95	445.78	63.35	446.63	66.63	448.48	73.7	-0.01	-0.01	-0.01	-0.01
Reach 3	3231	442.88	78.89	445.34	124	446.38	127.35	448.4	133.85	442.86	75.61	445.33	123.96	446.38	127.32	448.38	133.81	-0.02	-0.01	0	-0.02
Reach 3	2977	442.39	48.99	445.01	69.18	446.12	77.03	448.19	91.5	442.38	48.84	445.00	69.08	446.11	76.97	448.17	91.45	-0.01	-0.01	-0.01	-0.02
Reach 3	2773	441.91	76.66	444.86	124.28	446.02	128.46	448.15	136.36	441.89	76.22	444.85	124.23	446.01	128.42	448.13	136.31	-0.02	-0.01	-0.01	-0.02
Reach 3	2707	441.92	119.4	444.86	168.64	446.02	185.65	448.14	212.11	441.9	119.01	444.85	168.45	446.01	185.53	448.13	211.94	-0.02	-0.01	-0.01	-0.01
Reach 3	2629	441.74	63.66	444.58	103.32	445.72	123.05	447.81	191.1	441.72	63.29	444.57	103.11	445.71	122.9	447.8	190.74	-0.02	-0.01	-0.01	-0.01
Reach 3	2539 CONGRESS AVENUE	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	2447	441.25	30.72	443.09	35.14	443.53	36.21	444.35	38.09	441.23	30.69	443.07	35.10	443.53	36.19	444.34	38.07	-0.02	-0.02	0	-0.01
Reach 3	2362	440.55	30.94	442.32	35.66	442.78	36.91	443.53	39.04	440.53	30.9	442.31	35.62	442.77	36.89	443.53	39.02	-0.02	-0.01	-0.01	0

		ESD Revised Pre-Project - Ultimate Land Use								ESD Proposed Alternative 1 - Ultimate Land Use								Change in WS Elev from Pre-Project			
Reach	River Sta	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 3	2257	439.57	29.99	441.5	34.92	441.99	36.19	442.77	38.2	439.55	29.95	441.48	34.88	441.98	36.17	442.77	38.18	-0.02	-0.02	-0.01	0
Reach 3	2001	437.82	30.72	439.92	64.4	440.62	82.62	441.48	97.87	437.8	30.68	439.90	62.81	440.61	82.41	441.47	97.78	-0.02	-0.02	-0.01	-0.01
Reach 3	1823	437	32.84	439.15	39.1	439.99	302.68	440.86	306.85	436.98	32.77	439.12	39.02	439.97	302.61	440.86	306.84	-0.02	-0.03	-0.02	0
Reach 3	1534	436.11	46.96	438.47	52.62	439.42	54.9	440.39	57.22	436.09	46.91	438.44	52.55	439.41	54.87	440.38	57.21	-0.02	-0.03	-0.01	-0.01
Reach 3	1327	433.67	28.49	437.34	41.49	438.5	45.77	439.58	49.83	433.64	28.4	437.31	41.36	438.48	45.71	439.58	49.81	-0.03	-0.03	-0.02	0
Reach 3	1116	433.29	34.3	436.11		437.15	40.57	438.33	42.49	433.26	34.26	436.08		437.13	40.54	438.33	42.48	-0.03	-0.03	-0.02	0
Reach 3	1036 RIVERSIDE	Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert		Culvert					
Reach 3	956	432.48	52.06	434.28	54.92	434.86	55.22	435.47	55.52	432.46	52.02	434.26	54.91	434.85	55.21	435.46	55.52	-0.02	-0.02	-0.01	-0.01
Reach 3	682	431.88	62.67	433.66	67.02	434.25	68.45	434.87	69.97	431.86	62.63	433.64	66.98	434.24	68.43	434.86	69.96	-0.02	-0.02	-0.01	-0.01

Exhibit M.3

Proposed Channel Improvement Water Surface Elevations

and Comparison to

Revised Pre-Project Water Surface Elevations

		ESD Revised Pre-Project - Existing Land Use								ESD Proposed Channel Improvements - Existing Land Use								Change in WS Elev from Pre-Project			
Reach	River Sta	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 1	19568	654.44	108.86	654.73	129.39	654.87	138.83	655.08	152.57	654.44	108.86	654.73	129.39	654.87	138.83	655.08	152.57	0.00	0.00	0.00	0.00
Reach 1	19532	653.47	104.79	653.75	123.12	653.89	132.2	654.1	144.77	653.47	104.79	653.75	123.12	653.89	132.2	654.1	144.77	0.00	0.00	0.00	0.00
Reach 1	19488	651.72	85.42	652.07	111.23	652.24	121.09	652.48	131.96	651.72	85.42	652.07	111.23	652.24	121.09	652.48	131.96	0.00	0.00	0.00	0.00
Reach 1	19445	650.17	76.74	650.57	115.44	650.75	130.35	651.04	159.96	650.17	76.74	650.57	115.44	650.75	130.35	651.04	159.96	0.00	0.00	0.00	0.00
Reach 1	19401	648.13	75.56	648.47	97.2	648.64	109	648.86	122.13	648.13	75.56	648.47	97.20	648.64	109	648.86	122.13	0.00	0.00	0.00	0.00
Reach 1	19334	642.94	180.03	643.28	196.37	643.44	201.69	643.68	210.34	642.94	180.03	643.28	196.37	643.44	201.69	643.68	210.34	0.00	0.00	0.00	0.00
Reach 1	19312 FORT MCGRUDER	Inl Struct	0	Inl Struct	0	Inl Struct	0	Inl Struct	0	Inl Struct		Inl Struct		Inl Struct		Inl Struct					
Reach 1	19291	639.39	37.54	639.94	48.13	640.19	52.56	640.54	63.29	639.39	37.54	639.94	48.13	640.19	52.56	640.54	63.29	0.00	0.00	0.00	0.00
Reach 1	19219	635.94	25.45	636.65	34.89	636.98	40.64	637.4	49.56	635.94	25.45	636.65	34.89	636.98	40.64	637.4	49.56	0.00	0.00	0.00	0.00
Reach 1	19146	634.29	24.08	635.04	32.23	635.39	36.54	635.85	42.49	634.29	24.08	635.04	32.23	635.39	36.54	635.85	42.49	0.00	0.00	0.00	0.00
Reach 1	19001	629.42	24.46	630.1	30.65	630.41	33.5	630.91	38.44	629.42	24.46	630.10	30.65	630.41	33.5	630.91	38.44	0.00	0.00	0.00	0.00
Reach 1	18835	625.67	25.47	626.38	33.47	626.71	37.41	627.17	43.06	625.67	25.47	626.38	33.47	626.71	37.41	627.17	43.06	0.00	0.00	0.00	0.00
Reach 1	18655	619.69	32.44	620.33	38.92	620.56	41.37	620.9	45.38	619.69	32.44	620.33	38.92	620.56	41.37	620.9	45.38	0.00	0.00	0.00	0.00
Reach 1	18497	617.59	31.68	618.59	49.66	618.99	56.39	619.5	64.43	617.59	31.68	618.59	49.66	618.99	56.39	619.5	64.43	0.00	0.00	0.00	0.00
Reach 1	18372	616.69	34.28	617.85	49.15	618.31	55.01	618.89	64.75	616.69	34.28	617.85	49.15	618.31	55.01	618.89	64.75	0.00	0.00	0.00	0.00
Reach 1	18235	616.68	97.59	617.83	122.53	618.28	136.27	618.86	167.17	616.68	97.59	617.83	122.53	618.28	136.27	618.86	167.17	0.00	0.00	0.00	0.00
Reach 1	18206	616.68	145.66	617.83	173.44	618.28	187.35	618.86	217.25	616.68	145.66	617.83	173.44	618.28	187.35	618.86	217.25	0.00	0.00	0.00	0.00
Reach 1	18167	616.61	224.83	617.7	269.19	618.1	290.65	618.61	317.15	616.61	224.83	617.70	269.19	618.1	290.65	618.61	317.15	0.00	0.00	0.00	0.00
Reach 1	18096	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	18025	613.74	185.48	614.42	316.96	614.71	324.32	615.17	365.39	613.74	185.48	614.42	316.96	614.71	324.32	615.17	365.39	0.00	0.00	0.00	0.00
Reach 1	17964	613.76	472.28	614.44	529.03	614.74	536.09	615.21	548.98	613.76	472.28	614.44	529.03	614.74	536.09	615.21	548.98	0.00	0.00	0.00	0.00
Reach 1	17923	613.76	510.43	614.44	528.84	614.74	537.53	615.21	550.75	613.76	510.43	614.44	528.84	614.74	537.53	615.21	550.75	0.00	0.00	0.00	0.00
Reach 1	17827	613.76	506.6	614.44	529.39	614.74	538.64	615.21	552.11	613.76	506.6	614.44	529.39	614.74	538.64	615.21	552.11	0.00	0.00	0.00	0.00
Reach 1	17814 DETENTION BASIN	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	17796	608.1	20.25	609.47	23.27	609.84	24.07	610.22	26.46	608.1	20.25	609.47	23.27	609.84	24.07	610.22	26.46	0.00	0.00	0.00	0.00
Reach 1	17781	607.92	20.69	609.41	27.07	609.79	32.27	610.16	42.7	607.92	20.69	609.41	27.07	609.79	32.27	610.16	42.7	0.00	0.00	0.00	0.00
Reach 1	17771	608	23.37	609.47	44.99	609.87	68.07	610.28	116.9	608	23.37	609.47	44.99	609.87	68.07	610.28	116.9	0.00	0.00	0.00	0.00
Reach 1	17744 ALPINE	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	17716	607.22	19.96	608.26	33.08	608.75	41.25	609.35	107.68	607.22	19.96	608.26	33.08	608.75	41.25	609.35	107.68	0.00	0.00	0.00	0.00
Reach 1	17646	604.82	26.71	605.84	34.23	606.26	36.26	606.78	46.45	604.82	26.71	605.84	34.23	606.26	36.26	606.78	46.45	0.00	0.00	0.00	0.00
Reach 1	17501	602.44	21.39	603.47	29.2	603.86	32.25	604.45	40.1	602.44	21.39	603.47	29.20	603.86	32.25	604.45	40.1	0.00	0.00	0.00	0.00
Reach 1	17305	599.72	53.78	601.14	82.54	601.77	114.89	602.4	150.13	599.72	53.78	601.14	82.54	601.77	114.89	602.4	150.13	0.00	0.00	0.00	0.00
Reach 1	17192	598.17	20.98	599.56	33.39	600.18	55.35	601.12	138.17	598.17	20.98	599.56	33.39	600.18	55.35	601.12	138.17	0.00	0.00	0.00	0.00
Reach 1	17106	596.87	24.15	599.02	98.2	599.26	107.98	599.83	126.27	596.87	24.15	599.02	98.20	599.26	107.98	599.83	126.27	0.00	0.00	0.00	0.00
Reach 1	17070 LIGHTSEY	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	17034	594.16	12.99	596.01	23.87	596.77	28.08	597.68	33.65	594.16	12.99	596.01	23.87	596.77	28.08	597.68	33.65	0.00	0.00	0.00	0.00
Reach 1	17014	592.94	16.67	594.43	18.6	595.23	19.63	596.27	20.75	592.94	16.67	594.43	18.60	595.23	19.63	596.27	20.75	0.00	0.00	0.00	0.00
Reach 1	17010	591.9	15	593.85	17.46	594.82	18.66	596.07	20.39	591.9	15	593.85	17.46	594.82	18.66	596.07	20.39	0.00	0.00	0.00	0.00
Reach 1	16967	591.44	15.26	593.24	17.87	594.12	19.15	595.33	24.21	591.44	15.26	593.24	17.87	594.12	19.15	595.33	24.21	0.00	0.00	0.00	0.00
Reach 1	16797	588.95	18.42	590.75	23.47	591.59	25.78	592.62	28.59	588.95	18.42	590.75	23.47	591.59	25.78	592.62	28.59	0.00	0.00	0.00	0.00
Reach 1	16639	587.66	22.3	589.39	27.94	590.02	29.99	590.74	32.32	587.66	22.3	589.39	27.94	590.02	29.99	590.74	32.32	0.00	0.00	0.00	0.00
Reach 1	16447	585.34	23.65	586.82	43.05	587.48	53.29	588.34	66.06	585.34	23.65	586.82	43.05	587.48	53.29	588.34	66.06	0.00	0.00	0.00	0.00
Reach 1	16323	583.55	27.66	585.22	38.52	585.98	43.77	586.79	51.49	583.55	27.66	585.22	38.52	585.98	43.77	586.79	51.49	0.00	0.00	0.00	0.00
Reach 1	16124	582.1	32.95	584.15	50.58	585.08	70.57	586.04	105.86	582.1	32.95	584.15	50.58	585.08	70.57	586.04	105.86	0.00	0.00	0.00	0.00
Reach 1	16056	581.28	22.97	583.46	33.12	584.39	63.77	585.37	121.51	581.28	22.97	583.46	33.12	584.39	63.77	585.37	121.51	0.00	0.00	0.00	0.00
Reach 1	16030 HAVANA	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	16003	580.66	17.56	582.29	25.26	583.02	29.66	583.84	35.84	580.66	17.56	582.29	25.26	583.02	29.66	583.84	35.84	0.00	0.00	0.00	0.00
Reach 1	15893	578.22	25.81	579.71	33.43	580.41	36.89	581.3	41.37	578.22	25.81	579.71	33.43	580.41	36.89	581.3	41.37	0.00	0.00	0.00	0.00
Reach 1	15734	576.62	25.87	578.14	32.76	578.81	35.75	579.64	39.48	576.62	25.87	578.14	32.76	578.81	35.75	579.64	39.48	0.00	0.00	0.00	0.00
Reach 1	15547	574.59	26.66	575.94	35.43	576.56	39.49	577.34	44.57	574.59	26.66	575.94	35.43	576.56	39.49	577.34	44.57	0.00	0.00	0.00	0.00
Reach 1	15330	572.19	29.63	573.84	40.19	574.72	46	575.69	60.83	572.19	29.63	573.84	40.19	574.72	46	575.69	60.83	0.00	0.00	0.00	0.00
Reach 1	15107	569.28	19.6	571.21	25.01	572.47	32.8	573.13	47.21	569.28	19.6	571.21	25.01	572.47	32.8	573.13	47.21	0.00	0.00	0.00	0.00
Reach 1	15022	568.45	30.15	571.09	46.39	572.46	74.64	573.24	97.53	568.45	30.15	571.09	46.39	572.46	74.64	573.24	97.53	0.00	0.00	0.00	0.00
Reach 1	14950	568.15	25.63	570.87	38.21	572.23	64.03	572.98	106.66	568.15	25.63	570.87	38.21	572.23	64.03	572.98	106.66	0.00	0.00	0.00	0.00
Reach 1	14918 EL PASO	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	14885	566.29	20.81	567.68	25.79	568.34	28.19	569.17	31.22	566.29	20.81	567.68	25.79	568.34	28.19	569.17	31.22	0.00	0.00	0.00	0.00
Reach 1	14794	564.81	23.85	566.44	31.81	567.18	35.47	568.13	40	564.81	23.85	566.44	31.81	567.18	35.47	568.13	40	0.00	0.00	0.00	0.00
Reach 1	14628	562.57	23.25	564.02	29.96	564.67	32.96	565.42	37.24	562.57	23.25	564.02	29.96	564.67	32.96	565.42	37.24	0.00	0.00	0.00	0.00
Reach 1	14471	560.92	28.16	563.1	42.59	563.46	44.95	564.12	54.36	560.92	28.16	563.10	42.59	563.46	44.95	564.12	54.36	0.00	0.00	0.00	0.00
Reach 1	14363	559.62	26.54	562.87	64.54	563.11	73.39	563.75	109.41	559.62	26.54	562.87	64.54	563.11	73.39	563.75	109.41	0.00	0.00	0.00	0.00
Reach 1	14298	559.38	27.14	562.78	84.73	562.96	110.7	563.59	143.14	559.38	27.14	562.78	84.73	562.96	110.7	563.59	143.14	0.00	0.00	0.00	0.00
Reach 1	14252 CUMBERLAND	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	14206	555.44	35.62	557.23	43.3	558.51	48.71	560.23	55.93	555.44	35.62	557.23	43.30	558.51	48.71	560.23	55.93	0.00	0.00	0.00	0.00

		ESD Revised Pre-Project - Existing Land Use								ESD Proposed Channel Improvements - Existing Land Use								Change in WS Elev from Pre-Project			
Reach	**River Sta**	**2-year**		**10-year**		**25-year**		**100-year**		**2-year**		**10-year**		**25-year**		**100-year**		**2-year**	**10-year**	**25-year**	**100-year**
		WS Elev	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**				
		(ft)	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**
Reach 1	14096	554.29	38.79	556.25	50.68	557.45	58	559.14	68.46	554.29	38.79	556.25	50.68	557.45	58.01	559.14	68.46	0.00	0.00	0.00	0.00
Reach 1	13965	553.13	36.28	555.2	46.79	556.45	53.08	558.17	61.87	553.13	36.28	555.20	46.78	556.45	53.09	558.17	61.87	0.00	0.00	0.00	0.00
Reach 1	13818	551.89	33.54	554	41.91	555.26	46.81	556.98	70.93	551.89	33.54	554.00	41.90	555.26	46.82	556.98	70.93	0.00	0.00	0.00	0.00
Reach 1	13624	550.22	31.47	552.38	40.07	553.65	45.03	555.52	111.69	550.22	31.47	552.37	40.06	553.65	45.03	555.52	111.69	0.00	-0.01	0.00	0.00
Reach 1	13539	548.93	25.88	550.93	32.43	552.07	36.18	554.01	42.69	548.93	25.89	550.93	32.43	552.07	36.19	554.01	42.69	0.00	0.00	0.00	0.00
Reach 1	13477	548.37	27.86	550.27	32.49	551.33	35.08	553.2	55.51	548.37	27.86	550.27	32.49	551.33	35.08	553.2	55.51	0.00	0.00	0.00	0.00
Reach 1	13462 PEDESTRIAN BRID	Bridge	0	Bridge	0	Bridge	0	Bridge	0	Bridge		Bridge		Bridge		Bridge					
Reach 1	13447	547.8	27.11	549.54	32.97	550.48	36.29	551.76	41.03	547.81	27.11	549.53	32.97	550.48	36.29	551.76	41.03	0.01	-0.01	0.00	0.00
Reach 1	13393	547.45	36.39	549.25	47.2	550.25	53.07	551.65	63.58	547.45	36.39	549.25	47.20	550.25	53.07	551.65	63.58	0.00	0.00	0.00	0.00
Reach 1	13268	546.33	35.27	548.11	47.42	549.05	53.99	550.37	64.32	546.33	35.27	548.10	47.42	549.05	54	550.37	64.32	0.00	-0.01	0.00	0.00
Reach 1	13058	545.13	33.05	546.46	77.02	546.95	79.83	547.68	107.08	545.13	33.05	546.46	77.02	546.95	79.83	547.68	107.08	0.00	0.00	0.00	0.00
Reach 1	13056 LOW WATER CROSS	Inl Struct	0	Inl Struct	0	Inl Struct	0	Inl Struct	0	Inl Struct		Inl Struct		Inl Struct		Inl Struct					
Reach 1	12945	543.21	30.18	545.06	42.29	545.52	57.4	546.73	119.19	543.21	30.18	545.06	42.22	545.52	57.41	546.73	119.19	0.00	0.00	0.00	0.00
Reach 1	12812	540.99	25.1	542.72	34.29	544.19	147.75	545.21	223.59	540.99	25.1	542.72	34.29	544.19	147.82	545.21	223.59	0.00	0.00	0.00	0.00
Culvert Split	12685	538.18	20	539.88	20	540.9	0	542.26	0	538.18	20	539.88	20.00	540.9		542.26		0.00	0.00	0.00	0.00
Culvert Split	12636	537.54	20	539.24	20	540.05	0	541.52	0	537.54	20	539.24	20.00	540.05		541.52		0.00	0.00	0.00	0.00
Culvert Split	12587.1	536.91	20	538.61	20	539.67	0	541.19	0	536.91	20	538.61	20.00	539.67		541.19		0.00	0.00	0.00	0.00
Culvert Split	12538.2	536.27	20	537.97	20	539.29	0	540.86	0	536.27	20	537.97	20.00	539.29		540.86		0.00	0.00	0.00	0.00
Culvert Split	12489.3	535.63	20	537.33	20	538.91	0	540.53	0	535.63	20	537.33	20.00	538.91		540.53		0.00	0.00	0.00	0.00
Culvert Split	12440.4	534.99	20	537.07	0	538.53	0	540.2	0	534.99	20	537.07		538.53		540.2		0.00	0.00	0.00	0.00
Culvert Split	12391.5	534.36	20	536.74	0	538.15	0	539.88	0	534.36	20	536.74		538.15		539.88		0.00	0.00	0.00	0.00
Culvert Split	12342.6	533.96	20	536.42	0	537.77	0	539.55	0	533.96	20	536.42		537.77		539.55		0.00	0.00	0.00	0.00
Culvert Split	12293.7	534.17	20	536.09	0	537.39	0	539.22	0	534.17	20	536.09		537.39		539.22		0.00	0.00	0.00	0.00
Culvert Split	12244.8	534.25	20	535.77	0	537.01	0	538.89	0	534.25	20	535.77		537.01		538.89		0.00	0.00	0.00	0.00
Culvert Split	12195.9	534.23	0	535.45	0	536.63	0	538.56	0	534.23		535.45		536.63		538.56		0.00	0.00	0.00	0.00
Culvert Split	12147	534.04	0	534.71	0	535.77	0	537.82	0	534.04		534.71		535.77		537.82		0.00	0.00	0.00	0.00
Reach 2	12685	541	0.43	542.15	61.29	543.2	173.63	543.96	275.38	541	0.43	542.15	61.29	543.2	173.63	543.96	275.38	0.00	0.00	0.00	0.00
Reach 2	12636.0*	540.71	125.51	541.8	214.19	542.78	366.46	543.67	410.15	540.71	125.51	541.80	214.19	542.78	366.46	543.67	410.15	0.00	0.00	0.00	0.00
Reach 2	12587.1*	540.01	36.64	541.21	102.91	542.3	255.65	543.25	290.16	540.01	36.64	541.21	102.91	542.3	255.65	543.25	290.16	0.00	0.00	0.00	0.00
Reach 2	12538.2*	539.29	0.47	540.6	69.89	541.72	228.15	542.87	296.28	539.29	0.47	540.60	69.89	541.72	228.15	542.87	296.28	0.00	0.00	0.00	0.00
Reach 2	12489.3*	538.69	0.43	539.56	60.84	540.7	88.61	542.18	260.11	538.69	0.43	539.56	60.84	540.7	88.61	542.18	260.11	0.00	0.00	0.00	0.00
Reach 2	12440.4*	537.97	3.64	539.04	80.01	540.3	100.68	541.55	184.82	537.97	3.64	539.04	80.01	540.3	100.68	541.55	184.82	0.00	0.00	0.00	0.00
Reach 2	12391.5*	537.97	3.18	538.86	95.37	540.2	190.28	541.49	293.8	537.97	3.18	538.86	95.37	540.2	190.28	541.49	293.8	0.00	0.00	0.00	0.00
Reach 2	12342.6*	537.75	0.48	538.71	126.49	540.12	252.99	541.4	346.41	537.75	0.48	538.71	126.49	540.12	252.99	541.4	346.41	0.00	0.00	0.00	0.00
Reach 2	12293.7*	536.75	0.39	538.52	66.52	539.96	209.31	541.21	267.85	536.75	0.39	538.52	66.52	539.96	209.31	541.21	267.85	0.00	0.00	0.00	0.00
Reach 2	12244.8*	536.59	2.78	538.39	94.92	539.77	201.43	540.85	282.9	536.59	2.77	538.39	94.92	539.77	201.43	540.85	282.9	0.00	0.00	0.00	0.00
Reach 2	12195.9*	536.59	16.8	538.36	103.05	539.64	186.5	540.56	298.03	536.59	16.77	538.36	103.05	539.64	186.5	540.56	298.03	0.00	0.00	0.00	0.00
Reach 2	12147	536.59	18.5	538.34	142.66	539.53	223.3	540.41	278.18	536.59	18.47	538.34	142.66	539.53	223.3	540.41	278.18	0.00	0.00	0.00	0.00
Reach 3	12071	532.85	21.19	534.76	28.38	535.84	32.87	538.13	239.12	532.85	21.19	534.76	28.38	535.84	32.87	538.13	239.12	0.00	0.00	0.00	0.00
Reach 3	11925	530.56	25.31	532.44	30.96	533.34	43.07	534.42	61.27	530.56	25.29	532.43	30.93	533.33	42.95	534.41	61.2	0.00	-0.01	-0.01	-0.01
Reach 3	11657	526.98	31.79	528.44	42.76	529.35	53.16	530.54	69.28	526.96	31.7	528.44	42.72	529.34	53.09	530.53	69.21	-0.02	0.00	-0.01	-0.01
Reach 3	11444	524.68	42.82	526.92	55.3	528.38	63.38	529.61	70.47	524.68	42.82	526.92	55.30	528.38	63.38	529.61	70.47	0.00	0.00	0.00	0.00
Reach 3	11338	523.94	38.86	526.43	59.12	528.03	74.46	529.25	116.45	523.94	38.86	526.43	59.12	528.03	74.46	529.25	116.45	0.00	0.00	0.00	0.00
Reach 3	11211	523.75	41.94	526.18	74.37	527.84	126.62	529.07	169	523.75	41.94	526.18	74.37	527.84	126.62	529.07	169	0.00	0.00	0.00	0.00
Reach 3	11160 LIVE OAK	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	11110	522.53	28.14	524.14	41.25	525.05	50.19	526.39	101.72	522.53	28.14	524.14	41.25	525.05	50.19	526.39	101.72	0.00	0.00	0.00	0.00
Reach 3	11001	520.93	43.47	522.64	54.32	523.54	60.1	524.79	68.36	520.69	41.94	522.53	53.59	523.46	59.59	524.75	68.07	-0.24	-0.11	-0.08	-0.04
Reach 3	10809	519.71	81.29	521.77	122.49	522.76	131.01	524.08	140.6	519.53	74.29	521.70	121.86	522.72	130.74	524.07	140.54	-0.18	-0.07	-0.04	-0.01
Reach 3	10618	517.28	26.3	519.56	78.56	520.49	100.07	521.53	119.26	516.92	25.14	519.31	71.63	520.33	96.68	521.41	117.36	-0.36	-0.25	-0.16	-0.12
Reach 3	10559	517.25	39.75	519.64	106.28	520.57	146.81	521.63	181.93	516.82	38.16	519.38	98.30	520.42	139.75	521.51	178.65	-0.43	-0.26	-0.15	-0.12
Reach 3	10530 JOHANNA	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	10502	516.34	32.88	518.65	88.72	519.99	150.19	521.43	191.11	515.94	30.75	518.22	50.28	519.73	138.98	521.28	187.3	-0.40	-0.43	-0.26	-0.15
Reach 3	10412	513.72	23.05	516.66	54.05	517.61	87.22	519.03	113.92	513.26	21.71	516.66	53.80	517.52	84.87	518.92	112.03	-0.46	0.00	-0.09	-0.11
Reach 3	10284	513.35	33.64	516.85	72.99	517.8	107.55	518.67	122.22	513.35	33.61	516.83	72.41	517.74	106.61	518.53	117.4	0.00	-0.02	-0.06	-0.14
Reach 3	10203	513.16	39.4	516.73	49.88	517.65	107.81	518.43	144.41	513.15	38.96	516.73	49.76	517.61	105.03	518.3	135.47	-0.01	0.00	-0.04	-0.13
Reach 3	10171 MARY	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	10139	510.45	32.84	513.06	53.14	514.11	70	515.51	88.76	510.39	32.54	513.03	52.26	514.08	69.59	515.5	88.5	-0.06	-0.03	-0.03	-0.01
Reach 3	10067	509.87	36.23	512.8	72.36	513.91	94.47	515.25	111.4	509.75	35.29	512.72	70.59	513.85	93.63	515.21	110.91	-0.12	-0.08	-0.06	-0.04
Reach 3	9925	509.21	39.66	512.39	76.34	513.46	95.31	514.66	113.28	509.13	39.4	512.33	75.44	513.42	94.63	514.63	112.97	-0.08	-0.06	-0.04	-0.03
Reach 3	9840	508.58	34.13	511.89	83.93	512.92	102.47	513.78	161.92	508.49	33.86	511.82	83.70	512.86	100.54	513.76	160.11	-0.09	-0.07	-0.06	-0.02
Reach 3	9807 ANNIE	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	9774	507.55	30.82	509.7	45.94	510.77	60.67	512.28	147.57	507.43	30.28	509.60	44.82	510.69	59.2	512.21	143.73	-0.12	-0.10	-0.08	-0.07
Reach 3	9673	506.8	44.2	508.93	53.65	510.04	58.54	511.66	119.04	506.7	43.77	508.86	53.33	509.98	58.25	511.6	116.46	-0.10	-0.07	-0.06	-0.06

		ESD Revised Pre-Project - Existing Land Use								ESD Proposed Channel Improvements - Existing Land Use								Change in WS Elev from Pre-Project			
Reach	River Sta	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 3	9537	506.36	46.06	508.33	55.17	509.37	60.1	510.95	99.24	506.32	45.86	508.30	55.06	509.35	60.02	510.95	98.77	-0.04	-0.03	-0.02	0.00
Reach 3	9348	505.9	59.82	507.69	91.15	508.69	105.32	510.36	176.36	505.89	59.59	507.69	91.11	508.69	105.28	510.36	176.14	-0.01	0.00	0.00	0.00
Reach 3	9156	505.15	48.49	506.2	131.79	506.58	149.35	507.26	171.95	505.14	48.21	506.20	131.86	506.58	149.35	507.26	171.94	-0.01	0.00	0.00	0.00
Reach 3	9081	505.16	158.18	506.31	224.96	506.81	254.23	507.71	299.31	505.15	157.76	506.31	225.10	506.81	254.3	507.71	299.39	-0.01	0.00	0.00	0.00
Reach 3	9052 MONROE	Bridge	0	Bridge	0	Bridge	0	Bridge	0	Bridge		Bridge		Bridge		Bridge					
Reach 3	9024	501.66	39.28	504.14	126.02	505.25	180.76	506.71	277.05	501.65	39.13	504.14	125.95	505.25	180.92	506.71	277.3	-0.01	0.00	0.00	0.00
Reach 3	8942	499.93	30.35	501.92	44.47	502.97	69.75	504	122.24	499.92	30.31	501.92	44.42	502.97	69.81	504	122.28	-0.01	0.00	0.00	0.00
Reach 3	8857	498.11	34.52	500.69	64.3	501.77	129.9	503.28	210.99	498.08	34.38	500.68	64.14	501.76	129.42	503.28	210.81	-0.03	-0.01	-0.01	0.00
Reach 3	8764	497.9	47.75	500.5	94.28	501.62	139.95	503.06	175.14	497.84	47.49	500.48	93.72	501.6	139.52	503.05	174.53	-0.06	-0.02	-0.02	-0.01
Reach 3	8722 ELIZABETH	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	8679	496.54	34.83	498.35	47.74	499.25	55.24	501.32	122.94	496.52	34.72	498.33	47.60	499.24	55.14	501.32	122.9	-0.02	-0.02	-0.01	0.00
Reach 3	8591	494.86	35.44	497	45.15	497.74	48.36	498.83	53.51	494.75	34.94	496.92	44.84	497.67	48.04	498.76	53.15	-0.11	-0.08	-0.07	-0.07
Reach 3	8373	492.76	44.61	494.44	61.51	495.65	90.94	496.97	114.96	492.71	44.3	494.43	61.41	495.65	90.95	496.97	114.99	-0.05	-0.01	0.00	0.00
Reach 3	8244	490.2	41.84	493.05	59.47	494.88	68.17	496.12	115.14	490.19	41.76	493.04	59.45	494.88	68.17	496.12	115.16	-0.01	-0.01	0.00	0.00
Reach 3	8022	488.67	43.53	492.51	64.6	494.53	94.31	495.67	112.54	488.65	43.44	492.51	64.55	494.52	94.29	495.67	112.55	-0.02	0.00	-0.01	0.00
Reach 3	7832	488.02	38.03	492.14	70.57	494.33	197.68	495.47	221.08	488	37.95	492.13	69.48	494.33	197.64	495.47	221.09	-0.02	-0.01	0.00	0.00
Reach 3	7780	488.06	41.95	492.16	82.03	494.34	240.75	495.48	294.39	488.04	41.91	492.16	81.98	494.34	240.68	495.48	294.4	-0.02	0.00	0.00	0.00
Reach 3	7742 SOUTH FIRST STR	Bridge	0	Bridge	0	Bridge	0	Bridge	0	Bridge		Bridge		Bridge		Bridge					
Reach 3	7704	484.89	34.49	486.76	46.3	487.71	52.53	489.11	63.74	484.87	34.4	486.74	46.19	487.71	52.54	489.11	63.74	-0.02	-0.02	0.00	0.00
Reach 3	7609	482.53	45.15	483.94	60.5	484.65	70.33	485.66	90.69	482.52	45.07	483.93	60.49	484.65	70.36	485.66	90.72	-0.01	-0.01	0.00	0.00
Reach 3	7393	479.44	48.6	480.85	60.72	481.62	67.53	482.76	77.96	479.42	48.48	480.85	60.71	481.62	67.55	482.76	77.97	-0.02	0.00	0.00	0.00
Reach 3	7126	464.85	49.55	467.06	57.12	467.9	60.03	469.48	65.25	464.83	49.5	467.05	57.08	467.89	60.01	469.47	65.23	-0.02	-0.01	-0.01	-0.01
Reach 3	6915	463.1	42.64	464.98	49.75	465.73	52.55	467.22	58.39	463.09	42.59	464.97	49.71	465.72	52.53	467.22	58.36	-0.01	-0.01	-0.01	0.00
Reach 3	6735	461.98	100.22	464.3	116.21	465.2	122.19	466.95	135.08	461.96	100.11	464.29	116.13	465.19	122.14	466.94	135.02	-0.02	-0.01	-0.01	-0.01
Reach 3	6568	460.93	55.31	463.19	67.36	464.03	71.97	465.64	81.55	460.92	55.23	463.17	67.30	464.02	71.94	465.63	81.51	-0.01	-0.02	-0.01	-0.01
Reach 3	6418	459.95	54.91	461.97	67.72	462.75	72.34	464.3	81.64	459.94	54.82	461.96	67.65	462.75	72.3	464.29	81.61	-0.01	-0.01	0.00	-0.01
Reach 3	6253	457.93	49.66	459.42	60.81	459.88	64.53	460.72	71.83	457.92	49.58	459.41	60.75	459.88	64.51	460.72	71.79	-0.01	-0.01	0.00	0.00
Reach 3	6124	457.19	88.8	458.68	115.16	459.15	117.94	460.05	121.87	457.17	88.43	458.67	115.05	459.14	117.92	460.04	121.85	-0.02	-0.01	-0.01	-0.01
Reach 3	5916	454.94	72.6	456.51	134.42	457.11	145.18	458.27	160.48	454.93	72.21	456.50	134.25	457.1	145.1	458.27	160.42	-0.01	-0.01	-0.01	0.00
Reach 3	5717	454.14	122.8	455.9	171.39	456.56	178.2	457.79	188.89	454.13	121.97	455.90	171.29	456.55	178.14	457.78	188.85	-0.01	0.00	-0.01	-0.01
Reach 3	5591	453.23	95.5	454.92	123.43	455.56	132.45	456.77	148.71	453.22	95.26	454.91	123.29	455.56	132.38	456.77	148.65	-0.01	-0.01	0.00	0.00
Reach 3	5415	452.49	102.05	454.2	115.21	454.85	125.22	456.11	146.76	452.48	102	454.19	115.07	454.85	125.14	456.1	146.66	-0.01	-0.01	0.00	-0.01
Reach 3	5247	451.93	117.05	453.64	153.24	454.33	165.84	455.63	189.12	451.92	116.78	453.63	153.05	454.32	165.75	455.63	189.02	-0.01	-0.01	-0.01	0.00
Reach 3	5129	451.41	124.96	453.32	151.69	454.04	162.8	455.38	183	451.4	124.76	453.31	151.52	454.04	162.72	455.38	182.92	-0.01	-0.01	0.00	0.00
Reach 3	4941	450.84	88.36	452.87	109.34	453.61	123.45	455	155.01	450.83	88.23	452.85	109.20	453.6	123.32	455	154.88	-0.01	-0.02	-0.01	0.00
Reach 3	4822	450.23	57.67	452.03	66.3	452.66	69.09	453.83	79.74	450.22	57.6	452.02	66.26	452.66	69.07	453.83	79.66	-0.01	-0.01	0.00	0.00
Reach 3	4781	449.86	52.31	451.45	59.72	451.98	62.33	452.92	67.74	449.85	52.24	451.44	59.68	451.98	62.31	452.92	67.68	-0.01	-0.01	0.00	0.00
Reach 3	4735	449.72	59.47	451.31	70	451.86	73.42	452.84	79.82	449.7	59.4	451.31	69.95	451.85	73.4	452.84	79.79	-0.02	0.00	-0.01	0.00
Reach 3	4655	449.67	85.77	451.33	99.45	451.9	105.42	452.96	121.58	449.65	85.67	451.32	99.38	451.9	105.36	452.95	121.51	-0.02	-0.01	0.00	-0.01
Reach 3	4625	449.4	76.09	451	209.15	451.54	217.34	452.53	239.07	449.39	75.96	450.99	209.05	451.54	217.28	452.52	238.96	-0.01	-0.01	0.00	-0.01
Reach 3	4608	449.09	68.39	450.6	227.5	451.11	245.91	451.99	255.07	449.08	68.28	450.59	226.99	451.11	245.87	451.99	255.03	-0.01	-0.01	0.00	0.00
Reach 3	4593	448.83	67.27	450.35	207.92	450.86	227.34	451.72	235.63	448.82	67.14	450.35	207.42	450.86	227.31	451.72	235.59	-0.01	0.00	0.00	0.00
Reach 3	4571	448.71	75.68	450.3	183.55	450.84	286.8	451.75	325.83	448.7	75.56	450.30	182.87	450.83	286.76	451.75	325.63	-0.01	0.00	-0.01	0.00
Reach 3	4545	448.65	91.91	450.31	168.86	450.87	266.98	451.84	344.51	448.64	91.81	450.30	167.66	450.86	266.77	451.83	344.45	-0.01	-0.01	-0.01	-0.01
Reach 3	4477	447.35	84.08	449.93	117.93	450.47	138.51	451.34	175.75	447.35	84.06	449.92	117.66	450.47	138.39	451.34	175.57	0.00	-0.01	0.00	0.00
Reach 3	4476	Lat Struct	0	Lat Struct	0	Lat Struct	0	Lat Struct	0	Lat Struct		Lat Struct		Lat Struct		Lat Struct					
Reach 3	4415	447.28	88.08	450.1	109.14	450.69	113.45	451.67	141.25	447.27	87.99	450.09	109.08	450.68	113.42	451.66	140.98	-0.01	-0.01	-0.01	-0.01
Reach 3	4220	447.01	72.14	449.98	82.06	450.54	83.9	451.47	86.93	447	72.09	449.97	82.03	450.54	83.89	451.47	86.91	-0.01	-0.01	0.00	0.00
Reach 3	4022	446.7	48.13	449.74	63.06	450.25	65.58	451.04	84.15	446.69	48.06	449.73	63.03	450.24	65.57	451.04	83.97	-0.01	-0.01	-0.01	0.00
Reach 3	3855	446.58	43.77	449.65	88.91	450.16	92.06	450.96	97.96	446.57	43.71	449.65	88.89	450.16	92.04	450.96	97.94	-0.01	0.00	0.00	0.00
Reach 3	3817 SOUTH FIRST STR	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	3779	445.29	29.15	448.07	81.48	448.33	89.5	448.8	125.16	445.28	29.14	448.07	81.48	448.33	89.5	448.8	124.91	-0.01	0.00	0.00	0.00
Reach 3	3778	Lat Struct	0	Lat Struct	0	Lat Struct	0	Lat Struct	0	Lat Struct		Lat Struct		Lat Struct		Lat Struct					
Reach 3	3631	444.45	48.06	445.97	55.57	446.78	59.63	448.52	68.63	444.44	48	445.96	55.51	446.77	59.6	448.51	68.56	-0.01	-0.01	-0.01	-0.01
Reach 3	3454	444.2	57.5	445.68	62.99	446.56	66.36	448.41	73.41	444.19	57.46	445.67	62.94	446.55	66.33	448.39	73.37	-0.01	-0.01	-0.01	-0.02
Reach 3	3231	442.74	49.37	445.2	123.53	446.29	127.06	448.3	133.56	442.73	47.75	445.18	123.47	446.29	127.04	448.29	133.52	-0.01	-0.02	0.00	-0.01
Reach 3	2977	442.22	47.53	444.86	68.03	446.02	76.38	448.09	90.9	442.21	47.39	444.84	67.89	446.02	76.33	448.08	90.81	-0.01	-0.02	0.00	-0.01
Reach 3	2773	441.71	72.24	444.7	123.68	445.93	128.11	448.05	135.99	441.69	71.74	444.67	123.61	445.92	128.08	448.04	135.94	-0.02	-0.03	-0.01	-0.01
Reach 3	2707	441.72	115.48	444.7	166.2	445.93	184.32	448.04	210.91	441.7	115.06	444.68	165.89	445.92	184.19	448.03	210.74	-0.02	-0.02	-0.01	-0.01
Reach 3	2629	441.54	60.06	444.42	100.75	445.63	121.47	447.71	188.54	441.52	59.77	444.40	100.42	445.62	121.34	447.7	188.18	-0.02	-0.02	-0.01	-0.01
Reach 3	2539 CONGRESS AVENUE	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	2447	441.1	30.37	443	34.94	443.49	36.1	444.31	38	441.08	30.33	442.98	34.89	443.48	36.09	444.3	37.99	-0.02	-0.02	-0.01	-0.01
Reach 3	2362	440.4	30.56	442.24	35.44	442.73	36.78	443.49	38.92	440.39	30.52	442.22	35.39	442.72	36.76	443.49	38.9	-0.01	-0.02	-0.01	0.00

		ESD Revised Pre-Project - Existing Land Use								ESD Proposed Channel Improvements - Existing Land Use								Change in WS Elev from Pre-Project			
Reach	**River Sta**	**2-year**		**10-year**		**25-year**		**100-year**		**2-year**		**10-year**		**25-year**		**100-year**		**2-year**	**10-year**	**25-year**	**100-year**
		WS Elev	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**	**WS Elev**	**Top Width**				
		(ft)	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**	**(ft)**
Reach 3	2257	439.41	29.58	441.41	34.69	441.94	36.06	442.73	38.08	439.4	29.54	441.39	34.64	441.93	36.04	442.72	38.06	-0.01	-0.02	-0.01	-0.01
Reach 3	2001	437.66	30.36	439.81	57.12	440.55	81.28	441.4	96.59	437.64	30.32	439.79	55.84	440.54	81.03	441.4	96.45	-0.02	-0.02	-0.01	0.00
Reach 3	1823	436.85	32.4	439.03	38.78	439.9	297.71	440.77	306.54	436.83	32.37	439.00	38.70	439.89	292.42	440.77	306.51	-0.02	-0.03	-0.01	0.00
Reach 3	1534	435.97	46.5	438.34	52.3	439.33	54.68	440.29	57	435.96	46.44	438.31	52.22	439.31	54.64	440.29	56.98	-0.01	-0.03	-0.02	0.00
Reach 3	1327	433.42	27.57	437.18	40.91	438.39	45.39	439.48	49.44	433.39	27.48	437.14	40.77	438.37	45.32	439.47	49.4	-0.03	-0.04	-0.02	-0.01
Reach 3	1116	433.08	33.96	435.97	0	437.03	40.38	438.22	42.31	433.06	33.93	435.94		437.01	40.35	438.21	42.3	-0.02	-0.03	-0.02	-0.01
Reach 3	1036 RIVERSIDE	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	956	432.33	51.74	434.19	54.88	434.8	55.18	435.41	55.49	432.32	51.71	434.17	54.87	434.79	55.18	435.41	55.49	-0.01	-0.02	-0.01	0.00
Reach 3	682	431.74	62.33	433.57	66.8	434.18	68.3	434.81	69.84	431.72	62.3	433.55	66.76	434.17	68.27	434.81	69.83	-0.02	-0.02	-0.01	0.00

Reach	River Sta	ESD Revised Pre-Project - Ultimate Land Use								ESD Proposed Channel Improvements - Ultimate Land Use								Change in WS Elev from Pre-Project			
		2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 1	19568	654.44	108.86	654.73	129.39	654.87	138.83	655.08	152.57	654.44	108.86	654.73	129.39	654.87	138.83	655.08	152.57	0	0	0	0
Reach 1	19532	653.47	104.79	653.75	123.12	653.89	132.2	654.1	144.77	653.47	104.79	653.75	123.12	653.89	132.2	654.1	144.77	0	0	0	0
Reach 1	19488	651.72	85.42	652.07	111.23	652.24	121.09	652.48	131.96	651.72	85.42	652.07	111.23	652.24	121.09	652.48	131.96	0	0	0	0
Reach 1	19445	650.17	76.74	650.57	115.44	650.75	130.35	651.04	159.96	650.17	76.74	650.57	115.44	650.75	130.35	651.04	159.96	0	0	0	0
Reach 1	19401	648.13	75.56	648.47	97.2	648.64	109	648.86	122.13	648.13	75.56	648.47	97.20	648.64	109	648.86	122.13	0	0	0	0
Reach 1	19334	642.94	180.03	643.28	196.37	643.44	201.69	643.68	210.34	642.94	180.03	643.28	196.37	643.44	201.69	643.68	210.34	0	0	0	0
Reach 1	19312 FORT MCGRUDER	Inl Struct	0	Inl Struct	0	Inl Struct	0	Inl Struct	0	Inl Struct		Inl Struct		Inl Struct		Inl Struct					
Reach 1	19291	639.39	37.54	639.94	48.13	640.19	52.56	640.54	63.29	639.39	37.54	639.94	48.13	640.19	52.56	640.54	63.29	0	0	0	0
Reach 1	19219	635.94	25.45	636.65	34.89	636.98	40.64	637.4	49.56	635.94	25.45	636.65	34.89	636.98	40.64	637.4	49.56	0	0	0	0
Reach 1	19146	634.29	24.08	635.04	32.23	635.39	36.54	635.85	42.49	634.29	24.08	635.04	32.23	635.39	36.54	635.85	42.49	0	0	0	0
Reach 1	19001	629.42	24.46	630.1	30.65	630.41	33.5	630.91	38.44	629.42	24.46	630.10	30.65	630.41	33.5	630.91	38.44	0	0	0	0
Reach 1	18835	625.67	25.47	626.38	33.47	626.71	37.41	627.17	43.06	625.67	25.47	626.38	33.47	626.71	37.41	627.17	43.06	0	0	0	0
Reach 1	18655	619.69	32.44	620.33	38.92	620.56	41.37	620.9	45.38	619.69	32.44	620.33	38.92	620.56	41.37	620.9	45.38	0	0	0	0
Reach 1	18497	617.59	31.68	618.59	49.66	618.99	56.39	619.5	64.43	617.59	31.68	618.59	49.66	618.99	56.39	619.5	64.43	0	0	0	0
Reach 1	18372	616.69	34.28	617.85	49.15	618.31	55.01	618.89	64.75	616.69	34.28	617.85	49.15	618.31	55.01	618.89	64.75	0	0	0	0
Reach 1	18235	616.68	97.59	617.83	122.53	618.28	136.27	618.86	167.17	616.68	97.59	617.83	122.53	618.28	136.27	618.86	167.17	0	0	0	0
Reach 1	18206	616.68	145.66	617.83	173.44	618.28	187.35	618.86	217.25	616.68	145.66	617.83	173.44	618.28	187.35	618.86	217.25	0	0	0	0
Reach 1	18167	616.61	224.83	617.7	269.19	618.1	290.65	618.61	317.15	616.61	224.83	617.70	269.19	618.1	290.65	618.61	317.15	0	0	0	0
Reach 1	18096	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	18025	613.74	185.48	614.42	316.96	614.71	324.32	615.17	365.39	613.74	185.48	614.42	316.96	614.71	324.32	615.17	365.39	0	0	0	0
Reach 1	17964	613.76	472.28	614.44	529.03	614.74	536.09	615.21	548.98	613.76	472.28	614.44	529.03	614.74	536.09	615.21	548.98	0	0	0	0
Reach 1	17923	613.76	510.43	614.44	528.84	614.74	537.53	615.21	550.75	613.76	510.43	614.44	528.84	614.74	537.53	615.21	550.75	0	0	0	0
Reach 1	17827	613.76	506.6	614.44	529.39	614.74	538.64	615.21	552.11	613.76	506.6	614.44	529.39	614.74	538.64	615.21	552.11	0	0	0	0
Reach 1	17814 DETENTION BASIN	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	17796	608.1	20.25	609.47	23.27	609.84	24.07	610.22	26.46	608.1	20.25	609.47	23.27	609.84	24.07	610.22	26.46	0	0	0	0
Reach 1	17781	607.92	20.69	609.41	27.07	609.79	32.27	610.16	42.7	607.92	20.69	609.41	27.07	609.79	32.27	610.16	42.7	0	0	0	0
Reach 1	17771	608	23.37	609.47	44.99	609.87	68.07	610.28	116.9	608	23.37	609.47	44.99	609.87	68.07	610.28	116.9	0	0	0	0
Reach 1	17744 ALPINE	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	17716	607.22	19.96	608.26	33.08	608.75	41.25	609.35	107.68	607.22	19.96	608.26	33.08	608.75	41.25	609.35	107.68	0	0	0	0
Reach 1	17646	604.82	26.71	605.84	34.23	606.26	36.26	606.78	46.45	604.82	26.71	605.84	34.23	606.26	36.26	606.78	46.45	0	0	0	0
Reach 1	17501	602.44	21.39	603.47	29.2	603.86	32.25	604.45	40.1	602.44	21.39	603.47	29.20	603.86	32.25	604.45	40.1	0	0	0	0
Reach 1	17305	599.72	53.78	601.14	82.54	601.77	114.89	602.4	150.13	599.72	53.78	601.14	82.54	601.77	114.89	602.4	150.13	0	0	0	0
Reach 1	17192	598.17	20.98	599.56	33.39	600.18	55.35	601.12	138.17	598.17	20.98	599.56	33.39	600.18	55.35	601.12	138.17	0	0	0	0
Reach 1	17106	596.87	24.15	599.02	98.2	599.26	107.98	599.83	126.27	596.87	24.15	599.02	98.20	599.26	107.98	599.83	126.27	0	0	0	0
Reach 1	17070 LIGHTSEY	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	17034	594.16	12.99	596.01	23.87	596.77	28.08	597.68	33.65	594.16	12.99	596.01	23.87	596.77	28.08	597.68	33.65	0	0	0	0
Reach 1	17014	592.94	16.67	594.43	18.6	595.23	19.63	596.27	20.75	592.94	16.67	594.43	18.60	595.23	19.63	596.27	20.75	0	0	0	0
Reach 1	17010	591.9	15	593.85	17.46	594.82	18.66	596.07	20.39	591.9	15	593.85	17.46	594.82	18.66	596.07	20.39	0	0	0	0
Reach 1	16967	591.44	15.26	593.24	17.87	594.12	19.15	595.33	24.21	591.44	15.26	593.24	17.87	594.12	19.15	595.33	24.21	0	0	0	0
Reach 1	16797	588.95	18.42	590.75	23.47	591.59	25.78	592.62	28.59	588.95	18.42	590.75	23.47	591.59	25.78	592.62	28.59	0	0	0	0
Reach 1	16639	587.66	22.3	589.39	27.94	590.02	29.99	590.74	32.32	587.66	22.3	589.39	27.94	590.02	29.99	590.74	32.32	0	0	0	0
Reach 1	16447	585.34	23.65	586.82	43.05	587.48	53.29	588.34	66.06	585.34	23.65	586.82	43.05	587.48	53.29	588.34	66.06	0	0	0	0
Reach 1	16323	583.55	27.66	585.22	38.52	585.98	43.77	586.79	51.49	583.55	27.66	585.22	38.52	585.98	43.77	586.79	51.49	0	0	0	0
Reach 1	16124	582.1	32.95	584.15	50.58	585.08	70.57	586.04	105.86	582.1	32.95	584.15	50.58	585.08	70.57	586.04	105.86	0	0	0	0
Reach 1	16056	581.28	22.97	583.46	33.12	584.39	63.77	585.37	121.51	581.28	22.97	583.46	33.12	584.39	63.77	585.37	121.51	0	0	0	0
Reach 1	16030 HAVANA	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	16003	580.66	17.56	582.29	25.26	583.02	29.66	583.84	35.84	580.66	17.56	582.29	25.26	583.02	29.66	583.84	35.84	0	0	0	0
Reach 1	15893	578.22	25.81	579.71	33.43	580.41	36.89	581.3	41.37	578.22	25.81	579.71	33.43	580.41	36.89	581.3	41.37	0	0	0	0
Reach 1	15734	576.62	25.87	578.14	32.76	578.81	35.75	579.64	39.48	576.62	25.87	578.14	32.76	578.81	35.75	579.64	39.48	0	0	0	0
Reach 1	15547	574.59	26.66	575.94	35.43	576.56	39.49	577.34	44.57	574.59	26.66	575.94	35.43	576.56	39.49	577.34	44.57	0	0	0	0
Reach 1	15330	572.19	29.63	573.84	40.19	574.72	46	575.69	60.83	572.19	29.63	573.84	40.19	574.72	46	575.69	60.83	0	0	0	0
Reach 1	15107	569.28	19.6	571.21	25.01	572.47	32.8	573.13	47.21	569.28	19.6	571.21	25.01	572.47	32.8	573.13	47.21	0	0	0	0
Reach 1	15022	568.45	30.15	571.09	46.39	572.46	74.64	573.24	97.53	568.45	30.15	571.09	46.39	572.46	74.64	573.24	97.53	0	0	0	0
Reach 1	14950	568.15	25.63	570.87	38.21	572.23	64.03	572.98	106.66	568.15	25.63	570.87	38.21	572.23	64.03	572.98	106.66	0	0	0	0
Reach 1	14918 EL PASO	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	14885	566.29	20.81	567.68	25.79	568.34	28.19	569.17	31.22	566.29	20.81	567.68	25.79	568.34	28.19	569.17	31.22	0	0	0	0
Reach 1	14794	564.81	23.85	566.44	31.81	567.18	35.47	568.13	40	564.81	23.85	566.44	31.81	567.18	35.47	568.13	40	0	0	0	0
Reach 1	14628	562.57	23.25	564.02	29.96	564.67	32.96	565.42	37.24	562.57	23.25	564.02	29.96	564.67	32.96	565.42	37.24	0	0	0	0
Reach 1	14471	560.92	28.16	563.1	42.59	563.46	44.95	564.12	54.36	560.92	28.16	563.10	42.59	563.46	44.95	564.12	54.36	0	0	0	0
Reach 1	14363	559.62	26.54	562.87	64.54	563.11	73.39	563.75	109.41	559.62	26.54	562.87	64.54	563.11	73.39	563.75	109.41	0	0	0	0
Reach 1	14298	559.38	27.14	562.78	84.73	562.96	110.7	563.59	143.14	559.38	27.14	562.78	84.73	562.96	110.7	563.59	143.14	0	0	0	0
Reach 1	14252 CUMBERLAND	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 1	14206	555.44	35.62	557.23	43.3	558.51	48.71	560.23	55.93	555.44	35.62	557.23	43.30	558.51	48.71	560.23	55.93	0	0	0	0

		ESD Revised Pre-Project - Ultimate Land Use								ESD Proposed Channel Improvements - Ultimate Land Use								Change in WS Elev from Pre-Project			
Reach	River Sta	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 1	14096	554.29	38.79	556.25	50.68	557.45	58	559.14	68.46	554.29	38.79	556.25	50.68	557.45	58	559.14	68.46	0	0	0	0
Reach 1	13965	553.13	36.28	555.2	46.79	556.45	53.08	558.17	61.87	553.13	36.28	555.20	46.79	556.45	53.08	558.17	61.87	0	0	0	0
Reach 1	13818	551.89	33.54	554	41.91	555.26	46.81	556.98	70.93	551.89	33.54	554.00	41.91	555.26	46.81	556.98	70.93	0	0	0	0
Reach 1	13624	550.22	31.47	552.38	40.07	553.65	45.03	555.52	111.69	550.22	31.47	552.38	40.07	553.65	45.03	555.52	111.69	0	0	0	0
Reach 1	13539	548.93	25.88	550.93	32.43	552.07	36.18	554.01	42.69	548.93	25.88	550.93	32.43	552.07	36.18	554.01	42.69	0	0	0	0
Reach 1	13477	548.37	27.86	550.27	32.49	551.33	35.08	553.2	55.51	548.37	27.86	550.27	32.49	551.33	35.08	553.2	55.51	0	0	0	0
Reach 1	13462 PEDESTRIAN BRID	Bridge	0	Bridge	0	Bridge	0	Bridge	0	Bridge		Bridge		Bridge		Bridge					
Reach 1	13447	547.8	27.11	549.54	32.97	550.48	36.29	551.76	41.03	547.8	27.11	549.54	32.97	550.48	36.29	551.76	41.03	0	0	0	0
Reach 1	13393	547.45	36.39	549.25	47.2	550.25	53.07	551.65	63.58	547.45	36.39	549.25	47.20	550.25	53.07	551.65	63.58	0	0	0	0
Reach 1	13268	546.33	35.27	548.11	47.42	549.05	53.99	550.37	64.32	546.33	35.27	548.11	47.42	549.05	53.99	550.37	64.32	0	0	0	0
Reach 1	13058	545.13	33.05	546.46	77.02	546.95	79.83	547.68	107.08	545.13	33.05	546.46	77.02	546.95	79.83	547.68	107.08	0	0	0	0
Reach 1	13056 LOW WATER CROSS	Inl Struct	0	Inl Struct	0	Inl Struct	0	Inl Struct	0	Inl Struct		Inl Struct		Inl Struct		Inl Struct					
Reach 1	12945	543.21	30.18	545.06	42.29	545.52	57.4	546.73	119.19	543.21	30.18	545.06	42.29	545.52	57.4	546.73	119.19	0	0	0	0
Reach 1	12812	540.99	25.1	542.72	34.29	544.19	147.75	545.21	223.59	540.99	25.1	542.72	34.29	544.19	147.75	545.21	223.59	0	0	0	0
Culvert Split	12685	538.18	20	539.88	20	540.9	0	542.26	0	538.18	20	539.88	20.00	540.9		542.26		0	0	0	0
Culvert Split	12636	537.54	20	539.24	20	540.05	0	541.52	0	537.54	20	539.24	20.00	540.05		541.52		0	0	0	0
Culvert Split	12587.1	536.91	20	538.61	20	539.67	0	541.19	0	536.91	20	538.61	20.00	539.67		541.19		0	0	0	0
Culvert Split	12538.2	536.27	20	537.97	20	539.29	0	540.86	0	536.27	20	537.97	20.00	539.29		540.86		0	0	0	0
Culvert Split	12489.3	535.63	20	537.33	20	538.91	0	540.53	0	535.63	20	537.33	20.00	538.91		540.53		0	0	0	0
Culvert Split	12440.4	534.99	20	537.07	0	538.53	0	540.2	0	534.99	20	537.07		538.53		540.2		0	0	0	0
Culvert Split	12391.5	534.36	20	536.74	0	538.15	0	539.88	0	534.36	20	536.74		538.15		539.88		0	0	0	0
Culvert Split	12342.6	533.96	20	536.42	0	537.77	0	539.55	0	533.96	20	536.42		537.77		539.55		0	0	0	0
Culvert Split	12293.7	534.17	20	536.09	0	537.39	0	539.22	0	534.17	20	536.09		537.39		539.22		0	0	0	0
Culvert Split	12244.8	534.25	20	535.77	0	537.01	0	538.89	0	534.25	20	535.77		537.01		538.89		0	0	0	0
Culvert Split	12195.9	534.23	0	535.45	0	536.63	0	538.56	0	534.23		535.45		536.63		538.56		0	0	0	0
Culvert Split	12147	534.04	0	534.71	0	535.77	0	537.82	0	534.04		534.71		535.77		537.82		0	0	0	0
Reach 2	12685	541	0.43	542.15	61.3	543.2	173.63	543.96	275.38	541	0.43	542.15	61.29	543.2	173.63	543.96	275.38	0	0	0	0
Reach 2	12636.0*	540.71	125.51	541.8	214.21	542.78	366.46	543.67	410.15	540.71	125.51	541.80	214.18	542.78	366.46	543.67	410.15	0	0	0	0
Reach 2	12587.1*	540.01	36.64	541.21	102.92	542.3	255.65	543.25	290.16	540.01	36.64	541.21	102.91	542.3	255.65	543.25	290.16	0	0	0	0
Reach 2	12538.2*	539.29	0.47	540.6	69.91	541.72	228.15	542.87	296.28	539.29	0.47	540.60	69.90	541.72	228.15	542.87	296.28	0	0	0	0
Reach 2	12489.3*	538.69	0.43	539.56	60.85	540.7	88.61	542.18	260.11	538.69	0.43	539.56	60.83	540.7	88.61	542.18	260.11	0	0	0	0
Reach 2	12440.4*	537.97	3.64	539.04	80.01	540.3	100.68	541.55	184.82	537.97	3.64	539.04	80.01	540.3	100.68	541.55	184.82	0	0	0	0
Reach 2	12391.5*	537.97	3.18	538.86	95.4	540.2	190.28	541.49	293.8	537.97	3.18	538.86	95.37	540.2	190.28	541.49	293.8	0	0	0	0
Reach 2	12342.6*	537.75	0.48	538.71	126.5	540.12	252.99	541.4	346.41	537.75	0.48	538.71	126.49	540.12	252.99	541.4	346.41	0	0	0	0
Reach 2	12293.7*	536.75	0.39	538.52	66.56	539.96	209.31	541.21	267.85	536.75	0.39	538.52	66.53	539.96	209.31	541.21	267.85	0	0	0	0
Reach 2	12244.8*	536.59	2.78	538.39	94.93	539.77	201.43	540.85	282.9	536.59	2.77	538.39	94.92	539.77	201.43	540.85	282.9	0	0	0	0
Reach 2	12195.9*	536.59	16.8	538.36	103.06	539.64	186.5	540.56	298.03	536.59	16.77	538.36	103.05	539.64	186.5	540.56	298.03	0	0	0	0
Reach 2	12147	536.59	18.5	538.34	142.66	539.53	223.3	540.41	278.18	536.59	18.47	538.34	142.66	539.53	223.3	540.41	278.18	0	0	0	0
Reach 3	12071	532.85	21.19	534.76	28.38	535.84	32.87	538.13	239.12	532.85	21.19	534.76	28.38	535.84	32.87	538.13	239.12	0	0	0	0
Reach 3	11925	530.56	25.31	532.44	30.97	533.34	43.07	534.42	61.27	530.56	25.29	532.43	30.94	533.33	42.95	534.41	61.2	0	-0.01	-0.01	-0.01
Reach 3	11657	526.98	31.79	528.44	42.72	529.35	53.16	530.54	69.28	526.96	31.7	528.43	42.69	529.34	53.09	530.53	69.21	-0.02	-0.01	-0.01	-0.01
Reach 3	11444	524.68	42.82	526.92	55.3	528.38	63.38	529.61	70.47	524.68	42.82	526.92	55.30	528.38	63.38	529.61	70.47	0	0	0	0
Reach 3	11338	523.94	38.86	526.43	59.12	528.03	74.46	529.25	116.45	523.94	38.86	526.43	59.12	528.03	74.46	529.25	116.45	0	0	0	0
Reach 3	11211	523.75	41.94	526.18	74.37	527.84	126.62	529.07	169	523.75	41.94	526.18	74.37	527.84	126.62	529.07	169	0	0	0	0
Reach 3	11160 LIVE OAK	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	11110	522.53	28.14	524.14	41.25	525.05	50.19	526.39	101.72	522.53	28.14	524.14	41.25	525.05	50.19	526.39	101.72	0	0	0	0
Reach 3	11001	521	43.96	522.69	54.64	523.58	60.35	524.83	68.6	520.78	42.5	522.58	53.94	523.5	59.85	524.79	68.31	-0.22	-0.11	-0.08	-0.04
Reach 3	10809	519.81	84.46	521.82	122.99	522.8	131.31	524.11	140.82	519.64	78.73	521.75	122.38	522.76	131.04	524.11	140.77	-0.17	-0.07	-0.04	0
Reach 3	10618	517.41	26.71	519.62	80.16	520.52	100.68	521.55	119.71	517.05	25.55	519.38	73.66	520.37	97.49	521.44	117.79	-0.36	-0.24	-0.15	-0.11
Reach 3	10559	517.38	40.25	519.69	108.09	520.6	147.88	521.65	182.77	516.96	38.66	519.45	100.33	520.45	141.83	521.54	179.43	-0.42	-0.24	-0.15	-0.11
Reach 3	10530 JOHANNA	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	10502	516.45	33.42	518.72	92.39	520.03	151.76	521.47	192.21	516.05	31.33	518.33	52.12	519.78	141.4	521.33	188.36	-0.4	-0.39	-0.25	-0.14
Reach 3	10412	513.84	23.43	516.73	57.35	517.68	88.76	519.06	114.45	513.4	22.1	516.73	57.28	517.56	85.99	518.95	112.61	-0.44	0	-0.12	-0.11
Reach 3	10284	513.54	34.27	516.92	76.63	517.84	108.05	518.7	123.58	513.54	34.27	516.91	75.94	517.79	107.28	518.55	117.76	0	-0.01	-0.05	-0.15
Reach 3	10203	513.36	39.98	516.8	50.08	517.68	109.82	518.46	146.72	513.36	39.59	516.80	49.98	517.66	107.84	518.33	137.38	0	0	-0.02	-0.13
Reach 3	10171 MARY	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	10139	511.39	37.3	513.14	54.34	514.14	70.63	515.55	89.56	510.54	33.26	513.10	53.75	514.13	70.38	515.54	89.3	-0.85	-0.04	-0.01	-0.01
Reach 3	10067	511.12	47.21	512.88	74.28	513.95	95.04	515.29	111.82	509.91	36.57	512.80	72.50	513.9	94.36	515.25	111.35	-1.21	-0.08	-0.05	-0.04
Reach 3	9925	510.86	55.98	512.47	77.62	513.5	95.9	514.69	113.82	509.31	39.96	512.41	76.69	513.47	95.46	514.67	113.5	-1.55	-0.06	-0.03	-0.02
Reach 3	9840	510.62	40.09	511.97	84.19	512.94	103.6	513.81	162.96	508.66	34.38	511.90	83.95	512.9	101.92	513.79	162.26	-1.96	-0.07	-0.04	-0.02
Reach 3	9807 ANNIE	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	9774	507.68	31.41	509.78	46.79	510.83	61.61	512.33	149.97	507.56	30.83	509.68	45.64	510.74	60.11	512.25	146.01	-0.12	-0.1	-0.09	-0.08
Reach 3	9673	506.94	44.8	509.01	53.98	510.1	58.78	511.71	121.44	506.84	44.38	508.93	53.65	510.03	58.49	511.65	118.74	-0.1	-0.08	-0.07	-0.06

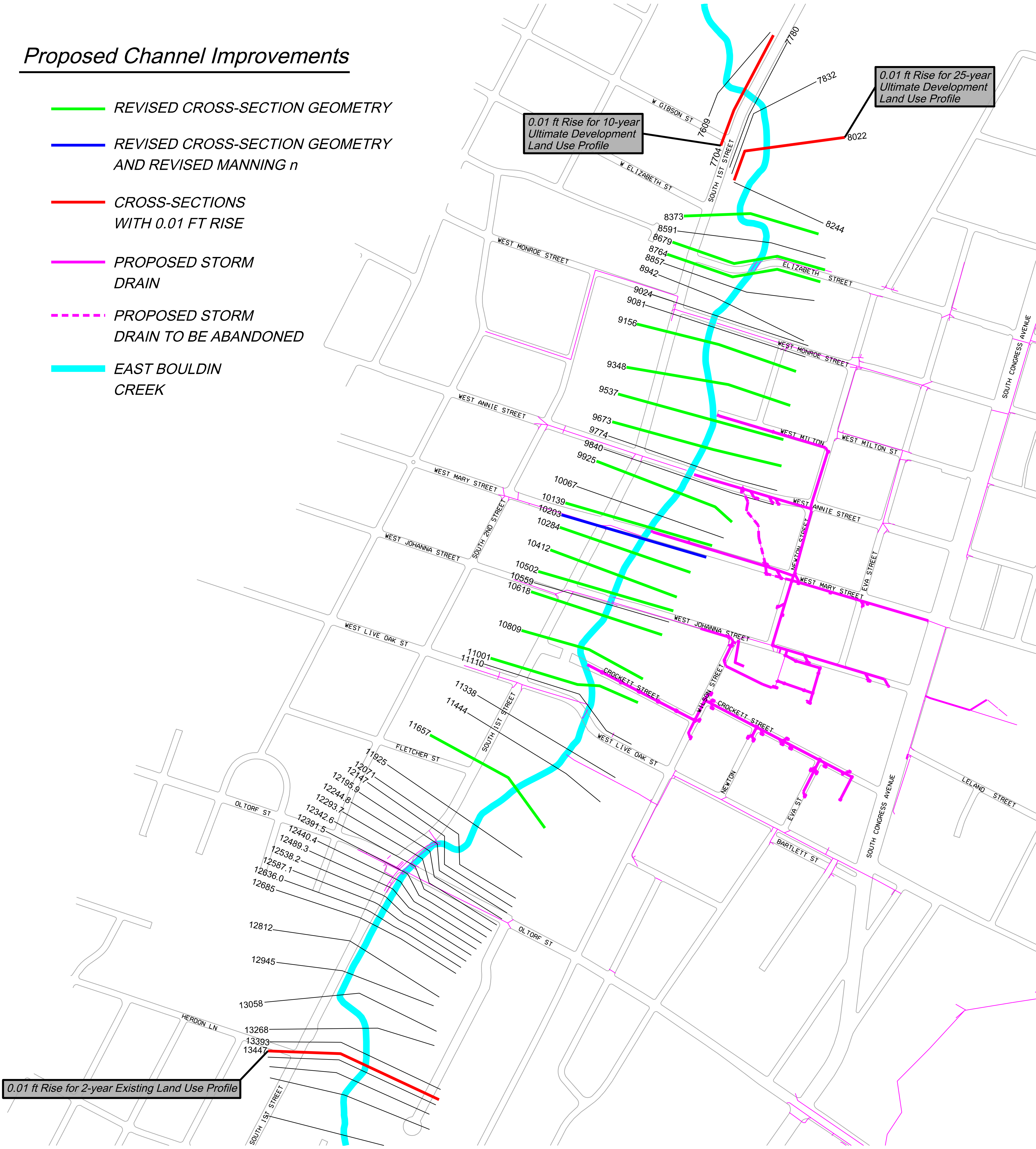
Reach	River Sta	ESD Revised Pre-Project - Ultimate Land Use								ESD Proposed Channel Improvements - Ultimate Land Use								Change in WS Elev from Pre-Project			
		2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 3	9537	506.5	46.65	508.4	55.51	509.42	60.35	511	102.18	506.45	46.45	508.37	55.39	509.4	60.27	510.99	101.6	-0.05	-0.03	-0.02	-0.01
Reach 3	9348	506.03	61.5	507.76	91.92	508.75	106.37	510.41	183.77	506.01	61.26	507.75	91.85	508.74	106.31	510.41	183.35	-0.02	-0.01	-0.01	0
Reach 3	9156	505.24	51.19	506.23	133.59	506.6	150.03	507.28	172.56	505.23	50.95	506.23	133.48	506.6	149.98	507.28	172.56	-0.01	0	0	0
Reach 3	9081	505.26	165.72	506.35	227.48	506.83	255.33	507.74	300.76	505.25	165.23	506.35	227.40	506.83	255.35	507.74	300.81	-0.01	0	0	0
Reach 3	9052 MONROE	Bridge	0	Bridge	0	Bridge	0	Bridge	0	Bridge		Bridge		Bridge		Bridge					
Reach 3	9024	501.78	40.69	504.23	129.38	505.3	183.97	506.76	281.18	501.77	40.6	504.23	129.15	505.3	184.07	506.76	281.34	-0.01	0	0	0
Reach 3	8942	500.08	30.8	502	45.63	503.01	72.01	504.02	123.32	500.07	30.75	502.00	45.54	503.01	72.04	504.02	123.31	-0.01	0	0	0
Reach 3	8857	498.31	36.65	500.78	65.32	501.83	132.8	503.32	212.74	498.27	36.24	500.76	65.11	501.82	132.3	503.31	212.29	-0.04	-0.02	-0.01	-0.01
Reach 3	8764	498.07	48.62	500.59	97.42	501.68	141.3	503.1	176.97	498.02	48.34	500.56	96.40	501.66	140.8	503.08	176.16	-0.05	-0.03	-0.02	-0.02
Reach 3	8722 ELIZABETH	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	8679	496.65	35.6	498.42	48.29	499.3	55.69	501.32	123.07	496.63	35.48	498.40	48.13	499.29	55.58	501.32	122.94	-0.02	-0.02	-0.01	0
Reach 3	8591	495.01	36.12	497.05	45.39	497.77	48.53	498.86	53.66	494.89	35.59	496.98	45.08	497.7	48.2	498.79	53.3	-0.12	-0.07	-0.07	-0.07
Reach 3	8373	492.9	45.76	494.51	62.51	495.73	92.98	497	115.41	492.84	45.21	494.50	62.42	495.73	93.03	497	115.38	-0.06	-0.01	0	0
Reach 3	8244	490.3	42.62	493.19	60.15	494.97	68.6	496.15	115.83	490.29	42.53	493.18	60.11	494.97	68.61	496.14	115.67	-0.01	-0.01	0	-0.01
Reach 3	8022	488.89	44.5	492.68	66.52	494.62	96.03	495.69	112.86	488.86	44.38	492.67	66.41	494.63	96.08	495.68	112.74	-0.03	-0.01	0.01	-0.01
Reach 3	7832	488.25	38.86	492.31	104.81	494.43	200.36	495.5	221.4	488.22	38.76	492.30	103.23	494.43	200.44	495.48	221.25	-0.03	-0.01	0	-0.02
Reach 3	7780	488.29	42.34	492.34	112.55	494.44	246.05	495.5	295.25	488.26	42.29	492.33	110.89	494.44	246.23	495.49	294.85	-0.03	-0.01	0	-0.01
Reach 3	7742 SOUTH FIRST STR	Bridge	0	Bridge	0	Bridge	0	Bridge	0	Bridge		Bridge		Bridge		Bridge					
Reach 3	7704	485.01	35.12	486.82	46.74	487.76	52.86	489.17	64.38	484.99	35.03	486.83	46.76	487.76	52.85	489.17	64.39	-0.02	0.01	0	0
Reach 3	7609	482.61	46.05	483.99	61.1	484.69	71.12	485.69	91.23	482.6	45.91	483.99	61.07	484.69	71.16	485.69	91.25	-0.01	0	0	0
Reach 3	7393	479.54	49.5	480.9	61.19	481.66	67.91	482.79	78.28	479.54	49.42	480.90	61.17	481.66	67.92	482.79	78.29	0	0	0	0
Reach 3	7126	465	50.07	467.17	57.49	467.97	60.28	469.54	65.43	464.98	50.02	467.16	57.45	467.96	60.26	469.52	65.4	-0.02	-0.01	-0.01	-0.02
Reach 3	6915	463.24	43.16	465.08	50.1	465.79	52.79	467.28	58.6	463.22	43.11	465.07	50.06	465.79	52.77	467.27	58.56	-0.02	-0.01	0	-0.01
Reach 3	6735	462.14	101.37	464.41	116.97	465.28	122.7	467.01	135.57	462.12	101.25	464.40	116.88	465.27	122.65	467	135.49	-0.02	-0.01	-0.01	-0.01
Reach 3	6568	461.1	56.19	463.29	67.95	464.1	72.37	465.7	81.87	461.08	56.09	463.28	67.88	464.09	72.33	465.69	81.82	-0.02	-0.01	-0.01	-0.01
Reach 3	6418	460.1	55.87	462.07	68.3	462.82	72.74	464.34	81.94	460.08	55.77	462.06	68.23	462.81	72.7	464.34	81.89	-0.02	-0.01	-0.01	0
Reach 3	6253	458.05	50.55	459.48	61.31	459.92	64.84	460.76	72.23	458.04	50.46	459.47	61.25	459.92	64.81	460.76	72.17	-0.01	-0.01	0	0
Reach 3	6124	457.31	92.69	458.74	116.09	459.19	118.12	460.08	122.01	457.3	92.43	458.73	116.06	459.18	118.1	460.07	121.98	-0.01	-0.01	-0.01	-0.01
Reach 3	5916	455.05	76.65	456.58	135.87	457.16	146.14	458.32	160.97	455.04	76.22	456.57	135.70	457.15	146.04	458.31	160.89	-0.01	-0.01	-0.01	-0.01
Reach 3	5717	454.27	132.07	455.99	172.25	456.61	178.8	457.83	189.23	454.26	130.77	455.98	172.15	456.61	178.74	457.82	189.18	-0.01	-0.01	0	-0.01
Reach 3	5591	453.36	97.98	455	124.6	455.62	133.2	456.82	149.3	453.34	97.75	454.99	124.47	455.61	133.12	456.81	149.2	-0.02	-0.01	-0.01	-0.01
Reach 3	5415	452.61	102.59	454.28	116.44	454.91	126.11	456.15	147.62	452.6	102.54	454.27	116.30	454.9	126.01	456.15	147.48	-0.01	-0.01	-0.01	0
Reach 3	5247	452.05	119.97	453.73	154.93	454.39	166.89	455.68	190	452.04	119.66	453.72	154.74	454.38	166.77	455.67	189.86	-0.01	-0.01	-0.01	-0.01
Reach 3	5129	451.55	127.03	453.42	153.13	454.1	163.73	455.43	183.75	451.53	126.82	453.40	152.97	454.1	163.63	455.42	183.65	-0.02	-0.02	0	-0.01
Reach 3	4941	450.99	89.71	452.96	110.49	453.67	124.97	455.05	156.08	450.98	89.57	452.95	110.36	453.67	124.8	455.05	155.91	-0.01	-0.01	0	0
Reach 3	4822	450.36	58.42	452.11	66.65	452.72	69.33	453.88	80.42	450.35	58.34	452.10	66.61	452.71	69.3	453.87	80.31	-0.01	-0.01	-0.01	-0.01
Reach 3	4781	449.98	52.9	451.52	60.07	452.03	62.55	452.95	68.24	449.96	52.84	451.51	60.03	452.02	62.52	452.95	68.16	-0.02	-0.01	-0.01	0
Reach 3	4735	449.83	60.24	451.39	70.45	451.9	73.7	452.87	80.06	449.82	60.16	451.38	70.40	451.9	73.67	452.87	80.02	-0.01	-0.01	0	0
Reach 3	4655	449.79	86.81	451.4	100.06	451.95	106.13	453	122.15	449.77	86.71	451.39	99.99	451.94	106.06	452.99	122.06	-0.02	-0.01	-0.01	-0.01
Reach 3	4625	449.51	77.47	451.07	210.02	451.59	218.2	452.56	239.99	449.5	77.33	451.06	209.91	451.58	218.11	452.56	239.84	-0.01	-0.01	-0.01	0
Reach 3	4608	449.19	69.48	450.67	231.68	451.16	246.36	452.02	255.43	449.18	69.37	450.66	231.21	451.15	246.32	452.02	255.37	-0.01	-0.01	-0.01	0
Reach 3	4593	448.92	68.41	450.42	211.58	450.9	227.72	451.75	235.92	448.91	68.31	450.41	211.22	450.9	227.68	451.75	235.88	-0.01	-0.01	0	0
Reach 3	4571	448.8	76.76	450.38	190.13	450.88	287.32	451.78	327.37	448.79	76.66	450.37	189.15	450.88	287.27	451.78	327.14	-0.01	-0.01	0	0
Reach 3	4545	448.74	92.82	450.38	198.22	450.91	270.71	451.87	345	448.73	92.73	450.37	190.06	450.91	270.26	451.86	344.92	-0.01	-0.01	0	-0.01
Reach 3	4477	447.43	84.72	450.01	120.96	450.52	140.36	451.37	177.03	447.42	84.64	449.99	120.38	450.51	140.17	451.36	176.85	-0.01	-0.02	-0.01	-0.01
Reach 3	4476	Lat Struct	0	Lat Struct	0	Lat Struct	0	Lat Struct	0	Lat Struct		Lat Struct		Lat Struct		Lat Struct					
Reach 3	4415	447.44	89.25	450.18	109.73	450.73	113.8	451.7	143.23	447.43	89.13	450.17	109.64	450.73	113.76	451.7	142.94	-0.01	-0.01	0	0
Reach 3	4220	447.18	72.71	450.05	82.31	450.58	84.05	451.5	87.03	447.16	72.65	450.04	82.27	450.58	84.03	451.5	87.01	-0.02	-0.01	0	0
Reach 3	4022	446.88	48.95	449.81	63.42	450.29	65.79	451.06	85.93	446.86	48.86	449.80	63.35	450.28	65.77	451.06	85.68	-0.02	-0.01	-0.01	0
Reach 3	3855	446.75	44.49	449.73	89.24	450.2	92.36	450.99	98.15	446.74	44.41	449.71	89.18	450.2	92.33	450.98	98.12	-0.01	-0.02	0	-0.01
Reach 3	3817 SOUTH FIRST STR	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	3779	445.42	30.31	448.11	82.42	448.36	90.44	448.82	126.08	445.41	30.2	448.10	82.14	448.35	90.33	448.81	125.62	-0.01	-0.01	-0.01	-0.01
Reach 3	3778	Lat Struct	0	Lat Struct	0	Lat Struct	0	Lat Struct	0	Lat Struct		Lat Struct		Lat Struct		Lat Struct					
Reach 3	3631	444.59	48.72	446.07	56.05	446.85	59.99	448.6	69.1	444.57	48.65	446.06	56.01	446.84	59.96	448.59	69.04	-0.02	-0.01	-0.01	-0.01
Reach 3	3454	444.33	58	445.79	63.38	446.64	66.66	448.49	73.74	444.32	57.95	445.78	63.35	446.63	66.63	448.48	73.7	-0.01	-0.01	-0.01	-0.01
Reach 3	3231	442.88	78.89	445.34	124	446.38	127.35	448.4	133.85	442.86	75.61	445.33	123.96	446.38	127.32	448.38	133.81	-0.02	-0.01	0	-0.02
Reach 3	2977	442.39	48.99	445.01	69.18	446.12	77.03	448.19	91.5	442.38	48.84	445.00	69.08	446.11	76.97	448.17	91.45	-0.01	-0.01	-0.01	-0.02
Reach 3	2773	441.91	76.66	444.86	124.28	446.02	128.46	448.15	136.36	441.89	76.22	444.85	124.23	446.01	128.42	448.13	136.31	-0.02	-0.01	-0.01	-0.02
Reach 3	2707	441.92	119.4	444.86	168.64	446.02	185.65	448.14	212.11	441.9	119.01	444.85	168.45	446.01	185.53	448.13	211.94	-0.02	-0.01	-0.01	-0.01
Reach 3	2629	441.74	63.66	444.58	103.32	445.72	123.05	447.81	191.1	441.72	63.29	444.57	103.11	445.71	122.9	447.8	190.74	-0.02	-0.01	-0.01	-0.01
Reach 3	2539 CONGRESS AVENUE	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	2447	441.25	30.72	443.09	35.14	443.53	36.21	444.35	38.09	441.23	30.69	443.07	35.10	443.53	36.19	444.34	38.07	-0.02	-0.02	0	-0.01
Reach 3	2362	440.55	30.94	442.32	35.66	442.78	36.91	443.53	39.04	440.53	30.9	442.31	35.62	442.77	36.89	443.53	39.02	-0.02	-0.01	-0.01	0

		ESD Revised Pre-Project - Ultimate Land Use								ESD Proposed Channel Improvements - Ultimate Land Use								Change in WS Elev from Pre-Project			
Reach	River Sta	2-year		10-year		25-year		100-year		2-year		10-year		25-year		100-year		2-year	10-year	25-year	100-year
		WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width	WS Elev	Top Width				
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
Reach 3	2257	439.57	29.99	441.5	34.92	441.99	36.19	442.77	38.2	439.55	29.95	441.48	34.88	441.98	36.17	442.77	38.18	-0.02	-0.02	-0.01	0
Reach 3	2001	437.82	30.72	439.92	64.4	440.62	82.62	441.48	97.87	437.8	30.68	439.90	62.81	440.61	82.41	441.47	97.78	-0.02	-0.02	-0.01	-0.01
Reach 3	1823	437	32.84	439.15	39.1	439.99	302.68	440.86	306.85	436.98	32.77	439.12	39.02	439.97	302.61	440.86	306.84	-0.02	-0.03	-0.02	0
Reach 3	1534	436.11	46.96	438.47	52.62	439.42	54.9	440.39	57.22	436.09	46.91	438.44	52.55	439.41	54.87	440.38	57.21	-0.02	-0.03	-0.01	-0.01
Reach 3	1327	433.67	28.49	437.34	41.49	438.5	45.77	439.58	49.83	433.64	28.4	437.31	41.36	438.48	45.71	439.58	49.81	-0.03	-0.03	-0.02	0
Reach 3	1116	433.29	34.3	436.11	0	437.15	40.57	438.33	42.49	433.26	34.26	436.08		437.13	40.54	438.33	42.48	-0.03	-0.03	-0.02	0
Reach 3	1036 RIVERSIDE	Culvert	0	Culvert	0	Culvert	0	Culvert	0	Culvert		Culvert		Culvert		Culvert					
Reach 3	956	432.48	52.06	434.28	54.92	434.86	55.22	435.47	55.52	432.46	52.02	434.26	54.91	434.85	55.21	435.46	55.52	-0.02	-0.02	-0.01	-0.01
Reach 3	682	431.88	62.67	433.66	67.02	434.25	68.45	434.87	69.97	431.86	62.63	433.64	66.98	434.24	68.43	434.86	69.96	-0.02	-0.02	-0.01	-0.01

Exhibit M.4

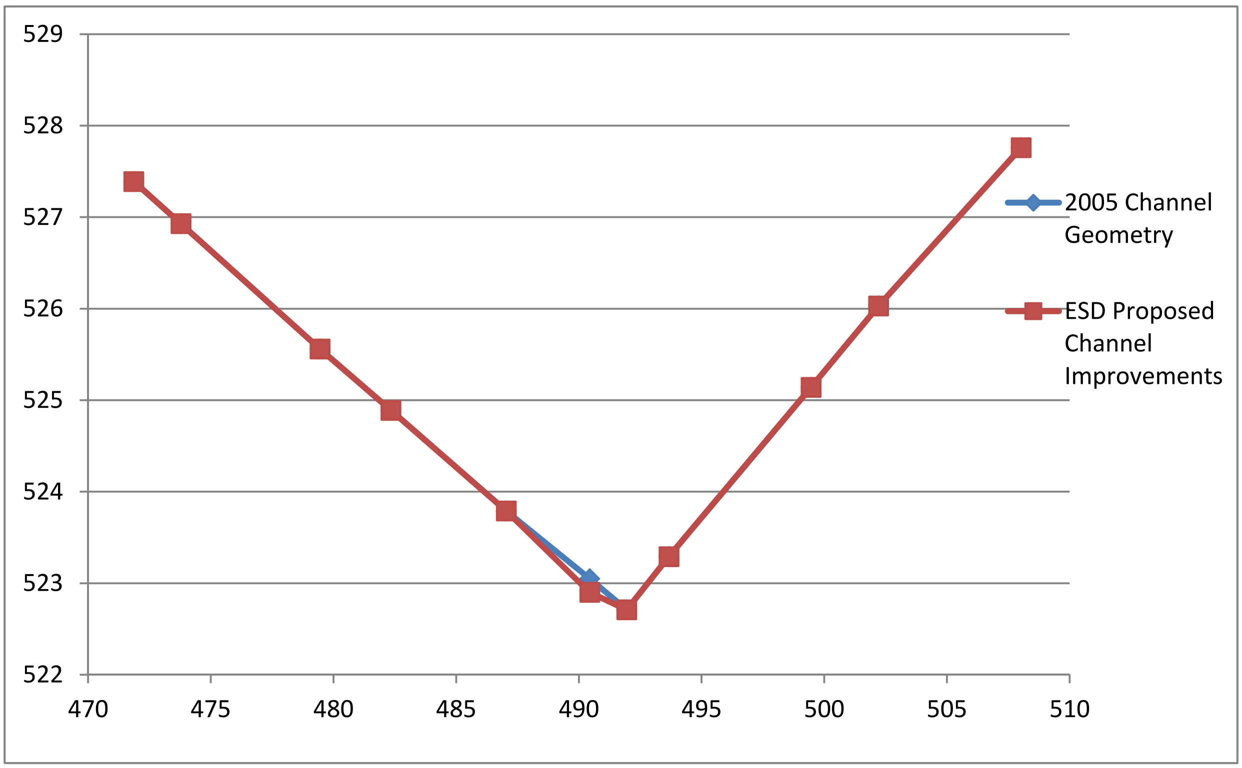
Proposed Channel Improvement

Revised Cross-Sections


Proposed Channel Improvements
REVISED CROSS-SECTION GEOMETRY
REVISED CROSS-SECTION GEOMETRY AND REVISED MANNING n
CROSS-SECTIONS WITH 0.01 FT RISE
PROPOSED STORM DRAIN
PROPOSED STORM DRAIN TO BE ABANDONED
EAST BOULDIN CREEK
0.01 ft Rise for 10-year Ultimate Development Land Use Profile
0.01 ft Rise for 25-year Ultimate Development Land Use Profile
0.01 ft Rise for 2-year Existing Land Use Profile
W GIBSON ST
W ELIZABETH ST
SOUTH 1ST STREET
WEST MONROE STREET
ELIZABETH STREET
WEST ANNIE STREET
WEST MILTON
WEST MILTON ST
WEST MARY STREET
WEST JOHANNA STREET
SOUTH 2ND STREET
NEWTON STREET
WEST LIVE OAK ST
CROCKETT STREET
EVA STREET
FLETCHER ST
OLTORF ST
NEWTON
EVA ST
BARTLETT ST
SOUTH CONGRESS AVENUE
LELAND STREET
HERDON LN
7609
7704
7780
7832
8022
8244
8373
8591
8679
8764
8857
8942
9024
9081
9156
9348
9537
9673
9774
9840
9925
10067
10139
10203
10284
10412
10502
10559
10618
10809
11001
11110
11338
11444
11657
11925
12071
12147
12195.9
12244.8
12293.7
12342.6
12391.5
12440.4
12489.3
12538.2
12587.1
12636.0
12685
12812
12945
13058
13268
13393
13447

Cross-Section = 11657

Prop Alt 1		Channel Improvements		
Station	Elevation	Station	Elevation	Elev. Change
471.86	527.39	471.86	527.39	0
473.78	526.93	473.78	526.93	0
479.45	525.56	479.45	525.56	0
482.34	524.89	482.34	524.89	0
487.04	523.79	487.04	523.79	0
490.44	523.05	490.44	522.9	-0.15
491.95	522.71	491.95	522.71	0
493.67	523.29	493.67	523.29	0
499.46	525.14	499.46	525.14	0
502.21	526.03	502.21	526.03	0
508.02	527.76	508.02	527.76	0



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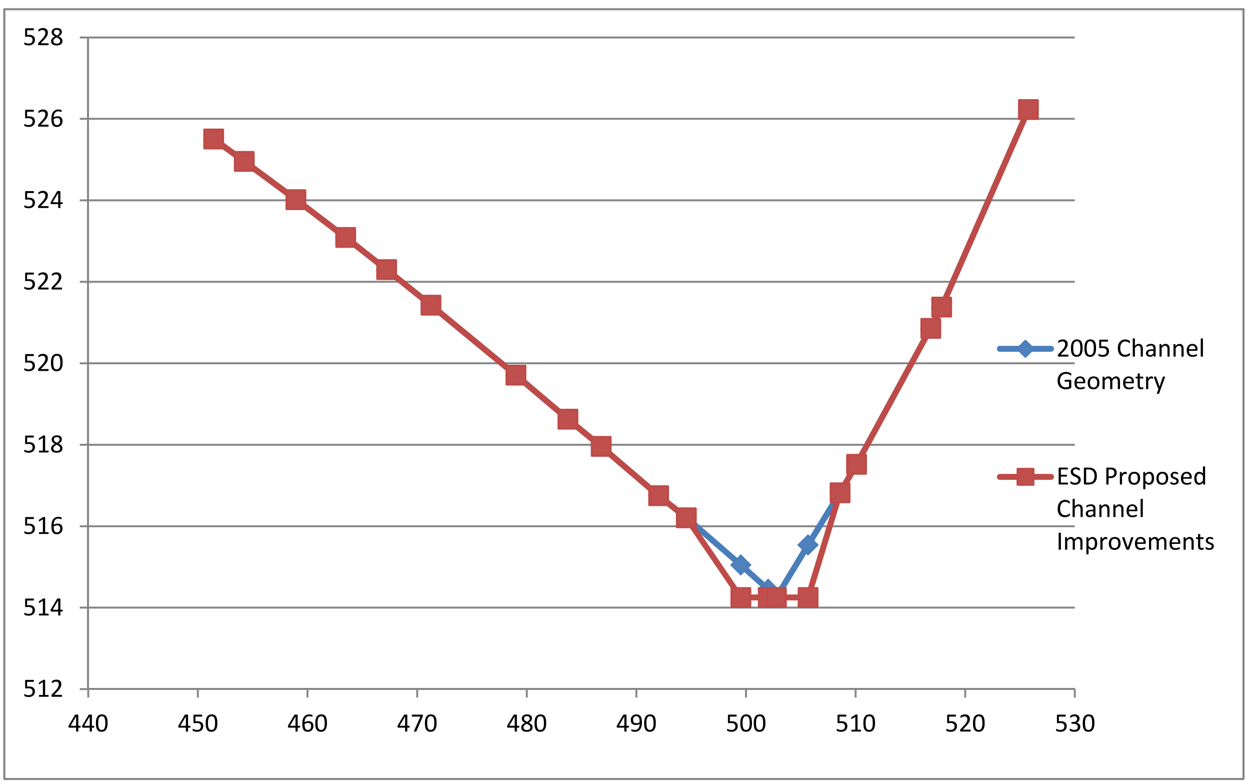
\RAS_results_revd EBLDN.xlsx

Cross-Section = 11001

Prop Alt 1		Channel Improvements		Elev. Change
Station	Elevation	Station	Elevation	
451.43	525.51	451.43	525.51	0
454.22	524.96	454.22	524.96	0
458.94	524.02	458.94	524.02	0
463.48	523.09	463.48	523.09	0
467.21	522.3	467.21	522.3	0
471.25	521.43	471.25	521.43	0
479.01	519.71	479.01	519.71	0
483.75	518.63	483.75	518.63	0
486.78	517.96	486.78	517.96	0
492.03	516.75	492.03	516.75	0
494.55	516.21	494.55	516.21	0
499.52	515.05	499.52	514.25	-0.80
502.02	514.45	502.02	514.25	-0.20
502.76	514.25	502.76	514.25	0
505.66	515.54	505.66	514.25	-1.29
508.57	516.82	508.57	516.82	0
510.08	517.52	510.08	517.52	0
516.85	520.86	516.85	520.86	0
517.85	521.38	517.85	521.38	0
525.76	526.23	525.76	526.23	0



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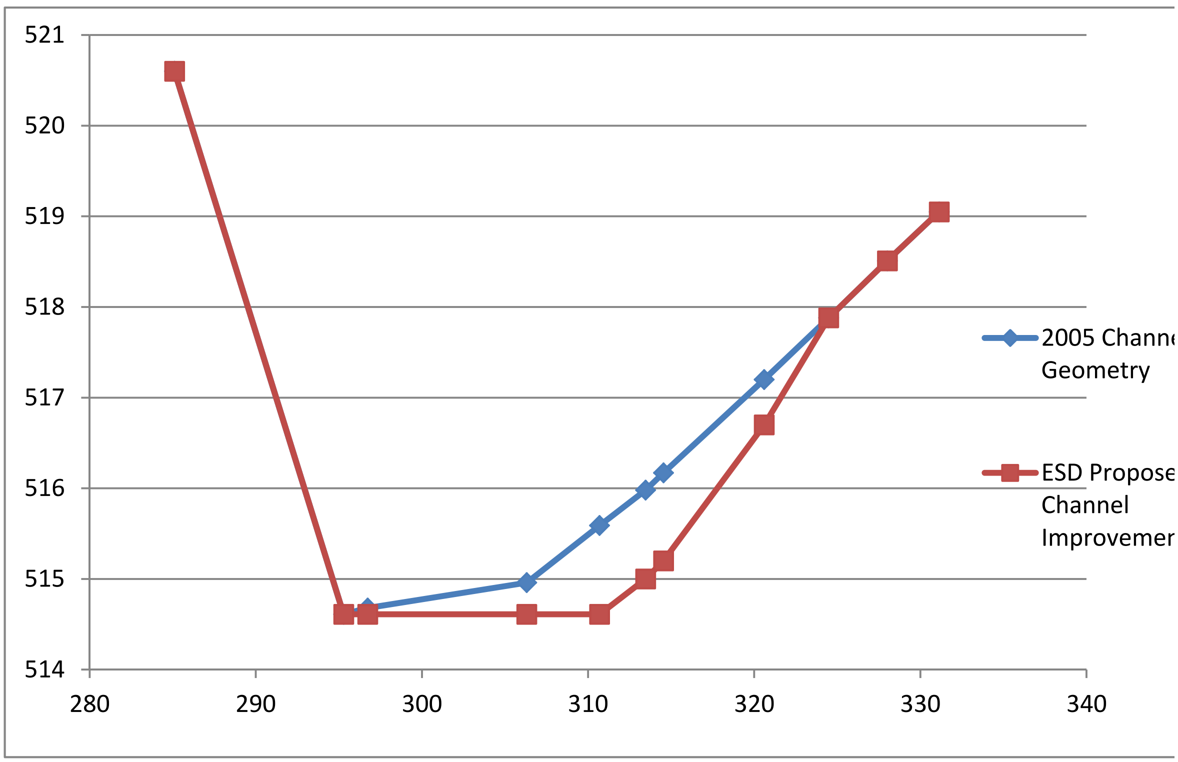
Cross-Section = 10809

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
285.11	520.6	285.11	520.6	0
295.29	514.61	295.29	514.61	0
296.74	514.68	296.74	514.61	-0.07
306.31	514.96	306.31	514.61	-0.35
310.69	515.59	310.69	514.61	-0.98
313.46	515.98	313.46	515	-0.98
314.54	516.17	314.54	515.2	-0.97
320.6	517.2	320.6	516.7	-0.5
324.48	517.88	324.48	517.88	0
328.01	518.51	328.01	518.51	0
331.13	519.05	331.13	519.05	0



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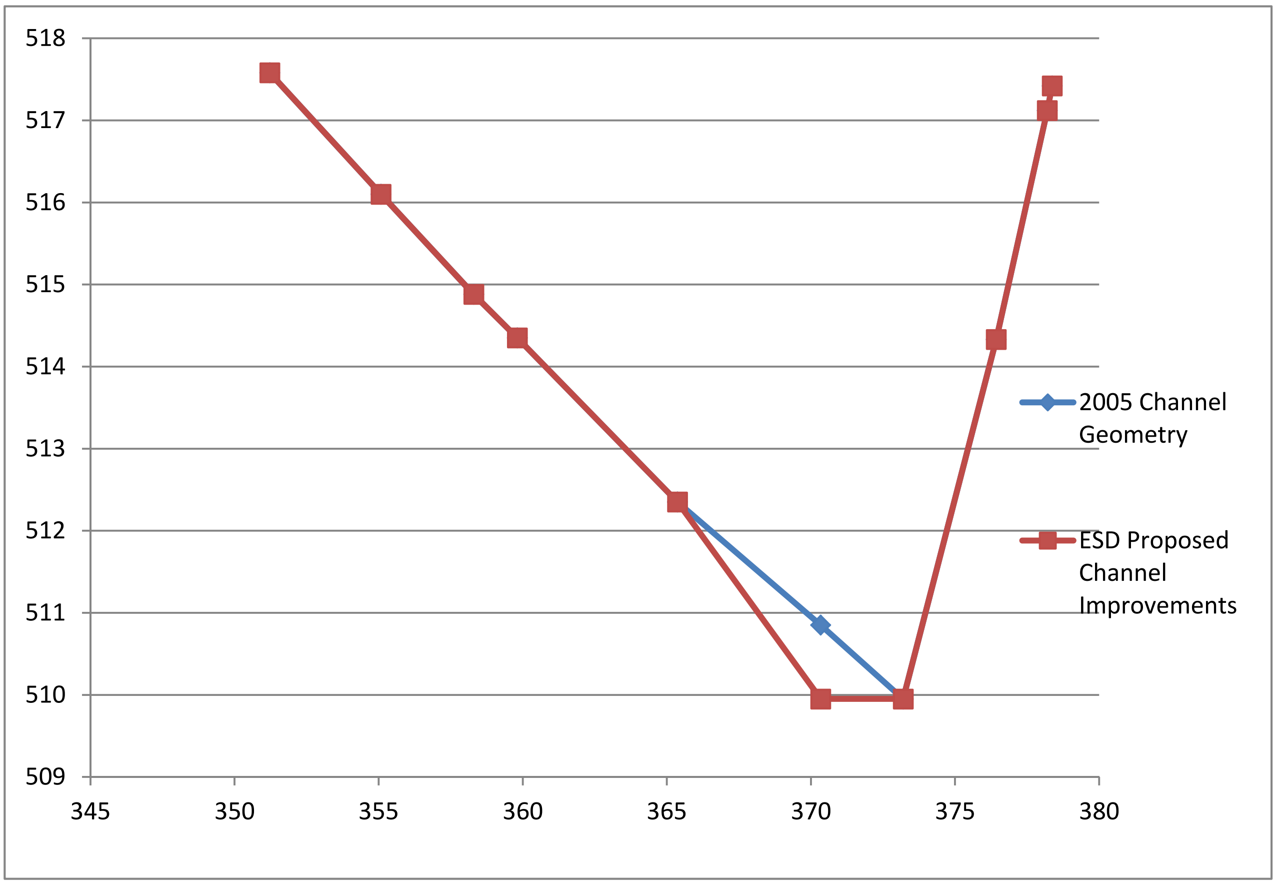
\RAS_results_revd EBLDN.xlsx

Cross-Section = 10618

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
351.22	517.58	351.22	517.58	0
355.08	516.1	355.08	516.1	0
358.3	514.88	358.3	514.88	0
359.81	514.35	359.81	514.35	0
365.37	512.35	365.37	512.35	0
370.34	510.85	370.34	509.95	-0.90
373.2	509.95	373.2	509.95	0
376.43	514.33	376.43	514.33	0
378.2	517.12	378.2	517.12	0
378.37	517.42	378.37	517.42	0



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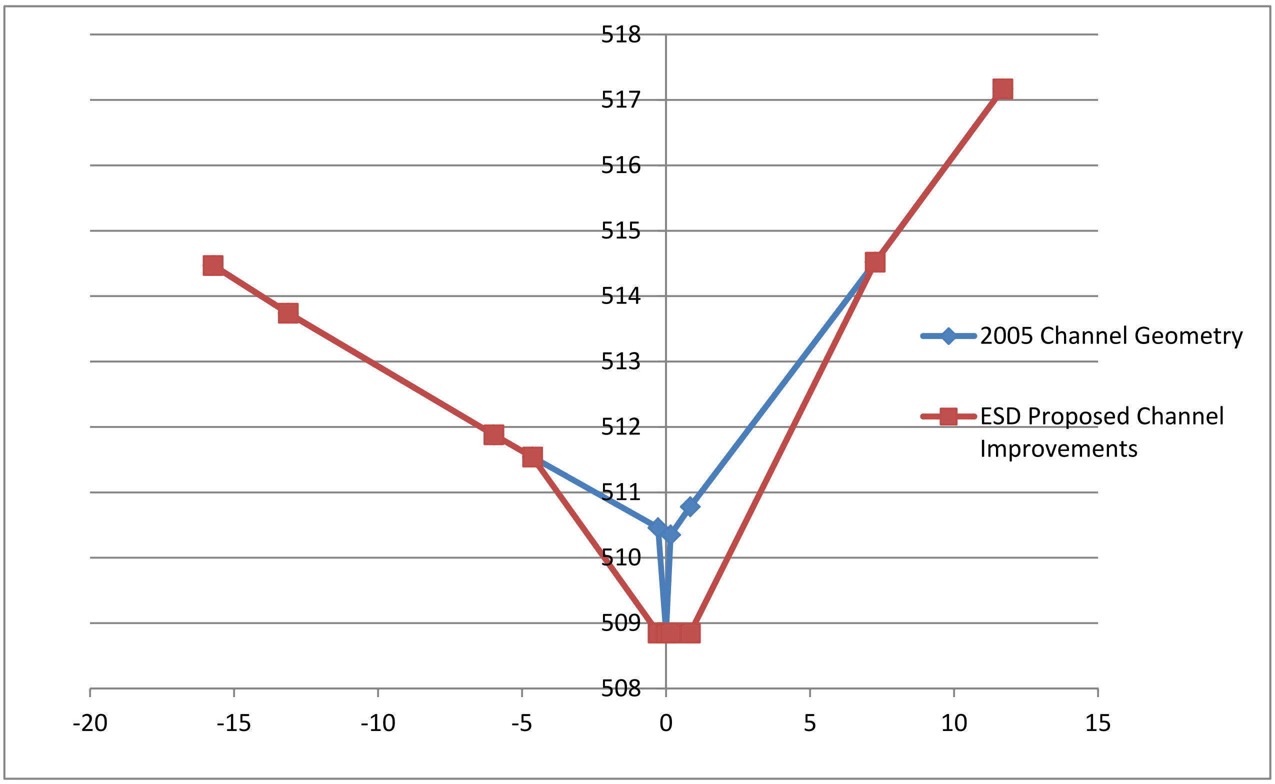
Cross-Section = 10502

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
-15.73	514.47	-15.73	514.47	0
-13.12	513.74	-13.12	513.74	0
-5.98	511.88	-5.98	511.88	0
-4.64	511.54	-4.64	511.54	0
-0.28	510.46	-0.28	508.85	-1.61
0	508.85	0	508.85	0
0.16	510.35	0.16	508.85	-1.5
0.84	510.78	0.84	508.85	-1.93
7.26	514.52	7.26	514.52	0
11.69	517.17	11.69	517.17	0



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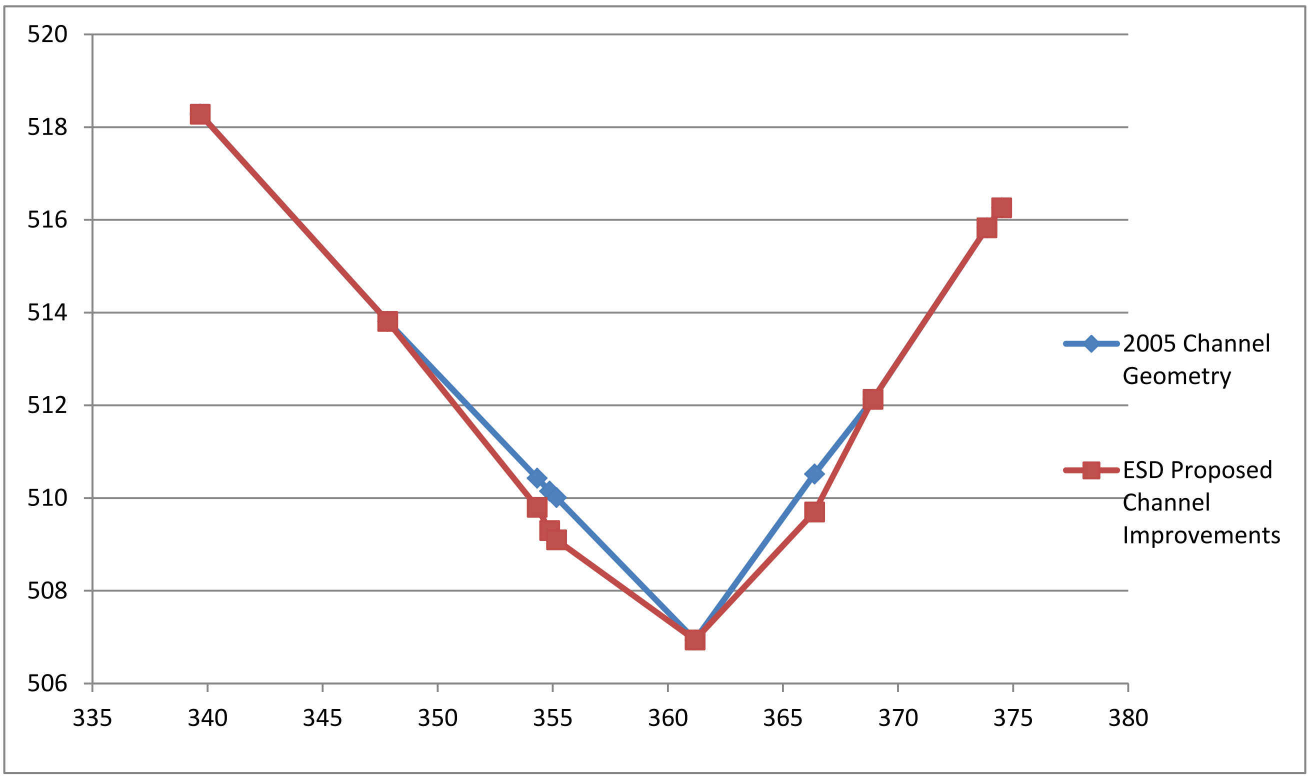
Cross-Section = 10412

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
339.68	518.28	339.68	518.28	0
347.83	513.81	347.83	513.81	0
354.32	510.43	354.32	509.8	-0.63
354.86	510.15	354.86	509.3	-0.85
355.16	510.01	355.16	509.1	-0.91
361.18	506.94	361.18	506.94	0
366.37	510.52	366.37	509.7	-0.82
368.91	512.13	368.91	512.13	0
373.86	515.83	373.86	515.83	0
374.5	516.26	374.5	516.26	0



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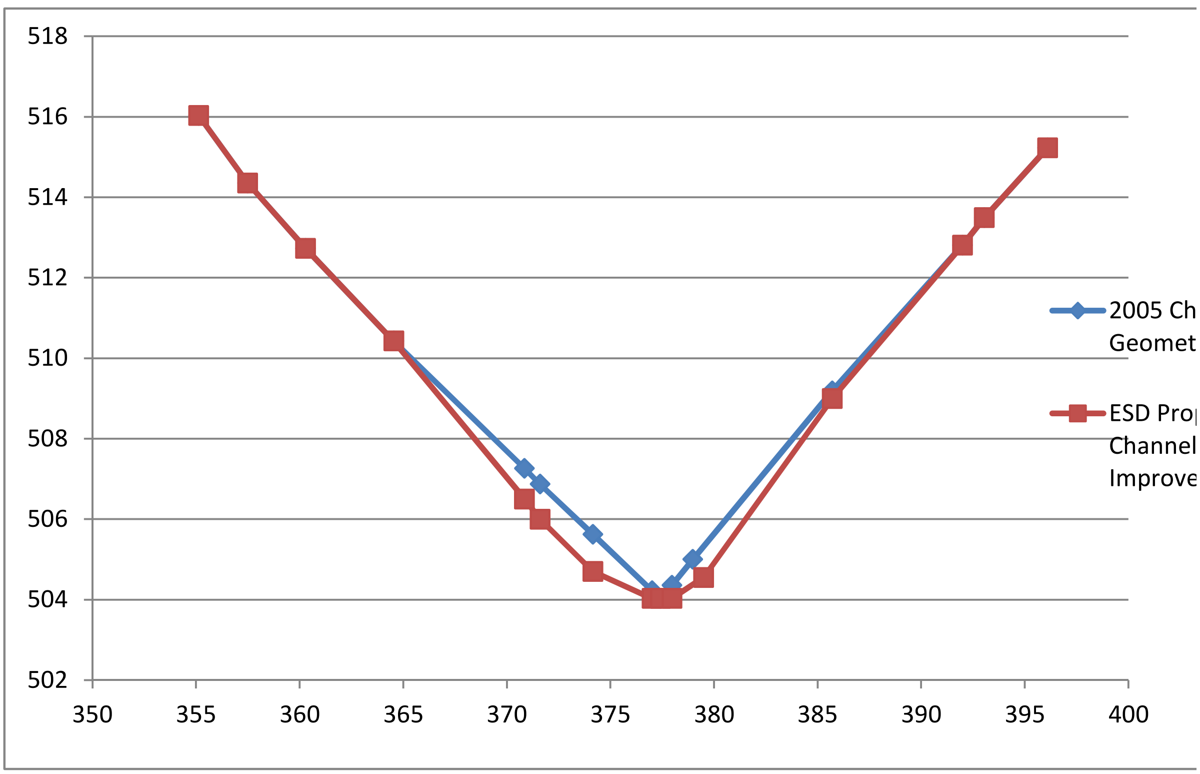
Cross-Section = 10284

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
355.13	516.03	355.13	516.03	0
357.49	514.35	357.49	514.35	0
360.28	512.73	360.28	512.73	0
364.54	510.43	364.54	510.43	0
370.85	507.26	370.85	506.5	-0.76
371.6	506.87	371.6	506	-0.87
374.16	505.62	374.16	504.7	-0.92
377.01	504.22	377.01	504.03	-0.19
377.42	504.03	377.42	504.03	0
377.97	504.36	377.97	504.03	-0.33
378.98	505	379.5	504.55	-0.45
385.71	509.19	385.71	509	-0.19
392	512.81	392	512.81	0
393.05	513.49	393.05	513.49	0
396.11	515.23	396.11	515.23	0



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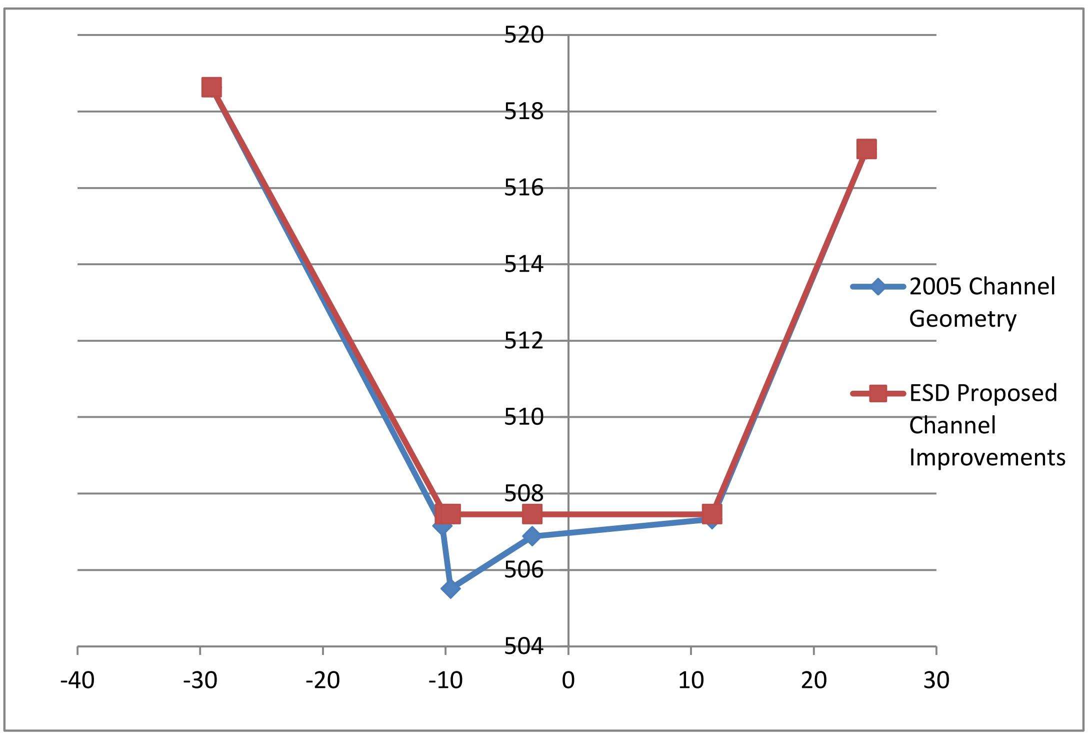
Cross-Section = 10203

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
-29.056	518.63	-29.056	518.63	0
-10.259	507.15	-10.05	507.46	0.31
-9.588	505.51	-9.588	507.46	1.95
-2.931	506.88	-2.931	507.46	0.58
11.724	507.33	11.724	507.46	0.13
24.3	517.01	24.3	517.01	0

Station change

	Manning's n	
	Original	Revised
LOB		
Channel	0.045	0.03
ROB		



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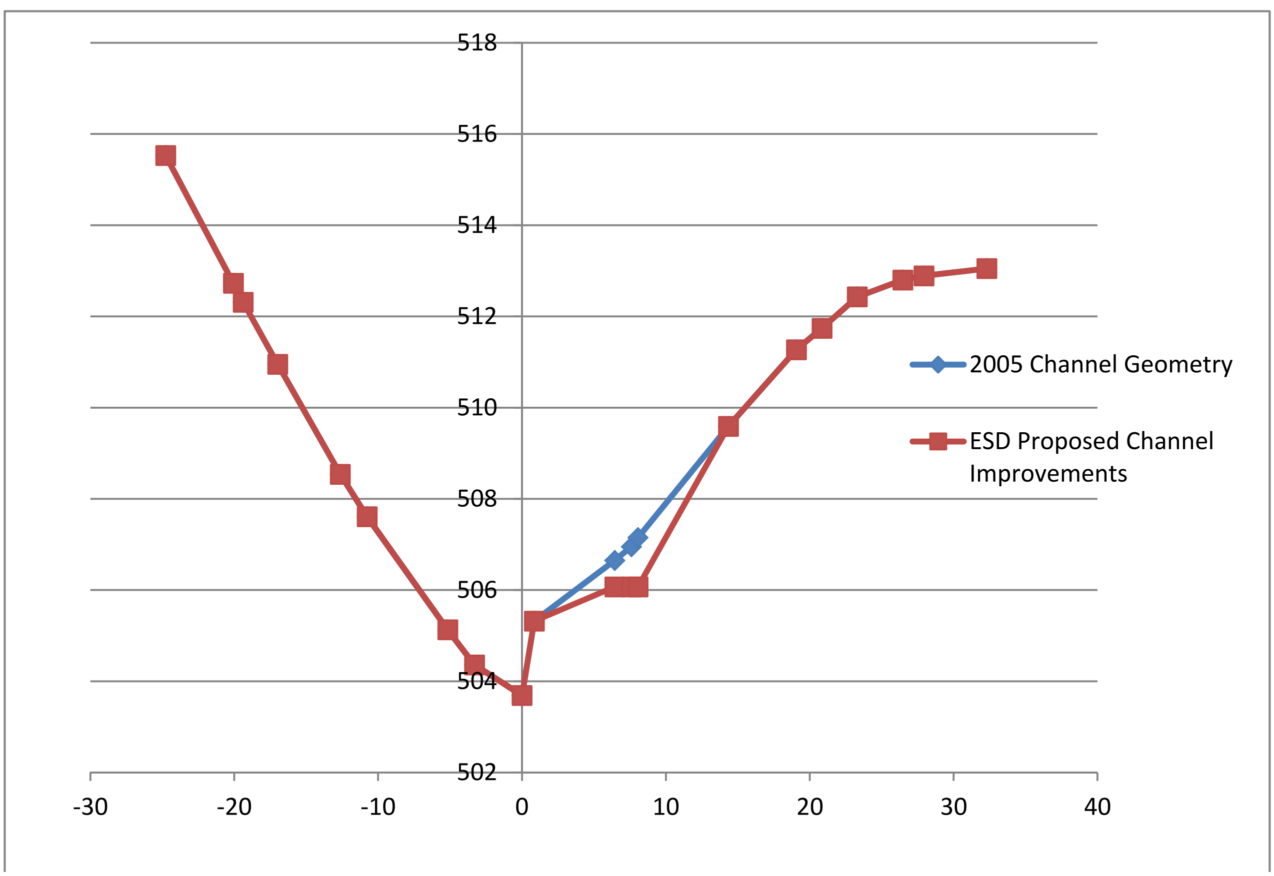
Cross-Section = 10139

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
-24.773	515.53	-24.773	515.53	0
-20.064	512.73	-20.064	512.73	0
-19.383	512.31	-19.383	512.31	0
-16.982	510.95	-16.982	510.95	0
-12.632	508.54	-12.632	508.54	0
-10.769	507.61	-10.769	507.61	0
-5.163	505.13	-5.163	505.13	0
-3.309	504.36	-3.309	504.36	0
0	503.69	0	503.69	0
0.851	505.32	0.851	505.32	0
6.448	506.65	6.448	506.07	-0.58
7.602	506.95	7.602	506.07	-0.88
8.065	507.15	8.065	506.07	-1.08
14.344	509.59	14.344	509.59	0
19.071	511.27	19.071	511.27	0
20.849	511.74	20.849	511.74	0
23.298	512.43	23.298	512.43	0
26.465	512.8	26.465	512.8	0
27.931	512.89	27.931	512.89	0
32.308	513.05	32.308	513.05	0



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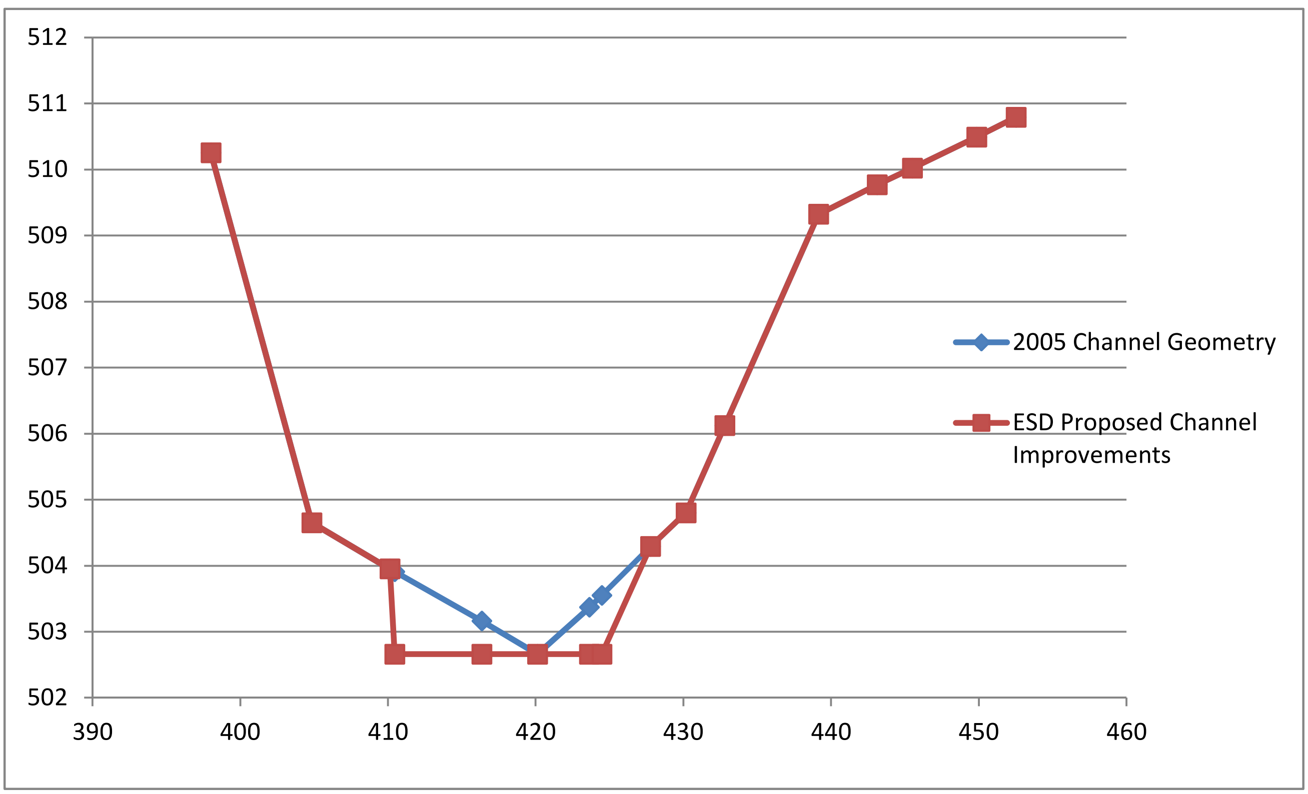
Cross-Section = 9925

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
398.02	510.25	398.02	510.25	0
404.85	504.65	404.85	504.65	0
410.14	503.95	410.14	503.95	0
410.46	503.91	410.46	502.66	-1.25
416.37	503.16	416.37	502.66	-0.5
420.13	502.66	420.13	502.66	0
423.65	503.37	423.65	502.66	-0.71
424.48	503.55	424.48	502.66	-0.89
427.78	504.29	427.78	504.29	0
430.18	504.8	430.18	504.8	0
432.81	506.12	432.81	506.12	0
439.15	509.32	439.15	509.32	0
443.13	509.77	443.13	509.77	0
445.52	510.02	445.52	510.02	0
449.86	510.49	449.86	510.49	0
452.53	510.79	452.53	510.79	0



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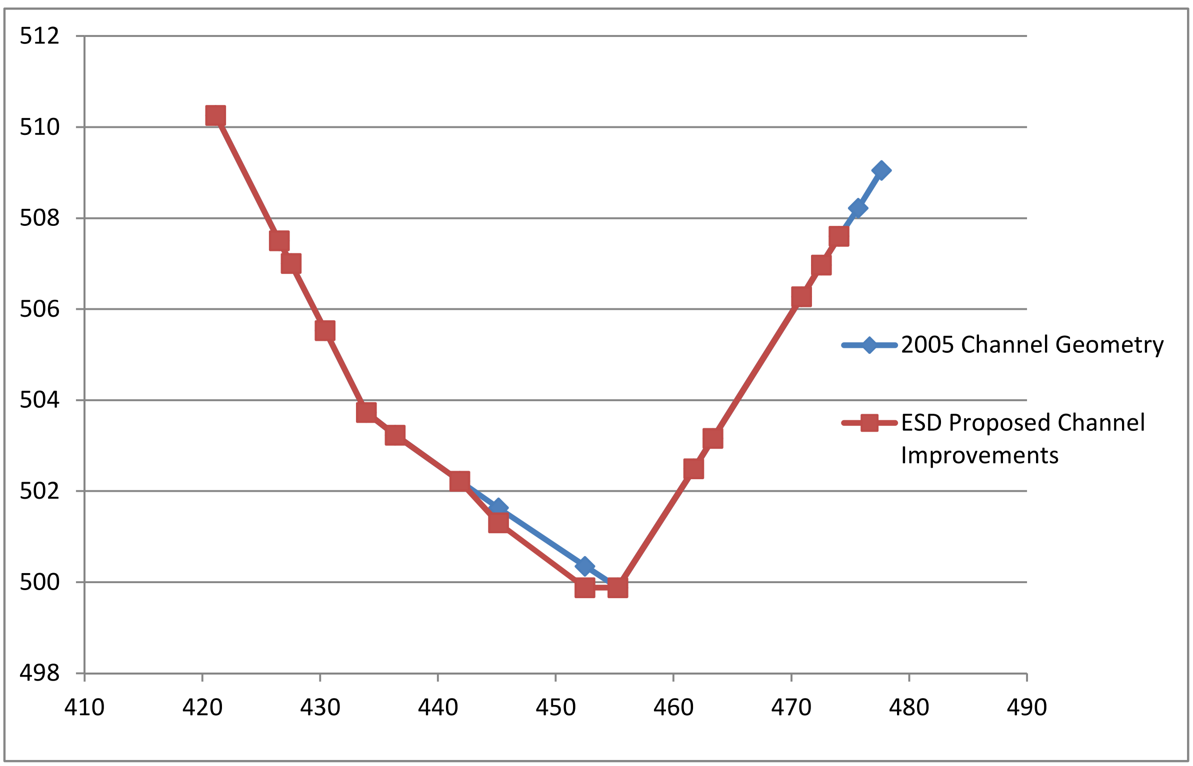
Cross-Section = 9673

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
421.13	510.26	421.13	510.26	0
426.53	507.5	426.53	507.5	0
427.54	507	427.54	507	0
430.43	505.53	430.43	505.53	0
433.92	503.73	433.92	503.73	0
436.38	503.23	436.38	503.23	0
441.86	502.22	441.86	502.22	0
445.13	501.63	445.13	501.3	-0.33
452.48	500.35	452.48	499.88	-0.47
455.27	499.88	455.27	499.88	0
461.72	502.49	461.72	502.49	0
463.35	503.16	463.35	503.16	0
470.87	506.27	470.87	506.27	0
472.54	506.97	472.54	506.97	0
474.05	507.6	474.05	507.6	0
475.69	508.22	475.69	508.22	0
477.67	509.05	477.67	509.05	0



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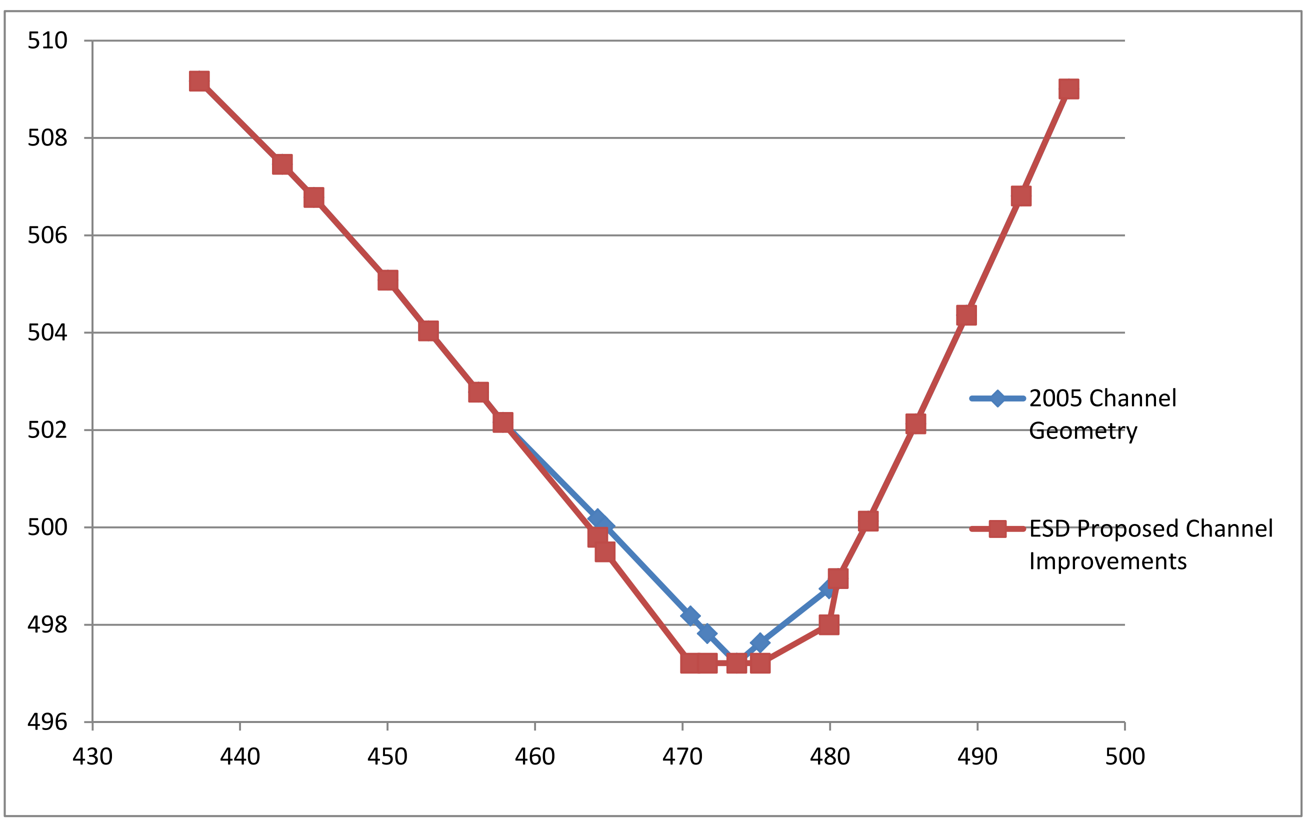
Cross-Section = 9537

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
437.23	509.17	437.23	509.17	0
442.86	507.46	442.86	507.46	0
445	506.78	445	506.78	0
450.02	505.08	450.02	505.08	0
452.77	504.04	452.77	504.04	0
456.17	502.78	456.17	502.78	0
457.82	502.16	457.82	502.16	0
464.25	500.18	464.25	499.8	-0.38
464.75	500.03	464.75	499.5	-0.53
470.54	498.18	470.54	497.21	-0.97
471.68	497.82	471.68	497.21	-0.61
473.67	497.21	473.67	497.21	0
475.27	497.63	475.27	497.21	-0.42
479.93	498.74	479.93	498	-0.74
480.55	498.95	480.55	498.95	0
482.59	500.13	482.59	500.13	0
485.81	502.13	485.81	502.13	0
489.25	504.36	489.25	504.36	0
492.96	506.81	492.96	506.81	0
496.19	509.01	496.19	509.01	0



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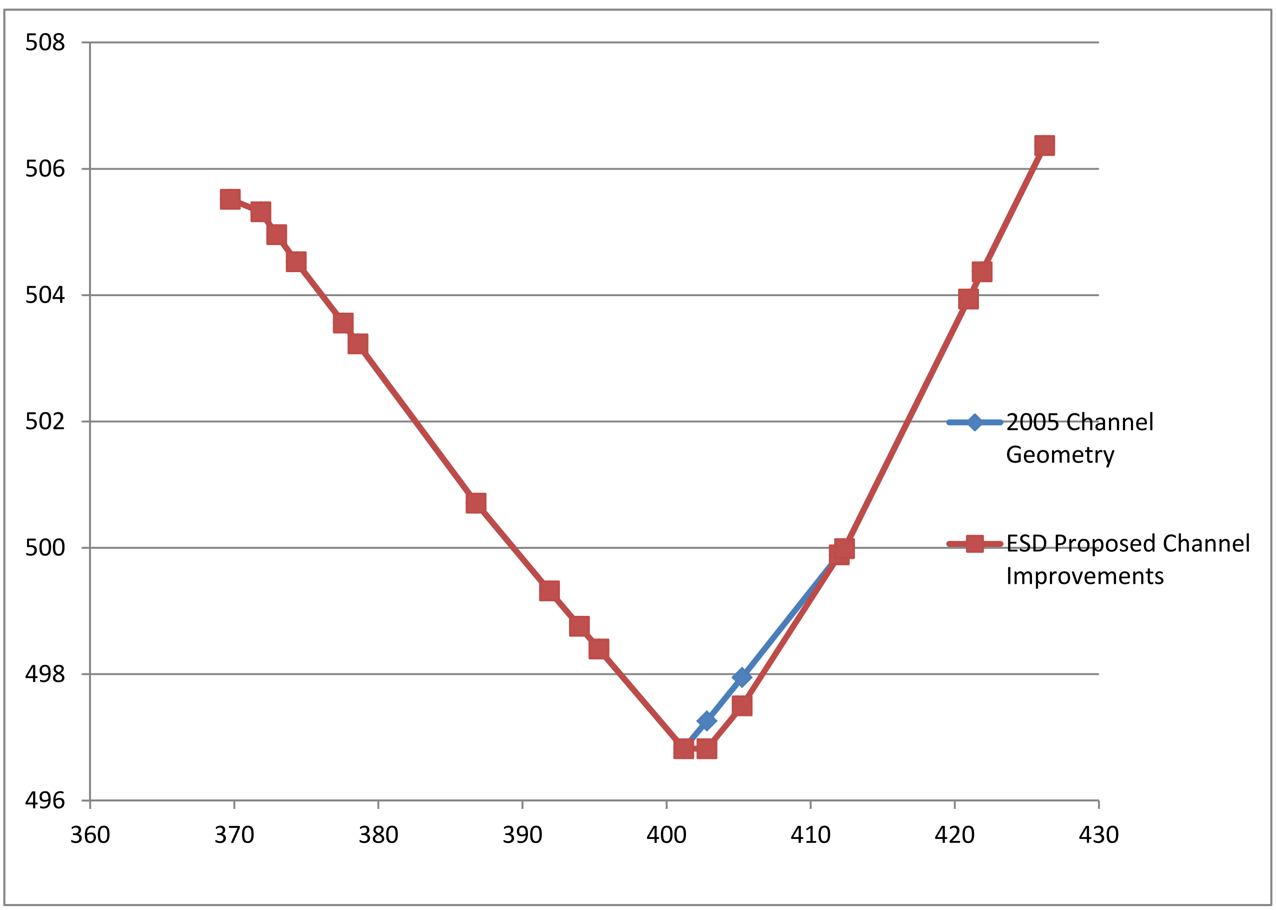
Cross-Section = 9348

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
369.72	505.52	369.72	505.52	0
371.84	505.32	371.84	505.32	0
372.94	504.96	372.94	504.96	0
374.3	504.53	374.3	504.53	0
377.56	503.56	377.56	503.56	0
378.58	503.23	378.58	503.23	0
386.78	500.71	386.78	500.71	0
391.87	499.32	391.87	499.32	0
393.95	498.76	393.95	498.76	0
395.3	498.4	395.3	498.4	0
401.19	496.82	401.19	496.82	0
402.8	497.26	402.8	496.82	-0.44
405.24	497.95	405.24	497.5	-0.45
411.98	499.89	411.98	499.89	0
412.35	499.99	412.35	499.99	0
420.95	503.94	420.95	503.94	0
421.89	504.37	421.89	504.37	0
426.23	506.37	426.23	506.37	0



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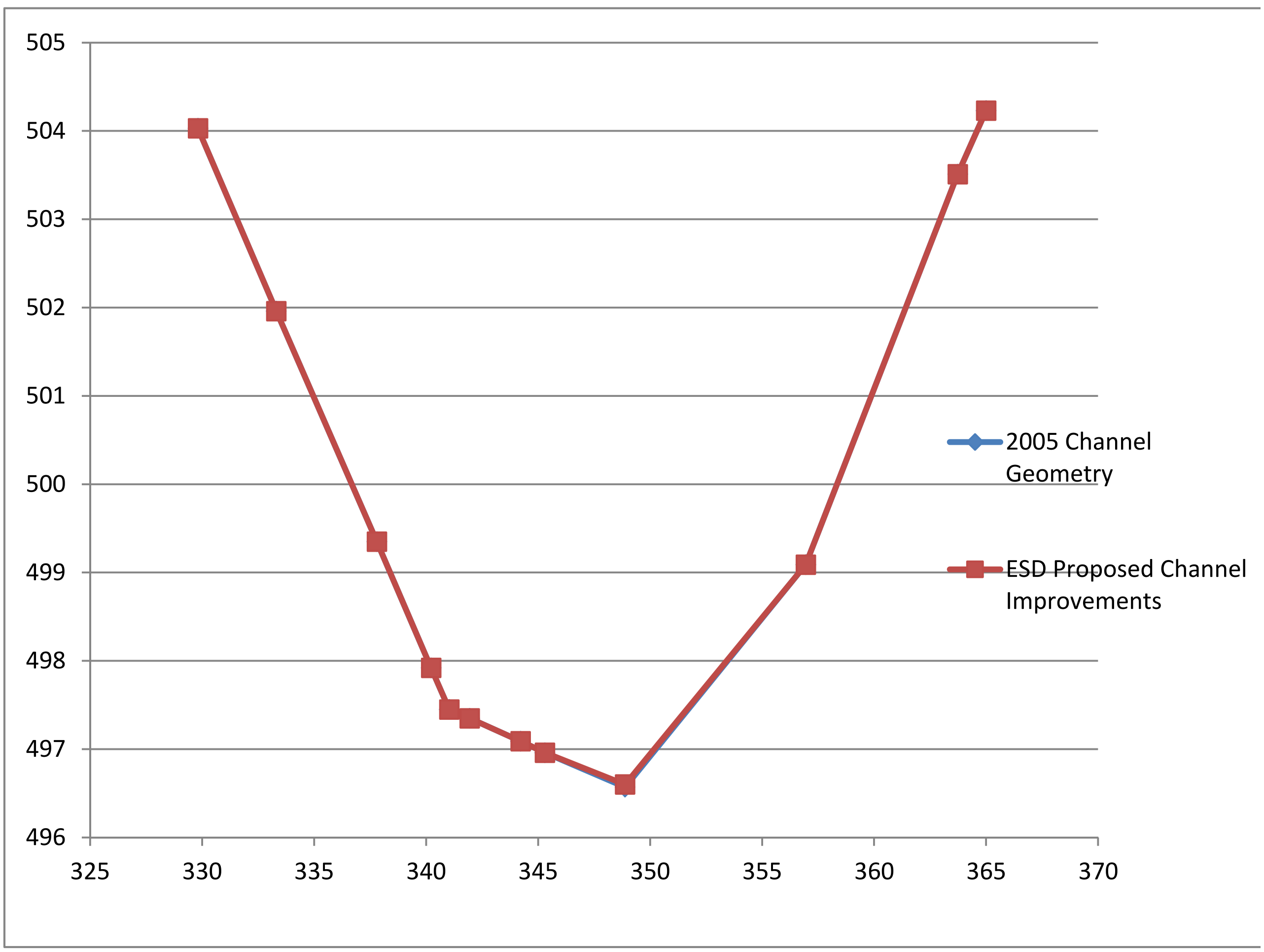
Cross-Section = 9156

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
329.81	504.03	329.81	504.03	0
333.31	501.96	333.31	501.96	0
337.8	499.35	337.8	499.35	0
340.22	497.92	340.22	497.92	0
341.03	497.45	341.03	497.45	0
341.94	497.35	341.94	497.35	0
344.22	497.09	344.22	497.09	0
345.3	496.96	345.3	496.96	0
348.88	496.57	348.88	496.6	0.03
356.95	499.09	356.95	499.09	0
363.73	503.51	363.73	503.51	0
365	504.23	365	504.23	0



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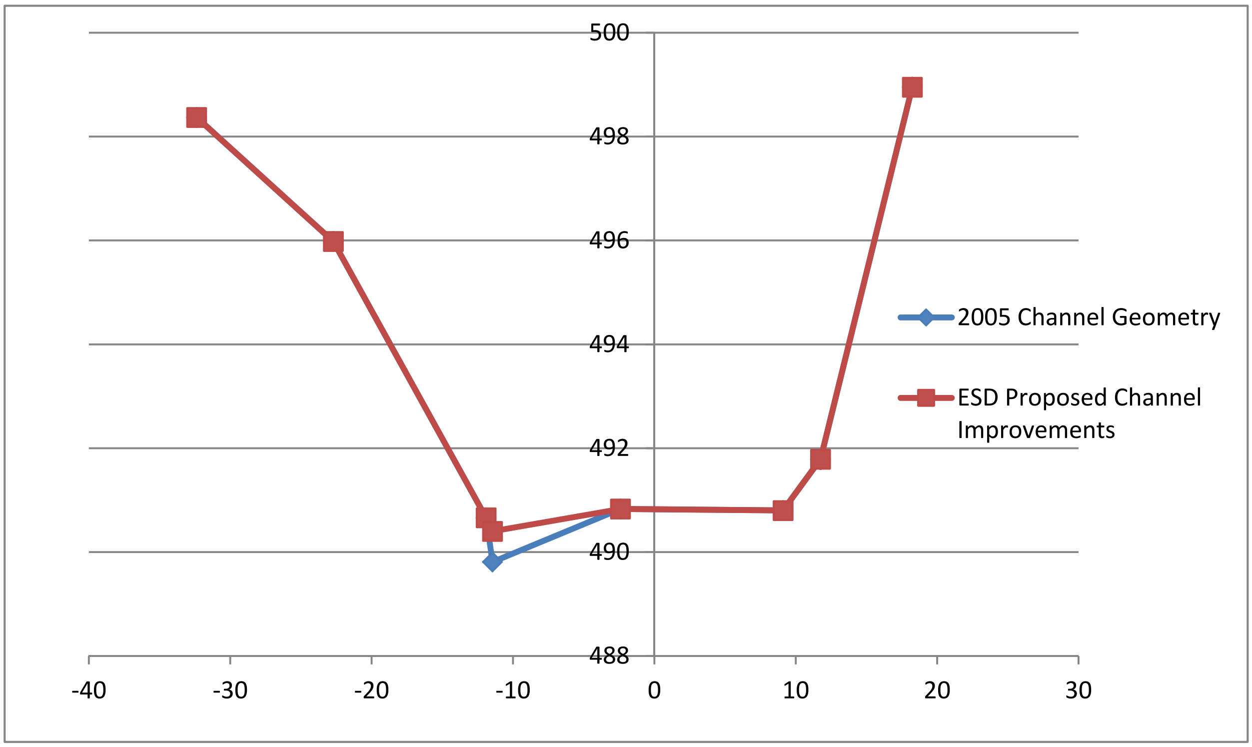
\RAS_results_revd EBLDN.xlsx

Cross-Section = 8764

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
-32.378	498.37	-32.378	498.37	0
-22.705	495.98	-22.705	495.98	0
-11.901	490.66	-11.901	490.66	0
-11.448	489.81	-11.448	490.4	0.59
-2.404	490.83	-2.404	490.83	0
9.1	490.8	9.1	490.8	0
11.752	491.79	11.752	491.79	0
18.243	498.95	18.243	498.95	0



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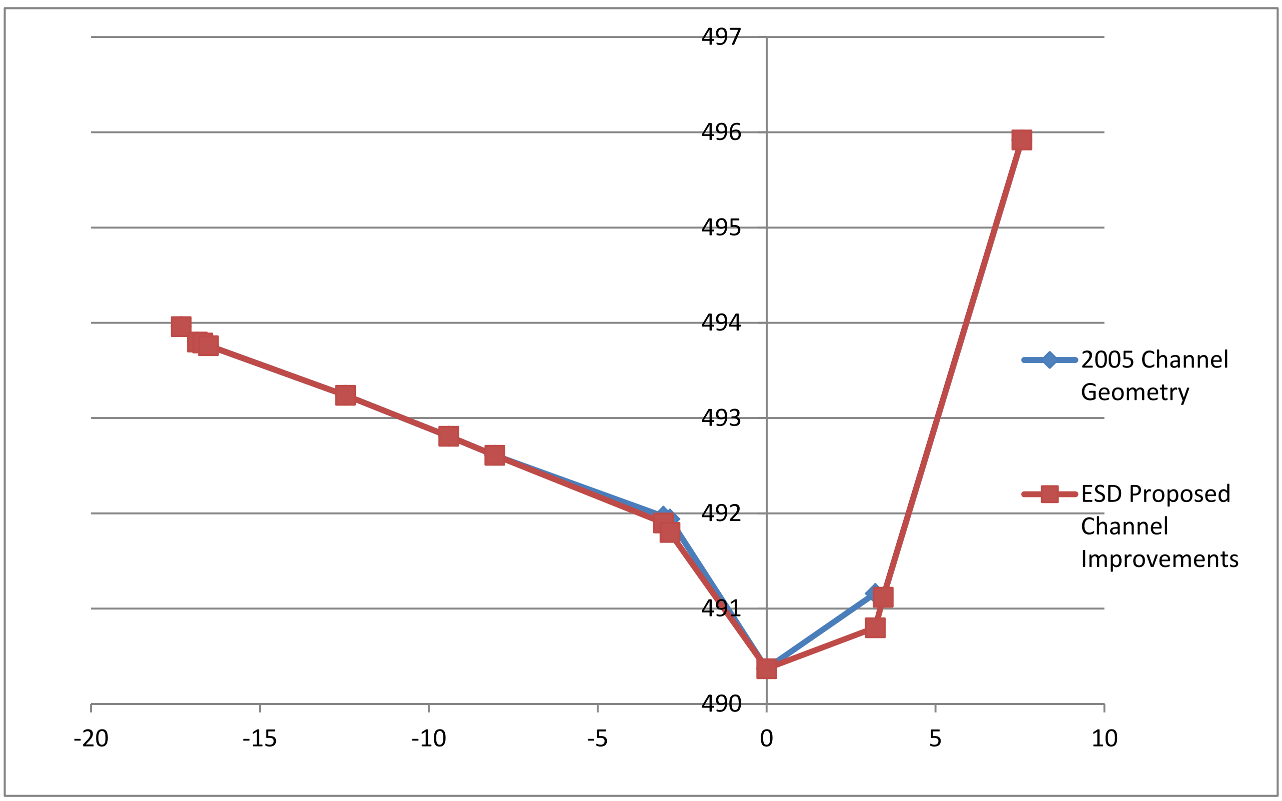
\RAS_results_revd EBLDN.xlsx

Cross-Section = 8679

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
-17.331	493.96	-17.331	493.96	0
-16.85	493.8	-16.85	493.8	0
-16.695	493.79	-16.695	493.79	0
-16.525	493.76	-16.525	493.76	0
-12.466	493.24	-12.466	493.24	0
-9.412	492.81	-9.412	492.81	0
-8.047	492.61	-8.047	492.61	0
-3.055	491.97	-3.055	491.9	-0.07
-2.864	491.94	-2.864	491.8	-0.14
0	490.37	0	490.37	0
3.217	491.16	3.217	490.8	-0.36
3.451	491.12	3.451	491.12	0
7.552	495.92	7.552	495.92	0



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\RAS_results_revd EBLDN.xlsx

Cross-Section = 8373

Prop Alt 1		Channel Imps		
Station	Elevation	Station	Elevation	Elev. Change
245.6	494.36	245.6	494.36	0
251.81	491.47	251.81	491.47	0
253.79	490.53	253.79	490.53	0
259.65	488.37	259.65	488	-0.37
261.97	487.52	261.97	487	-0.52
269.82	485.06	269.82	485.06	0
270.03	484.99	270.03	484.99	0
270.17	485.04	270.17	485.04	0
275.71	487.06	275.71	486.5	-0.56
278.34	488	278.34	488	0
283.15	489.65	283.15	489.65	0
286.53	490.72	286.53	490.72	0
289.6	491.66	289.6	491.66	0
293.75	492.79	293.75	492.79	0
299.16	493.55	299.16	493.55	0
302.9	493.99	302.9	493.99	0
306.65	494.41	306.65	494.41	0

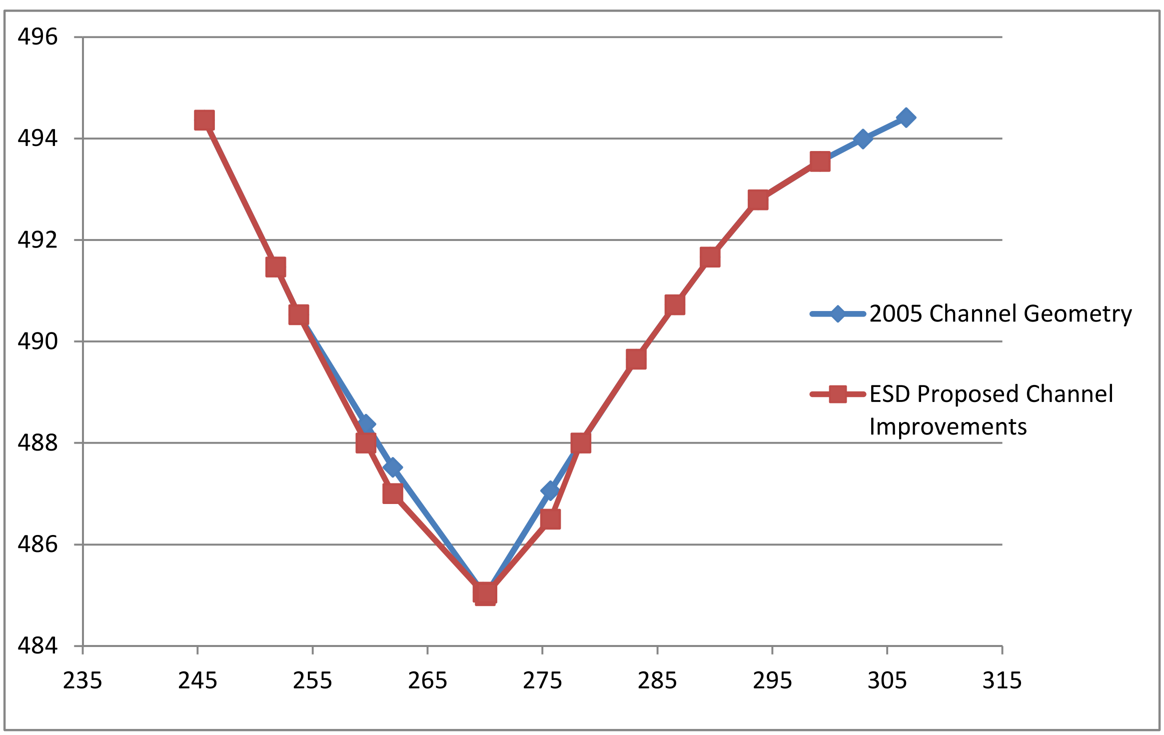

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Exhibit M.5

Channel Velocities and Shear Stress

γ = 64.4 lb/ft^3 unit weight of water
d = maximum channel depth from HEC-RAS model
S = slope of energy grade line from HEC-RAS model

Max shear stress = γ x d x S   Ref: Hec-22 EQ 5-8

			Effective Model				Revised Pre-Project Model								Velocity Change (Pre-Project) - (Effective)	
							Existing Land Use				Ultimate Development Land Use					
Reach	River Sta	Profile	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Channel Velocity ft/sec	Max Shear Stress (lb/sq ft)	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Channel Velocity ft/sec	Max Shear Stress (lb/sq ft)	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Channel Velocity ft/sec	Max Shear Stress (lb/sq ft)	EX ft/sec	Ult ft/sec
Reach 3	12071	1%	0.009114	10.78	10.04	6.3	0.009235	10.84	10.16	6.4	0.009235	10.84	10.16	6.4	0.12	0.12
Reach 3	11925	1%	0.011669	11.26	11.34	8.5	0.011821	11.35	11.52	8.6	0.011821	11.35	11.52	8.6	0.18	0.18
Reach 3	11657	1%	0.020382	7.74	10.49	10.2	0.020418	7.83	10.55	10.3	0.020418	7.83	10.55	10.3	0.06	0.06
Reach 3	11444	1%	0.002853	12	5.69	2.2	0.00291	12.09	5.78	2.3	0.00291	12.09	5.78	2.3	0.09	0.09
Reach 3	11338	1%	0.00366	10.4	5.83	2.5	0.003669	10.5	5.89	2.5	0.003669	10.5	5.89	2.5	0.06	0.06
Reach 3	11211	1%	0.00155	12.91	4.4	1.3	0.001561	13	4.45	1.3	0.001561	13	4.45	1.3	0.05	0.05
Reach 3	11160 LIVE OAK		Culvert		Culvert		Culvert				Culvert					
Reach 3	11110	1%	0.026099	12.08	10.52	20.3	0.024691	12.23	10.4	19.4	0.024691	12.23	10.4	19.4	-0.12	-0.12
Reach 3	11001	1%	0.010026	9.58	8.18	6.2	0.006433	10.54	6.97	4.4	0.00632	10.58	6.93	4.3	-1.21	-1.25
Reach 3	10809	1%	0.003588	8.58	6.11	2.0	0.003724	9.47	6.77	2.3	0.003724	9.5	6.79	2.3	0.66	0.68
Reach 3	10618	1%	0.005557	12.01	8.13	4.3	0.012669	11.58	11.85	9.4	0.012691	11.6	11.89	9.5	3.72	3.76
Reach 3	10559	1%	0.00179	11.74	5.22	1.4	0.004135	11.36	7.7	3.0	0.004148	11.38	7.73	3.0	2.48	2.51
Reach 3	10530 JOHANNA		Culvert		Culvert		Culvert				Culvert					
Reach 3	10502	1%	0.002104	13.11	5.1	1.8	0.005631	12.58	7.91	4.6	0.005582	12.62	7.91	4.5	2.81	2.81
Reach 3	10412	1%	0.012913	12.24	12.45	10.2	0.012996	12.09	12.31	10.1	0.012979	12.12	12.34	10.1	-0.14	-0.11
Reach 3	10284	1%	0.004692	14.63	8.89	4.4	0.004304	14.64	8.52	4.1	0.004316	14.67	8.55	4.1	-0.37	-0.34
Reach 3	10203	1%	0.00395	12.92	7.75	3.3	0.003807	12.92	7.61	3.2	0.003823	12.95	7.64	3.2	-0.14	-0.11
Reach 3	10171 MARY		Culvert		Culvert		Culvert				Culvert					
Reach 3	10139	1%	0.010869	11.73	10.04	8.2	0.010001	11.82	9.7	7.6	0.009999	11.86	9.73	7.6	-0.34	-0.31
Reach 3	10067	1%	0.005796	11.49	8.31	4.3	0.005238	11.61	7.98	3.9	0.005239	11.65	8.01	3.9	-0.33	-0.30
Reach 3	9925	1%	0.004323	11.78	8.25	3.3	0.003799	12	7.85	2.9	0.003816	12.03	7.89	3.0	-0.40	-0.36
Reach 3	9840	1%	0.007796	12.19	8.88	6.1	0.007999	12.25	9.05	6.3	0.008055	12.28	9.09	6.4	0.17	0.21
Reach 3	9807 ANNIE		Culvert		Culvert		Culvert				Culvert					
Reach 3	9774	1%	0.015521	12.71	10.83	12.7	0.015146	12.84	10.84	12.5	0.015019	12.89	10.84	12.5	0.01	0.01
Reach 3	9673	1%	0.007144	11.63	8.01	5.4	0.007037	11.78	8.05	5.3	0.007009	11.83	8.07	5.3	0.04	0.06
Reach 3	9537	1%	0.005033	13.61	7.3	4.4	0.005065	13.74	7.4	4.5	0.005066	13.79	7.43	4.5	0.10	0.13
Reach 3	9348	1%	0.003574	13.4	6.22	3.1	0.003567	13.54	6.28	3.1	0.003559	13.59	6.29	3.1	0.06	0.07
Reach 3	9156	1%	0.018973	10.47	12.31	12.8	0.018003	10.69	12.23	12.4	0.01819	10.71	12.31	12.5	-0.08	0.00
Reach 3	9081	1%	0.002739	11.69	5.61	2.1	0.002897	11.87	5.84	2.2	0.002916	11.9	5.87	2.2	0.23	0.26
Reach 3	9052 MONROE		Bridge		Bridge		Bridge				Bridge					
Reach 3	9024	1%	0.008058	11.16	7	5.8	0.007476	11.44	6.95	5.5	0.007403	11.48	6.94	5.5	-0.05	-0.06
Reach 3	8942	1%	0.023193	12.15	11.06	18.1	0.023665	12.31	11.39	18.8	0.023746	12.34	11.44	18.9	0.33	0.38
Reach 3	8857	1%	0.009963	11.4	9.21	7.3	0.009821	11.62	9.32	7.3	0.009767	11.66	9.33	7.3	0.11	0.12
Reach 3	8764	1%	0.003349	13.06	6.12	2.8	0.003491	13.25	6.34	3.0	0.003514	13.29	6.37	3.0	0.22	0.25
Reach 3	8722 ELIZABETH		Culvert		Culvert		Culvert				Culvert					
Reach 3	8679	1%	0.014532	10.63	12.17	9.9	0.013733	10.95	12.14	9.7	0.013964	10.95	12.25	9.8	-0.03	0.08
Reach 3	8591	1%	0.022867	9.16	12.11	13.5	0.023596	9.35	12.49	14.2	0.023708	9.38	12.55	14.3	0.38	0.44
Reach 3	8373	1%	0.008087	11.76	8.29	6.1	0.008157	11.98	8.5	6.3	0.008167	12.01	8.54	6.3	0.21	0.25
Reach 3	8244	1%	0.005705	10.88	7.89	4.0	0.005906	11.06	8.17	4.2	0.005938	11.09	8.21	4.2	0.28	0.32
Reach 3	8022	1%	0.00207	15.38	5.98	2.1	0.00223	15.53	6.27	2.2	0.002257	15.55	6.31	2.3	0.29	0.33
Reach 3	7832	1%	0.001102	16.96	5.62	1.2	0.001177	17.1	5.86	1.3	0.001189	17.13	5.89	1.3	0.24	0.27
Reach 3	7780	1%	0.000582	16.32	4.9	0.6	0.000625	16.46	5.12	0.7	0.000633	16.48	5.15	0.7	0.22	0.25
Reach 3	7742 SOUTH FIRST STR		Bridge		Bridge		Bridge				Bridge					
Reach 3	7704	1%	0.010867	10.66	13.99	7.5	0.010795	10.91	14.33	7.6	0.010711	10.97	14.35	7.6	0.34	0.36
Reach 3	7609	1%	0.009092	8.78	11.83	5.1	0.009298	8.97	12.2	5.4	0.009326	9	12.26	5.4	0.37	0.43
Reach 3	7393	1%	0.02386	7.03	11.4	10.8	0.023543	7.25	11.53	11.0	0.023496	7.28	11.55	11.0	0.13	0.15
Reach 3	7126	1%	0.006904	8.81	8.23	3.9	0.007743	8.85	8.74	4.4	0.007709	8.91	8.75	4.4	0.51	0.52
Reach 3	6915	1%	0.011399	12.14	9.62	8.9	0.011414	12.2	9.65	9.0	0.011428	12.26	9.69	9.0	0.03	0.07
Reach 3	6735	1%	0.003139	11.1	6.29	2.2	0.003125	11.17	6.31	2.2	0.003114	11.23	6.33	2.3	0.02	0.04
Reach 3	6568	1%	0.006217	11.13	8.61	4.5	0.006225	11.19	8.65	4.5	0.006234	11.25	8.69	4.5	0.04	0.08
Reach 3	6418	1%	0.008154	11.55	9.98	6.1	0.008178	11.61	10.03	6.1	0.008204	11.65	10.08	6.2	0.05	0.10
Reach 3	6253	1%	0.026975	8.56	12.96	14.9	0.026946	8.6	13.02	14.9	0.026871	8.64	13.06	15.0	0.06	0.10
Reach 3	6124	1%	0.00825	8.39	8.22	4.5	0.008305	8.43	8.27	4.5	0.008341	8.46	8.32	4.5	0.05	0.10
Reach 3	5916	1%	0.009988	8.46	7.86	5.4	0.010382	8.44	8	5.6	0.01031	8.49	8.01	5.6	0.14	0.15
Reach 3	5717	1%	0.002335	10.16	4.95	1.5	0.002457	10.12	5.05	1.6	0.002455	10.16	5.07	1.6	0.10	0.12

Reach	River Sta	Profile	Effective Model				Revised Pre-Project Model								Velocity Change (Pre-Project) - (Effective)	
							Existing Land Use				Ultimate Development Land Use					
			E.G. Slope	Max Chl Dpth	Channel Velocity	Max Shear Stress	E.G. Slope	Max Chl Dpth	Channel Velocity	Max Shear Stress	E.G. Slope	Max Chl Dpth	Channel Velocity	Max Shear Stress	EX	Ult
			(ft/ft)	(ft)	ft/sec	(lb/sq ft)	(ft/ft)	(ft)	ft/sec	(lb/sq ft)	(ft/ft)	(ft)	ft/sec	(lb/sq ft)	ft/sec	ft/sec
Reach 3	5591	1%	0.006119	10.03	8.29	4.0	0.006792	9.89	8.64	4.3	0.006782	9.94	8.66	4.3	0.35	0.37
Reach 3	5415	1%	0.004723	9.88	8.19	3.0	0.003694	9.99	7.3	2.4	0.003688	10.03	7.32	2.4	-0.89	-0.87
Reach 3	5247	1%	0.002759	10.31	6.68	1.8	0.002752	10.36	6.7	1.8	0.002743	10.41	6.72	1.8	0.02	0.04
Reach 3	5129	1%	0.002753	8.1	6.5	1.4	0.002744	8.15	6.52	1.4	0.002735	8.2	6.54	1.4	0.02	0.04
Reach 3	4941	1%	0.002142	9.11	5.11	1.3	0.002134	9.16	5.13	1.3	0.002124	9.21	5.14	1.3	0.02	0.03
Reach 3	4822	1%	0.005531	8.3	8.44	3.0	0.005558	8.34	8.5	3.0	0.00557	8.39	8.54	3.0	0.06	0.10
Reach 3	4781	1%	0.010643	7.99	10.25	5.5	0.010783	8.01	10.35	5.6	0.010825	8.04	10.41	5.6	0.10	0.16
Reach 3	4735	1%	0.007483	8.41	8.68	4.1	0.007586	8.43	8.76	4.1	0.007613	8.46	8.8	4.1	0.08	0.12
Reach 3	4655	1%	0.002572	9.68	5.93	1.6	0.002605	9.71	5.98	1.6	0.002615	9.75	6.02	1.6	0.05	0.09
Reach 3	4625	1%	0.005066	9.12	7.33	3.0	0.005147	9.14	7.41	3.0	0.005156	9.17	7.45	3.0	0.08	0.12
Reach 3	4608	1%	0.008885	8.07	8.77	4.6	0.009157	8.06	8.89	4.8	0.009175	8.09	8.94	4.8	0.12	0.17
Reach 3	4593	1%	0.01014	7.5	9.09	4.9	0.010658	7.47	9.28	5.1	0.010682	7.5	9.33	5.2	0.19	0.24
Reach 3	4571	1%	0.007063	7.71	7.95	3.5	0.007414	7.68	8.11	3.7	0.007428	7.71	8.15	3.7	0.16	0.20
Reach 3	4545	1%	0.00429	8.15	6.53	2.3	0.004487	8.13	6.66	2.3	0.004496	8.16	6.69	2.4	0.13	0.16
Reach 3	4477	1%	0.00479	8.2	7.3	2.5	0.005121	8.13	7.49	2.7	0.005149	8.16	7.53	2.7	0.19	0.23
Reach 3	4476		Lat Struct		Lat Struct		Lat Struct				Lat Struct					
Reach 3	4415	1%	0.000794	8.97	3.41	0.5	0.000829	8.92	3.47	0.5	0.000834	8.95	3.49	0.5	0.06	0.08
Reach 3	4220	1%	0.000795	9.09	3.63	0.5	0.000831	9.03	3.69	0.5	0.000838	9.06	3.72	0.5	0.06	0.09
Reach 3	4022	1%	0.00119	10.42	5.19	0.8	0.001253	10.35	5.29	0.8	0.001267	10.37	5.34	0.8	0.10	0.15
Reach 3	3855	1%	0.000705	12.25	3.77	0.6	0.000777	12.16	3.93	0.6	0.000781	12.19	3.95	0.6	0.16	0.18
Reach 3	3817 SOUTH FIRST STR		Culvert		Culvert		Culvert				Culvert					
Reach 3	3779	1%	0.0173	9.14	7.01	10.2	0.034232	8.6	8.85	19.0	0.034199	8.62	8.87	19.0	1.84	1.86
Reach 3	3778		Lat Struct		Lat Struct		Lat Struct				Lat Struct					
Reach 3	3631	1%	0.000891	8.9	3.94	0.5	0.001358	8.2	4.53	0.7	0.00132	8.28	4.51	0.7	0.59	0.57
Reach 3	3454	1%	0.000531	10.33	3.34	0.4	0.000788	9.59	3.82	0.5	0.000769	9.67	3.8	0.5	0.48	0.46
Reach 3	3231	1%	0.000438	10.79	3.24	0.3	0.000683	10	3.8	0.4	0.000663	10.1	3.77	0.4	0.56	0.53
Reach 3	2977	1%	0.000354	12.35	3.23	0.3	0.000523	11.5	3.71	0.4	0.000512	11.6	3.69	0.4	0.48	0.46
Reach 3	2773	1%	0.000268	12.53	2.92	0.2	0.000397	11.66	3.37	0.3	0.000388	11.76	3.35	0.3	0.45	0.43
Reach 3	2707	1%	0.000189	13.05	2.52	0.2	0.000271	12.18	2.86	0.2	0.000266	12.28	2.85	0.2	0.34	0.33
Reach 3	2629	1%	0.000736	13.36	4.12	0.6	0.001025	12.42	4.62	0.8	0.001012	12.52	4.61	0.8	0.50	0.49
Reach 3	2539 CONGRESS AVENUE		Culvert		Culvert		Culvert				Culvert					
Reach 3	2447	1%	0.005287	9.46	7.48	3.2	0.005173	9.95	7.66	3.3	0.005168	9.99	7.68	3.3	0.18	0.20
Reach 3	2362	1%	0.00739	8.24	8.3	3.9	0.007244	8.69	8.6	4.1	0.007209	8.73	8.62	4.1	0.30	0.32
Reach 3	2257	1%	0.007896	8.25	8.29	4.2	0.007553	8.74	8.53	4.3	0.007487	8.78	8.54	4.2	0.24	0.25
Reach 3	2001	1%	0.005561	9.02	6.96	3.2	0.005039	9.65	7.06	3.1	0.004947	9.73	7.04	3.1	0.10	0.08
Reach 3	1823	1%	0.003789	9.44	6.39	2.3	0.003389	10.16	6.45	2.2	0.003314	10.25	6.42	2.2	0.06	0.03
Reach 3	1534	1%	0.001947	9.95	4.78	1.2	0.001741	10.75	4.84	1.2	0.001721	10.85	4.85	1.2	0.06	0.07
Reach 3	1327	1%	0.004468	9.41	6.63	2.7	0.003611	10.34	6.51	2.4	0.003538	10.44	6.5	2.4	-0.12	-0.13
Reach 3	1116	1%	0.010366	12.99	6.37	8.7	0.01005	14.01	6.68	9.1	0.010016	14.12	6.72	9.1	0.31	0.35
Reach 3	1036 RIVERSIDE		Culvert		Culvert		Culvert				Culvert					
Reach 3	956	1%	0.003102	9.53	6.27	1.9	0.003296	10.05	6.76	2.1	0.003322	10.11	6.81	2.2	0.49	0.54
Reach 3	682	1%	0.002502	6.32	4.46	1.0	0.0025	6.85	4.69	1.1	0.0025	6.91	4.72	1.1	0.23	0.26

Max increase = 3.76 ft/sec

γ = 64.4
d = maximum channel depth from HEC-RAS model
S = slope of energy grade line from HEC-RAS model

Max shear stress = γ x d x S

		Proposed Alternative 1 Model								Proposed Channel Improvements Model								Velocity Change (Ch Imps) - (Pre-Project)	
		Existing Land Use				Ultimate Development Land Use				Existing Land Use				Ultimate Development Land Use					
River Sta	Profile	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Channel Velocity ft/sec	Max Shear Stress (lb/sq ft)	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Channel Velocity ft/sec	Max Shear Stress (lb/sq ft)	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Channel Velocity ft/sec	Max Shear Stress (lb/sq ft)	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Channel Velocity ft/sec	Max Shear Stress (lb/sq ft)	EX ft/sec	Ult ft/sec
12071	1%	0.009235	10.84	10.16	6.4	0.009235	10.84	10.16	6.4	0.009235	10.84	10.16	6.4	0.009235	10.84	10.16	6.4	0.00	0.00
11925	1%	0.011821	11.35	11.52	8.6	0.011821	11.35	11.52	8.6	0.011847	11.34	11.52	8.7	0.011847	11.34	11.52	8.7	0.00	0.00
11657	1%	0.020418	7.83	10.55	10.3	0.020418	7.83	10.55	10.3	0.020397	7.82	10.55	10.3	0.020397	7.82	10.55	10.3	0.00	0.00
11444	1%	0.00291	12.09	5.78	2.3	0.00291	12.09	5.78	2.3	0.00291	12.09	5.78	2.3	0.00291	12.09	5.78	2.3	0.00	0.00
11338	1%	0.003669	10.5	5.89	2.5	0.003669	10.5	5.89	2.5	0.003669	10.5	5.89	2.5	0.003669	10.5	5.89	2.5	0.00	0.00
11211	1%	0.001561	13	4.45	1.3	0.001561	13	4.45	1.3	0.001561	13	4.45	1.3	0.001561	13	4.45	1.3	0.00	0.00
11160 LIVE OAK		Culvert				Culvert				Culvert				Culvert					
11110	1%	0.024691	12.23	10.4	19.4	0.024691	12.23	10.4	19.4	0.024691	12.23	10.4	19.4	0.024691	12.23	10.4	19.4	0.00	0.00
11001	1%	0.006274	10.59	6.91	4.3	0.00616	10.63	6.86	4.2	0.006229	10.5	6.9	4.2	0.006115	10.54	6.85	4.2	-0.07	-0.01
10809	1%	0.003709	9.52	6.78	2.3	0.003707	9.55	6.8	2.3	0.003487	9.46	6.7	2.1	0.003487	9.5	6.72	2.1	-0.07	-0.08
10618	1%	0.012926	11.58	11.98	9.6	0.012991	11.61	12.03	9.7	0.013426	11.46	12.17	9.9	0.013464	11.49	12.21	10.0	0.32	0.18
10559	1%	0.004139	11.38	7.72	3.0	0.004167	11.4	7.76	3.1	0.00445	11.24	7.92	3.2	0.004471	11.27	7.96	3.2	0.22	0.20
10530 JOHANNA		Culvert				Culvert				Culvert				Culvert					
10502	1%	0.005599	12.6	7.91	4.5	0.005586	12.63	7.92	4.5	0.005643	12.43	8.06	4.5	0.005588	12.48	8.06	4.5	0.15	0.14
10412	1%	0.012984	12.11	12.33	10.1	0.012854	12.16	12.33	10.1	0.012762	11.97	12.32	9.8	0.012741	12.01	12.35	9.9	0.01	0.02
10284	1%	0.004286	14.67	8.52	4.0	0.004302	14.71	8.56	4.1	0.004243	14.5	8.51	4.0	0.004272	14.52	8.55	4.0	-0.01	-0.01
10203	1%	0.003868	12.94	7.68	3.2	0.003891	12.98	7.72	3.3	0.00209	10.84	8.28	1.5	0.002107	10.87	8.33	1.5	0.67	0.61
10171 MARY		Culvert				Culvert				Culvert				Culvert					
10139	1%	0.010359	11.8	9.86	7.9	0.010371	11.84	9.9	7.9	0.00983	11.81	9.69	7.5	0.009842	11.85	9.73	7.5	-0.01	-0.17
10067	1%	0.005464	11.58	8.13	4.1	0.005469	11.62	8.16	4.1	0.005499	11.57	8.15	4.1	0.005503	11.61	8.18	4.1	0.17	0.02
9925	1%	0.004015	11.93	8.03	3.1	0.004038	11.96	8.08	3.1	0.00377	11.97	7.81	2.9	0.003792	12.01	7.85	2.9	-0.04	-0.23
9840	1%	0.007998	12.23	9.03	6.3	0.007996	12.27	9.06	6.3	0.008019	12.23	9.04	6.3	0.008031	12.26	9.07	6.3	-0.01	0.01
9807 ANNIE		Culvert				Culvert				Culvert				Culvert					
9774	1%	0.015013	12.84	10.79	12.4	0.014897	12.88	10.79	12.4	0.01569	12.77	10.95	12.9	0.015564	12.81	10.95	12.8	0.11	0.16
9673	1%	0.006936	11.78	8	5.3	0.006912	11.83	8.02	5.3	0.006935	11.72	8	5.2	0.00691	11.77	8.02	5.2	-0.05	0.00
9537	1%	0.005065	13.75	7.4	4.5	0.005066	13.79	7.43	4.5	0.004787	13.74	7.25	4.2	0.004789	13.78	7.28	4.2	-0.15	-0.15
9348	1%	0.003567	13.54	6.28	3.1	0.00356	13.59	6.29	3.1	0.003518	13.54	6.25	3.1	0.003511	13.59	6.27	3.1	-0.03	-0.02
9156	1%	0.018014	10.69	12.23	12.4	0.018179	10.72	12.31	12.6	0.018055	10.66	12.24	12.4	0.01822	10.68	12.32	12.5	0.01	0.01
9081	1%	0.002898	11.87	5.84	2.2	0.002917	11.9	5.87	2.2	0.002898	11.87	5.84	2.2	0.002917	11.9	5.87	2.2	0.00	0.00
9052 MONROE		Bridge				Bridge				Bridge				Bridge					
9024	1%	0.007472	11.44	6.95	5.5	0.007401	11.48	6.94	5.5	0.007471	11.44	6.95	5.5	0.007398	11.48	6.94	5.5	0.00	0.00
8942	1%	0.023668	12.31	11.39	18.8	0.023748	12.34	11.44	18.9	0.023677	12.31	11.39	18.8	0.023762	12.33	11.44	18.9	0.00	0.00
8857	1%	0.009813	11.62	9.32	7.3	0.009767	11.66	9.33	7.3	0.00986	11.62	9.34	7.4	0.009836	11.65	9.35	7.4	0.02	0.02
8764	1%	0.00349	13.26	6.34	3.0	0.003515	13.29	6.37	3.0	0.003531	12.65	6.38	2.9	0.003558	12.68	6.42	2.9	0.04	0.05
8722 ELIZABETH		Culvert				Culvert				Culvert				Culvert					
8679	1%	0.013734	10.95	12.15	9.7	0.013923	10.96	12.24	9.8	0.013643	10.95	12.12	9.6	0.013894	10.95	12.23	9.8	-0.02	-0.01
8591	1%	0.023601	9.35	12.49	14.2	0.023694	9.38	12.55	14.3	0.02454	9.28	12.65	14.7	0.024635	9.31	12.71	14.8	0.16	0.16
8373	1%	0.008159	11.98	8.51	6.3	0.008185	12.01	8.54	6.3	0.007909	11.98	8.43	6.1	0.007936	12.01	8.47	6.1	-0.07	-0.07
8244	1%	0.00591	11.06	8.17	4.2	0.005962	11.08	8.22	4.3	0.00591	11.06	8.17	4.2	0.005962	11.08	8.22	4.3	0.00	0.00
8022	1%	0.002233	15.53	6.27	2.2	0.002265	15.54	6.32	2.3	0.002233	15.53	6.27	2.2	0.002265	15.54	6.32	2.3	0.00	0.00
7832	1%	0.001178	17.1	5.86	1.3	0.001195	17.11	5.91	1.3	0.001178	17.1	5.86	1.3	0.001195	17.11	5.91	1.3	0.00	0.00
7780	1%	0.000626	16.46	5.12	0.7	0.000636	16.47	5.16	0.7	0.000626	16.46	5.12	0.7	0.000636	16.47	5.16	0.7	0.00	0.00
7742 SOUTH FIRST STR		Bridge				Bridge				Bridge				Bridge					
7704	1%	0.010803	10.91	14.33	7.6	0.010709	10.97	14.35	7.6	0.010803	10.91	14.33	7.6	0.010709	10.97	14.35	7.6	0.00	0.00
7609	1%	0.009298	8.97	12.21	5.4	0.009326	9	12.26	5.4	0.009298	8.97	12.21	5.4	0.009326	9	12.26	5.4	0.01	0.00
7393	1%	0.023541	7.25	11.54	11.0	0.023495	7.28	11.56	11.0	0.023541	7.25	11.54	11.0	0.023495	7.28	11.56	11.0	0.01	0.00
7126	1%	0.007777	8.84	8.75	4.4	0.007748	8.89	8.77	4.4	0.007777	8.84	8.75	4.4	0.007748	8.89	8.77	4.4	0.01	0.00
6915	1%	0.011412	12.2	9.65	9.0	0.011425	12.25	9.68	9.0	0.011412	12.2	9.65	9.0	0.011425	12.25	9.68	9.0	0.00	0.00
6735	1%	0.003127	11.16	6.31	2.2	0.003116	11.22	6.32	2.3	0.003127	11.16	6.31	2.2	0.003116	11.22	6.32	2.3	0.00	0.00
6568	1%	0.006224	11.18	8.65	4.5	0.006233	11.24	8.69	4.5	0.006224	11.18	8.65	4.5	0.006233	11.24	8.69	4.5	0.00	0.00
6418	1%	0.008174	11.6	10.03	6.1	0.008199	11.65	10.07	6.2	0.008174	11.6	10.03	6.1	0.008199	11.65	10.07	6.2	0.00	0.00
6253	1%	0.026956	8.6	13.01	14.9	0.026885	8.64	13.05	15.0	0.026956	8.6	13.01	14.9	0.026885	8.64	13.05	15.0	-0.01	0.00
6124	1%	0.008301	8.42	8.27	4.5	0.008335	8.45	8.31	4.5	0.008301	8.42	8.27	4.5	0.008335	8.45	8.31	4.5	0.00	0.00
5916	1%	0.010391	8.44	8	5.6	0.010321	8.48	8.01	5.6	0.010391	8.44	8	5.6	0.010321	8.48	8.01	5.6	0.00	0.00
5717	1%	0.002457	10.11	5.05	1.6	0.002456	10.15	5.07	1.6	0.002457	10.11	5.05	1.6	0.002456	10.15	5.07	1.6	0.00	0.00

		Proposed Alternative 1 Model								Proposed Channel Improvements Model								Velocity Change (Ch Imps) - (Pre-Project)	
		Existing Land Use				Ultimate Development Land Use				Existing Land Use				Ultimate Development Land Use					
River Sta	Profile	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Channel Velocity ft/sec	Max Shear Stress (lb/sq ft)	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Channel Velocity ft/sec	Max Shear Stress (lb/sq ft)	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Channel Velocity ft/sec	Max Shear Stress (lb/sq ft)	E.G. Slope (ft/ft)	Max Chl Dpth (ft)	Channel Velocity ft/sec	Max Shear Stress (lb/sq ft)	EX ft/sec	Ult ft/sec
5591	1%	0.006793	9.89	8.63	4.3	0.006784	9.93	8.66	4.3	0.006793	9.89	8.63	4.3	0.006784	9.93	8.66	4.3	-0.01	0.00
5415	1%	0.003695	9.98	7.3	2.4	0.003689	10.03	7.32	2.4	0.003695	9.98	7.3	2.4	0.003689	10.03	7.32	2.4	0.00	0.00
5247	1%	0.002753	10.36	6.7	1.8	0.002744	10.4	6.71	1.8	0.002753	10.36	6.7	1.8	0.002744	10.4	6.71	1.8	0.00	0.00
5129	1%	0.002746	8.15	6.52	1.4	0.002736	8.19	6.54	1.4	0.002746	8.15	6.52	1.4	0.002736	8.19	6.54	1.4	0.00	0.00
4941	1%	0.002135	9.16	5.13	1.3	0.002126	9.21	5.14	1.3	0.002135	9.16	5.13	1.3	0.002126	9.21	5.14	1.3	0.00	0.00
4822	1%	0.005557	8.34	8.49	3.0	0.005568	8.38	8.53	3.0	0.005557	8.34	8.49	3.0	0.005568	8.38	8.53	3.0	-0.01	0.00
4781	1%	0.010779	8.01	10.34	5.6	0.010818	8.04	10.4	5.6	0.010779	8.01	10.34	5.6	0.010818	8.04	10.4	5.6	-0.01	0.00
4735	1%	0.007584	8.43	8.75	4.1	0.007609	8.46	8.8	4.1	0.007584	8.43	8.75	4.1	0.007609	8.46	8.8	4.1	-0.01	0.00
4655	1%	0.002604	9.7	5.98	1.6	0.002613	9.74	6.01	1.6	0.002604	9.7	5.98	1.6	0.002613	9.74	6.01	1.6	0.00	0.00
4625	1%	0.005146	9.13	7.4	3.0	0.005154	9.17	7.44	3.0	0.005146	9.13	7.4	3.0	0.005154	9.17	7.44	3.0	-0.01	0.00
4608	1%	0.009156	8.06	8.89	4.8	0.00917	8.09	8.93	4.8	0.009156	8.06	8.89	4.8	0.00917	8.09	8.93	4.8	0.00	0.00
4593	1%	0.010659	7.47	9.28	5.1	0.010674	7.5	9.32	5.2	0.010659	7.47	9.28	5.1	0.010674	7.5	9.32	5.2	0.00	0.00
4571	1%	0.007414	7.68	8.1	3.7	0.007424	7.71	8.14	3.7	0.007414	7.68	8.1	3.7	0.007424	7.71	8.14	3.7	-0.01	0.00
4545	1%	0.004487	8.12	6.65	2.3	0.004494	8.15	6.69	2.4	0.004487	8.12	6.65	2.3	0.004494	8.15	6.69	2.4	-0.01	0.00
4477	1%	0.00512	8.13	7.48	2.7	0.005142	8.15	7.52	2.7	0.00512	8.13	7.48	2.7	0.005142	8.15	7.52	2.7	-0.01	0.00
4476		Lat Struct				Lat Struct				Lat Struct				Lat Struct					
4415	1%	0.000828	8.91	3.47	0.5	0.000833	8.95	3.49	0.5	0.000828	8.91	3.47	0.5	0.000833	8.95	3.49	0.5	0.00	0.00
4220	1%	0.00083	9.03	3.69	0.5	0.000837	9.06	3.71	0.5	0.00083	9.03	3.69	0.5	0.000837	9.06	3.71	0.5	0.00	0.00
4022	1%	0.001251	10.35	5.29	0.8	0.001266	10.37	5.33	0.8	0.001251	10.35	5.29	0.8	0.001266	10.37	5.33	0.8	0.00	0.00
3855	1%	0.000776	12.16	3.93	0.6	0.000781	12.18	3.95	0.6	0.000776	12.16	3.93	0.6	0.000781	12.18	3.95	0.6	0.00	0.00
3817 SOUTH FIRST STR		Culvert				Culvert				Culvert				Culvert					
3779	1%	0.034327	8.6	8.85	19.0	0.034434	8.61	8.89	19.1	0.034327	8.6	8.85	19.0	0.034434	8.61	8.89	19.1	0.00	0.00
3778		Lat Struct				Lat Struct				Lat Struct				Lat Struct					
3631	1%	0.001364	8.19	4.54	0.7	0.001326	8.27	4.51	0.7	0.001364	8.19	4.54	0.7	0.001326	8.27	4.51	0.7	0.01	0.00
3454	1%	0.000791	9.57	3.82	0.5	0.000772	9.66	3.81	0.5	0.000791	9.57	3.82	0.5	0.000772	9.66	3.81	0.5	0.00	0.00
3231	1%	0.000686	9.99	3.8	0.4	0.000666	10.08	3.77	0.4	0.000686	9.99	3.8	0.4	0.000666	10.08	3.77	0.4	0.00	0.00
2977	1%	0.000525	11.49	3.71	0.4	0.000514	11.58	3.69	0.4	0.000525	11.49	3.71	0.4	0.000514	11.58	3.69	0.4	0.00	0.00
2773	1%	0.000398	11.65	3.37	0.3	0.00039	11.74	3.36	0.3	0.000398	11.65	3.37	0.3	0.00039	11.74	3.36	0.3	0.00	0.00
2707	1%	0.000272	12.17	2.86	0.2	0.000267	12.27	2.85	0.2	0.000272	12.17	2.86	0.2	0.000267	12.27	2.85	0.2	0.00	0.00
2629	1%	0.001027	12.41	4.62	0.8	0.001015	12.51	4.61	0.8	0.001027	12.41	4.62	0.8	0.001015	12.51	4.61	0.8	0.00	0.00
2539 CONGRESS AVENUE		Culvert				Culvert				Culvert				Culvert					
2447	1%	0.005172	9.94	7.66	3.3	0.005166	9.98	7.68	3.3	0.005172	9.94	7.66	3.3	0.005166	9.98	7.68	3.3	0.00	0.00
2362	1%	0.007245	8.69	8.6	4.1	0.007206	8.73	8.61	4.1	0.007245	8.69	8.6	4.1	0.007206	8.73	8.61	4.1	0.00	0.00
2257	1%	0.007556	8.73	8.53	4.2	0.007484	8.78	8.53	4.2	0.007556	8.73	8.53	4.2	0.007484	8.78	8.53	4.2	0.00	0.00
2001	1%	0.005042	9.65	7.06	3.1	0.00494	9.72	7.03	3.1	0.005042	9.65	7.06	3.1	0.00494	9.72	7.03	3.1	0.00	0.00
1823	1%	0.003391	10.16	6.44	2.2	0.003307	10.25	6.41	2.2	0.003391	10.16	6.44	2.2	0.003307	10.25	6.41	2.2	-0.01	0.00
1534	1%	0.001742	10.75	4.84	1.2	0.001722	10.84	4.85	1.2	0.001742	10.75	4.84	1.2	0.001722	10.84	4.85	1.2	0.00	0.00
1327	1%	0.003617	10.33	6.51	2.4	0.003541	10.44	6.5	2.4	0.003617	10.33	6.51	2.4	0.003541	10.44	6.5	2.4	0.00	0.00
1116	1%	0.010053	14	6.68	9.1	0.010018	14.12	6.72	9.1	0.010053	14	6.68	9.1	0.010018	14.12	6.72	9.1	0.00	0.00
1036 RIVERSIDE		Culvert				Culvert				Culvert				Culvert					
956	1%	0.003294	10.05	6.75	2.1	0.003321	10.1	6.81	2.2	0.003294	10.05	6.75	2.1	0.003321	10.1	6.81	2.2	-0.01	0.00
682	1%	0.0025	6.85	4.69	1.1	0.0025	6.9	4.71	1.1	0.0025	6.85	4.69	1.1	0.0025	6.9	4.71	1.1	0.00	0.00

Max increase = 0.67 ft/sec

Appendix N –
Class 4
Construction Cost Estimates
for Alternative 4

Preliminary Construction Cost Estimate Summary

Storm Drain Improvements - Alternative 4				
	Phase 1	**Phase 2A**	**Phase 2B**	**Total Proposed Storm Drain**
	System for Crockett Street neighborhood	**System with creek outfall at Annie Street**	**Modifications to Mary Street Relief Line**	
Storm Drain Bid Item Sub-total	$ 2,201,393	$ 2,166,890	$ 49,309	$ 4,417,592
Contingency	30%	30%	30%	30%
Contingency Amount	$ 660,418	$ 650,067	$ 14,793	$ 1,325,278
TOTAL CONSTRUCTION COST ESTIMATE	**$ 2,861,811**	**$ 2,816,957**	**$ 64,102**	**$ 5,742,870**

New Sidewalk (funded by Public Works - Sidewalks and Special Projects)		
Sidewalk Locations: Newton Street from W. Annie to Johanna Newton Street from Crockett to W. Live Oak Eva Street from Crockett to W. Live Oak		
Total LF of sidewalk	1,500	FT
Sidewalk width	5	FT
Total sidewalk area	7,500	SF
Unit Cost	$ 18.00	$ / SF
Total Construction Cost	$ 135,000.00	
Soft Cost contribution	$ 15,000.00	
TOTAL PROJECT COST ESTIMATE	**$ 150,000**	

Notes:

1. "Modifications to WPD's Mary St Relief Line" cost estimate includes pipe located east of the Mary Street sump inlets, one curb inlet and removal of restrictor plate.
2. The preliminary construction cost estimate is based on a preliminary drainage study and is subject to change during the design phase.
3. Unit prices are based on City of Austin bid tabs through March 2015 and Texas Department of Transportation bid tabs from 2017 for similar type projects. Unit costs were reviewed in January 2021 and updated as needed.
4. Unit prices are subject to change depending on the site and subsurface conditions.
5. The cost of mobilization, traffic control, erosion control and pavement restoration bid items could potentially be shared by Watershed Protection Department and Austin Water. This estimate assumes no cost sharing.
6. Temporary traffic control costs are included but may vary depending on final design and phasing.
7. Mobilization costs are included but could be higher if the project is construted in separate phases.
8. Cost for sidewalk in Phase 3 does not include sidewalk along WPD's Mary Street Relief Line.
9. Sidewalk scope and cost provided by Public Works - Sidewalk and Special Projects Division.

Preliminary Construction Cost Estimate Summary

Water Improvements		
Water Bid Item Sub-total	$	1,383,458
Contingency	30%	
Contingency Amount	$	415,038
TOTAL CONSTRUCTION COST ESTIMATE	**$**	**1,798,496**

Wastewater Improvements		
Wastewater Bid Item Sub-total	$	1,013,002
Contingency	30%	
Contingency Amount	$	303,901
TOTAL CONSTRUCTION COST ESTIMATE	**$**	**1,316,903**

Notes:

1. The preliminary construction cost estimate is based on a preliminary drainage study and is subject to change during the design phase.
2. Unit prices are based on City of Austin bid tabs through March 2015 and Texas Department of Transportation bid tabs from 2017 for similar type projects. Unit costs were reviewed in January 2021 and updated as needed.
3. Unit prices are subject to change depending on the site and subsurface conditions.
4. The cost of mobilization, traffic control, erosion control and pavement restoration bid items is shared by Watershed Protection Department and Austin Water. Payment for the shared items is divided proportionally among the utilities based on linear footage of proposed pipe.
5. Temporary traffic control costs are included but may vary depending on final design and phasing.
6. Mobilization costs are included but could be higher if the project is construted in separate phases.

Storm Drain Improvements Construction Cost Estimate - Alternative 4

Bid Item	Phase 1: Johanna (creek to Wilson)	Phase 1: Wilson, Crockett, Eva, Newton	Phase 2A: Annie and Newton (Annie to Johanna)	Phase 2A: Mary (Newton to SOCO) and Johanna (Wilson to SOCO)	Phase 2B: Addition to WPD's Mary St Relief Line	Alt 4 Total Quantity	Unit	Item Description	4/8/2021 Est. Unit Price	Phase 1: Johanna (creek to Wilson)	Phase 1: Wilson, Crockett, Eva, Newton	Phase 2A: Annie and Newton (Annie to Johanna)	Phase 2A: Mary (Newton to SOCO) and Johanna (Wilson to SOCO)	Phase 2B: Addition to WPD's Mary St Relief Line	Alt 4 Total Est. Amount
506-MSW:	4	10	5	8	1	28	EA	Standard Pre-cast Manhole, large dia.	$ 7,500.00	$ 30,000.00	$ 75,000.00	$ 37,500.00	$ 60,000.00	$ 7,500.00	$ 210,000.00
506 EDM:	24.7	31.7	34.0	15.6	0.0	106	VF	Extra Depth Manhole, large Dia.	$ 700.00	$ 17,283.00	$ 22,162.00	$ 23,779.00	$ 10,892.00	$ -	$ 74,116.00
508S-E:	1	0	1	0	0	2	EA	Erosion Protection - downstream of culvert	$ 4,000.00	$ 4,000.00	$ -	$ 4,000.00	$ -	$ -	$ 8,000.00
	1.0	0	1.0	0	0	2.0	LS	Connection to existing roadway culvert (Reinforcement to existing culvert)	$ 30,000.00	$ 30,000.00	$ -	$ 30,000.00	$ -	$ -	$ 60,000.00
508S-IG:	0	0	0	0	0	0	EA	Inlet, Grated	$ 5,200.00	$ -	$ -	$ -	$ -	$ -	$ -
508S-I5S:	0	0	0	1	0	1	EA	Inlet, Standard , 5'	$ 4,500.00	$ -	$ -	$ -	$ 4,500.00	$ -	$ 4,500.00
508S-I10S:	0	17	5	4	1	27	EA	Inlet, Standard , 10'	$ 5,000.00	$ -	$ 85,000.00	$ 25,000.00	$ 20,000.00	$ 5,000.00	$ 135,000.00
508S-I15S:	0	2	0	2	0	4	EA	Inlet, Standard , 15'	$ 6,000.00	$ -	$ 12,000.00	$ -	$ 12,000.00	$ -	$ 24,000.00
508S-I20S:	0	2	0	0	0	2	EA	Inlet, Standard , 20'	$ 8,000.00	$ -	$ 16,000.00	$ -	$ -	$ -	$ 16,000.00
509S-1:	1227	3443	2061	1713	100	8544	LF	Trench Excavation Safety Protective Systems (all depths)	$ 3.00	$ 3,681.00	$ 10,328.10	$ 6,183.00	$ 5,139.00	$ 300.90	$ 25,632.00
509S-1:	0	110	625	0	0	735	LF	WW Pipe, 6" Wastewater line relocation (upgrade IS requested by AW)	$ 180.00	$ -	$ 19,800.00	$ 112,500.00	$ -	$ -	$ 132,300.00
	0	70	0	0	0	70	LF	WATER Pipe, 8" Wastewater line relocation (upgrade IS requested by AW)	$ 180.00	$ -	$ 12,600.00	$ -	$ -	$ -	$ 12,600.00
510	610	350	0	0	0	960	LF	WW Pipe, 8" Wastewater line relocation (upgrade NOT requested by AW)	$ 180.00	$ 109,800.00	$ 63,000.00	$ -	$ -	$ -	$ 172,800.00
510	0	400	0	0	0	400	LF	WW Pipe, 10" Wastewater line relocation (upgrade NOT requested by AW)	$ 200.00	$ -	$ 80,000.00	$ -	$ -	$ -	$ 80,000.00
510-A:	0	663	127	329	14	1132	LF	Pipe, 18" Dia. (all depths), including Excavation and Backfill	$ 120.00	$ -	$ 79,512.00	$ 15,192.00	$ 39,456.00	$ 1,620.00	$ 135,780.00
510-A:	0	237	38	420	87	781	LF	Pipe, 24" Dia. (all depths), including Excavation and Backfill	$ 170.00	$ -	$ 40,205.00	$ 6,494.00	$ 71,349.00	$ 14,756.00	$ 132,804.00
510-A:	0	282	0	0	0	282	LF	Pipe, 30" Dia. (all depths), including Excavation and Backfill	$ 200.00	$ -	$ 56,460.00	$ -	$ -	$ -	$ 56,460.00
510-A:	0	324	0	571	0	895	LF	Pipe, 36" Dia. (all depths), including Excavation and Backfill	$ 250.00	$ -	$ 80,975.00	$ -	$ 142,700.00	$ -	$ 223,675.00
510-A:	0	61	0	0	0	61	LF	Pipe, 42" Dia. (all depths), including Excavation and Backfill	$ 300.00	$ -	$ 18,180.00	$ -	$ -	$ -	$ 18,180.00
510-A:	0	0	326	394	0	719	LF	Pipe, 48" Dia. (all depths), including Excavation and Backfill	$ 350.00	$ -	$ -	$ 113,925.00	$ 137,795.00	$ -	$ 251,720.00
510-A:	0	333	0	0	0	333	LF	Pipe, 54" Dia. (all depths), including Excavation and Backfill	$ 500.00	$ -	$ 166,250.00	$ -	$ -	$ -	$ 166,250.00
510-A:	617	614	0	0	0	1231	LF	Pipe, 66" Dia. (all depths), including Excavation and Backfill	$ 550.00	$ 339,350.00	$ 337,865.00	$ -	$ -	$ -	$ 677,215.00
	0	0	946	0	0	946	LF	Box Culvert 5 ft x 7 ft (all depths), including Excavation and Backfill	$ 800.00	$ -	$ -	$ 756,560.00	$ -	$ -	$ 756,560.00
							LS	Items that could be shared with AW (curb replacement, pavement, traffic control)	$ 858,592.94	$ 154,558.32	$ 245,214.58	$ 277,176.06	$ 163,908.33	$ 17,735.64	$ 858,592.94
	2.5	0	2.5	0	0	5.0	TON	Soil remediation	$ 3,000.00	$ 7,500.00	$ -	$ 7,500.00	$ -	$ -	$ 15,000.00
	0	0	0	0	1	1	EA	Remove restrictor plate	$ 500.00	$ -	$ -	$ -	$ -	$ 500.00	$ 500.00
									Sub-total	**$ 696,172.32**	**$ 1,420,551.68**	**$ 1,415,809.06**	**$ 667,739.33**	**$ 47,412.54**	**$ 4,247,684.94**
N/A	N/A	N/A	N/A	N/A	N/A	4%	%	Mobilization, 4% of Sub-total	$ 169,907.40	$ 27,846.89	$ 56,822.07	$ 56,632.36	$ 26,709.57	$ 1,896.50	$ 169,907.40
									Storm Drain Bid Item Sub-total	**$ 724,019.22**	**$ 1,477,373.75**	**$ 1,472,441.42**	**$ 694,448.91**	**$ 49,309.05**	**$ 4,417,592.34**

Storm Drain Improvements Construction Cost Estimate - Alternative 4

	Phase 1		Phase 2A		Phase 2B	
	Johanna (creek to Wilson)	Wilson, Crockett, Eva, Newton	Annie and Newton (Annie to Johanna)	Mary (Newton to SOCO) and Johanna (Wilson to SOCO)	Addition to WPD's Mary St Relief Line	Alt 4 Total Est. Amount
Storm Drain Bid Item Sub-total	$ 724,019.22	$ 1,477,373.75	$ 1,472,441.42	$ 694,448.91	$ 49,309.05	$ 4,417,592.34
Contingency	30%	30%	30%	30%	30%	30%
Contingency Amount	$ 217,205.77	$ 443,212.12	$ 441,732.43	$ 208,334.67	$ 14,792.71	$ 1,325,277.70
TOTAL CONSTRUCTION COST ESTIMATE	**$ 941,224.98**	**$ 1,920,585.87**	**$ 1,914,173.84**	**$ 902,783.58**	**$ 64,101.76**	**$ 5,742,870.04**
TOTAL COST ESTIMATE BY PHASE	**$ 2,861,810.85**		**$ 2,816,957.42**		**$ 64,101.76**	**$ 5,742,870.04**

Shared Bid Items Construction Cost Estimate

	Phase 1		Phase 2A		Phase 2B							Phase 1		Phase 2A		Phase 2B	
Bid Item	Johanna (creek to Wilson)	Wilson, Crockett, Eva, Newton	Annie and Newton (Annie to Johanna)	Mary (Newton to SOCO) and Johanna (Wilson to SOCO)	Addition to WPD's Mary St Relief Line	Alt 4 Total Quantity	Unit	Item Description	Unit Price	Amount	Est. Unit Price	Johanna (creek to Wilson)	Wilson, Crockett, Eva, Newton	Annie and Newton (Annie to Johanna)	Mary (Newton to SOCO) and Johanna (Wilson to SOCO)	Addition to WPD's Mary St Relief Line	Alt 4 Total Est. Amount
104S	0	340	600	0	0	940	LF	Remove curb and gutter			$ 15.25	$ -	$ 5,185.00	$ 9,150.00	$ -	$ -	$ 14,335.00
430S	0	340	600	0	0	940	LF	Curb and gutter			$ 32.00	$ -	$ 10,880.00	$ 19,200.00	$ -	$ -	$ 30,080.00
210S	129	373	313	225	11	1052	CY	Flexbase, 8"			$ 62.67	$ 8,114.95	$ 23,376.58	$ 19,612.01	$ 14,125.02	$ 687.94	$ 65,916.49
315S	1079	4000	2459	3057	373	10969	SY	Surface/center milling			$ 11.35	$ 12,250.43	$ 45,403.78	$ 27,914.69	$ 34,695.69	$ 4,237.33	$ 124,501.93
315S	928	3020	2728	2078	210	8965	SY	7' Edge milling			$ 15.67	$ 14,533.44	$ 47,318.56	$ 42,745.63	$ 32,562.30	$ 3,293.48	$ 140,453.41
340S	2007	7021	5188	5135	584	19934	SY	Pavement overlay, 1.5" Type D			$ 16.00	$ 32,112.00	$ 112,330.67	$ 83,006.22	$ 82,165.33	$ 9,336.89	$ 318,951.11
340S	0	0	0	0	0	0	SY	Pavement overlay, 2" Type D (structural)			$ 21.40	$ -	$ -	$ -	$ -	$ -	$ -
	45	0	45	0	0	90	CD	Coffer dam			$ 537.50	$ 24,187.50	$ -	$ 24,187.50	$ -	$ -	$ 48,375.00
628S-B	40	80	40	40	20	220	LF	Filter dike - triangular with filter fabric			$ 9.00	$ 360.00	$ 720.00	$ 360.00	$ 360.00	$ 180.00	$ 1,980.00
803S-MO:	21.0		17.0			38.0	MO	Barricades, Signs, and Traffic Handling	$________	$________	$ 3,000.00	$ 63,000.00	$ -	$ 51,000.00	$ -	$ -	$ 114,000.00
											Shared Items Sub-total	**$ 154,558.32**	**$ 245,214.58**	**$ 277,176.06**	**$ 163,908.33**	**$ 17,735.64**	**$ 858,592.94**

Total of all bid items (for mobilization calculation):	
Storm	$ 3,858,995.50
Water	$ 1,579,324.00
Wastewater	$ 1,415,320.00
Shared	$ 858,592.94
Total =	$ 7,712,232.44

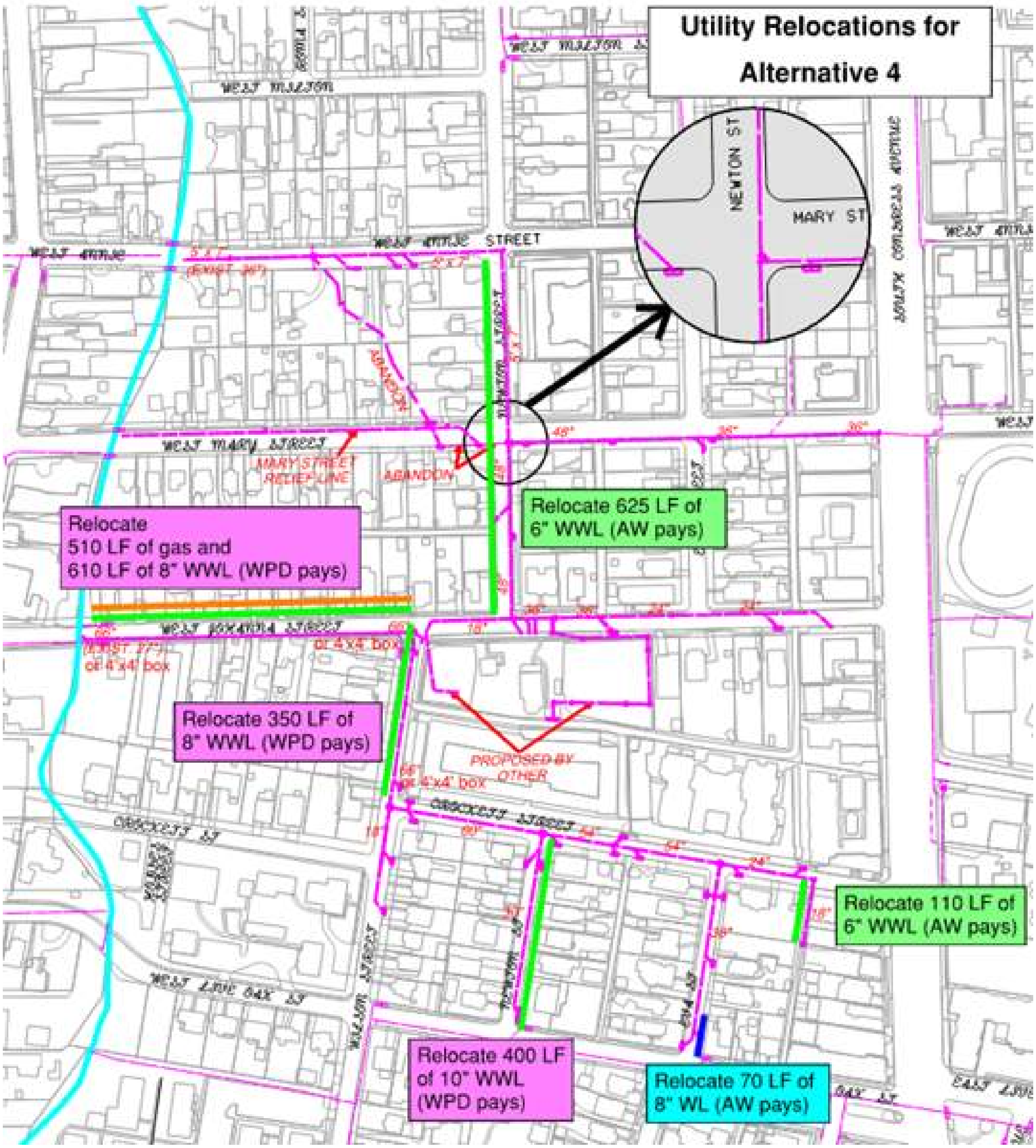
total of all bid items on STORM NO Sharing tab minus WL and WWL that AW IS requesting to upgrade minus $858k shared costs

Percent for each utility:

	LF	**% of total**	
Storm	6379	38%	
Water	5893	36%	$ 305,039.38
Wastewater	4315	26%	$ 223,357.36
Total =	**16587**	**100%**	**$ 528,396.74**

potential savings to WPD if the project is shared with AW

Note: All utility relocations shown in the map below are necessary for Alternative 4. The notes indicate which utility would fund the relocation if Austin Water partners with WPD in order to upgrade water and wastewater lines in the project area.



Water Improvements Construction Cost Estimate

Bid Item	Alt 4 Total Quantity	Unit	Item Description	Est. Unit Price	WATER Est. Amount
510	5893	LF	WATER Pipe, 8" Waterline replacement and upgrade	$ 180.00	$ 1,060,740.00
509S-1:	5893	LF	Trench Excavation Safety Protective Systems (all depths)	$ 3.00	$ 17,679.00
				Sub-total	**$ 1,078,419.00**
N/A	36	%	Mobilization, E&S, TCP, pavement resoration (Shared bid items. Payment divided proportionally based on LF of storm, water and wastewater)	$ 858,592.94	$ 305,039.38
				Water Bid Item Sub-total	**$ 1,383,458.38**

Water Bid Item Sub-total	$ 1,383,458.38
Contingency	30%
Contingency Amount	$ 415,037.51
TOTAL CONSTRUCTION COST ESTIMATE	**$ 1,798,495.89**

Wastewater Improvements Construction Cost Estimate

Bid Item	Alt 4 Total Quantity	Unit	Item Description	Est. Unit Price		WASTEWATER Est. Amount	
510	4315	LF	WASTEWATER Pipe, 8" Waterline replacement and upgrade	$	180.00	$	776,700.00
509S-1:	4315	LF	Trench Excavation Safety Protective Systems (all depths)	$	3.00	$	12,945.00
				Sub-total		**$**	**789,645.00**
N/A	26	%	Mobilization, E&S, TCP, pavement resoration (Shared bid items. Payment divided proportionally based on LF of storm, water and wastewater)	$	858,592.94	$	223,357.36
				Wastewater Bid Item Sub-total		**$**	**1,013,002.36**

Wastewater Bid Item Sub-total	$ 1,013,002.36
Contingency	30%
Contingency Amount	$ 303,900.71
TOTAL CONSTRUCTION COST ESTIMATE	**$ 1,316,903.07**

Life Cycle Cost Estimate for Storm Drain Improvements Alternative 4

Approximate Manhole Flushing Cost (2 days)

	Hours	Hourly Rate*	Total
Drainage Operations Crew Lead	16	$27.73	$443.68
Drainage Operations Team Member II	16	$21.72	$347.52
		Labor sub-total	$791.20
		Overhead Multiplier	3
		TOTAL	**$2,373.60**

*Mid-range pay from COA pay scales January 2021

Approximate Manhole Flushing Cost (5 days)

	Hours	Hourly Rate*	Total
Drainage Operations Crew Lead	40	$27.73	$1,109.20
Drainage Operations Team Member II	40	$21.72	$868.80
		Labor sub-total	$1,978.00
		Overhead Multiplier	3
		TOTAL	**$5,934.00**

*Mid-range pay from COA pay scales January 2021

Approximate Life Cycle Cost – Storm Drain Improvements

System Outfall Location	Number of Proposed Manholes	Number of Manholes flushed during 2-year Maintenance Cycle	Annual Manhole Flushing Cost (low estimate)	Annual Manhole Flushing Cost (high estimate)
Johanna Street (Phase 1)	14	3.5	$4,154	$10,385
Annie Street (Phase 2A)	13	3.25	$3,857	$9,643
		Total Annual Maintenance Cost	**$8,011**	**$20,027**
			Design Life Estimate (years)	**75**
			Total Life Cycle Cost (low estimate)	**$600,818**
			Total Life Cycle Cost (high estimate)	**$1,502,044**

total life cycle cost = (# manholes) x 0.25 / 2 x (annual manhole flushing cost) x (design life)

Appendix O – Pictures

Exhibit O.1

Map of Picture Locations


PHOTO LOCATIONS
East Bouldin Creek
Existing Storm Drain Lines
Proposed Storm Drain Lines
Proposed Storm Drain Lines To Be Abandoned
Photo Number and Direction
A.1
WEST MILTON ST
WEST MILTON
ROMA S
WEST ANNIE
WEST ANNIE STREET
WEST MARY STREET
WEST JOHANNA STREET
CROCKETT ST
CROCKETT STREET
WEST LIVE OAK ST
SOUTH 1ST STREET
HODGES STREET
WILSON STREET
NEWTON STREET
NEWTON ST
EVA STREET
EVA ST
SOUTH CONGRESS AVENUE
NICKERSON
NICKERSON STREET
LELAND STREET
FULMORE JR. HIGH
A.2
A.3
A.4
B.1
B.2
B.3
C.1
C.2
D.1
D.2
E.1
E.2
E.3
E.4
F.1
F.2
F.3
F.4
F.5
G.1
H.1
H.2

Exhibit O.2

Pictures

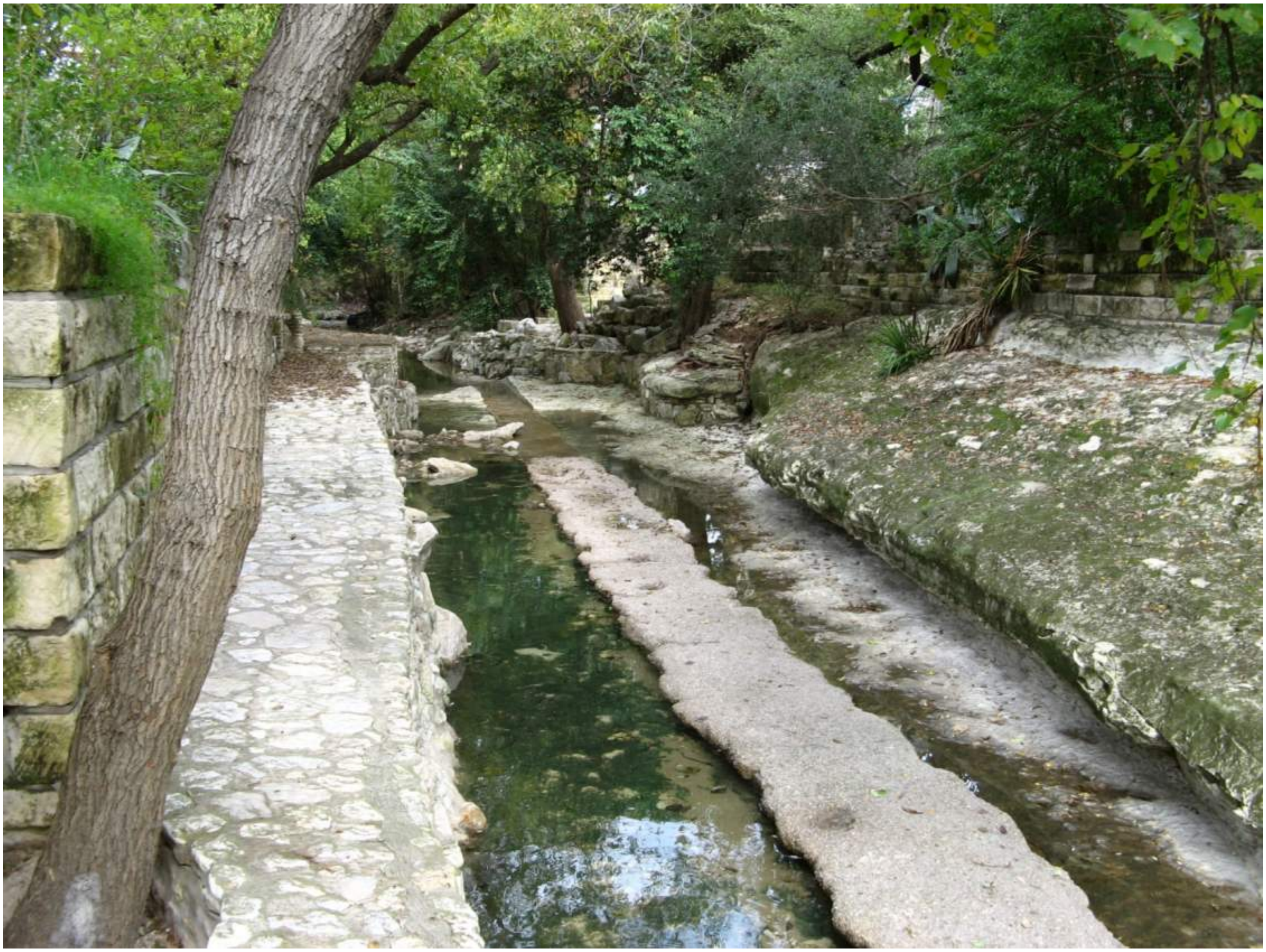
Location A.1 – Milton Street

Location A.1 – East Bouldin Creek at Milton Street

Location A.2 – Milton Street viewed from South First Street parking lot

Location A.2 – Milton Street viewed from South First Street parking lot

Location A.3 – East Bouldin Creek at Milton Street looking north



Location A.4 – East Bouldin Creek at Milton Street looking south

Location B.1 – East Bouldin Creek at Annie Street looking north

Location B.2 – East Bouldin Creek at Annie Street looking south

Location B.3a - Annie Street roadway culvert

Location B.3b - East creek bank viewed from north side of Annie Street road culvert

Location C.1 – East Bouldin Creek at Mary Street looking north

Location C.2 – East Bouldin Creek at Mary Street looking south

Location D.1 – East Bouldin Creek at Johanna Street looking north

Location D.2 – East Bouldin Creek at Johanna Street looking south

Location D.2 – East Bouldin Creek at Johanna Street looking south

Location E.1 – Crockett Street

Location E.1 – East Bouldin Creek at Crockett Street

Location E.2 – East Bouldin Creek at Live Oak Street looking north

Location E.3 – Hodges Street viewed from Live Oak Street

Location E.4 – Hodges Street viewed from Crockett Street

Location F.1 – Courtyard Condominiums (300 Crockett Street)

Location F.2 – Interior courtyard of Courtyard Condominiums (300 Crockett Street)

Interior courtyard drains under walkway to alley

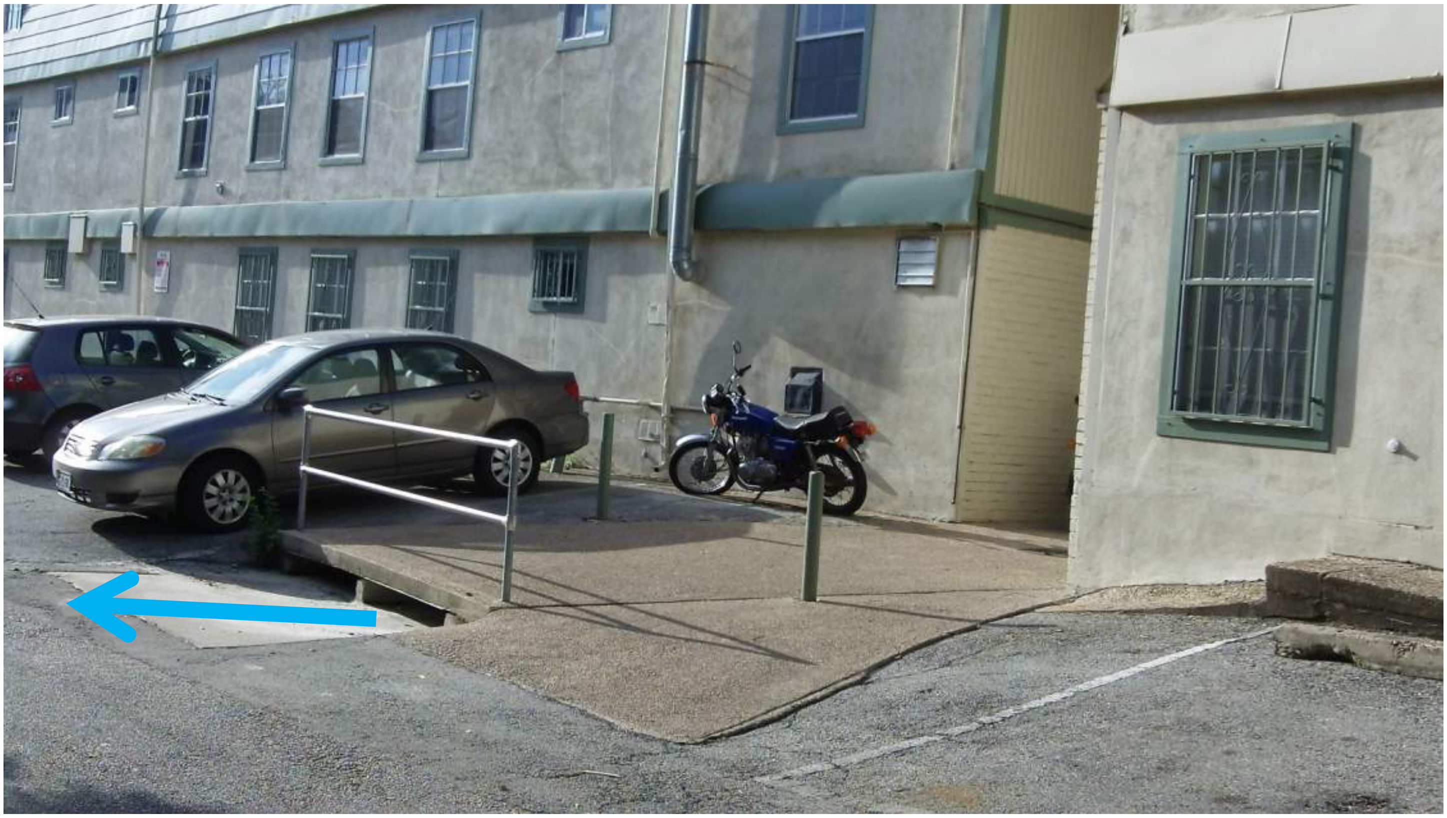
Location F.2 – Interior courtyard of Courtyard Condominiums (300 Crockett Street)

View from northeast corner of interior courtyard –
units on the right side of photo flood

Location F.2 –Courtyard Condominiums (300 Crockett Street)

Driveway along eastern edge of complex

Location F.3 – Alley north of Courtyard Condominiums (300 Crockett Street)



Runoff exits condominium courtyard under concrete walkway

Courtyard runoff flows to sump inlet in alley

Location F.4 – Alley north of Courtyard Condominiums (300 Crockett Street)

Power pole on left side of photo is near location of proposed inlet on grade in alley (DA-A21-B)

Location F.5 – Existing sump inlets on Johanna Street

Location G.1 – South Congress Avenue at Fulmore Middle School

Location G.1 – South Congress Avenue at Fulmore Middle School

Location H.1 – Storm drain across private property

View from Annie Street looking toward Mary Street – sump inlet overflow path

Location H.2 – Storm drain across private property

View from Mary Street sump inlet looking toward Annie Street

Appendix P –
Quality Assurance and
Quality Control Documentation

Exhibit P.1

Internal Quality Assurance and Quality Control

Public Works

ENGINEERING SERVICES DIVISION

30% Independent Technical Quality Review Certification

Project CIP ID No.: 5789.106
Project: East Bouldin Creek and Annie Street Storm Sewer Improvements
Taskorder #: ____________
Design Engineer: Jennifer Massie-Gore

Quality Reviewer(s): ____________

Submittal Requirements: (See Back Page)

I certify that I have completed a Quality Review Setup for this project in accordance with ESD CAD Standards.

CAD Manager/Date: N/A NOT PLANS
(signature)

I certify that the Design Team has performed a self QA/QC of all submittal documents

Design Engineer/Date: 4/26/16 Team Leader/Date: 4/26/16
(signature(s))

I certify that I have completed a Quality Review for this project in accordance with the project plan.

Quality Reviewer/Date: 4/26/2016
(signature)

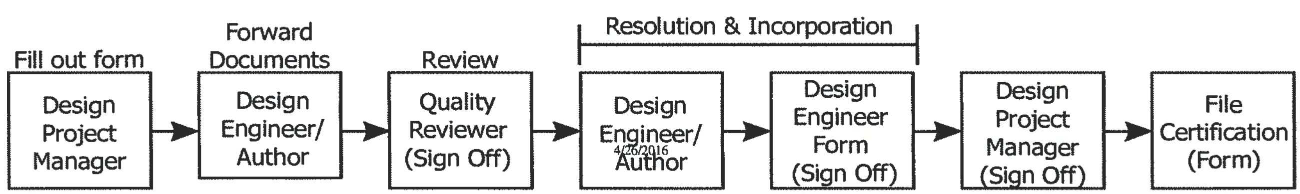
I certify that a Quality Review for this project has been completed. Review comments have been resolved.

Design Engineer/Date: 4/26/16
(signature)

I certify that my review comments have been incorporated to my satisfaction.

Quality Reviewer/Date: 4/26/2016 (Gold Form Issued)
(signature)

UCM Checklist included with submittal: N/A



QAQC Internal Project Review Schedule

Project Name:
Annie Storm Drainage Improvements - PER

Sub-Project No.: 5789.106	Task Order No.: 6006505ESD
Sponsor Contact: Annabell Ulary	Project Manager: Annabell Ulary
Team 3 Supervisor: Jennifer Massie-Gore, P.E.	Team 3 Designer: Kiersten Dube
Independent Technical Reviewer: (60%, 90%) Thu Cao, P.E.	CID Reviewer: (60%, 90%) Lek Mateo

Phase	QAQC Review Due Date	Internal Submittal Review Date	Internal Complete Review Date	Sponsor Delivery Date	
Preliminary Review Phase	April 26, 2016	April 26, 2016	April 26, 2016	May 4, 2016	
30% Review Phase					
60% Review Phase					
60% On-Site review				N/A	
90% Review Phase					

eCAPRIS Design End Date:

Schedule Change Requested By

Sponsor/Project Manager/ESD Engineer:

Date

Reason for Change:

Team Leader & Team Members:
Jennifer Massie-Gore
Kiersten Dube

Initial(s)
JMG
KD

Internal QA/QC Review of
Revised Pre-project Lag Times – 1st Review
and
Revised Pre-project HMS Model – 1st Review

Response by Kiersten Dube in green 1/26/2015
Response by Ella Zhang in Dark Blue Rev. 02/06/2015

Spreadsheet

1. The maximum sheet flow in original HMS model created by Halff Associates is 300ft. The maximum sheet flow in modified HMS model is 100ft. How do we compare the two models in case we need?
   Use 100' max sheet flow for revised existing model to reflect method change for time of concentration calculation, and then use 100' max for the ultimate conditions.

2. The paths for channel flow are not clear. When is the flow considered as channel, no defined channel and slightly defined channel?
   All flows contained in East Bouldin Creek are considered as defined channel flow. Others like gutter, storm pipe flow should be considered as no defined channel and use manning's equation for storm drain system velocity calculations.

3. East Bouldin Main Channel Velocity Equation = 178.89 *(slope 2/100) +3.5055 may be apply for channel only (not for No Defined Channel)?
   For existing storm systems, Manning's equation can be used for velocity estimates (V=Qfull/A).

EBLDNA:

-Check slope 2 (0.005 ft/ft is low)
-Check no defined channel flow?
-Final Tlag is high (42.34 min) compared to Tlag of EBLDN070 (23 min)
Corrected slope for shallow concentrated flow. Different methods are used for times of concentration calculation, and channel lengths are different compared to the FEMA model.

EBLDNB:

- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (530-520)
Channel flow changed to 359' w/ a slope of 0.010 ft/ft.

EBLDNC:

-See mark-up sheet for Drainage area dividing line.
1. No revision, checked in field on 11-18-14 and 11-18-9-14
-The total length in excel (765') does not match with the CAD file (771')
- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope. (503-492)
Revised total flow path from 771' to 878' (channel flow 110').

EBLDND:?

-See mark-up sheet for Drainage area dividing line.
2. Revised
-The total length in excel (5909') does not match with the CAD file (1717')?
Need to add channel flow w/ East Bouldin Creek.
-Length 3: where does it end?
Added 4,395 LF channel flow.

EBLDNE: N/A

EBLDNF:
-The total length in excel (1280') does not match with the CAD file (1821')?
-Length 2= 329' (too short)
-Length 3= 851' (too long)
Total flow path has changed from 1821'.

EBLDNG:
- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (530-513)
Changed channel flow to 195' defined channel.

EBLDNH:
4. Revised drainage area between H and F along Johanna Street between1st and 2nd Streets
-Length 3: The path for channel flow is not clear. The length does not match with calculated elevation (524-505)
Channel flow 696' based on storm drainage pipe GIS information.

EBLDNI:
-Drainage dividing line should be at the highest point. (See mark-up sheet)
3. No change; previously revised as part of Annie Drainage Area DA-A06 QA/QC comments
- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (518-505)
Changed channel flow 260'.

EBLDNJ:
- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (515-505)
No change: total length 416' (channel flow 265').

EBLDNK:
- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (510-505)
Total flow path changed from 408 to 532.75'.

EBLDNL:
- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (518-510)

No change: total flow path 1,797’ and channel flow changed to 769’ based on GIS drainage pipes and manning’s calculations.

EBLDNM:

- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (517-505)

Drainage path for channel flows consist of 30” & 36” storm drain pipes. Manning’s equation is used for channel flow estimate assuming pipe flowing full for average velocity estimates.

EBLDNN:

-See mark-up sheet for Drainage area dividing line.

No change; field verified parking lot drainage on 11-18-14 and 11-18-9-14

-Why there is no channel flow?

Changed total flow path to 463’ (channel flow 200’).

EBLDNO:

-See mark-up sheet for Drainage area dividing line.

No change; field verified Sept and Oct 2014

-Channel flow run from downstream to upstream

- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (505-500)

Changed drainage flow path (channel flow 137’).

EBLDNP:

-See mark-up sheet for Drainage area dividing line.

Revised; see comments for EBLDN-D

- There are two areas named EBLDNP. Suggesting name these areas as EBLDNP-1 and EBLDNP-2 Areas renamed EBLND-P1 and EBLDN-P2

-The path of Tc does not show the path of actual flow

- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (508-497)

Two (2) sub-basins contributing to the same downstream channel (channel flow 1,514’ based on GIS storm drain information).

EBLDNQ:

- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (533-500)

Total flow path changed to 2,245’ and channel flow 1,024’ based on GIS storm drain pipes.

EBLDNR:

- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (558-554)

No change: Total flow path 1,357’ and channel flow 302’.

EBLDNS:

- The path for channel flow is not clear. The length in excel does not match with the measured length matching with elevations that used to calculate the slope (583-568)

Channel flow path changed to 1,259’.

HMS MODEL

1. Comparing the peak discharge for 25year at Confluence of the following model:

	Peak Discharge (CFS)
EastBldn_Ex_pre-project:	1549.1
EastBldn_Ult_pre-project:	1563.5
EastBldn:	1569.3

They show the peak flow at confluence of Ultimate condition is less than the one in Eff-COA model. It is not reasonable. The revised model changed the flow patter for EBLDN080; the original model is based on topography only. The revised model divides EBLDN080 as necessary to create control points (junctions) at EBC/road crossings. The runoff actually flows west to east through storm drain to reach these critical points; drainage areas were drawn to reflect this. The original model, based on topography, has the water flowing north. The ESD revised drainage areas would impact the timing of flow and therefore, I don’t think peak flows at the confluence with Town Lake can be compared between the original consultant’s model and the ESD revised model.

2. Comparing the peak discharge for 25year at Alpine of the following model:

	Peak Discharge (CFS)
EastBldn_Ex_pre-project:	571.3
EastBldn_Ult_pre-project:	571.3
EastBldn:	570.5

The impervious cover at upstream are the same for two models, but the results show the peak flow at Alpine of Ultimate condition is more than the one in Eff-COA model? The consultant ran the model with 2 minute interval, ESD revised model used 1 minute interval. When the consultant’s model was re-run with 1 minute interval, the peak flows match for all features upstream of any ESD revisions.

3. Comparing the peak discharge for 25year at JEBLDN080 of the following model:

	Peak Discharge (CFS)
EastBldn_Ex_pre-project:	2456.2
EastBldn_Ult_pre-project:	2480.4
EastBldn:	2389.1

The impervious cover at upstream are the same for two models, but the results show the peak flow at JEBLDN080 of Ultimate condition is more than the one in Eff-COA model? See response to 1 and 2 above.

4. Edit Annie System 1
Comparing HEC-HMS model and storm cad model. The differences are bold. Please check the differences:
Existing pipes are grouped together in the HMS model for simplicity's sake. HMS inputs appendix includes how this was done.

	HMS	**StormCad**
	Annie Sys 1	Conduit 21643
Dia:	36"	36"
Length:	30ft,	30 ft
slope:	0.05 ft/ft	0.048ft/ft
	Annie Sys 2	Conduit 21648
Dia:	30"	30"
Length**:**	**215ft**,	**180 ft**
slope:	0.05 ft/ft	0.048ft/ft
	Annie Sys 3	**Conduit 21640.1 ?**
Dia:	18"	30"
Length:	81ft,	124 ft
slope:	0.05 ft/ft	0.048ft/ft
	Annie Sys 4	Conduit 23333
Dia:	30"	30"
Length:	71ft,	71 ft
slope:	0.05 ft/ft	0.048ft/ft
	Annie Sys 5	Conduit 23330
Dia:	30"	30"
Length:	48ft,	48 ft
slope:	**0.021** ft/ft	**0.006** ft/ft
	Annie Sys 6	Conduit 21850
Dia:	30"	30"
Length:	125ft,	125 ft
slope:	**0.053** ft/ft	**0.064** ft/ft
		Conduit 21819.1
Dia:		30"
Length:		**125** ft
slope:		0.064ft/ft
	Annie Sys 7	Conduit 21849
Dia:	30"	30"
Length:	**325** ft,	**251** ft
slope:	0.017 ft/ft	0.015ft/ft

	Annie Sys 8	Conduit 21845 **(CO-17 & CO-18 ?)**
Dia:	18”	18”
Length:	**199** ft	**161** ft
slope:	**0.032** ft/ft	**0.036** ft/ft

	Annie Sys 9	Conduit 21853,21858,21858.1 21862,21860
Dia:	24”	24”
Length:	**192** ft,	**183+161+41+94+195 = 674** ft
slope:	**0.008** ft/ft	**0.011,0.068, 0.002, 0.027, 0.027**
		Average=(556-539.54/674)=**0.024** ft/ft

There are different slopes in stormcad, but there is only one slope in HEC-HMS

Add junctions where having flow or simplify by ignore them? Simplification of HMS model came from a meeting with Thuan Nguyen in November 2014

	Annie Sys 10	Conduit 21853,21858,21858.1 21862,21860
Dia:	24”	24”
Length:	**558** ft	**92** ft
slope:	0.037 ft/ft	0.027ft/ft

Revised.

5. Diversion-S: Check the calculations of inflow of Diversion-S (rational method) and the flow of EBLDN-S in HEC-HMS (check % impervious cover)

Diversion S- Ex Inflow (cfs)	EBLDN-S Peak discharge (cfs)
0.00	
41.46	44
69.35	80
88.50	100.8
127.04	135.5

6. Diversion-R: Check the calculations of inflow of Diversion-R (rational method) and the flow of EBLDN-R in HEC-HMS (check % impervious cover)

Diversion R- Ex Inflow (cfs)	EBLDN-R Peak discharge (cfs)
0.00	
19.91	21.6
33.35	39.9
42.65	50.4
61.40	67.9

In Summary:

1. Tc calculation Spreadsheet:

-The longest Tc does not include the time the water the flow in the creek. Please check the channel flow for most of drainage areas.

-Please check specially the Tc for EBLDNA, EBLDND and EBLDNP

-Please check drainage area EBLDNP. Revised

2. HEC-HMS model:

-Edit Annie System 1 Revised

-Verify the size, length, slope of storm pipes in the field and edit the data in HEC-HMS. Make sure they match with the data in Stormcad.

- Check the inflow of Division-S and Division-R

File: N:\Team3\WPD_EBC_Annie_Documents_QAQC_PER\Annie_HMS_TCao_comments_EZ response.doc

<u>Internal QA/QC Review of Revised Pre-project Lag Times – 2nd Review</u>

Spreadsheet
Date received: 02/03/15
Date responded: 02/06/15 & 02/11/15
Thu's comments in Violet: 2/10/2015
-Please turn on building level
Please refer to Team 3\WPD_EBC_Annie\DGN\Annie_Exist_TC_021115.dgn

EBLDNA:
-Longest flow-path does not include flow in channel.
Total drainage path: 6,592.02' (5040.91'+1,551.11'). OK

EBLDNB:
-Longest flow-path=100+1973+372=2445 (not = 2837)
Total drainage path: 2,804.30 (2,445.05'+359.25') OK.
-Adjust sheet flow path so that it does not go through the buildings.
Sheet flow path changed (L1/L2: 63.09'/2443.85, L3 remains the same 359.25').

EBLDNC:
-Adjust flow path so that it does not go through the buildings.
Flow path changed (L1/L2: 100'/710.44').

EBLDND:
-Adjust flow path so that it does not go through the buildings.
Flow path changed (L1/L2: 71.81'/1,838.04').

EBLDNE:

EBLDNF:
-Adjust flow path so that it does not go through the buildings.
Flow path changed (L1/L2: 91.66'/1,184.49').

EBLDNG:
-Length3 corresponds to elevation (515-511) is ~72 (excel shows 195)?
Drainage path changed (Total flow length 878.39', Channel flow length is 195.47'). OK

EBLDNH:
-Longest flow-path=100+660+806=1566 (not = 1757).
Drainage path changed to 1,772.43'. OK

EBLDNI:
-Longest flow-path is not clear: (the length in excel =741, the measured length in micro-station is 571.46)
Drainage path changed to 741.48. OK.
-Adjust sheet flow path so that it perpendicular to contour line.
Flow path changed (L2/L3: 425.37'/238.40').

EBLDNJ:

EBLDNK:
-Longest flow-path is not clear: (the length in excel =533, the measured length in micro-station is 408)?

-Adjust flow path so that it does not go through the buildings.
Flow path changed (L1/L2/L3: 52.32'/319.10'/168.12').

EBLDNL:
EBLDNM:
EBLDNN:

-The Longest flow-path= 463 is not clear. It is longer than measured one in Micro-station (352.60+50.72=403.32)?

Total drainage path changed to 463'. OK

EBLDNO:

-Length 3 runs from downstream to upstream?

-Adjust flow path so that it does not go through the buildings.

Flow path changed (L1/L2/L3: 100'/666.34'/156.39').

EBLDNP:

- The longest path cannot run through EBLDND at dividing line.

EBLDN-P1 & P2 are connected through existing storm drain pipes and contributing to the same downstream drainage channel. Changed flow path of EBLDN-P (Total length changed from 2,319' to 2,464.02'). OK

EBLDNQ:

-Length3 correspond to elevation (533-500) is ~953(in excel=1153)?

Channel flow changed from 953' to 1,514' based on GIS drainage pipes. OK.

-Adjust flow path so that it does not go through the buildings.

Flow path changed (L1/L2/L3: 100'/1,111.79'/1024').

EBLDNR:

-Longest flow-path=100+775+302=1157 (not = 1357).

Total drainage path changed to 1,357'. OK

EBLDNS:

-Length3 correspond to elevation (583-568) is ~1259 (in excel 1459)?

Channel flow changed from 1459' to 1259'. OK

Note: a) CAD file N:\Team3\WPD_EBC_Annie\DGN\Annie_Exist_TC_020515.dgn.
N:\Team3\WPD_EBC_Annie\DGN\Annie_Exist_TC_021115.dgn.

b) N:\Team3\WPD_EBC_Annie\Eng_Analysis\Prelim Eng Phase\Lag Time Calculations for Annie_Existing/Ultimate conditions_REV_020615.xls (Tabs: EXIST/Ultimate LAG Time & Manning's Calcs)
N:\Team3\WPD_EBC_Annie\Eng_Analysis\Prelim Eng Phase\Lag Time Calculations for Annie_Existing/Ultimate conditions_REV_021115.xls (Tabs: EXIST/Ultimate LAG Time & Manning's Calcs)

Internal QA/QC Review of
Revised Pre-project HMS Model – 2nd Review
and
Revised Pre-project RAS Model

Thu Cao's Comment (6/16/2015)
Kiersten Response (6/22/15)

HMS Inputs_IC and CN_revd EBLDN pre_project.xlsx
HMS Inputs *tab*
- According to City of Austin Suburban Future Land Use Impervious Cover, Land use code of 700 (Open space) has average percent Impervious is 0. Please check EBLDN- A (has %IC 700 = 69%) Revised.

Notes:
-If EuC soil is classify as type C, the following drainage areas include both soil type C and type D: EBLDN_Q2, EBLDN_H, EBLDN_F, and EBLDN_B. The CN number should be calculated as composite CN. Current info from SSURGO classifies EuC as Type D. Additional explanation will be added to report.

Haff Associate classified EuC as soil group C, but current "Soil Survey of Travis County" classifies EuC as group D.
Generally, use type D to calculate for the ultimate condition is more conservative, but the calculated flow will increase.

Land Development Code does not indicate how many percent impervious cover for Zone P. If there is any increasing impervious cover inside the perimeter of the area, the owner has to build a pond to detain the water that increases because the increase of impervious cover. Unless the City owns/maintains the pond, we are modeling runoff as undetained.

Bring up to Watershed Protection Department about the following:

- *Locations where existing impervious cover are higher than the ultimate condition This is included in the report text.*
- *Originally there are 3 zones in Fulmore Middle school area: Zone CS, Zone SF-3 and Zone P. In current zoning, the whole area of the school is Zone P. Since the area is a school, assume it will remain a school and impervious cover calculated based on what is allowed for Zone P.*

HMS Inputs_revised EBLDN_pre_project.xlsx

HMS Summary_revd EBLDN_pre_project.xlsx
Comparison *tab*
Give the description for each table. Complete.

HEC-RAS models:

Suggestion: Run HEC-RAS existing Condition. Show the differences in elevation and top width by making comparison tables for original FEMA model, Pre-Existing model and Ultimate model for 10yr, 25yr and 100yr. Existing land use RAS model complete. .

Internal QA/QC Review of Existing Inlet Calculations

2/20/2015

Thu's comments
KD response in green
Thu's second comments in violet (3/17/2015)
Thu's Third comments in Brown (4/23/2015)
General comments:
-It is easier to review and follow the excel spreadsheet if putting the "Drainage Area" (column F) in the first column (col. A). Revised

Please note that in DCM "a" in Figure 4-1 to Figure 4-7 is different from "a" in Figure 4-9. This makes the reader confuse. This may be talked to Watershed Protection Department. Revised spreadsheet to use "a" value shown in HEC-22

-Because there are several inlets that are not standard inlets the Depth of Depression "a" may be different. The following inlets are not standard inlets: A1, A2, A18, and A19

-Use EQ. 3-1 in DCM to calculate the spread on one side of the street. Make sure Yo is less than or equal to 6" (or below the top of the curb). Revised. If Yo is greater than crown height, the distance from crown to curb is used for T. Note: even if Yo is less than crown height, water can still be over curb.
Equations in Cell: if the formula from HEC-22, please put the equation number Revised; equation source added to "equation in cell" description.

-Create a separate tab for street flow calculations. Revised.

Excel Spread sheet:

<u>Tc:</u>

Column "Channel Min. V": list calculating formula V = k*S^.5 with Reference book: Richard McCuen, <u>Hydrologic Analysis and Design</u> (New Jersey: Prentice Hall, 1998), p.143. Added the equations and reference to Tc tab (3/19/15)

<u>Street Flow Summary_EX:</u>

Street Classification can be found in GIS by adding "TRANSPORTATION.stree_segment" layer in Arc Map.
Revised 4/7/15

-Add column " Meet DCM Requirement or Not".
Revised 4/7/15

<u>Street Flow_Clear With_EX:</u>

-Column "Drainage Areas": Add DA- A17
~~-Column "Clear width from Crown" (cell S24): Check DA-08~~

-Column “DCM 3.2.0 Meet Clear Width Criteria”: add “on this sheet” after sentence “See Total Clear Width Analysis”
-How is “Ground Height at ROW” determined? Description included in PER.
Suggestion: Request Survey Company getting the elevation of the ROW in design phase.

-Column “Meets Clear Width Criteria?”: Add a note to explain why “Cannot determine”

Street Flow_Intersection_EX:

Check DA-18
Notes: Inlet A18 is sump inlet. The analysis of 2 year storm shows that the “Over Capacity Flow” of DA-18 is 3.44 cfs. The contour shows that the flow can cross W. Johanna St. and Newton St. intersection.

CURBInletsOnGrade-EX:
-Inlet A16: Contour map shows it is a sump inlet. Please check it. No change per discussion with JMG. Runoff primarily flows down Congress, although may back up a bit at the inlet.
-Curb Height Unit is inches, not feet (col. Y) Revised

-Curb Split Unit is inches, not feet (col. Z) No change. Split was measured on DGN file and is in feet. DCM Tables 3-3 and 3-4 report split in feet.

-Ponded Width (column AK) shows the widths are wider than the street width. Use EQ. 3-1 in DCM to calculate the spread on one side of the street. Make sure Yo is less than or equal to 6” (or below the top of the curb). Revised. If Yo is greater than crown height, the distance from crown to curb is used for T. Note: even if Yo is less than crown height, water can still be over curb.

- S’w (Col. AP): cross slope of the gutter measures from the cross slope of the pavement or = Sw-Sx. “a” is calculated as it is shown in Figure 4-1 (page 4-7, HEC 22) Revised to use the “a” value shown in HEC 22 Fig 4-1.a.2

Please note that in DCM “a” in Figure 4-1 to Figure 4-7 is different from “a” in Figure 4-9
As definition in HEC-22 standard COA inlet (508S-3) has Sw = 7”/18”=0.3888

Notes: Inlets A13 & A16: based on calculation for 25yr storm they act as orifices. In DCM orifice calculation is found in sag inlet.

-Inlet A-26: is on a driveway, pond width for parabolic crown is not applicable. Revised.

GRATE Inlets-GradeParabolic-EX:
-Curb Height (Col.Q): unit is “inches”, not “ft” Revised

-K3 (col. W): please check? Revised. Added a K3 value for DA-A10

-Ponded Width (col. AC). Use EQ. 3-1 to calculate the spread on one side of the street. Make sure Yo is less than or equal 6" (or below the top of the curb). Revised. If Yo is greater than crown height, the distance from crown to curb is used for T. Note: even if Yo is less than crown height, water can still be over curb.

-Depression a (col. AD): "a" is calculated as it is shown in Figure 4-1 (page 4-7, HEC 22) "a" is not used directly in the calculations. However, I used a_{DCM} to calculate Aw and Aw'. Clarified spreadsheet to distinguish between a_{DCM} and a_{HEC22}.

<u>GRATE Inlets-Grade-Vgutter-EX:</u>
Curb Height (Col.Q): unit is "inches", not "ft" Revised

Note:
Grate Inlet Reduction Factor (col. AR): Field observation (video) show the grate inlet A22 was blocked more than 35% because it was covered by leaves. Per JMG, use 35%

Cross section of the street at the grate inlet A22 shows there is no crown at the center line of the street. Although geopak doesn't show a cross slope, the cross slope was measured in the field with a smart level.

<u>CURB Inlets in supms-EX:</u>
Curb Height (col. U) unit is "inches", not "ft". Revised

-Inlet A6: check the curb opening and curb height. Depression cannot larger than curb opening height. No change; inlet parameters measured in the field.

Notes:
-Inlet A11 & A12: Contour show they are on grate inlets, but picture show they are in-sump inlets because COA adding the curb ramps. There are in-sump inlets for 2yr storm, but may be on-grate inlet for 25yr or 100yr Over Capacity Flow continues down Congress when it overtops the Mary Street crown. For the Inlet Calculation spreadsheet, Over Capacity Flow from these inlets is not routed to any other inlets in the Annie Street system since it continues down Congress.

- Inlet A18 and A19 have two opening. The openings is perpendicular to W. Johanna St. are in sumps. The ones that parallel to the street are on grade but the lengths are small The total length (length of perpendicular opening plus length of longitudinal opening) was used in the calculations

-Ponded Width (col. AG): Use EQ. 3-1 in DCM to calculate the spread on one side of the street. Make sure Yo is less than or equal to 6" (or below the top of the curb). Revised. If Yo is greater than crown height, the distance from crown to curb is used for T. Note: even if Yo is less than crown height, water can still be over curb.

-Gutter Depression (col AH): "a" is calculated as it is shown in Figure 4-1 (page 4-7, HEC 22) No change; "a_{DCM}" is used to calculate effective head on the orifice (d_o). See HEC22 Fig 4-18 on page 4-61. di = Yo + a_{DCM}/12. Clarified spreadsheet to distinguish between a_{DCM} and $a_{HEC22.}$ "a" in figure 4.9 (DCM) and "a" in Chart 10B (HEC-22, page A-21) are the same. Revised

-There is no depression for inlet A1 and A2 and a= 0 No change; depression measured in the field.

-Where is the flow of Drainage Area A25 going? There is no inlet for A25, flow from this area will be directly connected to the 24" line on Congress when modeled in StormCAD

Suggestion:

See the sheet 3 of 17 of the project "Fulmore Middle school Building Additional and Renovations for Storm Drain" for existing systems under the new building.

Attach the JPG file so that the picture is matched with the building line and trace the existing storm system in the boundary the school. (May be the system outlet to Inlet A13?). Modify the drainage areas in the school and recalculating if needed. No change to drainage areas. Inlet A13 inspected in the field 3-3-15; line from school is not connected to the inlet box, therefore, assume 15" line from school connects directly to 24" line on Congress.

Notes from Review Meeting Feb 27, 2014

1. For curb inlets on grate, use orifice flow when depth exceeds 1.4*h. Revised.

Internal QA/QC Review of Existing StormCAD Model

Thu's Comment (4/2/2015)
All comments addressed by Aaron Hanna, PE

Annie_ESD_Exist.stsw

-Project Properties: Because the file will be sent to Watershed Protection Department for review. Suggest fill in the blank as following:

-Title
-Engineer:
-Company:
-Note: Description of the project and notes (such as inlet A-25)

-Conduit Prototype-1:

Length (Scaled) (ft): -1.0?

-Gutter Catalog:

Based on standard detail 430-1 Gutter Cross Slope = (1/12) ft /1.5ft = 0.056 (not 0.375)

-Base Design:
Gravity Pipe:
Note: Storm cad set up minimum slope = 0.2 (ft/ft)

-Maximum Spread in Sag: Based on Table 3-1 DCM and Street Cross Sections standard Detail 1000S, the Inlet Maximum Spread in Sag depends on street Classification and the width of the street.

-Inlet A-25: Based on sheet 10 of 17 in the plan set "Fulmore Middle School –Building Additions and Renovations" Inlet A-25 connects to SS-A53 only (delete SS-A54, SS-A55 and SS-A56).

-Check the slopes of pipes below:

Element Type	Message
GU-5	The catch basin ground elevation at the upstream end of this gutter is lower than the catch basin ground elevation at the downstream end.
GU-5	Slope (Calculated) should be greater than zero.
I-A3	There is no gutter leaving this 'On Grade' catch basin. Bypassed flow is directed to the subnetwork outfall.
I-A4	There is no gutter leaving this 'On Grade' catch basin. Bypassed flow is directed to the subnetwork outfall.

SS-A49	Slope (0.636 ft/ft, V:H) is greater than (0.200 ft/ft, V:H). Check to see if the Start and Stop Inverts are correct.
SS-A47	Slope (0.304 ft/ft, V:H) is greater than (0.200 ft/ft, V:H). Check to see if the Start and Stop Inverts are correct.
SS-A45	Slope (0.478 ft/ft, V:H) is greater than (0.200 ft/ft, V:H). Check to see if the Start and Stop Inverts are correct.
SS-A39	Slope (0.577 ft/ft, V:H) is greater than (0.200 ft/ft, V:H). Check to see if the Start and Stop Inverts are correct.
SS-A40	Slope (0.213 ft/ft, V:H) is greater than (0.200 ft/ft, V:H). Check to see if the Start and Stop Inverts are correct.
SS-A41	Slope (0.711 ft/ft, V:H) is greater than (0.200 ft/ft, V:H). Check to see if the Start and Stop Inverts are correct.

-In other to have Stormcad showing the HGL correctly, please add short lateral pipes between the inlet I-A5 and the main and between the inlet I-A5 and the main. Remember to save as the model with different name before adding the lateral pipes.

-Set up Flextab to print the calculations for pipes and inlets of the project.

Annie_ESD_Mary.stsw

-The comments about the setup of the model are the same as above.

-Adjust distance from MH-20 to MH-19 so that it is equal or less than 300ft

- Explain diversion at T-40 and T-44 Project Properties

Internal QA/QC Review of Proposed HMS and Proposed RAS and Proposed Alt 1 StormCAD Models

Thu Cao's Comment (11/02/2015)
KD Response (11/05/15)

Annie_PROP_Alt1_KD.dgn

Proposed HMS Impervious Cover:
HMS Inputs_IC and CN_EBLDN_PropAlt1.xlsx

Proposed HMS other input values:
HMS Inputs_EBLDN_ProAlt1.xlsx
Div S In-Div funct *Tab*

HMS column name -->	Inflow	Diversion
Inlet Calcs column name -->	Q for EBLDN-S CFS	Flow to Congress Ave CFS
	(5)	(6)
	0	0
2 year_Ex	36.44	0.00
10 year_Ex	61.08	9.35
25 year_Ex	78.15	18.84
100 year_Ex	112.97	41.44
500 year_Ex	161.75	75.92

These diversion flows do not meet design criteria *3.1.4- Allowable Flow of Water Through Intersections: As the stormwater flow approaches a street or tee intersection (except alleys), an inlet is required if more than three (3) cubic feet per second for the 25-year storm shall flow across the intersection. No more than three (3) cfs for the 25-year storm shall be allowed to enter the bulb of a cul-de-sac or corner bubble. In both situations, the inlet cannot be placed inside the curb return.*
Because ESD was told that do not touch the existing system on Congress Ave., remember to mention in in the report. Included in report.

Proposed HMS Lag Time
Lag Time Calculations_EBLDN_ProAlt1_ExLU.xlsx
Lag Time Calculations_EBLDN_ProAlt1_UltLU.xlsx

Proposed HEC-HMS model:
HMS_Summary_EBLDN__ProAlt1.xlsx

-Diversion flow S in the model is not the same in Inflow/ Diversion Table in Excel file
Revised

Proposed RAS Flow Change Locations
RAS flow change locations_Prop Alt1.xls

Proposed HEC-RAS models:

RAS Results – change in water surface elevation
RAS_results_revd EBLDN.xlsx
Revised

Proposed Storm Cad Model:
-Remember clean up the file before sending to sponsor department for review.
-Proposed storm line shall match soffit, not match invert
-Downstream pipes have bigger size than upstream size (Annie-Newton-Milton) This is due to diversion and limits of pipe size through existing Annie St bridge.
- HGL of Pipe PR-SS-M1 is high; consider increase the pipe size to 48". Report recommends further structural evaluation of existing bridges to see if pipes can be larger.
-Suggestion: The HGL 100 year of the pipe on Congress from Leland St to Mary Street is above the ground and very high. Consider upsizing the pipes on Congress from Leland St to Mary Street. Included in report is discussion of why Congress was not upsized
-The velocities of the following trunk pipes are > 20 ft/s (for 25yr):

Pipe Label	Velocity (ft/s)	
SS-A20	23.68	Existing pipe
SS-A21	21.78	Existing pipe
PR-CO-158	21.45	utility conflict
PR-CO-162	22.89	utility conflict
PR-CO-197	21.89	utility conflict and diversion

Consider to modify the slope of the pipes to reduce the velocities to maximum velocity = 20ft/s These pipes are impacted by utility conflicts with existing wastewater lines that have poor record drawings. I noted in report that velocity issue should be resolved in design after potholing for existing wastewater lines.

Internal QA/QC Review of Proposed Rain Gardens

RAIN GARDEN
Thu Cao's comment 5/14/2015
Comments addressed by Micheal Singleton, EIT

EXHIBIT (or Attachment1):

- Add North Arrow
-Some call-out texts are difficult to read. Please change the color of the text.
Suggest create one exhibit with aerial view and one without aerial view.

Rain Garden location selection:
- Spots for Rain Garden need full or partial sun with the slope is less than 15%. The locations of RG4, RG5, RG5B, RG6A, RG6B, RG6C may not have enough sun light for plants.
- Minimum required steps for establishing infiltration rate are in Table 1.6.7.1 (required Desktop study, Field sampling, In-situ Testing)
- Need tree survey to verify the root zone of the trees for RG3, RG4, RG5, RG5B, RG6A, RG6B & RG6C.

Detention pond location selection:
-The location of proposed detention pond DP1 is existing External Filter Area (see sheet 4 of 8 of the project "Running Track Renovations Fulmore Middle School" and also ground water was encountered at one foot below ground.)
- Reconsider the selection of DP2. The design of Track and Field may not allow to lower the area inside the running track because other activities.

MEMORANDUM:

-Suggest changing "To" and "Subject" as below:
To: Jorge Morales, P.E.
Supervising Engineer
Watershed Protection Department

Subject: Annie Storm Drainage Improvements *(the same name in Ecapris)*
Proposed Fulmore Middle school Rain Gardens and Detention Ponds.

-Page 1, 1st Paragraph: (CIP ID 5789.106)

-Page 1,2nd Paragraph, last sentence: any water quality credit from Equation 1.6.7-1 9 (ECM)?

-Page 2, 3rd Paragraph:
Here is the landscape design from 1.6.7.8 (ECM):

“Although an essential role of the vegetation is to make the rain garden attractive, the highest priority shall be to meet the water quality and soil stabilization functional requirements. Another important function of the vegetation is to help reduce clogging of the growing medium. Vegetation should be selected based on its ability to survive under alternating conditions of inundation and extended dry periods .High plant diversity is recommended and will provide resiliency to the system and help prevent a situation where all vegetation is lost. Over time, the plant species that are best suited to the unique conditions of each rain garden will naturally self-select and spread.”
So besides native grasses, other plant species that appropriate for rain garden should be selected.

Last sentence: According to ECM 1.6.7.4, *“For runoff up to the design volume, full infiltration rain gardens provide 100% total suspended solids (TSS) removal compared to 87% TSS removal for sedimentation/filtration systems”*. Do we need to calculate sediment removal?

SPREADSHEET:
-Add title for each attachment
- Calculate the water quantity credit (WQC) (if have time). The WQC may be based on the impervious cover of the track and field and the tennis court (see Example Case Study 1 in 1.6.7.9, ECM)

Exhibit P.2

Watershed Protection Department Reviews

Dube, Kiersten

From:	Nguyen, Thuan
Sent:	Tuesday, June 09, 2015 8:17 AM
To:	Massie-Gore, Jennifer; Dube, Kiersten
Cc:	Banse, Meagan; Morales, Jorge (WPD); Odufuye, Adewale
Subject:	RE: Annie St - revised existing conditions model

Jennifer,

The responses, along with the inclusion of additional language and figures (as mentioned in previous emails) into the final PER, address my comments on the revised existing conditions model.

Thanks,

Thuan

From: Massie-Gore, Jennifer
Sent: Monday, June 08, 2015 2:34 PM
To: Nguyen, Thuan; Dube, Kiersten
Cc: Banse, Meagan; Morales, Jorge (WPD); Odufuye, Adewale
Subject: RE: Annie St - revised existing conditions model

Thuan,
Please see our responses below in orange. Let us know if this doesn't clear your comments for our revised existing conditions model.

Thank you for all your help.

Jenny Massie-Gore, P.E.
Engineer C - Engineering Services Division
City of Austin - Public Works Dept.
505 Barton Springs Rd., Ste. 900
Austin, TX 78704
(512) 974-7774
jennifer.massie-gore@austintexas.gov

From: Nguyen, Thuan
Sent: Friday, May 29, 2015 2:27 PM
To: Massie-Gore, Jennifer; Dube, Kiersten
Cc: Banse, Meagan; Morales, Jorge (WPD)
Subject: Annie St - revised existing conditions model

Jennifer and Kiersten,

Below are my comments on the revised existing conditions model, some were discussed in Wednesday's meeting;

1) The revised existing conditions model show significant flow increases downstream of the project area when compared to the effective model. There appear to be many reasons for this, including:

a. The splitting of subbasins EBLDN070, 080, and 100 into a number of smaller subbasins with shorter times of concentrations
b. changing of the computation time step from 2 minutes to 1 minute to account for minimum lag times that were the result of the smaller subbasins
c. the Modified Puls routing subreaches getting doubled as a result of the decrease in the computation time step
d. the decrease in Modified Puls storage for REBLDN070 and REBLDN090 when compared revised existing to effective
e. the increase in curve numbers for subbasins EBLDN070, 080 and 100; the IC actually decreased in many cases – especially for existing land use conditions

RESPONSE – Subbasins EBLDN070, 080, and 100 were split into smaller subbasins to determine a pre-project flow. The pre-project flow will be compared to the post-project flow at these catchment point locations. The comparisons will be done to determine the impacts to the creek at these catchment locations. Plus, splitting of the subbasins is a more accurate representation of the runoff direction (directly to the creek vs. overland to the bottom of the basin). We agree that the time step changes from 2 minutes to one minute as a result of the splitting of the subbasins and that the Modified Puls routing subreaches double as a result of the decrease in computation time step. The Curve numbers for subbasins EBLDN070, 080 and 100 were determined using the soil type and impervious cover. The project area is Hydrologic Soil Group D according to current Soil Survey Geographical Maps. We will add this description to the final PER. Also, the Sheet Flow lengths in the Time of Concentration calculations were revised according to the current Drainage Criteria Manual (DCM). The original study was completed when the DCM allowed for Sheet Flow lengths up to 300 ft. The current DCM limits Sheet flow lengths up to 100 ft in urbanized areas.

2) While the revisions in 1 may be justifiable to establish a good baseline point for comparison purposes between existing and proposed conditions, the following observations were made that warrant a closer look:
   a. The CN for EBLDN070, 080, and 100 are 76, 76, and 78, respectively, based on a combination of C and D soils. The revised subbasins (A-T) all have CN of 80, suggesting all D soils. Was more up to date soil data used? Please confirm and clarify.
   b. The lag time for EBLDN-A for the revised existing conditions submittal (dated April 2015) reduced by almost half when compared to the original existing conditions submittal (dated December 2014) with most of the change being in the shallow concentrated time. It appeared that the slope changed quite a bit. Please confirm and clarify.
   c. The lag time for P-1 in the April 2015 submittal is also almost half of the lag time for P (only slightly bigger than P-1) in the Dec 2014 submittal. Please confirm and clarify.
   d. Please explain why there are two lag times, one for existing land use conditions and one for ultimate land use conditions. What assumptions are being made under ultimate land use conditions to change the lag time?
   e. Consider combining some subbasins, unless they are needed to establish comparison points or for diversions, to eliminate the really small subbasins with minimum lag times.
   f. Check the starting and ending XS's of the routing reaches. R070REVD1 US XS of 12391.5 and R070REVD7 DS XS of 8764 do not match the effective R070 US XS of 12685 and DS XS of 8857. R090REVD1 US XS of 3779 and R090REVD2 DS XS of 1534 do not match the effective R090 US XS of 4022 and DS XS of 1823. Some cross sections may have been moved between the effective routing run and the final effective model in HEC-RAS, but the differences are large and confirmation is needed. Also, consider using the same range of flows (or similar) as effective model for easier comparison and to remove crossing profiles (i.e. volume reduced as flows went up).

RESPONSE –a. The project area is Hydrologic Soil Group D according to current Soil Survey Geographical Maps.
b. The lag time for EBLDN-A was revised from the first submittal (in December 2014) to the second submittal (April 2015). Our QA/QC reviewer noticed the incorrect Time of Concentration which resulted in the longer lag time.

c. Yes, the lag time is shorter in the April 2015 submittal. The original configuration of the subbasins had a disconnected basin for P. Most of the runoff for P was overland (slower) flow. The breakup of subbasin P into P1 and P2 led to shorter (faster) piped runoff.
d. Impervious cover is a factor in the lag time calculations in the original watershed study performed by the consultant. The impervious cover increases in the ultimate and existing conditions and that change is reflected in the lag time.
e. We combined EBLDN P2 and EBLDN Q, then combined EBLDN N with EBLDN O. We incorporated EBLDN T to the Diversion Table for S.
f. We revised the starting and ending cross sections for the routing reach. The cross sections now match exactly. The effective HEC-RAS model was used as the routing run and used the same upstream and downstream cross sections as the 2005 study to create the storage discharge function. A range of flows more similar to the effective model flows was used in our routing run and produced storage-discharge tables without crossing profiles.

Thanks,

Thuan Nguyen, P.E., CFM
City of Austin
Watershed Protection Department
Watershed Engineering Division
(512) 974-3513

Dube, Kiersten

From: Nguyen, Thuan
Sent: Thursday, June 04, 2015 2:44 PM
To: Dube, Kiersten
Cc: Massie-Gore, Jennifer; Banse, Meagan
Subject: Annie St

Kiersten,

As you're responding to the comments, are you going to produce a final report reflecting the latest revisions? If so, please include hard copies of maps showing Tc flow paths, soils, and existing and ultimate landuse/zoning. This would help support your calculations of these parameters and it's nice to have it contained in one report even though I know you will submit electronic versions as well.

Thanks,

Thuan Nguyen, P.E., CFM
City of Austin
Watershed Protection Department
Watershed Engineering Division
(512) 974-3513

Dube, Kiersten

From: Nguyen, Thuan
Sent: Tuesday, June 02, 2015 3:20 PM
To: Dube, Kiersten
Cc: Banse, Meagan; Massie-Gore, Jennifer; Morales, Jorge (WPD)
Subject: RE: Annie Street Storm Drain Improvements - HMS and RAS

Kiersten,

See below for my responses to your questions.

From: Dube, Kiersten
Sent: Monday, June 01, 2015 12:50 PM
To: Nguyen, Thuan
Cc: Banse, Meagan; Byars, Morgan; Massie-Gore, Jennifer
Subject: Annie Street Storm Drain Improvements - HMS and RAS

Hi Thuan,

I just sent a meeting invite so we can wrap up the revised pre-project HMS comments. We also have a couple of RAS questions.

HMS:
In response to Thuan's comments, we have simplified some of the drainage areas and revised storage-discharge tables, but still need to run the model with a 1 minute interval. Peak flows are still higher than the original model. We will include discussion of why the flows are higher in the final PER and in a follow up to Thuan's latest email (5/29/15).

RAS Questions:

1. If the Eff_FEMA RAS model is run in RAS 4.1.0 without any revisions, the 25-year profile fails to optimize at Junction A (culvert split). Increasing the "Max difference in junction split flow" to 0.1 resolves the issue. Is this an acceptable fix?
   Try increasing the "maximum iteration in Split flow" to 60 first and if that does not work, try increasing the "max difference in junction split flow" by increment of .01 from the default of .02 until the issue is resolved.

2. We have been asked to analyze 2-year water surface elevations, but the Eff_FEMA model does not have a 2-year profile. We can get necessary flow data from running Eff_COA HMS with 2-year rainfall. For low flows, there is only water in the Culvert Split and nothing in Reach 2. So, for the 2-year profile, I turned Flow Optimization off at Junction A. RAS won't run with zero flow in Reach 2, so I gave it a negligible flow (0.00001 cfs). Is this acceptable?
   That should be fine. We have used 1 cfs before to get the model going so something even smaller should be ok.

Kiersten Dube
Project Coordinator
City of Austin
Engineering Services Division
512.974.7134
kiersten.dube@austintexas.gov

Dube, Kiersten

From: Nguyen, Thuan
Sent: Tuesday, March 10, 2015 1:40 PM
To: Massie-Gore, Jennifer; Banse, Meagan; Morales, Jorge (WPD)
Cc: Dube, Kiersten; Cao, Thu; Odufuye, Adewale
Subject: RE: Annie PER - Monthly Meeting Minutes

Jennifer,

My answer to question 1 below is to leave the sub-basins that are not affected by the project as they exist in the effective model.

Thuan

From: Massie-Gore, Jennifer
Sent: Wednesday, March 04, 2015 2:36 PM
To: Banse, Meagan; Morales, Jorge (WPD); Nguyen, Thuan
Cc: Dube, Kiersten; Cao, Thu; Odufuye, Adewale
Subject: FW: Annie PER - Monthly Meeting Minutes

Meagan, Jorge and Thuan,
Thank you for meeting with us Monday morning regarding the Annie PER review comments and for the technical support. Please see below for our responses and some additional questions and items that still need attention and points of clarification. We are getting close to completing Task 5. Our target date for Task 5 is March 5. However, I think we will have to push the Target Date out a few weeks (March 20) to wrap up the StormCAD alternatives. Please let me know if the schedule adjustment causes any issues.

Item / Questions

1. Should ESD leave the sheet flow as 300 ft vs. 100 ft part of the Time of Concentration calculation for the sub-basins we are not "touching"?
2. It appears that the definition of "a" in the inlet calculations changed from the previous DCM and the current DCM. Figures 4-1 through 4-7 have a similar definition of "a" and Figures 4-9, 4-14 and 4-16 have a different definition of "a". What is watershed's intent and what is the definition of "a"?
3. How is the number of steps used in the routing calculations? How is the time step used in the calculations? – Thuan provided an answer in email 3/3/15. (Thank you!)

Clarification

1. The new storm sewer pipe for Mary Street being design by Mr. Lopez in ESD will be part of the proposed, possible alternative scenarios. There will be at least three condition for the stormCAD models. 1) Existing Condition, 2) Existing Condition with the proposed West Mary Street Storm repair and 3)Proposed West Mary Street Storm sewer repair with storm sewer alternatives.

Responses – See Below in orange.

Please let me know if I have missed anything or if I misstated something.
Thank you,

Jenny Massie-Gore, P.E.
Engineer C

City of Austin - Dept. of Public Works
505 Barton Springs Rd., Ste. 900
Austin, TX 78704
(512) 974-7774
jennifer.massie-gore@austintexas.gov

From: Banse, Meagan
Sent: Friday, January 30, 2015 2:41 PM
To: Massie-Gore, Jennifer
Cc: Dube, Kiersten; Morales, Jorge (WPD); Nguyen, Thuan
Subject: Annie PER - Pre-Project Hydrology Review

Jennie and Kiersten,
Here are the combined comments from CFHM & LFHM for the Annie Project's drainage report dated December 12, 2014. It may be beneficial to meet in person to discuss these comments after you have had a chance to review them.

Comments:

1) Please add to Section 2.2 of the report a description of which sub-basin(s) from the effective model were altered to create the project specific sub-basins (EBLDN-A through EBLDN-T). **RESPONSE – ESD will add a section to describe which sub-basins from the effective model were altered.**
2) Consider summarizing relevant hydrologic differences between effective and pre-project in a table within the report. Differences in total drainage area, travel time or time of peak, and flow at key junctions such as the confluence with the Colorado River and the junction immediately downstream of the revised sub-basins would help to validate and understand the pre-project better. **RESPONSE – ESD will add a summary of the relevant hydrologic differences between the effective and pre-project in a table and a map.**
3) The storage for the revised reaches should be obtained from the HEC-RAS model similar to the way it was done for the effective model. Additional HEC-RAS cross sections may need to be added as appropriate. Also, the routing sub-reaches (routing steps) should be calculated and not be default to 1. See East Bouldin Hydrologic TSDN Appendix B. The latest East Bouldin HEC-RAS model can be obtained from Floodpro. The East Bouldin Hydrologic (and the Hydraulic) TSDN can be obtained by emailing Katina.Bohrer@austintexas.gov. **RESPONSE - The storage for the revised reaches will be obtained from the HEC-RAS effective model. The routing sub-reaches (routing steps) will be calculated.**
4) Please provide plans or system maps so that the parameters and layouts of the Diversions and the Annie system reaches could be confirmed. Annie System 3 seems to be the wrong size at 18" diameter while the segments upstream and downstream are 30". **RESPONSE – ESD will the available record drawings and field books for the existing storm sewer system. Plus, Watershed will check to see if they have any information that has not been given to ESD yet.**
5) Typically, the diverted flows should represent flows that are not captured by the system (i.e. flows that are being diverted). The way they are currently modeled may produce the correct flows, but is not being represented in a typical fashion, particularly Diversion S. Revise inflow-diversion tables and connections for diversions R and S as appropriate. **RESPONSE – For this study, ESD understands that the diversions represent the storm water captured by the storm sewer inlets. ESD will add descriptions in the report to that point.**
6) The Curve Numbers for the revised sub-basins should reflect the soil and land use conditions without impervious cover as the IC is input as a separate parameter similar to how it was done in the effective model (see East Bouldin Hydrology TSDN Appendix B). By using the composite CN and inputting the IC, the IC is being double counted. **RESPONSE – ESD will revise the model to reflect the CN for the soil group and the IC.**
7) Lag time:

a. The sheet flow length should reflect field conditions and not default to 100 feet unless it is 100 feet or greater. Please revise as necessary and provide longest flow paths for review. **RESPONSE – ESD will revise the sheet flow lengths to reflect real world conditions and not default to 100 ft.**

b. Channel velocities – only sub-basins that have East Bouldin creek as the channel flow segment should use the statistical analysis East Bouldin Creek main channel velocity equation. And for these, since the slope is already represented as ft/ft, it should not be divided by 100. The sub-basins where the channel flow segment represents pipe flow or open channel flow that is not East Bouldin creek, the velocities should be calculated using Manning's equation for full pipe or bank-full conditions. **RESPONSE – ESD will revise the channel flow segment calculations so that only the East Bouldin Creek main channel will be use the statistical analysis velocity equation. Velocities will be calculated using Manning's equation for full pipe or bank-full conditions for the sub-basins where the channel flow segment that is not East Bouldin Creek. ESD will revise the slopes.**

8) Exhibit B.1 – please show the outlines of the effective sub-basins that were altered and modify the colors for easier viewing and identification. **RESPONSE – ESD will show the outlines (in a different color) of the effective sub-basins that were altered.**

Thanks,

Meagan Banse, PE, MBA, LEED AP
Engineer C
City of Austin - Watershed Protection Dept.
505 Barton Springs Rd, 12th Floor
Austin, Texas 78704
Ph**:(512) 974-1863* ***Email: *meagan.banse@austintexas.gov*

M E M O R A N D U M

KD response in green

TO: Jenny Massie-Gore, PE

FROM: Jorge Morales, PE, CFM and Annabell Ulary, EIT, CFM

DATE: September 28, 2015

RE: Review of Annie Street Storm Sewer System Improvements: Task 5 – Hydraulic Analysis

BODY:

This memo contains a list of comments for that were generated upon review of ESD's Task 5 submittal.

- *Section 1.13 – Tailwater Conditions* (pg. 4) – There is no mention about using the alternative tailwater elevations (e.g. using the 10-year water surface elevations for the 25-year storm drain analysis and using the 25-year water surface elevations for the 100-year storm drain analysis) **This information is included in the final report.**
- *Section 1.15 – Proposed Alternatives (pg. 5)* – In a discussion with Jorge, he disagrees with the statement, "*after discussions with WPD during a project meeting, Congress Avenue was omitted from upgrades due to protected street status and difficulty of construction on Congress Avenue*." **Final report includes hydrologic and hydraulic reasons for not upgrading Congress Avenue**
- *Appendix E* – The table does not include SS-A1 through SS-A11 and the "Record Drawing Notes" does not include SS-A30 through SS-A53 **Revised**
- *Appendix F* – This appendix appears to be for the existing storm drains, if this is the case a clarification in the appendix title is suggested **Revised**
- *Appendix G* – Clarify the source of the boundary for the Mary Street Relief line. The boundary as it is does not appear to follow the catchments, the streets or the existing system **The boundary was from WPD. The boundary was used for interim analysis, but is not included in the final report**
- *Appendix G – Exhibit A.2* – There is a 15-inch pipe located on the east side of Johanna St, per DCM the smallest pipe that we currently install is an 18-inch. **Revised**
- *Appendix H – Exhibit H.1* – Under the "issues" section why are both alternatives listed as "lines may not be feasible?" **Final report includes discussion of structural limits of the bride and discussion with Pirouz Moin**.
- *General comment* – The alternative where there is an outfall on Milton is not mentioned. **This information is included in the final report.**

Dube, Kiersten

From: Nguyen, Thuan
Sent: Friday, January 22, 2016 2:44 PM
To: Dube, Kiersten
Subject: RE: Annie Street review

Kiersten,

I have done an overall HMS review and in general everything looks reasonable in terms of flows increasing where I would expect them to. Flows decreased downstream of the project area. Do you think the faster lag time under the proposed conditions were the main reason for this? While I didn't have time to do a complete review, I have the following comments based on what I have reviewed:

1) Consider including a background map showing subbasins within the HMS model.
2) Consider providing a write up summary of all the changes in the model between pre-project and post project.
3) Please make sure the reaches representing the pipe segments are appropriately named between pre-project and post project.

Sorry I wasn't able to do a more complete review. I had a lot of things to wrap up. I was informed that I'll be the PM on this project so I'll still be involved and we can discuss it further at that time.

Thanks,

Thuan

HMS and Alternative 4 StormcAD Reievw
December 2020 comments from WPD

Annie St. CIP
HMS/StormCAD Model Submittal Comments

Comment No.	Model	Comment	Responder	Response	author	Cleared?	Additional Comments	Response
1	HMS	The meteorological data is pre-atlas 14, please update.	Kiersten Dube	~~Meterological data was updated to Atlas 14.~~	Jason Recker	Y	-	Update: Per Watershed Engineering, the 500-year pre-Atlas 14 storm can still be used in place of the Atlas 14 100-year storm. The HMS pre-project and proposed models were revised back to using pre-Atlas 14 rainfall. A computation run for the 500-year pre-Atlas14 storm was also added. The Annie Street HMS models were created from the effective HMS model, which includes the SCS Storm and 24-hour rainfall depths. The current DCM method is based on frequency storms derived from Atlas 14 rainfall data. Combining Atlas 14 24-hour rainfall depths with the SCS storm is not a method accepted by Watershed Engineering.~KD
2	HMS	Why is DA A-7 not included as input at the junction "J-Eva"?	Kiersten Dube	DA-A7 is an area used in the inlet calculations. HMS drainage areas are a simplification of inlet drainage areas. The area for DA-A7 is combined with several other inlet drainage areas to form HMS subbasin area EBLDN-M1.	Jason Recker	Y	-	
3	HMS	The pipe diameters in the HMS model for the Annie and Johanna st. stormdrains do not match the proposed pipe diameters in the StormCAD model. Please explain the reasoning behind this.	Kiersten Dube	The intent is for proposed pipe data to be included in the proposed HMS model. Please see submittal dated 11/06/2020.	Jason Recker	Y	-	
4	HMS - ALT. 4	The proposed peak flows on the HMS summary do not match the peak flows shown in the model. Please check.	Kiersten Dube	Please see submittal dated 11/06/2020.	Jason Recker	Y	-	
5	HMS Model	Can you provide a brief description of how you are modeling the annie st. system. It is unclear to me why only M1 is included in the annie st. system pipes when m2 and m3 are also conveyed by the annie st. pipe system.	Kiersten Dube	The pre-project HMS model was revised so that EBLDN-M2 is connected to J_9 and then flows through Reach Annie Sys Pipes1, which represents the pipes across private property and outfalling to the creek at Annie Street. Travel time through the Annie storm drain pipes is included in the EBLDN-M3 time of concentration. The HMS junction J_9 represents the outflow points for areas M1 and M2. The M1 outflow point is at the corner of Mary/Newton and the M2 outflow point is at the Mart Street sump. The points are not in the exact same location, but are close enough to model as one HMS junction. Runoff from M2 and M3 continues in storm drain after the subbasin outfall points. In contrast, runoff from M3 travels through storm drain within the subbasin area. As a result, pipe travel time is included in area M3's time of concentration.	Jason Recker	Y	Why is M2 not outfalled at Mary St. in the proposed model (ALT 4)?	The proposed HMS model was revised so that M2 is connected to a reach representing the Mary Street Relief Line. The reach is connected to the Mary creek junction. ~KD
6	StormCAD	Please included the background files for the stormcad model.	Kiersten Dube	Please see submittal dated 11/06/2020.	Jason Recker	Y	-	
7	StormCAD	Please provide the C-value and time of concentration calculations.	Kiersten Dube	Please see submittal dated 11/06/2020.	Jason Recker	Y	Could you please provide the Tc calcs, Inlet calcs and DA Map.	Tc and Inlet calcs are in the submittal dated 11/06/2020 (StormCAD_Alt4 folder --> Inlet_calculation_spreadsheets folder). Inlet drainage areas are shown in Appendix K.1 of the April 2016 draft PER submittal. The different alternatives all have the same inlets and inlet areas. The differences between alternatives are related to where the storm drain pipes ultimatley outfall into the creek. An inlet area map with Alternative 4 storm drain will be provided with the Alternative 4 PER submittal. ~KD
8	StormCAD	Please Explain reasoning behind using full capture inlets instead the specified catalog inlets.	Kiersten Dube	Catalog inlets and gutters are not used because StormCAD is not used to calculate inlet capture and bypass. Inlet capture and bypass are calculated on inlet calculation spreadsheets. The capture and bypass values are enterend into StormCAD in the System Flows alternatives under the column titled Flow (Additional Subsurface).	Jason Recker	Y	-	
9	StormCAD	How are you accounting for bypass flows without any gutters included in your model?	Kiersten Dube	same response as #8	Jason Recker	Y	-	
10	StormCAD	The proposed outfall along Annie St. is a 5'x7' RBC. A previous ESD PER submittal stated the following: "The maximum allowable size of pipe that can penetrate bridges on Mary Street and Annie Street is 42-inches. This has been determined by Pirouz Moin, PE from COA's Public Works Department. Mr. Moin has reviewed record drawings for these bridges and developed a detail of reinforcement at the bridge that is necessary for a 42"	Kiersten Dube	ESD is investigating the feasibility of a larger pipe through the existing Annie Street culvert. ESD is also looking at the possibiltiy of outfalling into the creek beside the culvert.	Jason Recker	Y	Unresolved but working on solution.	Structural analysis of existing roadway culvert is needed. We're waiting on a response from Street and Bridge to see if they can analyze the bridge.
11	StormCAD	The tailwater water surface elevation at the Johanna St. outfall for the 25-yr storm event appears to be low. Please check.	Kiersten Dube	Tailwater elevations are from the effective RAS model. An Alternative 4 RAS model was not created as part of this submittal.	Jason Recker	Y	Why not use the 500-yr WSE as the tailwater elevation for the Atlas-14 100 -yr model, as well as using the 100-yr WSE for the Atlas-14 25-yr model?	Watershed Engineering suggested using coincident peaks for the storm drain tailwater during an early project review. The method is described in April 2016 draft PER Section 12.9 and Appendix I. It appears that Watershed Engineering may no longer allow using coincident peaks for tailwater elevations based on DCM 5.5.0, second paragraph. The StormCAD model was updated to use peak-on-peak tailwater elevations with the assumption that the Effective model 500-year approximates Atlas 14 100-year and Effective model 100-year approximates Atlas 14 25-year water surface elevations. ~KD
12	StormCAD	Ensure that there is a transition included at every bend along the alignment with the appropriate headloss coefficient for each bend angle.	Kiersten Dube	Transitions were added to the StormCAD model as needed.	Jason Recker	Y	-	

Appendix Q –
Electronic Files

Index of Electronic Files

File No.	File Description
1	Microstation basemap of existing conditions
2	Microstation file of Proposed Alternative 1
3	Land Use and Impervious cover shapefiles
4	Drainage area shapefiles
5	Pre-Project HEC-HMS model (for comparison to Alternative 1)
6	Effective HEC-HMS model for 2-year storm
7	Revised Pre-Project HEC-RAS routing run and DSS files
8	Revised Pre-Project HEC-RAS model
9	Proposed Alternative 1 HEC-HMS model
10	Proposed Alternative 1 HEC-RAS model
11	Proposed Channel Improvements HEC-RAS model
12	StormCAD file for existing system
13	StormCAD file for Proposed Alternative 1
14	StormCAD file for Proposed Alternative 2
15	Rain Garden Spreadsheets - Adams&Papa and SLAT
16	Alternative 3 StormCAD files
17	Alternative 3 HEC-HMS files
18	HEC-HMS files for Detention options
19	Autocad files of existing conditions and existing utilities
20	Micorstation, AutoCAD and DXF files of Proposed Alternative 4
21	Pre-Project HEC-HMS model (for comparison to Alternative 4)
22	Proposed Alternative 4 HEC-HMS model
23	Proposed Alternative 4 StormCAD file

Appendix R –
Revised Pre-Project HEC-HMS Model
(October 2020)

Exhibit R.1	**Map of Effective and Revised Pre-Project Basins**
Exhibit R.2	**Map of Revised Pre-Project Basins, Storm Drains and Contours**
Exhibit R.3	**Map of Revised Pre-Project HEC-HMS Elements**
Exhibit R.4	**Model Schematic**
Exhibit R.5	**Area, Impervious Cover and Curve Number**
Exhibit R.6	**Sub-basin Lag Times**
Exhibit R.7	**Routing Steps**
Exhibit R.8	**Storage-Discharge Functions**
Exhibit R.9	**Travel (lag) Time for HMS Reach Elements**
Exhibit R.10	**Inflow-Diversion Tables**

Exhibit R.1

Map of Effective and Revised Pre-Project Basins

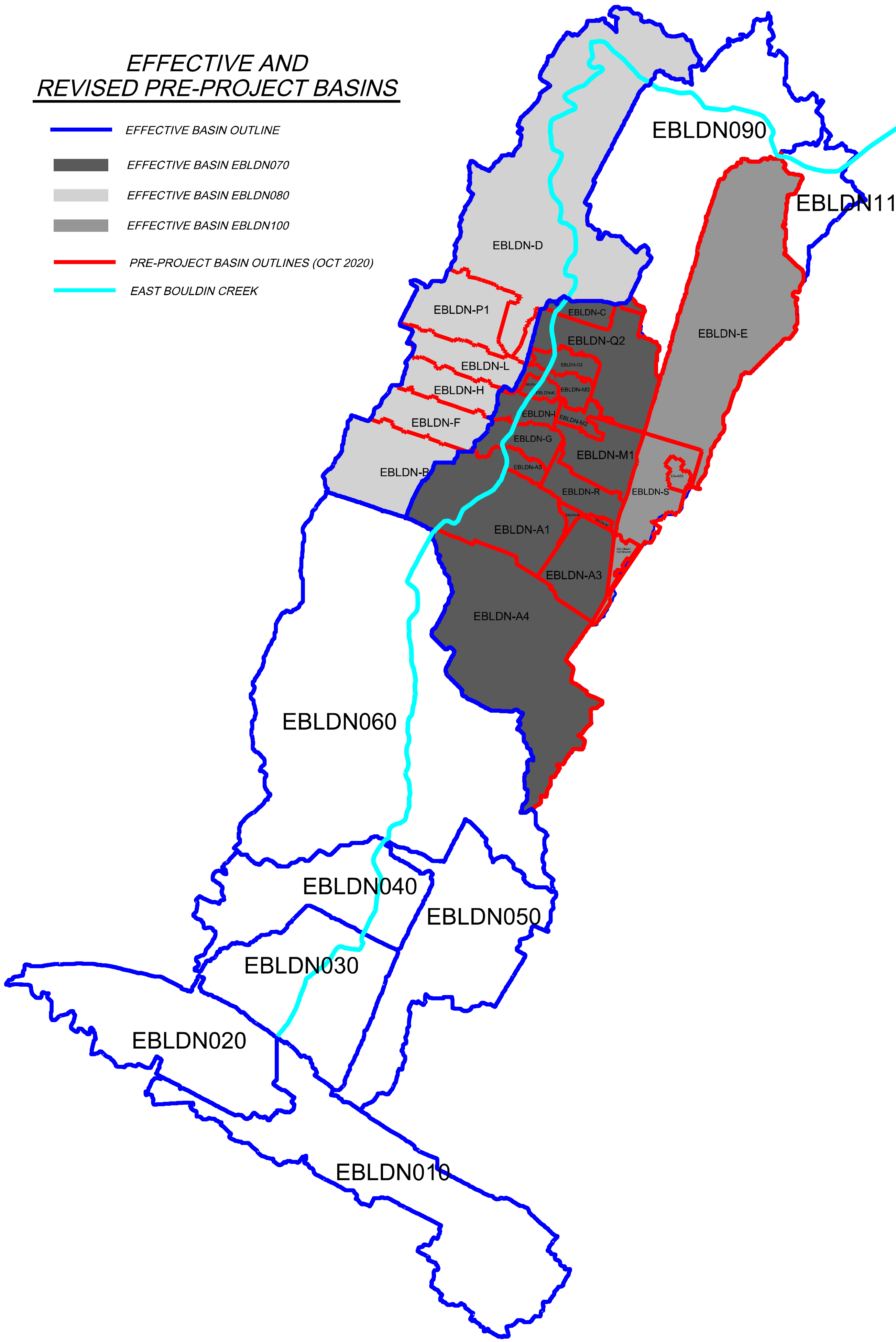
Exhibit R.2

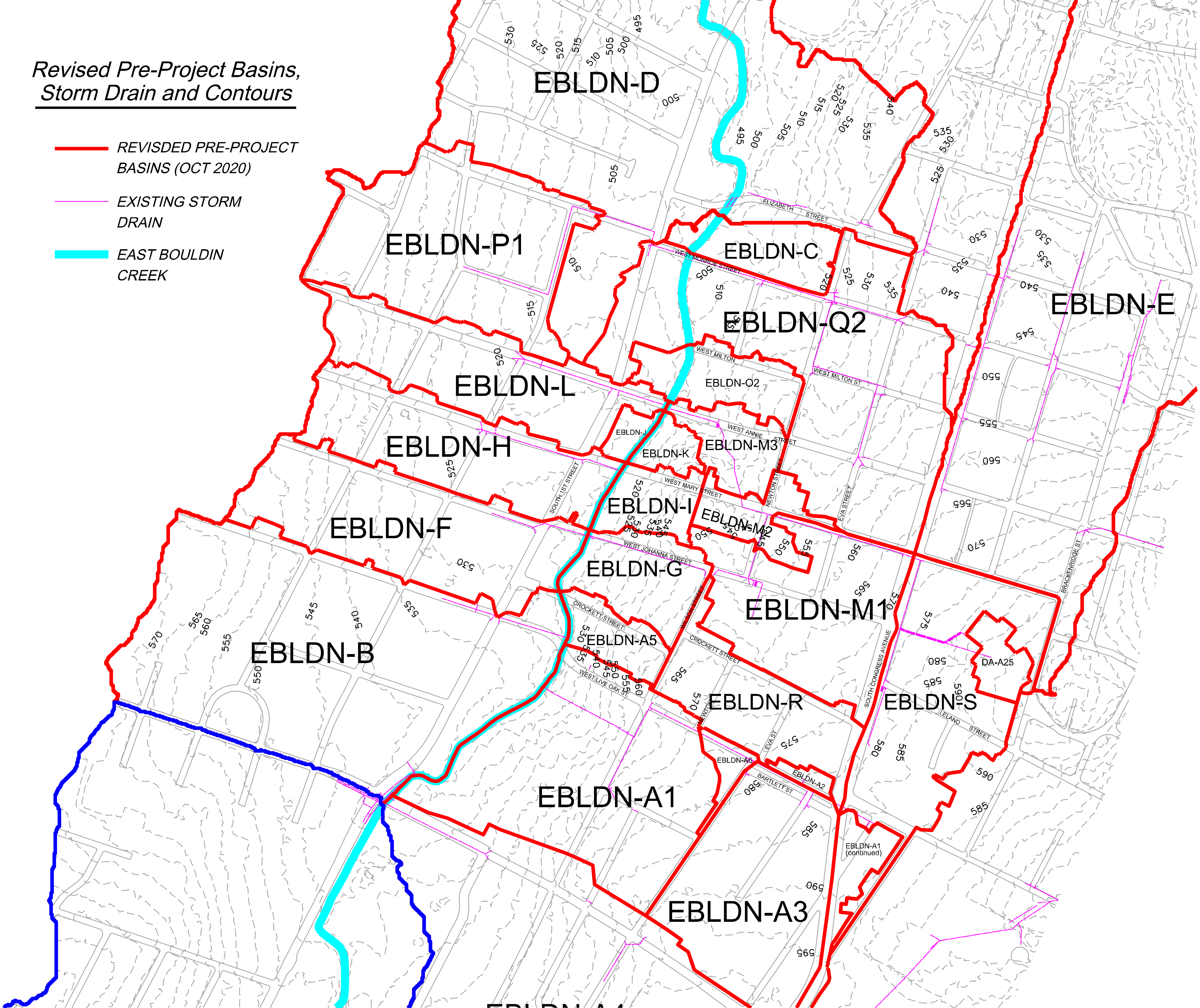
Map of Revised Pre-Project Basins, Storm Drains and Contours

Exhibit R.3

Map of Revised Pre-Project HEC-HMS Elements

EFFECTIVE AND REVISED PRE-PROJECT BASINS




Revised Pre-Project Basins,
Storm Drain and Contours
REVISDED PRE-PROJECT BASINS (OCT 2020)
EXISTING STORM DRAIN
EAST BOULDIN CREEK
EBLDN-D
EBLDN-P1
EBLDN-C
EBLDN-Q2
EBLDN-E
EBLDN-O2
EBLDN-L
EBLDN-J
EBLDN-K
EBLDN-M3
EBLDN-H
EBLDN-I
EBLDN-M2
EBLDN-F
EBLDN-G
EBLDN-M1
EBLDN-A5
DA-A25
EBLDN-B
EBLDN-R
EBLDN-S
EBLDN-A6
EBLDN-A2
EBLDN-A1
EBLDN-A1 (continued)
EBLDN-A3
ELIZABETH STREET
WEST MONROE STREET
WEST MILTON
WEST MILTON ST
WEST ANNIE STREET
WEST MARY STREET
NEWTON STREET
EVA STREET
SOUTH 1ST STREET
WEST JOHANNA STREET
CROCKETT STREET
WEST LIVE OAK ST.
SOUTH CONGRESS AVENUE
LELAND STREET
BARTLETT ST
BRACKENRIDGE ST

Revised Pre-Project (Oct 2020)
HEC-HMS Elements

HMS JUNCTIONS

HMS DIVERSIONS

HMS REACH - ANNIE PIPES

HMS REACH - JOHANNA PIPES

HMS REACH - LIVE OAK GUTTER

HMS REACH - EVA/CROCKETT GUTTER

HMS REACH - NEWTON/CROCKETT GUTTER

HMS REACH - WILSON GUTTER

HMS REACH - CONGRESS AVE

EXISTING STORM DRAIN

EAST BOULDIN CREEK

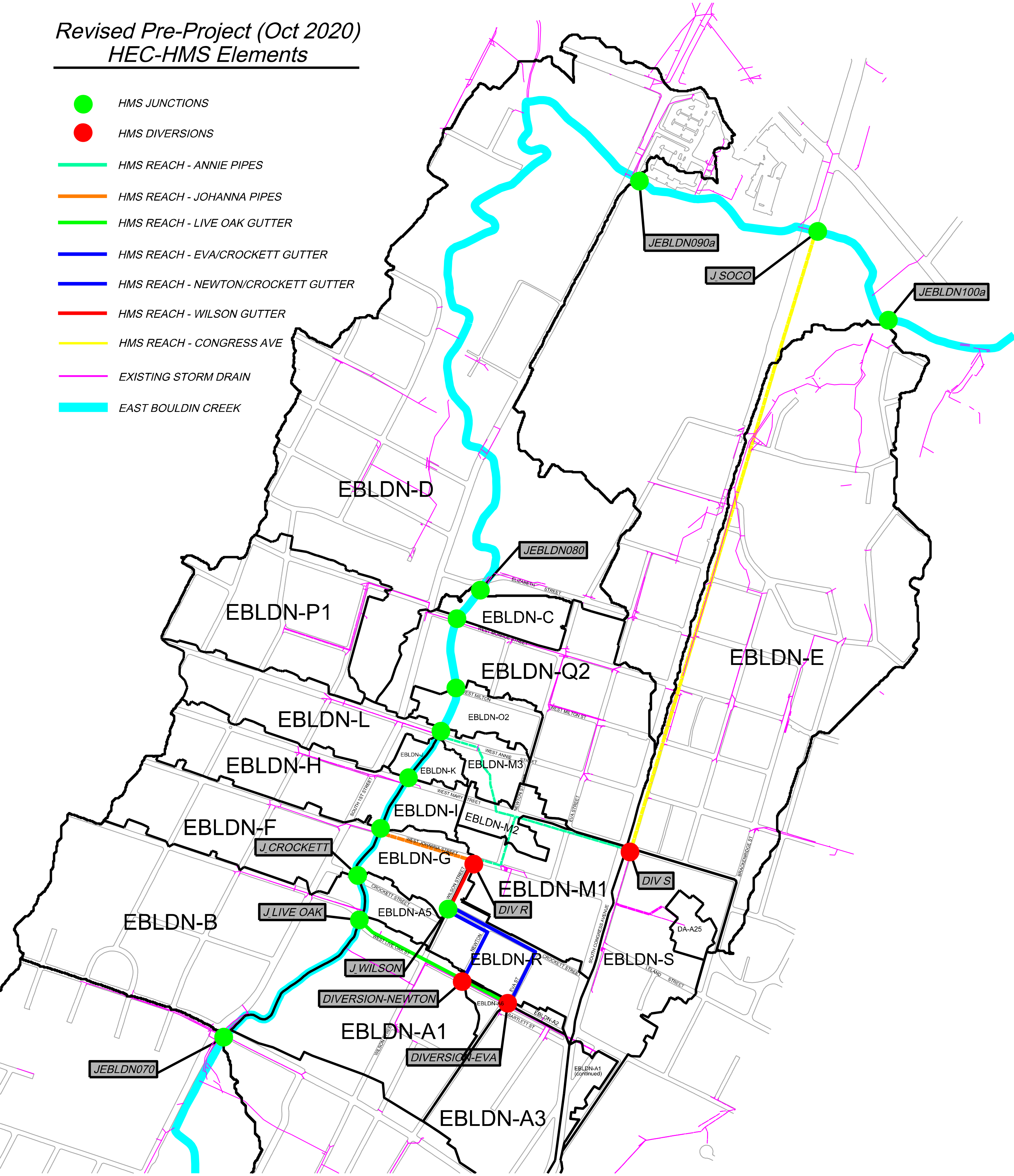


Exhibit R.4

Model Schematic

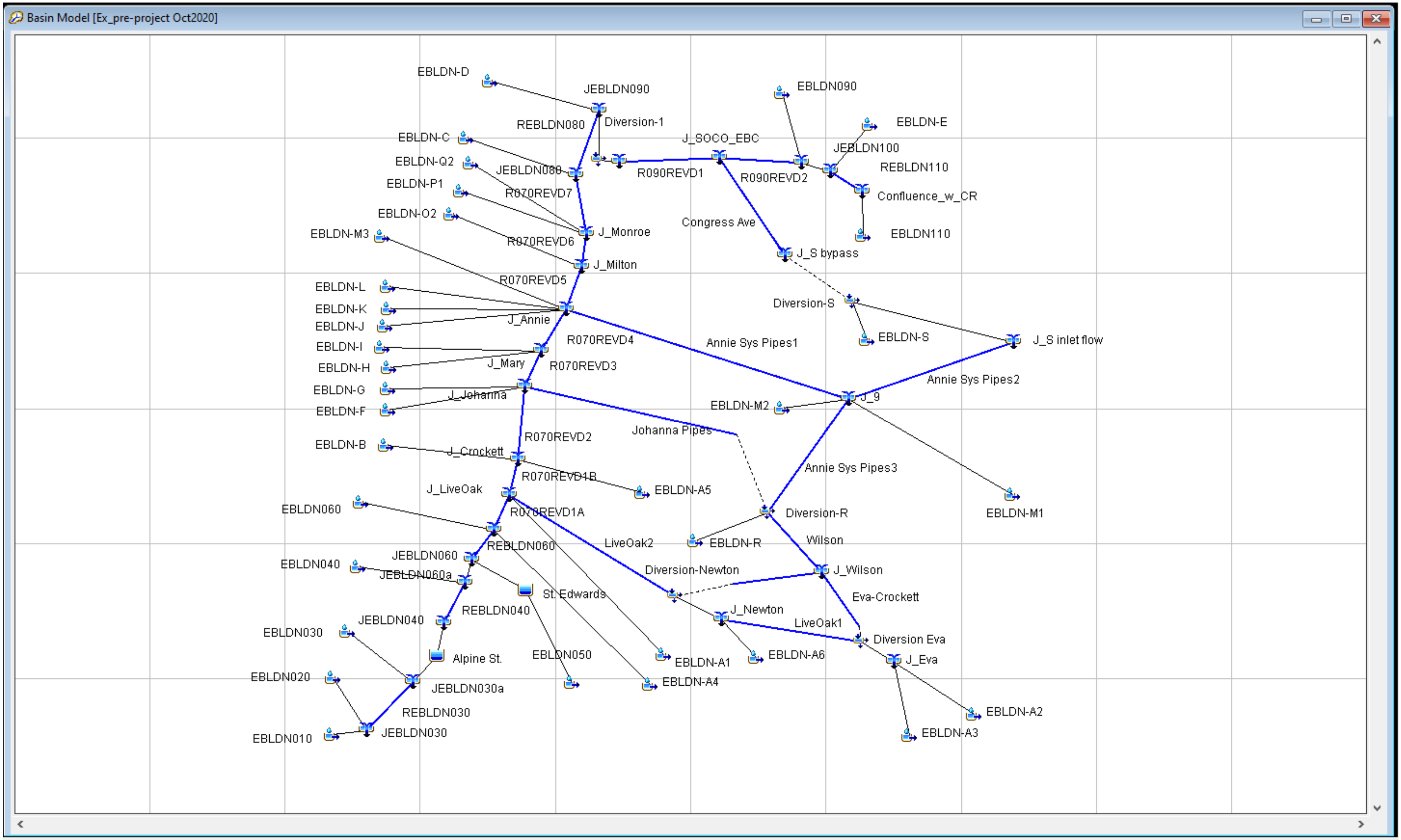

Basin Model [Ex_pre-project Oct2020]
EBLDN-D
JEBLDN090
EBLDN090
Diversion-1
REBLDN080
EBLDN-E
EBLDN-C
J_SOCO_EBC
JEBLDN100
EBLDN-Q2
JEBLDN080
R090REVD1
R090REVD2
REBLDN110
EBLDN-P1
R070REVD7
Confluence_w_CR
EBLDN-O2
Congress Ave
EBLDN110
EBLDN-M3
J_Monroe
R070REVD6
J_Milton
J_S bypass
R070REVD5
EBLDN-L
Diversion-S
EBLDN-K
J_Annie
EBLDN-J
EBLDN-S
J_S inlet flow
R070REVD4
Annie Sys Pipes1
EBLDN-I
J_Mary
R070REVD3
EBLDN-H
Annie Sys Pipes2
EBLDN-G
J_Johanna
J_9
EBLDN-F
EBLDN-M2
Johanna Pipes
R070REVD2
EBLDN-B
J_Crockett
Annie Sys Pipes3
R070REVD1B
J_LiveOak
EBLDN-A5
EBLDN060
R070REVD1A
Diversion-R
EBLDN-M1
LiveOak2
EBLDN-R
Wilson
REBLDN060
JEBLDN060
EBLDN040
JEBLDN060a
Diversion-Newton
J_Wilson
St. Edwards
Eva-Crockett
REBLDN040
J_Newton
JEBLDN040
LiveOak1
EBLDN030
Diversion Eva
Alpine St.
EBLDN050
EBLDN-A1
EBLDN-A6
J_Eva
EBLDN020
JEBLDN030a
EBLDN-A4
REBLDN030
EBLDN-A2
EBLDN010
JEBLDN030
EBLDN-A3

Exhibit R.5

Area, Impervious Cover and Curve Number

Name	Area	Area	Area	Ex_%IC	Area 700	Area 800	Area not 700 or 800	Area Pervious 700	Area Pervious 800	%IC 700	%IC 800	Ult_%IC not 700 or 800	Ult_%IC	CN for Pervious Soil Type D
	SF	AC	sq mi		SF	SF	SF	SF	SF					
Calc Notes -->	(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
EBLDN-B	1833447	42.09	0.0658	48.8%	0	397444	1436003	0	89020	0%	78%	77%	77.5%	80
EBLDN-C	193475	4.44	0.0069	31.0%	0	7279	186196	0	5659	0%	22%	69%	67.1%	80
EBLDN-D	5497139	126.20	0.1972	50.0%	173294	1041875	4281970	143659	311218	17%	70%	76%	73.2%	80
EBLDN-E	3811129	87.49	0.1367	57.0%	85483	1028071	2697575	81659	292774	4%	72%	79%	75.2%	80
EBLDN-F	734427	16.86	0.0263	53.3%	0	203634	530793	0	65059	0%	68%	71%	70.1%	80
EBLDN-G	248097	5.70	0.0089	42.0%	0	47777	200320	0	14797	0%	69%	66%	66.3%	80
EBLDN-H	579249	13.30	0.0208	53.6%	0	169827	409422	0	41860	0%	75%	73%	73.4%	80
EBLDN-I	141785	3.25	0.0051	43.4%	0	31799	109986	0	8258	0%	74%	66%	67.7%	80
EBLDN-J	42247	0.97	0.0015	46.6%	0	1120	41127	0	497	0%	56%	95%	94.0%	80
EBLDN-K	65108	1.49	0.0023	26.8%	0	1536	63572	0	1375	0%	10%	67%	65.6%	80
EBLDN-L	567898	13.04	0.0204	55.5%	0	186177	381721	0	43011	0%	77%	71%	72.8%	80
EBLDN-O2	214122	4.92	0.0077	46.3%	0	28668	185454	0	8203	0%	71%	73%	72.7%	80
EBLDN-P1	865081	19.86	0.0310	48.5%	0	241343	623738	0	80859	0%	66%	66%	65.8%	80
EBLDN-Q2	1292455	29.67	0.0464	58.6%	0	417645	874810	0	97176	0%	77%	76%	76.0%	80
EBLDN-R	393040	9.02	0.0141	58.5%	0	121890	271150	0	19452	0%	84%	71%	75.4%	80
EBLDN-S	753334	17.29	0.0270	67.2%	0	179946	573388	0	28718	0%	84%	83%	83.4%	80

(1) Drainage Area
(2) Area (sq mi) = Area / 27,878,400
(3) Ex_%IC = 1 - (sum(remaining pervious area)) / Area
(4) Area 700 = area that is LU category 700
(5) Area 800 = area that is LU category 800
(6) Area not 700 or 800 = (Area) - (Area 700) - (Area 800)
(7) Area Pervious 700 = remaining pervious area within LU category 700
(8) Area Pervious 800 = remaining pervious area within LU category 800
(9) %IC 700 = 1 - (Area Pervious 700)/(Area 700)
(10) %IC 800 = 1 - (Area Pervious 800)/(Area 800)
(11) Ult_%IC not 700 or 800 = weighted average for area not within LU categories 700 or 800; see GIS Join Table for Impervious Cover percentages by Land Use Category
(12) Ult_%IC = weighted average of (9) , (10) and (11)
(13) Reference TR-55 Table 2-2a, Open Space Good Condition

Name	Area	Area	Area	Ex_%IC	Area 700	Area 800	Area not 700 or 800	Area Pervious 700	Area Pervious 800	%IC 700	%IC 800	Ult_%IC not 700 or 800	Ult_%IC	CN for Pervious Soil Type D
	SF	AC	sq mi		SF	SF	SF	SF	SF					
Calc Notes -->	(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
EBLDN-A1	1164331	26.73	0.0418	56.8%	2969	256663	904699	2448	76549	18%	70%	76%	74.2%	80
EBLDN-A2	25220	0.58	0.0009	88.5%	0	11386	13834	0	1778	0%	84%	88%	88.5%	80
EBLDN-A3	720618	16.54	0.0258	65.5%	0	209310	511308	0	51480	0%	75%	77%	76.7%	80
EBLDN-A4	3452207	79.25	0.1238	61.8%	81513	604690	2766004	55073	123192	32%	80%	81%	80.0%	80
EBLDN-A5	129182	2.97	0.0046	46.4%	0	43149	86033	0	14808	0%	66%	76%	72.3%	80
EBLDN-A6	49249	1.13	0.0018	63.9%	0	26915	22334	0	4912	0%	82%	65%	74.2%	80
EBLDN-M1	637660	14.64	0.0229	67.3%	0	203372	434288	0	36490	0%	82%	80%	80.6%	80
EBLDN-M2	148395	3.41	0.0053	52.2%	0	52655	95740	0	12034	0%	77%	66%	69.8%	80
EBLDN-M3	161210	3.70	0.0058	43.8%	0	40875	120335	0	8932	0%	78%	65%	68.3%	80
	0	0.00	0.0000	#DIV/0!	0	0	0	0	0	0%	0%	#DIV/0!	#DIV/0!	80
	0	0.00	0.0000	#DIV/0!	0	0	0	0	0	0%	0%	#DIV/0!	#DIV/0!	80
	0	0.00	0.0000	#DIV/0!	0	0	0	0	0	0%	0%	#DIV/0!	#DIV/0!	80
	0	0.00	0.0000	#DIV/0!	0	0	0	0	0	0%	0%	#DIV/0!	#DIV/0!	80
	0	0.00	0.0000	#DIV/0!	0	0	0	0	0	0%	0%	#DIV/0!	#DIV/0!	80
	0	0.00	0.0000	#DIV/0!	0	0	0	0	0	0%	0%	#DIV/0!	#DIV/0!	80
	0	0.00	0.0000	#DIV/0!	0	0	0	0	0	0%	0%	#DIV/0!	#DIV/0!	80
	0	0.00	0.0000	#DIV/0!	0	0	0	0	0	0%	0%	#DIV/0!	#DIV/0!	80
	0	0.00	0.0000	#DIV/0!	0	0	0	0	0	0%	0%	#DIV/0!	#DIV/0!	80

(1) Drainage Area
(2) Area (sq mi) = Area / 27,878,400
(3) Ex_%IC = 1 - (sum(remaining pervious area)) / Area
(4) Area 700 = area that is LU category 700
(5) Area 800 = area that is LU category 800
(6) Area not 700 or 800 = (Area) - (Area 700) - (Area 800)
(7) Area Pervious 700 = remaining pervious area within LU category 700
(8) Area Pervious 800 = remaining pervious area within LU category 800
(9) %IC 700 = 1 - (Area Pervious 700)/(Area 700)
(10) %IC 800 = 1 - (Area Pervious 800)/(Area 800)
(11) Ult_%IC not 700 or 800 = weighted average for area not within LU categories 700 or 800; see GIS Join Table for Impervious Cover percentages by Land Use Category
(12) Ult_%IC = weighted average of (9) , (10) and (11)
(13) Reference TR-55 Table 2-2a, Open Space Good Condition

GIS Join Table

LU	Ult_IC
100	0.65
111	0.65
200	0.80
201	0.88
300	0.95
330	0.95
430	0.95
600	0.80
601	0.80
602	0.88
700	N/A
800	N/A
870	0.86

Exhibit R.6

Sub-basin Lag Times

Lag Time Calculations for the East Bouldin Creek Watershed (Existing Conditions)

Sheet Flow

HMS Program Basin Name	Longest Flowpath (ft) (1)	Length (ft) (2)	IC% (3)	Land Use (4)	Surface Description (5)	Manning's roughness n (6)	Slope (ft/ft) (7)	Tt1 (min.) (8)
EBLDN-B	2,866	63	49	SF, MF, Paved Surface	Dense grass	0.24	0.023	9.01
EBLDN-C	921	100	31	SF, Commercial, Paved Surface	Short Grass	0.15	0.023	8.94
EBLDN-D	6,305	72	50	SF, Mixed Use Paved Surface	Short Grass	0.15	0.018	7.55
EBLDN-E	5,536	100	57	SF, MF, Commercial, Mixed Use, Paved Surface	Asphalt	0.016	0.015	1.77
EBLDN-F	1,927	92	53	SF, Mixed Use	Short Grass	0.15	0.022	8.51
EBLDN-G	878	100	42	SF, Mixed Use, Paved Surface	Short Grass	0.15	0.038	7.31
EBLDN-H	1,772	100	54	SF, Mixed Use	Dense grass	0.24	0.005	23.96
EBLDN-I	739	75	43	SF, Mixed Use	Short Grass	0.15	0.009	10.24
EBLDN-J	416	52	47	Paved Surface	Concrete & Asphalt	0.0155	0.029	0.79
EBLDN-K	540	52	27	SF	Asphalt	0.016	0.081	0.54
EBLDN-L	1,797	100	55	SF, Mixed Use, Paved Surface	Dense grass	0.24	0.040	10.43
EBLDN-O2	923	100	46	SF, Mixed Use, Paved Surface	Asphalt	0.016	0.013	1.87
EBLDN-P1	2,464	58	48	SF, Mixed Use, Paved Surface	Short Grass	0.15	0.009	8.62
EBLDN-Q2	2,236	100	59	SF, Mixed Use, Paved Surface	Asphalt	0.016	0.027	1.40
EBLDN-S	2,354	100	67	SF, MF, Mixed Use, Fulmore MS,Paved Surface	Asphalt	0.016	0.015	1.77

Shallow Concentrated Flow

HMS Program Basin Name	Length 2 (ft) (9)	L2 paved (ft) (10)	L2 unpaved (ft) (11)	Slope 2 (ft/ft) (12)	Assumption for Tt2 (13)	Tt2 (paved) (min.) (13)	Tt2 (unpaved) (min.) (14)	Tt2 (min.) (15)
EBLDN-B	2,444	1,197	1,246	0.023	Paved & Unpaved	6.54	8.57	15.11
EBLDN-C	710	220	490	0.039	Paved & Unpaved	0.92	2.57	3.49
EBLDN-D	1,838	919	919	0.030	Paved & Unpaved	4.38	5.51	9.89
EBLDN-E	4,072	2,321	1,751	0.027	Paved & Unpaved	11.61	11.03	22.64
EBLDN-F	1,184	628	557	0.030	Paved & Unpaved	2.97	3.32	6.29
EBLDN-G	583	245	338	0.070	Paved & Unpaved	0.76	1.32	2.07
EBLDN-H	976	527	449	0.029	Paved & Unpaved	2.53	2.71	5.24
EBLDN-I	425	183	242	0.094	Paved & Unpaved	0.49	0.82	1.31
EBLDN-J	99	47	52	0.040	Paved & Unpaved	0.19	0.27	0.46
EBLDN-K	319	86	233	0.005	Paved & Unpaved	1.03	3.51	4.54
EBLDN-L	928	510	418	0.036	Paved & Unpaved	2.20	2.27	4.47
EBLDN-O2	666	307	360	0.060	Paved & Unpaved	1.02	1.51	2.54
EBLDN-P1	892	428	464	0.024	Paved & Unpaved	2.27	3.10	5.37
EBLDN-Q2	1,112	656	456	0.023	Paved & Unpaved	3.58	3.13	6.71
EBLDN-S	995	667	328	0.011	Paved & Unpaved	5.32	3.30	8.63

Channel Flow

HMS Program Basin Name	Length 3 (ft) (16)	Slope 3 (ft/ft) (17)	V (ft/s) (18)	Assumption for V (19)	Tt3 (sec) (20)	Tt3 (min.) (21)
EBLDN-B	359	0.010	3.52	Defined Channel	102	1.70
EBLDN-C	110	0.027	3.55	Defined Channel	31	0.52
EBLDN-D	4,395	0.010	3.52	Defined Channel	1248	20.79
EBLDN-E	1,364	0.045	4.00	No Defined Channel	341	5.68
EBLDN-F	651	0.022	3.00	No Defined Channel	217	3.62
EBLDN-G	195	0.020	3.54	Defined Channel	55	0.92
EBLDN-H	696	0.027	8.58	Manning's Equation	81	1.35
EBLDN-I	238	0.013	3.53	Defined Channel	68	1.13
EBLDN-J	265	0.038	3.57	Defined Channel	74	1.24
EBLDN-K	168	0.170	3.81	Defined Channel	44	0.74
EBLDN-L	769	0.010	7.70	Manning's Equation	100	1.66
EBLDN-O2	156	0.013	3.53	Defined Channel	44	0.74
EBLDN-P1	1,514	0.014	10.68	Manning's Equation	142	2.36
EBLDN-Q2	1,024	0.039	12.57	Manning's Equation	81	1.36
EBLDN-S	1,259	0.012	2.50	No Defined Channel	504	8.39

HMS Program Basin Name	**Tc (min) (22)**	**Final Tc (min) (23)**	**Tlag (min) (24)**	**Final Tlag (min) (25)**	**Total Flowpath Lenth (ft)**	Sub-basin
EBLDN-B	25.82	25.82	15.49	15.5	2866	EBLDN-B
EBLDN-C	12.94	12.94	7.77	7.8	921	EBLDN-C
EBLDN-D	38.23	38.23	22.94	22.9	6305	EBLDN-D
EBLDN-E	30.09	30.09	18.05	18.1	5536	EBLDN-E
EBLDN-F	18.42	18.42	11.05	11.1	1927	EBLDN-F
EBLDN-G	10.30	10.30	6.18	6.2	878	EBLDN-G
EBLDN-H	30.56	30.56	18.34	18.3	1772	EBLDN-H
EBLDN-I	12.68	12.68	7.61	7.6	739	EBLDN-I
EBLDN-J	2.48	5.00	3.00	3.5	416	EBLDN-J
EBLDN-K	5.81	5.81	3.49	3.5	540	EBLDN-K
EBLDN-L	16.57	16.57	9.94	9.9	1797	EBLDN-L
EBLDN-O2	5.15	5.15	3.09	3.5	923	EBLDN-O2
EBLDN-P1	16.35	16.35	9.81	9.8	2464	EBLDN-P1
EBLDN-Q2	9.47	9.47	5.68	5.7	2236	EBLDN-Q2
EBLDN-S	18.79	18.79	11.27	11.3	2354	EBLDN-S

Notes:

Please refer to N:\Team3\WPD_EBC_Annie\DGN\Annie_EXIST_TC_021115.dgn for drainage sub-basins and times of concentration flow paths.

(1) Longest flow path equals sum of sheet, shallow concentrated and channel flow lengths.
(2) Sheet flow was considered to occur at short distances with a maximum of 100 feet for both natural (undeveloped) and developed conditions;
(3) Percent impervious cover calculations presented as part of HEC-HMS input data.
(4) Land use determined from 2012 aerial photography.
(5) Surface description (DCM Table 2-2)
(6) Manning's roughness n (DCM Table 2-2)
(7) Sheet flow slope = (US elevation - DS elevation) / overland flow length
(8) Sheet Flow Time of concentration (Tt1) = 0.42(nL)^08/((P2)^0.5 S^0.4) (DCM Eq. 2-3)
(9) Shallow concentrated flow length
(10) paved length = shallow concentrated paved length x IC% / 100
(11) unpaved length = shallow concentrated flow length - paved length
(12) slope = (US elevation - DS elevation) / shallow concentrated flow length
(13) Tt2 (Paved) = L/60(20.3282)(S)^0.5) DCM Eq. 2-5
(14) Tt2 (Unpaved) = L/60(16.1345)(S)^0.5) DCM Eq. 2-4
(15) = (13) + (14)
(16) Total Channel flow length
(18) Channel velocity equations were determined by statistical analysis on the existing HEC-RAS models for East Bouldin Creek
East Bouldin Main Channel Velocity Equation (Halff Associates, July 2005) = 178.89 *(slope 2/100)+3.5055 (For "no defined channel" flow paths, velocity is assumed 2.5 - 4.0 fps based on channel slope)
Manning's equation is used for storm drain system velocity calculations assuming pipe flowing full (V=Vfull/Area). See Manning's Equation calculation sheet.
(19) Channel flow assumptions
(20) T = L / V in seconds
(21) Channel Time of Concentration = time in seconds / 60
(22) Tc = Sheet Flow Time of Concentration (Tt1) + Shallow Concentrated Flow (Tt2)+Channel Flow Time of Concentration (Tt3)
(23) If Tc > 5 minutes, Tc = Final Tc, else Final Tc = 5 minutes
(24) Lag Time (T lag) = 0.6* Final Tc (Soil Conservation Service)
(25) A minimum lag time of 3.5 minutes is required by HMS so that lag*0.29 is greater than the minimum time step of 1 min

The following Data were collected from City of Austin Watershed Protection Department GIS information (Drainage Pipe)

Manning's Calculation (Existing Land Use Conditions) n = 0.013

EBLDN-P1&P2

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	24	308	520.13	511.00	0.0296	2.96	38.92	3.14	12.39	0.20	2.52
2	24	91	511.00	507.65	0.0368	3.68	43.39	3.14	13.82	0.06	0.83
3	24	39	507.43	506.00	0.0367	3.67	43.34	3.14	13.80	0.03	0.36
4	42	242	504.50	502.72	0.0074	0.74	86.54	9.62	9.00	0.16	1.44
5	42	150	502.72	501.61	0.0074	0.74	86.54	9.62	9.00	0.10	0.89
6	42	48	501.61	501.26	0.0073	0.73	85.96	9.62	8.94	0.03	0.28
7	42	148	501.26	499.79	0.0099	0.99	100.10	9.62	10.41	0.10	1.02
8	42	256	499.75	497.20	0.00996	0.996	100.40	9.62	10.44	0.17	1.76
9	42	40	497.20	496.90	0.0075	0.75	87.13	9.62	9.06	0.03	0.24
10	42	6	496.90	496.86	0.0067	0.67	82.35	9.62	8.56	0.00	0.03
11	42	15	496.86	496.75	0.0073	0.73	85.96	9.62	8.94	0.01	0.09
12	42	40	496.75	496.44	0.0078	0.78	88.85	9.62	9.24	0.03	0.24
13	42	131	496.44	494.92	0.0116	1.16	108.35	9.62	11.26	0.09	0.97
	Total	**1,514**								**1.00**	**10.68**

EBLDN-Q2

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	30	358.79	-	-	0.0290	2.90	69.85	4.91	14.23	0.35	4.98
2	30	344.47	-	-	0.0290	2.90	69.85	4.91	14.23	0.34	4.79
3	15	320.8	-	-	0.0290	2.90	11.00	1.23	8.94	0.31	2.80
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**1,024**								**1.00**	**12.57**

EBLDN-L

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope* (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	18	33	-	-	0.0100	1.00	17.89	1.77	10.11	0.04	0.43
2	18	27	-	-	0.0100	1.00	17.89	1.77	10.11	0.04	0.35
3	36	87	511.56	511.01	0.0063	0.63	52.94	7.07	7.49	0.11	0.85
4	36	359	511.01	508.92	0.0058	0.58	50.79	7.07	7.18	0.47	3.35
5	36	34	508.86	508.65	0.0062	0.62	52.52	7.07	7.43	0.04	0.33
6	36	229	508.65	507.00	0.0072	0.72	56.59	7.07	8.00	0.30	2.38
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**769**								**1.00**	**7.70**

EBLDN-H

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	18	10	-	-	**0.0230**	**2.30**	**15.93**	**1.77**	9.00	0.01	0.13
2	30	8	-	-	**0.0230**	**2.30**	**62.20**	**4.91**	12.67	0.01	0.15
3	30	5	-	-	**0.0230**	2.30	**62.20**	**4.91**	12.67	0.01	0.09
4	30	17	-	-	**0.0230**	2.30	**62.20**	**4.91**	12.67	0.02	0.31
5	36	44	516.72	516.51	**0.0048**	**0.48**	**46.21**	**7.07**	6.54	0.06	0.41
6	36	58	516.51	516.22	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.08	0.56
7	36	341	516.22	514.51	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.49	3.27
8	36	18	514.51	514.42	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.03	0.17
9	36	19	514.42	514.10	**0.0168**	**1.68**	**86.45**	**7.07**	12.23	0.03	0.33
10	36	176	514.10	511.00	**0.0176**	**1.76**	**88.48**	**7.07**	12.51	0.25	3.16
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**696**								**1.00**	**8.58**

Lag Time Calculations for the East Bouldin Creek Watershed (Ultimate Conditions)

HMS Program Basin Name	Longest Flowpath (ft) (1)	Sheet Flow: Length (ft) (2)	IC% (3)	Land Use (4)	Surface Description (5)	Manning's roughness n (6)	Slope (ft/ft) (7)	Tt1 (min.) (8)
EBLDN-B	2,866	63	78	SF, MF, Paved Surface	Dense grass	0.24	0.023	9.01
EBLDN-C	921	100	67	SF, Commercial, Paved Surface	Short Grass	0.15	0.023	8.94
EBLDN-D	6,305	72	73	SF, Mixed Use Paved Surface	Short Grass	0.15	0.018	7.55
EBLDN-E	5,536	100	75	SF, MF, Commercial, Mixed Use, Paved Surface	Asphalt	0.016	0.015	1.77
EBLDN-F	1,927	92	70	SF, Mixed Use	Short Grass	0.15	0.022	8.51
EBLDN-G	878	100	66	SF, Mixed Use, Paved Surface	Short Grass	0.15	0.038	7.31
EBLDN-H	1,772	100	73	SF, Mixed Use	Dense grass	0.24	0.005	23.96
EBLDN-I	739	75	68	SF, Mixed Use	Short Grass	0.15	0.009	10.24
EBLDN-J	416	52	94	Paved Surface	Concrete & Asphalt	0.0155	0.029	0.79
EBLDN-K	540	52	66	SF	Asphalt	0.016	0.081	0.54
EBLDN-L	1,797	100	73	SF, Mixed Use, Paved Surface	Dense grass	0.24	0.040	10.43
EBLDN-O2	923	100	73	SF, Mixed Use, Paved Surface	Asphalt	0.016	0.013	1.87
EBLDN-P1	2,464	58	66	SF, Mixed Use, Paved Surface	Short Grass	0.15	0.009	8.62
EBLDN-Q2	2,236	100	76	SF, Mixed Use, Paved Surface	Asphalt	0.016	0.027	1.40
EBLDN-S	2,354	100	83	SF, MF, Mixed Use, Fulmore MS,Paved Surface	Asphalt	0.016	0.015	1.77

HMS Program Basin Name	Shallow Concentrated Flow: Length 2 (ft) (9)	L2 paved (ft) (10)	L2 unpaved (ft) (11)	Slope 2 (ft/ft) (12)	Assumption for Tt2 (13)	Tt2 (paved) (min.) (13)	Tt2 (unpaved) (min.) (14)	Tt2 (min.) (15)
EBLDN-B	2,444	1,906	538	0.023	Paved & Unpaved	10.41	3.70	14.11
EBLDN-C	710	476	234	0.039	Paved & Unpaved	1.98	1.23	3.21
EBLDN-D	1,838	1,342	496	0.030	Paved & Unpaved	6.39	2.98	9.37
EBLDN-E	4,072	3,054	1,018	0.027	Paved & Unpaved	15.27	6.41	21.69
EBLDN-F	1,184	829	355	0.030	Paved & Unpaved	3.93	2.12	6.05
EBLDN-G	583	385	198	0.070	Paved & Unpaved	1.19	0.77	1.96
EBLDN-H	976	712	264	0.029	Paved & Unpaved	3.42	1.59	5.01
EBLDN-I	425	289	136	0.094	Paved & Unpaved	0.78	0.46	1.23
EBLDN-J	99	93	6	0.040	Paved & Unpaved	0.38	0.03	0.41
EBLDN-K	319	211	108	0.005	Paved & Unpaved	2.52	1.63	4.15
EBLDN-L	928	677	251	0.036	Paved & Unpaved	2.92	1.36	4.28
EBLDN-O2	666	486	180	0.060	Paved & Unpaved	1.62	0.76	2.38
EBLDN-P1	892	589	303	0.024	Paved & Unpaved	3.12	2.03	5.15
EBLDN-Q2	1,112	845	267	0.023	Paved & Unpaved	4.61	1.83	6.45
EBLDN-S	995	826	169	0.011	Paved & Unpaved	6.59	1.70	8.29

HMS Program Basin Name	Channel Flow: Length 3 (ft) (16)	Slope 3 (ft/ft) (17)	V (ft/s) (18)	Assumption for V (19)	Tt3 (sec) (20)	Tt3 (min.) (21)	**Tc (min) (22)**	**Final Tc (min) (23)**	**Tlag (min) (24)**	**Final Tlag (min) (25)**	**Total Flowpath Length (ft)**	Sub-basin
EBLDN-B	359	0.010	3.52	Defined Channel	102	1.70	24.81	24.81	14.89	14.9	2866	EBLDN-B
EBLDN-C	110	0.027	3.55	Defined Channel	31	0.52	12.67	12.67	7.60	7.6	921	EBLDN-C
EBLDN-D	4,395	0.010	3.52	Defined Channel	1248	20.79	37.70	37.70	22.62	22.6	6305	EBLDN-D
EBLDN-E	1,364	0.045	4.00	No Defined Channel	341	5.68	29.14	29.14	17.48	17.5	5536	EBLDN-E
EBLDN-F	651	0.022	3.00	No Defined Channel	217	3.62	18.18	18.18	10.91	10.9	1927	EBLDN-F
EBLDN-G	195	0.020	3.54	Defined Channel	55	0.92	10.19	10.19	6.11	6.1	878	EBLDN-G
EBLDN-H	696	0.027	8.58	Manning's Equation	81	1.35	30.33	30.33	18.20	18.2	1772	EBLDN-H
EBLDN-I	238	0.013	3.53	Defined Channel	68	1.13	12.60	12.60	7.56	7.6	739	EBLDN-I
EBLDN-J	265	0.038	3.57	Defined Channel	74	1.24	2.43	5.00	3.00	3.5	416	EBLDN-J
EBLDN-K	168	0.170	3.81	Defined Channel	44	0.74	5.42	5.42	3.25	3.5	540	EBLDN-K
EBLDN-L	769	0.010	7.70	Manning's Equation	100	1.66	16.38	16.38	9.83	9.8	1797	EBLDN-L
EBLDN-O2	156	0.013	3.53	Defined Channel	44	0.74	4.99	5.00	3.00	3.5	923	EBLDN-O2
EBLDN-P1	1,514	0.014	10.68	Manning's Equation	142	2.36	16.13	16.13	9.68	9.7	2464	EBLDN-P1
EBLDN-Q2	1,024	0.039	12.57	Manning's Equation	81	1.36	9.20	9.20	5.52	5.5	2236	EBLDN-Q2
EBLDN-S	1,259	0.012	2.50	No Defined Channel	504	8.39	18.46	18.46	11.07	11.1	2354	EBLDN-S

Notes:

Please refer to N:\Team3\WPD_EBC_Annie\DGN\Annie_EXIST_TC_021115.dgn for drainage sub-basins and times of concentration flow paths.

(1) Longest flow path equals sum of sheet, shallow concentrated and channel flow lengths.
(2) Sheet flow was considered to occur at short distances with a maximum of 100 feet for both natural (undeveloped) and developed conditions;
(3) Percent impervious cover calculations presented as part of HEC-HMS input data.
(4) Land use determined from 2012 aerial photography.
(5) Surface description (DCM Table 2-2)
(6) Manning's roughness n (DCM Table 2-2)
(7) Sheet flow slope = (US elevation - DS elevation) / overland flow length
(8) Sheet Flow Time of concentration (Tt1) = 0.42(nL)^08/((P2)^0.5 S^0.4) (DCM Eq. 2-3)
(9) Shallow concentrated flow length
(10) paved length = shallow concentrated paved length x IC% / 100
(11) unpaved length = shallow concentrated flow length - paved length
(12) slope = (US elevation - DS elevation) / shallow concentrated flow length
(13) Tt2 (Paved) = L/60(20.3282)(S)^0.5) DCM Eq. 2-5
(14) Tt2 (Unpaved) = L/60(16.1345)(S)^0.5) DCM Eq. 2-4
(15) = (13) + (14)
(16) Total Channel flow length
(18) Channel velocity equations were determined by statistical analysis on the existing HEC-RAS models for East Bouldin Creek
East Bouldin Main Channel Velocity Equation (Halff Associates, July 2005) = 178.89 *(slope 2/100)+3.5055 (For "no defined channel" flow paths, velocity is assumed 2.5 - 4.0 fps based on channel slope)
Manning's equation is used for storm drain system velocity calculations assuming pipe flowing full (V=Vfull/Area). See Manning's Equation calculation sheet.
(19) Channel flow assumptions
(20) T = L / V in seconds
(21) Channel Time of Concentration = time in seconds / 60
(22) Tc = Sheet Flow Time of Concentration (Tt1) + Shallow Concentrated Flow (Tt2)+Channel Flow Time of Concentration (Tt3)

The following Data were collected from City of Austin Watershed Protection Department GIS information (Drainage Pipe)

Manning's Calculation (Ultimate Development Land Use Conditions) n = 0.013

EBLDN-P1&P2

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	24	308	520.13	511.00	0.0296	2.96	38.92	3.14	12.39	0.20	2.52
2	24	91	511.00	507.65	0.0368	3.68	43.39	3.14	13.82	0.06	0.83
3	24	39	507.43	506.00	0.0367	3.67	43.34	3.14	13.80	0.03	0.36
4	42	242	504.50	502.72	0.0074	0.74	86.54	9.62	9.00	0.16	1.44
5	42	150	502.72	501.61	0.0074	0.74	86.54	9.62	9.00	0.10	0.89
6	42	48	501.61	501.26	0.0073	0.73	85.96	9.62	8.94	0.03	0.28
7	42	148	501.26	499.79	0.0099	0.99	100.10	9.62	10.41	0.10	1.02
8	42	256	499.75	497.20	0.00996	0.996	100.40	9.62	10.44	0.17	1.76
9	42	40	497.20	496.90	0.0075	0.75	87.13	9.62	9.06	0.03	0.24
10	42	6	496.90	496.86	0.0067	0.67	82.35	9.62	8.56	0.00	0.03
11	42	15	496.86	496.75	0.0073	0.73	85.96	9.62	8.94	0.01	0.09
12	42	40	496.75	496.44	0.0078	0.78	88.85	9.62	9.24	0.03	0.24
13	42	131	496.44	494.92	0.0116	1.16	108.35	9.62	11.26	0.09	0.97
	Total	**1,514**								**1.00**	**10.68**

EBLDN-Q2

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	30	358.79	-	-	0.0290	2.90	69.85	4.91	14.23	0.35	4.98
2	30	344.47	-	-	0.0290	2.90	69.85	4.91	14.23	0.34	4.79
3	15	320.8	-	-	0.0290	2.90	11.00	1.23	8.94	0.31	2.80
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**1,024**								**1.00**	**12.57**

EBLDN-L

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope* (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	18	33	-	-	0.0100	1.00	17.89	1.77	10.11	0.04	0.43
2	18	27	-	-	0.0100	1.00	17.89	1.77	10.11	0.04	0.35
3	36	87	511.56	511.01	0.0063	0.63	52.94	7.07	7.49	0.11	0.85
4	36	359	511.01	508.92	0.0058	0.58	50.79	7.07	7.18	0.47	3.35
5	36	34	508.86	508.65	0.0062	0.62	52.52	7.07	7.43	0.04	0.33
6	36	229	508.65	507.00	0.0072	0.72	56.59	7.07	8.00	0.30	2.38
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**769**								**1.00**	**7.70**

EBLDN-H

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	18	10	-	-	**0.0230**	**2.30**	**15.93**	**1.77**	9.00	0.01	0.13
2	30	8	-	-	**0.0230**	**2.30**	**62.20**	**4.91**	12.67	0.01	0.15
3	30	5	-	-	**0.0230**	2.30	**62.20**	**4.91**	12.67	0.01	0.09
4	30	17	-	-	**0.0230**	2.30	**62.20**	**4.91**	12.67	0.02	0.31
5	36	44	516.72	516.51	**0.0048**	**0.48**	**46.21**	**7.07**	6.54	0.06	0.41
6	36	58	516.51	516.22	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.08	0.56
7	36	341	516.22	514.51	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.49	3.27
8	36	18	514.51	514.42	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.03	0.17
9	36	19	514.42	514.10	**0.0168**	**1.68**	**86.45**	**7.07**	12.23	0.03	0.33
10	36	176	514.10	511.00	**0.0176**	**1.76**	**88.48**	**7.07**	12.51	0.25	3.16
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**696**								**1.00**	**8.58**

Lag Time Calculations for the East Bouldin Creek Watershed (Existing Conditions)

HMS Program Basin Name	Longest Flowpath (ft) (1)	Sheet Flow: Length (ft) (2)	IC% (3)	Land Use (4)	Surface Description (5)	Manning's roughness n (6)	Slope (ft/ft) (7)	Tt1 (min.) (8)
EBLDN-A1		100	56.8	SF, MF, Paved Surface	Short Grass	0.15	0.022	9.18
EBLDN-A2							#DIV/0!	#DIV/0!
EBLDN-A3	1,537	74	65.5	Civic, Mixed Use, Single Family	Short Grass	0.15	0.027	6.59
EBLDN-A4	5,041	100	61.8	Single Family	Short Grass	0.15	0.015	10.60
EBLDN-A5		100	46.4	SF, MF, Commercial, Mixed Use, Paved Surface	Asphalt	0.016	0.032	1.31
EBLDN-A6		17	63.9	SF, Paved Surface	Asphalt	0.016	0.025	0.35
EBLDN-M1		48.6	67.3	SF, Paved Surface	Asphalt	0.016	0.010	1.17
EBLDN-M2		37.75	52.2	SF, Paved Surface	Asphalt	0.016	0.031	0.61
EBLDN-M3		98.8	43.8	SF, Paved Surface	Asphalt	0.016	0.012	1.92
EBLDN-R		56	58	SF, Commercial, Paved Surface	Short Grass	0.15	0.013	7.06

HMS Program Basin Name	Shallow Concentrated Flow: Length 2 (ft) (9)	L2 paved (ft) (10)	L2 unpaved (ft) (11)	Slope 2 (ft/ft) (12)	Assumption for Tt2 (13)	Tt2 (paved) (min.) (13)	Tt2 (unpaved) (min.) (14)	Tt2 (min.) (15)
EBLDN-A1	204	116	88	0.037	Paved & Unpaved	0.49	0.47	0.96
EBLDN-A2		0	0	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!
EBLDN-A3	73	46	27	0.027	Paved & Unpaved	0.23	0.17	0.40
EBLDN-A4	4,941	3,053	1,887	0.025	Paved & Unpaved	15.96	12.43	28.40
EBLDN-A5	446	207	239	0.098	Paved & Unpaved	0.54	0.79	1.33
EBLDN-A6	0	0	0	#DIV/0!		#DIV/0!	#DIV/0!	0.00
EBLDN-M1	559	377	183	0.035	Paved & Unpaved	1.65	1.01	2.66
EBLDN-M2	328.6	172	157	0.048	Paved & Unpaved	0.64	0.74	1.38
EBLDN-M3	311	136	175	0.048	Paved & Unpaved	0.51	0.82	1.33
EBLDN-R	367	317	50	0.026	Paved & Unpaved	1.61	0.32	1.93

HMS Program Basin Name	Channel Flow: Length 3 (ft) (16)	Slope 3 (ft/ft) (17)	V (ft/s) (18)	Assumption for V (19)	Tt3 (sec) (20)	Tt3 (min.) (21)	**Tc (min) (22)**	**Final Tc (min) (23)**	**Tlag (min) (24)**	**Final Tlag (min) (25)**	**Total Flowpath Lenth (ft)**	Sub-basin
EBLDN-A1	1,238	0.042		gutter flow		2.18	12.32	12.32	7.39	7.4	1542	EBLDN-A1
EBLDN-A2	0	#DIV/0!	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	3.5	0	EBLDN-A2
EBLDN-A3	1,389	0.015	5.67	gutter flow	N/A	4.09	11.07	11.07	6.64	6.6	1536	EBLDN-A3
EBLDN-A4	0	#DIV/0!	#DIV/0!				39.00	39.00	23.40	23.4	5041	EBLDN-A4
EBLDN-A5	226	0.028	3.56	Defined Channel	64	1.06	3.70	5.00	3.00	3.5	772	EBLDN-A5
EBLDN-A6	722		5.90	gutter flow	N/A	2.05	2.40	5.00	3.00	3.5	739	EBLDN-A6
EBLDN-M1		N/A	N/A	pipe flow	N/A	2.71	6.54	6.54	3.92	3.9	608	EBLDN-M1
EBLDN-M2		N/A	N/A		N/A		1.99	5.00	3.00	3.5	366	EBLDN-M2
EBLDN-M3		N/A	N/A	gutter and pipe flow	N/A	0.34	3.59	5.00	3.00	3.5	410	EBLDN-M3
EBLDN-R	1,143	N/A	N/A	gutter flow	N/A	3.19	12.18	12.18	7.31	7.3	1566	EBLDN-R

Notes:

Please refer to N:\Team3\WPD_EBC_Annie\DGN\Annie_EXIST_revdJan2017.dgn (level EX_Drainage_LN_Tc_EBLDN) for drainage sub-basins and times of concentration flow paths.

(1) Longest flow path equals sum of sheet, shallow concentrated and channel flow lengths.
(2) Sheet flow was considered to occur at short distances with a maximum of 100 feet for both natural (undeveloped) and developed conditions;
(3) Percent impervious cover calculations presented as part of HEC-HMS input data.
(4) Land use determined from 2012 aerial photography.
(5) Surface description (DCM Table 2-2)
(6) Manning's roughness n (DCM Table 2-2)
(7) Sheet flow slope = (US elevation - DS elevation) / overland flow length
(8) Sheet Flow Time of concentration (Tt1) = 0.42(nL)^08/((P2)^0.5 S^0.4) (DCM Eq. 2-3)
(9) Shallow concentrated flow length
(10) paved length = shallow concentrated paved length x IC% / 100
(11) unpaved length = shallow concentrated flow length - paved length
(12) slope = (US elevation - DS elevation) / shallow concentrated flow length
(13) Tt2 (Paved) = L/60(20.3282)(S)^0.5) DCM Eq. 2-5
(14) Tt2 (Unpaved) = L/60(16.1345)(S)^0.5) DCM Eq. 2-4
(15) = (13) + (14)
(16) Total Channel flow length
(18) Channel velocity equations were determined by statistical analysis on the existing HEC-RAS models for East Bouldin Creek
East Bouldin Main Channel Velocity Equation (Halff Associates, July 2005) = 178.89 *(slope 2/100)+3.5055 (For "no defined channel" flow paths, velocity is assumed 2.5 - 4.0 fps based on channel slope)
Manning's equation is used for storm drain system velocity calculations assuming pipe flowing full (V=Vfull/Area). See Manning's Equation calculation sheet.
(19) Channel flow assumptions
(20) T = L / V in seconds
(21) Channel Time of Concentration = time in seconds / 60; or gutter flow; or pipe flow
(22) Tc = Sheet Flow Time of Concentration (Tt1) + Shallow Concentrated Flow (Tt2)+Channel Flow Time of Concentration (Tt3)
(23) If Tc > 5 minutes, Tc = Final Tc, else Final Tc = 5 minutes
(24) Lag Time (T lag) = 0.6* Final Tc (Soil Conservation Service)
(25) A minimum lag time of 3.5 minutes is required by HMS so that lag*0.29 is greater than the minimum time step of 1 min

EBLDN-A1

			measured
Gutter Length =	1237.71	ft	on dgn file
Gutter Slope =	0.042	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Velocity =	9.5	ft/sec	Ref: V = k * S0.5 , where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	2.18	min	time = length /

Weighted average slope

	length (ft)	slope	slope*length
	86.85	0.0088	0.76428
	188.39	0.058	10.92662
	455.75	0.01	4.5575
	506.72	0.07	35.4704
total	1237.71		51.7188

weighted avg slope = 0.041786

EBLDN-A3

			measured
Gutter Length =	1390	ft	on dgn file
Gutter Slope =	0.015	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Velocity =	5.7	ft/sec	McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	4.09	min	time = length /

Weighted average slope

	length (ft)	slope	slope*length
	486.47	0.0162	7.880814
	419.98	0.0155	6.50969
	482.52	0.0133	6.417516
			0
total	1388.97		20.80802

weighted avg slope = 0.014981

EBLDN-A6

			measured
Gutter Length =	722	ft	on dgn file
Gutter Slope =	0.016	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Veloctiy =	5.9	ft/sec	McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	2.05	min	time = length /

Weighted average slope

	length (ft)	slope	slope*length
	414	0.0140	5.796
	308	0.019	5.852
			0
			0
total	722		11.648

weighted avg slope = 0.016133

EBLDN-M2

			measured
Gutter Length =	118	ft	on dgn file
Gutter Slope =	0.043	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Veloctiy =	9.6	ft/sec	McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	0.20	min	time = length /

EBLDN-M3

			measured
Gutter Length =	102	ft	on dgn file
Gutter Slope =	0.063	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Veloctiy =	11.6	ft/sec	McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	0.15	min	time = length /

EBLDN-R

			measured
Gutter Length =	1143	ft	on dgn file
Gutter Slope =	0.017	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Velociiy =	6.0	ft/sec	Ref: V = k * S0.5 , where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p.
Gutter Flow time =	3.19	min	time = length /

Existing elevations:

Elev at Crockett and alley =	573
Elev at Wilson and Johanna =	554

The following Data were collected from City of Austin Watershed Protection Department GIS information (Drainage Pipe)

Manning's Calculation (Existing Land Use Conditions) n = 0.013

EBLDN-P1&P2

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	24	308	520.13	511.00	0.0296	2.96	38.92	3.14	12.39	0.20	2.52
2	24	91	511.00	507.65	0.0368	3.68	43.39	3.14	13.82	0.06	0.83
3	24	39	507.43	506.00	0.0367	3.67	43.34	3.14	13.80	0.03	0.36
4	42	242	504.50	502.72	0.0074	0.74	86.54	9.62	9.00	0.16	1.44
5	42	150	502.72	501.61	0.0074	0.74	86.54	9.62	9.00	0.10	0.89
6	42	48	501.61	501.26	0.0073	0.73	85.96	9.62	8.94	0.03	0.28
7	42	148	501.26	499.79	0.0099	0.99	100.10	9.62	10.41	0.10	1.02
8	42	256	499.75	497.20	0.00996	0.996	100.40	9.62	10.44	0.17	1.76
9	42	40	497.20	496.90	0.0075	0.75	87.13	9.62	9.06	0.03	0.24
10	42	6	496.90	496.86	0.0067	0.67	82.35	9.62	8.56	0.00	0.03
11	42	15	496.86	496.75	0.0073	0.73	85.96	9.62	8.94	0.01	0.09
12	42	40	496.75	496.44	0.0078	0.78	88.85	9.62	9.24	0.03	0.24
13	42	131	496.44	494.92	0.0116	1.16	108.35	9.62	11.26	0.09	0.97
	Total	**1,514**								**1.00**	**10.68**

EBLDN-Q2

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	30	358.79	-	-	0.0290	2.90	69.85	4.91	14.23	0.35	4.98
2	30	344.47	-	-	0.0290	2.90	69.85	4.91	14.23	0.34	4.79
3	15	320.8	-	-	0.0290	2.90	11.00	1.23	8.94	0.31	2.80
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**1,024**								**1.00**	**12.57**

EBLDN-L

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope* (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	18	33	-	-	0.0100	1.00	17.89	1.77	10.11	0.04	0.43
2	18	27	-	-	0.0100	1.00	17.89	1.77	10.11	0.04	0.35
3	36	87	511.56	511.01	0.0063	0.63	52.94	7.07	7.49	0.11	0.85
4	36	359	511.01	508.92	0.0058	0.58	50.79	7.07	7.18	0.47	3.35
5	36	34	508.86	508.65	0.0062	0.62	52.52	7.07	7.43	0.04	0.33
6	36	229	508.65	507.00	0.0072	0.72	56.59	7.07	8.00	0.30	2.38
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**769**								**1.00**	**7.70**

EBLDN-M

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	36	172	507.48	501.75	0.0333	3.33	121.71	7.07	17.21	0.34	5.85
2	36	88	511.00	507.48	0.0400	4.00	133.39	7.07	18.87	0.17	3.28
3	36	31	-	-	**0.0500**	**5.00**	149.13	7.07	21.09	0.06	1.29
4	30	215.5	-	-	**0.0500**	**5.00**	91.71	4.91	18.68	0.43	7.95
Note: Average channel slope was changed from 0.051 to 0.050 based on StormCAD											
	Total	**507**								**1.00**	**18.36**

EBLDN-H

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	18	10	-	-	**0.0230**	**2.30**	**15.93**	**1.77**	9.00	0.01	0.13
2	30	8	-	-	**0.0230**	**2.30**	**62.20**	**4.91**	12.67	0.01	0.15
3	30	5	-	-	**0.0230**	2.30	**62.20**	**4.91**	12.67	0.01	0.09
4	30	17	-	-	**0.0230**	2.30	**62.20**	**4.91**	12.67	0.02	0.31
5	36	44	516.72	516.51	**0.0048**	**0.48**	**46.21**	**7.07**	6.54	0.06	0.41
6	36	58	516.51	516.22	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.08	0.56
7	36	341	516.22	514.51	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.49	3.27
8	36	18	514.51	514.42	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.03	0.17
9	36	19	514.42	514.10	**0.0168**	**1.68**	**86.45**	**7.07**	12.23	0.03	0.33
10	36	176	514.10	511.00	**0.0176**	**1.76**	**88.48**	**7.07**	12.51	0.25	3.16
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**696**								**1.00**	**8.58**

Pipe Flow times
Ref ..\StormCAD\Base

EBLDN-M1

Conduit	Time (Pipe Flow) min	start at Catch Basin I-A21
SS-A36	1.42	
SS-A32	0.08	
SS-A31	0.04	
SS-A30	0.04	
SS-A27	0.63	
SS-A8	0.07	
SS-A7	0.03	
SS-A6	0.1	
SS-A5	0.05	
SS-A4	0.06	
SS-A3	0.07	
SS-A2	0.04	
SS-A1	0.08	
Total =	**2.71**	

EBLDN-M3

Conduit	Time (Pipe Flow) min	start at Catch Basin I-A21
SS-A3	0.07	
SS-A2	0.04	
SS-A1	0.08	
Total =	**0.19**	

Lag Time Calculations for the East Bouldin Creek Watershed (Ultimate Conditions)

Sheet Flow

HMS Program Basin Name	Longest Flowpath (ft) (1)	Length (ft) (2)	IC% (3)	Land Use (4)	Surface Description (5)	Manning's roughness n (6)	Slope (ft/ft) (7)	Tt1 (min.) (8)
EBLDN-B	2,866	63	78	SF, MF, Paved Surface	Dense grass	0.24	0.023	9.01
EBLDN-C	921	100	67	SF, Commercial, Paved Surface	Short Grass	0.15	0.023	8.94
EBLDN-D	6,305	72	73	SF, Mixed Use Paved Surface	Short Grass	0.15	0.018	7.55
EBLDN-E	5,536	100	75	SF, MF, Commercial, Mixed Use, Paved Surface	Asphalt	0.016	0.015	1.77
EBLDN-F	1,927	92	70	SF, Mixed Use	Short Grass	0.15	0.022	8.51
EBLDN-G	878	100	66	SF, Mixed Use, Paved Surface	Short Grass	0.15	0.038	7.31
EBLDN-H	1,772	100	73	SF, Mixed Use	Dense grass	0.24	0.005	23.96
EBLDN-I	739	75	68	SF, Mixed Use	Short Grass	0.15	0.009	10.24
EBLDN-J	416	52	94	Paved Surface	Concrete & Asphalt	0.0155	0.029	0.79
EBLDN-K	540	52	66	SF	Asphalt	0.016	0.081	0.54
EBLDN-L	1,797	100	73	SF, Mixed Use, Paved Surface	Dense grass	0.24	0.040	10.43
EE								
EBLDN-O2	923	100	73	SF, Mixed Use, Paved Surface	Asphalt	0.016	0.013	1.87
EBLDN-P1	2,464	58	66	SF, Mixed Use, Paved Surface	Short Grass	0.15	0.009	8.62
EBLDN-Q2	2,236	100	76	SF, Mixed Use, Paved Surface	Asphalt	0.016	0.027	1.40
EB								
EBLDN-S	2,354	100	83	SF, MF, Mixed Use, Fulmore MS,Paved Surface	Asphalt	0.016	0.015	1.77

Shallow Concentrated Flow

HMS Program Basin Name	Length 2 (ft) (9)	L2 paved (ft) (10)	L2 unpaved (ft) (11)	Slope 2 (ft/ft) (12)	Assumption for Tt2 (13)	Tt2 (paved) (min.) (13)	Tt2 (unpaved) (min.) (14)	Tt2 (min.) (15)
EBLDN-B	2,444	1,906	538	0.023	Paved & Unpaved	10.41	3.70	14.11
EBLDN-C	710	476	234	0.039	Paved & Unpaved	1.98	1.23	3.21
EBLDN-D	1,838	1,342	496	0.030	Paved & Unpaved	6.39	2.98	9.37
EBLDN-E	4,072	3,054	1,018	0.027	Paved & Unpaved	15.27	6.41	21.69
EBLDN-F	1,184	829	355	0.030	Paved & Unpaved	3.93	2.12	6.05
EBLDN-G	583	385	198	0.070	Paved & Unpaved	1.19	0.77	1.96
EBLDN-H	976	712	264	0.029	Paved & Unpaved	3.42	1.59	5.01
EBLDN-I	425	289	136	0.094	Paved & Unpaved	0.78	0.46	1.23
EBLDN-J	99	93	6	0.040	Paved & Unpaved	0.38	0.03	0.41
EBLDN-K	319	211	108	0.005	Paved & Unpaved	2.52	1.63	4.15
EBLDN-L	928	677	251	0.036	Paved & Unpaved	2.92	1.36	4.28
EE								
EBLDN-O2	666	486	180	0.060	Paved & Unpaved	1.62	0.76	2.38
EBLDN-P1	892	589	303	0.024	Paved & Unpaved	3.12	2.03	5.15
EBLDN-Q2	1,112	845	267	0.023	Paved & Unpaved	4.61	1.83	6.45
EB								
EBLDN-S	995	826	169	0.011	Paved & Unpaved	6.59	1.70	8.29

Channel Flow

HMS Program Basin Name	Length 3 (ft) (16)	Slope 3 (ft/ft) (17)	V (ft/s) (18)	Assumption for V (19)	Tt3 (sec) (20)	Tt3 (min.) (21)	**Tc (min) (22)**	**Final Tc (min) (23)**	**Tlag (min) (24)**	**Final Tlag (min) (25)**	**Total Flowpath Length (ft)**	Sub-basin
EBLDN-B	359	0.010	3.52	Defined Channel	102	1.70	24.81	24.81	14.89	14.9	2866	EBLDN-B
EBLDN-C	110	0.027	3.55	Defined Channel	31	0.52	12.67	12.67	7.60	7.6	921	EBLDN-C
EBLDN-D	4,395	0.010	3.52	Defined Channel	1248	20.79	37.70	37.70	22.62	22.6	6305	EBLDN-D
EBLDN-E	1,364	0.045	4.00	No Defined Channel	341	5.68	29.14	29.14	17.48	17.5	5536	EBLDN-E
EBLDN-F	651	0.022	3.00	No Defined Channel	217	3.62	18.18	18.18	10.91	10.9	1927	EBLDN-F
EBLDN-G	195	0.020	3.54	Defined Channel	55	0.92	10.19	10.19	6.11	6.1	878	EBLDN-G
EBLDN-H	696	0.027	8.58	Manning's Equation	81	1.35	30.33	30.33	18.20	18.2	1772	EBLDN-H
EBLDN-I	238	0.013	3.53	Defined Channel	68	1.13	12.60	12.60	7.56	7.6	739	EBLDN-I
EBLDN-J	265	0.038	3.57	Defined Channel	74	1.24	2.43	5.00	3.00	3.5	416	EBLDN-J
EBLDN-K	168	0.170	3.81	Defined Channel	44	0.74	5.42	5.42	3.25	3.5	540	EBLDN-K
EBLDN-L	769	0.010	7.70	Manning's Equation	100	1.66	16.38	16.38	9.83	9.8	1797	EBLDN-L
EE												
EBLDN-O2	156	0.013	3.53	Defined Channel	44	0.74	4.99	5.00	3.00	3.5	923	EBLDN-O2
EBLDN-P1	1,514	0.014	10.68	Manning's Equation	142	2.36	16.13	16.13	9.68	9.7	2464	EBLDN-P1
EBLDN-Q2	1,024	0.039	12.57	Manning's Equation	81	1.36	9.20	9.20	5.52	5.5	2236	EBLDN-Q2
EB												
EBLDN-S	1,259	0.012	2.50	No Defined Channel	504	8.39	18.46	18.46	11.07	11.1	2354	EBLDN-S

Notes:

Please refer to N:\Team3\WPD_EBC_Annie\DGN\Annie_EXIST_TC_021115.dgn for drainage sub-basins and times of concentration flow paths.
(1) Longest flow path equals sum of sheet, shallow concentrated and channel flow lengths.
(2) Sheet flow was considered to occur at short distances with a maximum of 100 feet for both natural (undeveloped) and developed conditions;
(3) Percent impervious cover calculations presented as part of HEC-HMS input data.
(4) Land use determined from 2012 aerial photography.
(5) Surface description (DCM Table 2-2)
(6) Manning's roughness n (DCM Table 2-2)
(7) Sheet flow slope = (US elevation - DS elevation) / overland flow length
(8) Sheet Flow Time of concentration (Tt1) = 0.42(nL)^08/((P2)^0.5 S^0.4) (DCM Eq. 2-3)
(9) Shallow concentrated flow length
(10) paved length = shallow concentrated paved length x IC% / 100
(11) unpaved length = shallow concentrated flow length - paved length
(12) slope = (US elevation - DS elevation) / shallow concentrated flow length
(13) Tt2 (Paved) = L/60(20.3282)(S)^0.5) DCM Eq. 2-5
(14) Tt2 (Unpaved) = L/60(16.1345)(S)^0.5) DCM Eq. 2-4
(15) = (13) + (14)
(16) Total Channel flow length
(18) Channel velocity equations were determined by statistical analysis on the existing HEC-RAS models for East Bouldin Creek
East Bouldin Main Channel Velocity Equation (Halff Associates, July 2005) = 178.89 *(slope 2/100)+3.5055 (For "no defined channel" flow paths, velocity is assumed 2.5 - 4.0 fps based on channel slope)
Manning's equation is used for storm drain system velocity calculations assuming pipe flowing full (V=Vfull/Area). See Manning's Equation calculation sheet.
(19) Channel flow assumptions
(20) T = L / V in seconds
(21) Channel Time of Concentration = time in seconds / 60
(22) Tc = Sheet Flow Time of Concentration (Tt1) + Shallow Concentrated Flow (Tt2)+Channel Flow Time of Concentration (Tt3)

The following Data were collected from City of Austin Watershed Protection Department GIS information (Drainage Pipe)

Manning's Calculation (Ultimate Development Land Use Conditions) n = 0.013

EBLDN-P1&P2

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	24	308	520.13	511.00	0.0296	2.96	38.92	3.14	12.39	0.20	2.52
2	24	91	511.00	507.65	0.0368	3.68	43.39	3.14	13.82	0.06	0.83
3	24	39	507.43	506.00	0.0367	3.67	43.34	3.14	13.80	0.03	0.36
4	42	242	504.50	502.72	0.0074	0.74	86.54	9.62	9.00	0.16	1.44
5	42	150	502.72	501.61	0.0074	0.74	86.54	9.62	9.00	0.10	0.89
6	42	48	501.61	501.26	0.0073	0.73	85.96	9.62	8.94	0.03	0.28
7	42	148	501.26	499.79	0.0099	0.99	100.10	9.62	10.41	0.10	1.02
8	42	256	499.75	497.20	0.00996	0.996	100.40	9.62	10.44	0.17	1.76
9	42	40	497.20	496.90	0.0075	0.75	87.13	9.62	9.06	0.03	0.24
10	42	6	496.90	496.86	0.0067	0.67	82.35	9.62	8.56	0.00	0.03
11	42	15	496.86	496.75	0.0073	0.73	85.96	9.62	8.94	0.01	0.09
12	42	40	496.75	496.44	0.0078	0.78	88.85	9.62	9.24	0.03	0.24
13	42	131	496.44	494.92	0.0116	1.16	108.35	9.62	11.26	0.09	0.97
	Total	**1,514**								**1.00**	**10.68**

EBLDN-Q2

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	30	358.79	-	-	0.0290	2.90	69.85	4.91	14.23	0.35	4.98
2	30	344.47	-	-	0.0290	2.90	69.85	4.91	14.23	0.34	4.79
3	15	320.8	-	-	0.0290	2.90	11.00	1.23	8.94	0.31	2.80
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**1,024**								**1.00**	**12.57**

EBLDN-L

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope* (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	18	33	-	-	0.0100	1.00	17.89	1.77	10.11	0.04	0.43
2	18	27	-	-	0.0100	1.00	17.89	1.77	10.11	0.04	0.35
3	36	87	511.56	511.01	0.0063	0.63	52.94	7.07	7.49	0.11	0.85
4	36	359	511.01	508.92	0.0058	0.58	50.79	7.07	7.18	0.47	3.35
5	36	34	508.86	508.65	0.0062	0.62	52.52	7.07	7.43	0.04	0.33
6	36	229	508.65	507.00	0.0072	0.72	56.59	7.07	8.00	0.30	2.38
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**769**								**1.00**	**7.70**

EBLDN-H

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	18	10	-	-	**0.0230**	**2.30**	**15.93**	**1.77**	9.00	0.01	0.13
2	30	8	-	-	**0.0230**	**2.30**	**62.20**	**4.91**	12.67	0.01	0.15
3	30	5	-	-	**0.0230**	2.30	**62.20**	**4.91**	12.67	0.01	0.09
4	30	17	-	-	**0.0230**	2.30	**62.20**	**4.91**	12.67	0.02	0.31
5	36	44	516.72	516.51	**0.0048**	**0.48**	**46.21**	**7.07**	6.54	0.06	0.41
6	36	58	516.51	516.22	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.08	0.56
7	36	341	516.22	514.51	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.49	3.27
8	36	18	514.51	514.42	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.03	0.17
9	36	19	514.42	514.10	**0.0168**	**1.68**	**86.45**	**7.07**	12.23	0.03	0.33
10	36	176	514.10	511.00	**0.0176**	**1.76**	**88.48**	**7.07**	12.51	0.25	3.16
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**696**								**1.00**	**8.58**

Lag Time Calculations for the East Bouldin Creek Watershed Ultimate Conditions)

HMS Program Basin Name	Longest Flowpath (ft) (1)	Sheet Flow: Length (ft) (2)	IC% (3)	Land Use (4)	Surface Description (5)	Manning's roughness n (6)	Slope (ft/ft) (7)	Tt1 (min.) (8)
EBLDN-A1		100	74.2	SF, MF, Paved Surface	Short Grass	0.15	0.022	9.18
EBLDN-A2							#DIV/0!	#DIV/0!
EBLDN-A3	1,537	74	76.7	Civic, Mixed Use, Single Family	Short Grass	0.15	0.027	6.59
EBLDN-A4	5,041	100	80	Single Family	Short Grass	0.15	0.015	10.60
EBLDN-A5		100	72.3	SF, MF, Commercial, Mixed Use, Paved Surface	Asphalt	0.016	0.032	1.31
EBLDN-A6		17	74.2	SF, Paved Surface	Asphalt	0.016	0.025	0.35
EBLDN-M1		48.6	80.6	SF, Paved Surface	Asphalt	0.016	0.010	1.17
EBLDN-M2		37.75	69.8	SF, Paved Surface	Asphalt	0.016	0.031	0.61
EBLDN-M3		98.8	68.3	SF, Paved Surface	Asphalt	0.016	0.012	1.92
EBLDN-R		56	75	SF, Commercial, Paved Surface	Short Grass	0.15	0.013	7.06

HMS Program Basin Name	Shallow Concentrated Flow: Length 2 (ft) (9)	L2 paved (ft) (10)	L2 unpaved (ft) (11)	Slope 2 (ft/ft) (12)	Assumption for Tt2 (13)	Tt2 (paved) (min.) (13)	Tt2 (unpaved) (min.) (14)	Tt2 (min.) (15)
EBLDN-A1	204	151	53	0.037	Paved & Unpaved	0.64	0.28	0.92
EBLDN-A2		0	0	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!
EBLDN-A3	73	46	27	0.027	Paved & Unpaved	0.23	0.17	0.40
EBLDN-A4	4,941	3,953	988	0.025	Paved & Unpaved	20.67	6.51	27.18
EBLDN-A5	446	323	124	0.098	Paved & Unpaved	0.84	0.41	1.25
EBLDN-A6		0	0	#DIV/0!		#DIV/0!	#DIV/0!	0.00
EBLDN-M1	559	451	108	0.035	Paved & Unpaved	1.97	0.60	2.57
EBLDN-M2	328.6	229	99	0.087	Paved & Unpaved	0.64	0.35	0.99
EBLDN-M3	311	212	99	0.048	Paved & Unpaved	0.79	0.46	1.26
EBLDN-R	367	337	30	0.026	Paved & Unpaved	1.71	0.19	1.91

HMS Program Basin Name	Channel Flow: Length 3 (ft) (16)	Slope 3 (ft/ft) (17)	V (ft/s) (18)	Assumption for V (19)	Tt3 (sec) (20)	Tt3 (min.) (21)	**Tc (min) (22)**	**Final Tc (min) (23)**	**Tlag (min) (24)**	**Final Tlag (min) (25)**	**Total Flowpath Lenth (ft)**	Sub-basin
EBLDN-A1	1,238	0.042		gutter flow		2.18	12.28	12.28	7.37	7.4	1542	EBLDN-A1
EBLDN-A2	0	#DIV/0!	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	3.5	0	EBLDN-A2
EBLDN-A3	1,389	0.015	5.67	gutter flow	N/A	4.09	11.07	11.07	6.64	6.6	1536	EBLDN-A3
EBLDN-A4	0	#DIV/0!	#DIV/0!				37.78	37.78	22.67	22.7	5041	EBLDN-A4
EBLDN-A5	226	0.028	3.56	Defined Channel	64	1.06	3.62	5.00	3.00	3.5	772	EBLDN-A5
EBLDN-A6	722		5.90	gutter flow	122	2.04	2.39	5.00	3.00	3.5	739	EBLDN-A6
EBLDN-M1		N/A	N/A	pipe flow	N/A	2.71	6.45	6.45	3.87	3.9	608	EBLDN-M1
EBLDN-M2		N/A	N/A		N/A		1.59	5.00	3.00	3.5	366	EBLDN-M2
EBLDN-M3		N/A	N/A	gutter and pipe flow	N/A	0.34	3.51	5.00	3.00	3.5	410	EBLDN-M3
EBLDN-R		N/A	N/A	gutter flow	N/A	3.19	12.16	12.16	7.29	7.3	423	EBLDN-R

Notes:

Please refer to N:\Team3\WPD_EBC_Annie\DGN\Annie_EXIST_revdJan2017.dgn (level EX_Drainage_LN_Tc_EBLDN) for drainage sub-basins and times of concentration flow paths.

(1) Longest flow path equals sum of sheet, shallow concentrated and channel flow lengths.
(2) Sheet flow was considered to occur at short distances with a maximum of 100 feet for both natural (undeveloped) and developed conditions;
(3) Percent impervious cover calculations presented as part of HEC-HMS input data.
(4) Land use determined from 2012 aerial photography.
(5) Surface description (DCM Table 2-2)
(6) Manning's roughness n (DCM Table 2-2)
(7) Sheet flow slope = (US elevation - DS elevation) / overland flow length
(8) Sheet Flow Time of concentration (Tt1) = 0.42(nL)^08/((P2)^0.5 S^0.4) (DCM Eq. 2-3)
(9) Shallow concentrated flow length
(10) paved length = shallow concentrated paved length x IC% / 100
(11) unpaved length = shallow concentrated flow length - paved length
(12) slope = (US elevation - DS elevation) / shallow concentrated flow length
(13) Tt2 (Paved) = L/60(20.3282)(S)^0.5) DCM Eq. 2-5
(14) Tt2 (Unpaved) = L/60(16.1345)(S)^0.5) DCM Eq. 2-4
(15) = (13) + (14)
(16) Total Channel flow length
(18) Channel velocity equations were determined by statistical analysis on the existing HEC-RAS models for East Bouldin Creek
East Bouldin Main Channel Velocity Equation (Halff Associates, July 2005) = 178.89 *(slope 2/100)+3.5055 (For "no defined channel" flow paths, velocity is assumed 2.5 - 4.0 fps based on channel slope)
Manning's equation is used for storm drain system velocity calculations assuming pipe flowing full (V=Vfull/Area). See Manning's Equation calculation sheet.
(19) Channel flow assumptions
(20) T = L / V in seconds
(21) Channel Time of Concentration = time in seconds / 60; or gutter flow; or pipe flow
(22) Tc = Sheet Flow Time of Concentration (Tt1) + Shallow Concentrated Flow (Tt2)+Channel Flow Time of Concentration (Tt3)
(23) If Tc > 5 minutes, Tc = Final Tc, else Final Tc = 5 minutes
(24) Lag Time (T lag) = 0.6* Final Tc (Soil Conservation Service)
(25) A minimum lag time of 3.5 minutes is required by HMS so that lag*0.29 is greater than the minimum time step of 1 min

EBLDN-A1

Gutter Length =	1237.71	ft	measured on dgn file
Gutter Slope =	0.042	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Velociy =	9.5	ft/sec	McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	2.18	min	time = length /

Weighted average slope

	length (ft)	slope	slope*length
	86.85	0.0088	0.76428
	188.39	0.058	10.92662
	455.75	0.01	4.5575
	506.72	0.07	35.4704
total	1237.71		51.7188

weighted avg slope = 0.041786

EBLDN-A3

Gutter Length =	1390	ft	measured on dgn file
Gutter Slope =	0.015	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Velociy =	5.7	ft/sec	McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	4.09	min	time = length /

Weighted average slope

	length (ft)	slope	slope*length
	486.47	0.0162	7.880814
	419.98	0.0155	6.50969
	482.52	0.0133	6.417516
			0
total	1388.97		20.80802

weighted avg slope = 0.014981

EBLDN-A6

Gutter Length =	722	ft	measured on dgn file
Gutter Slope =	0.016	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Veloctiy =	5.9	ft/sec	McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	2.05	min	time = length /

Weighted average slope

	length (ft)	slope	slope*length
	414	0.0140	5.796
	308	0.019	5.852
			0
			0
total	722		11.648

weighted avg slope = 0.016133

EBLDN-M2

Gutter Length =	118	ft	measured on dgn file
Gutter Slope =	0.043	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Veloctiy =	9.6	ft/sec	Ref: V = k * S0.5 , where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p.
Gutter Flow time =	0.20	min	time = length /

EBLDN-M3

Gutter Length =	102	ft	measured on dgn file
Gutter Slope =	0.063	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Veloctiy =	11.6	ft/sec	Ref: V = k * S0.5 , where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p.
Gutter Flow time =	0.15	min	time = length /

EBLDN-R

Gutter Length =	1143	ft	measured on dgn file
Gutter Slope =	0.017	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Velociy =	6.0	ft/sec	Ref: V = k * S0.5 , where k = 46.3 for paved gutter. Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p.
Gutter Flow time =	3.19	min	time = length /

Existing elevations:

Elev at Crockett and alley =	573
Elev at Wilson and Johanna =	554

The following Data were collected from City of Austin Watershed Protection Department GIS information (Drainage Pipe)

Manning's Calculation (Existing Land Use Conditions) n = 0.013

EBLDN-P1&P2

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	24	308	520.13	511.00	0.0296	2.96	38.92	3.14	12.39	0.20	2.52
2	24	91	511.00	507.65	0.0368	3.68	43.39	3.14	13.82	0.06	0.83
3	24	39	507.43	506.00	0.0367	3.67	43.34	3.14	13.80	0.03	0.36
4	42	242	504.50	502.72	0.0074	0.74	86.54	9.62	9.00	0.16	1.44
5	42	150	502.72	501.61	0.0074	0.74	86.54	9.62	9.00	0.10	0.89
6	42	48	501.61	501.26	0.0073	0.73	85.96	9.62	8.94	0.03	0.28
7	42	148	501.26	499.79	0.0099	0.99	100.10	9.62	10.41	0.10	1.02
8	42	256	499.75	497.20	0.00996	0.996	100.40	9.62	10.44	0.17	1.76
9	42	40	497.20	496.90	0.0075	0.75	87.13	9.62	9.06	0.03	0.24
10	42	6	496.90	496.86	0.0067	0.67	82.35	9.62	8.56	0.00	0.03
11	42	15	496.86	496.75	0.0073	0.73	85.96	9.62	8.94	0.01	0.09
12	42	40	496.75	496.44	0.0078	0.78	88.85	9.62	9.24	0.03	0.24
13	42	131	496.44	494.92	0.0116	1.16	108.35	9.62	11.26	0.09	0.97
	Total	**1,514**								**1.00**	**10.68**

EBLDN-Q2

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	30	358.79	-	-	0.0290	2.90	69.85	4.91	14.23	0.35	4.98
2	30	344.47	-	-	0.0290	2.90	69.85	4.91	14.23	0.34	4.79
3	15	320.8	-	-	0.0290	2.90	11.00	1.23	8.94	0.31	2.80
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**1,024**								**1.00**	**12.57**

EBLDN-L

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope* (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	18	33	-	-	0.0100	1.00	17.89	1.77	10.11	0.04	0.43
2	18	27	-	-	0.0100	1.00	17.89	1.77	10.11	0.04	0.35
3	36	87	511.56	511.01	0.0063	0.63	52.94	7.07	7.49	0.11	0.85
4	36	359	511.01	508.92	0.0058	0.58	50.79	7.07	7.18	0.47	3.35
5	36	34	508.86	508.65	0.0062	0.62	52.52	7.07	7.43	0.04	0.33
6	36	229	508.65	507.00	0.0072	0.72	56.59	7.07	8.00	0.30	2.38
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**769**								**1.00**	**7.70**

EBLDN-M

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	36	172	507.48	501.75	0.0333	3.33	121.71	7.07	17.21	0.34	5.85
2	36	88	511.00	507.48	0.0400	4.00	133.39	7.07	18.87	0.17	3.28
3	36	31	-	-	**0.0500**	**5.00**	149.13	7.07	21.09	0.06	1.29
4	30	215.5	-	-	**0.0500**	**5.00**	91.71	4.91	18.68	0.43	7.95
Note: Average channel slope was changed from 0.051 to 0.050 based on StormCAD											
	Total	**507**								**1.00**	**18.36**

EBLDN-H

Segment	Pipe Size (in)	Length (ft)	Upstream Flow El. (ft)	Downstream Flow El. (ft)	Slope (ft/ft)	Slope (%)	Flow Capacity (cfs)	Flow Area (s.f.)	Vfull (fps)	Li/Ltotal	Average V (ft/s)
1	18	10	-	-	**0.0230**	**2.30**	**15.93**	**1.77**	9.00	0.01	0.13
2	30	8	-	-	**0.0230**	**2.30**	**62.20**	**4.91**	12.67	0.01	0.15
3	30	5	-	-	**0.0230**	2.30	**62.20**	**4.91**	12.67	0.01	0.09
4	30	17	-	-	**0.0230**	2.30	**62.20**	**4.91**	12.67	0.02	0.31
5	36	44	516.72	516.51	**0.0048**	**0.48**	**46.21**	**7.07**	6.54	0.06	0.41
6	36	58	516.51	516.22	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.08	0.56
7	36	341	516.22	514.51	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.49	3.27
8	36	18	514.51	514.42	**0.0050**	**0.50**	**47.16**	**7.07**	6.67	0.03	0.17
9	36	19	514.42	514.10	**0.0168**	**1.68**	**86.45**	**7.07**	12.23	0.03	0.33
10	36	176	514.10	511.00	**0.0176**	**1.76**	**88.48**	**7.07**	12.51	0.25	3.16
Note: Average channel slope is assumed for unknown U.S./D.S. Flow Elevations											
	Total	**696**								**1.00**	**8.58**

Pipe Flow times
Ref ..\StormCAD\Base

EBLDN-M1

Conduit	Time (Pipe Flow)	
	min	start at Catch Basin I-A21
SS-A36	1.42	
SS-A32	0.08	
SS-A31	0.04	
SS-A30	0.04	
SS-A27	0.63	
SS-A8	0.07	
SS-A7	0.03	
SS-A6	0.1	
SS-A5	0.05	
SS-A4	0.06	
SS-A3	0.07	
SS-A2	0.04	
SS-A1	0.08	
Total =	**2.71**	

EBLDN-M3

Conduit	Time (Pipe Flow)	
	min	start at Catch Basin I-A21
SS-A3	0.07	
SS-A2	0.04	
SS-A1	0.08	
Total =	**0.19**	

Exhibit R.7

Routing Steps

Routing Step Calculations

COA_Eff_REV2 Time Step = 1 mins
Eff_COA time step = 2 mins

Reach Name	Length (1)	Slope (2)	Average Velocity (3)	Steps (4)	Rounded Steps (Subreaches) (5)	Steps in Effective model
REBLDN030	1950		7.07	4.60	5.0	3
REBLDN040	1331		6.44	3.44	4.0	2
REBLDN060	4490		7.29	10.27	11.0	6
R070REVD1A	1575	0.019	6.84	3.84	4.0	
R070REVD1B	301	0.009	5.04	0.99	1.0	
R070REVD2	366	0.018	6.77	0.90	1.0	
R070REVD3	398	0.013	5.81	1.14	2.0	
R070REVD4	382	0.010	5.24	1.21	2.0	
R070REVD5	314	0.009	5.19	1.01	2.0	
R070REVD6	467	0.003	4.02	1.94	2.0	
R070REVD7	250	0.022	7.40	0.56	1.0	
REBLDN080	5214		6.18	14.06	15.0	8
R090REVD1	1315	0.005	4.41	4.97	5.0	
R090REVD2	882	0.006	4.58	3.21	4.0	
REBLDN110	1098		4.44	4.12	5.0	3

(1) Length of main channel measured on DGN file or providedin 2005 study
(2) Average slope computed from RAS channel invert slopes
(3) Equation developed in 2005 study: average channel velocity = 179.98 * (channel slope) + 3.5055
(4) Steps = (length) / (Velocity * time step)
(5) steps rounded up
Note: The Revised Pre-project model uses a 1-minute time step due to shorter lag times as compared to the Effective model. HEC-HMS warning message 47184 states that the simulation time interval should not be greater than 0.29 x lag time. See Section 9.1 of the report for further discussion.

Exhibit R.8

Storage-Discharge Functions

Ref file ..\Revised PreProject RAS routing run_Jan2017

RAS Stations used for Storage-Discharge Functions

	RAS Reach	Upstream RAS Cross Section	Upstream HMS Junction	RAS Reach	Downstream RAS Cross Section	Downstream HMS Junction	HEC_DSS file name
R070REVD1A - Culvert Split	Culvert Split	12685	JEBLDN070	Reach 3	12071	N/A	12071
R070REVD1A - Reach 2/3	Reach 2	12685	JEBLDN070	Reach 3	11110	J_LIveOak	11110
R070REVD1B - Culvert Split	Culvert Split	11110	J_LiveOak	Culvert Split	12147	N/A	12147
R070REVD1B - Reach 2/3	Reach 3	11110	J_LiveOak	Reach 3	10809	J_Crockett	10809
R070REVD2	Reach 3	10809	J_Crockett	Reach 3	10559	J_Johanna	10559
R070REVD3	Reach 3	10559	J_Johanna	Reach 3	10203	J_Mary	10203
R070REVD4	Reach 3	10203	J_Mary	Reach 3	9840	J_Annie	9840
R070REVD5	Reach 3	9840	J_Annie	Reach 3	9537	J_Milton	9537
R070REVD6	Reach 3	9537	J_Milton	Reach 3	9081	J_Monroe	9081
R070REVD7	Reach 3	9081	J_Monroe	Reach 3	8857	JEBLDN080	8857
R090REVD1	Reach 3	4022	JEBLDN090	Reach 3	2447	J_SOCO	2447
R090REVD2	Reach 3	2447	J_SOCO	Reach 3	1823	JEBLDN100a	1823

Culvert Split 12071	Reach 2/3 11110	Total Storage R070REVD1A	Flow
AC-FT	AC-FT	AC-FT	CFS
0.00	0.00	0.00	0
0.71	3.13	3.84	400
1.08	3.90	4.97	900
1.22	6.30	7.52	1300
1.23	11.37	12.61	1900
1.23	14.96	16.19	2400
1.23	18.16	19.40	2900
1.23	21.16	22.40	3400
1.23	24.35	25.59	3900
1.23	28.17	29.40	4400

Total Storage R070REVD1B 10809	Flow
AC-FT	CFS
0.00	0
0.57	400
1.09	900
1.48	1300
1.99	1900
2.37	2400
2.75	2900
3.07	3400
3.36	3900
3.65	4400

R070REVD2	R070REVD3	R070REVD4	R070REVD5	R070REVD6	R070REVD7	Flow
10559	10203	9840	9537	9081	8857	
AC-FT	AC-FT	AC-FT	AC-FT	AC-FT	AC-FT	CFS
0.00	0.00	0.00	0.00	0.00	0.00	0
0.43	0.54	0.58	0.54	1.31	0.39	400
0.86	1.00	1.10	1.05	2.63	0.74	900
1.30	1.44	1.56	1.32	3.20	1.04	1300
1.96	2.21	2.39	1.85	4.05	1.47	1900
2.43	2.86	2.99	2.27	4.70	1.85	2400
2.84	3.44	3.52	2.67	5.33	2.34	2900
3.26	3.98	4.04	3.15	6.09	2.88	3400
3.66	4.48	4.48	3.73	7.03	3.39	3900
4.05	5.01	4.92	4.35	8.17	3.91	4400
4.55	5.64	5.50	5.16	9.69	4.60	5000
					9.19	8000

R090REVD1	R090REVD2	Flow	
2447	1823		
AC-FT	AC-FT	CFS	
0	0.00	0.00	
3.90	1.18	400.00	
7.90	2.05	900.00	
12.28	2.53	1233.60	
17.46	3.27	1631.20	
22.27	3.90	1874.50	
26.98	4.45	2071.50	
29.99	4.71	2172.00	
32.20	4.83	2222.30	
33.97	4.93	2258.30	
36.05	5.03	2297.20	
151.83		3500.00	from chart EQ

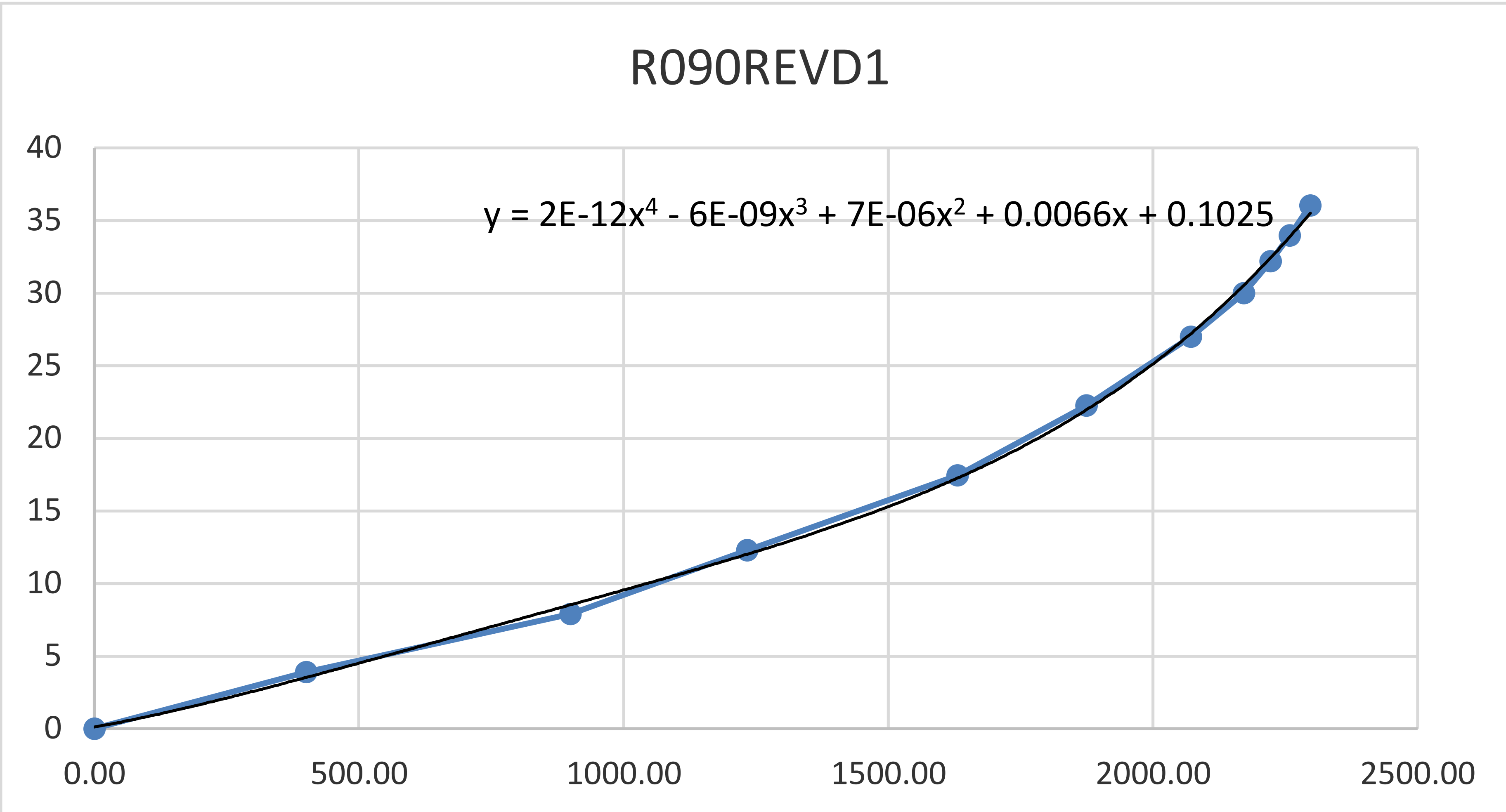

R090REVD1
y = 2E-12x4 - 6E-09x3 + 7E-06x2 + 0.0066x + 0.1025
40
35
30
25
20
15
10
5
0
0.00
500.00
1000.00
1500.00
2000.00
2500.00

Exhibit R.9

Travel (lag) Time for HMS Reach Elements

Reach: Congress Ave
Lag = travel time from South Congress and Mary (Diversion-R) to Congress and East Bouldin Creek (J_SOCO_EBC)

US Elev	DS Elev	Distance	Slope	Velocity	Travel Time	
			S	V		
		ft	ft/ft	ft/sec	sec	
				(1)	(2)	
566.9	543	1158	0.021	6.65	174	
543	500	1028.5	0.042	9.47	109	
500	490.5	1121.4	0.008	4.26	263	
490.5	459.75	814.5	0.038	9.00	91	
			Total Travel Time =		**636**	seconds
			Total Travel Time =		**10.6**	**minutes**

(1) V = k*S$^{0.5}$; k for paved gutter is 46.3 as found in Table 3-14 of: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall, 1998), p.143.

(2) time = length / velocity

Note: All three pipe segments connect at J_9, which is the intersection of Mary and Newton Streets

Reach: Annie Sys Pipes1 Ref: ..\StormCAD_CONNECT\Base\Annie_ESD_Base_Ult.stsw

Pipes on Annie street from Creek to Newton AND pipes on Newton from Annie to Mary

Scenario: 100 YR Ex sys_Ult LU

Pipe	Time (Pipe Flow) MIN
SS-A8	0.15
SS-A7	0.06
SS-A6	0.19
SS-A5	0.09
SS-A4	0.09
SS-A3	0.06
SS-A2	0.11
SS-A1	0.12
	0.9 MIN

Reach: Annie Sys Pipes2

Pipes on Mary Street from Newton to South Congress

Pipe	Time (Pipe Flow) MIN
SS-A9	0.1
SS-A10	0.12
SS-A11	0.02
SS-A12	0.15
SS-A13	0.07
SS-A14	0.02
SS-A15	0.04
SS-A16	0.06
SS-A17	0.07
SS-A18	0.2
SS-A19	0.01
SS-A20	0.11
	1.0 MIN

Reach: Annie Sys Pipes3

Pipes on Newton from Johanna to Mary St

Pipe	Time (Pipe Flow) MIN
SS-A27	0.41
SS-A29	0.27
	0.7 MIN

Reach: Johanna Pipes

Storm drain on Johanna from Wilson to creek

Ref ..\StormCAD_CONNECT\Exist_Johanna_WPD\StormCAD_103232\EBO_103232.stsw

Scenario: 100 Year Storm FLUM

Pipe	Time (Pipe Flow)
	MIN
402368	0.114
402371	0.029
402378	0.206
402381	0.101
402387	0.062
402362	0.069
CO-7	0.014
	0.6 MIN

Reach: LiveOak1

Lag = travel time from Eva/Live Oak (Diversion-Eva) to Newton/Live Oak (Diversion-Newton)

US Elev	DS Elev	Distance	Slope	Velocity	Travel Time
			S	V	
		ft	ft/ft	ft/sec	sec
				(1)	(2)
		341	0.017	6.04	56

Total Travel Time =	**56**	seconds
Total Travel Time =	**0.9**	**minutes**

(1) $V = k*S^{0.5}$; k for paved gutter is 46.3 as found in Table 3-14 of: Richard McCuen, Hydrologic

(2) time = length / velocity

Reach: LiveOak2

Lag = travel time from Newton/Live Oak (Diversion-Newton) to Live Oak and East Bouldin Creek (J_Liv

US Elev	DS Elev	Distance	Slope	Velocity	Travel Time
			S	V	
		ft	ft/ft	ft/sec	sec
				(1)	(2)
		275	0.037	8.91	31
		505	0.077	12.85	39

Total Travel Time =	**70**	seconds
Total Travel Time =	**1.2**	**minutes**

(1) $V = k*S^{0.5}$; k for paved gutter is 46.3 as found in Table 3-14 of: Richard McCuen, Hydrologic

(2) time = length / velocity

veOak)

Reach: Eva-Crockett

Lag = travel time from Eva/Live Oak (Diversion-Eva) to Crockett/Wilson (J_Wilson)

US Elev	DS Elev	Distance	Slope	Velocity	Travel Time	
			S	V		
		ft	ft/ft	ft/sec	sec	
				(1)	(2)	
		379	0.022	6.87	55	
		612	0.018	6.21	99	
			Total Travel Time =		**154**	seconds
			Total Travel Time =		**2.6**	**minutes**

(1) $V = k*S^{0.5}$; k for paved gutter is 46.3 as found in Table 3-14 of: Richard McCuen, Hydrologic

(2) time = length / velocity

Reach: Newton-Crockett

Lag = travel time from Newton/Live Oak (Diversion-Newton) to Crockett/Wilson (J_Wilson)

US Elev	**DS Elev**	**Distance**	**Slope**	**Velocity**	**Travel Time**	
			S	**V**		
		ft	**ft/ft**	**ft/sec**	**sec**	
				(1)	**(2)**	
		356	0.022	6.87	52	
		275	0.019	6.38	43	
			Total Travel Time =		**95**	seconds
			Total Travel Time =		**1.6**	**minutes**

(1) $V = k*S^{0.5}$; k for paved gutter is 46.3 as found in Table 3-14 of: Richard McCuen, Hydrologic

(2) time = length / velocity

Reach: Wilson

Lag = travel time from Crockett/Wilson (J_Wilson) to Wilson/Johanna (Diversion-R)

US Elev	DS Elev	Distance	Slope	Velocity	Travel Time	
			S	V		
		ft	ft/ft	ft/sec	sec	
				(1)	(2)	
		324	0.012	5.07	64	
			Total Travel Time =		**64**	seconds
			Total Travel Time =		**1.1**	**minutes**

(1) $V = k*S^{0.5}$; k for paved gutter is 46.3 as found in Table 3-14 of: Richard McCuen, Hydrologic

(2) time = length / velocity

Exhibit R.10

Inflow-Diversion Tables

Diversion R Inflow-Diversion Function - Existing and Ultimate Conditions

Ref for Q and inlet calcs: Inlet Calcs_Ultimate Conditions_Div R.xls
Diversion R is located at the intersection of Johanna Street and Wilson Street

% of Total Inflow to east side of Wilson (DA-A22) =	50%
% of Total Inflow to inlets on west side of Wilson =	50%

Based on video provided by Courtyard Condominiums at 300 Crockett, showing street flow overtopping curb, assume flow from Crockett overtops crown of Wilson and half the flow travels along west side of Wilson and half along th eeast side.

Grate Inlet on east side of Wilson (DA-A22):

Water Intercepted by this inlet goes to Johanna Street Storm Drain System
Water that bypasses this inlet goes to Annie Street Storm Drain System

Inlet Calcs column name -->	Total Runoff	Intercepted Flow
HMS column name -->	Inflow	Diversion to Johanna Sys
	CFS	CFS
	0	0
	12.50	4.43
	25.00	8.44
	37.50	12.65
	50.00	16.87

Inlets on west side of Wilson:

Question: Is a diversion needed on the west side of Wilson? Or, can 50% of total runoff be diverted to Johanna System?

Notes:

Water that overtops the crown and is intercepted by inlets on west side of Wilson goes to Johanns Street Storm Drain System

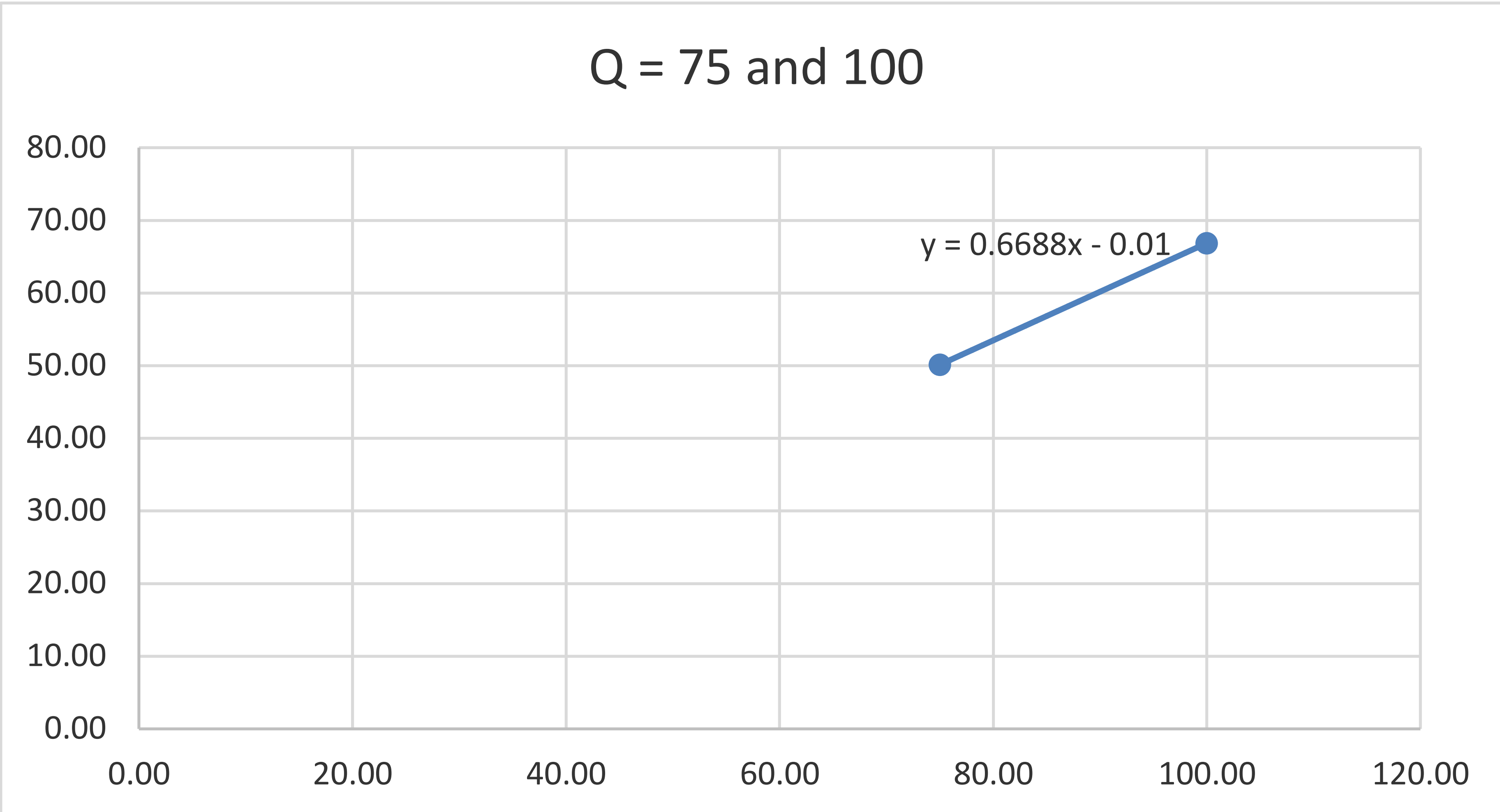
Water that bypasses inlets on west side of Wilson flows through gutter to Johanna/EBC.
Travel time through gutter = L/(k*S^.5) = (627 ft) / (43.6 * (.057)^.5) = 56.5 sec = 0.94 min
Revised Pre-projec HMSmodel peak flow at diversion = 12:11 hrs ; Revised Pre-project HMS model peak flow from Johanna Sys into EBC = 12:12 hrs (10-year existing conditions)

Gutter flow enters EBC through inlet that outfalls directly into creek; storm drain flow enters EBC through pipe through culvert wall; both flows in RAS should be routed through the culvert

Conclusion: Since travel time through gutter and difference between HMS peaks are both approx 1 min and both flows go through culvert in RAS, a diversion is not needed on the east side of Wilson. 50% of runoff can be routed to Johanna Sys through Inflow-Diversion Table below

	Total Runoff	Intercepted Flow
HMS column name -->	Inflow	Diversion to Johanna Sys
	CFS	CFS
	0	0
	12.50	12.50
	25.00	25.00
	37.50	37.50
	50.00	50.00

Total Runoff to Diversion-R	Total Intercepted Flow	
Inflow	**Diversion**	
CFS	CFS	
0	0	
25.00	16.93	
50.00	33.44	
75.00	50.15	
100.00	66.87	
300	200.39	<-- calculated based on equation for line between 75 cfs and 100 cfs points


Q = 75 and 100
y = 0.6688x - 0.01
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00

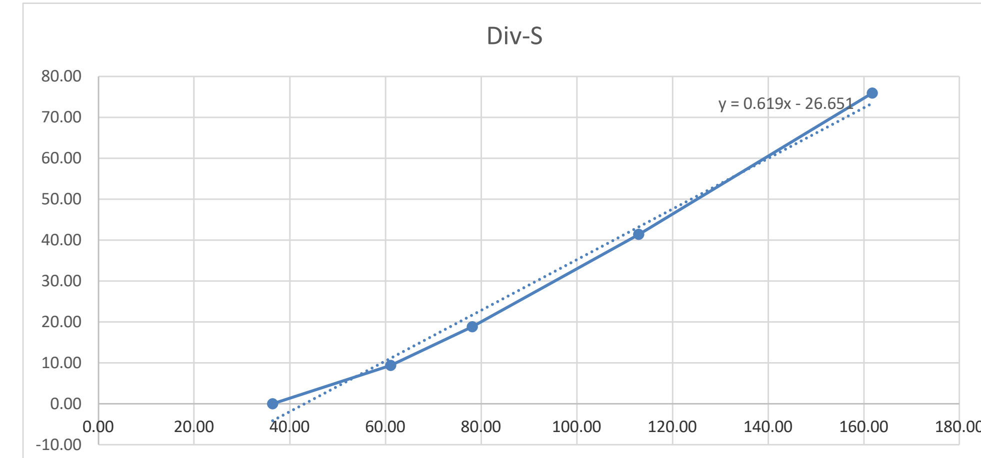
Diversion S Inflow-Diversion Function - Existing and Ultimate Conditions

Ref: Inlet Calcs_Equivalent Long Inlet_Div S.xls
Lag Time Calculations for Annie_Existing Conditions_REV_021215.xls

Notes: Intercepted Flow and Max Capacity Flow is calclated on referenced spreadsheet assuming no bypass flow from upstream inlets.

Diverted flow into inlets:

GIS Drainage ID -->	**21880**	**21879**	**none**				
Drainage Area -->	**DA-A11**	**DA-A12**	**13, 14, 15, 16, 26**	**EBLDN T = DA-A25**			
Location -->	**Mary St sump**	**Congress at Mary sump**	**Equivalent Long Inlet on grade**	**Fulmore Middle School**			
HMS column name -->						**Inflow**	**Diversion**
Inlet Calcs column name -->	**Maximum Capacity Flow CFS**	**Maximum Capacity Flow CFS**	**Intercepted Flow CFS**	**Design Flow CFS**	**Flow to Annie Storm Drain CFS**	**Q for EBLDN-S CFS**	**Flow to Congress Ave CFS**
	(1)		**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
					0	**0**	**0**
2 year_Ex	3.68	3.56	23.79	7.8	38.83	**36.44**	**0.00**
10 year_Ex	4.76	3.63	30.47	12.87	51.73	**61.08**	**9.35**
25 year_Ex	5.37	4.02	33.77	16.15	59.31	**78.15**	**18.84**
100 year_Ex	6.35	4.62	38.40	22.16	71.53	**112.97**	**41.44**
500 year_Ex	8.29	5.28	43.00	29.26	85.83	**161.75**	**75.92**
						200	**97.15** <--EQ from chart



(1) Maximum Capacity Flow calculated for sump inlets assuming no bypass from upstream inlets
(2) Intercepted flow for Equivalent Long Inlet
(3) Rational Method peak flow for EBLDN-T (DA-A25)
(4) Sum of columns (1), (2) and (3) flows to Annie Street Storm Drain system
(5) Rational Method peak flow calculated below
(6) Flow to Congress Ave = (5) - (4)

Q for EBLDN-S, Existing Conditions

		Rational Method C, Existing Conditions									
Sub-basins	**Area (AC)**	**2-year**	**10-year**	**25-year**	**100-year**	**500-year**	**C2*Area**	**C10*Area**	**C25*Area**	**C100*Area**	**C500*Area**
DA-A11	3.42	0.53	0.59	0.63	0.71	0.78	1.80	2.02	2.17	2.45	2.68
DA-A12	3.19	0.55	0.61	0.66	0.74	0.80	1.75	1.96	2.10	2.36	2.56
Equivalent Long Inlet (Areas DA-A13, DA-A14, DA-A15, DA-A16, DA-A26)	10.68	0.65	0.72	0.77	0.85	0.91	6.92	7.70	8.21	9.12	9.67
Total Area	17.29										

Tc for EBLDN-S = 18.77 mins Calculated on Existing Lag Time spreadsheet

	Composite C	**i**	**A**	**Q = Inflow**
2-year	0.61	3.48	17.29	36.44
10-year	0.68	5.23	17.29	61.08
25-year	0.72	6.26	17.29	78.15
100-year	0.81	8.11	17.29	112.97
500-year	0.86	10.85	17.29	161.75

	2-year	10-year	25-year	100-year	500-year
a=	54.767	70.820	82.9360	118.3000	188.0
b=	11.051	10.396	10.7460	13.1850	17.233
c=	0.8116	0.7725	0.7634	0.7736	0.7959

Div-Eva			
Inflow = Total Peak Flow	**Diversion = Bypass to Eva Street**		
0	0.00		
42.9	0.96	<--	Inflow = 2-year Ult HMS peak flow at J_Eva; Diversion = total bypass to Eva Street from "Bypass for StormCAD" tab (bypass to west gutter + bypass to east gutter)
60	40.00	<--	Two thirds of flow to Live Oak / Eva intersection is diverted to Eva Street; flow split based on contours and possible flow directions from
300	200.00		

Div-Newton			
Inflow = Total Peak Flow	**Diversion = Bypass to Newton Street**		
0	0.00		
44.8	10.18	<--	Inflow = 2-year Ult HMS peak flow at J_Newton; Diversion = 2-year Total Live Oak System Bypass to Newton Street from "Bypass for StormCAD" tab
60	30.00	<--	One half of flow to Live Oak / Newton intersection is diverted to Newton Street; flow split based on contours and possible flow
200	100.00		

Appendix S –
Proposed Alternative 4
Storm Drain System

Exhibit S.1	**Map of Proposed Inlet Drainage Areas and Pipes**
Exhibit S.2	**Map of Proposed Pipe Diameters and Utility Relocations**
Exhibit S.3	**Inlet Calculations for Proposed Storm Drain System and Ultimate Land Use Conditions**
Exhibit S.4	**Proposed StormCAD Profiles**

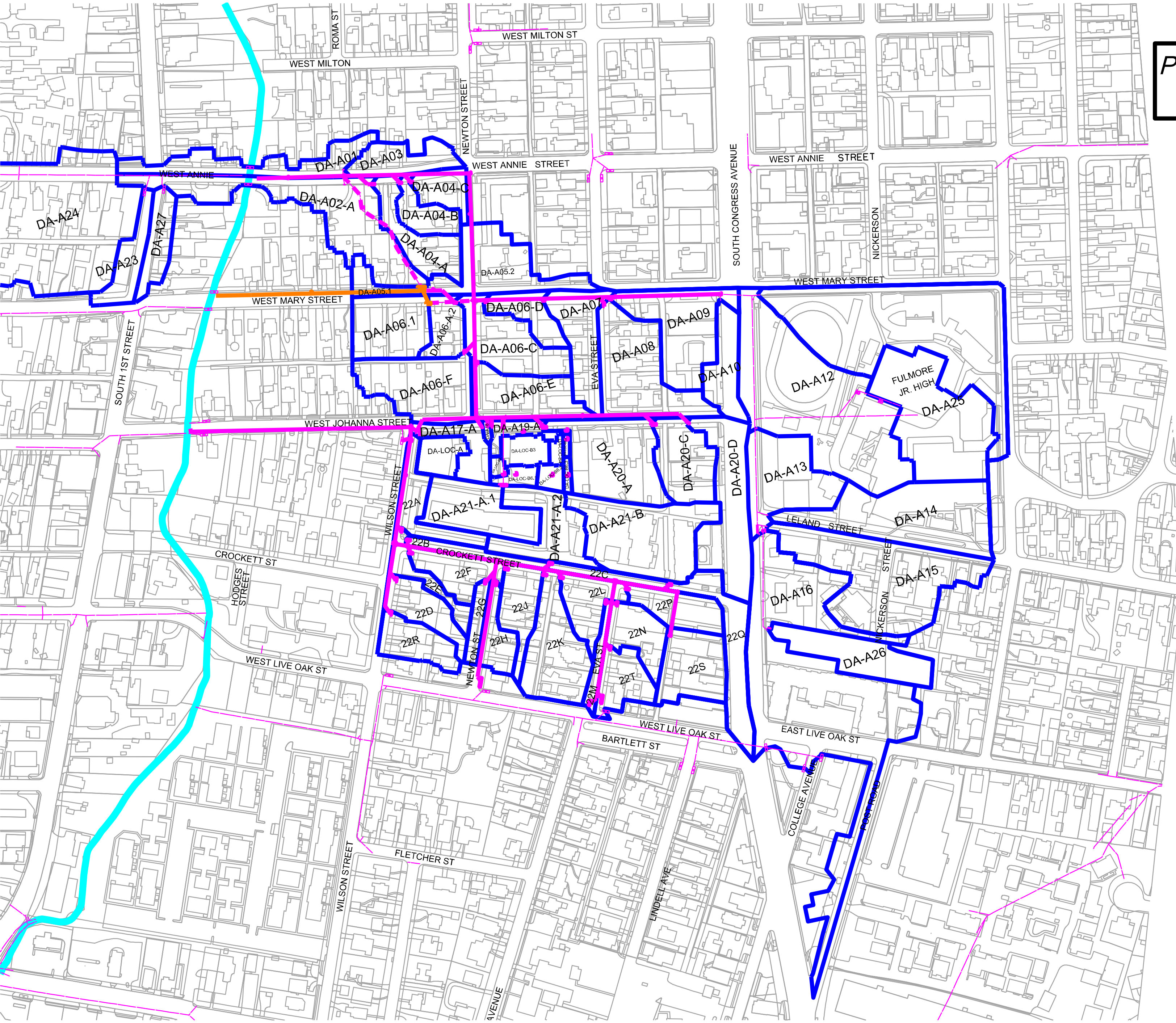
Exhibit S.1

Map of Proposed Inlet Drainage Areas and Pipes

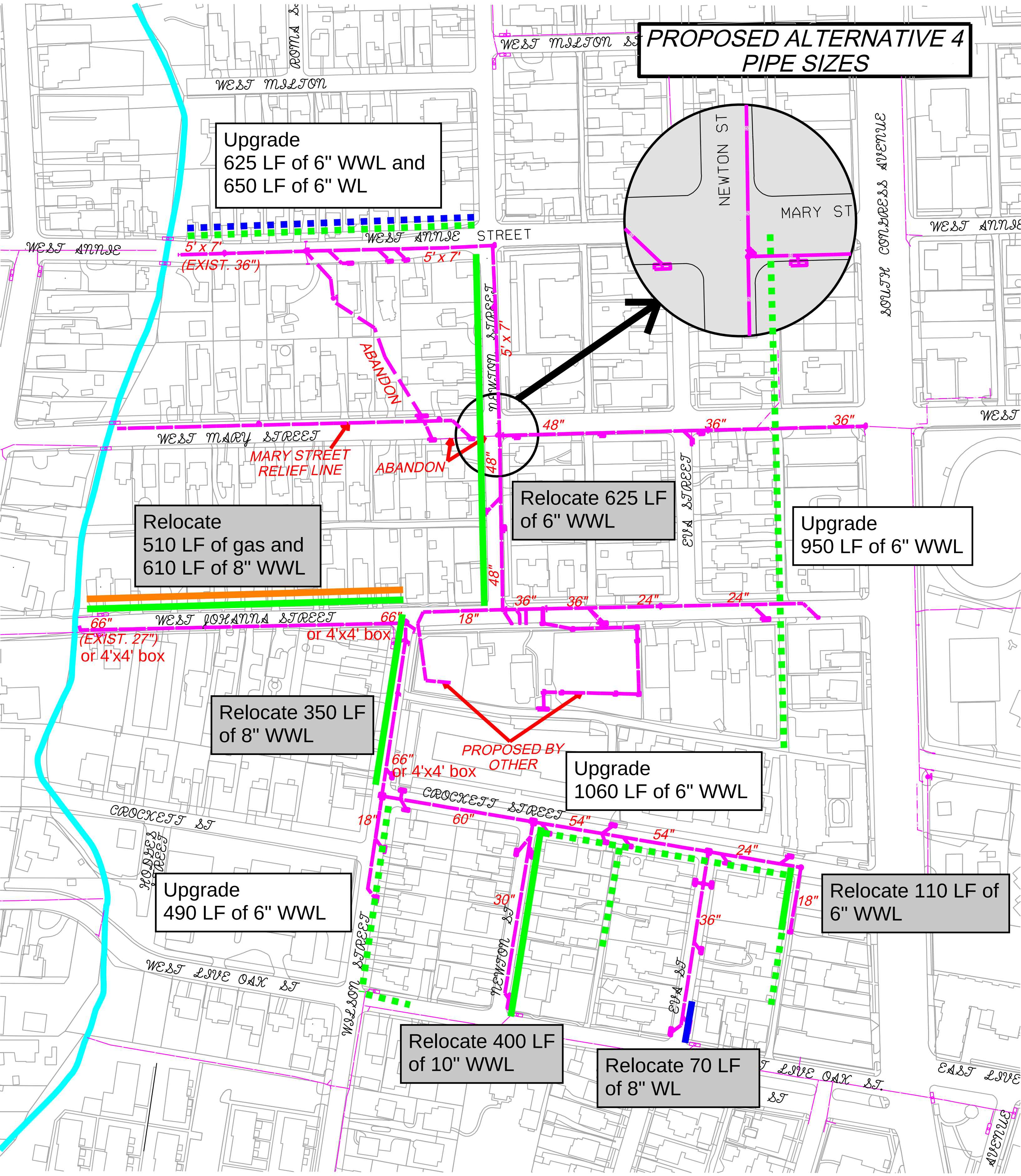
Exhibit S.2

Map of Proposed Pipe Diameters and Utility Relocations

PROPOSED ALTERNATIVE 4 INLET DRAINAGE AREAS



- East Bouldin Creek
- Drainage Areas
- Existing Storm Drain Lines
- Proposed Storm Drain Lines
- Mary Street Relief Line
- Storm Drain Lines To Be Abandoned



PROPOSED ALTERNATIVE 4
PIPE SIZES
Upgrade
625 LF of 6" WWL and
650 LF of 6" WL
WEST MILTON
WEST MILTON ST
ROMA ST
WEST ANNIE STREET
WEST ANNIE
5' x 7'
(EXIST. 36")
5' x 7'
NEWTON ST
MARY ST
SOUTH CONGRESS AVENUE
NEWTON STREET
5' x 7'
ABANDON
WEST MARY STREET
MARY STREET
RELIEF LINE
ABANDON
48"
48"
36"
36"
Relocate 625 LF
of 6" WWL
EVA STREET
Upgrade
950 LF of 6" WWL
Relocate
510 LF of gas and
610 LF of 8" WWL
48"
36"
36"
24"
24"
WEST JOHANNA STREET
66"
(EXIST. 27")
or 4'x4' box
66"
or 4'x4' box
18"
Relocate 350 LF
of 8" WWL
PROPOSED BY
OTHER
66"
or 4'x4' box
Upgrade
1060 LF of 6" WWL
CROCKETT STREET
CROCKETT ST
18"
60"
54"
54"
24"
Upgrade
490 LF of 6" WWL
30"
36"
18"
Relocate 110 LF of
6" WWL
WEST LIVE OAK ST
WILSON STREET
NEWTON ST
EVA ST
Relocate 400 LF
of 10" WWL
Relocate 70 LF
of 8" WL
LIVE OAK ST.
EAST LIVE
AVENUE

Exhibit S.3

Inlet Calculations for

Proposed Storm Drain System and

Ultimate Land Use Conditions

Summary of Inlet Calculations for Alternative 4

Note: Intercepted Flow or Maximum Capacity Flow values from the inlet calculation spreadsheets are entered into StormCAD under the System Flows Alternative, in the column titled Flow (additional subsurface).

Inlet Calculation Spreadsheets:		
	Source 1	Proposed Alt 4 inlets (except for Crockett inlets)
	Source 2	use for existing inlets that are not replaced as part of Alt 4
	Source 3	Proposed Alt 4 inlets - Crockett Street inlets
	Source 4	Live Oak Condos inlets in drainage easement
	Source 5	Estimate of area and flow to Inlet 101625

Inlet Calculation and StormCAD Flow Data					
25-yr Atlas14			100-yr Atlas 14		
	CFS			CFS	Data Source
101625	2.52		101625	3.50	Source 5
DA-LOC-A	2.46		DA-LOC-A	3.56	Source 4
DA-LOC-B3	2.44		DA-LOC-B3	3.54	
DA-LOC-B4	0.68		DA-LOC-B4	0.98	
DA-LOC-B5	0.50		DA-LOC-B5	0.73	
DA-LOC-B6.1	0.91		DA-LOC-B6.1	1.31	
DA-LOC-B6.2	0.78		DA-LOC-B6.2	1.13	
DA-LOC-B6.3	0.32		DA-LOC-B6.3	0.46	
DA-LOC-B6.4	0.18		DA-LOC-B6.4	0.26	
I-A3	2.27		I-A3	4.37	Source 2, Inlet On Grade
I-A10	2.00		I-A10	2.49	Source 2, Grate Inlet_Grade_Parabolic
I-A11	6.49		I-A11	6.76	Source 2, Curb Inlet Sump Submerged
I-A12	5.76		I-A12	6.32	
I-A13	9.80		I-A13	10.68	
I-A14	7.53		I-A14	9.22	Source 2, Inlet On Grade
I-A15	7.66		I-A15	10.11	
I-A16	8.67		I-A16	9.28	Source 2, Curb Inlet Sump Submerged
I-A22-A	1.90		I-A22-A	2.60	Source 3 - Grate Inlet On Grade_V-gutter
I-A22-B	2.40		I-A22-B	3.47	Source 3 - CURB Inlet On Grade
I-A22-C	1.98		I-A22-C	2.87	
I-A22-D	4.55		I-A22-D	7.39	
I-A22-E	2.41		I-A22-E	3.51	
I-A22-F	4.33		I-A22-F	6.32	
I-A22-G	1.98		I-A22-G	2.89	
I-A22-H	4.16		I-A22-H	7.13	
I-A22-J	4.50		I-A22-J	6.57	
I-A22-K	6.04		I-A22-K	8.80	
I-A22-L	3.85		I-A22-L	6.06	
I-A22-M	1.60		I-A22-M	4.33	
I-A22-N	3.51		I-A22-N	5.88	
I-A22-P	9.47		I-A22-P	13.63	
I-A22-Q	8.07		I-A22-Q	11.66	
I-A22-R	4.29		I-A22-R	5.50	
I-A22-S	3.20		I-A22-S	4.30	Source 3 - Grate Inlet On Grade_V-gutter
I-A22-T	4.30		I-A22-T	6.82	Source 3 - CURB Inlet On Grade
I-A25	18.79		I-A25	27.18	Source 2 - Storm 2, 10, 25, 100 tab
I-A26	8.00		I-A26	10.18	Source 2, Inlet On Grade
I-PR-21823	2.30		I-PR-21823	2.81	Source 1, Curb Inlets On Grade
I-PR-A4-A	3.92		I-PR-A4-A	4.75	
I-PR-A4-B	3.16		I-PR-A4-B	4.59	
I-PR-A4-C	3.11		I-PR-A4-C	4.44	
I-PR-A6-D	3.75		I-PR-A6-D	6.87	
I-PR-A6-E	6.78		I-PR-A6-E	8.99	
I-PR-A6-F	9.10		I-PR-A6-F	11.32	
I-PR-A7	8.60		I-PR-A7	13.64	
I-PR-A8	9.77		I-PR-A8	12.95	
I-PR-A9	9.91		I-PR-A9	12.49	

Inlet Calculation and StormCAD Flow Data					
25-yr Atlas14			100-yr Atlas 14		
	CFS			CFS	Data Source
I-PR-A17	1.09		I-PR-A17	1.54	Source 1, Grate Inlet on Grade V-gutter
I-PR-A18	3.72		I-PR-A18	4.79	Source 1, Curb Inlet Sump
I-PR-A19	3.98		I-PR-A19	5.19	
I-PR-A20-A	12.19		I-PR-A20-A	17.75	Source 1, Curb Inlets On Grade
I-PR-A20-C	14.17		I-PR-A20-C	18.78	
I-PR-A20-D	5.46		I-PR-A20-D	6.51	
I-PR-A21-A	21.49		I-PR-A21-A	25.80	Source 1, Curb Inlet Sump
I-PR-Johanna	3.00		I-PR-Johanna	4.50	Source 3, bypass flow from Inlet I-A22-A
LO-OV-EVA-E	32.81		LO-OV-EVA-E	43.63	Source 3 - CURB Inlet On Grade
LO-OV-EVA-W	14.94		LO-OV-EVA-W	20.75	
LO-OV-NEWTON	46.04		LO-OV-NEWTON	62.3	
I-PR-A21-B	deleted		I-PR-A21-B	deleted	alley inlet deleted per request of WPD in Alt 3 Storm CAD review meeting; flow from area DA-A21-B routed to I-PR-A21-A
I-PR-A5	Mary St Relief Line		I-PR-A5	Mary St Relief Line	Source 1, Curb Inlet Sump
I-PR-A6-A	Mary St Relief Line		I-PR-A6-A	Mary St Relief Line	
I-PR-A6-C	Mary St Relief Line		I-PR-A6-C	Mary St Relief Line	Source 1, Curb Inlets On Grade

Source 1

Annie Street Storm Drain Improvements
C Values - Ultimate Development Conditions for Proposed Alternative 4 System

Drainage Input				Asphalt		Concrete		Grass		Total	Asphalt	Concrete	Grass
Basin	Area (sf)	Drainage Area EX %IC	Area IC (sf)	Asph. % of IC	Asph.. Area (sf)	Conc. % of IC	Conc. Area (sf)	Grass Percentile	Grass Area (sf)	Area (acres)	Asp. Area (acres)	Conc. Area (acres)	Grass Area (acres)
DA-A04-A	27878			5.76%	1606.03	59.40%	16560.32	34.84%	9711.65	0.64	0.04	0.38	0.22
DA-A04-B	16366			5.72%	935.68	58.40%	9558.22	35.88%	5872.10	0.38	0.02	0.22	0.13
DA-A04-C	15698			37.14%	5829.91	29.62%	4650.14	33.24%	5217.95	0.36	0.13	0.11	0.12
DA-A06-A.2	16934			10.36%	1753.70	48.55%	8221.00	41.10%	6959.30	0.39	0.04	0.19	0.16
DA-A06-C	40321			20.00%	8063.11	48.84%	19692.69	31.16%	12565.20	0.93	0.19	0.45	0.29
DA-A06-D	18359			27.82%	5106.93	42.81%	7858.57	29.38%	5393.50	0.42	0.12	0.18	0.12
DA-A06-E	39010			26.57%	10364.93	43.93%	17137.27	29.50%	11507.80	0.90	0.24	0.39	0.26
DA-A06-F	48617			19.82%	9638.17	47.13%	22911.03	33.05%	16067.80	1.12	0.22	0.53	0.37
DA-A17-A	17466			47.88%	8362.30	36.01%	6289.10	16.11%	2814.60	0.40	0.19	0.14	0.06
DA-A19-A	9304			45.24%	4209.07	40.43%	3761.33	14.33%	1333.60	0.21	0.10	0.09	0.03
DA-A20-A	57639			18.70%	10776.53	57.91%	33378.42	23.39%	13484.05	1.32	0.25	0.77	0.31
DA-A20-C	33462			30.17%	10096.42	59.54%	19923.43	10.29%	3442.15	0.77	0.23	0.46	0.08
DA-A20-D	55349			72.95%	40377.07	20.27%	11217.73	6.78%	3754.20	1.27	0.93	0.26	0.09
DA-A21-A.2	36530			44.57%	16279.71	41.57%	15184.69	13.87%	5065.60	0.84	0.37	0.35	0.12
DA-A21-B	67407			19.53%	13165.79	65.57%	44195.66	14.90%	10045.55	1.55	0.30	1.01	0.23
total area	500340												

									0.37	0.42	0.46	0.53						
									0.25	0.30	0.34	0.41						
	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	Combined				Grass Area	
Basin	Asph.C2	Asph.C10	Asph.C25	Asph. C100	Conc. C2	Conc. C10	Conc. C25	Conc. C100	Grass C2	Grass C10	Grass C25	Grass C100	Comb. C2	Comb. C10	Comb. C25	Comb. C100	Condition	Slope
DA-A04-A	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.60	0.67	0.72	0.80	Fair	average
DA-A04-B	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.60	0.67	0.71	0.80	Fair	average
DA-A04-C	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.37	0.42	0.46	0.53	0.62	0.69	0.73	0.82	Fair	steep
DA-A06-A.2	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.58	0.64	0.69	0.77	Fair	average
DA-A06-C	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.62	0.69	0.73	0.82	Fair	average
DA-A06-D	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.62	0.69	0.74	0.82	Fair	average
DA-A06-E	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.62	0.69	0.74	0.82	Fair	average
DA-A06-F	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.61	0.68	0.72	0.81	Fair	average
DA-A17-A	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.67	0.75	0.80	0.88	Fair	average
DA-A19-A	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.68	0.76	0.81	0.89	Fair	average
DA-A20-A	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.65	0.72	0.77	0.85	Fair	average
DA-A20-C	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.70	0.78	0.83	0.91	Fair	average
DA-A20-D	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.25	0.30	0.34	0.41	0.70	0.78	0.83	0.92	Fair	flat
DA-A21-A.2	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.68	0.76	0.81	0.89	Fair	average
DA-A21-B	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.68	0.76	0.81	0.89	Fair	average

DESIGNER NOTES
Basis for Calculations:

Area of imervious cover that is asphalt versus concrete is calculated on Impervious Cover Breakdown sheet
Area of grass = total area - asphalt area - area concrete

Source 1

Annie Street Storm Drain Improvements
Time of Concentration (Ultimate Conditions for Proposed Alternative 4 System)

Equation in cell ==>		(1)	(2)			(3)	(4)	(5)			(6)	(7)	(8)			(9)	(10)			(9)	(10)
Drainage Input				Sheet Flow - roof/pavement					Sheet Flow - overland					Shallow Conc. 1 - unpaved				Shallow Conc. 2 - unpaved			
Basin	Area (acres)	Calc. Tc	Tc used mins	Sheet Flow Length (ft)	Sheet Flow Slope (ft/ft)	n	P	tc1 mins	Sheet Flow Length (ft)	Sheet Flow Slope (ft/ft)	n	P	tc1 mins	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc2 mins	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc3 mins
DA-A04-A	0.64	3.77	5.00	98.76	0.012	0.02	3.44	2.33	0.00	--	0.15	3.44	0.00	54.05	0.052	0.05	0.24	42.96	0.104	0.05	0.14
DA-A04-B	0.38	1.30	5.00	28.40	0.032	0.02	3.44	0.57	0.00	--	0.15	3.44	0.00	56.69	0.101	0.05	0.18	44.06	0.033	0.05	0.25
DA-A04-C	0.36	2.72	5.00	19.03	0.046	0.02	3.44	0.36	15.82	0.034	0.15	3.44	1.76	54.20	0.020	0.05	0.40	28.24	0.140	0.05	0.08
DA-A06-C	0.93	3.42	5.00	22.33	0.029	0.02	3.44	0.49	15.41	0.033	0.15	3.44	1.73	208.20	0.045	0.05	1.02	0.00	--	--	0.00
DA-A06-D	0.42	1.72	5.00	54.31	0.041	0.02	3.44	0.87	0.00	--	0.15	3.44	0.00	71.03	0.032	0.05	0.41	0.00	--	--	0.00
DA-A06-E	0.90	5.47	5.47	18.33	0.019	0.02	3.44	0.50	47.89	0.040	0.15	3.44	3.97	76.36	0.042	0.025	0.31	84.50	0.034	--	0.48
DA-A06-F	1.12	3.32	5.00	66.12	0.017	0.02	3.44	1.46	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	--	0.00
DA-A17-A	0.40	7.89	7.89	0.00	--	0.02	3.44	0.00	86.50	0.027	0.15	3.44	7.51	56.06	0.066	0.05	0.23	0.00	--	--	0.00
DA-A19-A	0.21	6.89	6.89	0.00	--	0.02	3.44	0.00	89.56	0.039	0.15	3.44	6.62	0.00	--	0.05	0.00	0.00	--	--	0.00
DA-A20-A	1.32	2.19	5.00	39.63	0.048	0.02	3.44	0.63	0.00	--	0.15	3.44	0.00	105.11	0.015	0.05	0.89	0.00	--	--	0.00
DA-A20-C	0.77	2.47	5.00	73.47	0.048	0.02	3.44	1.04	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	--	0.00
DA-A20-D	1.27	3.42	5.00	66.63	0.035	0.02	3.44	1.09	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	--	0.00
DA-A21-B	1.55	2.89	5.00	48.62	0.010	0.02	3.44	1.38	0.00	--	0.15	3.44	0.00	128.56	0.043	0.05	0.64	0.00	--	--	0.00
DA-A06-A.2	0.39	1.35	5.00	52.39	0.076	0.02	3.44	0.66	0.00	--	0.15	3.44	0.00	54.34	0.015	0.05	0.46	0.00	--	--	0.00
DA-A21-A.2	0.84	2.89	5.00	81.73	0.031	0.02	3.44	1.35	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	--	0.00

Equations

(1) Calculated Tc = Sheet Flow Tc + Shallwo Concentrated Tc + Gutter Flow Tc
(2) Tc used = min (5, Calculated Tc)
(3) n = 0.020 for roofs/pavement
(4) See DCM Table 2-3: 2-year 24-hour rainfall
(5) DCM EQ 2-3: Sheet Flow Tc for roofs/pavement (mins) = $0.42 * (nL)^{0.8} / (P^{0.5} * S^{0.4})$
(6) n = 0.15 for Grass, short-grass prairie; See DCM Table 2-2
(7) See DCM Table 2-3: 2-year 24-hour rainfall
(8) DCM EQ 2-3Sheet Flow for roofs/pavement (mins) = $0.42 * (nL)^{0.8} / (P^{0.5} * S^{0.4})$
(9) Given in DCM Section 2.4.2.B
(10) DCM EQ 2-4: Unpaved Shallow Concentrated Tc = $L / (60(16.1345)(S^{0.5}))$
(11) Given in DCM Section 2.4.2.B; cells hilighted in green use the unpaved equation
(12) DCM EQ 2-5: Paved Shallow Concentrated Tc = $L / (60(20.3282)(S^{0.5}))$; cells hilighted in green use the unpaved equation
(13) $V = k * S^{0.5}$ Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143.
(14) Tc = L / (60 * V)

Source 1

Annie Street Storm Drain Improvements
Time of Concentration (Ultimate Conditions for Proposed Alternative 4 System)

Equation in cell ==>			**(11)**	**(12)**			**(11)**	**(12)**			**(13)**	**(14)**			**(13)**	**(14)**			**(13)**	**(14)**
	Shallow Conc. 3 - paved				Shallow Conc. 4 - paved				Gutter 1 (paved)				Gutter 2 (paved)				Gutter 3			
Basin	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc4 mins	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc5 mins	Channel Length (ft)	slope	Channel Min. V (fps)	tc6 mins	Channel Length (ft)	slope	Channel Min. V (fps)	tc7	Channel Length (ft)	slope	Channel Min. V (fps)	tc8
DA-A04-A	161.83	0.033	0.050	0.92	51.79	51.790	0.025	0.01	102.15	0.068	12.06	0.14	0.00	--	--	0.00	0.00	--	--	0.00
DA-A04-B	22.99	0.132	0.050	0.07	105.21	105.210	0.050	0.01	165.73	0.073	12.51	0.22	0.00	--	--	0.00	0.00	--	--	0.00
DA-A04-C	22.63	0.093	0.025	0.06	0.00	0.000	0.025	0.00	51.97	0.087	13.62	0.06	0.00	--	--	0.00	0.00	--	--	0.00
DA-A06-C	35.22	0.072	0.025	0.11	85.20	85.200	0.025	0.01	44.68	0.054	10.73	0.07	0.00	--	--	0.00	0.00	--	--	0.00
DA-A06-D	55.32	0.043	0.025	0.22	0.00	0.000	0.025	0.00	131.99	0.044	9.71	0.23	0.00	--	--	0.00	0.00	--	--	0.00
DA-A06-E	59.91	0.053	0.025	0.21	24.23	24.230	0.025	0.00	0.00	--	--	0.00	0.00	--	--	0.00	0.00	--	--	0.00
DA-A06-F	298.49	0.019	0.025	1.76	0.00	0.000	0.025	0.00	23.02	0.007	3.74	0.10	0.00	--	--	0.00	0.00	--	--	0.00
DA-A17-A	25.68	0.019	0.025	0.15	0.00	0.000	0.025	0.00	0.00	--	--	0.00	0.00	--	--	0.00	0.00	--	--	0.00
DA-A19-A	16.69	0.108	0.025	0.04	0.00	0.000	0.025	0.00	118.69	0.035	8.71	0.23	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
DA-A20-A	52.64	0.025	0.025	0.27	119.32	119.320	0.025	0.01	193.00	0.034	8.53	0.38	0.00	--	--	0.00	0.00	--	--	0.00
DA-A20-C	248.66	0.023	0.025	1.35	0.00	0.000	0.025	0.00	30.79	0.016	5.90	0.09	0.00	--	--	0.00	0.00	--	--	0.00
DA-A20-D	119.41	0.013	0.025	0.85	0.00	0.000	0.025	0.00	351.55	0.009	4.45	1.32	102.60	0.053	10.67	0.16	0.00	--	--	0.00
DA-A21-B	160.83	0.024	0.025	0.86	97.47	97.470	0.025	0.01	0.00	--	--	0.00	0.00	--	--	0.00	0.00	--	--	0.00
DA-A06-A.2	55.83	0.064	0.025	0.18	0.00	0.000	0.025	0.00	22.97	0.026	7.48	0.05	0.00	--	--	0.00	0.00	--	--	0.00
DA-A21-A.2	332.26	0.032	0.025	1.53	0.00	0.000	0.025	0.00	0.00	--	--	0.00	0.00	--	--	0.00	0.00	--	--	0.00

Source 1

RUNOFF COMPUTATIONS (Ultimate Conditions for Proposed Alternative 4 System)

			2 Year Storm Event			10 Year Storm Event			25 Year Storm Event ATLLAS 14			100 Year Storm Event ATLAS 14		
Drainage Area Number	Drainage Area (acres)	Time of Concentration Tc (min)	Runoff Coefficient C2	Intensity I2	Design Flow Q2 (cfs)	Runoff Coefficient C10	Intensity I10	Design Flow Q10 (cfs)	Runoff Coefficient C25	Intensity I25	Design Flow Q25 (cfs)	Runoff Coefficient C100	Intensity I100	Design Flow Q100 (cfs)
DA-A04-A	0.64	5.00	0.60	0.00	0.00	0.67	0.00	0.00	0.72	11.79	5.42	0.80	15.42	7.91
DA-A04-B	0.38	5.00	0.60	0.00	0.00	0.67	0.00	0.00	0.71	11.79	3.16	0.80	15.42	4.62
DA-A04-C	0.36	5.00	0.62	0.00	0.00	0.69	0.00	0.00	0.73	11.79	3.11	0.82	15.42	4.54
DA-A06-A.2	0.39	5.00	0.58	0.00	0.00	0.64	0.00	0.00	0.69	11.79	3.16	0.77	15.42	4.62
DA-A06-C	0.93	5.00	0.62	0.00	0.00	0.69	0.00	0.00	0.73	11.79	8.00	0.82	15.42	11.66
DA-A06-D	0.42	5.00	0.62	0.00	0.00	0.69	0.00	0.00	0.74	11.79	3.67	0.82	15.42	5.35
DA-A06-E	0.90	5.47	0.62	0.00	0.00	0.69	0.00	0.00	0.74	11.50	7.61	0.82	15.04	11.08
DA-A06-F	1.12	5.00	0.61	0.00	0.00	0.68	0.00	0.00	0.72	11.79	9.53	0.81	15.42	13.90
DA-A17-A	0.40	7.89	0.67	0.00	0.00	0.75	0.00	0.00	0.80	10.25	3.27	0.88	13.38	4.74
DA-A19-A	0.21	6.89	0.68	0.00	0.00	0.76	0.00	0.00	0.81	10.73	1.84	0.89	14.00	2.67
DA-A20-A	1.32	5.00	0.65	0.00	0.00	0.72	0.00	0.00	0.77	11.79	11.99	0.85	15.42	17.43
DA-A20-C	0.77	5.00	0.70	0.00	0.00	0.78	0.00	0.00	0.83	11.79	7.49	0.91	15.42	10.84
DA-A20-D	1.27	5.00	0.70	0.00	0.00	0.78	0.00	0.00	0.83	11.79	12.42	0.92	15.42	17.98
DA-A21-A.2	0.84	5.00	0.68	0.00	0.00	0.76	0.00	0.00	0.81	11.79	7.98	0.89	15.42	11.57
DA-A21-B	1.55	5.00	0.68	0.00	0.00	0.76	0.00	0.00	0.81	11.79	14.74	0.89	15.42	21.35

From DCM Section 2.3.2, Table 2-2A (Zone 1):	2-year		10-year		25-year Atlas14, Zone1		100-year Atlas14 Zone1	
	a=		a=		a=	69.9600	a=	77.3100
	b=		b=		b=	7.9410	b=	6.8320
	c=		c=		c=	0.6954	c=	0.6524

Source 1

Ultimate Development Conditions for Proposed Alternative 4 System

CURB INLETS ON GRADE, Type G-1 OR Type G-3, parabolic crown

25 YEAR STORM

Equation in cell ==>									(1)											(2)				(3)	
DRAINAGE AREA	Prop or Exist Inlet	Prop or Exist Drainage Area	INLET (StormCAD)	Drainage_ID (GIS)	Ultimate Outfall Location ALT3	STREET NAME	DRAINAGE AREA	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	2nd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	3rd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	4th UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	5th UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$	Street Width (FOC-FOC) (ft) W
DA-A04-A	**Prop**	**Prop**	I-PR-A4-A	N/A	EBC/Annie	Annie St.	DA-A04-A	0.64	5.42	DA-A04-B	0.00									5.42				0.0712	40.0
DA-A04-B	**Prop**	**Prop**	I-PR-A4-B	N/A	EBC/Annie	Annie St.	DA-A04-B	0.38	3.16	DA-A04-C	0.00									3.16				0.0743	40.0
DA-A04-C	**Prop**	**Prop**	I-PR-A4-C	N/A	EBC/Annie	Annie St.	DA-A04-C	0.36	3.11	none										3.11				0.0743	40.0
DA-A06-C	**Prop**	**Prop**	I-PR-A6-C	N/A	EBC/Mary	Mary St.	DA-A06-C	0.93	8.00	DA-A06-D	0.00	DA-A06-E	0.84	DA-A06-F	0.43					9.26				0.0331	41.5
DA-A06-D	**Prop**	**Prop**	I-PR-A6-D	N/A	EBC/Annie	Mary St.	DA-A06-D	0.42	3.67	DA-A07	0.07									3.75				0.0495	41.5
DA-A06-E	**Prop**	**Prop**	I-PR-A6-E	N/A	EBC/Annie	Newton St.	DA-A06-E	0.90	7.61	none										7.61				0.0267	31.5
DA-A06-F	**Prop**	**Prop**	I-PR-A6-F	N/A	EBC/Annie	Newton St.	DA-A06-F	1.12	9.53	none										9.53				0.0168	31.5
DA-A07	**Prop**	**Exist**	I-PR-A7	N/A	EBC/Annie	Mary St.	DA-A07	0.78	5.72	DA-A08	1.19	DA-A09	1.76							8.67				0.0199	40.5
DA-A08	**Prop**	**Exist**	I-PR-A8	N/A	EBC/Annie	Eva St.	DA-A08	1.39	10.96	none										10.96				0.0196	32.5
DA-A09	**Prop**	**Exist**	I-PR-A9	N/A	EBC/Annie	Mary St.	DA-A09	1.21	11.67	none										11.67				0.0341	41.0
DA-A20-A	**Prop**	**Prop**	I-PR-A20-A	N/A	EBC/Annie	Johanna St	DA-A20-A	1.32	11.99	DA-A20-C	0.27									12.27				0.0359	32.0
DA-A20-C	**Prop**	**Prop**	I-PR-A20-C	N/A	EBC/Annie	Johanna St	DA-A20-C	0.77	7.49	DA-A20-D	6.96									14.45				0.0220	32.0
DA-A20-D	**Prop**	**Prop**	I-PR-A20-D	N/A	EBC/Annie	Johanna St	DA-A20-D	1.27	12.42	none										12.42				0.0608	32.0
Inlet 21823 (DS of grate inlet DA-A22)	**Exist**	**Prop bypass to this inlet**	I-PR-21823	21823	EBC/Annie	Wilson St	Inlet 21823 (DS of grate inlet DA-A22)	0.00	0.00	DA-A22-A	3.00									3.00				0.0175	29.8

Equations in cell

(1) DCM EQ 2-1: $Q_{peak} = CiA$
(2) Total flow = sum of discharge from drainage area and carry over flow
(3) So = (high elev - low elev)/length
(4) See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
(5) DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
For DA-A26 only, use straight crown equation since the driveway does not have a parabolic crown: HEC-22 EQ 4-3: d = T * Sx
(6) Sx measured in Field by ESD 3-3-15 or 3-31-15
(7) For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
(8) measured in field, lidar or record drawing; see "Crown Height Calcs" tab
(9) Hec-22 EQ B-11: $Yo = (2H/B)*x - (H/B^2)*x^2$; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
HEC-22 EQ 4-2: $T = [Qn / (Ku * Sx^{1.67} * SL^{0.5})]^{0.375}$; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56
(10) Given in DCM EQ 4-10
(11) a_{DIG} was measured in the field by ESD or DIG Data consultants. a_{DIG} = (upstream curb height) - (depth from top of curb to inlet gutter)
(12) See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation; for proposed curb inlets, aHEC22 = 6.75 - 18*Sx
$a_{HEC22} = a_{DIG} - W*Sx$
(13) DCM EQ 4-9: $S'w = a_{HEC22} / (12*W)$
(14) DCM EQ 4-9: Sw = S'w + Sx
(15) HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1
(16) DCM EQ 4-9: Se = Sx + S'w*Eo
(17) See DCM Table 2-2
(18) DCM EQ 4-10: $L_T = K_T$ * Q^0.42 * S_L^0.3 * [1/ (n*Se)]^0.6
(19) DCM EQ 4-8: E = 1 - [1 - (L/L_T)]^1.8
(20) DCM EQ 4-14: Qi = E * Q
(21) DCM EQ 4-15: Qb = Q - Qi

Ultimate Development Conditions for Proposed Alternative 4 System

CURB INLETS ON GRADE, Type G-1 OR Type G-3, parabolic crown

100 YEAR STORM

Equation in cell ==>									(1)											(2)				(3)	
DRAINAGE AREA	Prop or Exist Inlet		INLET ID (StormCAD)	Drainage_ID (GIS)	Ultimate Outfall Location ALT3	STREET NAME	DRAINAGE AREA	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	2nd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	3rd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	4th UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	5th UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$	Street Width (FOC-FOC) (ft) W
DA-A04-A	**Prop**	**Prop**	I-PR-A4-A	N/A	EBC/Annie	Annie St.	DA-A04-A	0.64	7.91	DA-A04-B	0.13									8.04				0.0712	40.0
DA-A04-B	**Prop**	**Prop**	I-PR-A4-B	N/A	EBC/Annie	Annie St.	DA-A04-B	0.38	4.62	DA-A04-C	0.10									4.71				0.0743	40.0
DA-A04-C	**Prop**	**Prop**	I-PR-A4-C	N/A	EBC/Annie	Annie St.	DA-A04-C	0.36	4.54	none										4.54				0.0743	40.0
DA-A06-C	**Prop**	**Prop**	I-PR-A6-C	N/A	EBC/Mary	Mary St.	DA-A06-C	0.93	11.66	DA-A06-D	0.56	DA-A06-E	2.09	DA-A06-F	2.58					16.88				0.0331	41.5
DA-A06-D	**Prop**	**Prop**	I-PR-A6-D	N/A	EBC/Annie	Mary St.	DA-A06-D	0.42	5.35	DA-A07	2.07									7.42				0.0495	41.5
DA-A06-E	**Prop**	**Prop**	I-PR-A6-E	N/A	EBC/Annie	Newton St.	DA-A06-E	0.90	11.08	none										11.08				0.0267	31.5
DA-A06-F	**Prop**	**Prop**	I-PR-A6-F	N/A	EBC/Annie	Newton St.	DA-A06-F	1.12	13.90	none										13.90				0.0168	31.5
DA-A07	**Prop**	**Exist**	I-PR-A7	N/A	EBC/Annie	Mary St.	DA-A07	0.78	8.32	DA-A08	2.99	DA-A09	4.41							15.71				0.0199	40.5
DA-A08	**Prop**	**Exist**	I-PR-A8	N/A	EBC/Annie	Eva St.	DA-A08	1.39	15.94	none										15.94				0.0196	32.5
DA-A09	**Prop**	**Exist**	I-PR-A9	N/A	EBC/Annie	Mary St.	DA-A09	1.21	16.90	none										16.90				0.0341	41.0
DA-A20-A	**Prop**	**Prop**	I-PR-A20-A	N/A	EBC/Annie	Johanna St	DA-A20-A	1.32	17.43	DA-A20-C	3.53									20.95				0.0359	32.0
DA-A20-C	**Prop**	**Prop**	I-PR-A20-C	N/A	EBC/Annie	Johanna St	DA-A20-C	0.77	10.84	DA-A20-D	11.47									22.31				0.0220	32.0
DA-A20-D	**Prop**	**Prop**	I-PR-A20-D	N/A	EBC/Annie	Johanna St	DA-A20-D	1.27	17.98	none										17.98				0.0608	32.0
Inlet 21823 (DS of grate inlet DA-A22)	**Exist**	**Prop bypass to this inlet**	I-PR-21823	21823	EBC/Annie	Wilson St	Inlet 21823 (DS of grate inlet DA-A22)	0.00	0.00	DA-A22-A	4.50									4.50				0.0175	29.8

Source 1

Ultimate Development Conditions for Proposed System

CURB INLETS ON GRADE, Type G-1 OR Type G-3, parabolic crown

25 YEAR STORM

DRAINAGE AREA	Curb Height (in)	Curb Height (ft)	CURB OPENING HEIGHT (in)	CURB OPENING HEIGHT (ft) h	Split (ft) CS	High or low gutter	K_o	K_1	K_2	K_3	WATER FLOW DEPTH (ft) Yo = d	Is Yo > 1.4*h?	Over Curb?	ESD Field Measured Street Cross Slope Sx	Dist. Curb to Crown (ft) B	Crown Height (ft) H	Quadratic Formula T = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a: a H / B^2	b -(2H/B)	c Yo	x1	x2	PONDED WIDTH (ft) T	Half CLEAR WIDTH (ft)	Over Crown?	DEPTH OVER CROWN	Outside ROW?
Equation in cell ==>								(4)			(5)			(6)	(7)	(8)						(9)				
DA-A04-A	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.2927	no	no	0.028	20.0	0.30	0.0008	-0.0300	0.2927	23.1136	16.8864	16.89	**3.1**	no	0.00	no
DA-A04-B	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.2411	no	no	0.032	20.0	0.85	0.0021	-0.0850	0.2411	36.9278	3.0722	3.07	**16.9**	no	0.00	no
DA-A04-C	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.2398	no	no	0.032	20.0	0.85	0.0021	-0.0850	0.2398	36.9453	3.0547	3.05	**16.9**	no	0.00	no
DA-A06-C	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.4023	no	no	0.043	20.8	0.80	0.0019	-0.0771	0.4023	35.3797	6.1203	6.12	**14.6**	no	0.00	no
DA-A06-D	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.2743	no	no	0.043	20.8	0.80	0.0019	-0.0771	0.2743	37.5700	3.9300	3.93	**16.8**	no	0.00	no
DA-A06-E	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	3.03	0	0.4074	no	no	0.014	15.8	0.18	0.0007	-0.0229	0.4074	--	--	~~15.75~~	~~**0.0**~~	over crown	0.23	no
DA-A06-F	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	3.03	0	0.4738	no	no	0.026	15.8	0.55	0.0022	-0.0698	0.4738	21.6136	9.8864	~~9.89~~	~~**5.9**~~	no	0.00	no
DA-A07	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.4292	no	no	0.045	20.3	0.94	0.0023	-0.0928	0.4292	35.1775	5.3225	5.32	**14.9**	no	0.00	no
DA-A08	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	3.03	0	0.4837	no	no	0.010	16.3	0.17	0.0006	-0.0209	0.4837	--	--	~~16.25~~	~~**0.0**~~	over crown	0.31	no
DA-A09	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.4335	no	no	0.054	20.5	0.81	0.0019	-0.0790	0.4335	34.4770	6.5230	6.52	**14.0**	no	0.00	no
DA-A20-A	6.0	0.5	6.25	0.52	0.5	low	2.70	0.50	2.74	-0.215	0.5185	no	over curb	0.027	16.0	0.68	0.0027	-0.0850	0.5185	23.7974	8.2026	8.20	**7.8**	no	0.00	no
DA-A20-C	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	3.03	0	0.5196	no	over curb	0.022	16.0	0.55	0.0021	-0.0688	0.5196	19.7609	12.2391	12.24	**3.8**	no	0.00	no
DA-A20-D	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	3.03	0	0.4180	no	no	0.024	16.0	0.57	0.0022	-0.0713	0.4180	24.2629	7.7371	7.74	**8.3**	no	0.00	no
Inlet 21823 (DS of grate inlet DA-A22)	8.0	0.7	6.00	0.50	0.0	N/A	2.85	0.50	3.03	0	0.3211	no	no	0.035	14.9	0.34	0.0015	-0.0456	0.3211	18.4092	11.3908	~~11.39~~	~~**3.5**~~	no	0.00	no

Equations in cell

- **(1)** DCM EQ 2-1: Q_{peak} = CiA
- **(2)** Total flow = sum of discharge from drainage area and carry over flow
- **(3)** So = (high elev - low elev)/length
- **(4)** See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
- **(5)** DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
  For DA-A26 only, use straight crown equation since the driveway does not have a parabolic crown: HEC-22 EQ 4-3: d = T * Sx
- **(6)** Sx measured in Field by ESD 3-3-15 or 3-31-15
- **(7)** For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
- **(8)** measured in field, lidar or record drawing; see "Crown Height Calcs" tab
- **(9)** Hec-22 EQ B-11: Yo = (2H/B)*x - $(H/B^2)*x^2$; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
  For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
  HEC-22 EQ 4-2: T = $[Qn / (Ku * Sx^{1.67} * SL^{0.5})]^{0.375}$; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56
- **(10)** Given in DCM EQ 4-10
- **(11)** a_{DIG} was measured in the field by ESD or DIG Data consultants. a_{DIG} = (upstream curb height) - (depth from top of curb to inlet gutter)
- **(12)** See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation; for proposed curb inlets, aHEC22 = 6.75 - 18*Sx
  a_{HEC22} = a_{DIG} - W*Sx
- **(13)** DCM EQ 4-9: S'w = a_{HEC22} / (12*W)
- **(14)** DCM EQ 4-9: Sw = S'w + Sx
- **(15)** HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1
- **(16)** DCM EQ 4-9: Se = Sx + S'w*Eo
- **(17)** See DCM Table 2-2
- **(18)** DCM EQ 4-10: L_T = K_T * Q^0.42 * S_L^0.3 * [1/ (n*Se)]^0.6
- **(19)** DCM EQ 4-8: E = 1 - [1 - (L/L_T)]^1.8
- **(20)** DCM EQ 4-14: Qi = E * Q
- **(21)** DCM EQ 4-15: Qb = Q - Qi

Ultimate Development Conditions for Proposed System

CURB INLETS ON GRADE, Type G-1 OR Type G-3, parabolic crown

100 YEAR STORM

DRAINAGE AREA	Curb Height (in)	Curb Height (ft)	CURB OPENING HEIGHT (in)	CURB OPENING HEIGHT (ft) h	Split (ft) CS	High or low gutter	K_o	K_1	K_2	K_3	WATER FLOW DEPTH (ft) Yo = d	Is Yo > 1.4*h?	Over Curb?	ESD Field Measured Street Cross Slope Sx	Dist. Curb to Crown (ft) B	Crown Height (ft) H	Quadratic Formula T = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a: a H / B^2	b -(2H/B)	c Yo	x1	x2	PONDED WIDTH (ft) T	CLEAR WIDTH (ft)	Over Crown?	DEPTH OVER CROWN	Outside ROW?
Equation in cell ==>								(4)			(5)			(6)	(7)	(8)						(9)				
DA-A04-A	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.3354	no	no	0.028	20.0	0.30	0.0008	-0.0300	0.3354	--	--	20.00	**0.0**	over crown	**0.04**	**no**
DA-A04-B	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.2768	no	no	0.032	20.0	0.85	0.0021	-0.0850	0.2768	36.4239	3.5761	3.58	**16.4**	no	**0.00**	**no**
DA-A04-C	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.2732	no	no	0.032	20.0	0.85	0.0021	-0.0850	0.2732	36.4759	3.5241	3.52	**16.5**	no	**0.00**	**no**
DA-A06-C	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.4952	no	no	0.043	20.8	0.80	0.0019	-0.0771	0.4952	33.5583	7.9417	7.94	**12.8**	no	**0.00**	**no**
DA-A06-D	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.3475	no	no	0.043	20.8	0.80	0.0019	-0.0771	0.3475	36.3558	5.1442	5.14	**15.6**	no	**0.00**	**no**
DA-A06-E	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	3.03	0	0.4612	no	no	0.014	15.8	0.18	0.0007	-0.0229	0.4612	--	--	~~15.75~~	~~**0.0**~~	over crown	**0.28**	**no**
DA-A06-F	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	3.03	0	0.5366	no	over curb	0.026	15.8	0.55	0.0022	-0.0698	0.5366	18.2064	13.2936	~~13.29~~	~~**2.5**~~	no	**0.00**	**no**
DA-A07	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.5272	no	over curb	0.045	20.3	0.94	0.0023	-0.0928	0.5272	33.6688	6.8312	6.83	**13.4**	no	**0.00**	**no**
DA-A08	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	3.03	0	0.5473	no	over curb	0.010	16.3	0.17	0.0006	-0.0209	0.5473	--	--	~~16.25~~	~~**0.0**~~	over crown	**0.38**	**no**
DA-A09	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	2.89	0	0.4927	no	no	0.054	20.5	0.81	0.0019	-0.0790	0.4927	33.3301	7.6699	7.67	**12.8**	no	**0.00**	**no**
DA-A20-A	6.0	0.5	6.25	0.52	0.5	low	2.70	0.50	2.74	-0.215	0.6304	no	over curb	0.027	16.0	0.68	0.0027	-0.0850	0.6304	20.3214	11.6786	11.68	**4.3**	no	**0.00**	**outside ROW**
DA-A20-C	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	3.03	0	0.5998	no	over curb	0.022	16.0	0.55	0.0021	-0.0688	0.5998	--	--	16.00	**0.0**	over crown	**0.05**	**outside ROW**
DA-A20-D	6.0	0.5	6.25	0.52	0.0	N/A	2.85	0.50	3.03	0	0.4723	no	no	0.024	16.0	0.57	0.0022	-0.0713	0.4723	22.6249	9.3751	9.38	**6.6**	no	**0.00**	**no**
Inlet 21823 (DS of grate inlet DA-A22)	8.0	0.7	6.00	0.50	0.0	N/A	2.85	0.50	3.03	0	0.3671	no	no	0.035	14.9	0.34	0.0015	-0.0456	0.3671	--	--	~~14.90~~	~~**0.0**~~	over crown	**0.03**	**no**

Source 1

Ultimate Development Conditions for Proposed System

CURB INLETS ON GRADE, Type G-1 OR Type G-3, parabolic crown

25 YEAR STORM

DRAINAGE AREA	K_T	GUTTER DEPRESSION (in) a_{DIG}	(in) a_{HEC22}	Gutter Depression Width (in)	Gutter Depression Width (ft) W	S'w	Sw	Eo	Se	Manning's n n	INLET LENGTH FOR TOTAL CAPTURE L_T	CURB INLET REDUCTION FACTOR (%)	CURB OPENING LENGTH (in)	CURB OPENING LENGTH (ft) L	INLET EFFICIENCY E	INTERCEPTED FLOW (cfs) Qi	BYPASS FLOW (cfs) Qb	INLET TYPE
Equation in cell ==>	(10)	(11)	(12)			(13)	(14)	(15)	(16)	(17)	(18)	?			(19)	(20)	(21)	
DA-A04-A	0.6		6.2	17.0	1.42	0.37	0.40	0.37	0.16	0.016	19.63	0%	120	10.00	0.72	3.92	1.51	Type G-1
DA-A04-B	0.6		6.2	18.0	1.50	0.34	0.38	0.99	0.37	0.016	9.69	0%	120	10.00	1.00	3.16	0.00	Type G-1
DA-A04-C	0.6		6.2	18.0	1.50	0.34	0.38	0.99	0.37	0.016	9.62	0%	120	10.00	1.00	3.11	0.00	Type G-1
DA-A06-C	0.6		6.0	18.0	1.50	0.33	0.38	0.80	0.31	0.016	13.29	0%	120	10.00	0.92	8.51	0.75	Type G-1
DA-A06-D	0.6		6.0	18.0	1.50	0.33	0.38	0.94	0.36	0.016	9.43	0%	120	10.00	1.00	3.75	0.00	Type G-1
DA-A06-E	0.6		6.5	18.0	1.50	0.36	0.38	0.57	0.22	0.016	14.15	0%	120	10.00	0.89	6.78	0.84	Type G-1
DA-A06-F	0.6		6.3	18.0	1.50	0.35	0.38	0.67	0.26	0.016	12.18	0%	120	10.00	0.95	9.10	0.43	Type G-1
DA-A07	0.6		5.9	18.0	1.50	0.33	0.38	0.85	0.33	0.016	10.76	0%	120	10.00	0.99	8.60	0.07	Type G-1
DA-A08	0.6		6.6	18.0	1.50	0.37	0.38	0.64	0.24	0.016	14.11	0%	120	10.00	0.89	9.77	1.19	Type G-1
DA-A09	0.6		5.8	18.0	1.50	0.32	0.38	0.73	0.29	0.016	15.38	0%	120	10.00	0.85	9.91	1.76	Type G-1
DA-A20-A	0.6		6.3	18.0	1.50	0.35	0.38	0.75	0.29	0.016	15.95	0%	180	15.00	0.99	12.19	0.08	Type G-1
DA-A20-C	0.6		6.4	18.0	1.50	0.35	0.38	0.59	0.23	0.016	16.86	0%	180	15.00	0.98	14.17	0.27	Type G-1
DA-A20-D	0.6		6.3	18.0	1.50	0.35	0.38	0.80	0.31	0.016	18.17	0%	60	5.00	0.44	5.46	6.96	Type G-1
Inlet 21823 (DS of grate inlet DA-A22)	0.6	3.5	2.9	18.0	1.50	0.16	0.19	0.43	0.10	0.016	13.24	0%	88	7.33	0.77	2.30	0.70	Type G-1

Equations in cell

(1) DCM EQ 2-1: Q_{peak} = CiA
(2) Total flow = sum of discharge from drainage area and carry over flow
(3) So = (high elev - low elev)/length
(4) See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
(5) DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
For DA-A26 only, use straight crown equation since the driveway does not have a parabolic crown: HEC-22 EQ 4-3: d = T * Sx
(6) Sx measured in Field by ESD 3-3-15 or 3-31-15
(7) For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
(8) measured in field, lidar or record drawing; see "Crown Height Calcs" tab
(9) Hec-22 EQ B-11: $Yo = (2H/B)*x - (H/B^2)*x^2$; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
HEC-22 EQ 4-2: $T = [Qn / (Ku * Sx^{1.67} * SL^{0.5})]^{0.375}$; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56
(10) Given in DCM EQ 4-10
(11) a_{DIG} was measured in the field by ESD or DIG Data consultants. a_{DIG} = (upstream curb height) - (depth from top of curb to inlet gutter)
(12) See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation; for proposed curb inlets, aHEC22 = 6.75 - 18*Sx
$a_{HEC22} = a_{DIG} - W*Sx$
(13) DCM EQ 4-9: $S'w = a_{HEC22} / (12*W)$
(14) DCM EQ 4-9: Sw = S'w + Sx
(15) HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1
(16) DCM EQ 4-9: Se = Sx + S'w*Eo
(17) See DCM Table 2-2
(18) DCM EQ 4-10: $L_T = K_T$ * Q^0.42 * S_L^0.3 * [1/ (n*Se)]^0.6
(19) DCM EQ 4-8: E = 1 - [1 - (L/L_T)]^1.8
(20) DCM EQ 4-14: Qi = E * Q
(21) DCM EQ 4-15: Qb = Q - Qi

Ultimate Development Conditions for Proposed System

CURB INLETS ON GRADE, Type G-1 OR Type G-3, parabolic crown

100 YEAR STORM

DRAINAGE AREA	K_T	GUTTER DEPRESSION (in) a_{DIG}	(in) a_{HEC22}	Gutter Depression Width (in)	Gutter Depression Width (ft) W	S'w	Sw	Eo	Se	Manning's n n	INLET LENGTH FOR TOTAL CAPTURE L_T	CURB INLET REDUCTION FACTOR (%)	CURB OPENING LENGTH (in)	CURB OPENING LENGTH (ft) L	INLET EFFICIENCY E	INTERCEPTED FLOW (cfs) Qi	BYPASS FLOW (cfs) Qb	INLET TYPE
Equation in cell ==>	(10)	(11)	(12)			(13)	(14)	(15)	(16)	(17)	(18)	?			(19)	(20)	(21)	
DA-A04-A	0.6		6.2	17.0	1.42	0.37	0.40	0.30	0.14	0.016	25.56	0%	120	10.00	0.59	4.75	3.29	Type G-1
DA-A04-B	0.6		6.2	18.0	1.50	0.34	0.38	0.97	0.37	0.016	11.54	0%	120	10.00	0.97	4.59	0.13	Type G-1
DA-A04-C	0.6		6.2	18.0	1.50	0.34	0.38	0.97	0.37	0.016	11.35	0%	120	10.00	0.98	4.44	0.10	Type G-1
DA-A06-C	0.6		6.0	18.0	1.50	0.33	0.38	0.68	0.27	0.016	18.63	0%	120	10.00	0.75	12.66	4.23	Type G-1
DA-A06-D	0.6		6.0	18.0	1.50	0.33	0.38	0.87	0.33	0.016	13.11	0%	120	10.00	0.93	6.87	0.56	Type G-1
DA-A06-E	0.6		6.5	18.0	1.50	0.36	0.38	0.57	0.22	0.016	16.56	0%	120	10.00	0.81	8.99	2.09	Type G-1
DA-A06-F	0.6		6.3	18.0	1.50	0.35	0.38	0.51	0.20	0.016	16.45	0%	120	10.00	0.81	11.32	2.58	Type G-1
DA-A07	0.6		5.9	18.0	1.50	0.33	0.38	0.74	0.29	0.016	14.80	0%	120	10.00	0.87	13.64	2.07	Type G-1
DA-A08	0.6		6.6	18.0	1.50	0.37	0.38	0.64	0.24	0.016	16.51	0%	120	10.00	0.81	12.95	2.99	Type G-1
DA-A09	0.6		5.8	18.0	1.50	0.32	0.38	0.65	0.26	0.016	19.00	0%	120	10.00	0.74	12.49	4.41	Type G-1
DA-A20-A	0.6		6.3	18.0	1.50	0.35	0.38	0.57	0.23	0.016	23.16	0%	180	15.00	0.85	17.75	3.20	Type G-1
DA-A20-C	0.6		6.4	18.0	1.50	0.35	0.38	0.45	0.18	0.016	23.39	0%	180	15.00	0.84	18.78	3.53	Type G-1
DA-A20-D	0.6		6.3	18.0	1.50	0.35	0.38	0.71	0.27	0.016	22.64	0%	60	5.00	0.36	6.51	11.47	Type G-1
Inlet 21823 (DS of grate inlet DA-A22)	0.6	3.5	2.9	18.0	1.50	0.16	0.19	0.32	0.09	0.016	17.44	0%	88	7.33	0.63	2.81	1.69	Type G-1

Source 1

Ultimate Development Conditions for Proposed Alternative 4 System

CURB INLETS IN SUMPS, Type S-1, parabolic crown and SUBMERGED CURB INLETS ON GRADE, parabolic crown

25 YEAR STORM

Equation in cell ==>									(1)											(2)				(3)
DRAINAGE AREA	Prop or Exist Inlet	Pop or Exist Drainage Area	INLET (StormCAD)	INLET GIS ID	Ultimate Outfall Location ALT3	STREET	DRAINAGE AREA	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM DRAINAGE AREA	1st CARRY OVER FLOW (cfs)	2nd UPSTREAM DRAINAGE AREA	2nd CARRY OVER FLOW (cfs)	3rd UPSTREAM DRAINAGE AREA	3rd CARRY OVER FLOW (cfs)	4th UPSTREAM DRAINAGE AREA	4th CARRY OVER FLOW (cfs)	5th UPSTREAM DRAINAGE AREA	5th CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$
DA-A05.1	**n/a**	**exist**	N/A		N/A	Mary	DA-A05.1	0.21	1.97	none										1.97	539.00	536.00	117.67	0.025
DA-A05.2	**n/a**	**exist**	N/A		N/A	Mary	DA-A05.2	1.04	9.34	none										9.34	539.00	536.00	87.15	0.034
DA-A05	**Prop**	**exist**	I-PR-A5	2181	EBC/Mary	Mary	DA-A05	0.00	0.00	DA-A05.1	1.97	DA-A05.2	9.34	DA-A06-A	1.83					13.14				N/A
DA-A06.1	**n/a**	**exist**	N/A		N/A	Mary	DA-A06.1	0.84	7.16	none										7.16				0.024
DA-A06-A.2	**n/a**	**prop**	N/A		N/A	Mary	DA-A06-A.2	0.39	3.16	DA-A06-C	0.75									3.91				0.039
DA-A06-A	**Prop**	**prop**	I-PR-A6-A	2185	EBC/Mary	Mary	DA-A06-A	0.00	0.00	DA-A06.1	7.16	DA-A06-A.2	3.91							11.07				N/A
DA-A18	**Exist**	**prop bypass**	I-PR-A18		EBC/Annie	Johanna	DA-A18-A	0.03	0.30	DA-A17-A	2.89									3.19	553.50	550.00	161.82	0.022
DA-A19-A	**Exist**	**prop**	I-PR-A19		EBC/Annie	Johanna	DA-A19-A	0.21	1.84	DA-A20-A	0.08	DA-A18	1.83							3.75	553.50	550.00	94.36	0.037
DA-A21.1	**n/a**	**prop**	N/A		N/A	alley	DA-A21-A.1	0.90	8.68	none										8.68	557.00	555.00	126.00	0.016
DA-A21-A.2	**n/a**	**prop**	N/A		N/A	alley	DA-A21-A.2	0.84	7.98											7.98	558.00	555.00	107.69	0.028
DA-A21-A	**Prop**	**prop**	I-PR-A21-A		EBC/Annie	alley	DA-A21-A	0.00	0.00	DA-A21-A.1	8.68	DA-A21-A.2	7.98	DA-A21-B	14.74					31.40				N/A

Equations in Cells

- **(1)** DCM EQ 2-1: $Q_{peak} = CiA$
- **(2)** Total flow = sum of discharge from drainage area and carry over flow
- **(3)** So = (high elev - low elev)/length
- **(4)** See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
- **(5)** DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
- **(6)** Sx measured in Field by ESD 3-3-15 or 3-31-15
- **(7)** For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
- **(8)** measured in field, lidar or record drawing; see "Crown Height Calcs" tab
- **(9)** HEC-22 EQ B-11: Yo = (2H/B)*x - (H/B2)*x2 ; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
- **(10)** a_{DIG} was measured in the field by ESD or DIG Data consultants. a_{DIG} = (upstream curb height) - (depth from top of curb to inlet gutter)
- **(11)** See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation
  $a_{HEC22} = a_{DIG} - W*Sx$
- **(12)** If d > 1.4*h, use orifice EQ, else use weir EQ
- **(13)** See DCM EQ 4-1: For depressed curb inlet, Cw = 2.3; for curb inlets without depression, Cw = 3.0
- **(14)** HEC-22 EQ 4-31a or DCM EQ 4-4a: $d_o = d_i - (h/2)$; where di = Yo + a_{HEC22}/12; for proposed inlets, do = di - (h/2)sinθ, where sinθ = 0.937
- **(15)** See DCM EQ 4-4: Co = 0.67
- **(16)** DCM EQ 4-1: $Qi = Cw * (L + 1.8*W) * d^{1.5}$
- **(17)** DCM EQ 4-4a: $Qi = Co * h * L * (2*g*do)^{0.5}$
- **(18)** Qover = Q - Qi

100 YEAR STORM

Equation in cell ==>									(1)											(2)				(3)
DRAINAGE AREA	Prop or Exist Inlet		INLET (StormCAD)	INLET GIS ID	Ultimate Outfall Location ALT3	STREET	DRAINAGE AREA	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM DRAINAGE AREA	1st CARRY OVER FLOW (cfs)	2nd UPSTREAM DRAINAGE AREA	2nd CARRY OVER FLOW (cfs)	3rd UPSTREAM DRAINAGE AREA	3rd CARRY OVER FLOW (cfs)	4th UPSTREAM DRAINAGE AREA	4th CARRY OVER FLOW (cfs)	5th UPSTREAM DRAINAGE AREA	5th CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$
DA-A05.1	**n/a**	**exist**	*N/A*		N/A	Mary	DA-A05.1	0.21	2.87	none										2.87	539.00	536.00	117.67	0.025
DA-A05.2	**n/a**	**exist**	*N/A*		N/A	Mary	DA-A05.2	1.04	13.58	none										13.58	539.00	536.00	87.15	0.034
DA-A05	**Prop**	**exist**	I-PR-A5	2181	EBC/Mary	Mary	DA-A05	0.00	0.00	DA-A05.1	2.87	DA-A05.2	13.58	DA-A06-A	8.05					24.50				N/A
DA-A06.1	**n/a**	**exist**	N/A		N/A	Mary	DA-A06.1	0.84	10.44	none										10.44				0.024
DA-A06-A.2	**n/a**	**prop**	N/A		N/A	Mary	DA-A06-A.2	0.39	4.62	DA-A06-C	4.23									8.85				0.039
DA-A06-A	**Prop**	**prop**	I-PR-A6-A	2185	EBC/Mary	Mary	DA-A06-A	0.00	0.00	DA-A06.1	10.44	DA-A06-A.2	8.85							19.29				N/A
DA-A18	**Exist**	**exist**	I-PR-A18		EBC/Mary	Johanna	DA-A18-A	0.03	0.43	DA-A17-A	4.88									5.31	553.50	550.00	161.82	0.022
DA-A19-A	**Exist**	**prop**	I-PR-A19		EBC/Mary	Johanna	DA-A19-A	0.21	2.67	DA-A20-A	3.20	DA-A18	0.52							6.39	553.50	550.00	94.36	0.037
DA-A21.1	**n/a**	**prop**	N/A		N/A	alley	DA-A21-A.1	0.90	12.56	none										12.56	557.00	555.00	126.00	0.016
DA-A21-A.2	**n/a**	**prop**	N/A		N/A	alley	DA-A21-A.2	0.84	11.57											11.57	558.00	555.00	107.69	0.028
DA-A21-A	**Prop**	**prop**	I-PR-A21-A		EBC/Johanna	alley	DA-A21-A	0.00	0.00	DA-A21-A.1	12.56	DA-A21-A.2	11.57	DA-A21-B	21.35					45.48				N/A

Source 1

Ultimate Development Conditions for Proposed Alternative 4 System

CURB INLETS IN SUMPS, Type S-1, parabolic crown and SUBMERGED CURB INLETS ON GRADE, parabolic crown

25 YEAR STORM

Equation in cell ==>							(4)			(5)		(6)	(7)	(8)						(9)				
DRAINAGE AREA	Street Width (FOC-FOC) (ft)	Curb Height (in)	Curb Height (ft)	Split (ft) CS	High or low gutter	K_o	K_1	K_2	K_3	WATER FLOW DEPTH (ft) Yo = d	Over Curb?	ESD Field Measured Street Cross Slope Sx	Dist. Curb to Crown (ft) B	Crown Height (ft) H	Quadratic Formula T = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a — a H / B^2	b -(2H/B)	c Yo	x1	x2	PONDED WIDTH (ft) T	CLEAR WIDTH (ft)	Over Crown?		Outside ROW?
DA-A05.1	41.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.246														
DA-A05.2	41.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.401														
DA-A05	41.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.401	**no**	0.022	20.8	0.44	0.001	-0.042	0.401	26.957	14.543	14.5	**6.2**	no		no
DA-A06.1	41.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.389														
DA-A06-A.2	41.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.290														
DA-A06-A	41.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.389	**no**	0.017	20.8	0.44	0.001	-0.042	0.389	27.818	13.682	13.7	**7.1**	no		no
DA-A18	32.0	9.5	0.8	0.0	N/A	2.85	0.50	3.03	0.000	0.316	**no**	0.039	16.0	0.60	0.002	-0.075	0.316	27.001	4.999	5.0	**11.0**	no		no
DA-A19-A	32.0	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0.000	0.305	**no**	0.048	16.0	0.54	0.002	-0.068	0.305	26.546	5.454	5.5	**10.5**	no		no
DA-A21.1	38.1	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0.000	0.464	**no**	0.090	38.1	1.45	N/A, crown not parabolic					5.2	~~32.9~~	no		
DA-A21-A.2	38.1	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0.000	0.411	**no**	0.090	38.1	1.45	N/A, crown not parabolic					4.6	~~33.5~~	no		
DA-A21-A	38.1	**8.0**	0.7	0.0	N/A	2.85	0.50	3.03	0.000	0.464	**no**	0.090	38.1	1.45	0.001	-0.076	0.464	69.526	6.674	5.2	~~32.9~~	no		

Equations in Cells

- **(1)** DCM EQ 2-1: Q_{peak} = CiA
- **(2)** Total flow = sum of discharge from drainage area and carry over flow
- **(3)** So = (high elev - low elev)/length
- **(4)** See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
- **(5)** DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
- **(6)** Sx measured in Field by ESD 3-3-15 or 3-31-15
- **(7)** For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
- **(8)** measured in field, lidar or record drawing; see "Crown Height Calcs" tab
- **(9)** HEC-22 EQ B-11: Yo = (2H/B)*x - (H/B2)*x2 ; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
- **(10)** a_{DIG} was measured in the field by ESD or DIG Data consultants. a_{DIG} = (upstream curb height) - (depth from top of curb to inlet gutter)
- **(11)** See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation
  $a_{HEC22} = a_{DIG}$ - W*Sx
- **(12)** If d > 1.4*h, use orifice EQ, else use weir EQ
- **(13)** See DCM EQ 4-1: For depressed curb inlet, Cw = 2.3; for curb inlets without depression, Cw = 3.0
- **(14)** HEC-22 EQ 4-31a or DCM EQ 4-4a: $d_o = d_i$ - (h/2); where di = Yo + a_{HEC22}/12; for proposed inlets, do = di - (h/2)sinθ, where sinθ = 0.937
- **(15)** See DCM EQ 4-4: Co = 0.67
- **(16)** DCM EQ 4-1: Qi = Cw * (L + 1.8*W) * $d^{1.5}$
- **(17)** DCM EQ 4-4a: Qi = Co * h * L * $(2*g*do)^{0.5}$
- **(18)** Qover = Q - Qi

100 YEAR STORM

Equation in cell ==>							(4)			(5)		(6)	(7)	(8)						(9)				
DRAINAGE AREA	Street Width (FOC-FOC) (ft)	Curb Height (in)	Curb Height (ft)	Split (ft) CS	High or low gutter	K_o	K_1	K_2	K_3	WATER FLOW DEPTH (ft) Yo = d	Over Curb?	ESD Field Measured Street Cross Slope Sx	Dist. Curb to Crown (ft) B	Crown Height (ft) H	Quadratic Formula T = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a — a H / B^2	b -(2H/B)	c Yo	x1	x2	PONDED WIDTH (ft) T	CLEAR WIDTH (ft)	Over Crown?	DEPTH OVER CROWN	Outside ROW?
DA-A05.1	41.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.281														
DA-A05.2	41.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.456														
DA-A05	41.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.456	no	0.000	20.8	0.00	0.000	0.000	0.456	--	--	20.8	**0.0**	over crown	**0.5**	**no**
DA-A06.1	41.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.443														
DA-A06-A.2	41.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.385														
DA-A06-A		6.0	0.5	0.0	N/A	2.85	0.50	2.89	0.000	0.443	no	0.017	0.0	0.00	--	--	0.443	--	--	0.0	**0.0**	over crown	**0.4**	**no**
DA-A18	32.0	9.5	0.8	0.0	N/A	2.85	0.50	3.03	0.000	0.374	no	0.039	16.0	0.60	0.002	-0.075	0.374	25.810	6.190	6.2	**9.8**	no	**0.0**	**no**
DA-A19-A	32.0	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0.000	0.364	no	0.048	16.0	0.54	0.002	-0.068	0.364	25.129	6.871	6.9	**9.1**	no	**0.0**	**no**
DA-A21.1	38.1	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0.000	0.524	over curb	0.028	38.1	1.45	N/A, crown not parabolic					18.7	~~19.4~~	no	**0.0**	**no**
DA-A21-A.2	38.1	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0.000	0.464	no	0.028	38.1	1.45	N/A, crown not parabolic					16.6	~~21.5~~	no	**0.0**	**no**
DA-A21-A	38.1	**8.0**	0.7	0.0	N/A	2.85	0.50	3.03	0.000	0.524	no	0.028	38.1	1.45								no	**0.0**	**no**

Source 1

Ultimate Development Conditions for Proposed Alternative 4 System

CURB INLETS IN SUMPS, Type S-1, parabolic crown and SUBMERGED CURB INLETS ON GRADE, parabolic crown

25 YEAR STORM

Equation in cell ==>	(10)	(11)									(12)	(13)	(14)	(15)			(16)	(17)	(18)	
DRAINAGE AREA	GUTTER DEPRESSION (in) a_{DIG}	(in) a_{HEC22}	CURB OPENING HEIGHT (in)	CURB OPENING HEIGHT (ft) h	Gutter Depression Width (in)	Gutter Depression Width (ft) W	CURB INLET LENGTH (in)	CURB INLET LENGTH (ft) L	(ft) $h + a_{HEC22}/12$	(ft) 1.4*h	If d > 1.4*h, use orifice EQ Else, use weir EQ	WEIR COEFFICIENT Cw	EFFECTIVE HEAD ON ORIFICE (ft) d_o	ORIFICE COEFFICIENT Co	GRAVITY (ft/s^2) g	CURB INLET REDUCTION FACTOR (%)	MAXIMUM CAPACITY FLOW WEIR EQ (cfs) Qi	MAXIMUM CAPACITY FLOW ORIFICE EQ (cfs) Qi	OVER CAPACITY FLOW (cfs) Q_{over}	INLET TYPE
DA-A05.1	[redacted]																			
DA-A05.2																				
DA-A05		6.35	6.25	0.52	18.00	1.50	240.0	20.00	1.05	0.73	weir EQ	3.00	0.69	0.67	32.2		17.27	----	**0.00**	TYPE S-1
DA-A06.1	[redacted]																			
DA-A06-A.2																				
DA-A06-A		6.44	6.25	0.52	18.00	1.50	120.0	10.00	1.06	0.73	weir EQ	3.00	0.68	0.67	32.2		9.24	----	~~1.83~~	TYPE S-1
DA-A18		6.59	10.00	0.83	17.00	1.42	53.0	4.42	1.38	1.17	weir EQ	3.00	0.45	0.67	32.2		3.72	----	~~0.00~~	TYPE S-1
DA-A19-A		5.89	7.00	0.58	18.00	1.50	62.0	5.17	1.07	0.82	weir EQ	3.00	0.50	0.67	32.2		3.98	----	**0.00**	TYPE S-1
DA-A21.1	[redacted]																			
DA-A21-A.2																				
DA-A21-A		5.13	6.25	0.52	18.00	1.50	240.0	20.00	0.95	0.73	weir EQ	3.00	0.65	0.67	32.2		21.49	----	**9.91**	TYPE S-1

Equations in Cells

- (1) DCM EQ 2-1: $Q_{peak} = CiA$
- (2) Total flow = sum of discharge from drainage area and carry over flow
- (3) So = (high elev - low elev)/length
- (4) See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
- (5) DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
- (6) Sx measured in Field by ESD 3-3-15 or 3-31-15
- (7) For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
- (8) measured in field, lidar or record drawing; see "Crown Height Calcs" tab
- (9) HEC-22 EQ B-11: Yo = (2H/B)*x - (H/B2)*x2 ; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
- (10) a_{DIG} was measured in the field by ESD or DIG Data consultants. a_{DIG} = (upstream curb height) - (depth from top of curb to inlet gutter)
- (11) See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation
  $a_{HEC22} = a_{DIG} - W*Sx$
- (12) If d > 1.4*h, use orifice EQ, else use weir EQ
- (13) See DCM EQ 4-1: For depressed curb inlet, Cw = 2.3; for curb inlets without depression, Cw = 3.0
- (14) HEC-22 EQ 4-31a or DCM EQ 4-4a: $d_o = d_i - (h/2)$; where di = Yo + $a_{HEC22}/12$; for proposed inlets, do = di - (h/2)sinθ, where sinθ = 0.937
- (15) See DCM EQ 4-4: Co = 0.67
- (16) DCM EQ 4-1: $Qi = Cw * (L + 1.8*W) * d^{1.5}$
- (17) DCM EQ 4-4a: $Qi = Co * h * L * (2*g*do)^{0.5}$
- (18) Qover = Q - Qi

100 YEAR STORM

Equation in cell ==>	(10)	(11)									(12)	(13)	(14)	(15)			(16)	(17)	(18)	
DRAINAGE AREA	GUTTER DEPRESSION (in) a_{DIG}	(in) a_{HEC22}	CURB OPENING HEIGHT (in)	CURB OPENING HEIGHT (ft) h	Gutter Depression Width (in)	Gutter Depression Width (ft) W	CURB INLET LENGTH (in)	CURB INLET LENGTH (ft) L	(ft) $h + a_{HEC22}/12$	(ft) 1.4*h	If d > 1.4*h, use orifice EQ Else, use weir EQ	WEIR COEFFICIENT Cw	EFFECTIVE HEAD ON ORIFICE (ft) d_o	ORIFICE COEFFICIENT Co	GRAVITY (ft/s^2) g	CURB INLET REDUCTION FACTOR (%)	MAXIMUM CAPACITY FLOW WEIR EQ (cfs) Qi	MAXIMUM CAPACITY FLOW ORIFICE EQ (cfs) Qi	OVER CAPACITY FLOW (cfs) Q_{over}	INLET TYPE
DA-A05.1	[redacted]																			
DA-A05.2																				
DA-A05		6.75	6.25	0.52	18.00	1.50	240.0	20.00	1.08	1.92	weir EQ	3.00	0.77	0.67	32.2		20.97	----	**3.52**	TYPE S-1
DA-A06.1	[redacted]																			
DA-A06-A.2																				
DA-A06-A		6.44	6.25	0.52	18.00	1.50	120.0	10.00	1.06	1.92	weir EQ	3.00	0.74	0.67	32.2		11.24	----	~~8.05~~	TYPE S-1
DA-A18		6.59	10.00	0.83	17.00	1.42	53.0	4.42	1.38	2.23	weir EQ	3.00	0.51	0.67	32.2		4.79	----	~~0.52~~	TYPE S-1
DA-A19-A		5.89	7.00	0.58	18.00	1.50	62.0	5.17	1.07	1.98	weir EQ	3.00	0.56	0.67	32.2		5.19	----	**1.20**	TYPE S-1
DA-A21.1	[redacted]																			
DA-A21-A.2																				
DA-A21-A		6.25	6.25	0.52	18.00	1.50	240.0	20.00	1.04	1.92	weir EQ	3.00	0.80	0.67	32.2		25.80	----	**19.68**	TYPE S-1

Source 1

Ultimate Development Conditions for Proposed Alternative 4 System

GRATE INLETS ON GRADE, Type G-2 V-shaped gutter

Equations in cell

- **(1)** DCM EQ 2-1: Q_{peak} = CiA
- **(2)** Total flow = sum of discharge from drainage area and carry over flow
- **(3)** So = (high elev - low elev)/length
- **(4)** Sx = (Sx1 * Sx2) / (Sx1 + Sx2)
- **(5)** See HEC-22 Figure 4-1.b.2; AB = width of parking lane between grate inlet and curb; BC = distance crown to grate inlet
- **(6)** See DCM Table 2-2
- **(7)** Given in HEC-22 EQ 4-2
- **(8)** HEC-22 EQ 4-2 and EX 4-3: T' = [(Q * n)/(Ku * Sx^1.67 * So^0.5)]^0.375
- **(9)** T,max = AB + BC
- **(10)** T = min(T',Tmax)
- **(11)** HEC-22 EQ 4-16: Eo = 1 - (1 - W_{grate}/T)^2.67
- **(12)** If assume velocity in gutter is equal or less than splash over velocity, then R_f = 1
- **(13)** Ku is given in HEC-22 EQ 4-19
- **(14)** V calculated similarly to TR-55 Figure 3-1; V = k * $S^{0.5}$ where k = 46.3 for paved gutter; Ref: Hydrologic Analysis and Design by R. H. McCuen EQ 3-46 and Table 3-14.
- **(15)** HEC-22 EQ 4-19: Rs = ratio of side flow intercepted to total side flow = 1 / [1 + (Ku * V^1.8) / (Sx * L^2.3)]
- **(16)** HEC-22 EQ 4-20: E = Rf * Eo + Rs * (1 - Eo)
- **(17)** See DCM 4.3.2.B
- **(18)** DCM EQ 4-14: Qi = E * Q * Reduction Factor
- **(19)** DCM EQ 4-15: Qb = Q - Qi

25 YEAR STORM

Equation in cell ==>										(1)					(2)				(3)				
DRAINAGE AREA	Prop or Exist Inlet	Pop or Exist Drainage Area	INLET (StormCAD)	INLET GIS ID	Ultimate Outfall Location ALT3		STREET NAME	DRAINAGE AREA	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM INLET /DRAINAGE AREA	1st CARRY OVER FLOW (cfs)	2nd UPSTREAM INLET /DRAINAGE AREA	2nd CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$	Street Width (FOC-FOC) (ft)	Curb Height (in)	Parking lane cross slope Sx1	Street Cross Slope Sx2
DA-A17-A	exist	**prop**	**I-PR-A17**	**84375**	EBC/Annie		Johanna St.	DA-A17-A	0.40	3.27	Inlet 21823 (DS of grate inlet DA-A22)	0.70			3.98	553.50	550.00	161.82	0.0216	30.5	6.0	0.042	0.064

100 YEAR STORM

Equation in cell ==>										(1)					(2)				(3)				
DRAINAGE AREA	Prop or Exist Inlet	Pop or Exist Drainage Area	INLET ID (StormCAD)	INLET GIS ID	Ultimate Outfall Location ALT3		STREET NAME	DRAINAGE AREA	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM INLET /DRAINAGE AREA	1st CARRY OVER FLOW (cfs)	2nd UPSTREAM INLET /DRAINAGE AREA	2nd CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$	Street Width (FOC-FOC) (ft)	Curb Height (in)	Parking lane cross slope Sx1	Street Cross Slope Sx2
DA-A17-A	exist	**prop**	**I-PR-A17**	**84375**	EBC/Annie		Johanna St.	DA-A17-A	0.40	4.74	Inlet 21823 (DS of grate inlet DA-A22)	1.69			6.42	553.50	550.00	161.82	0.0216	30.5	6.0	0.042	0.064

Source 1

Ultimate Development Conditions for Proposed Alternative 4 System

GRATE INLETS ON GRADE, Type G-2 V-shaped gutter

Equations in cell

- **(1)** DCM EQ 2-1: Q_{peak} = CiA
- **(2)** Total flow = sum of discharge from drainage area and carry over flow
- **(3)** So = (high elev - low elev)/length
- **(4)** Sx = (Sx1 * Sx2) / (Sx1 + Sx2)
- **(5)** See HEC-22 Figure 4-1.b.2; AB = width of parking lane between grate inlet and curb; BC = distance crown to grate inlet
- **(6)** See DCM Table 2-2
- **(7)** Given in HEC-22 EQ 4-2
- **(8)** HEC-22 EQ 4-2 and EX 4-3: T' = [(Q * n)/(Ku * Sx^1.67 * So^0.5)]^0.375
- **(9)** T,max = AB + BC
- **(10)** T = min(T',Tmax)
- **(11)** HEC-22 EQ 4-16: Eo = 1 - (1 - W_{grate}/T)^2.67
- **(12)** If assume velocity in gutter is equal or less than splash over velocity, then R_f = 1
- **(13)** Ku is given in HEC-22 EQ 4-19
- **(14)** V calculated similarly to TR-55 Figure 3-1; V = k * $S^{0.5}$ where k = 46.3 for paved gutter; Ref: Hydrologic Analysis and Design by R. H. McCuen EQ 3-46 and Table 3-14.
- **(15)** HEC-22 EQ 4-19: Rs = ratio of side flow intercepted to total side flow = 1 / [1 + (Ku * V^1.8) / (Sx * L^2.3)]
- **(16)** HEC-22 EQ 4-20: E = Rf * Eo + Rs * (1 - Eo)
- **(17)** See DCM 4.3.2.B
- **(18)** DCM EQ 4-14: Qi = E * Q * Reduction Factor
- **(19)** DCM EQ 4-15: Qb = Q - Qi

25 YEAR STORM

(4)	Equation in cell =>	(5)	(5)	(6)	(7)	(8)	(9)	(10)				(11)	(12)	(13)			(14)	(15)	(16)	(17)	(18)	(19)	
Sx	DRAINAGE AREA	(ft) AB	(ft) BC	Manning's n n	Ku	HYPOTHETICAL PONDED WIDTH (ft) T'	MAXIMUM PONDED WIDTH (ft) Tmax	PONDED WIDTH (ft) T	Gutter Depression Width (ft) W_{gutter}	Grate Width (in)	Grate Width (ft) W_{grate}	Eo	R_f	Ku	Grate Length (in)	Grate Length (ft) L	Gutter Velocity (ft/s) V	R_s	E	GRATE INLET REDUCTION FACTOR (%)	INTERCEPTED FLOW (cfs) Qi	BYPASS FLOW (cfs) Qb	INLET TYPE
0.025	DA-A17-A	9.0	18.0	0.016	0.56	9.1	27.0	9.1	0.00	18.00	1.50	0.38	1.0	0.15	36.00	3.00	6.81	0.063	0.42	35%	1.09	2.89	Type G-2

100 YEAR STORM

(4)	Equation in cell =>	(5)	(5)	(6)	(7)	(8)	(9)	(10)				(11)	(12)	(13)			(14)	(15)	(16)	(17)	(18)	(19)	
Sx	DRAINAGE AREA	(ft) AB	(ft) BC	Manning's n n	Ku	HYPOTHETICAL PONDED WIDTH (ft) T'	MAXIMUM PONDED WIDTH (ft) Tmax	PONDED WIDTH (ft) T	Gutter Depression Width (ft) W_{gutter}	Grate Width (in)	Grate Width (ft) W_{grate}	Eo	R_f	Ku	Grate Length (in)	Grate Length (ft) L	Gutter Velocity (ft/s) V	R_s	E	GRATE INLET REDUCTION FACTOR (%)	INTERCEPTED FLOW (cfs) Qi	BYPASS FLOW (cfs) Qb	INLET TYPE
0.025	DA-A17-A	9.0	18.0	0.016	0.56	10.9	27.0	10.9	0.00	18.00	1.50	0.33	1.0	0.15	36.00	3.00	6.81	0.063	0.37	35%	1.54	4.88	Type G-2

Source 2

Annie Street Storm Drain Improvements

C Values - Ultimate Development Conditions for Existing Storm Drain System

																						0.37	0.42	0.46	0.53						
																						0.25	0.30	0.34	0.41						
Drainage Input				Asphalt		Concrete		Grass		Total	Asphalt	Concrete	Grass	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	Combined				Grass Area	
Basin	Area (sf)	Drainage Area EX %IC	Area IC (sf)	Asph. % of IC	Asph.. Area (sf)	Conc. % of IC	Conc. Area (sf)	Grass Percentile	Grass Area (sf)	Area (acres)	Asp. Area (acres)	Conc. Area (acres)	Grass Area (acres)	Asph.C2	Asph.C10	Asph.C25	Asph. C100	Conc. C2	Conc. C10	Conc. C25	Conc. C100	Grass C2	Grass C10	Grass C25	Grass C100	Comb. C2	Comb. C10	Comb. C25	Comb. C100	Condition	Slope
DA-A03	22598				3704.10		12946.30		5947.60	0.52	0.09	0.30	0.14	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.37	0.42	0.46	0.53	0.65	0.72	0.77	0.85	Fair	steep
DA-A08	60513				8043.08		34070.62		18399.30	1.39	0.18	0.78	0.42	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.62	0.69	0.74	0.82	Fair	average
DA-A10	23950				21657.59		1393.66		898.75	0.55	0.50	0.03	0.02	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.25	0.30	0.34	0.41	0.71	0.79	0.84	0.93	Fair	flat
DA-A11	149109				44119.90		75727.70		29261.40	3.42	1.01	1.74	0.67	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.66	0.74	0.78	0.87	Fair	average
DA-A12	138786				32085.80		80812.80		25887.40	3.19	0.74	1.86	0.59	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.67	0.74	0.79	0.88	Fair	average
DA-A13	49355				10019.95		30072.05		9263.00	1.13	0.23	0.69	0.21	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.67	0.74	0.79	0.88	Fair	average
DA-A14	79528				18678.53		44211.67		16637.80	1.83	0.43	1.01	0.38	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.66	0.73	0.78	0.86	Fair	average
DA-A15	97857				18057.97		55584.73		24214.30	2.25	0.41	1.28	0.56	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.64	0.71	0.76	0.85	Fair	average
DA-A16	201385				84022.73		99426.47		17935.80	4.62	1.93	2.28	0.41	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.25	0.30	0.34	0.41	0.70	0.77	0.82	0.91	Fair	flat
DA-A17	30376				3758.09		21221.31		5396.60	0.70	0.09	0.49	0.12	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.67	0.75	0.80	0.88	Fair	average
DA-A25	84148				0.00		74046.32		10101.68	1.93	0.00	1.70	0.23	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.70	0.78	0.82	0.91	Fair	Average
DA-A26	37114				8239.55		26826.50		2047.95	0.85	0.19	0.62	0.05	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.33	0.38	0.42	0.49	0.72	0.80	0.85	0.94	Fair	Average
DA-L1	72327				47552.44		11851.76		12922.80	1.66	1.09	0.27	0.30	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.25	0.30	0.34	0.41	0.65	0.72	0.77	0.86	Fair	flat
DA-L2	5570				2588.73		1642.27		1339.00	0.13	0.06	0.04	0.03	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.25	0.30	0.34	0.41	0.62	0.69	0.74	0.83	Fair	flat
DA-L3	51834				36761.49		11591.51		3481.00	1.19	0.84	0.27	0.08	0.73	0.81	0.86	0.95	0.75	0.83	0.88	0.97	0.25	0.30	0.34	0.41	0.70	0.78	0.83	0.92	Fair	flat

Source 2

Annie Street Storm Drain Improvements
Time of Concentration (Ultimate Development Conditions for Existing System)

Equation in cell ==>		(1)		(2)			(3)	(4)	(5)			(6)	(7)	(8)			(9)	(10)			(9)	(10)
Drainage Input					Sheet Flow - roof/pavement					Sheet Flow - overland					Shallow Conc. 1 - unpaved				Shallow Conc. 2 - unpaved			
Basin	Area (acres)	Calc. Tc	EBLDN Tc	Tc used mins	Sheet Flow Length (ft)	Sheet Flow Slope (ft/ft)	n	P	tc1 mins	Sheet Flow Length (ft)	Sheet Flow Slope (ft/ft)	n	P	tc1 mins	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc2 mins	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc3 mins
DA-A03	0.52	4.93		5.00	0.00	--	0.02	3.44	0.00	69.26	0.069	0.15	3.44	4.28	123.19	0.076	0.05	0.46	0.00	--	0.05	0.00
DA-A08	1.39	6.94		6.94	0.00	--	0.02	3.44	0.00	63.79	0.031	0.15	3.44	5.51	112.55	0.021	0.05	0.81	0.00	--	0.05	0.00
DA-A10	0.55	1.81		5.00	55.49	0.040	0.02	3.44	0.90	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	0.05	0.00
DA-A11	3.42	2.48		5.00	37.20	0.040	0.02	3.44	0.65	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	0.05	0.00
DA-A12	3.19	2.85		5.00	0.00	--	0.02	3.44	0.00	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	0.05	0.00
DA-A13	1.13	2.28		5.00	40.78	0.023	0.02	3.44	0.87	0.00	--	0.15	3.44	0.00	46.97	0.081	0.025	0.14	71.72	0.049	0.025	0.27
DA-A14	1.83	2.12		5.00	24.37	0.062	0.02	3.44	0.39	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	0.05	0.00
DA-A15	2.25	3.47		5.00	35.99	0.005	0.02	3.44	1.48	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	0.05	0.00
DA-A16	4.62	7.46		7.46	98.83	0.019	0.02	3.44	1.90	0.00	0.000	0.15	3.44	0.00	0.00	0.000	0.05	0.00	0.00	0.000	0.05	0.00
DA-A17	0.70	1.49		5.00	45.11	0.028	0.02	3.44	0.88	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	0.05	0.00
DA-A25	1.93	1.63	5.00	5.00	44.37	0.103	0.02	3.44	0.51	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	0.05	0.00
DA-A26	0.85	3.07		5.00	59.09	0.055	0.02	3.44	0.83	0.00	--	0.15	3.44	0.00	0.00	--	0.05	0.00	0.00	--	0.05	0.00
DA-L1	1.66	4.08		5.00	48.62	0.010	0.02	3.44	1.38	0.00	--	0.15	3.44	0.00	128.56	0.043	0.05	0.64	0.00	--	0.05	0.00
DA-L2	0.13	4.08		5.00	48.62	0.010	0.02	3.44	1.38	0.00	--	0.15	3.44	0.00	128.56	0.043	0.05	0.64	0.00	--	0.05	0.00
DA-L3	1.19	4.08		5.00	48.62	0.010	0.02	3.44	1.38	0.00	--	0.15	3.44	0.00	128.56	0.043	0.05	0.64	0.00	--	0.05	0.00

Equations

(1) Calculated Tc = Sheet Flow Tc + Shallwo Concentrated Tc + Gutter Flow Tc
(2) Tc used = min (5, Calculated Tc)
(3) n = 0.020 for roofs/pavement
(4) See DCM Table 2-3: 2-year 24-hour rainfall
(5) DCM EQ 2-3: Sheet Flow Tc for roofs/pavement (mins) = $0.42 * (nL)^{0.8} / (P^{0.5} * S^{0.4})$
(6) n = 0.15 for Grass, short-grass prairie; See DCM Table 2-2
(7) See DCM Table 2-3: 2-year 24-hour rainfall
(8) DCM EQ 2-3Sheet Flow for roofs/pavement (mins) = $0.42 * (nL)^{0.8} / (P^{0.5} * S^{0.4})$
(9) Given in DCM Section 2.4.2.B
(10) DCM EQ 2-4: Unpaved Shallow Concentrated Tc = $L / (60(16.1345)(S^{0.5}))$
(11) Given in DCM Section 2.4.2.B; cells hilighted in green use the unpaved equation
(12) DCM EQ 2-5: Paved Shallow Concentrated Tc = $L / (60(20.3282)(S^{0.5}))$; cells hilighted in green use the unpaved equation
(13) $V = k * S^{0.5}$ Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143.
(14) Tc = L / (60 * V)

Source 2

Annie Street Storm Drain Improvements
Time of Concentration (Ultimate Development Conditions for Existing System)

Equation in cell ==>																				
			(11)	(12)			(11)	(12)			(13)	(14)			(13)	(14)			(13)	(14)
	Shallow Conc. 3 - paved				Shallow Conc. 4 - paved				Gutter 1 (paved)				Gutter 2 (paved)				Gutter 3			
Basin	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc4 mins	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc5 mins	Channel Length (ft)	slope	Channel Min. V (fps)	tc6 mins	Channel Length (ft)	slope	Channel Min. V (fps)	tc7	Channel Length (ft)	slope	Channel Min. V (fps)	tc8
DA-A03	16.93	0.106	0.025	0.04	0.00	--	0.025	0.00	107.21	0.070	12.29	0.15	0.00	--	--	0.00	0.00	--	--	0.00
DA-A08	0.00	--	0.025	0.00	0.00	--	0.025	0.00	249.28	0.021	6.67	0.62	0.00	--	--	0.00	0.00	--	--	0.00
DA-A10	0.00	--	0.025	0.00	0.00	--	0.025	0.00	277.71	0.012	5.05	0.92	0.00	--	--	0.00	0.00	--	--	0.00
DA-A11	98.18	0.058	0.025	0.33	115.12	0.058	0.025	0.39	534.08	0.030	8.04	1.11	0.00	--	--	0.00	0.00	--	--	0.00
DA-A12	90.08	0.120	0.025	0.21	325.68	0.024	0.025	1.74	310.84	0.015	5.75	0.90	0.00	--	--	0.00	0.00	--	--	0.00
DA-A13	69.55	0.032	0.025	0.32	0.00	--	0.025	0.00	181.33	0.009	4.35	0.69	0.00	--	--	0.00	0.00	--	--	0.00
DA-A14	105.13	0.035	0.025	0.46	25.70	0.078	0.025	0.08	569.10	0.030	7.96	1.19	0.00	--	--	0.00	0.00	--	--	0.00
DA-A15	64.24	0.023	0.025	0.34	0.00	--	0.025	0.00	334.45	0.010	4.74	1.18	232.94	0.032	8.25	0.47	0.00	--	--	0.00
DA-A16	74.68	0.012	0.025	0.56	0.00	0.000	0.025	0.00	667.48	0.009	4.28	2.60	435.12	0.015	5.66	1.28	338.76	0.012	5.03	1.12
DA-A17	69.20	0.029	0.025	0.33	63.10	0.055	0.025	0.22	21.98	0.018	6.25	0.06	0.00	--	--	0.00	0.00	--	--	0.00
DA-A25	78.87	0.020	0.025	0.45	161.58	0.045	0.025	0.63	37.30	0.155	18.23	0.03	0.00	--	--	0.00	0.00	--	--	0.00
DA-A26	382.77	0.020	0.025	2.24	0.00	--	0.025	0.00	0.00	--	--	0.00	0.00	--	--	0.00	0.00	--	--	0.00
DA-L1	160.83	0.024	0.025	0.86	270.05	0.034	0.025	1.20	0.00	--	--	0.00	0.00	--	--	0.00	0.00	--	--	0.00
DA-L2	160.83	0.024	0.025	0.86	270.05	0.034	0.025	1.20	0.00	--	--	0.00	0.00	--	--	0.00	0.00	--	--	0.00
DA-L3	160.83	0.024	0.025	0.86	270.05	0.034	0.025	1.20	0.00	--	--	0.00	0.00	--	--	0.00	0.00	--	--	0.00

Equations

(1) Calculated Tc = Sheet Flow Tc + Shallwo Concentrated Tc + Gutter Flow Tc
(2) Tc used = min (5, Calculated Tc)
(3) n = 0.020 for roofs/pavement
(4) See DCM Table 2-3: 2-year 24-hour rainfall
(5) DCM EQ 2-3: Sheet Flow Tc for roofs/pavement (mins) = $0.42 * (nL)^{0.8} / (P^{0.5} * S^{0.4})$
(6) n = 0.15 for Grass, short-grass prairie; See DCM Table 2-2
(7) See DCM Table 2-3: 2-year 24-hour rainfall
(8) DCM EQ 2-3Sheet Flow for roofs/pavement (mins) = $0.42 * (nL)^{0.8} / (P^{0.5} * S^{0.4})$
(9) Given in DCM Section 2.4.2.B
(10) DCM EQ 2-4: Unpaved Shallow Concentrated Tc = $L / (60(16.1345)(S^{0.5}))$
(11) Given in DCM Section 2.4.2.B; cells hilighted in green use the unpaved equation
(12) DCM EQ 2-5: Paved Shallow Concentrated Tc = $L / (60(20.3282)(S^{0.5}))$; cells hilighted in green use the unpaved equation
(13) $V = k * S^{0.5}$ Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143.
(14) Tc = L / (60 * V)

Source 2

RUNOFF COMPUTATIONS (Ultimate Development Conditions for Existing System)

			2 Year Storm Event			10 Year Storm Event			25 Year Storm Event ATLLAS 14			100 Year Storm Event ATLAS 14		
Drainage Area Number	Drainage Area (acres)	Time of Concentration Tc (min)	Runoff Coefficient C2	Intensity I2	Design Flow Q2 (cfs)	Runoff Coefficient C10	Intensity I10	Design Flow Q10 (cfs)	Runoff Coefficient C25	Intensity I25	Design Flow Q25 (cfs)	Runoff Coefficient C100	Intensity I100	Design Flow Q100 (cfs)
DA-A03	0.52	5.00	0.65	0.00	0.00	0.72	0.00	0.00	0.77	11.79	4.69	0.85	15.42	6.81
DA-A04	1.51	12.26	0.61	0.00	0.00	0.68	0.00	0.00	0.72	8.65	9.44	0.81	11.29	13.74
DA-A05.1	0.21	5.00	0.66	0.00	0.00	0.73	0.00	0.00	0.78	11.79	1.97	0.87	15.42	2.87
DA-A05.2	1.04	5.00	0.64	0.00	0.00	0.72	0.00	0.00	0.76	11.79	9.34	0.85	15.42	13.58
DA-A05	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.79	0.00	0.00	15.42	0.00
DA-A06.1	0.84	5.00	0.61	0.00	0.00	0.67	0.00	0.00	0.72	11.79	7.16	0.80	15.42	10.44
DA-A06.2	3.75	5.00	0.61	0.00	0.00	0.68	0.00	0.00	0.73	11.79	32.26	0.81	15.42	47.03
DA-A06	0.00	9.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.51	0.00	0.00	12.40	0.00
DA-A07	0.78	8.04	0.61	0.00	0.00	0.68	0.00	0.00	0.72	10.18	5.72	0.81	13.29	8.32
DA-A08	1.39	6.94	0.62	0.00	0.00	0.69	0.00	0.00	0.74	10.70	10.96	0.82	13.97	15.94
DA-A09	1.21	5.00	0.70	0.00	0.00	0.77	0.00	0.00	0.82	11.79	11.67	0.91	15.42	16.90
DA-A10	0.55	5.00	0.71	0.00	0.00	0.79	0.00	0.00	0.84	11.79	5.46	0.93	15.42	7.89
DA-A11	3.42	5.00	0.66	0.00	0.00	0.74	0.00	0.00	0.78	11.79	31.64	0.87	15.42	45.93
DA-A12	3.19	5.00	0.67	0.00	0.00	0.74	0.00	0.00	0.79	11.79	29.66	0.88	15.42	43.04
DA-A13	1.13	5.00	0.67	0.00	0.00	0.74	0.00	0.00	0.79	11.79	10.55	0.88	15.42	15.31
DA-A14	1.83	5.00	0.66	0.00	0.00	0.73	0.00	0.00	0.78	11.79	16.77	0.86	15.42	24.35
DA-A15	2.25	5.00	0.64	0.00	0.00	0.71	0.00	0.00	0.76	11.79	20.20	0.85	15.42	29.37
DA-A16	4.62	7.46	0.70	0.00	0.00	0.77	0.00	0.00	0.82	10.45	39.78	0.91	13.64	57.48
DA-A17	0.70	5.00	0.67	0.00	0.00	0.75	0.00	0.00	0.80	11.79	6.54	0.88	15.42	9.49
DA-A25	1.93	5.00	0.70	0.00	0.00	0.78	0.00	0.00	0.82	11.79	18.79	0.91	15.42	27.18
DA-A26	0.85	5.00	0.72	0.00	0.00	0.80	0.00	0.00	0.85	11.79	8.54	0.94	15.42	12.34
DA-L1	1.66	5.00	0.65	0.00	0.00	0.72	0.00	0.00	0.77	11.79	15.08	0.86	15.42	21.94
DA-L2	0.13	5.00	0.62	0.00	0.00	0.69	0.00	0.00	0.74	11.79	1.12	0.83	15.42	1.63
DA-L3	1.19	5.00	0.70	0.00	0.00	0.78	0.00	0.00	0.83	11.79	11.64	0.92	15.42	16.85

From DCM Section 2.3.2, Table 2-2A (Zone 1):

	2-year	10-year	25-year Atlas14, Zone1	100-year Atlas14 Zone1
a=			69.9600	77.3100
b=			7.9410	6.8320
c=			0.6954	0.6524

Ultimate Development Conditions for Existing System

CURB INLETS ON GRADE, Type G-1 OR Type G-3, parabolic crown

Equations in cell

(1) DCM EQ 2-1: Q_{peak} = CiA
(2) Total flow = sum of discharge from drainage area and carry over flow
(3) So = (high elev - low elev)/length
(4) See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
(5) DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
For DA-A26 only, use straight crown equation since the driveway does not have a parabolic crown: HEC-22 EQ 4-3: d = T * Sx
(6) Sx measured in Field by ESD 3-3-15 or 3-31-15
(7) For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
(8) measured in field, lidar or record drawing; see "Crown Height Calcs" tab
(9) Hec-22 EQ B-11: Yo = (2H/B)*x - $(H/B^2)*x^2$; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = E
For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
HEC-22 EQ 4-2: T = $[Qn / (Ku * Sx^{1.67} * SL^{0.5})]^{0.375}$; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56
(10) Given in DCM EQ 4-10
(11) a_{DIG} was measured in the field by ESD or DIG Data consultants. a_{DIG} = (upstream curb height) - (depth from top of curb to inlet gutter)
(12) See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation
$a_{HEC22} = a_{DIG}$ - W*Sx
(13) DCM EQ 4-9: S'w = a_{HEC22} / (12*W)
(14) DCM EQ 4-9Sw = S'w + Sx
(15) HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1
(16) DCM EQ 4-9: Se = Sx + S'w*Eo
(17) See DCM Table 2-2
(18) DCM EQ 4-10: $L_T = K_T$ * Q^0.42 * S_L^0.3 * [1/ (n*Se)]^0.6
(19) DCM EQ 4-8: E = 1 - [1 - (L/L_T)]^1.8
(20) DCM EQ 4-14: Qi = E * Q
(21) DCM EQ 4-15: Qb = Q - Qi

25 YEAR STORM

DRAINAGE AREA	Drainage_ID (GIS)	INLET (StormCAD)	INLET GIS ID	INLET Number (Label)	STREET NAME	DRAINAGE AREA	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	2nd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	3rd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	4th UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	5th UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$
Equation in cell ==>								(1)											(2)				(3)
DA-L1	**18958**	N/A			S. Congress	DA-L1	1.66	15.08	none										15.08	587.00	583.40	250.89	0.0143
DA-L2	**251629**	N/A			College Ave	DA-L2	0.13	1.12	none										1.12	587.00	586.00	181.53	0.0055
DA-L3	**18952**	N/A			College Ave	DA-L3	1.19	11.64	none										11.64	588.00	586.00	293.98	0.0068
DA-A26	BMW shop	I-A26			driveway	DA-A26	0.85	8.54	none										8.54	slope shown on as-builts			0.0050
DA-A15	**21894**	**I-A15**	**2195**	100696	Leland St.	DA-A15	2.25	20.20	none										20.20	582.00	577.00	112.78	0.0443
DA-A16	**21895**	**I-A16**	**2196**	100938	S. Congress Ave.	DA-A16	4.62	39.78	DA-L1	2.03	DA-L2	0.00	DA-L3	5.32	DA-A26	0.54	DA-A15	12.54	60.21	578.00	576.00	177.66	0.0113
DA-A14	**21893**	**I-A14**	**2194**	101247	Leland St.	DA-A14	1.83	16.77	none										16.77	582.00	576.00	119.82	0.0501
DA-A13	**21892**	**I-A13**	**2193**	100654	S. Congress Ave.	DA-A13	1.13	10.55	DA-A16	51.54	DA-A14	9.25							71.33	575.00	573.17	195.30	0.0094
DA-A08	**none**	**I-A8**	**-**	100636	Eva St.	DA-A08	1.39	10.96	none										10.96	558.00	554.50	178.98	0.0196
DA-A03	**21638**	**I-A3**	**2152**	101187	Annie St.	DA-A03	0.52	4.69	none										4.69	527.50	516.80	147.69	0.0724

100 YEAR STORM

DRAINAGE AREA	Drainage_ID (GIS)	INLET (StormCAD)	INLET GIS ID	INLET Number (Label)	STREET NAME	DRAINAGE AREA	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	2nd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	3rd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	4th UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	5th UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$
DA-L1	**18958**	N/A			S. Congress	DA-L1	1.66	21.94	none										21.94	587.00	583.40	250.89	0.0143
DA-L2	**251629**	N/A			College Ave	DA-L2	0.13	1.63	none										1.63	587.00	586.00	181.53	0.0055
DA-L3	**18952**	N/A			College Ave	DA-L3	1.19	16.85	none										16.85	588.00	586.00	293.98	0.0068
DA-A26	BMW shop	I-A26			driveway	DA-A26	0.85	12.34	none										12.34	slope shown on as-builts			0.0050
DA-A15	**21894**	**I-A15**	**2195**	100696	Leland St.	DA-A15	2.25	29.37	none										29.37	582.00	577.00	112.78	0.0443
DA-A16	**21895**	**I-A16**	**2196**	100938	S. Congress Ave.	DA-A16	4.62	57.48	DA-L1	4.55	DA-L2	0.00	DA-L3	8.82	DA-A26	2.16	DA-A15	19.25	92.25	578.00	576.00	177.66	0.0113
DA-A14	**21893**	**I-A14**	**2194**	101247	Leland St.	DA-A14	1.83	24.35	none										24.35	582.00	576.00	119.82	0.0501
DA-A13	**21892**	**I-A13**	**2193**	100654	S. Congress Ave.	DA-A13	1.13	15.31	DA-A16	82.97	DA-A14	15.14							113.41	575.00	573.17	195.30	0.0094
DA-A08	**none**	**I-A8**	**-**	100636	Eva St.	DA-A08	1.39	15.94	none										15.94	558.00	554.50	178.98	0.0196
DA-A03	**21638**	**I-A3**	**2152**	101187	Annie St.	DA-A03	0.52	6.81	none										6.81	527.50	516.80	147.69	0.0724

Source 2

Ultimate Development Conditions for Existing System

CURB INLETS ON GRADE, Type G-1 OR Type G-3, parabolic crown

Equations in cell

- **(1)** DCM EQ 2-1: Qpeak = CiA
- **(2)** Total flow = sum of discharge from drainage area and carry over flow
- **(3)** So = (high elev - low elev)/length
- **(4)** See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
- **(5)** DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
  For DA-A26 only, use straight crown equation since the driveway does not have a parabolic crown: HEC-22 EQ 4-3: d = T * Sx
- **(6)** Sx measured in Field by ESD 3-3-15 or 3-31-15
- **(7)** For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
- **(8)** measured in field, lidar or record drawing; see "Crown Height Calcs" tab
- **(9)** Hec-22 EQ B-11: Yo = (2H/B)*x - (H/B2)*x2 ; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
  For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
  HEC-22 EQ 4-2: T = [Qn / (Ku * Sx1.67 * SL0.5)]0.375; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56
- **(10)** Given in DCM EQ 4-10
- **(11)** aDIG was measured in the field by ESD or DIG Data consultants. aDIG = (upstream curb height) - (depth from top of curb to inlet gutter)
- **(12)** See HEC-22 Fig 4-13. aHEC22 is the difference between the inlet edge of gutter elevation and the projected street slope elevation
  aHEC22 = aDIG - W*Sx
- **(13)** DCM EQ 4-9: S'w = aHEC22 / (12*W)
- **(14)** DCM EQ 4-9Sw = S'w + Sx
- **(15)** HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1
- **(16)** DCM EQ 4-9: Se = Sx + S'w*Eo
- **(17)** See DCM Table 2-2
- **(18)** DCM EQ 4-10: LT = KT * Q^0.42 * SL^0.3 * [1/ (n*Se)]^0.6
- **(19)** DCM EQ 4-8: E = 1 - [1 - (L/LT)]^1.8
- **(20)** DCM EQ 4-14: Qi = E * Q
- **(21)** DCM EQ 4-15: Qb = Q - Qi

25 YEAR STORM

Equation in cell ==>									(4)			(5)			(6)	(7)	(8)						(9)				
DRAINAGE AREA	Street Width (FOC-FOC) (ft) W	Curb Height (in)	Curb Height (ft)	CURB OPENING HEIGHT (in)	CURB OPENING HEIGHT (ft) h	Split (ft) CS	High or low gutter	K_o	K_1	K_2	K_3	WATER FLOW DEPTH (ft) Yo = d	Is Yo > 1.4*h?	Over Curb?	ESD Field Measured Street Cross Slope Sx	Dist. Curb to Crown (ft) B	Crown Height (ft) H	Quadratic Formula = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a — a H / B^2	b -(2H/B)	c Yo	x1	x2	PONDED WIDTH (ft) T	Clear Width	Over Crown?		Outside ROW?
DA-L1	78.0	6.0	0.5	6.0	0.5	0.0	N/A	2.85	0.50	2.74	0	0.5325		**over curb**	0.052	37.7	0.49	0.0003	-0.0258	0.5325	--	--	37.66	**0.00**	over crown		no
DA-L2	32.5	6.0	0.5	5.0	0.4	0.0	N/A	2.85	0.50	3.03	0	0.2806		**no**	0.032	16.3	0.45	0.0017	-0.0554	0.2806	26.2210	6.2790	6.28	**9.97**	no		no
DA-L3	32.5	6.0	0.5	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0	0.5873		**over curb**	0.053	16.3	0.45	0.0017	-0.0554	0.5873	--	--	16.25	**0.00**	over crown		outside ROW
DA-A26	24.0	6.0	0.5	7.0	0.6	0.0	N/A	2.85	0.50	3.03	0	0.3285		**no**	0.020	24.0	0.47	0.0008	-0.0392	0.3285	37.1703	10.8297	16.77	**7.23**	no		no
DA-A15	30.0	6.0	0.5	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0	0.5170		**over curb**	0.043	15.0	0.85	0.0038	-0.1133	0.5170	24.3882	5.6118	5.61	**9.39**	no		no
DA-A16	91.5	6.0	0.5	6.0	0.5	2.0	high	2.85	0.50	2.74	-0.043	0.9916	use orifice EQ	**over curb**	0.060	23.3	1.14	0.0021	-0.0979	0.9916	31.6798	14.8802	14.88	**8.40**	no		outside ROW
DA-A14	30.0	6.0	0.5	9.0	0.8	0.0	N/A	2.85	0.50	3.03	0	0.4766		**no**	0.044	15.0	0.85	0.0038	-0.1133	0.4766	24.9420	5.0580	5.06	**9.94**	no		no
DA-A13	91.5	6.0	0.5	7.0	0.6	2.5	high	2.85	0.50	2.74	-0.043	1.1107	use orifice EQ	**over curb**	0.101	30.8	1.28	0.0013	-0.0829	1.1107	41.8027	19.7173	19.72	**11.04**	no		outside ROW
DA-A08	32.5	6.0	0.5	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0	0.4837		**no**	0.010	16.3	0.17	0.0006	-0.0209	0.4837	--	--	16.25	**0.00**	over crown		no
DA-A03	40.0	6.0	0.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0	0.2775		**no**	0.028	20.0	0.30	0.0008	-0.0300	0.2775	25.4811	14.5189	14.52	**5.48**	no		no

100 YEAR STORM

DRAINAGE AREA	Street Width (FOC-FOC) (ft) W	Curb Height (in)	Curb Height (ft)	CURB OPENING HEIGHT (in)	CURB OPENING HEIGHT (ft) h	Split (ft) CS	High or low gutter	K_o	K_1	K_2	K_3	WATER FLOW DEPTH (ft) Yo = d	Is Yo > 1.4*h?	Over Curb?	ESD Field Measured Street Cross Slope Sx	Dist. Curb to Crown (ft) B	Crown Height (ft) H	Quadratic Formula = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a — a H / B^2	b -(2H/B)	c Yo	x1	x2	PONDED WIDTH (ft) T		Over Crown?	Depth Over Crown	Outside ROW?
DA-L1	78.0	6.0	0.5	6.0	0.5	0.0	N/A	2.85	0.50	2.74	0	0.6105		over curb	0.052	37.7	0.49	0.0003	-0.0258	0.6105	--	--	37.66		over crown	**0.13**	**outside ROW**
DA-L2	32.5	6.0	0.5	5.0	0.4	0.0	N/A	2.85	0.50	3.03	0	0.3178		no	0.032	16.3	0.45	0.0017	-0.0554	0.3178	25.0584	7.4416	7.44		no	**0.00**	**no**
DA-L3	32.5	6.0	0.5	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0	0.6636		over curb	0.053	16.3	0.45	0.0017	-0.0554	0.6636	--	--	16.25		over crown	**0.21**	**outside ROW**
DA-A26	24.0	6.0	0.5	7.0	0.6	0.0	N/A	2.85	0.50	3.03	0	0.3771		no	0.020	24.0	0.47	0.0008	-0.0392	0.3771	34.6728	13.3272	19.25		no	**0.00**	**no**
DA-A15	30.0	6.0	0.5	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0	0.5850		over curb	0.043	15.0	0.85	0.0038	-0.1133	0.5850	23.3755	6.6245	6.62		no	**0.00**	**outside ROW**
DA-A16	91.5	6.0	0.5	6.0	0.5	2.0	high	2.85	0.50	2.74	-0.043	1.1587	use orifice EQ	over curb	0.060	23.3	1.14	0.0021	-0.0979	1.1587	--	--	23.28		over crown	**0.02**	**outside ROW**
DA-A14	30.0	6.0	0.5	9.0	0.8	0.0	N/A	2.85	0.50	3.03	0	0.5390		over curb	0.044	15.0	0.85	0.0038	-0.1133	0.5390	24.0730	5.9270	5.93		no	**0.00**	**no**
DA-A13	91.5	6.0	0.5	7.0	0.6	2.5	high	2.85	0.50	2.74	-0.043	1.3155	use orifice EQ	over curb	0.101	30.8	1.28	0.0013	-0.0829	1.3155	--	--	30.76		over crown	**0.04**	**outside ROW**
DA-A08	32.5	6.0	0.5	6.0	0.5	0.0	N/A	2.85	0.50	3.03	0	0.5473		over curb	0.010	16.3	0.17	0.0006	-0.0209	0.5473	--	--	16.25		over crown	**0.38**	**no**
DA-A03	40.0	6.0	0.5	6.0	0.5	0.0	N/A	2.85	0.50	2.89	0	0.3157		no	0.028	20.0	0.30	0.0008	-0.0300	0.3157	--	--	20.00		over crown	**0.02**	**no**

Source 2

Ultimate Development Conditions for Existing System

CURB INLETS ON GRADE, Type G-1 OR Type G-3, parabolic crown

Equations in cell

(1) DCM EQ 2-1: Qpeak = CiA
(2) Total flow = sum of discharge from drainage area and carry over flow
(3) So = (high elev - low elev)/length
(4) See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
(5) DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
For DA-A26 only, use straight crown equation since the driveway does not have a parabolic crown: HEC-22 EQ 4-3: d = T * Sx
(6) Sx measured in Field by ESD 3-3-15 or 3-31-15
(7) For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
(8) measured in field, lidar or record drawing; see "Crown Height Calcs" tab
(9) Hec-22 EQ B-11: Yo = (2H/B)*x - (H/B2)*x2 ; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
HEC-22 EQ 4-2: T = [Qn / (Ku * Sx1.67 * SL0.5)]0.375; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56
(10) Given in DCM EQ 4-10
(11) aDIG was measured in the field by ESD or DIG Data consultants. aDIG = (upstream curb height) - (depth from top of curb to inlet gutter)
(12) See HEC-22 Fig 4-13. aHEC22 is the difference between the inlet edge of gutter elevation and the projected street slope elevation
aHEC22 = aDIG - W*Sx
(13) DCM EQ 4-9: S'w = aHEC22 / (12*W)
(14) DCM EQ 4-9Sw = S'w + Sx
(15) HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1
(16) DCM EQ 4-9: Se = Sx + S'w*Eo
(17) See DCM Table 2-2
(18) DCM EQ 4-10: LT = KT * Q^0.42 * SL^0.3 * [1/ (n*Se)]^0.6
(19) DCM EQ 4-8: E = 1 - [1 - (L/LT)]^1.8
(20) DCM EQ 4-14: Qi = E * Q
(21) DCM EQ 4-15: Qb = Q - Qi

25 YEAR STORM

Equation in cell ==>	(10)	(11)	(12)			(13)	(14)	(15)	(16)	(17)	(18)	?			(19)	(20)	(21)
DRAINAGE AREA	K_T	GUTTER DEPRESSION (in) a_{DIG}	(in) a_{HEC22}	Gutter Depression Width (in)	Gutter Depression Width (ft) W	S'w	Sw	Eo	Se	Manning's n n	INLET LENGTH FOR TOTAL CAPTURE L_T	CURB INLET REDUCTION FACTOR (%)	CURB OPENING LENGTH (in)	CURB OPENING LENGTH (ft) L	INLET EFFICIENCY E	INTERCEPTED FLOW (cfs) Qi	BYPASS FLOW (cfs) Qb
DA-L1	0.6	2.0	1.1	18.0	1.50	0.06	0.11	0.11	0.06	0.016	34.54	0%	72	6.00	0.29	4.38	see COMBO for Intercepted and bypass flow
DA-L2	0.6	5.0	4.6	14.0	1.17	0.33	0.36	0.72	0.27	0.016	3.50	0%	61	5.08	1.00	1.12	0.00
DA-L3	0.6	6.0	5.1	17.0	1.42	0.30	0.35	0.29	0.14	0.016	14.64	0%	62	5.17	0.54	6.32	5.32
DA-A26	0.6	5.0	4.6	18.0	1.50	0.26	0.28	0.40	0.12	0.016	12.75	0%	120	10.00	0.94	8.00	0.54
DA-A15	0.6	7.0	6.2	18.0	1.50	0.35	0.39	0.84	0.33	0.016	19.21	0%	59	4.92	0.41	7.66	12.54
DA-A16	0.6	6.0	5.0	17.0	1.42	0.29	0.35	0.31	0.15	0.016	32.54	0%	36	3.00	0.16	See Calcs on Sump/Submerged tab	
DA-A14	0.6	7.0	6.2	18.0	1.50	0.34	0.39	0.88	0.35	0.016	18.05	0%	61	5.08	0.45	7.53	9.25
DA-A13	0.6	5.0	3.2	18.0	1.50	0.18	0.28	0.21	0.14	0.016	34.83	0%	36	3.00	0.15	See Calcs on Sump/Submerged tab	
DA-A08	0.6	6.0	5.8	18.0	1.50	0.32	0.33	0.60	0.21	0.016	15.57	0%	61	5.08	0.51	5.58	5.38
DA-A03	0.6	7.0	6.5	17.0	1.42	0.38	0.41	0.44	0.20	0.016	16.50	0%	61	5.08	0.48	2.27	2.42

100 YEAR STORM

DRAINAGE AREA	K_T	GUTTER DEPRESSION (in) a_{DIG}	(in) a_{HEC22}	Gutter Depression Width (in)	Gutter Depression Width (ft) W	S'w	Sw	Eo	Se	Manning's n n	INLET LENGTH FOR TOTAL CAPTURE L_T	CURB INLET REDUCTION FACTOR (%)	CURB OPENING LENGTH (in)	CURB OPENING LENGTH (ft) L	INLET EFFICIENCY E	INTERCEPTED FLOW (cfs) Qi	BYPASS FLOW (cfs) Qb
DA-L1	0.6	2.0	1.1	18.0	1.50	0.06	0.11	0.11	0.06	0.016	40.43	0%	72	6.00	0.25	5.51	see COMBO for Intercepted and bypass flow
DA-L2	0.6	5.0	4.6	14.0	1.17	0.33	0.36	0.63	0.24	0.016	4.39	0%	61	5.08	1.00	1.63	0.00
DA-L3	0.6	6.0	5.1	17.0	1.42	0.30	0.35	0.29	0.14	0.016	17.10	0%	62	5.17	0.48	8.03	8.82
DA-A26	0.6	5.0	4.6	18.0	1.50	0.26	0.28	0.34	0.11	0.016	16.12	0%	120	10.00	0.82	10.18	2.16
DA-A15	0.6	7.0	6.2	18.0	1.50	0.35	0.39	0.77	0.31	0.016	23.51	0%	59	4.92	0.34	10.11	19.25
DA-A16	0.6	6.0	5.0	17.0	1.42	0.29	0.35	0.19	0.12	0.016	45.64	0%	36	3.00	0.12	See Calcs on Sump/Submerged tab	
DA-A14	0.6	7.0	6.2	18.0	1.50	0.34	0.39	0.82	0.33	0.016	21.89	0%	61	5.08	0.38	9.22	15.14
DA-A13	0.6	5.0	3.2	18.0	1.50	0.18	0.28	0.13	0.12	0.016	44.98	0%	36	3.00	0.12	See Calcs on Sump/Submerged tab	
DA-A08	0.6	6.0	5.8	18.0	1.50	0.32	0.33	0.60	0.21	0.016	18.22	0%	61	5.08	0.45	7.09	8.85
DA-A03	0.6	7.0	6.5	17.0	1.42	0.38	0.41	0.30	0.14	0.016	23.27	0%	61	5.08	0.36	2.44	4.37

Source 2

Ultimate Development Conditions for Existing System

GRATE INLETS ON GRADE, Type G-2 OR Type G-3, parabolic crown

Equations in cell

- **(1)** DCM EQ 2-1: Q_{peak} = CiA
- **(2)** Total flow = sum of discharge from drainage area and carry over flow
- **(3)** So = (high elev - low elev)/length
- **(4)** See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
- **(5)** DCM EQ 3-5:Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
- **(6)** Sx measured in Field by ESD 3-3-15 or 3-31-15
- **(7)** For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
- **(8)** measured in field, lidar or record drawing; see "Crown Height Calcs" tab
- **(9)** Hec-22 EQ B-11: Yo = (2H/B)*x - (H/B^2)*x^2 ; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = E
- **(10)** HEC-22 EQ 4-16: Eo = 1 - (1 - W_{grate}/T)^2.67
- **(11)** HEC-22 EQ 4-18: If assume velocity in gutter is equal or less than splash over velocity, then R_f = 1; if not, Rf = 1 - Ku *(V - Vo), where Ku = 0.09; ref HEC-12 Chart 7 for Vo; minimum Rf = 0
- **(12)** Ku is given in HEC-22 EQ 4-19
- **(13)** gutter (and street) area in flow approximated by = 0.5 * (ponded width) * (water flow depth) = 0.5 * T * Yo; true area would be found by integrating parabolic equation
- **(14)** HEC-22 EQ 4-18: V = (total gutter flow)/(gutter area in flow)
- **(15)** HEC-22 EQ 4-10: Rs = ratio of side flow intercepted to total side flow = 1 / [1 + (Ku * V^1.8) / (Sx * L^2.3)]
- **(16)** a_{DIG} was measured in the field by ESD or DIG Data consultants. a_{DIG} = (upstream curb height) - (depth from top of curb to inlet gutter)
- **(17)** Parameters used to calculate Aw'; see image on "Aw and Aw' notes" tab
  θ = arctan(a_{DIG} / Wgutter)
  x = cos(θ) * Wgrate
  y = sin(θ) * Wgrate
- **(18)** See HEC-22 EQ 4-20a and "Aw and Aw' notes" tab. Grate width flow area = x * (Yo + a_{DIG} - y) + 0.5 * x * y
- **(19)** See HEC-22 EQ 4-20a and "Aw and Aw' notes" tab. Depressed Gutter width flow area = Yo * Wgutter + 0.5 * a_{DIG} * Wgutter
- **(20)** HEC-22 EQ 4-20a: Eo' = Eo * (Aw' / Aw)
- **(21)** HEC-22 EQ 4-20: E = Rf * Eo' + Rs * (1 - Eo')
- **(22)** See DCM 4.3.2.B
- **(23)** HEC-22 EQ 4-21: Qi = (1-0.35)*Q*E
- **(24)** DCM EQ 4-15: Qb = Q - Qi

25 YEAR STORM

HEC-22 variable or EQ ==>			Q			Q				S_L										d	
DCM Variable or EQ==>			Q			Q				S_o						K_o	K_1	K_2	K_3	Y_o EQ 3-5	
GIS StormwaterInfrastructureFIELD ==>																					
Data Source ===>							DGN	DGN	DGN		DGN	assumed		DGN	DGN	DCM					
Equation in cell ==>			(1)			(2)				(3)							(4)			(5)	
DRAINAGE AREA	STREET NAME	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$	Street Width (FOC-FOC) (ft)	Curb Height (in)	Curb Height (ft)	Split (ft) CS	High or low gutter	K_o	K_1	K_2	K_3	WATER FLOW DEPTH (ft) Yo = d	Over Curb?
DA-L1	S. Congress	1.66	15.08	none	0.00	15.08	587.00	583.40	250.89	0.0143	78.0	6.0	0.5	0.0	N/A	2.85	0.50	2.74	0.0	0.532	over curb
DA-A10	S. Congress Ave.	0.55	5.46	none	0.00	5.46	569.50	566.50	127.35	0.0236	91.5	6.0	0.5	1.0	low	2.8	0.5	2.7	-0.159	0.396	no

100 YEAR STORM

HEC-22 variable or EQ ==>			Q			Q				S_L										d	
DCM Variable or EQ==>			Q			Q				S_o						K_o	K_1	K_2	K_3	Y_o EQ 3-5	
GIS StormwaterInfrastructureFIELD ==>																					
Data Source ===>							DGN	DGN	DGN		DGN	assumed		DGN	DGN	DCM					
Equation in cell ==>			(1)			(2)				(3)							(4)			(5)	
DRAINAGE AREA	STREET NAME	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$	Street Width (FOC-FOC) (ft)	Curb Height (in)	Curb Height (ft)	Split (ft) CS	High or low gutter	K_o	K_1	K_2	K_3	WATER FLOW DEPTH (ft) Yo = d	Over Curb?
DA-L1	S. Congress	1.66	21.94	none	0.00	21.94	587.00	583.40	250.89	0.0143	78.0	6.0	0.5	0.0	N/A	2.85	0.50	2.74	0.0	0.611	over curb
DA-A10	S. Congress Ave.	0.55	7.89	none	0.00	7.89	569.50	566.50	127.35	0.0236	91.5	6.0	0.5	1.0	low	2.8	0.5	2.7	-0.159	0.454	no

Source 2

Ultimate Development Conditions for Existing System

GRATE INLETS ON GRADE, Type G-2 OR Type G-3, parabolic crown

Equations in cell

- (1) DCM EQ 2-1: Qpeak = CiA
- (2) Total flow = sum of discharge from drainage area and carry over flow
- (3) So = (high elev - low elev)/length
- (4) See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
- (5) DCM EQ 3-5:Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
- (6) Sx measured in Field by ESD 3-3-15 or 3-31-15
- (7) For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
- (8) measured in field, lidar or record drawing; see "Crown Height Calcs" tab
- (9) Hec-22 EQ B-11: Yo = (2H/B)*x - (H/B2)*x2 ; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
- (10) HEC-22 EQ 4-16: Eo = 1 - (1 - Wgrate/T)^2.67
- (11) HEC-22 EQ 4-18: If assume velocity in gutter is equal or less than splash over velocity, then Rf = 1; if not, Rf = 1 - Ku *(V - Vo), where Ku = 0.09; ref HEC-12 Chart 7 for Vo; minimum Rf = 0
- (12) Ku is given in HEC-22 EQ 4-19
- (13) gutter (and street) area in flow approximated by = 0.5 * (ponded width) * (water flow depth) = 0.5 * T * Yo; true area would be found by integrating parabolic equation
- (14) HEC-22 EQ 4-18: V = (total gutter flow)/(gutter area in flow)
- (15) HEC-22 EQ 4-10: Rs = ratio of side flow intercepted to total side flow = 1 / [1 + (Ku * V^1.8) / (Sx * L^2.3)]
- (16) aDIG was measured in the field by ESD or DIG Data consultants. aDIG = (upstream curb height) - (depth from top of curb to inlet gutter)
- (17) Parameters used to calculate Aw'; see image on "Aw and Aw' notes" tab
  - θ = arctan(aDIG / Wgutter)
  - x = cos(θ) * Wgrate
  - y = sin(θ) * Wgrate
- (18) See HEC-22 EQ 4-20a and "Aw and Aw' notes" tab. Grate width flow area = x * (Yo + aDIG - y) + 0.5 * x * y
- (19) See HEC-22 EQ 4-20a and "Aw and Aw' notes" tab. Depressed Gutter width flow area = Yo * Wgutter + 0.5 * aDIG * Wgutter
- (20) HEC-22 EQ 4-20a: Eo' = Eo * (Aw' / Aw)
- (21) HEC-22 EQ 4-20: E = Rf * Eo' + Rs * (1 - Eo')
- (22) See DCM 4.3.2.B
- (23) HEC-22 EQ 4-21: Qi = (1-0.35)*Q*E
- (24) DCM EQ 4-15: Qb = Q - Qi

25 YEAR STORM

HEC-22 variable o	Sx	B EQ B-11	H EQ B-11						x and T EQ B-11			W		W	Eo EQ 4-16		R_f EQ 4-18	Ku EQ 4-19
DCM Variable or E	Sx	assumes crown to curb = street width/2; not true for streets with curb split	H EQ 3-1						S and T EQ 3-1			W		W				
GIS StormwaterInfrastructureFIELD ==>											Width		Width					
Data Source ===>											GIS or ESD field visit		GIS or ESD field visit				Vo calcs	HEC-22
Equation in cell ==	(6)	(7)	(8)						(9)						(10)		(11)	(12)
DRAINAGE AREA	ESD Field Measured Street Cross Slope Sx	Dist. Curb to Crown (ft) B	Crown Height (ft) H	Quadratic Formula T = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a a H / B^2	b -(2H/B)	c Yo	x1	x2	PONDED WIDTH (ft) T	Over Crown?	Gutter Depression Width (in)	Gutter Depression Width (ft) W_{gutter}	Grate Width (in)	Grate Width (ft) W_{grate}	Eo	Splash Over Velocity (ft/s) Vo	R_f	Ku
DA-L1	0.052	37.7	0.49	0.000	-0.026	0.532	--	--	37.66	over crown	18.0	1.50	18.00	1.50	0.10	8.7	1.00	0.15
DA-A10	0.116	50.4	2.20	0.001	-0.087	0.396	96.039	4.761	4.76	no	18.0	1.50	15.00	1.25	0.56	4.70	0.90	0.15

100 YEAR STORM

HEC-22 variable o	Sx	B EQ B-11	H EQ B-11						x and T EQ B-11			W		W	Eo EQ 4-16		R_f EQ 4-18	Ku EQ 4-19
DCM Variable or E	Sx	assumes crown to curb = street width/2; not true for streets with curb split	H EQ 3-1						S and T EQ 3-1			W		W				
GIS StormwaterInfrastructureFIELD ==>											Width		Width					
Data Source ===>											GIS or ESD field visit		GIS or ESD field visit				Vo calcs	HEC-22
Equation in cell ==	(6)	(7)	(8)						(9)						(10)		(11)	(12)
DRAINAGE AREA	ESD Field Measured Street Cross Slope Sx	Dist. Curb to Crown (ft) B	Crown Height (ft) H	Quadratic Formula T = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a a H / B^2	b -(2H/B)	c Yo	x1	x2	PONDED WIDTH (ft) T	Over Crown?	Gutter Depression Width (in)	Gutter Depression Width (ft) W_{gutter}	Grate Width (in)	Grate Width (ft) W_{grate}	Eo	Splash Over Velocity (ft/s) Vo	R_f	Ku
DA-L1	0.052	37.7	0.49	0.000	-0.026	0.611	--	--	37.66	over crown	18.0	1.50	18.00	1.50	0.10	8.70	1.00	0.15
DA-A10	0.116	50.4	2.20	0.001	-0.087	0.454	95.301	5.499	5.50	no	18.0	1.50	15.00	1.25	0.50	4.70	0.85	0.15

Source 2

Ultimate Development Conditions for Existing System

GRATE INLETS ON GRADE, Type G-2 OR Type G-3, parabolic crown

Equations in cell

(1)	DCM EQ 2-1: Qpeak = CiA
(2)	Total flow = sum of discharge from drainage area and carry over flow
(3)	So = (high elev - low elev)/length
(4)	See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
(5)	DCM EQ 3-5:Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
(6)	Sx measured in Field by ESD 3-3-15 or 3-31-15
(7)	For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
(8)	measured in field, lidar or record drawing; see "Crown Height Calcs" tab
(9)	Hec-22 EQ B-11: Yo = (2H/B)*x - (H/B2)*x2 ; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
(10)	HEC-22 EQ 4-16: Eo = 1 - (1 - Wgrate/T)^2.67
(11)	HEC-22 EQ 4-18: If assume velocity in gutter is equal or less than splash over velocity, then Rf = 1; if not, Rf = 1 - Ku *(V - Vo), where Ku = 0.09; ref HEC-12 Chart 7 for Vo; minimum Rf = 0
(12)	Ku is given in HEC-22 EQ 4-19
(13)	gutter (and street) area in flow approximated by = 0.5 * (ponded width) * (water flow depth) = 0.5 * T * Yo; true area would be found by integrating parabolic equation
(14)	HEC-22 EQ 4-18: V = (total gutter flow)/(gutter area in flow)
(15)	HEC-22 EQ 4-10: Rs = ratio of side flow intercepted to total side flow = 1 / [1 + (Ku * V^1.8) / (Sx * L^2.3)]
(16)	aDIG was measured in the field by ESD or DIG Data consultants. aDIG = (upstream curb height) - (depth from top of curb to inlet gutter)
(17)	Parameters used to calculate Aw'; see image on "Aw and Aw' notes" tab θ = arctan(aDIG / Wgutter) x = cos(θ) * Wgrate y = sin(θ) * Wgrate
(18)	See HEC-22 EQ 4-20a and "Aw and Aw' notes" tab. Grate width flow area = x * (Yo + aDIG - y) + 0.5 * x * y
(19)	See HEC-22 EQ 4-20a and "Aw and Aw' notes" tab. Depressed Gutter width flow area = Yo * Wgutter + 0.5 * aDIG * Wgutter
(20)	HEC-22 EQ 4-20a: Eo' = Eo * (Aw' / Aw)
(21)	HEC-22 EQ 4-20: E = Rf * Eo' + Rs * (1 - Eo')
(22)	See DCM 4.3.2.B
(23)	HEC-22 EQ 4-21: Qi = (1-0.35)*Q*E
(24)	DCM EQ 4-15: Qb = Q - Qi

25 YEAR STORM

HEC-22 variable or EQ =	L EQ 4-19		V EQ 4-18	R_s EQ 4-19			See "Aw and Aw' notes" tab			Aw' EQ 4-20a	Aw EQ 4-20a	Eo' EQ 4-20a	E EQ 4-20		Qi EQ 4-21	Qb	
DCM Variable or EQ==>					DIG Data Instructions									4.3.2.B	Qi		
GIS StormwaterInfrastructureFIELD ==>					Depression_a												
Data Source ===>					GIS or ESD field visit					DGN	DGN			DCM			ESD field visit
Equation in cell ==>		(13)	(14)	(15)	(16)		(17)			(18)	(19)	(20)	(21)	(22)	(23)	(24)	
DRAINAGE AREA	**Grate Length** *(ft)* L	**Gutter (Street) Area in Flow** *(sq ft)*	**Gutter Velocity** *(ft/s)* V	R_s	**GUTTER DEPRESSION** *(in)* a_{DIG}	*(ft)* a_{DIG}	θ	*(ft)* x	*(ft)* y	**Grate width flow area** Aw'	**Depressed Gutter width flow area** Aw	Eo'	E	**GRATE INLET REDUCTION FACTOR** *(%)*	**INTERCEPTED FLOW** *(cfs)* Qi	**BYPASS FLOW** *(cfs)* Qb	**INLET TYPE**
DA-L1	5.00	10.03	1.50	0.87	2.00	0.17	0.11	1.49	0.17	0.92	0.92	0.10	0.88	35%	8.67	see COMBO for Intercepted and bypass flow	Type G-3
DA-A10	2.00	0.94	5.79	0.14	1.00	0.08	0.06	1.50	0.08	0.66	0.66	0.56	0.56	35%	2.00	3.46	Type G-2

100 YEAR STORM

HEC-22 variable or EQ =	L EQ 4-19		V EQ 4-18	R_s EQ 4-19			See "Aw and Aw' notes" tab			Aw' EQ 4-20a	Aw EQ 4-20a	Eo' EQ 4-20a	E EQ 4-20		Qi EQ 4-21	Qb	
DCM Variable or EQ==>					DIG Data Instructions									4.3.2.B	Qi		
GIS StormwaterInfrastructureFIELD ==>					Depression_a												
Data Source ===>					GIS or ESD field visit					DGN	DGN			DCM			ESD field visit
Equation in cell ==>		(13)	(14)	(15)	(16)		(17)			(18)	(19)	(20)	(21)	(22)	(23)	(24)	
DRAINAGE AREA	**Grate Length** *(ft)* L	**Gutter (Street) Area in Flow** *(sq ft)*	**Gutter Velocity** *(ft/s)* V	R_s	**GUTTER DEPRESSION** *(in)* a_{DIG}	*(ft)* a_{DIG}	θ	*(ft)* x	*(ft)* y	**Grate width flow area** Aw'	**Depressed Gutter width flow area** Aw	Eo'	E	**GRATE INLET REDUCTION FACTOR** *(%)*	**INTERCEPTED FLOW** *(cfs)* Qi	**BYPASS FLOW** *(cfs)* Qb	**INLET TYPE**
DA-L1	5.00	11.50	1.91	0.81	2.00	0.17	0.11	1.49	0.17	1.04	1.04	0.10	0.83	35%	11.89	see COMBO for Intercepted and bypass flow	Type G-3
DA-A10	2.00	1.25	6.33	0.12	1.00	0.08	0.06	1.50	0.08	0.74	0.74	0.50	0.49	35%	2.49	5.40	Type G-2

Source 2

Ultimate Development Conditions for Existing System

CURB INLETS IN SUMPS, Type S-1, parabolic crown and SUBMERGED CURB INLETS ON GRADE, parabolic crown

Equations in Cells

(1) DCM EQ 2-1: Q_{peak} = CiA
(2) Total flow = sum of discharge from drainage area and carry over flow
(3) So = (high elev - low elev)/length
(4) See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
(5) DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2] ; for inlets in sag, Yo = maximum of Yo values calculated for both side of inlet
(6) Sx measured in Field by ESD 3-3-15 or 3-31-15
(7) For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
(8) measured in field, lidar or record drawing; see "Crown Height Calcs" tab
(9) HEC-22 EQ B-11: Yo = (2H/B)*x - (H/B2)*x2 ; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
(10) a_{DIG} was measured in the field by ESD or DIG Data consultants. a_{DIG} = (upstream curb height) - (depth from top of curb to inlet gutter)
(11) See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation
$a_{HEC22} = a_{DIG}$ - W*Sx
(12) If d > 1.4*h, use orifice EQ, else use weir EQ
(13) See DCM EQ 4-1: For depressed curb inlet, Cw = 2.3; for curb inlets without depression, Cw = 3.0
(14) HEC-22 EQ 4-31a or DCM EQ 4-4a: $d_o = d_i$ - (h/2); where di = Yo + a_{HEC22}/12
(15) See DCM EQ 4-4: Co = 0.67
(16) DCM EQ 4-1: Qi = Cw * (L + 1.8*W) * $d^{1.5}$
(17) DCM EQ 4-4a: Qi = Co * h * L * $(2*g*do)^{0.5}$
(18) Qover = Q - Qi

25 YEAR STORM

HEC-22 variable or EQ ==>														**Q**							
DCM Variable or EQ==>														**Q**							
GIS StormwaterInfrastructureFIELD ==>																					
Equation in cell ==>			**(1)**											**(2)**				**(3)**			
DRAINAGE AREA	**STREET**	**DRAINAGE AREA** (ac.)	**DISCHARGE FROM DRAINAGE AREA** (cfs)	**1st UPSTREAM DRAINAGE AREA**	**1st CARRY OVER FLOW** (cfs)	**2nd UPSTREAM DRAINAGE AREA**	**2nd CARRY OVER FLOW** (cfs)	**3rd UPSTREAM DRAINAGE AREA**	**3rd CARRY OVER FLOW** (cfs)	**4th UPSTREAM DRAINAGE AREA**	**4th CARRY OVER FLOW** (cfs)	**5th UPSTREAM DRAINAGE AREA**	**5th CARRY OVER FLOW** (cfs)	**TOTAL RUNOFF** (cfs) Q	**Hig elev** (ft)	**low elev** (ft)	**length** (ft)	**SLOPE** (ft/ft) $S_o = S_L$	**Street Width (FOC-FOC)** (ft)	**Curb Height** (in)	**Curb Height** (ft)
DA-A11	Mary	3.42	31.64	none										31.64	570.00	567.50	114.36	0.022	37.0	6.0	0.5
DA-A12	Congress	3.19	29.66	DA-A13	61.54									91.20	570.00	567.50	117.12	0.021	91.5	6.0	0.5
DA-A16	Congress	4.62	39.78	DA-L1	2.03	DA-L2	0.00	DA-L3	5.32	DA-A26	0.54	DA-A15	12.54	60.21				0.011	91.5	6.0	0.500
DA-A13	Congress	1.13	10.55	DA-A16	51.54	DA-A14	9.25							71.33				0.009	91.5	6.0	0.500

100 YEAR STORM

DRAINAGE AREA	**STREET**	**DRAINAGE AREA** (ac.)	**DISCHARGE FROM DRAINAGE AREA** (cfs)	**1st UPSTREAM DRAINAGE AREA**	**1st CARRY OVER FLOW** (cfs)	**2nd UPSTREAM DRAINAGE AREA**	**2nd CARRY OVER FLOW** (cfs)	**3rd UPSTREAM DRAINAGE AREA**	**3rd CARRY OVER FLOW** (cfs)	**4th UPSTREAM DRAINAGE AREA**	**4th CARRY OVER FLOW** (cfs)	**5th UPSTREAM DRAINAGE AREA**	**5th CARRY OVER FLOW** (cfs)	**TOTAL RUNOFF** (cfs) Q	**Hig elev** (ft)	**low elev** (ft)	**length** (ft)	**SLOPE** (ft/ft) $S_o = S_L$	**Street Width (FOC-FOC)** (ft)	**Curb Height** (in)	**Curb Height** (ft)
DA-A11	Mary	3.42	45.93	none										45.93	570.00	567.50	114.36	0.022	37.0	6.0	0.5
DA-A12	Congress	3.19	43.04	DA-A13	102.73									145.77	570.00	567.50	117.12	0.021	91.5	6.0	0.5
DA-A16	Congress	4.62	57.48	DA-L1	4.55	DA-L2	0.00	DA-L3	8.82	DA-A26	2.16	DA-A15	19.25	92.25				0.011	91.5	6.0	0.500
DA-A13	Congress	1.13	15.31	DA-A16	82.97	DA-A14	15.14							113.41				0.009	91.5	6.0	0.500

Ultimate Development Conditions for Existing System

CURB INLETS IN SUMPS, Type S-1, parabolic crown and SUBMERGED CURB INLETS ON GRADE, parabolic crown

Equations in Cells

- **(1)** DCM EQ 2-1: Qpeak = CiA
- **(2)** Total flow = sum of discharge from drainage area and carry over flow
- **(3)** So = (high elev - low elev)/length
- **(4)** See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
- **(5)** DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2] ; for inlets in sag, Yo = maximum of Yo values calculated for both side of inlet
- **(6)** Sx measured in Field by ESD 3-3-15 or 3-31-15
- **(7)** For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
- **(8)** measured in field, lidar or record drawing; see "Crown Height Calcs" tab
- **(9)** HEC-22 EQ B-11: Yo = (2H/B)*x - (H/B2)*x2 ; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
- **(10)** aDIG was measured in the field by ESD or DIG Data consultants. aDIG = (upstream curb height) - (depth from top of curb to inlet gutter)
- **(11)** See HEC-22 Fig 4-13. aHEC22 is the difference between the inlet edge of gutter elevation and the projected street slope elevation
  aHEC22 = aDIG - W*Sx
- **(12)** If d > 1.4*h, use orifice EQ, else use weir EQ
- **(13)** See DCM EQ 4-1: For depressed curb inlet, Cw = 2.3; for curb inlets without depression, Cw = 3.0
- **(14)** HEC-22 EQ 4-31a or DCM EQ 4-4a: do = di - (h/2); where di = Yo + aHEC22/12
- **(15)** See DCM EQ 4-4: Co = 0.67
- **(16)** DCM EQ 4-1: Qi = Cw * (L + 1.8*W) * d1.5
- **(17)** DCM EQ 4-4a: Qi = Co * h * L * (2*g*do)0.5
- **(18)** Qover = Q - Qi

25 YEAR STORM

HEC-22 variable or EQ ==>							d		Sx	B EQ B-11	H EQ B-11						T EQ 4-3				
DCM Variable or EQ==>			K_o	K_1	K_2	K_3	Y_o EQ 3-5		Sx	assumes crown to curb = street width/2; not true for streets with curb split	H EQ 3-1										
GIS StormwaterInfrastructureFIELD ==>																					
Equation in cell ==>			(4)				(5)		(6)	(7)	(8)						(9)				
DRAINAGE AREA	Split	High or low gutter	K_o	K_1	K_2	K_3	WATER FLOW DEPTH	Over Curb?	ESD Field Measured Street Cross Slope	Dist. Curb to Crown	Crown Height	Quadratic Formula T = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a					PONDED WIDTH	CLEAR WIDTH	Over Crown?		
	(ft) CS						(ft) Yo = d		Sx	(ft) B	(ft) H	a H / B^2	b -(2H/B)	c Yo	x1	x2	(ft) T	(ft)			
DA-A11	0.0		2.89	0.50	2.99	0.000	0.650	**over curb**	0.022	18.5	0.30	0.001	-0.032	0.650	--	--	18.5	**0.0**	over crown		
DA-A12	1.0	high	2.85	0.50	2.74	-0.043	0.990	**over curb**	0.018	43.5	1.41	0.001	-0.065	0.990	67.234	19.766	19.8	**23.7**	no		
DA-A16	2.0	high	2.85	0.50	2.74	-0.043	0.992	**over curb**	0.060	23.3	1.14	0.002	-0.098	0.992	31.680	14.880	14.9	**8.4**	no		
DA-A13	2.5	high	2.85	0.50	2.74	-0.043	1.111	**over curb**	0.101	30.8	1.28	0.001	-0.083	1.111	41.803	19.717	19.7	**11.0**	no		

100 YEAR STORM

DRAINAGE AREA	Split	High or low gutter	K_o	K_1	K_2	K_3	WATER FLOW DEPTH	Over Curb?	ESD Field Measured Street Cross Slope	Dist. Curb to Crown	Crown Height	Quadratic Formula T = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a					PONDED WIDTH	CLEAR WIDTH	Over Crown?	Depth Over Crown	Outside ROW?
	(ft) CS						(ft) Yo = d		Sx	(ft) B	(ft) H	a H / B^2	b -(2H/B)	c Yo	x1	x2	(ft) T	(ft)			
DA-A11	0.0		2.89	0.50	2.99	0.000	0.736	over curb	0.022	18.5	0.30	0.001	-0.032	0.736	--	--	18.5	0.0	over crown	**0.4**	**outsied ROW**
DA-A12	1.0	high	2.85	0.50	2.74	-0.043	1.175	over curb	0.018	43.5	1.41	0.001	-0.065	1.175	61.255	25.745	25.7	17.8	no	**0.0**	**outsied ROW**
DA-A16	2.0	high	2.85	0.50	2.74	-0.043	1.159	over curb	0.060	23.3	1.14	0.002	-0.098	1.159	--	--	23.3	0.0	over crown	**0.0**	**outsied ROW**
DA-A13	2.5	high	2.85	0.50	2.74	-0.043	1.315	over curb	0.101	30.8	1.28	0.001	-0.083	1.315	--	--	30.8	0.0	over crown	**0.0**	**outsied ROW**

Source 2

Ultimate Development Conditions for Existing System

CURB INLETS IN SUMPS, Type S-1, parabolic crown and SUBMERGED CURB INLETS ON GRADE, parabolic crown

Equations in Cells

- **(1)** DCM EQ 2-1: Qpeak = CiA
- **(2)** Total flow = sum of discharge from drainage area and carry over flow
- **(3)** So = (high elev - low elev)/length
- **(4)** See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
- **(5)** DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2] ; for inlets in sag, Yo = maximum of Yo values calculated for both side of inlet
- **(6)** Sx measured in Field by ESD 3-3-15 or 3-31-15
- **(7)** For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
- **(8)** measured in field, lidar or record drawing; see "Crown Height Calcs" tab
- **(9)** HEC-22 EQ B-11: Yo = (2H/B)*x - (H/B2)*x2 ; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
- **(10)** aDIG was measured in the field by ESD or DIG Data consultants. aDIG = (upstream curb height) - (depth from top of curb to inlet gutter)
- **(11)** See HEC-22 Fig 4-13. aHEC22 is the difference between the inlet edge of gutter elevation and the projected street slope elevation
aHEC22 = aDIG - W*Sx
- **(12)** If d > 1.4*h, use orifice EQ, else use weir EQ
- **(13)** See DCM EQ 4-1: For depressed curb inlet, Cw = 2.3; for curb inlets without depression, Cw = 3.0
- **(14)** HEC-22 EQ 4-31a or DCM EQ 4-4a: do = di - (h/2); where di = Yo + aHEC22/12
- **(15)** See DCM EQ 4-4: Co = 0.67
- **(16)** DCM EQ 4-1: Qi = Cw * (L + 1.8*W) * d1.5
- **(17)** DCM EQ 4-4a: Qi = Co * h * L * (2*g*do)0.5
- **(18)** Qover = Q - Qi

25 YEAR STORM

HEC-22 variable or EQ ==>		a Fig 4-13		h EQ 4-29, Fig 4-18.a				L			EQ 4-29	EQ 4-28, 4-30 Cw	d_o EQ 4-31a	Co EQ 4-31		?	EQ 4-28	EQ 4-29		
DCM Variable or EQ	DIG instructions			EQ 4-2 h				L			EQ 4-2	EQ 4-1, 4-3 Cw	d_o EQ 4-4a	Co EQ 4-4		?	EQ 4-1	EQ 4-4a		
GIS StormwaterInfra	Depression_a		Height		Width		st_length													
Equation in cell ==>	(10)	(11)									(12)	(13)	(14)	(15)			(16)	(17)	(18)	
DRAINAGE AREA	GUTTER DEPRESSION *(in)* a_{DIG}	*(in)* a_{HEC22}	CURB OPENING HEIGHT *(in)*	CURB OPENING HEIGHT *(ft)* h	Gutter Depression Width *(in)*	Gutter Depression Width *(ft)* W	CURB INLET LENGTH *(in)*	CURB INLET LENGTH *(ft)* L	*(ft)* $h + a_{HEC22}/12$	*(ft)* 1.4*h	If d > 1.4*h, use orifice EQ Else, use weir EQ	WEIR COEFFICIENT Cw	EFFECTIVE HEAD ON ORIFICE *(ft)* d_o	ORIFICE COEFFICIENT Co	GRAVITY *(ft/s^2)* g	CURB INLET REDUCTION FACTOR *(%)*	MAXIMUM CAPACITY FLOW WEIR EQ *(cfs)* Qi	MAXIMUM CAPACITY FLOW ORIFICE EQ *(cfs)* Qi	OVER CAPACITY FLOW *(cfs)* Q_{over}	INLET TYPE
DA-A11	4.00	3.63	6.00	0.50	17.00	1.42	34.0	2.83	0.80	0.70	weir EQ	2.30	0.70	0.67	32.2		6.49	----	25.15	TYPE S-1
DA-A12	1.50	1.23	4.50	0.38	15.00	1.25	36.00	3.00	0.48	0.53	orifice EQ	2.30	0.91	0.67	32.2		----	5.76	85.44	TYPE S-1
DA-A16	6.00	4.98	6.00	0.50	17.00	1.42	36.00	3.00	0.92	0.70	orifice EQ	N/A	1.16	0.67	32.2		----	8.67	51.54	TYPE G-1
DA-A13	5.00	3.18	7.00	0.58	18.00	1.50	36.00	3.00	0.85	0.82	orifice EQ	N/A	1.08	0.67	32.2		----	9.80	61.54	TYPE-G1

100 YEAR STORM

DRAINAGE AREA	GUTTER DEPRESSION *(in)* a_{DIG}	*(in)* a_{HEC22}	CURB OPENING HEIGHT *(in)*	CURB OPENING HEIGHT *(ft)* h	Gutter Depression Width *(in)*	Gutter Depression Width *(ft)* W	CURB INLET LENGTH *(in)*	CURB INLET LENGTH *(ft)* L	*(ft)* $h + a_{HEC22}/12$	*(ft)* 1.4*h	If d > 1.4*h, use orifice EQ Else, use weir EQ	WEIR COEFFICIENT Cw	EFFECTIVE HEAD ON ORIFICE *(ft)* d_o	ORIFICE COEFFICIENT Co	GRAVITY *(ft/s^2)* g	CURB INLET REDUCTION FACTOR *(%)*	MAXIMUM CAPACITY FLOW WEIR EQ *(cfs)* Qi	MAXIMUM CAPACITY FLOW ORIFICE EQ *(cfs)* Qi	OVER CAPACITY FLOW *(cfs)* Q_{over}	INLET TYPE
DA-A11	4.00	3.63	6.00	0.50	17.00	1.42	34.0	2.83	0.80	0.70	orifice EQ	2.30	0.79	0.67	32.2		----	6.76	39.16	TYPE S-1
DA-A12	1.50	1.23	4.50	0.38	15.00	1.25	36.00	3.00	0.48	0.53	orifice EQ	2.30	1.09	0.67	32.2		----	6.32	139.45	TYPE S-1
DA-A16	6.00	4.98	6.00	0.50	17.00	1.42	36.00	3.00	0.92	0.70	orifice EQ	N/A	1.32	0.67	32.2		----	9.28	82.97	TYPE G-1
DA-A13	5.00	3.18	7.00	0.58	18.00	1.50	36.00	3.00	0.85	0.82	orifice EQ	N/A	1.29	0.67	32.2		----	10.68	102.73	TYPE-G1

Source 3

Annie Street Storm Drain Improvements
C Values - Ultimate Development Conditions for Proposed Alternative 1 - Crockett System

																								0.37	0.42	0.46	0.53					
																								0.25	0.30	0.34	0.41					
Drainage Input				Asphalt		Concrete		Grass		Total	Asphalt	Concrete	Grass	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	Combined				
Basin	Area (sf)	Drainage Area EX %IC	Area IC (sf)	Asph. % of IC	Asph.. Area (sf)	Conc. % of IC	Conc. Area (sf)	Grass Percentile	Grass Area (sf)	Area (acres)	Asp. Area (acres)	Conc. Area (acres)	Grass Area (acres)	Asph.C2	Asph.C10	Asph.C25	Asph. C100	Asph C500	Conc. C2	Conc. C10	Conc. C25	Conc. C100	Conc. C500	Grass C2	Grass C10	Grass C25	Grass C100	Comb. C2	Comb. C10	Comb. C25	Comb. C100	Comb. C500
DA-A22-A	22605			62.1%	14027	23.85%	5391	14.10%	3187	0.52	0.32	0.12	0.07	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.68	0.75	0.80	0.89	0.94
DA-A22-B	10385			97.7%	10146	0.78%	81	1.52%	158	0.24	0.23	0.00	0.00	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.72	0.80	0.85	0.94	0.99
DA-A22-C	8632			95.6%	8255	1.62%	140	2.75%	237	0.20	0.19	0.00	0.01	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.72	0.80	0.85	0.94	0.99
DA-A22-D	22451			9.4%	2106	57.25%	12852	33.37%	7493	0.52	0.05	0.30	0.17	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.61	0.68	0.72	0.81	0.86
DA-A22-E	14237			22.3%	3177	46.30%	6592	31.39%	4469	0.33	0.07	0.15	0.10	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.61	0.68	0.73	0.81	0.87
DA-A22-F	22258			23.8%	5294	42.14%	9380	34.07%	7584	0.51	0.12	0.22	0.17	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.60	0.67	0.72	0.80	0.86
DA-A22-G	10062			35.0%	3525	33.09%	3329	31.88%	3208	0.23	0.08	0.08	0.07	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.61	0.68	0.73	0.81	0.87
DA-A22-H	22993			16.5%	3795	51.91%	11937	31.58%	7261	0.53	0.09	0.27	0.17	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.61	0.68	0.73	0.82	0.87
DA-A22-J	22899			5.9%	1342	61.02%	13972	33.12%	7585	0.53	0.03	0.32	0.17	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.61	0.68	0.73	0.81	0.86
DA-A22-K	45563			9.7%	4414	56.96%	25952	33.35%	15197	1.05	0.10	0.60	0.35	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.61	0.68	0.72	0.81	0.86
DA-A22-L	22569			14.9%	3355	53.77%	12135	31.37%	7080	0.52	0.08	0.28	0.16	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.62	0.69	0.73	0.82	0.87
DA-A22-M	7518			63.0%	4736	19.69%	1480	17.31%	1302	0.17	0.11	0.03	0.03	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.66	0.74	0.79	0.87	0.93
DA-A22-N	22612			11.7%	2647	51.82%	11718	36.47%	8247	0.52	0.06	0.27	0.19	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.59	0.66	0.71	0.79	0.85
DA-A22-P	22853			54.1%	12374	30.53%	6976	15.33%	3503	0.52	0.28	0.16	0.08	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.67	0.75	0.80	0.89	0.94
DA-A22-Q	35001			84.4%	29558	13.06%	4570	2.49%	873	0.80	0.68	0.10	0.02	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.72	0.80	0.85	0.94	0.99
DA-A22-R	22773			9.3%	2126	56.14%	12784	34.52%	7862	0.52	0.05	0.29	0.18	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.60	0.67	0.72	0.80	0.85
DA-A22-S	34083			8.1%	2775	83.20%	28357	8.66%	2951	0.78	0.06	0.65	0.07	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.71	0.79	0.84	0.93	0.96
DA-A22-T	22472			13.0%	2929	49.85%	11203	37.11%	8340	0.52	0.07	0.26	0.19	0.73	0.81	0.86	0.95	1.00	0.75	0.83	0.88	0.97	1.00	0.33	0.38	0.42	0.49	0.59	0.66	0.71	0.79	0.84
Total Area	**391966**																															

DESIGNER NOTES
Basis for Calculations:

Area of imervious cover that is asphalt versus concrete is calculated on Impervious Cover Breakdown sheet
Area of grass = total area - asphalt area - area concrete

Source 3

Annie Street Storm Drain Improvements
Time of Concentration (Ultimate Conditions for Proposed Alternative 1 - Crockett System)

Equation in cell ==>		(1)	(2)			(3)	(4)	(5)			(6)	(7)	(8)			(9)	(10)			(9)	(10)
Drainage Input				Sheet Flow - roof/pavement					Sheet Flow - overland					Shallow Conc. 1 - unpaved				Shallow Conc. 2 - unpaved			
Basin	Area (acres)	Calc. Tc	Tc used mins	Sheet Flow Length (ft)	Sheet Flow Slope (ft/ft)	n	P	tc1 mins	Sheet Flow Length (ft)	Sheet Flow Slope (ft/ft)	n	P	tc1 mins	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc2 mins	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc3 mins
DA-A22-A	0.52	2.3	5.0	0.0	0.000	0.02	3.44	0.0	0.0	0.000	0.15	3.44	0.0	0.0	0.000	0.05	0.0	0.0	0.000	0.05	0.0
DA-A22-B	0.24	1.3	5.0	0.0	0.000	0.02	3.44	0.0	0.0	0.000	0.15	3.44	0.0	0.0	0.000	0.05	0.0	0.0	0.000	0.05	0.0
DA-A22-C	0.20	0.7	5.0	0.0	0.000	0.02	3.44	0.0	0.0	0.000	0.15	3.44	0.0	0.0	0.000	0.05	0.0	0.0	0.000	0.05	0.0
DA-A22-D	0.52	4.8	5.0	0.0	0.000	0.02	3.44	0.0	27.0	0.022	0.15	3.44	3.2	232.0	0.029	0.05	1.4	29.0	0.100	0.05	0.1
DA-A22-E	0.33	8.3	8.3	0.0	0.000	0.02	3.44	0.0	74.0	0.028	0.15	3.44	6.5	207.0	0.025	0.05	1.4	40.0	0.077	0.05	0.1
DA-A22-F	0.51	1.6	5.0	9.0	0.022	0.02	3.44	0.3	0.0	0.000	0.15	3.44	0.0	115.0	0.017	0.05	0.9	36.0	0.092	0.05	0.1
DA-A22-G	0.23	3.5	5.0	0.0	0.000	0.02	3.44	0.0	26.0	0.023	0.15	3.44	3.0	0.0	0.000	0.05	0.0	0.0	0.000	0.05	0.0
DA-A22-H	0.53	6.8	6.8	0.0	0.000	0.02	3.44	0.0	54.0	0.020	0.15	3.44	5.7	0.0	0.000	0.05	0.0	0.0	0.000	0.05	0.0
DA-A22-J	0.53	2.7	5.0	27.0	0.019	0.02	3.44	0.7	0.0	0.000	0.15	3.44	0.0	289.0	0.028	0.05	1.8	0.0	0.000	0.05	0.0
DA-A22-K	1.05	14.8	14.8	0.0	0.000	0.02	3.44	0.0	132.0	0.017	0.15	3.44	12.7	329.0	0.029	0.05	2.0	0.0	0.000	0.05	0.0
DA-A22-L	0.52	8.1	8.1	0.0	0.000	0.02	3.44	0.0	91.0	0.035	0.15	3.44	7.0	188.0	0.028	0.05	1.2	0.0	0.000	0.05	0.0
DA-A22-M	0.17	1.6	5.0	0.0	0.000	0.02	3.44	0.0	0.0	0.000	0.15	3.44	0.0	71.0	0.023	0.05	0.5	0.0	0.000	0.05	0.0
DA-A22-N	0.52	10.7	10.7	0.0	0.000	0.02	3.44	0.0	104.0	0.019	0.15	3.44	9.9	130.0	0.044	0.050	0.6	0.0	0.000	0.05	0.0
DA-A22-P	0.52	1.1	5.0	0.0	0.000	0.02	3.44	0.0	0.0	0.000	0.15	3.44	0.0	106.0	0.030	0.05	0.6	0.0	0.000	0.05	0.0
DA-A22-Q	0.80	2.1	5.0	0.0	0.000	0.02	3.44	0.0	0.0	0.000	0.15	3.44	0.0	0.0	0.000	0.05	0.0	0.0	0.000	0.05	0.0
DA-A22-R	0.52	2.0	5.0	21.0	0.014	0.02	3.44	0.6	0.0	0.000	0.15	3.44	0.0	173.0	0.025	0.05	1.1	54.0	0.076	0.05	0.2
DA-A22-S	0.78	2.4	5.0	27.0	0.022	0.02	3.44	0.6	0.0	0.000	0.15	3.44	0.0	192.0	0.022	0.05	1.3	0.0	0.000	0.05	0.0
DA-A22-T	0.52	1.7	5.0	26.0	0.031	0.02	3.44	0.5	0.0	0.000	0.15	3.44	0.0	194.0	0.032	0.05	1.1	0.0	0.000	0.05	0.0

Equations

(1) Calculated Tc = Sheet Flow Tc + Shallow Concentrated Tc + Gutter Flow Tc
(2) Tc used = min (5, Calculated Tc)
(3) n = 0.020 for roofs/pavement
(4) See DCM Table 2-3: 2-year 24-hour rainfall
(5) DCM EQ 2-3: Sheet Flow Tc for roofs/pavement (mins) = $0.42 * (nL)^{0.8} / (P^{0.5} * S^{0.4})$
(6) n = 0.15 for Grass, short-grass prairie; See DCM Table 2-2
(7) See DCM Table 2-3: 2-year 24-hour rainfall
(8) DCM EQ 2-3Sheet Flow for roofs/pavement (mins) = $0.42 * (nL)^{0.8} / (P^{0.5} * S^{0.4})$
(9) Given in DCM Section 2.4.2.B
(10) DCM EQ 2-4: Unpaved Shallow Concentrated Tc = $L / (60(16.1345)(S^{0.5}))$
(11) Given in DCM Section 2.4.2.B; cells hilighted in green use the unpaved equation
(12) DCM EQ 2-5: Paved Shallow Concentrated Tc = $L / (60(20.3282)(S^{0.5}))$; cells hilighted in green use the unpaved equation
(13) $V = k * S^{0.5}$ Reference: Richard McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143.
(14) Tc = L / (60 * V)

Source 3

Annie Street Storm Drain Improvements
Time of Concentration (Ultimate Conditions for Proposed Alternative 1 - Crockett System)

Equation in cell ==>			**(11)**	**(12)**			**(11)**	**(12)**			**(13)**	**(14)**			**(13)**	**(14)**
	Shallow Conc. 3 - paved				Shallow Conc. 4 - paved				Gutter 1 (paved)				Gutter 2 (paved)			
Basin	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc4 mins	Shallow Flow Length (ft)	Shallow Flow Slope (ft/ft)	n	tc5 mins	Channel Length (ft)	slope	Channel Min. V (fps)	tc6 mins	Channel Length (ft)	slope	Channel Min. V (fps)	tc7
DA-A22-A	267.0	0.017	0.025	1.7	0.0	0.000	0.025	0.0	232.0	0.016	5.9	0.7	0.0	0.000	0.0	0.0
DA-A22-B	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	395.0	0.012	5.2	1.3	0.0	0.000	0.0	0.0
DA-A22-C	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	317.0	0.024	7.2	0.7	0.0	0.000	0.0	0.0
DA-A22-D	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	48.0	0.017	6.0	0.1	0.0	0.000	0.0	0.0
DA-A22-E	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	101.0	0.016	5.8	0.3	0.0	0.000	0.0	0.0
DA-A22-F	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	105.0	0.017	6.1	0.3	0.0	0.000	0.0	0.0
DA-A22-G	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	214.0	0.024	7.2	0.5	0.0	0.000	0.0	0.0
DA-A22-H	52.0	0.006	0.025	0.6	43.0	0.037	0.025	0.2	156.0	0.026	7.4	0.4	0.0	0.000	0.0	0.0
DA-A22-J	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	55.0	0.009	4.4	0.2	0.0	0.000	0.0	0.0
DA-A22-K	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	27.0	0.015	5.6	0.1	0.0	0.000	0.0	0.0
DA-A22-L	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	0.0	0.000	0.0	0.0	0.0	0.000	0.0	0.0
DA-A22-M	218.0	0.024	0.025	1.2	0.0	0.000	0.025	0.0	0.0	0.000	0.0	0.0	0.0	0.000	0.0	0.0
DA-A22-N	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	50.0	0.014	5.5	0.2	0.0	0.000	0.0	0.0
DA-A22-P	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	218.0	0.024	7.2	0.5	0.0	0.000	0.0	0.0
DA-A22-Q	103.0	0.023	0.025	0.6	54.0	0.031	0.025	0.2	343.0	0.015	5.6	1.0	120.0	0.023	7.1	0.3
DA-A22-R	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	37.0	0.022	6.8	0.1	0.0	0.000	0.0	0.0
DA-A22-S	69.0	0.017	0.025	0.4	0.0	0.000	0.025	0.0	0.0	0.000	0.0	0.0	0.0	0.000	0.0	0.0
DA-A22-T	0.0	0.000	0.025	0.0	0.0	0.000	0.025	0.0	0.0	0.000	0.0	0.0	0.0	0.000	0.0	0.0

Source 3

RUNOFF COMPUTATIONS (Ultimate Conditions)

			2 Year Storm Event			10 Year Storm Event			25 Year Storm Event ATLLAS 14			100 Year Storm Event ATLAS 14		
Drainage Area Number	Drainage Area (acres)	Time of Concentration Tc (min)	Runoff Coefficient C2	Intensity I2	Design Flow Q2 (cfs)	Runoff Coefficient C10	Intensity I10	Design Flow Q10 (cfs)	Runoff Coefficient C25	Intensity I25	Design Flow Q25 (cfs)	Runoff Coefficient C100	Intensity I100	Design Flow Q100 (cfs)
DA-A22-A	0.52	5.0	0.68	0.00	0.0	0.75	0.00	0.0	0.80	11.79	4.9	0.89	15.42	7.1
DA-A22-B	0.24	5.0	0.72	0.00	0.0	0.80	0.00	0.0	0.85	11.79	2.40	0.94	15.42	3.5
DA-A22-C	0.20	5.0	0.72	0.00	0.0	0.80	0.00	0.0	0.85	11.79	2.0	0.94	15.42	2.9
DA-A22-D	0.52	5.0	0.61	0.00	0.0	0.68	0.00	0.0	0.72	11.79	4.4	0.81	15.42	6.4
DA-A22-E	0.33	8.3	0.61	0.00	0.0	0.68	0.00	0.0	0.73	10.09	2.4	0.81	13.16	3.5
DA-A22-F	0.51	5.0	0.60	0.00	0.0	0.67	0.00	0.0	0.72	11.79	4.3	0.80	15.42	6.3
DA-A22-G	0.23	5.0	0.61	0.00	0.0	0.68	0.00	0.0	0.73	11.79	2.0	0.81	15.42	2.9
DA-A22-H	0.53	6.8	0.61	0.00	0.0	0.68	0.00	0.0	0.73	10.76	4.2	0.82	14.05	6.0
DA-A22-J	0.53	5.0	0.61	0.00	0.0	0.68	0.00	0.0	0.73	11.79	4.5	0.81	15.42	6.6
DA-A22-K	1.05	14.8	0.61	0.00	0.0	0.68	0.00	0.0	0.72	7.97	6.0	0.81	10.41	8.8
DA-A22-L	0.52	8.1	0.62	0.00	0.0	0.69	0.00	0.0	0.73	10.13	3.8	0.82	13.22	5.6
DA-A22-M	0.17	5.0	0.66	0.00	0.0	0.74	0.00	0.0	0.79	11.79	1.6	0.87	15.42	2.3
DA-A22-N	0.52	10.7	0.59	0.00	0.0	0.66	0.00	0.0	0.71	9.15	3.4	0.79	11.93	4.9
DA-A22-P	0.52	5.0	0.67	0.00	0.0	0.75	0.00	0.0	0.80	11.79	4.9	0.89	15.42	7.2
DA-A22-Q	0.80	5.0	0.72	0.00	0.0	0.80	0.00	0.0	0.85	11.79	8.1	0.94	15.42	11.7
DA-A22-R	0.52	5.00	0.60	0.00	0.00	0.67	0.00	0.00	0.72	11.79	4.43	0.80	15.42	6.47
DA-A22-S	0.78	5.00	0.71	0.00	0.00	0.79	0.00	0.00	0.84	11.79	7.74	0.93	15.42	11.18
DA-A22-T	0.52	5.00	0.59	0.00	0.00	0.66	0.00	0.00	0.71	11.79	4.30	0.79	15.42	6.28

From DCM Section 2.3.2,
Table 2-2A (Zone 1):

	2-year	10-year	25-year Atlas14, Zone1	100-year Atlas14 Zone1
a=			69.9600	77.3100
b=			7.9410	6.8320
c=			0.6954	0.6524

Source 3

Ultimate Development Conditions for Proposed Crockett Street System

CURB INLETS ON GRADE (508S-3), Type G-1 OR Type G-3, parabolic crown

100 YEAR STORM

HEC-22 variable or EQ ==>		Q											Q	S_L	
DCM Variable or EQ==>		Q											Q	S_o	W EQ 3-1
GIS StormwaterInfrastructureFIELD ==>															
Data Source ===>															DGN
Equation in cell ==>		(1)											(2)	(3)	
DRAINAGE AREA	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	2nd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	3rd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)		LIVE OAK SYSTEM BYPASS (cfs)	5th UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	SLOPE (ft/ft) $S_o = S_L$	Street Width (FOC-FOC) (ft) W
DA-A22-B	0.24	3.47	DA-A22-C	0.00									3.47	0.0200	30.00
DA-A22-C	0.20	2.87	DA-A22-Q	0.00									2.87	0.0100	30.00
DA-A22-D	0.52	6.42	DA-A22-R	0.97									7.39	0.0050	35.00
DA-A22-E	0.33	3.51	DA-A22-B	0.00	DA-A22-D	0.00	DA-A22-F	0.00					3.51	0.0082	35.00
DA-A22-F	0.51	6.32	DA-A22-G	0.00	DA-A22-H	0.00	DA-A22-J	0.00					6.32	0.0070	30.00
DA-A22-G	0.23	2.89											2.89	0.0140	25.00
LO-OV-NEWTON	none									62.30			62.30	0.0230	25.00
DA-A22-H	0.53	6.04	LO-OV-NEWTON	1.41									7.46	0.0230	25.00
DA-A22-J	0.53	6.57	DA-A22-K	0.00									6.57	0.0040	30.00
DA-A22-K	1.05	8.80	DA-A22-L	0.00									8.80	0.0040	30.00
DA-A22-L	0.52	5.59	DA-A22-M	0.00	DA-A22-N	0.00	DA-A22-P	0.47					6.06	0.0020	30.00
DA-A22-M	0.17	2.33	LO-OV-EVA-W	2.00									4.33	0.0040	27.00
DA-A22-N	0.52	4.91	DA-A22-T	0.97									5.88	0.0040	27.00
DA-A22-P	0.52	7.17	DA-A22-S	6.93									14.10	0.0150	30.00
DA-A22-Q	0.80	11.66											11.66	0.0100	30.00
DA-A22-R	0.52	6.47											6.47	0.0273	35.00
LO-OV-EVA-E	none									43.63			43.63	0.0120	30.00
LO-OV-EVA-W	none									20.75			20.75	0.0120	30.00
DA-A22-T	0.52	6.28	LO-OV-EVA-E	0.69									6.97	0.0120	30.00

Equations in cell

(9)

(10)
(11)
(12)

(13)
(14)
(15)
(16)
(17)
(18)
(19)
(20)
(21)

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tab: CURB Inlets On Grade_ULT

Source 3

Ultimate Development Conditions for Proposed Crockett Street System

CURB INLETS ON GRADE (508S-3), Type G-1 OR Type G-3, parabolic crown

100 YEAR STORM

HEC-22 variable or EQ ==>				EQ 4-29 Figure 4-18.b							d			
DCM Variable or EQ==>				EQ 4-2 h			K_o	K_1	K_2	K_3	Y_o EQ 3-5			
GIS StormwaterInfrastructureFIELD ==>			Height											
Data Source ===>	assumed				DGN	DGN	DCM							
Equation in cell ==>								(4)			(5)			
DRAINAGE AREA	**Curb Height** *(in)*	**Curb Height** *(ft)*	**CURB OPENING HEIGHT** *(in)*	**CURB OPENING HEIGHT** *(ft)* h	**Split** *(ft)* CS	**High or low gutter**	K_o	K_1	K_2	K_3	**WATER FLOW DEPTH** *(ft)* Yo = d	**Is Yo > 1.4*h?**	**Over Curb or Gutter?**	**Contained within R.O.W.** *Assume if flow depth (ft) <* **0.58**
DA-A22-B	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.33	no	No	Yes
DA-A22-C	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.35	no	No	Yes
DA-A22-D	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.53	no	Over Curb	Yes
DA-A22-E	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.38	no	No	Yes
DA-A22-F	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.48	no	No	Yes
DA-A22-G	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.33	no	No	Yes
LO-OV-NEWTON	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.84	use orifice EQ	Over Curb	No
DA-A22-H	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.41	no	No	Yes
DA-A22-J	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.53	no	Over Curb	Yes
DA-A22-K	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.58	no	Over Curb	No
DA-A22-L	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.58	no	Over Curb	Yes
DA-A22-M	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.46	no	No	Yes
DA-A22-N	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.51	no	Over Curb	Yes
DA-A22-P	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.55	no	Over Curb	Yes
DA-A22-Q	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.55	no	Over Curb	Yes
DA-A22-R	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.38	no	No	Yes
LO-OV-EVA-E	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.83	use orifice EQ	Over Curb	No
LO-OV-EVA-W	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.65	no	Over Curb	No
DA-A22-T	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.45	no	No	Yes

Equations in cell

(9) Hec-22 EQ B-11: $Yo = (2H/B)*x - (H/B^2)*x^2$; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
HEC-22 EQ 4-2: $T = [Qn / (Ku * Sx^{1.67} * SL^{0.5})]^{0.375}$; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56

(10) Given in DCM EQ 4-10

(11) Not used for proposed curb inlet

(12) See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation; aHEC22 = 6.75 - 18*Sx
$a_{HEC22} = a_{DIG} - W*Sx$

(13) DCM EQ 4-9: $S'w = a_{HEC22} / (12*W)$

(14) DCM EQ 4-9Sw = S'w + Sx

(15) HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1

(16) DCM EQ 4-9: Se = Sx + S'w*Eo

(17) See DCM Table 2-2

(18) DCM EQ 4-10: $L_T = K_T * Q^{0.42} * S_L^{0.3} * [1/ (n*Se)]^{0.6}$

(19) DCM EQ 4-8: $E = 1 - [1 - (L/L_T)]^{1.8}$

(20) DCM EQ 4-14: Qi = E * Q

(21) DCM EQ 4-15: Qb = Q - Qi

Source 3

Ultimate Development Conditions for Proposed Crockett Street System

CURB INLETS ON GRADE (508S-3), Type G-1 OR Type G-3, parabolic crown

100 YEAR STORM

HEC-22 variable or EQ ==>	Sx	B EQ B-11	H EQ B-11						x and T EQ B-11			L_T 4-22a		a Fig 4-13
DCM Variable or EQ==>	Sx	assumes crown to curb = street width/2; not true for streets with curb split	H EQ 3-1						S and T EQ 3-1			K_T EQ 4-10	DIG Data instructions	
GIS StormwaterInfrastructureFIELD ==>													Depression_a	
Data Source ===>	ESD Field Visit or as-builts											DCM	GIS or ESD field visit	
Equation in cell ==>	(6)	(7)	(8)						(9)			(10)	(11)	(12)
DRAINAGE AREA	ESD Field Measured Street Cross Slope	Dist. Curb to Crown	Crown Height	Quadratic Formula T = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a					PONDED WIDTH	Over Crown?	Depth Over Crown		GUTTER DEPRESSION	
	(ft/ft)	*(ft)*	*(ft)*	*a*	*b*	*c*	*x1*	*x2*	*(ft)*		*(ft)*		*(in)*	*(in)*
	Sx	B	H	H / B^2	-(2H/B)	Yo			T			K_T	a_{DIG}	a_{HEC22}
DA-A22-B	0.0170	15.00	0.49	0.0022	-0.0653	0.3296	23.5817	6.4183	6.42	no	0.00	0.6		6.44
DA-A22-C	0.0550	15.00	1.10	0.0049	-0.1467	0.3470	27.4105	2.5895	2.59	no	0.00	0.6		5.76
DA-A22-D	0.0330	17.50	0.69	0.0023	-0.0789	0.5319	25.8769	9.1231	9.12	no	0.00	0.6		6.16
DA-A22-E	0.0113	17.50	0.95	0.0031	-0.1086	0.3834	31.0155	3.9845	3.98	no	0.00	0.6		6.55
DA-A22-F	0.0320	15.00	0.47	0.0021	-0.0627	0.4778	--	--	15.00	over crown	0.01	0.6		6.17
DA-A22-G	0.0330	12.50	0.70	0.0045	-0.1120	0.3290	21.5999	3.4001	3.40	no	0.00	0.6		6.16
LO-OV-NEWTON	0.0150	12.50	0.26	0.0017	-0.0416	0.8356	--	--	12.50	over crown	0.58	0.6		6.48
DA-A22-H	0.0150	12.50	0.26	0.0017	-0.0416	0.4147	--	--	12.50	over crown	0.15	0.6		6.48
DA-A22-J	0.0310	15.00	0.46	0.0020	-0.0613	0.5307	--	--	15.00	over crown	0.07	0.6		6.19
DA-A22-K	0.0290	15.00	0.62	0.0028	-0.0827	0.5845	18.5901	11.4099	11.41	no	0.00	0.6		6.23
DA-A22-L	0.0410	15.00	0.77	0.0034	-0.1027	0.5795	22.4614	7.5386	7.54	no	0.00	0.6		6.01
DA-A22-M	0.0320	13.50	0.34	0.0019	-0.0504	0.4626	--	--	13.50	over crown	0.12	0.6		6.17
DA-A22-N	0.0320	13.50	0.34	0.0019	-0.0504	0.5117	--	--	13.50	over crown	0.17	0.6		6.17
DA-A22-P	0.0320	15.00	0.34	0.0015	-0.0453	0.5491	--	--	15.00	over crown	0.21	0.6		6.17
DA-A22-Q	0.0360	15.00	0.87	0.0039	-0.1160	0.5515	24.0762	5.9238	5.92	no	0.00	0.6		6.10
DA-A22-R	0.0200	17.50	0.35	0.0011	-0.0400	0.3847	--	--	17.50	over crown	0.03	0.6		6.39
LO-OV-EVA-E	0.0200	15.00	0.38	0.0017	-0.0507	0.8271	--	--	15.00	over crown	0.45	0.6		6.39
LO-OV-EVA-W	0.0200	15.00	0.64	0.0028	-0.0853	0.6472	--	--	15.00	over crown	0.01	0.6		6.39
DA-A22-T	0.0200	15.00	0.27	0.0012	-0.0360	0.4514	--	--	15.00	over crown	0.18	0.6		6.39

Equations in cell

(9)	Hec-22 EQ B-11: $Yo = (2H/B)*x - (H/B^2)*x^2$; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
	For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
	HEC-22 EQ 4-2: $T = [Qn / (Ku * Sx^{1.67} * SL^{0.5})]^{0.375}$; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56
(10)	Given in DCM EQ 4-10
(11)	Not used for proposed curb inlet
(12)	See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation; aHEC22 = 6.75 - 18*Sx
	$a_{HEC22} = a_{DIG} - W*Sx$
(13)	DCM EQ 4-9: $S'w = a_{HEC22} / (12*W)$
(14)	DCM EQ 4-9Sw = S'w + Sx
(15)	HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1
(16)	DCM EQ 4-9: Se = Sx + S'w*Eo
(17)	See DCM Table 2-2
(18)	DCM EQ 4-10: $L_T = K_T$ * Q^0.42 * S_L^0.3 * [1/ (n*Se)]^0.6
(19)	DCM EQ 4-8: E = 1 - [1 - (L/L_T)]^1.8
(20)	DCM EQ 4-14: Qi = E * Q
(21)	DCM EQ 4-15: Qb = Q - Qi

Source 3

Ultimate Development Conditions for Proposed Crockett Street System

CURB INLETS ON GRADE (508S-3), Type G-1 OR Type G-3, parabolic crown

100 YEAR STORM

HEC-22 variable or EQ ==>		W	S'w 4-24	Sw 4-4, 4-5, 4-6	Eo 4-4	Se 4-24	n	L_T 4-22a	?		L	E 4-23	Qi 4-14	Qb 4-15	
DCM Variable or EQ==>		W	S'w 4-9	Sw 4-9	Eo	Se 4-9	n	L_T 4-10	?		L	E 4-8	Qi		
GIS StormwaterInfrastru	Width									st_length					
Data Source ===>	GIS or ESD field visit						DCM		?	GIS or ESD field visit					ESD field visit
Equation in cell ==>			(13)	(14)	(15)	(16)	(17)	(18)	?			(19)	(20)	(21)	
DRAINAGE AREA	Gutter Depression Width (in)	Gutter Depression Width (ft) W	S'w	Sw	Eo	Se	Manning's n n	INLET LENGTH FOR TOTAL CAPTURE L_T	CURB INLET REDUCTION FACTOR (%)	CURB OPENING LENGTH (in)	CURB OPENING LENGTH (ft) L	INLET EFFICIENCY E	INTERCEPTED FLOW (cfs) Qi	BYPASS FLOW (cfs) Qb	INLET TYPE
DA-A22-B	18.00	1.50	0.36	0.38	0.91	0.34	0.016	7.09	0.00%	120.00	10.00	100.00%	3.47	0.00	Type G-1
DA-A22-C	18.00	1.50	0.32	0.38	0.99	0.37	0.016	5.08	0.00%	120.00	10.00	100.00%	2.87	0.00	Type G-1
DA-A22-D	18.00	1.50	0.34	0.38	0.66	0.26	0.016	7.63	0.00%	120.00	10.00	100.00%	7.39	0.00	Type G-1
DA-A22-E	18.00	1.50	0.36	0.38	0.99	0.37	0.016	5.20	0.00%	120.00	10.00	100.00%	3.51	0.00	Type G-1
DA-A22-F	18.00	1.50	0.34	0.38	0.41	0.17	0.016	10.03	0.00%	120.00	10.00	100.00%	6.32	0.00	Type G-1
DA-A22-G	18.00	1.50	0.34	0.38	0.98	0.37	0.016	5.68	0.00%	120.00	10.00	100.00%	2.89	0.00	Type G-1
LO-OV-NEWTON	18.00	1.50	0.36	0.38	0.67	0.26	0.016	29.62	0.00%	312.00	26.00	97.73%	60.89	1.41	Type G-1
DA-A22-H	18.00	1.50	0.36	0.38	0.67	0.26	0.016	12.14	0.00%	120.00	10.00	95.60%	7.13	0.33	Type G-1
DA-A22-J	18.00	1.50	0.34	0.38	0.42	0.18	0.016	8.58	0.00%	120.00	10.00	100.00%	6.57	0.00	Type G-1
DA-A22-K	18.00	1.50	0.35	0.38	0.57	0.23	0.016	8.33	0.00%	120.00	10.00	100.00%	8.80	0.00	Type G-1
DA-A22-L	18.00	1.50	0.33	0.38	0.71	0.28	0.016	5.10	0.00%	120.00	10.00	100.00%	6.06	0.00	Type G-1
DA-A22-M	18.00	1.50	0.34	0.38	0.46	0.19	0.016	6.84	0.00%	120.00	10.00	100.00%	4.33	0.00	Type G-1
DA-A22-N	18.00	1.50	0.34	0.38	0.46	0.19	0.016	7.78	0.00%	120.00	10.00	100.00%	5.88	0.00	Type G-1
DA-A22-P	18.00	1.50	0.34	0.38	0.41	0.17	0.016	17.66	0.00%	180.00	15.00	96.69%	13.63	0.47	Type G-1
DA-A22-Q	18.00	1.50	0.34	0.38	0.84	0.32	0.016	9.99	0.00%	120.00	10.00	100.00%	11.66	0.00	Type G-1
DA-A22-R	18.00	1.50	0.36	0.38	0.43	0.17	0.016	15.34	0.00%	120.00	10.00	85.02%	5.50	0.97	Type G-1
LO-OV-EVA-E	18.00	1.50	0.36	0.38	0.51	0.20	0.016	24.43	0.00%	264.00	22.00	98.43%	42.94	0.69	Type G-1
LO-OV-EVA-W	18.00	1.50	0.36	0.38	0.51	0.20	0.016	17.88	0.00%	156.00	13.00	90.34%	18.75	2.00	
DA-A22-T	18.00	1.50	0.36	0.38	0.51	0.20	0.016	11.30	0.00%	120.00	10.00	97.95%	6.82	0.14	Type G-1

Equations in cell

(9) Hec-22 EQ B-11: $Yo = (2H/B)*x - (H/B^2)*x^2$; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
HEC-22 EQ 4-2: $T = [Qn / (Ku * Sx^{1.67} * SL^{0.5})]^{0.375}$; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56

(10) Given in DCM EQ 4-10

(11) Not used for proposed curb inlet

(12) See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation; aHEC22 = 6.75 - 18*Sx
$a_{HEC22} = a_{DIG} - W*Sx$

(13) DCM EQ 4-9: $S'w = a_{HEC22} / (12*W)$

(14) DCM EQ 4-9Sw = S'w + Sx

(15) HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1

(16) DCM EQ 4-9: Se = Sx + S'w*Eo

(17) See DCM Table 2-2

(18) DCM EQ 4-10: $L_T = K_T * Q^{0.42} * S_L^{0.3} * [1/ (n*Se)]^{0.6}$

(19) DCM EQ 4-8: $E = 1 - [1 - (L/L_T)]^{1.8}$

(20) DCM EQ 4-14: Qi = E * Q

(21) DCM EQ 4-15: Qb = Q - Qi

Source 3

Ultimate Development Conditions for Proposed Crockett Street System

CURB INLETS ON GRADE (508S-3), Type G-1 OR Type G-3, parabolic crown

25 YEAR STORM

DRAINAGE AREA	DRAINAGE AREA	DISCHARGE FROM DRAINAGE AREA	1st UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW	2nd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW	3rd UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW		LIVE OAK SYSTEM BYPASS	5th UPSTREAM INLET /DRAINAGE AREA	CARRY OVER FLOW	TOTAL RUNOFF	SLOPE	Street Width (FOC-FOC)
HEC-22 variable or EQ ==>		Q											Q	S_L	
DCM Variable or EQ==>		Q											Q	S_o	W EQ 3-1
GIS StormwaterInfrastructureFIELD ==>															
Data Source ===>															DGN
Equation in cell ==>		(1)											(2)	(3)	
	(ac.)	(cfs)		(cfs)		(cfs)		(cfs)		(cfs)		(cfs)	(cfs)	(ft/ft)	(ft)
													Q	$S_o = S_L$	W
DA-A22-B	0.24	2.40	DA-A22-C	0.00									2.40	0.0200	30.00
DA-A22-C	0.20	1.98	DA-A22-Q	0.00									1.98	0.0100	30.00
DA-A22-D	0.52	4.40	DA-A22-R	0.14									4.55	0.0050	35.00
DA-A22-E	0.33	2.41	DA-A22-B	0.00	DA-A22-D	0.00	DA-A22-F	0.00					2.41	0.0082	35.00
DA-A22-F	0.51	4.33	DA-A22-G	0.00	DA-A22-H	0.00	DA-A22-J	0.00					4.33	0.0070	30.00
DA-A22-G	0.23	1.98											1.98	0.0140	25.00
LO-OV-NEWTON	none									46.04			46.04	0.0230	25.00
DA-A22-H	0.53	4.15	LO-OV-NEWTON	0.00									4.16	0.0230	25.00
DA-A22-J	0.53	4.50	DA-A22-K	0.00									4.50	0.0040	30.00
DA-A22-K	1.05	6.04	DA-A22-L	0.00									6.04	0.0040	30.00
DA-A22-L	0.52	3.85	DA-A22-M	0.00	DA-A22-N	0.00	DA-A22-P	0.00					3.85	0.0020	30.00
DA-A22-M	0.17	1.60											1.60	0.0040	27.00
DA-A22-N	0.52	3.37	DA-A22-T	0.14									3.51	0.0040	27.00
DA-A22-P	0.52	4.94	DA-A22-S	4.53									9.47	0.0150	30.00
DA-A22-Q	0.80	8.07											8.07	0.0100	30.00
DA-A22-R	0.52	4.43											4.43	0.0273	35.00
LO-OV-EVA-E	none									32.81			32.81	0.0120	30.00
LO-OV-EVA-W	none									14.94			14.94	0.0120	30.00
DA-A22-T	0.52	4.30	LO-OV-EVA-E	0.00									4.30	0.0120	30.00

Equations in cell

(1)
(2)
(3)
(4)
(5)
(6)
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(12)
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(20)
(21)

Source 3

Ultimate Development Conditions for Proposed Crockett Street System

CURB INLETS ON GRADE (508S-3), Type G-1 OR Type G-3, parabolic crown

25 YEAR STORM

HEC-22 variable or EQ ==>				EQ 4-29 Figure 4-18.b							d			
DCM Variable or EQ==>				EQ 4-2 h			K_o	K_1	K_2	K_3	Y_o EQ 3-5			
GIS StormwaterInfrastructureFIELD ==>			Height											
Data Source ===>	assumed				DGN	DGN	DCM							
Equation in cell ==>								(4)			(5)			
DRAINAGE AREA	**Curb Height** *(in)*	**Curb Height** *(ft)*	**CURB OPENING HEIGHT** *(in)*	**CURB OPENING HEIGHT** *(ft)* h	**Split** *(ft)* CS	**High or low gutter**	K_o	K_1	K_2	K_3	**WATER FLOW DEPTH** *(ft)* Yo = d	**Is Yo > 1.4*h?**	**Over Curb or Gutter?**	**Contained within R.O.W.** *Assume if depth <* 0.58
DA-A22-B	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.29	no	No	Yes
DA-A22-C	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.31	no	No	Yes
DA-A22-D	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.45	no	No	Yes
DA-A22-E	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.34	no	No	Yes
DA-A22-F	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.42	no	No	Yes
DA-A22-G	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.29	no	No	Yes
LO-OV-NEWTON	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.76	use orifice EQ	Over Curb	No
DA-A22-H	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.34	no	No	Yes
DA-A22-J	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.47	no	No	Yes
DA-A22-K	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.52	no	Over Curb	Yes
DA-A22-L	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.50	no	No	Yes
DA-A22-M	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.33	no	No	Yes
DA-A22-N	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.43	no	No	Yes
DA-A22-P	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.48	no	No	Yes
DA-A22-Q	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.49	no	No	Yes
DA-A22-R	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.34	no	No	Yes
LO-OV-EVA-E	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.75	use orifice EQ	Over Curb	No
LO-OV-EVA-W	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.58	no	Over Curb	No
DA-A22-T	6.00	0.50	6.25	0.52	0.00	N/A	2.85	0.50	3.03	0.00	0.38	no	No	Yes

Equations in cell

(1) DCM EQ 2-1: Q_{peak} = CiA
(2) Total flow = sum of discharge from drainage area and carry over flow
(3) So = (high elev - low elev)/length
(4) See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
(5) DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
For DA-A26 only, use straight crown equation since the driveway does not have a parabolic crown: HEC-22 EQ 4-3: d = T * Sx
(6) Sx measured in Field by ESD 3-3-15 or 3-31-15
(7) For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
(8) measured in field, lidar or record drawing; see "Crown Height Calcs" tab
(9) Hec-22 EQ B-11: Yo = (2H/B)*x - $(H/B^2)*x^2$; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = E
For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
HEC-22 EQ 4-2: $T = [Qn / (Ku * Sx^{1.67} * SL^{0.5})]^{0.375}$; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56
(10) Given in DCM EQ 4-10
(11) Not used for proposed curb inlet
(12) See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation; aHEC22 = 6.75 - 18*Sx
$a_{HEC22} = a_{DIG}$ - W*Sx
(13) DCM EQ 4-9: S'w = a_{HEC22} / (12*W)
(14) DCM EQ 4-9Sw = S'w + Sx
(15) HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1
(16) DCM EQ 4-9: Se = Sx + S'w*Eo
(17) See DCM Table 2-2
(18) DCM EQ 4-10: $L_T = K_T$ * Q^0.42 * S_L^0.3 * [1/ (n*Se)]^0.6
(19) DCM EQ 4-8: E = 1 - [1 - (L/L_T)]^1.8
(20) DCM EQ 4-14: Qi = E * Q
(21) DCM EQ 4-15: Qb = Q - Qi

file: N:\Team3\WPD_EBC_Annie\Eng_Analysis\Prelim Eng Phase\PROP_ALT4_Inlet_Calcs\Source3_Crockett_PROP_Alt4_Inlet Calcs_ULT_Atals14
tab: CURB Inlets On Grade_ULT

Source 3

Ultimate Development Conditions for Proposed Crockett Street System

CURB INLETS ON GRADE (508S-3), Type G-1 OR Type G-3, parabolic crown

25 YEAR STORM

HEC-22 variable or EQ ==>	Sx	B EQ B-11	H EQ B-11						x and T EQ B-11			L_T 4-22a		a Fig 4-13
DCM Variable or EQ==>	Sx	assumes crown to curb = street width/2; not true for streets with curb split	H EQ 3-1						S and T EQ 3-1			K_T EQ 4-10	DIG Data instructions	
GIS StormwaterInfrastructureFIELD ==>													Depression_a	
Data Source ===>	ESD Field Visit or as-builts											DCM	GIS or ESD field visit	
Equation in cell ==>	(6)	(7)	(8)						(9)			(10)	(11)	(12)
DRAINAGE AREA	ESD Field Measured Street Cross Slope (ft/ft) Sx	Dist. Curb to Crown (ft) B	Crown Height (ft) H	Quadratic Formula T = min(x1, x2); x = [-b +/- (b^2 - 4ac)^0.5] / 2a a H / B^2	b -(2H/B)	c Yo	x1	x2	PONDED WIDTH (ft) T	Over Crown?	Depth Over Crown (ft)	K_T	GUTTER DEPRESSION (in) a_{DIG}	(in) a_{HEC22}
DA-A22-B	0.0170	15.0000	0.4900	0.0022	-0.0653	0.2919	24.5380	5.4620	5.46	no	0.00	0.6		6.44
DA-A22-C	0.0550	15.0000	1.1000	0.0049	-0.1467	0.3073	27.7339	2.2661	2.27	no	0.00	0.6		5.76
DA-A22-D	0.0330	17.5000	0.6900	0.0023	-0.0789	0.4531	27.7550	7.2450	7.25	no	0.00	0.6		6.16
DA-A22-E	0.0113	17.5000	0.9500	0.0031	-0.1086	0.3388	31.5368	3.4632	3.46	no	0.00	0.6		6.55
DA-A22-F	0.0320	15.0000	0.4700	0.0021	-0.0627	0.4217	19.8069	10.1931	10.19	no	0.00	0.6		6.17
DA-A22-G	0.0330	12.5000	0.7000	0.0045	-0.1120	0.2905	22.0609	2.9391	2.94	no	0.00	0.6		6.16
LO-OV-NEWTON	0.0150	12.5000	0.2600	0.0017	-0.0416	0.7562	--	--	12.50	over crown	0.50	0.6		6.48
DA-A22-H	0.0150	12.5000	0.2600	0.0017	-0.0416	0.3419	--	--	12.50	over crown	0.08	0.6		6.48
DA-A22-J	0.0310	15.0000	0.4600	0.0020	-0.0613	0.4686	--	--	15.00	over crown	0.01	0.6		6.19
DA-A22-K	0.0290	15.0000	0.6200	0.0028	-0.0827	0.5163	21.1338	8.8662	8.87	no	0.00	0.6		6.23
DA-A22-L	0.0410	15.0000	0.7700	0.0034	-0.1027	0.4988	23.9024	6.0976	6.10	no	0.00	0.6		6.01
DA-A22-M	0.0320	13.5000	0.3400	0.0019	-0.0504	0.3332	15.4030	11.5970	11.60	no	0.00	0.6		6.17
DA-A22-N	0.0320	13.5000	0.3400	0.0019	-0.0504	0.4317	--	--	13.50	over crown	0.09	0.6		6.17
DA-A22-P	0.0320	15.0000	0.3400	0.0015	-0.0453	0.4816	--	--	15.00	over crown	0.14	0.6		6.17
DA-A22-Q	0.0360	15.0000	0.8700	0.0039	-0.1160	0.4883	24.9350	5.0650	5.06	no	0.00	0.6		6.10
DA-A22-R	0.0200	17.5000	0.3500	0.0011	-0.0400	0.3396	20.5112	14.4888	14.49	no	0.00	0.6		6.39
LO-OV-EVA-E	0.0200	15.0000	0.3800	0.0017	-0.0507	0.7528	--	--	15.00	over crown	0.37	0.6		6.39
LO-OV-EVA-W	0.0200	15.0000	0.6400	0.0028	-0.0853	0.5807	19.5662	10.4338	10.43	no	0.00	0.6		6.39
DA-A22-T	0.0200	15.0000	0.2700	0.0012	-0.0360	0.3849	--	--	15.00	over crown	0.11	0.6		6.39

Equations in cell

(1) DCM EQ 2-1: $Q_{peak} = CiA$

(2) Total flow = sum of discharge from drainage area and carry over flow

(3) So = (high elev - low elev)/length

(4) See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)

(5) DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
For DA-A26 only, use straight crown equation since the driveway does not have a parabolic crown: HEC-22 EQ 4-3: d = T * Sx

(6) Sx measured in Field by ESD 3-3-15 or 3-31-15

(7) For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file

(8) measured in field, lidar or record drawing; see "Crown Height Calcs" tab

(9) Hec-22 EQ B-11: $Yo = (2H/B)*x - (H/B^2)*x^2$; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = B
For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
HEC-22 EQ 4-2: $T = [Qn / (Ku * Sx^{1.67} * SL^{0.5})]^{0.375}$; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56

(10) Given in DCM EQ 4-10

(11) Not used for proposed curb inlet

(12) See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation; aHEC22 = 6.75 - 18*Sx
$a_{HEC22} = a_{DIG} - W*Sx$

(13) DCM EQ 4-9: $S'w = a_{HEC22} / (12*W)$

(14) DCM EQ 4-9Sw = S'w + Sx

(15) HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1

(16) DCM EQ 4-9: Se = Sx + S'w*Eo

(17) See DCM Table 2-2

(18) DCM EQ 4-10: $L_T = K_T * Q^{0.42} * S_L^{0.3} * [1/ (n*Se)]^{0.6}$

(19) DCM EQ 4-8: $E = 1 - [1 - (L/L_T)]^{1.8}$

(20) DCM EQ 4-14: Qi = E * Q

(21) DCM EQ 4-15: Qb = Q - Qi

Source 3

Ultimate Development Conditions for Proposed Crockett Street System

CURB INLETS ON GRADE (508S-3), Type G-1 OR Type G-3, parabolic crown

25 YEAR STORM

HEC-22 variable or EQ ==>		W	S'w 4-24	Sw 4-4, 4-5, 4-6	Eo 4-4	Se 4-24	n	L_T 4-22a	?		L	E 4-23	Qi 4-14	Qb 4-15	
DCM Variable or EQ==>		W	S'w 4-9	Sw 4-9	Eo	Se 4-9	n	L_T 4-10	?		L	E 4-8	Qi		
GIS StormwaterInfrastru	Width									st_length					
Data Source ===>	GIS or ESD field visit						DCM		?	GIS or ESD field visit					ESD field visit
Equation in cell ==>			(13)	(14)	(15)	(16)	(17)	(18)	?			(19)	(20)	(21)	
DRAINAGE AREA	Gutter Depression Width (in)	Gutter Depression Width (ft) W	S'w	Sw	Eo	Se	Manning's n n	INLET LENGTH FOR TOTAL CAPTURE L_T	CURB INLET REDUCTION FACTOR (%)	CURB OPENING LENGTH (in)	CURB OPENING LENGTH (ft) L	INLET EFFICIENCY E	INTERCEPTED FLOW (cfs) Qi	BYPASS FLOW (cfs) Qb	INLET TYPE
DA-A22-B	18.00	1.50	0.36	0.38	0.95	0.36	0.016	5.95	0.00%	120.00	10.00	100.00%	2.40	0.00	Type G-1
DA-A22-C	18.00	1.50	0.32	0.38	0.99	0.37	0.016	4.34	0.00%	120.00	10.00	100.00%	1.98	0.00	Type G-1
DA-A22-D	18.00	1.50	0.34	0.38	0.77	0.30	0.016	5.72	0.00%	120.00	10.00	100.00%	4.55	0.00	Type G-1
DA-A22-E	18.00	1.50	0.36	0.38	0.99	0.37	0.016	4.44	0.00%	120.00	10.00	100.00%	2.41	0.00	Type G-1
DA-A22-F	18.00	1.50	0.34	0.38	0.61	0.24	0.016	7.04	0.00%	120.00	10.00	100.00%	4.33	0.00	Type G-1
DA-A22-G	18.00	1.50	0.34	0.38	0.99	0.37	0.016	4.81	0.00%	120.00	10.00	100.00%	1.98	0.00	Type G-1
LO-OV-NEWTON	18.00	1.50	0.36	0.38	0.67	0.26	0.016	26.08	0.00%	312.00	26.00	100.00%	46.04	0.00	Type G-1
DA-A22-H	18.00	1.50	0.36	0.38	0.67	0.26	0.016	9.50	0.00%	120.00	10.00	100.00%	4.16	0.00	Type G-1
DA-A22-J	18.00	1.50	0.34	0.38	0.42	0.18	0.016	7.32	0.00%	120.00	10.00	100.00%	4.50	0.00	Type G-1
DA-A22-K	18.00	1.50	0.35	0.38	0.70	0.27	0.016	6.37	0.00%	120.00	10.00	100.00%	6.04	0.00	Type G-1
DA-A22-L	18.00	1.50	0.33	0.38	0.81	0.31	0.016	3.94	0.00%	120.00	10.00	100.00%	3.85	0.00	Type G-1
DA-A22-M	18.00	1.50	0.34	0.38	0.54	0.22	0.016	4.17	0.00%	120.00	10.00	100.00%	1.60	0.00	Type G-1
DA-A22-N	18.00	1.50	0.34	0.38	0.46	0.19	0.016	6.27	0.00%	120.00	10.00	100.00%	3.51	0.00	Type G-1
DA-A22-P	18.00	1.50	0.34	0.38	0.41	0.17	0.016	14.94	0.00%	180.00	15.00	100.00%	9.47	0.00	Type G-1
DA-A22-Q	18.00	1.50	0.34	0.38	0.89	0.34	0.016	8.28	0.00%	120.00	10.00	100.00%	8.07	0.00	Type G-1
DA-A22-R	18.00	1.50	0.36	0.38	0.52	0.21	0.016	11.74	0.00%	120.00	10.00	96.80%	4.29	0.14	Type G-1
LO-OV-EVA	18.00	1.50	0.36	0.38	0.51	0.20	0.016	21.68	0.00%	264.00	22.00	100.00%	32.81	0.00	Type G-1
LO-OV-EVA-W	18.00	1.50	0.36	0.38	0.70	0.27	0.016	13.05	0.00%	156.00	13.00	100.00%	14.94	0.00	
DA-A22-T	18.00	1.50	0.36	0.38	0.51	0.20	0.016	9.23	0.00%	120.00	10.00	100.00%	4.30	0.00	Type G-1

Equations in cell

(1) DCM EQ 2-1: Q_{peak} = CiA
(2) Total flow = sum of discharge from drainage area and carry over flow
(3) So = (high elev - low elev)/length
(4) See DCM Table 3-2 (no split) or Table 3-3 (split, high gutter) or Table 3-4 (split, low gutter)
(5) DCM EQ 3-5: Yo = 10^[(logQ - Ko - K1 * log So - K3*CS)/K2]
For DA-A26 only, use straight crown equation since the driveway does not have a parabolic crown: HEC-22 EQ 4-3: d = T * Sx
(6) Sx measured in Field by ESD 3-3-15 or 3-31-15
(7) For all streets except Congress, B = W/2 = Street Width / 2; for Congress, B = crown to curb distance measured on DGN file
(8) measured in field, lidar or record drawing; see "Crown Height Calcs" tab
(9) Hec-22 EQ B-11: Yo = (2H/B)*x - $(H/B^2)*x^2$; same as DCM EQ 3-1 except allows for crown not at centerline of street; use quadratic equation to solve for x; T is the minimum of x1 or x2; if Yo > H, T = E
For DA-A26 only, use straight crown equation, HEC-22 EQ 4-2. If T calculated from HEC-22 EQ 4-2 is greater than B, use T=B
HEC-22 EQ 4-2: $T = [Qn / (Ku * Sx^{1.67} * SL^{0.5})]^{0.375}$; where n = 0.012 (HEC-22 Table 4-3) and Ku = 0.56
(10) Given in DCM EQ 4-10
(11) Not used for proposed curb inlet
(12) See HEC-22 Fig 4-13. a_{HEC22} is the difference between the inlet edge of gutter elevation and the projected street slope elevation; aHEC22 = 6.75 - 18*Sx
$a_{HEC22} = a_{DIG}$ - W*Sx
(13) DCM EQ 4-9: S'w = a_{HEC22} / (12*W)
(14) DCM EQ 4-9Sw = S'w + Sx
(15) HEC 22 EQ 4-4: For W < T, Eo = 1 / (1 + Sw/Sx/(((1 + Sw/Sx / (T/W))^2.67) - 1)); For T < W, Eo = 1
(16) DCM EQ 4-9: Se = Sx + S'w*Eo
(17) See DCM Table 2-2
(18) DCM EQ 4-10: $L_T = K_T$ * Q^0.42 * S_L^0.3 * [1/ (n*Se)]^0.6
(19) DCM EQ 4-8: E = 1 - [1 - (L/L_T)]^1.8
(20) DCM EQ 4-14: Qi = E * Q
(21) DCM EQ 4-15: Qb = Q - Qi

file: N:\Team3\WPD_EBC_Annie\Eng_Analysis\Prelim Eng Phase\PROP_ALT4_Inlet_Calcs\Source3_Crockett_PROP_Alt4_Inlet Calcs_ULT_Atals14
tab: CURB Inlets On Grade_ULT

Live Oak Storm Drain System - Overflow to Eva Street

Ref: EBO_375383_SCS_SWMM_model
..\..\..\DGN\Annie_EXIST_revdJan2017.dgn
Bypass flow patterns are shown on this DGN file on layer EX_Drainage_LN_LiveOak_arrows

Alternate 4 StormCAD - bypass from Live Oak System to Eva Street East Gutter

Notes:
1. In the inlet calculation tables: bypass flow is added to area draining to proposed curb inlet(S) on Eva Street between Crockett Street and Live Oak Street

	storm drain overflow - data from CivilStorm model						street overflow	
Ultimate LU	Catch Basin 96743			Catchment DA-L4 (same as EBLDN-A2)		Catch Basin 96743	Overflow from Live Oak South gutter	
	Flow (Overflow Maximum)	Time	Overflow druation	Flow (Maximum)	Time	Flow (Bypassed) at time = 725 mins		Total Live Oak System Bypass to Eva Street east gutter
	cfs	min	mins	cfs	min	cfs	cfs	cfs
	(1)			(2)		(3)	(4)	(5)
2-year	0	N/A	N/A	not used	725	1.13	5.88	7.01
10-year	8.89	726.63	130	4.88	725	not used	11.13	24.90
25-year	11.86	725.37	180	6.01	725	not used	14.94	32.81
100-year	15.02	725.08	330	7.86	725	not used	20.75	43.63

Equations:

(4) See Street Flow Calculations
(5) If overflow occurs: Total System Bypass = (1) + (2) + (4)
If overflow does not occur: Total System Bypass = (3) + (4)

Alternate 4 StormCAD - bypass from Live Oak System to Eva Street West Gutter

Ultimate LU	Flow Diverted to Eva west gutter
	(cfs)
2-year	5.88
10-year	11.13
25-year	14.94
100-year	20.75

Alternate 4 StormCAD - bypass from Live Oak System to Crockett System at Live Oak/Newton

	storm drain overflow								street overflow				
Ultimate LU	Catch Basin 100626			Catch Basin 100626		Catch Basin 100626							
	Flow (Overflow Maximum)	Time	Overflow druation	Flow (Surface Maximum)	Time	Flow (Bypassed) at time = 720 mins	Total Over Crown Flow Diverted from Live Oak south gutter to Eva Street	Flow in Live Oak North Gutter between Eva and Newton	Overflow from Live Oak south gutter	Total Live Oak System Bypass to Newton = Total Overflow at CB 100626	% Bypass to Newton Street	Total Live Oak System Bypass to Newton Street (flows to east gutter)	
	cfs	min	mins	cfs	min	cfs	cfs	cfs	cfs	cfs	cfs	cfs	
	(1)			(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)	
2-year	0	N/A	N/A	not used	N/A	14.66	11.77	2.89	36.82	39.71	50%	19.86	0
10-year	23.63	725.69	25	35.79	725	not used	22.25	13.54	60.41	73.95	50%	36.97	0
25-year	30.92	725.29	45	46.15	725	not used	29.88	16.27	75.81	92.08	50%	46.04	0
100-year	46.89	725.06	135	62.18	725	not used	41.49	20.69	103.92	124.61	50%	62.30	0

Equations:

(4) See Street Flow Calculations.
(5) (5) = (2) - (4) if overflow occurs OR (5) = (3) - (4) if no overflow; CivilStorm cannot split gutter flow. Flow diverted to Eva Street is subtracted from the Maximum Surface Flow to Catch Basin 100626
(6) Overflow from south gutter = (gutter flow) - (gutter flow that remains below crown); see Street Flow Calculations
(7) (7) = (5) + (6)
(8) Assume that flow splits evenly; half flows to Newton Street and half continues downstream on Live Oak. See flow pattern map.
(9) Total System Bypass = (7) x (8)

Source 3

Ultimate Development Conditions for Proposed Crockett Street System

GRATE INLETS ON GRADE, Type G-2 V-shaped gutter

100 YEAR STORM

DRAINAGE AREA	Drainage_ID (GIS)	INLET ID (StormCAD)	INLET GIS ID	INLET Number (Label)	STREET NAME	DRAINAGE AREA	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM INLET /DRAINAGE AREA	1st CARRY OVER FLOW (cfs)	2nd UPSTREAM INLET /DRAINAGE AREA	2nd CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$
DA-A22-A	**402356**				Wilson St	DA-A22-A	0.52	7.12	DA-A22-E	0.0			7.1	556.0	554.0	114.1	0.0175
DA-A22-S	**402356**				Alley	DA-A22-S	0.78	11.18					11.2				0.0180

25 YEAR STORM

DRAINAGE AREA	Drainage_ID (GIS)	INLET ID (StormCAD)	INLET GIS ID	INLET Number (Label)	STREET NAME	DRAINAGE AREA	DRAINAGE AREA (ac.)	DISCHARGE FROM DRAINAGE AREA (cfs)	1st UPSTREAM INLET /DRAINAGE AREA	1st CARRY OVER FLOW (cfs)	2nd UPSTREAM INLET /DRAINAGE AREA	2nd CARRY OVER FLOW (cfs)	TOTAL RUNOFF (cfs) Q	Hig elev (ft)	low elev (ft)	length (ft)	SLOPE (ft/ft) $S_o = S_L$
DA-A22-A	**402356**				Wilson St	DA-A22-A	0.52	4.91	DA-A22-E	0.0			4.9	556.0	554.0	114.1	0.0175
DA-A22-S	**402356**				Alley	DA-A22-S	0.78	7.74					7.7				0.018

Equations in cell

(1)	DCM EQ 2-1: Q_{peak} = CiA
(2)	Total flow = sum of discharge from drainage area and carry over flow
(3)	So = (high elev - low elev)/length
(4)	Sx = (Sx1 * Sx2) / (Sx1 + Sx2)
(5)	See HEC-22 Figure 4-1.b.2; AB = width of parking lane between grate inlet and curb; BC = distance crown to grate inlet
(6)	See DCM Table 2-2
(7)	Given in HEC-22 EQ 4-2
(8)	HEC-22 EQ 4-2 and EX 4-3: T' = [(Q * n)/(Ku * Sx^1.67 * So^0.5)]^0.375
(9)	T,max = AB + BC
(10)	T = min(T',Tmax)
(11)	HEC-22 EQ 4-16: Eo = 1 - (1 - W_{grate}/T)^2.67
(12)	If assume velocity in gutter is equal or less than splash over velocity, then R_f = 1
(13)	Ku is given in HEC-22 EQ 4-19
(14)	V calculated similarly to TR-55 Figure 3-1; V = k * $S^{0.5}$ where k = 46.3 for paved gutter; Ref: Hydrologic Analysis and Design by R. H. McCuen EQ 3-46 and Table 3-14.
(15)	HEC-22 EQ 4-19: Rs = ratio of side flow intercepted to total side flow = 1 / [1 + (Ku * V^1.8) / (Sx * L^2.3)]
(16)	HEC-22 EQ 4-20: E = Rf * Eo + Rs * (1 - Eo)
(17)	See DCM 4.3.2.B
(18)	DCM EQ 4-14: Qi = E * Q * Reduction Factor
(19)	DCM EQ 4-15: Qb = Q - Qi

Source 3

Ultimate Development Conditions for Proposed Crockett Street System

GRATE INLETS ON GRADE, Type G-2 V-shaped gutter

100 YEAR STORM

DRAINAGE AREA	Street Width (FOC-FOC) (ft)	Curb Height (in)	Parking lane cross slope Sx1	Street Cross Slope Sx2	Sx	(ft) AB	(ft) BC	Manning's n n	Ku	HYPOTHETICAL PONDED WIDTH (ft) T'	MAXIMUM PONDED WIDTH (ft) Tmax	PONDED WIDTH (ft) T
DA-A22-A	29.8	8.0	0.028	0.054	0.018	9.0	14.0	0.016	0.56	14.3	23.0	14.3
DA-A22-S	10.0	6.0	0.020	0.020	0.020	9.0	14.0	0.016	0.56	16.0	23.0	16.0

25 YEAR STORM

DRAINAGE AREA	Street Width (FOC-FOC) (ft)	Curb Height (in)	Parking lane cross slope Sx1	Street Cross Slope Sx2	Sx	(ft) AB	(ft) BC	Manning's n n	Ku	HYPOTHETICAL PONDED WIDTH (ft) T'	MAXIMUM PONDED WIDTH (ft) Tmax	PONDED WIDTH (ft) T
DA-A22-A	29.8	8.0	0.028	0.054	0.018	9.0	14.0	0.016	0.56	12.5	23.0	12.5
DA-A22-S	10.000	6.000	0.020	0.020	0.020	9.0	14.0	0.016	0.56	14.0	23.0	14.0

Equations in cell

- **(1)** DCM EQ 2-1: Q_{peak} = CiA
- **(2)** Total flow = sum of discharge from drainage area and carry over flow
- **(3)** So = (high elev - low elev)/length
- **(4)** Sx = (Sx1 * Sx2) / (Sx1 + Sx2)
- **(5)** See HEC-22 Figure 4-1.b.2; AB = width of parking lane between grate inlet and curb; BC = distance crown to grate inlet
- **(6)** See DCM Table 2-2
- **(7)** Given in HEC-22 EQ 4-2
- **(8)** HEC-22 EQ 4-2 and EX 4-3: T' = [(Q * n)/(Ku * Sx^1.67 * So^0.5)]^0.375
- **(9)** T,max = AB + BC
- **(10)** T = min(T',Tmax)
- **(11)** HEC-22 EQ 4-16: Eo = 1 - (1 - W_{grate}/T)^2.67
- **(12)** If assume velocity in gutter is equal or less than splash over velocity, then R_f = 1
- **(13)** Ku is given in HEC-22 EQ 4-19
- **(14)** V calculated similarly to TR-55 Figure 3-1; V = k * $S^{0.5}$ where k = 46.3 for paved gutter; Ref: Hydrologic Analysis and Design by R. H. McCuen EQ 3-46 and Table 3-14.
- **(15)** HEC-22 EQ 4-19: Rs = ratio of side flow intercepted to total side flow = 1 / [1 + (Ku * V^1.8) / (Sx * L^2.3)]
- **(16)** HEC-22 EQ 4-20: E = Rf * Eo + Rs * (1 - Eo)
- **(17)** See DCM 4.3.2.B
- **(18)** DCM EQ 4-14: Qi = E * Q * Reduction Factor
- **(19)** DCM EQ 4-15: Qb = Q - Qi

Ultimate Development Conditions for Proposed Crockett Street System

GRATE INLETS ON GRADE, Type G-2 V-shaped gutter

100 YEAR STORM

DRAINAGE AREA	Gutter Depression Width (ft) W_{gutter}	Grate Width (in)	Grate Width (ft) W_{grate}	Eo	R_f	Ku	Grate Length (in)	Grate Length (ft) L	Gutter Velocity (ft/s) V	R_s	E
DA-A22-A	0.0	18.0	1.5	0.26	1.0	0.15	108.0	9.0	6.1	0.424	0.57
DA-A22-S	0.0	48.0	4.0	0.53	1.0	0.15	48.0	4.0	6.2	0.108	0.59

25 YEAR STORM

DRAINAGE AREA	Gutter Depression Width (ft) W_{gutter}	Grate Width (in)	Grate Width (ft) W_{grate}	Eo	R_f	Ku	Grate Length (in)	Grate Length (ft) L	Gutter Velocity (ft/s) V	R_s	E
DA-A22-A	0.0	18.0	1.5	0.29	1.0	0.15	108.0	9.0	6.1	0.424	0.59
DA-A22-S	0.0	48.0	4.0	0.59	1.0	0.15	48.0	4.0	6.2	0.108	0.64

Equations in cell

(1) DCM EQ 2-1: Q_{peak} = CiA
(2) Total flow = sum of discharge from drainage area and carry over flow
(3) So = (high elev - low elev)/length
(4) Sx = (Sx1 * Sx2) / (Sx1 + Sx2)
(5) See HEC-22 Figure 4-1.b.2; AB = width of parking lane between grate inlet and curb; BC = distance crown to grate inlet
(6) See DCM Table 2-2
(7) Given in HEC-22 EQ 4-2
(8) HEC-22 EQ 4-2 and EX 4-3: T' = [(Q * n)/(Ku * Sx^1.67 * So^0.5)]^0.375
(9) T,max = AB + BC
(10) T = min(T',Tmax)
(11) HEC-22 EQ 4-16: Eo = 1 - (1 - W_{grate}/T)^2.67
(12) If assume velocity in gutter is equal or less than splash over velocity, then R_f = 1
(13) Ku is given in HEC-22 EQ 4-19
(14) V calculated similarly to TR-55 Figure 3-1; V = k * $S^{0.5}$ where k = 46.3 for paved gutter; Ref: Hydrologic Analysis and Design by R. H. McCuen EQ 3-46 and Table 3-14.
(15) HEC-22 EQ 4-19: Rs = ratio of side flow intercepted to total side flow = 1 / [1 + (Ku * V^1.8) / (Sx * L^2.3)]
(16) HEC-22 EQ 4-20: E = Rf * Eo + Rs * (1 - Eo)
(17) See DCM 4.3.2.B
(18) DCM EQ 4-14: Qi = E * Q * Reduction Factor
(19) DCM EQ 4-15: Qb = Q - Qi

Source 3

Ultimate Development Conditions for Proposed Crockett Street System

GRATE INLETS ON GRADE, Type G-2 V-shaped gutter

100 YEAR STORM

DRAINAGE AREA	GRATE INLET REDUCTION FACTOR (%)	INTERCEPTED FLOW (cfs) Qi	BYPASS FLOW (cfs) Qb	INLET TYPE
DA-A22-A	35%	2.6	4.5	Type G-2
DA-A22-S	35%	4.3	6.9	Type G-2

25 YEAR STORM

DRAINAGE AREA	GRATE INLET REDUCTION FACTOR (%)	INTERCEPTED FLOW (cfs) Qi	BYPASS FLOW (cfs) Qb	INLET TYPE
DA-A22-A	35%	1.9	3.0	Type G-2
DA-A22-S	35%	3.2	4.5	Type G-2

Equations in cell

(1) DCM EQ 2-1: Q_{peak} = CiA
(2) Total flow = sum of discharge from drainage area and carry over flow
(3) So = (high elev - low elev)/length
(4) Sx = (Sx1 * Sx2) / (Sx1 + Sx2)
(5) See HEC-22 Figure 4-1.b.2; AB = width of parking lane between grate inlet and curb; BC = distance crown to grate inlet
(6) See DCM Table 2-2
(7) Given in HEC-22 EQ 4-2
(8) HEC-22 EQ 4-2 and EX 4-3: T' = [(Q * n)/(Ku * Sx^1.67 * So^0.5)]^0.375
(9) T,max = AB + BC
(10) T = min(T',Tmax)
(11) HEC-22 EQ 4-16: Eo = 1 - (1 - W_{grate}/T)^2.67
(12) If assume velocity in gutter is equal or less than splash over velocity, then R_f = 1
(13) Ku is given in HEC-22 EQ 4-19
(14) V calculated similarly to TR-55 Figure 3-1; V = k * $S^{0.5}$ where k = 46.3 for paved gutter; Ref: Hydrologic Analysis and Design by R. H. McCuen EQ 3-46 and Table 3-14.
(15) HEC-22 EQ 4-19: Rs = ratio of side flow intercepted to total side flow = 1 / [1 + (Ku * V^1.8) / (Sx * L^2.3)]
(16) HEC-22 EQ 4-20: E = Rf * Eo + Rs * (1 - Eo)
(17) See DCM 4.3.2.B
(18) DCM EQ 4-14: Qi = E * Q * Reduction Factor
(19) DCM EQ 4-15: Qb = Q - Qi

Drainage Area Calculations for Live Oak Condos

Source 4

Area Name	Area (ac) (1)	% IC on plans (2)	Max % IC by zoning	%IC used (3)	C25 (4)	C100 (5)	Tc (min) (6)	Atlas14 25-year intensity (in/hr) (7)	Atlas14 100-year intensity (in/hr)	Q25 (cfs) (8)	Q100 (cfs)	Ultimate Outfall Location Alt 4
DA-LOC-A	0.250	0.9040	0.80	0.9040	0.84	0.92	5.0	11.79	15.42	2.46	3.56	EBC/Annie
DA-LOC-B3	0.253	0.8667	0.80	0.8667	0.82	0.91	5.0	11.79	15.42	2.44	3.54	EBC/Annie
DA-LOC-B4	0.069	0.9014	0.80	0.9014	0.83	0.92	5.0	11.79	15.42	0.68	0.98	EBC/Annie
DA-LOC-B5	0.054	0.5525	0.80	0.8000	0.79	0.87	5.0	11.79	15.42	0.50	0.73	EBC/Annie
DA-LOC-B6.1	0.092	0.8985	0.80	0.8985	0.83	0.92	5.0	11.79	15.42	0.91	1.31	EBC/Annie
DA-LOC-B6.2	0.079	0.8985	0.80	0.8985	0.83	0.92	5.0	11.79	15.42	0.78	1.13	EBC/Annie
DA-LOC-B6.3	0.033	0.8985	0.80	0.8985	0.83	0.92	5.0	11.79	15.42	0.32	0.46	EBC/Annie
DA-LOC-B6.4	0.018	0.8985	0.80	0.8985	0.83	0.92	5.0	11.79	15.42	0.18	0.26	EBC/Annie
	0.849											

Equations

(1) Areas are from SP-2014-0349C sheet 21; area B6 subdivisions were drawn and estimated in microstation

(2) %IC from SP-2014-0349C sheet 21

(3) max (IC on plans, IC by zoning)

(4) 25 year C value assumptions:
- all impervious cover is concrete
- C for concrete = 0.88
- all pervious cover is grass, average slope, fair condition
- C for pervious cover = 0.42

(5) 100 year C value assumptions:
- all impervious cover is concrete
- C for concrete = 0.97
- all pervious cover is grass, average slope, fair condition
- C for pervious cover = 0.49

(6) Tc from SP-2014-0349C sheet 21

(7) i = a/(Tc +b)^c

For Atlas14 25 year storm:

a= 69.9600
b= 7.9410
c= 0.6954

For Atlas 100 year storm:

a= 77.3100
b= 6.8320
c= 0.6524

(8) Qpeak = CiA

Source 5

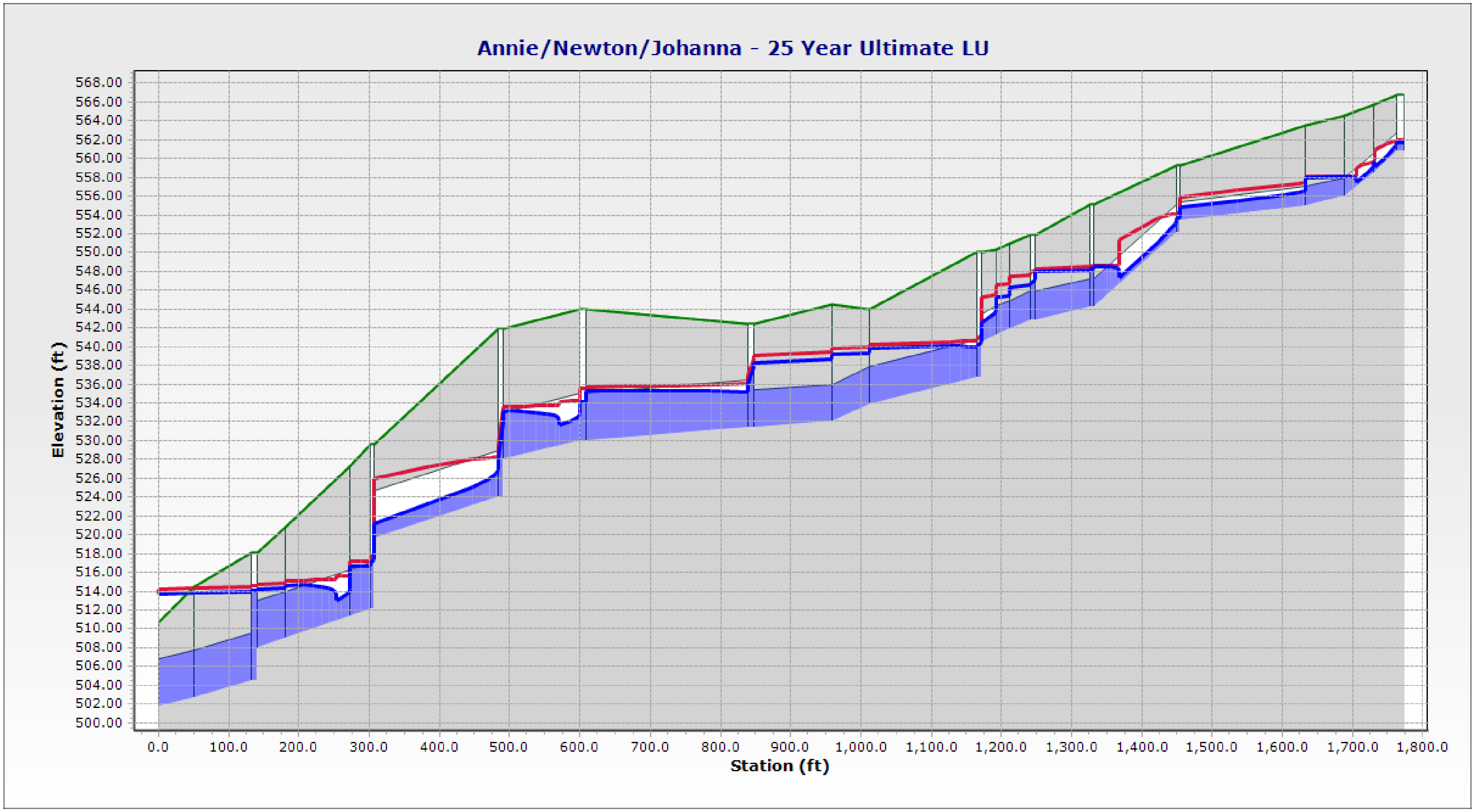
Ref: ..\Prop_Johanna

Catch Basin 101625

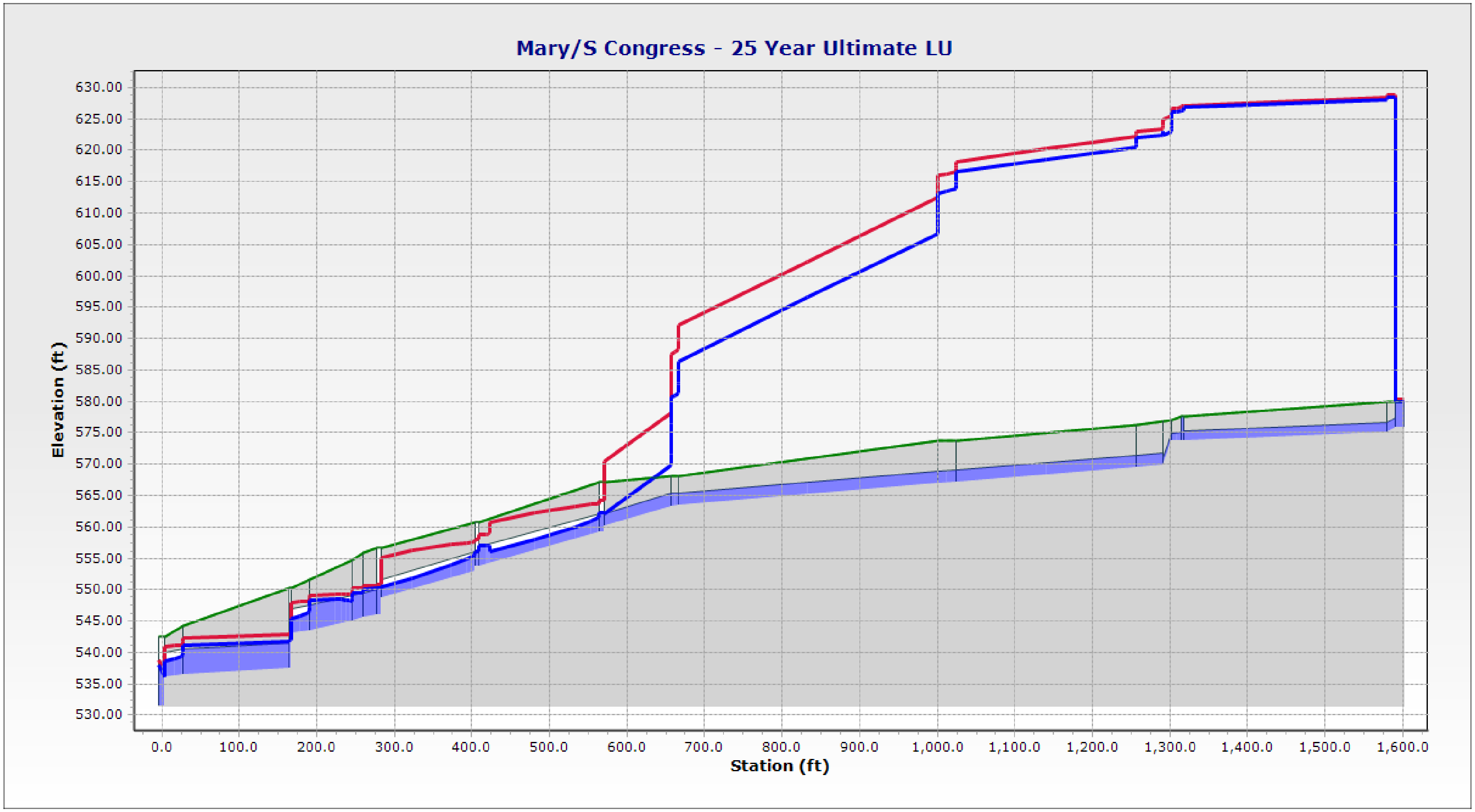
	25yr Atlas14	100yr Atlas14		
C	0.8	0.85	estimate	
i	11.79	15.42	IN/HR	5 min Tc
Area	0.267	0.267	AC	
Q	2.52	3.50	CFS	

Exhibit S.4

Proposed StormCAD Profiles



Annie/Newton/Johanna - 25 Year Ultimate LU
Elevation (ft)
568.00
566.00
564.00
562.00
560.00
558.00
556.00
554.00
552.00
550.00
548.00
546.00
544.00
542.00
540.00
538.00
536.00
534.00
532.00
530.00
528.00
526.00
524.00
522.00
520.00
518.00
516.00
514.00
512.00
510.00
508.00
506.00
504.00
502.00
500.00
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
1,000.0
1,100.0
1,200.0
1,300.0
1,400.0
1,500.0
1,600.0
1,700.0
1,800.0
Station (ft)



Mary/S Congress - 25 Year Ultimate LU
Elevation (ft)
630.00
625.00
620.00
615.00
610.00
605.00
600.00
595.00
590.00
585.00
580.00
575.00
570.00
565.00
560.00
555.00
550.00
545.00
540.00
535.00
530.00
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
1,000.0
1,100.0
1,200.0
1,300.0
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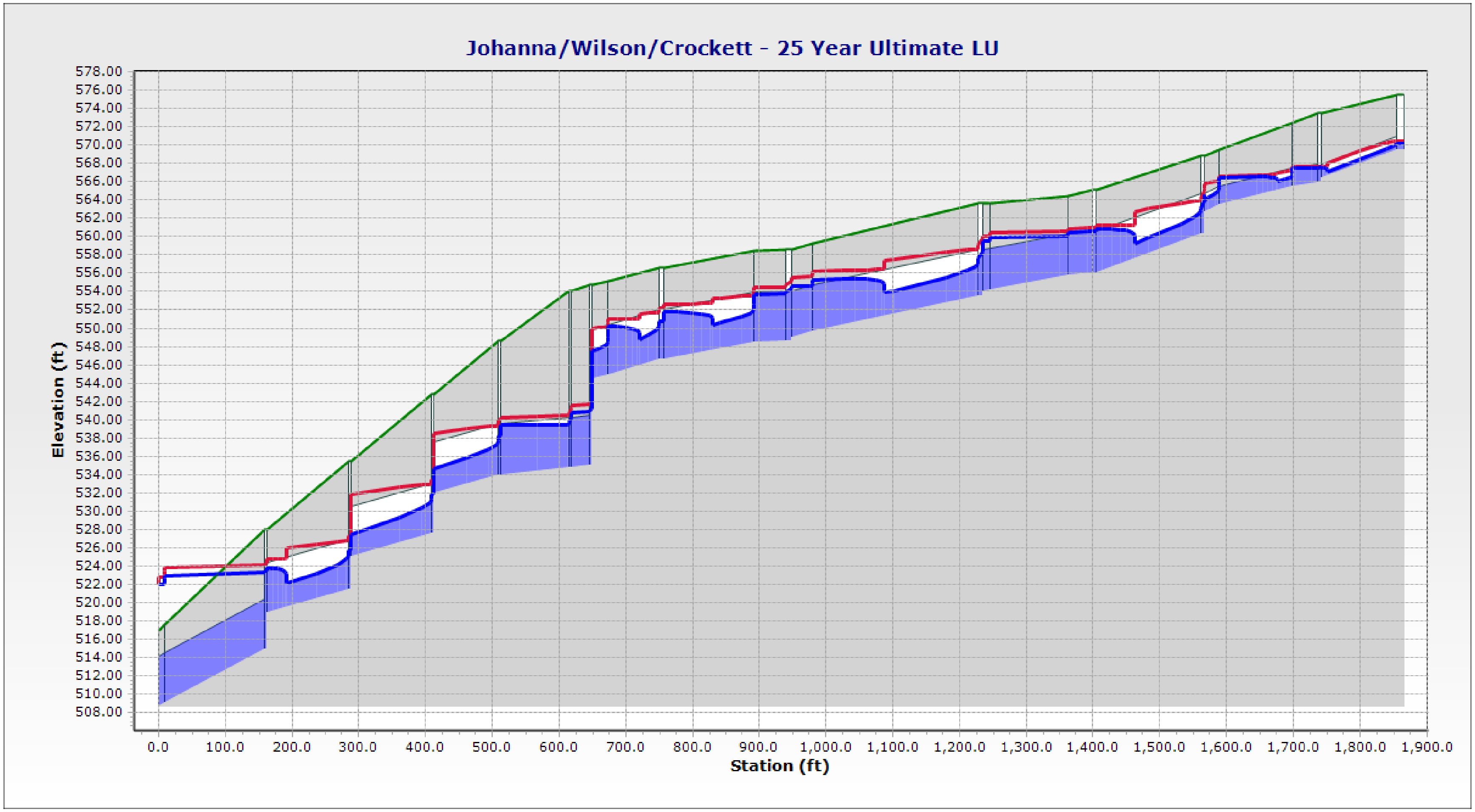
1,500.0
1,600.0
Station (ft)



Johanna/Wilson/Crockett - 25 Year Ultimate LU
Elevation (ft)
578.00
576.00
574.00
572.00
570.00
568.00
566.00
564.00
562.00
560.00
558.00
556.00
554.00
552.00
550.00
548.00
546.00
544.00
542.00
540.00
538.00
536.00
534.00
532.00
530.00
528.00
526.00
524.00
522.00
520.00
518.00
516.00
514.00
512.00
510.00
508.00
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
1,000.0
1,100.0
1,200.0
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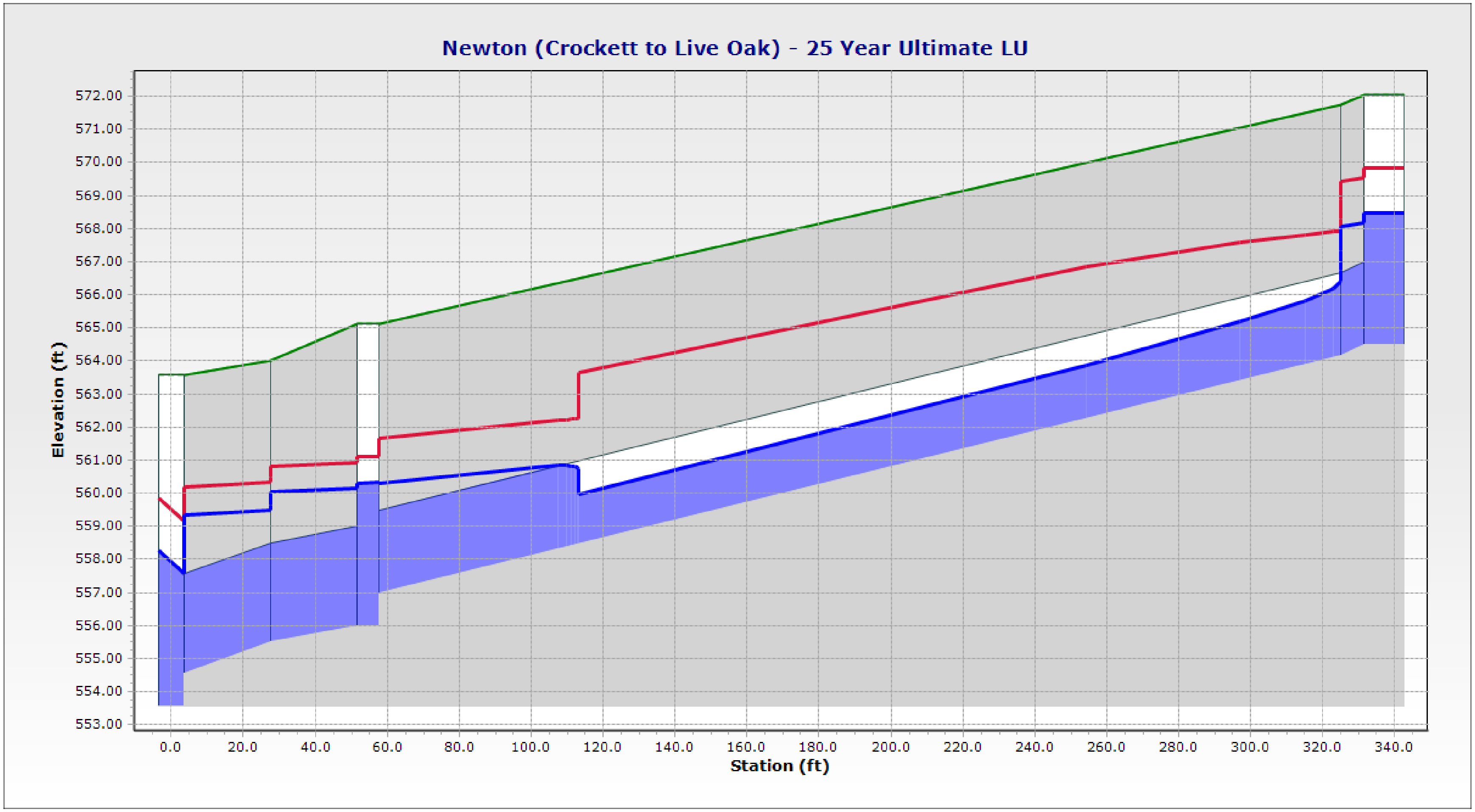
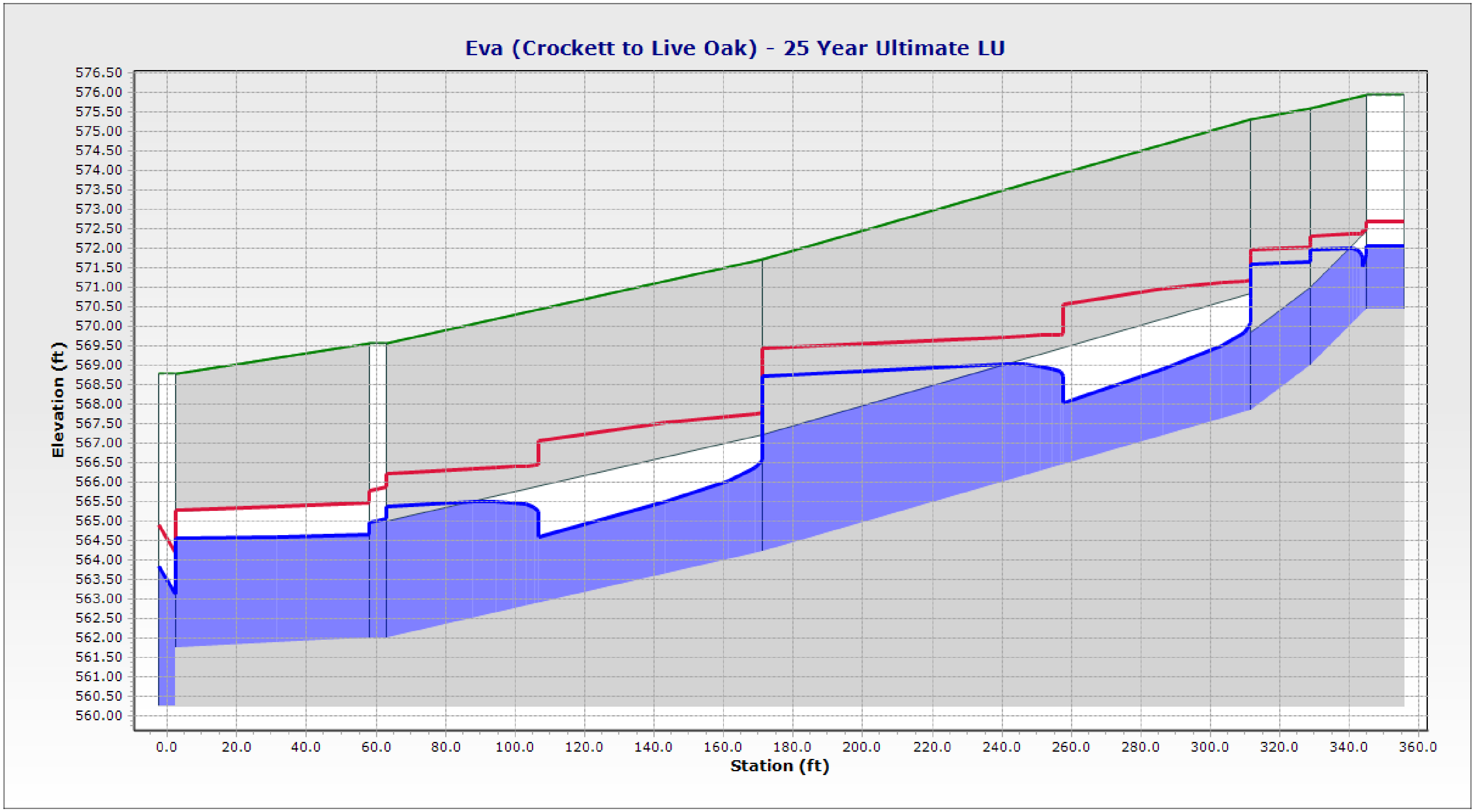
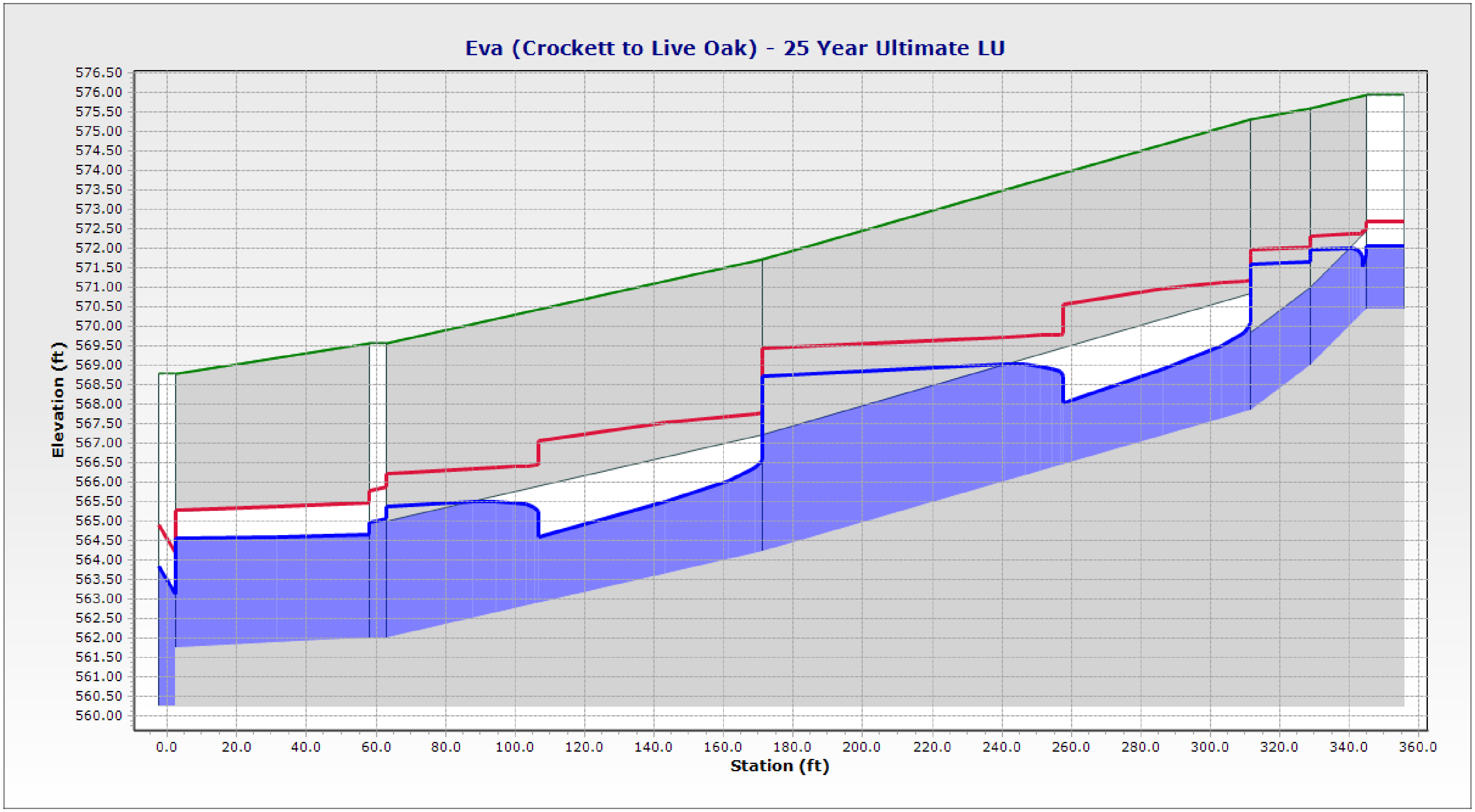
1,800.0
1,900.0
Station (ft)



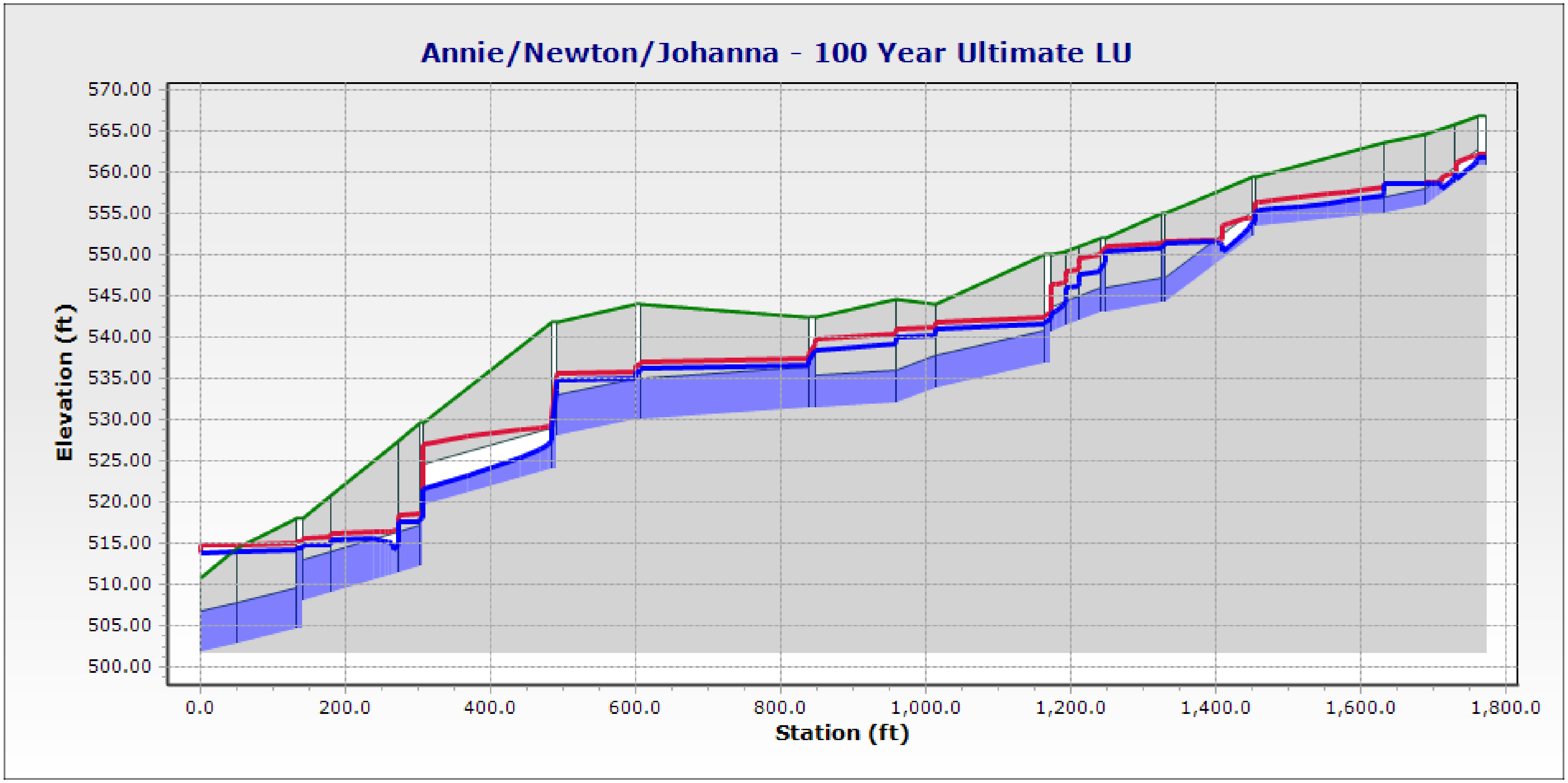
Newton (Crockett to Live Oak) - 25 Year Ultimate LU
Elevation (ft)
572.00
571.00
570.00
569.00
568.00
567.00
566.00
565.00
564.00
563.00
562.00
561.00
560.00
559.00
558.00
557.00
556.00
555.00
554.00
553.00
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
220.0
240.0
260.0
280.0
300.0
320.0
340.0
Station (ft)

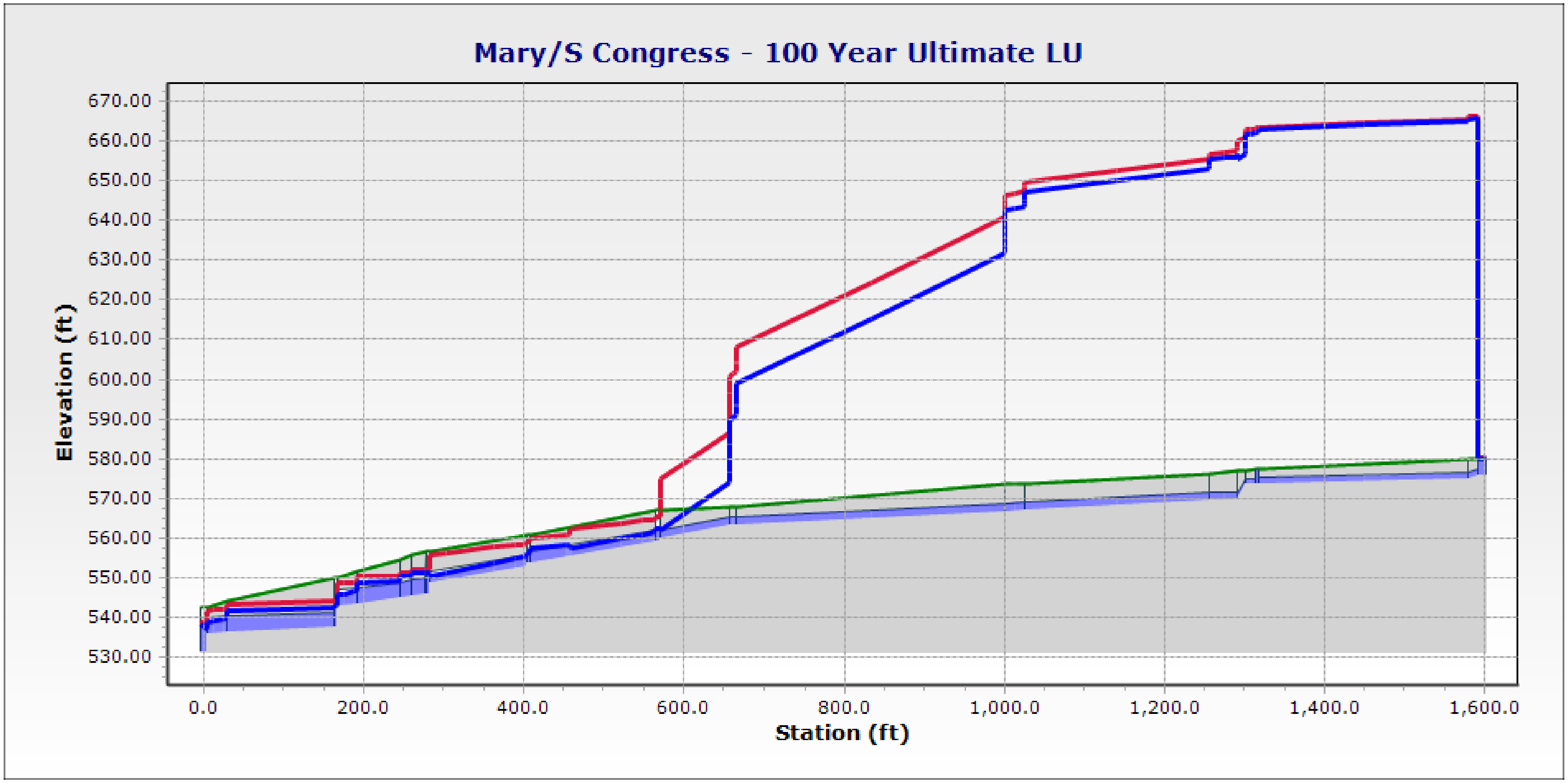


Eva (Crockett to Live Oak) - 25 Year Ultimate LU
Elevation (ft)
Station (ft)
576.50
576.00
575.50
575.00
574.50
574.00
573.50
573.00
572.50
572.00
571.50
571.00
570.50
570.00
569.50
569.00
568.50
568.00
567.50
567.00
566.50
566.00
565.50
565.00
564.50
564.00
563.50
563.00
562.50
562.00
561.50
561.00
560.50
560.00
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
220.0
240.0
260.0
280.0
300.0
320.0
340.0
360.0

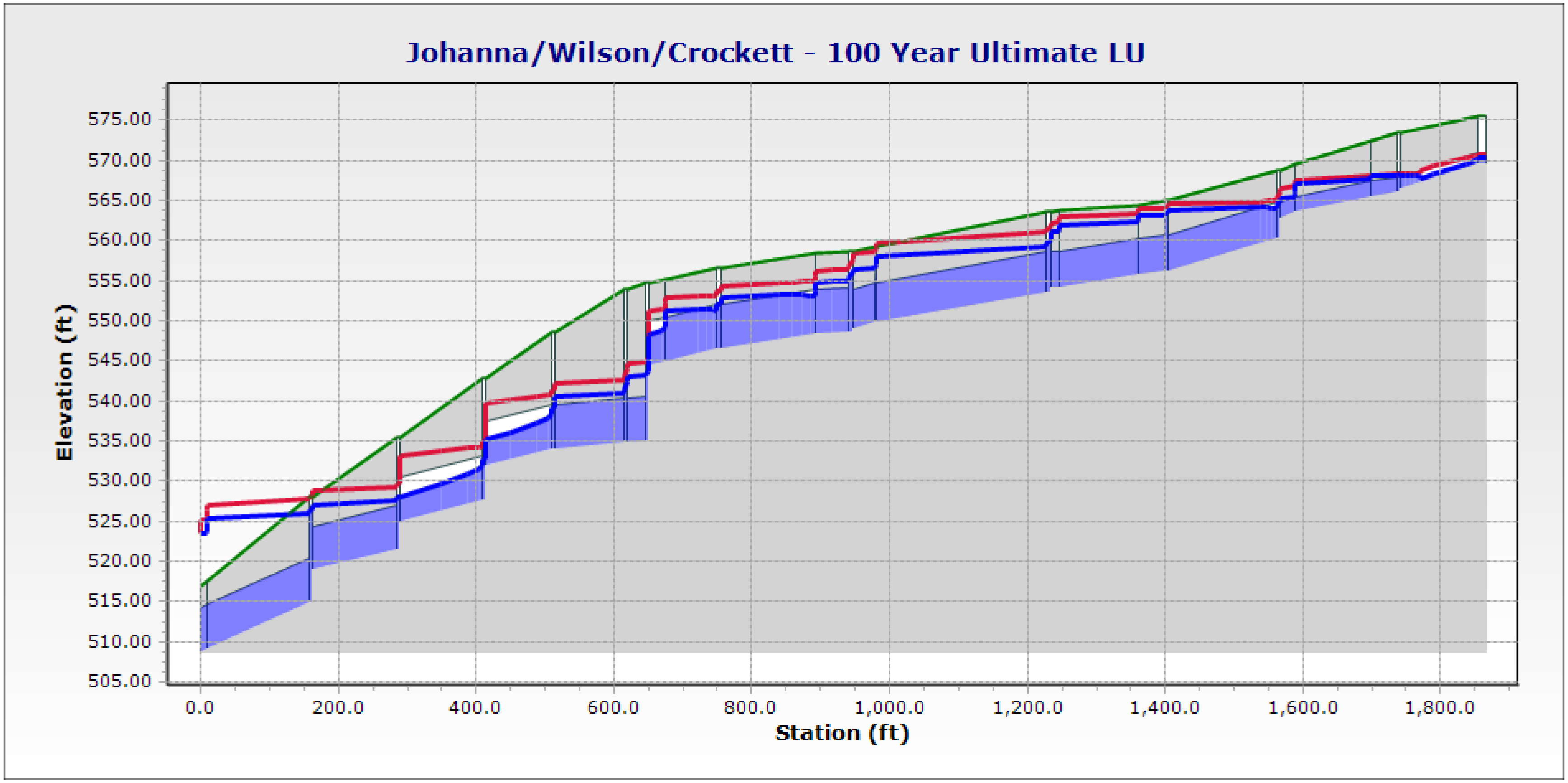


Eva (Crockett to Live Oak) - 25 Year Ultimate LU
Elevation (ft)
576.50
576.00
575.50
575.00
574.50
574.00
573.50
573.00
572.50
572.00
571.50
571.00
570.50
570.00
569.50
569.00
568.50
568.00
567.50
567.00
566.50
566.00
565.50
565.00
564.50
564.00
563.50
563.00
562.50
562.00
561.50
561.00
560.50
560.00
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
220.0
240.0
260.0
280.0
300.0
320.0
340.0
360.0
Station (ft)

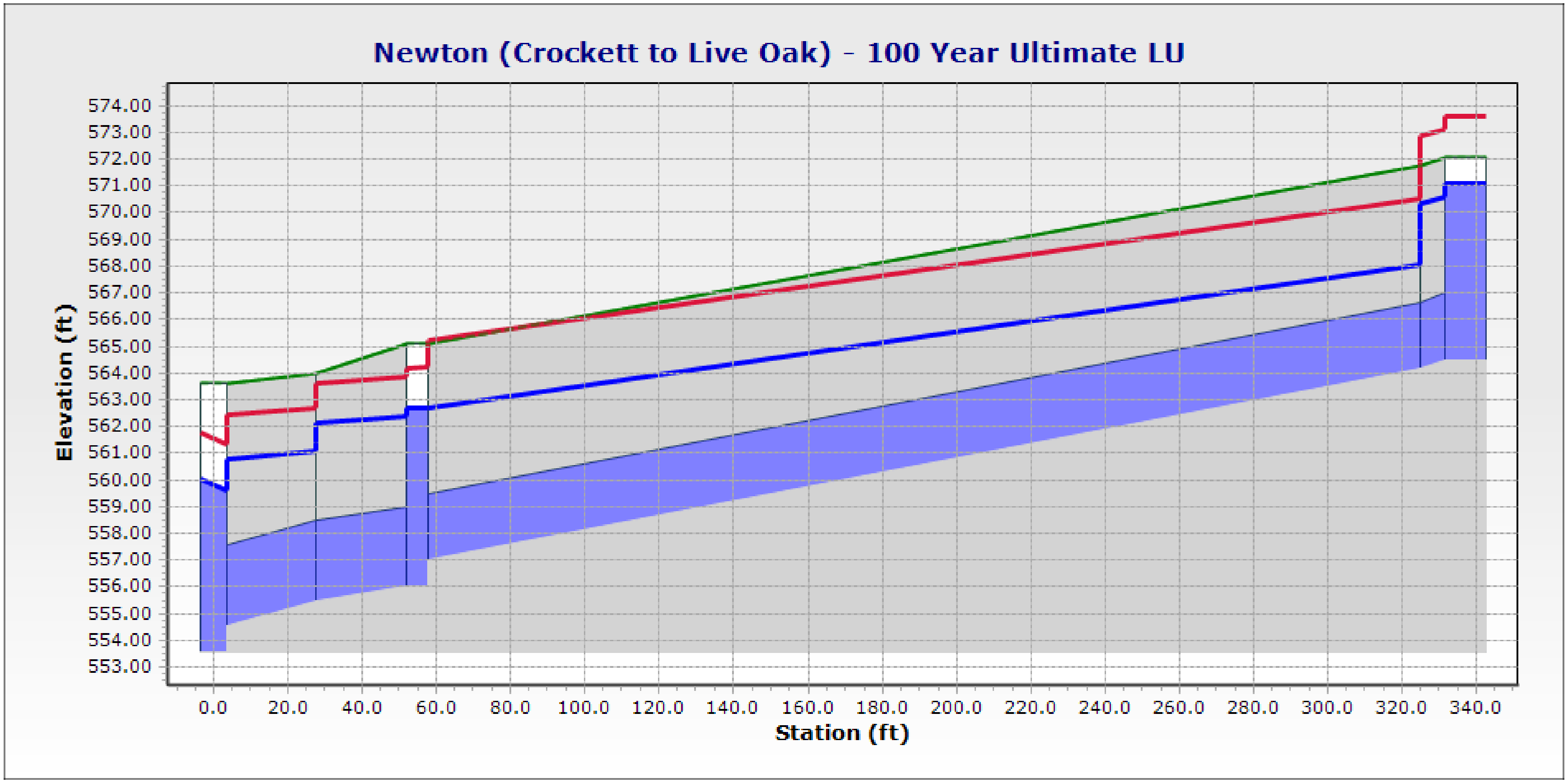

Annie/Newton/Johanna - 100 Year Ultimate LU
Elevation (ft)
570.00
565.00
560.00
555.00
550.00
545.00
540.00
535.00
530.00
525.00
520.00
515.00
510.00
505.00
500.00
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
1,400.0
1,600.0
1,800.0
Station (ft)



Mary/S Congress - 100 Year Ultimate LU
Elevation (ft)
670.00
660.00
650.00
640.00
630.00
620.00
610.00
600.00
590.00
580.00
570.00
560.00
550.00
540.00
530.00
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
1,400.0
1,600.0
Station (ft)



Johanna/Wilson/Crockett - 100 Year Ultimate LU
Elevation (ft)
575.00
570.00
565.00
560.00
555.00
550.00
545.00
540.00
535.00
530.00
525.00
520.00
515.00
510.00
505.00
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
1,400.0
1,600.0
1,800.0
Station (ft)


Newton (Crockett to Live Oak) - 100 Year Ultimate LU
Elevation (ft)
574.00
573.00
572.00
571.00
570.00
569.00
568.00
567.00
566.00
565.00
564.00
563.00
562.00
561.00
560.00
559.00
558.00
557.00
556.00
555.00
554.00
553.00
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
220.0
240.0
260.0
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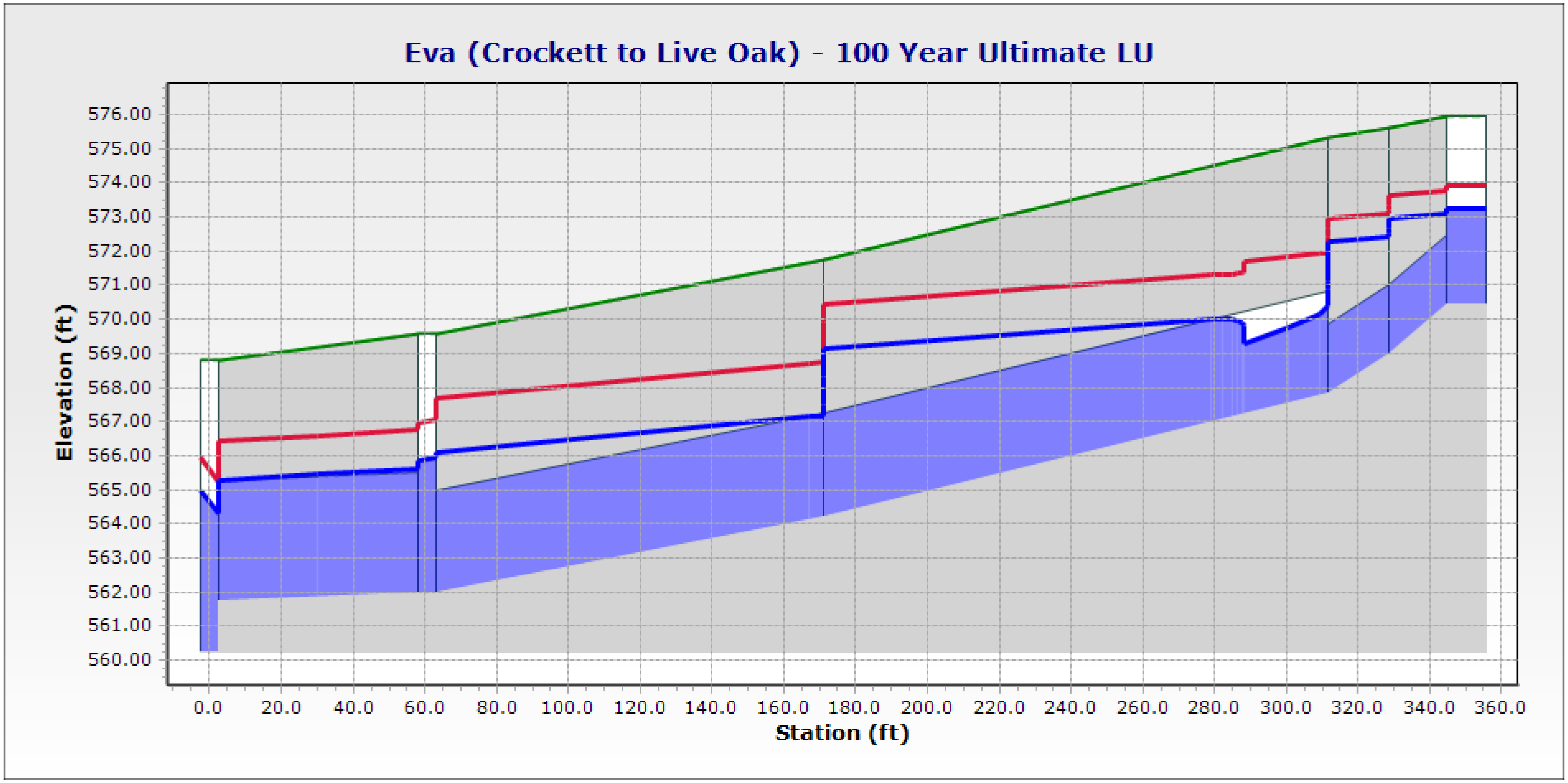
300.0
320.0
340.0
Station (ft)



Eva (Crockett to Live Oak) - 100 Year Ultimate LU
Elevation (ft)
576.00
575.00
574.00
573.00
572.00
571.00
570.00
569.00
568.00
567.00
566.00
565.00
564.00
563.00
562.00
561.00
560.00
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
220.0
240.0
260.0
280.0
300.0
320.0
340.0
360.0
Station (ft)

Appendix T –
Proposed Alternative 4
HEC-HMS Model

Exhibit T.1	**Map of Proposed Alternative 4 Basins, Storm Drains and Contours**
Exhibit T.2	**Map of Proposed Alternative 4 HEC-HMS Elements**
Exhibit T.3	**Map of Proposed Alternative 4 Pipe Diameters, Utility Relocations and Utility Upgrades**
Exhibit T.4	**Model Schematic**
Exhibit T.5	**Proposed Sub-basin Lag Times**
Exhibit T.6	**Proposed Travel (lag) Time for HMS Reach Elements**
Exhibit T.7	**Proposed Alternative 4 Model Results and Comparison to Pre-Project Model (October 2020)**

Exhibit T.1

Map of Proposed Alternate 4 Basins,

Storm Drains and Contours

Exhibit T.2

Map of Proposed Alternative 4 HEC-HMS Elements

Exhibit T.3

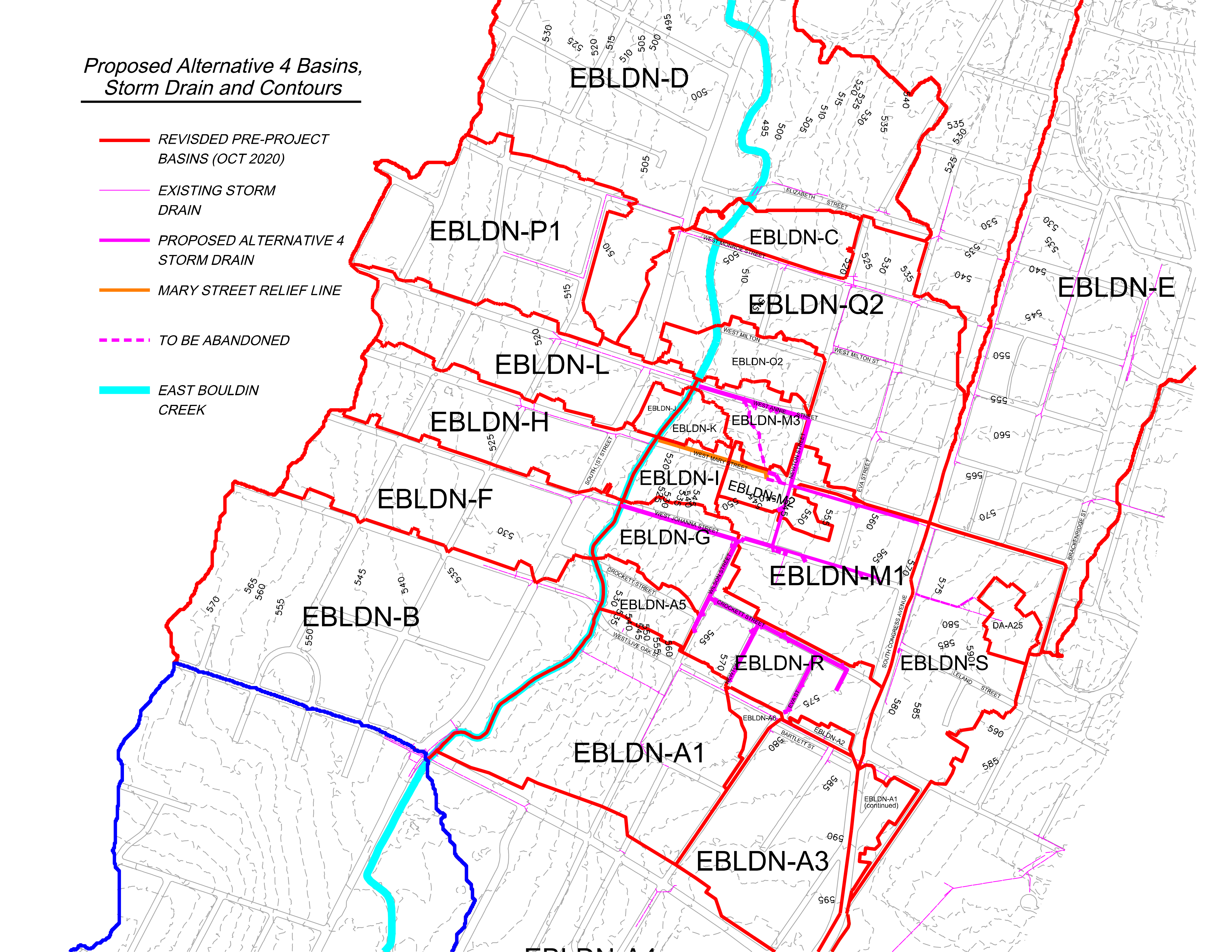
Map of Proposed Alternative 4 Pipe Diameters,

Utility Relocations and Utility Upgrades

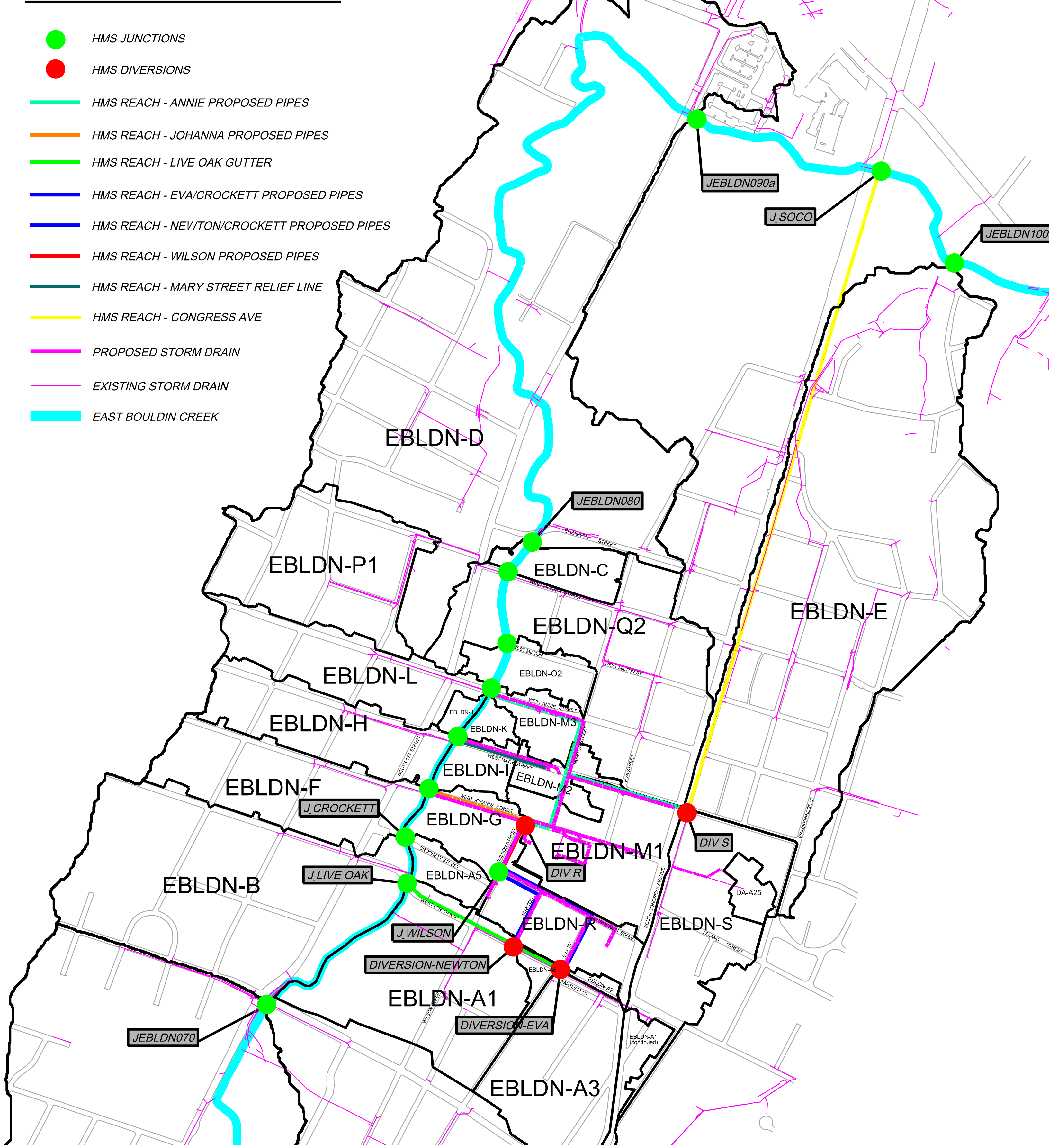
Exhibit T.4

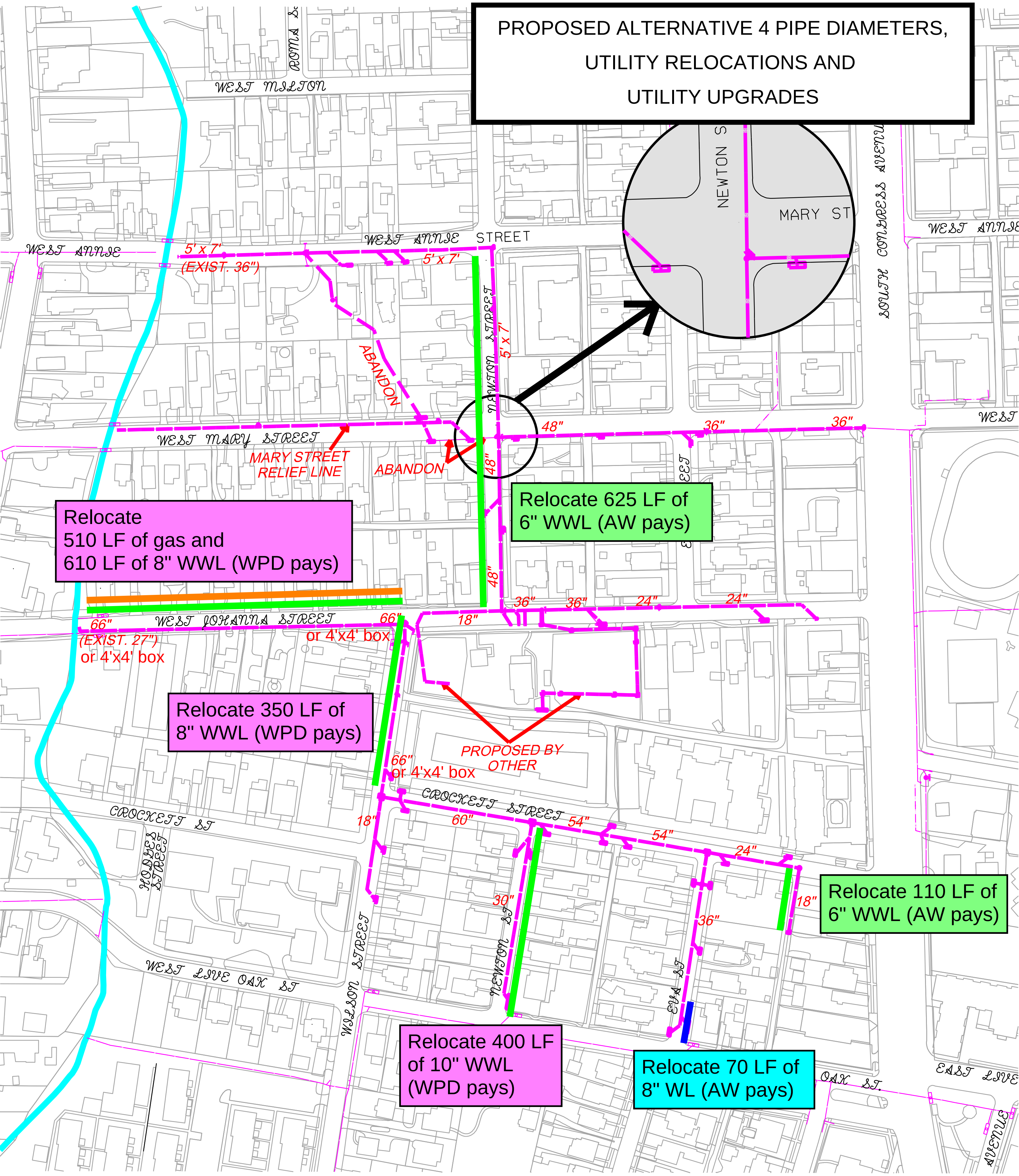
Model Schematic

Proposed Alternative 4 Basins, Storm Drain and Contours



Proposed Alternative 4
HEC-HMS Elements





PROPOSED ALTERNATIVE 4 PIPE DIAMETERS,
UTILITY RELOCATIONS AND
UTILITY UPGRADES
NEWTON S
MARY ST
WEST MILTON
ROMA S
WEST ANNIE
WEST ANNIE STREET
5' x 7'
(EXIST. 36")
5' x 7'
NEWTON STREET
5' x 7'
ABANDON
WEST MARY STREET
MARY STREET
RELIEF LINE
ABANDON
48"
48"
36"
36"
SOUTH CONGRESS AVENUE
Relocate 625 LF of
6" WWL (AW pays)
Relocate
510 LF of gas and
610 LF of 8" WWL (WPD pays)
48"
36"
36"
24"
24"
WEST JOHANNA STREET
66"
(EXIST. 27")
or 4'x4' box
66"
or 4'x4' box
18"
Relocate 350 LF of
8" WWL (WPD pays)
PROPOSED BY
OTHER
66"
or 4'x4' box
CROCKETT STREET
CROCKETT ST
60"
54"
54"
24"
18"
HODGES STREET
30"
36"
18"
Relocate 110 LF of
6" WWL (AW pays)
WEST LIVE OAK ST
WILSON STREET
NEWTON ST
EVA ST
Relocate 400 LF
of 10" WWL
(WPD pays)
Relocate 70 LF of
8" WL (AW pays)
OAK ST.
EAST LIVE
AVENUE

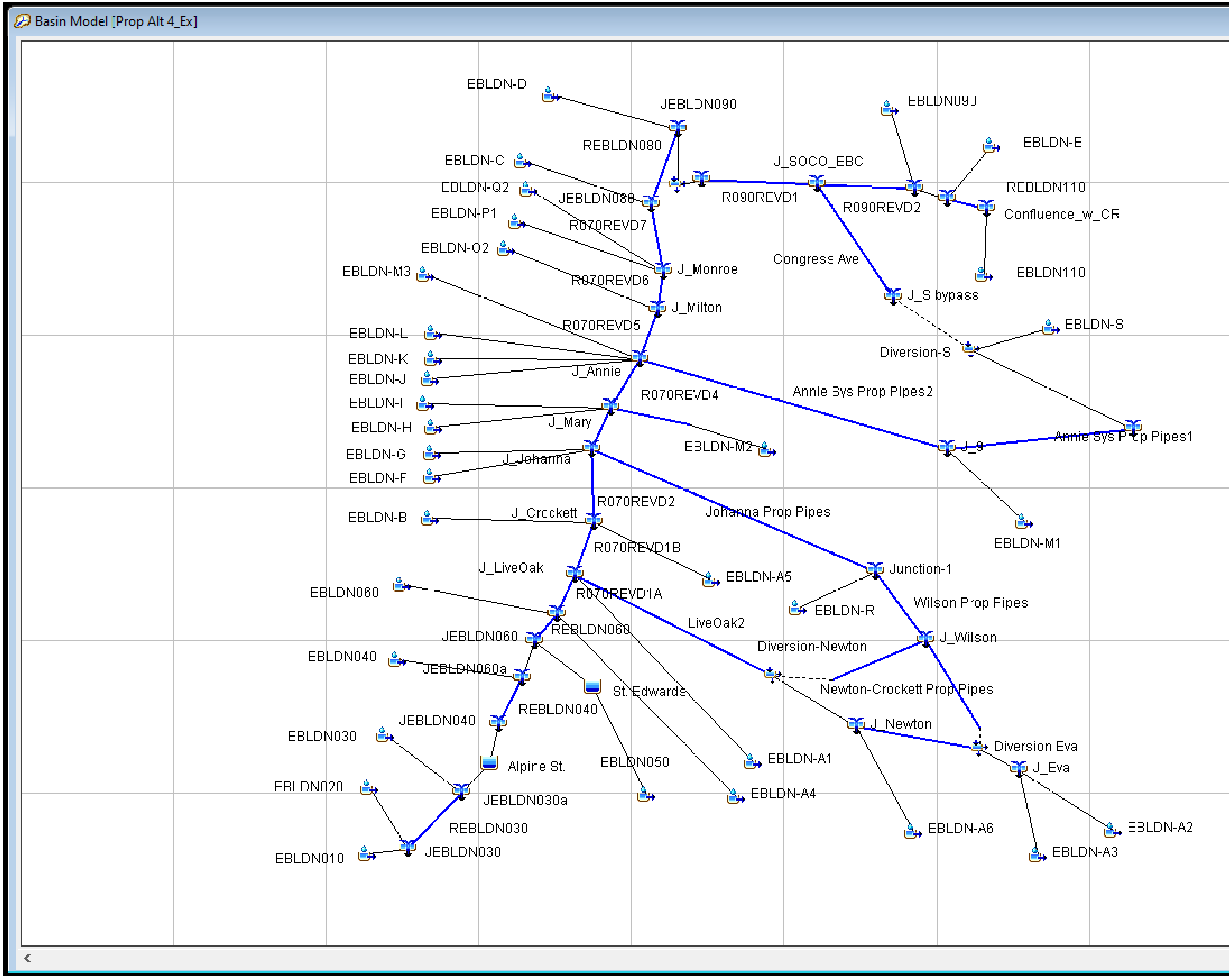

Basin Model [Prop Alt 4_Ex]
EBLDN-D
JEBLDN090
EBLDN090
EBLDN-E
REBLDN080
EBLDN-C
J_SOCO_EBC
EBLDN-Q2
JEBLDN080
R090REVD1
REBLDN110
R090REVD2
EBLDN-P1
R070REVD7
Confluence_w_CR
EBLDN-O2
J_Monroe
Congress Ave
EBLDN-M3
R070REVD6
EBLDN110
J_Milton
J_S bypass
R070REVD5
EBLDN-S
EBLDN-L
Diversion-S
EBLDN-K
J_Annie
EBLDN-J
Annie Sys Prop Pipes2
R070REVD4
EBLDN-I
J_Mary
EBLDN-H
Annie Sys Prop Pipes1
EBLDN-M2
J_9
EBLDN-G
J_Johanna
EBLDN-F
R070REVD2
Johanna Prop Pipes
EBLDN-B
J_Crockett
EBLDN-M1
R070REVD1B
J_LiveOak
Junction-1
EBLDN-A5
EBLDN060
R070REVD1A
Wilson Prop Pipes
EBLDN-R
LiveOak2
JEBLDN060
REBLDN060
J_Wilson
Diversion-Newton
EBLDN040
JEBLDN060a
Newton-Crockett Prop Pipes
St. Edwards
REBLDN040
JEBLDN040
J_Newton
EBLDN030
Diversion Eva
Alpine St.
EBLDN050
EBLDN-A1
J_Eva
EBLDN020
JEBLDN030a
EBLDN-A4
REBLDN030
EBLDN-A6
EBLDN-A2
EBLDN010
JEBLDN030
EBLDN-A3

Exhibit T.5

Proposed Sub-basin Lag Times

Lag Time Calculations for the East Bouldin Creek Watershed (Existing Conditions)

HMS Program Basin Name	Longest Flowpath (ft) (1)	Sheet Flow: Length (ft) (2)	IC% (3)	Land Use (4)	Surface Description (5)	Manning's roughness n (6)	Slope (ft/ft) (7)	Tt1 (min.) (8)	Shallow Concentrated Flow: Length 2 (ft) (9)	L2 paved (ft) (10)	L2 unpaved (ft) (11)	Slope 2 (ft/ft) (12)	Assumption for Tt2 (13)	Tt2 (paved) (min.) (13)	Tt2 (unpaved) (min.) (14)	Tt2 (min.) (15)
EBLDN-M1		48.6	67.3	SF, Paved Surface	Asphalt	0.016	0.010	1.17	559	377	183	0.035	Paved & Unpaved	1.65	1.01	2.66
EBLDN-M3		98.8	43.8	SF, Paved Surface	Asphalt	0.016	0.012	1.92	311	136	175	0.048	Paved & Unpaved	0.51	0.82	1.33
EBLDN-R		56	58	SF, Commercial, Paved Surface	Short Grass	0.15	0.013	7.06	253	203	50	0.026	Paved & Unpaved	1.03	0.32	1.35

HMS Program Basin Name	Channel Flow: Length 3 (ft) (16)	Slope 3 (ft/ft) (17)	V (ft/s) (18)	Assumption for V (19)	Tt3 (sec) (20)	Tt3 (min.) (21)	**Tc (min) (22)**	**Final Tc (min) (23)**	**Tlag (min) (24)**	**Final Tlag (min) (25)**	**Total Flowpath Lenth (ft)**	Sub-basin
EBLDN-M1		N/A	N/A	pipe flow	N/A	1.93	5.76	5.76	3.46	3.5	608	EBLDN-M1
EBLDN-M3		N/A	N/A	gutter + pipe flow	N/A	0.33	3.58	5.00	3.00	3.5	410	EBLDN-M3
EBLDN-R		N/A	N/A	pipe flow	N/A	1.49	9.90	9.90	5.94	5.9	309	EBLDN-R

Notes:

Please refer to N:\Team3\WPD_EBC_Annie\DGN\Annie_EXIST_revdJan2017.dgn (level EX_Drainage_LN_Tc_EBLDN) for drainage sub-basins and times of concentration flow paths.

(1) Longest flow path equals sum of sheet, shallow concentrated and channel flow lengths.
(2) Sheet flow was considered to occur at short distances with a maximum of 100 feet for both natural (undeveloped) and developed conditions;
(3) Percent impervious cover calculations presented as part of HEC-HMS input data.
(4) Land use determined from 2012 aerial photography.
(5) Surface description (DCM Table 2-2)
(6) Manning's roughness n (DCM Table 2-2)
(7) Sheet flow slope = (US elevation - DS elevation) / overland flow length
(8) Sheet Flow Time of concentration (Tt1) = 0.42(nL)^08/((P2)^0.5 S^0.4) (DCM Eq. 2-3)
(9) Shallow concentrated flow length
(10) paved length = shallow concentrated paved length x IC% / 100
(11) unpaved length = shallow concentrated flow length - paved length
(12) slope = (US elevation - DS elevation) / shallow concentrated flow length
(13) Tt2 (Paved) = L/60(20.3282)(S)^0.5) DCM Eq. 2-5
(14) Tt2 (Unpaved) = L/60(16.1345)(S)^0.5) DCM Eq. 2-4
(15) = (13) + (14)
(16) Total Channel flow length
(18) Channel velocity equations were determined by statistical analysis on the existing HEC-RAS models for East Bouldin Creek
East Bouldin Main Channel Velocity Equation (Halff Associates, July 2005) = 178.89 *(slope 2/100)+3.5055 (For "no defined channel" flow paths, velocity is assumed 2.5 - 4.0 fps based on channel slope)
Manning's equation is used for storm drain system velocity calculations assuming pipe flowing full (V=Vfull/Area). See Manning's Equation calculation sheet.
(19) Channel flow assumptions
(20) T = L / V in seconds
(21) Channel Time of Concentration = time in seconds / 60; or gutter flow; or pipe flow
(22) Tc = Sheet Flow Time of Concentration (Tt1) + Shallow Concentrated Flow (Tt2)+Channel Flow Time of Concentration (Tt3)
(23) If Tc > 5 minutes, Tc = Final Tc, else Final Tc = 5 minutes
(24) Lag Time (T lag) = 0.6* Final Tc (Soil Conservation Service)
(25) A minimum lag time of 3.5 minutes is required by HMS so that lag*0.29 is greater than the minimum time step of 1 min

EBLDN-M1 Prop Alt 4

..\StormCAD_CONNECT\Alternative_4

Selection set: EBLDN Tc in pipes

Conduit	Time (Pipe Flow) min	
		start at Catch Basin I-A21
PR-SS-A30	0.02	
PR-SS-A31	0.02	
PR-SS-A32	0.03	
PR-CO-116	0.22	
PR-CO-118	0.15	
PR-CO-119	0.04	
PR-CO-123	0.04	
PR-CO-124	0.09	
PR-CO-125	0.3	
PR-CO-126	0.13	
PR-CO-127	0.3	
PR-CO-129	0.3	
PR-CO-130	0.1	
PR-CO-131	0.05	
PR-CO-132	0.08	
PR-CO-140	0.06	end at MH-3
Total =	**1.93**	**min**

EBLDN-M3 Prop Alt 4

EBLDN-M3 Gutter flow:

Gutter Length =	102	ft	measured on dgn file
Gutter Slope =	0.063	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Veloctiy =	11.6	ft/sec	McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	**0.15**	**min**	time = length /

EBLDN-M3 Piped flow: ..\StormCAD_CONNECT\Alternative_4

selection set: EBLDN-M3 Tc in pipes

Conduit	Time (Pipe Flow) min
PR-SS-A2	0.04
PR-SS-A3	0.06
PR-CO-108	0.03
PR-CO-174	0.04
PR-CO-175	0.01
Pipe flow time =	**0.18**

Total pipe + gutter time = 0.33 min

EBLDN-R Prop Alt 4

Piped flow: same time for existing and ultimate land use; use 100-year flow (Atlas 14)

Ref: ..\StormCAD_CONNECT\Alternative_4 selection set: EBLDN-R Tc in pipes

Conduit	Time (Pipe Flow) min
P-S	0.24
P-18	0.08
P-17	0.18
P-16	0.03
P-15	0.14
P-14	0.06
P-13	0.12
P-11	0.02
P-10	0.24
P-09	0.03
P-E1	0.1
PR-CO-247	0.13
PR-CO-248(1)	0.06
PR-CO-248(2)	0.02
PR-CO-242(1)(1)	0.04
Total Tim =	**1.49 min**

Lag Time Calculations for the East Bouldin Creek Watershed Ultimate Conditions)

HMS Program Basin Name	Longest Flowpath (ft) (1)	Sheet Flow Length (ft) (2)	IC% (3)	Land Use (4)	Surface Description (5)	Manning's roughness n (6)	Slope (ft/ft) (7)	Tt1 (min.) (8)
EBLDN-M1		48.6	80.6	SF, Paved Surface	Asphalt	0.016	0.010	1.17
EBLDN-M3		98.8	68.3	SF, Paved Surface	Asphalt	0.016	0.012	1.92
EBLDN-R		56	75	SF, Commercial, Paved Surface	Short Grass	0.15	0.013	7.06

HMS Program Basin Name	Shallow Concentrated Flow Length 2 (ft) (9)	L2 paved (ft) (10)	L2 unpaved (ft) (11)	Slope 2 (ft/ft) (12)	Assumption for Tt2 (13)	Tt2 (paved) (min.) (13)	Tt2 (unpaved) (min.) (14)	Tt2 (min.) (15)
EBLDN-M1	559	451	108	0.035	Paved & Unpaved	1.97	0.60	2.57
EBLDN-M3	311	212	99	0.048	Paved & Unpaved	0.79	0.46	1.26
EBLDN-R	253	223	30	0.026	Paved & Unpaved	1.13	0.19	1.33

HMS Program Basin Name	Channel Flow Length 3 (ft) (16)	Slope 3 (ft/ft) (17)	V (ft/s) (18)	Assumption for V (19)	Tt3 (sec) (20)	Tt3 (min.) (21)
EBLDN-M1	940	N/A	N/A	pipe flow	N/A	1.93
EBLDN-M3	429	N/A	N/A	gutter + pipe flow	N/A	0.33
EBLDN-R	1,244	N/A	N/A	pipe flow	N/A	1.49

HMS Program Basin Name	**Tc (min) (22)**	**Final Tc (min) (23)**	**Tlag (min) (24)**	**Final Tlag (min) (25)**	**Total Flowpath Lenth (ft)**	Sub-basin
EBLDN-M1	5.67	5.67	3.40	3.5	1547	EBLDN-M1
EBLDN-M3	3.50	5.00	3.00	3.5	839	EBLDN-M3
EBLDN-R	9.88	9.88	5.93	5.9	1553	EBLDN-R

Notes:

Please refer to N:\Team3\WPD_EBC_Annie\DGN\Annie_EXIST_revdJan2017.dgn (level EX_Drainage_LN_Tc_EBLDN) for drainage sub-basins and times of concentration flow paths.

(1) Longest flow path equals sum of sheet, shallow concentrated and channel flow lengths.
(2) Sheet flow was considered to occur at short distances with a maximum of 100 feet for both natural (undeveloped) and developed conditions;
(3) Percent impervious cover calculations presented as part of HEC-HMS input data.
(4) Land use determined from 2012 aerial photography.
(5) Surface description (DCM Table 2-2)
(6) Manning's roughness n (DCM Table 2-2)
(7) Sheet flow slope = (US elevation - DS elevation) / overland flow length
(8) Sheet Flow Time of concentration (Tt1) = 0.42(nL)^08/((P2)^0.5 S^0.4) (DCM Eq. 2-3)
(9) Shallow concentrated flow length
(10) paved length = shallow concentrated paved length x IC% / 100
(11) unpaved length = shallow concentrated flow length - paved length
(12) slope = (US elevation - DS elevation) / shallow concentrated flow length
(13) Tt2 (Paved) = L/60(20.3282)(S)^0.5) DCM Eq. 2-5
(14) Tt2 (Unpaved) = L/60(16.1345)(S)^0.5) DCM Eq. 2-4
(15) = (13) + (14)
(16) Total Channel flow length
(18) Channel velocity equations were determined by statistical analysis on the existing HEC-RAS models for East Bouldin Creek
East Bouldin Main Channel Velocity Equation (Halff Associates, July 2005) = 178.89 *(slope 2/100)+3.5055 (For "no defined channel" flow paths, velocity is assumed 2.5 - 4.0 fps based on channel slope)
Manning's equation is used for storm drain system velocity calculations assuming pipe flowing full (V=Vfull/Area). See Manning's Equation calculation sheet.
(19) Channel flow assumptions
(20) T = L / V in seconds
(21) Channel Time of Concentration = time in seconds / 60; or gutter flow; or pipe flow
(22) Tc = Sheet Flow Time of Concentration (Tt1) + Shallow Concentrated Flow (Tt2)+Channel Flow Time of Concentration (Tt3)
(23) If Tc > 5 minutes, Tc = Final Tc, else Final Tc = 5 minutes
(24) Lag Time (T lag) = 0.6* Final Tc (Soil Conservation Service)
(25) A minimum lag time of 3.5 minutes is required by HMS so that lag*0.29 is greater than the minimum time step of 1 min

EBLDN-M3 Prop Alt 4

EBLDN-M3 Gutter flow:

Gutter Length =	102	ft	measured on dgn file
Gutter Slope =	0.063	ft/ft	measured on DGN file with Geopak EBCA_WSHD.tin
k =	46.3		
Gutter Velociy =	11.6	ft/sec	McCuen, Hydrologic Analysis and Design (New Jersey: Prentice Hall 1998), p. 143. See Channel Flow calculation sheet
Gutter Flow time =	**0.15**	**min**	time = length /

EBLDN-M3 Piped flow: ..\StormCAD_CONNECT\Alternative_4

selection set: EBLDN-M3 Tc in pipes

Conduit	Time (Pipe Flow) min	FT
PR-SS-A2	0.04	150.2
PR-SS-A3	0.06	88.8
PR-CO-108	0.03	43.5
PR-CO-174	0.04	26.4
PR-CO-175	0.01	18.2
Pipe flow time =	**0.18**	327.1 FT

Total pipe + gutter time =	**0.33 min**
Total pipe + gutter length =	**429.1 FT**

EBLDN-R Prop Alt 4

Piped flow: same time for existing and ultimate land use; use 100-year flow (Atlas 14)

Ref: ..\StormCAD_CONNECT\Alternative_4 selection set: EBLDN-R Tc in pipes

Conduit	Time (Pipe Flow) min	ft
P-S	0.24	35.7
P-18	0.08	251.5
P-17	0.18	15.4
P-16	0.03	115.2
P-15	0.14	40.7
P-14	0.06	161.2
P-13	0.12	24.3
P-11	0.02	111.2
P-10	0.24	40.1
P-09	0.03	52.1
P-E1	0.1	121.4
PR-CO-247	0.13	30.8
PR-CO-248(1)	0.06	138.8
PR-CO-248(2)	0.02	79.3
PR-CO-242(1)(1)	0.04	26.1
Total Tim =	**1.49 min**	

Total length =	**1243.80 ft**

EBLDN-M1 Prop Alt 4

..\StormCAD_CONNECT\Alternative_4

Selection set: EBLDN Tc in pipes

Conduit	Time (Pipe Flow) min	FT	
PR-SS-A30	0.02	24.2	start at Catch Basin I-A
PR-SS-A31	0.02	19	
PR-SS-A32	0.03	32	
PR-CO-116	0.22	115.3	
PR-CO-118	0.15	155.8	
PR-CO-119	0.04	54.4	
PR-CO-123	0.04	30.2	
PR-CO-124	0.09	42.1	
PR-CO-125	0.3	94.1	
PR-CO-126	0.13	42.4	
PR-CO-127	0.3	104.9	
PR-CO-129	0.3	108.4	
PR-CO-130	0.1	56.2	
PR-CO-131	0.05	27.3	
PR-CO-132	0.08	20.8	
PR-CO-140	0.06	12.4	end at MH-3
Total =	**1.93**	**min**	

Exhibit T.6

Proposed Travel (lag) Times for HMS Reach Elements

Reach: Eva-Crockett Prop Pipes

Ref ..\StormCAD_CONNECT\Alternative_4

Selection set: Eva-Crocektt Reach lag time

Lag = travel time from Eva/Live Oak (Diversion-Eva) to Crockett/Wilson (J_Wilson) through proposed pipes

Pipe	Time (Pipe Flow) MIN
CO-265(1)	0.02
CO-26521)	0.01
CO-264	0.14
PR-CO-252	0.13
P-201	0.14
P-15	0.14
P-14	0.06
P-13	0.12
P-11	0.02
P-10	0.24
P-09	0.03
	1.1 MIN

Reach: Newton-Crockett Prop Pipes
Lag = travel time from Newton/Live Oak (Diversion-Newton) to Crockett/Wilson (J_Wilson) through proposed pipes

ref	..\StormCAD_CONNECT\Alternative_4
	Selection set: Newton-Crockett Reach lag time

Pipe	Time (Pipe Flow)
	MIN
PR-CO-256(1)	0.01
PR-CO-256(2)	0.31
PR-CO-254	0.03
P-101	0.02
P-10	0.24
P-09	0.03
	0.6 MIN

Reach: Wilson Prop Pipes
Lag = travel time from Crockett/Wilson (J_Wilson) to Wilson/Johanna (Junction_1) through proposed pipes

Ref	..\StormCAD_CONNECT\Alternative_4
	Selection set: Wilson Reach lag time
Pipe	Time (Pipe Flow)
	MIN
P-E1	0.10
PR-CO-247	0.13
PR-CO-248(1)	0.06
PR-CO-248(2)	0.02
PR-CO-242(1)(1)	0.04
	0.4 MIN

Reach: Johanna Prop Pipes

Proposed Johanna Street Storm Drain System - from Wilson to EBC

Lag = travel time in proposed pipes on Johanna Street from Wilson/Johanna (Junction-1) to Creek

Ref	..\StormCAD_CONNECT\Alternative_4
	Selection set: Johanna (creek to Wilson)
Pipe	Time (Pipe Flow) MIN
CO-267(1)(1)(1)	0.14
CO-267(1)(1)(2)	0.08
CO-267(1)(2)(1)	0.10
CO-267(1)(2)(2)	0.10
CO-267(2)(1)	0.08
CO-267(2)(2)	0.00
	0.5 MIN Lag

Reach: Annie Sys Prop Pipes1
Proposed Storm Drain System (eventually outfalling to Annie/EBC) running on Mary Street from Congress (Div-S) to Newton (J-9)

Lag = travel time in proposed pipes on Johanna Street from Wilson/Johanna (Junction-1) to Creek

Ref	..\StormCAD_CONNECT\Alternative_4
	Selection set: Annie Sys Prop Pipes1 (reach lag time)

Pipe	Time (Pipe Flow) MIN
SS-A20	0.05
PR-CO-158	0.13
PR-CO-259	0.10
PR-CO-260	0.02
PR-SS-A14	0.01
PR-SS-A13	0.04
PR-CO-160	0.02
PR-CO-162	0.22
PR-CO-163	0.03
	0.6 MIN Lag

Reach: Annie Sys Prop Pipes2
Proposed Storm Drain System outfalling to Annie/EBC and running on Newton (Mary/Newton) and Annie (from Newton/EBC)

Lag = travel time in proposed pipes on Johanna Street from Wilson/Johanna (Junction-1) to Creek

Ref	..\StormCAD_CONNECT\Alternative_4
	Selection set: Annie Sys Prop Pipes2 (reach lag time)

Pipe	Time (Pipe Flow) MIN
PR-CO-136	0.32
PR-CO-196	0.09
PR-CO-197	0.15
PR-CO-106	0.02
PR-CO-107	0.07
PR-CO-108	0.03
PR-SS-A3	0.06
PR-SS-A2	0.04
	0.8 MIN Lag

Reach: Mary St Relief Line

Mary Street Relief Line

Lag = travel time in proposed pipes on Johanna Street from Wilson/Johanna (Junction-1) to Creek

Ref Mary St Relief
Selection set: Mary St Relief Line

Pipe	Time (Pipe Flow) MIN
PR-SS-M1	0.12
PR-SS-M2	0.04
PR-SS-M3	0.06
PR-SS-M4	0.34

0.6 MIN Lag

Exhibit T.7

Proposed Alternative 4 Model Results and Comparison to Pre-Project Model (October 2020)

Comparison of ESD Revised Pre-Project Model and Proposed Alternative 4 Model

Model Descriptions:

ESD Revisded Pre-Project - Existing Conditions is the effective COA HEC-HMS model that has been revised by ESD and is based on existing land use conditions.
ESD Revisded Pre-Project - Ultimate Development Conditions is the effective COA HEC-HMS model that has been revised by ESD and is based on future land use conditions.
ESD Revised Pre-Project time interval: 1 min

Proposed Alternative 4 - Existing Conditions is the proposed conditions that has been modified from the ESD Revised Pre-Project model and is based on existing land use conditions.
Proposed Alternative 4 - Ultimate Development Conditions is the proposed conditions that has been modified from the ESD Revised Pre-Project model and is based on future land use conditions.
ESD Revised Pre-Project time interval: 1 min

Rainfall: SCS Unit Storm with pre-Atlas 14 24-hour depths

Simulation start time: 01Jan2001, 00:00

Junction Name	ESD Revised OCT 2020 Pre-Project - Existing Conditions									
	Peak Flow (cfs) and Time to Peak (hour)									
	2-year		10-year		25-year		100-year		500-year	
	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time
JEBLDN070	678	01Jan2001, 12:19	1411	01Jan2001, 12:24	1957	01Jan2001, 12:22	2900	01Jan2001, 12:21	3973	01Jan2001, 12:19
J_LiveOak	729	01Jan2001, 12:20	1462	01Jan2001, 12:28	2019	01Jan2001, 12:28	2946	01Jan2001, 12:26	4069	01Jan2001, 12:24
J_Crockett	798	01Jan2001, 12:20	1573	01Jan2001, 12:27	2164	01Jan2001, 12:27	3160	01Jan2001, 12:26	4377	01Jan2001, 12:24
J_Johanna	842	01Jan2001, 12:20	1634	01Jan2001, 12:27	2240	01Jan2001, 12:28	3295	01Jan2001, 12:26	4577	01Jan2001, 12:24
J_Mary	866	01Jan2001, 12:20	1677	01Jan2001, 12:27	2293	01Jan2001, 12:28	3369	01Jan2001, 12:27	4686	01Jan2001, 12:24
J_Annie	943	01Jan2001, 12:20	1788	01Jan2001, 12:25	2414	01Jan2001, 12:28	3553	01Jan2001, 12:27	4946	01Jan2001, 12:25
J_Milton	947	01Jan2001, 12:21	1795	01Jan2001, 12:25	2421	01Jan2001, 12:29	3559	01Jan2001, 12:28	4958	01Jan2001, 12:25
J_Monroe	1006	01Jan2001, 12:21	1889	01Jan2001, 12:25	2519	01Jan2001, 12:29	3694	01Jan2001, 12:28	5148	01Jan2001, 12:27
JEBLDN080	1011	01Jan2001, 12:21	1896	01Jan2001, 12:25	2525	01Jan2001, 12:30	3703	01Jan2001, 12:29	5155	01Jan2001, 12:28
JEBLDN090	1108	01Jan2001, 12:39	2154	01Jan2001, 12:37	2635	01Jan2001, 12:53	3774	01Jan2001, 12:53	5219	01Jan2001, 12:53
JEBLDN090a	611	01Jan2001, 12:39	1205	01Jan2001, 12:37	1474	01Jan2001, 12:53	2089	01Jan2001, 12:53	2811	01Jan2001, 12:53
JEBLDN100a	671	01Jan2001, 12:44	1316	01Jan2001, 12:43	1568	01Jan2001, 12:38	2110	01Jan2001, 13:09	2394	01Jan2001, 13:31
JEBLDN100	743	01Jan2001, 12:43	1471	01Jan2001, 12:38	1807	01Jan2001, 12:35	2292	01Jan2001, 12:27	2918	01Jan2001, 12:23
Confluence w/ CR	746	01Jan2001, 12:47	1482	01Jan2001, 12:44	1826	01Jan2001, 12:39	2337	01Jan2001, 12:31	2992	01Jan2001, 12:27

Junction Name	Prop Alternative 4 (Prop Crockett storm drain system to Johanna/EBC, Prop Mary, no detention) - Existing Conditions									
	Peak Flow (cfs) and Time to Peak (hour)									
	2-year		10-year		25-year		100-year		500-year	
	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time
JEBLDN070	678	01Jan2001, 12:19	1411	01Jan2001, 12:24	1957	01Jan2001, 12:22	2900	01Jan2001, 12:21	3973	01Jan2001, 12:19
J_LiveOak	729	01Jan2001, 12:20	1462	01Jan2001, 12:28	2019	01Jan2001, 12:28	2946	01Jan2001, 12:26	4069	01Jan2001, 12:24
J_Crockett	798	01Jan2001, 12:20	1573	01Jan2001, 12:27	2164	01Jan2001, 12:27	3160	01Jan2001, 12:26	4377	01Jan2001, 12:24
J_Johanna	846	01Jan2001, 12:20	1640	01Jan2001, 12:26	2247	01Jan2001, 12:28	3309	01Jan2001, 12:26	4605	01Jan2001, 12:24
J_Mary	873	01Jan2001, 12:20	1688	01Jan2001, 12:27	2304	01Jan2001, 12:28	3394	01Jan2001, 12:26	4727	01Jan2001, 12:24
J_Annie	940	01Jan2001, 12:20	1785	01Jan2001, 12:25	2408	01Jan2001, 12:29	3543	01Jan2001, 12:27	4936	01Jan2001, 12:25
J_Milton	945	01Jan2001, 12:21	1791	01Jan2001, 12:26	2415	01Jan2001, 12:29	3550	01Jan2001, 12:27	4947	01Jan2001, 12:25
J_Monroe	1003	01Jan2001, 12:21	1883	01Jan2001, 12:25	2511	01Jan2001, 12:29	3686	01Jan2001, 12:28	5137	01Jan2001, 12:27
JEBLDN080	1007	01Jan2001, 12:21	1890	01Jan2001, 12:26	2518	01Jan2001, 12:30	3695	01Jan2001, 12:29	5144	01Jan2001, 12:28
JEBLDN090	1106	01Jan2001, 12:39	2146	01Jan2001, 12:37	2628	01Jan2001, 12:53	3765	01Jan2001, 12:53	5207	01Jan2001, 12:53
JEBLDN090a	610	01Jan2001, 12:39	1200	01Jan2001, 12:37	1470	01Jan2001, 12:53	2084	01Jan2001, 12:53	2808	01Jan2001, 12:53
JEBLDN100a	670	01Jan2001, 12:44	1313	01Jan2001, 12:43	1570	01Jan2001, 12:38	2107	01Jan2001, 13:09	2394	01Jan2001, 13:31
JEBLDN100	742	01Jan2001, 12:42	1471	01Jan2001, 12:38	1810	01Jan2001, 12:32	2295	01Jan2001, 12:27	2921	01Jan2001, 12:23
Confluence w/ CR	745	01Jan2001, 12:47	1483	01Jan2001, 12:43	1829	01Jan2001, 12:39	2341	01Jan2001, 12:31	2995	01Jan2001, 12:27

Junction Name	Peak Flow Change from Pre-Project					% Change from Pre-Project					
	2-year	10-year	25-year	100-year	500-year	2-year	10-year	25-year	100-year	500-year	
JEBLDN070	0	0	0	0	0	0.00%	0.00%	0.00%	0.00%	0.00%	JEBLDN070
J_LiveOak	0	0	0	0	0	0.00%	0.00%	0.00%	0.00%	0.00%	J_LiveOak
J_Crockett	0	0	0	0	0	0.00%	0.00%	0.00%	0.00%	0.00%	J_Crockett
J_Johanna	4	6	6	14	27	0.49%	0.34%	0.29%	0.42%	0.59%	J_Johanna
J_Mary	7	10	11	25	41	0.85%	0.61%	0.48%	0.75%	0.87%	J_Mary
J_Annie	-3	-4	-6	-10	-10	-0.32%	-0.20%	-0.26%	-0.27%	-0.21%	J_Annie
J_Milton	-3	-4	-6	-9	-11	-0.31%	-0.22%	-0.26%	-0.24%	-0.22%	J_Milton
J_Monroe	-3	-6	-8	-9	-11	-0.32%	-0.33%	-0.31%	-0.23%	-0.21%	J_Monroe
JEBLDN080	-3	-6	-7	-9	-11	-0.33%	-0.30%	-0.29%	-0.24%	-0.22%	JEBLDN080
JEBLDN090	-3	-9	-7	-9	-12	-0.23%	-0.39%	-0.27%	-0.24%	-0.22%	JEBLDN090
JEBLDN090a	-1	-5	-4	-5	-3	-0.23%	-0.40%	-0.26%	-0.23%	-0.11%	JEBLDN090a
JEBLDN100a	-1	-3	2	-4	0	-0.16%	-0.23%	0.11%	-0.17%	0.00%	JEBLDN100a
JEBLDN100	-1	0	3	3	2	-0.12%	0.00%	0.18%	0.14%	0.08%	JEBLDN100
Confluence w/ CR	-1	0	4	3	3	-0.11%	0.01%	0.19%	0.14%	0.09%	Confluence w/ CR

Junction Name	ESD Revised OCT 2020 Pre-Project - Ultimate Development Conditions									
	Peak Flow (cfs) and Time to Peak (hour)									
	2-year		10-year		25-year		100-year		500-year	
	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time
JEBLDN070	693	01Jan2001, 12:19	1427	01Jan2001, 12:24	1975	01Jan2001, 12:22	2920	01Jan2001, 12:21	3996	01Jan2001, 12:19
J_LiveOak	748	01Jan2001, 12:19	1481	01Jan2001, 12:28	2041	01Jan2001, 12:27	2966	01Jan2001, 12:26	4090	01Jan2001, 12:24
J_Crockett	829	01Jan2001, 12:20	1598	01Jan2001, 12:27	2192	01Jan2001, 12:27	3184	01Jan2001, 12:25	4401	01Jan2001, 12:24
J_Johanna	877	01Jan2001, 12:19	1662	01Jan2001, 12:26	2271	01Jan2001, 12:27	3322	01Jan2001, 12:26	4602	01Jan2001, 12:24
J_Mary	904	01Jan2001, 12:20	1707	01Jan2001, 12:27	2325	01Jan2001, 12:28	3399	01Jan2001, 12:26	4715	01Jan2001, 12:24
J_Annie	989	01Jan2001, 12:20	1823	01Jan2001, 12:24	2450	01Jan2001, 12:28	3585	01Jan2001, 12:27	4979	01Jan2001, 12:24
J_Milton	994	01Jan2001, 12:20	1831	01Jan2001, 12:25	2457	01Jan2001, 12:29	3593	01Jan2001, 12:27	4991	01Jan2001, 12:25
J_Monroe	1058	01Jan2001, 12:20	1930	01Jan2001, 12:24	2556	01Jan2001, 12:29	3729	01Jan2001, 12:28	5181	01Jan2001, 12:27
JEBLDN080	1063	01Jan2001, 12:21	1938	01Jan2001, 12:25	2564	01Jan2001, 12:29	3738	01Jan2001, 12:29	5188	01Jan2001, 12:28
JEBLDN090	1189	01Jan2001, 12:37	2218	01Jan2001, 12:36	2682	01Jan2001, 12:52	3816	01Jan2001, 12:53	5254	01Jan2001, 12:53
JEBLDN090a	657	01Jan2001, 12:37	1241	01Jan2001, 12:36	1499	01Jan2001, 12:52	2112	01Jan2001, 12:53	2820	01Jan2001, 12:53
JEBLDN100a	719	01Jan2001, 12:43	1357	01Jan2001, 12:42	1595	01Jan2001, 12:37	2133	01Jan2001, 13:09	2395	01Jan2001, 13:30
JEBLDN100	798	01Jan2001, 12:41	1519	01Jan2001, 12:38	1843	01Jan2001, 12:34	2329	01Jan2001, 12:27	2959	01Jan2001, 12:22
Confluence w/ CR	800	01Jan2001, 12:46	1529	01Jan2001, 12:43	1862	01Jan2001, 12:38	2376	01Jan2001, 12:31	3034	01Jan2001, 12:27

Junction Name	Prop Alternative 4 (Prop Crockett storm drain system to Johanna/EBC, Prop Mary, no detention) - Ultimate Conditions									
	Peak Flow (cfs) and Time to Peak (hour)									
	2-year		10-year		25-year		100-year		500-year	
	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time	Peak Flow	Time
JEBLDN070	693	01Jan2001, 12:19	1427	01Jan2001, 12:24	1975	01Jan2001, 12:22	2920	01Jan2001, 12:21	3996	01Jan2001, 12:19
J_LiveOak	748	01Jan2001, 12:19	1481	01Jan2001, 12:28	2041	01Jan2001, 12:27	2966	01Jan2001, 12:26	4090	01Jan2001, 12:24
J_Crockett	829	01Jan2001, 12:20	1598	01Jan2001, 12:27	2192	01Jan2001, 12:27	3184	01Jan2001, 12:25	4401	01Jan2001, 12:24
J_Johanna	881	01Jan2001, 12:19	1668	01Jan2001, 12:26	2276	01Jan2001, 12:27	3338	01Jan2001, 12:25	4630	01Jan2001, 12:24
J_Mary	912	01Jan2001, 12:20	1718	01Jan2001, 12:26	2336	01Jan2001, 12:28	3426	01Jan2001, 12:26	4756	01Jan2001, 12:24
J_Annie	985	01Jan2001, 12:20	1819	01Jan2001, 12:25	2443	01Jan2001, 12:28	3577	01Jan2001, 12:26	4968	01Jan2001, 12:24
J_Milton	990	01Jan2001, 12:20	1826	01Jan2001, 12:25	2450	01Jan2001, 12:29	3586	01Jan2001, 12:27	4980	01Jan2001, 12:25
J_Monroe	1054	01Jan2001, 12:20	1922	01Jan2001, 12:25	2548	01Jan2001, 12:29	3722	01Jan2001, 12:28	5170	01Jan2001, 12:27
JEBLDN080	1059	01Jan2001, 12:21	1930	01Jan2001, 12:25	2555	01Jan2001, 12:29	3730	01Jan2001, 12:29	5176	01Jan2001, 12:28
JEBLDN090	1186	01Jan2001, 12:37	2209	01Jan2001, 12:36	2674	01Jan2001, 12:52	3807	01Jan2001, 12:53	5243	01Jan2001, 12:53
JEBLDN090a	655	01Jan2001, 12:37	1236	01Jan2001, 12:36	1495	01Jan2001, 12:52	2107	01Jan2001, 12:53	2817	01Jan2001, 12:53
JEBLDN100a	717	01Jan2001, 12:43	1354	01Jan2001, 12:42	1596	01Jan2001, 12:37	2129	01Jan2001, 13:09	2395	01Jan2001, 13:30
JEBLDN100	796	01Jan2001, 12:41	1519	01Jan2001, 12:37	1846	01Jan2001, 12:34	2332	01Jan2001, 12:27	2962	01Jan2001, 12:22
Confluence w/ CR	799	01Jan2001, 12:46	1530	01Jan2001, 12:43	1865	01Jan2001, 12:38	2379	01Jan2001, 12:31	3036	01Jan2001, 12:27

Junction Name	Peak Flow Change from Pre-Project					% Change from Pre-Project					
	2-year	10-year	25-year	100-year	500-year	2-year	10-year	25-year	100-year	500-year	
JEBLDN070	0	0	0	0	0	0.00%	0.00%	0.00%	0.00%	0.00%	JEBLDN070
J_LiveOak	0	0	0	0	0	0.00%	0.00%	0.00%	0.00%	0.00%	J_LiveOak
J_Crockett	0	0	0	0	0	0.00%	0.00%	0.00%	0.00%	0.00%	J_Crockett
J_Johanna	4	6	5	16	27	0.50%	0.36%	0.24%	0.49%	0.60%	J_Johanna
J_Mary	8	11	11	27	41	0.86%	0.64%	0.46%	0.78%	0.87%	J_Mary
J_Annie	-4	-5	-8	-8	-11	-0.35%	-0.26%	-0.31%	-0.22%	-0.22%	J_Annie
J_Milton	-4	-5	-7	-7	-11	-0.38%	-0.27%	-0.28%	-0.19%	-0.22%	J_Milton
J_Monroe	-4	-8	-8	-8	-11	-0.37%	-0.40%	-0.32%	-0.20%	-0.21%	J_Monroe
JEBLDN080	-4	-8	-9	-8	-11	-0.36%	-0.42%	-0.35%	-0.22%	-0.22%	JEBLDN080
JEBLDN090	-3	-9	-8	-9	-12	-0.27%	-0.40%	-0.28%	-0.24%	-0.22%	JEBLDN090
JEBLDN090a	-2	-5	-4	-5	-3	-0.29%	-0.41%	-0.27%	-0.24%	-0.11%	JEBLDN090a
JEBLDN100a	-2	-3	2	-3	0	-0.21%	-0.20%	0.12%	-0.15%	0.00%	JEBLDN100a
JEBLDN100	-1	0	3	3	3	-0.15%	0.01%	0.17%	0.12%	0.08%	JEBLDN100
Confluence w/ CR	-1	1	4	3	3	-0.12%	0.03%	0.19%	0.13%	0.09%	Confluence w/ CR