BLEYL ENGINEERING
PLANNING • DESIGN • MANAGEMENT

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2/14/20

Mr. Kevin Lacy
Lake Conroe Association
P.O. Box 376
Willis, TX 77378

Re: Lake Conroe Lowering Analysis

Mr. Lacy:

Background

The City of Houston and the surrounding region has, within the last few years, seen numerous storm events that have caused widespread flooding. The frequency and severity of the flooding has caused an increase in public awareness of the region's proneness to flooding and of potential causes of negative impacts to flood levels. One event in particular, Hurricane Harvey, has caused a focused awareness of the relationship between upstream drainage infrastructure and their impact to downstream flood levels. Specifically, the Lake Conroe Dam and its relationship to flood levels along the West Fork of the San Jacinto River ("West Fork") has been put under public scrutiny.

In response to the widespread flood damage caused by Hurricane Harvey, Lyle Larson, Chair of the Texas House of Representatives Committee on Natural Resources, requested that the San Jacinto River Authority ("SJRA") investigate the flood benefits obtained from lowering the normal pool level of Lake Conroe (201 ft-msl) by two to three feet. SJRA, in turn, hired Freese and Nichols, Inc ("FNI") to perform this analysis. Based on this scientific study, and other non-scientific factors, the SJRA and City of Houston agreed to seasonally lower the normal pool level of Lake Conroe by two feet in the summer in order to gain additional flood storage in the lake prior to the commencement of hurricane season. This is intended to potentially reduce downstream flows and downstream flood levels during heavy rain events associated with hurricanes for the purpose of mitigating flood damage along the West Fork and to provide downstream relief to the dredging efforts along the West Fork. However, disagreements among upstream and downstream home owners, as well as those in regional political leadership, have arisen as to the effectiveness of this strategy and the benefits compared to the costs.

The purpose of this study is to provide a second, objective professional engineering opinion to the effectiveness of the lake lowering flood mitigation strategy by checking the validity of the FNI analysis and its conclusions and by evaluating any immediately available hydrologic and hydraulic data for the West Fork watershed. A secondary objective of this study is to spread additional light on the situation that may not have been previously discussed in the FNI report.

Freese and Nichols, Inc Analysis
The report, *Lake Conroe Dam Gate Operations Modification Analysis*, was completed in April of 2018 by FNI. The report specifically analyzed the reduction in downstream flood elevations in the West Fork due to the lowering of the normal pool elevation of Lake Conroe by two and three feet (mean sea level).

The study utilized the existing SJRA gate operation procedures to develop lake outflow hydrographs (flow rate of water as a function of time) for three different scenarios: a starting normal pool elevation for Lake Conroe at (1) 201 ft-msl, (2) 199 ft-msl, and (3) 198 ft-msl. For the 199 ft-msl normal pool scenario (the scenario currently being implemented by SJRA), the reduction to the peak outflow rates are 5,827 cubic feet per second ("cfs") and 11,183 cfs for the 1-percent annual chance ("100-year") and the 0.2-percent annual chance ("500-year") storm events respectively. Additionally, the time to peak for the outflow hydrographs were increased by 7.5 and 5.5 hours for the 100-year and 500-year storm events respectively.

The analysis then took the peak flow rate for each resulting outflow hydrograph and modeled them in a 1-dimensional steady-state hydraulic model. The hydraulic model determined the 100-year and 500-year water surface elevations along the West Fork for the three scenarios from a location just downstream of the Lake Conroe Dam to a point just upstream of the IH-45 bridge (see **Appendix A – West Fork Overall**). The results from the hydraulic model for the 199-ft-msl scenario show an average reduction of 1-ft to the water surface elevation of the West Fork between the Lake Conroe Dam and IH-45 for both the 100-year and 500-year storm events. Due to the moderately steep topography along this stretch of the West Fork, the mapped floodplain comparison for the 201 ft-msl and 199 ft-msl storm events, provided in the FNI study, show minimal reduction to the floodplain extents between Lake Conroe and IH-45.

We generally agree with the methodology of the study. However, some limitations of the study should be noted.

First, the 24-hour precipitation estimates used in the study are generally consistent with the statistical rainfall data produced in the USGS Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas, 2004. Rainfall statistics for Texas have since been updated with the release of Atlas 14, Volume 11 in 2018. The estimated 100-year and 500-year 24-hour rainfall depths have increased by 37% and 34% respectively at Lake Conroe when compared to the estimates used in the FNI study. For general comparison, the 500-year event of 17.5 inches over 24-hours is used in the FNI report while the 100-year Atlas 14 storm event is 15.8 inches over 24-hours. In other words, the "new" Atlas 14 100-year storm event flows and water surface elevations can be estimated by using the "old" 500-year storm event flows and water surface elevations.

Secondly, the FNI study was limited to the section of the West Fork between the Lake Conroe Dam and IH-45. Therefore, flood reduction benefits for the region south of IH-45 cannot be determined based solely on the FNI study. While inferences on the impact to the West Fork flood levels downstream of IH-45 can be drawn from this data, the study does not make any such inferences. So, the conclusions found in the FNI study are only applicable to the region between the Lake Conroe Dam and IH-45.

Thirdly, the steady state hydraulic model used peak flows produced at the Lake Conroe Dam for each normal pool lowering scenario. Therefore, it does not appear that reduction in storage in the floodplain resulting from a lower water surface elevation was considered. As the water surface elevation in the West Fork is reduced, so is the available floodplain storage. The steady state model does not account for this reduction in floodplain storage. So, the reduction in the water surface elevations in the West Fork are slightly overestimated.

Considering that the Atlas 14, Volume 11 100-year rainfall is close to the 500-year rainfall used in the FNI study, that the 500-year event in the FNI study resulted in a 1-ft rise, and that the resulting 500-year floodplain delineations showed minimal reduction to the floodplain extents, we agree with the conclusion of the FNI study that the lowering of the Lake Conroe normal pool elevation to 199 ft-msl is "generally not enough to be considered wholesale improvements to the flood hazard" in the region of the West Fork between Lake Conroe and IH-45.

Based solely on the FNI study, there is no information provided to fully understand the effects that the seasonal lake lowering will have on flood levels downstream of IH-45.

Additional Analysis

Bleyl Engineering ("Bleyl") reached out to SJRA, City of Conroe, and Harris County Flood Control District ("HCFCD") to obtain any immediately available data for the entire West Fork. Bleyl performed additional limited analysis based on the FNI report and the other publicly available data provided by City of Conroe and HCFCD such as:

1. FEMA Flood Insurance Rate Maps ("FIRM")
2. FEMA Flood Insurance Rate Studies ("FIS")
3. Harris County Flood Control District hydraulic models
4. Hydrologic and hydraulic models associated with the Flood Protection Study and Early Warning System Project for the West Fork completed by Halff and Associates for the City of Conroe and SJRA.

Our analysis first included the flow rate reduction of 5,827 cfs for the 100-year storm event and 11,833 cfs for the 500-year storm event, as determined in the FNI study, at the Lake Conroe Dam and applied these reductions to the HCFCD steady state hydraulic model for the West Fork between US-59 and Lake Houston (see **Attachment A – West Fork Overall**). **Table 1** below shows the reduction in the flow rate, water surface elevation, and resulting flood plain extent top widths for the 100-year and 500-year storm events as compared to the values provided in the HCFCD hydraulic model.

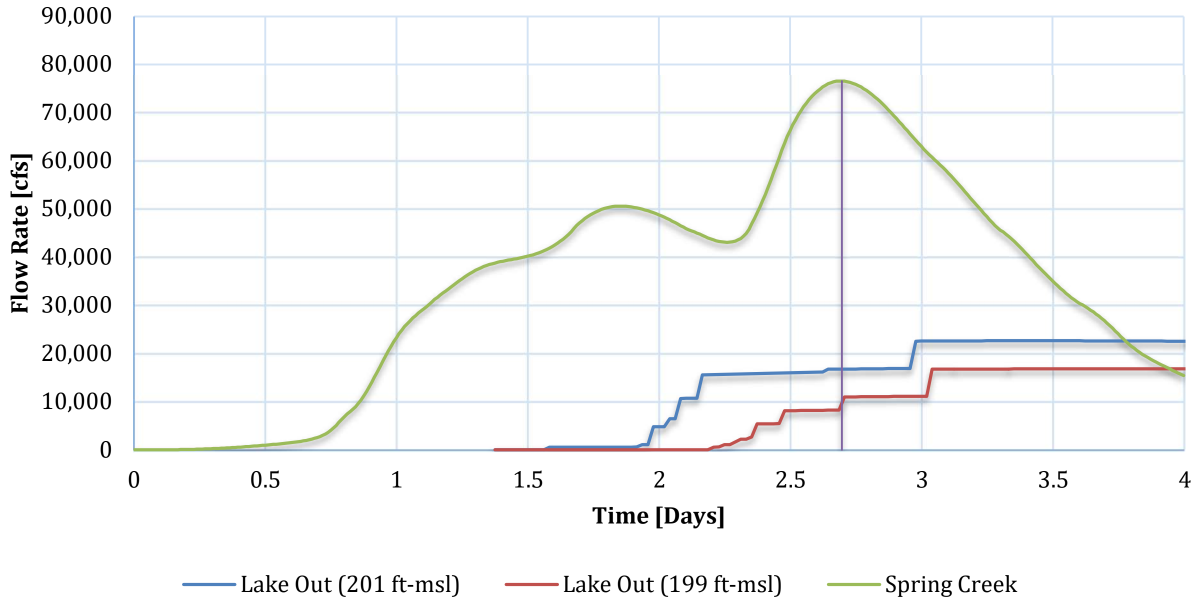
Table 1 – Water Surface Elevation and Flood Extent Reductions

	Flow Rate cfs / (% total)	Max WSEL ft. / (% total)	Avg WSEL ft. / (% total)	Min WSEL Ft. / (% total)	Avg Top Width ft. / (% total)
100-Year Reduction	5,827 (3.4)	0.37 (0.54)	0.23 (0.39)	0 (0)	145 (0.15)
500-Year Reduction	11,833 (1.8)	0.35 (0.47)	0.25 (0.39)	0 (0)	33 (0.03)

One variable that is not accounted for when transposing the flow reduction downstream is that the loss of floodplain storage resulting from the lower water surface elevation along the West Fork will result in a lower flow reduction. The lower flood storage means the West Fork floodplain does not provide as much flow attenuation as the base scenario. Therefore, the flow reduction values of 5,827 cfs and 11,833 at US-59 are slightly higher than expected. To put it conversely, the higher outlet flows caused by raising the lake normal pool from 199 ft-msl to 201 ft-msl will cause the water surface elevation to rise along the West Fork thereby allowing some of that additional flow to be stored within the floodplain of the West Fork (mostly around the time of the crest of the West Fork). While this will reduce the flow reduction as flow travels downstream, the attenuation is likely negligible.

Another variable that is not considered is the lag in the Lake Conroe hydrograph that was caused by the additional storage provided in the lake during the rising limb of the Lake Conroe inflow hydrograph (7.5 hours for the 100-year and 5.5 hours for the 500-year). The impacts of this lag cannot be known without performing a full hydrologic study of the entire West Fork watershed and its tributaries (existing hydrologic models for the entire West Fork watershed were not made available for this analysis). By way of example, when comparing the Lake Conroe dam outflow hydrographs (translated downstream to the Spring Creek confluence) to the HCFCD Spring Creek confluence hydrograph, the peak of Spring Creek occurs later in the rising limb of the 201 ft-msl hydrograph than the 199 ft-msl hydrograph. While there is a lot of variability due to numerous watersheds contributing to the flows at US-59, the West Fork is the largest contributing watershed and, therefore, likely drives the hydrograph crest timing of the West Fork at US-59.

Figure 1 – Spring Creek and Lake Conroe Outlet Flow Rates



1. Lake Conroe outlet hydrographs are translated by 33 hours per FEMA FIS floodway tables

Regardless of the limitations mentioned above, the transposition of peak flow rates from the Lake Conroe Dam to US-59 is still a reasonable estimate for flood impacts caused by the seasonal lowering of Lake Conroe, given the available data. While there is a positive impact to the water surface elevations of West Fork from US-59 to Lake Houston, it is our professional opinion that these reductions, under the given storm characteristics, are still generally not enough to be considered wholesale improvements to the flood hazards along the West Fork.

Additional Considerations

It should be noted that the FEMA FIS has a peak 100-year flow rate at the Lake Conroe Dam of 83,249 cfs, and that the FEMA floodplain extents within Montgomery County are mapped based on this flow. This peak flow rate is 60,585 cfs more than the peak 100-year outflow rate in the FNI report. Additionally, according to the FEMA FIRMs, the 100-year water surface elevation for Lake Conroe is 203 ft-msl compared to the FNI 100-year water surface elevation of 205.73 ft-msl. In other words, Lake Conroe is currently providing additional storage as compared to the FIS and, in turn, is already providing reduction to the outlet flow rate by 73% as compared to the FEMA FIS. Based on a comparison of the Harris County FIS and the Montgomery County FIS summary of discharges for the West Fork, we believe this is also true of the Harris County FIS and the delineated floodplains along the West Fork in Harris County.

It should also be noted that the FEMA FIS studies, the HCFCD models (used to map the FEMA special flood hazard areas in Harris County), and the hydrologic model used to compute the inflow and outflow hydrographs in the FNI study are all based on synthetic (i.e. manmade) 24-hour storm events. They do not, and cannot, consider every hypothetical storm event. There are likely hypothetical storm events that cause greater or lower impacts than what is shown in this study. Additional storm events (e.g. squall line, Tropical Storm Imelda, Hurricane Harvey, etc.) could be modeled to provide a conglomerate idea of flood reductions.

Finally, as shown on the FEMA FIRMs, the Kingwood area is located just upstream of Lake Houston and also near the confluence of several creeks and rivers including Spring Creek, the West Fork of the San Jacinto River, and the East Fork of the San Jacinto River. Due to its location, this area is sensitive to extreme storm events, and flooding levels can be impacted by various factors such as:

1. Duration, intensity, and direction of storm events in the upstream watersheds (an intense frontal system moving southeast versus a long duration hurricane moving northwest),
2. Differences in watershed responses to regional storms (e.g. creeks with smaller watersheds cresting before creeks with larger watersheds),
3. Cumulative increases in impervious cover due to development in upstream watersheds increasing both volume and timing of runoff,
4. Detention mitigation regulations and policies in upstream watersheds,
5. Floodplain development regulations and policies both downstream and upstream of the region,
6. The construction of upstream drainage infrastructure such as bridges, culverts, fixed outlet lakes, etc. (attenuating runoff),
7. Lake Conroe outlet flows controlled by gate operation procedures (change in flow rate of the West Fork),
8. Lake Houston water level controlled by gate operation procedures (change in tailwater conditions for all inlet creeks).

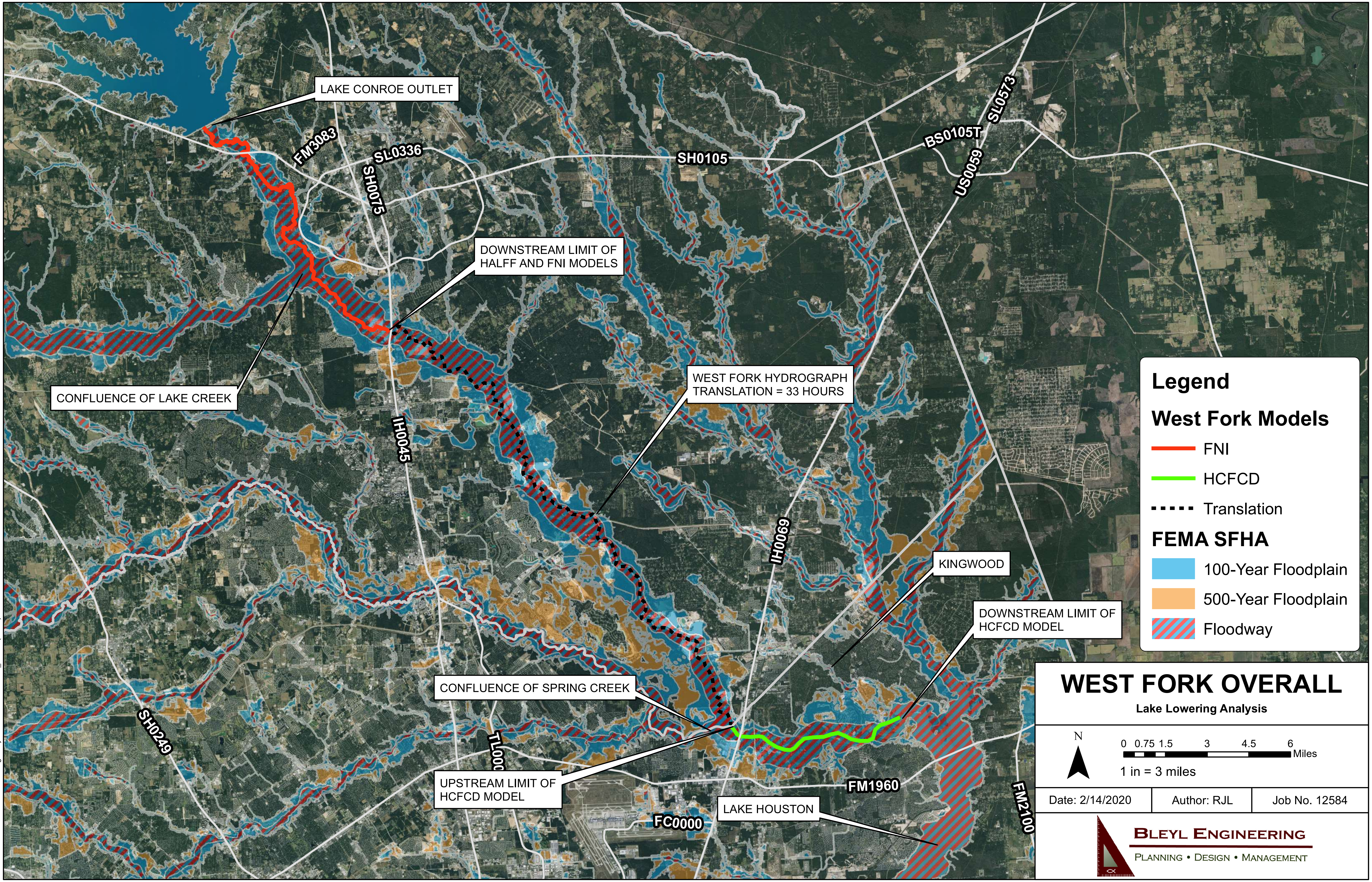
Due to the large number of variables, a holistic understanding of the entire watershed for the West Fork needs to be achieved in order to accurately determine the effectiveness of flood mitigation strategies, especially the seasonal lowering of the normal pool of Lake Conroe. Currently, HCFCD is leading a study of the entire West Fork watershed that will likely be able to provide a holistic understanding of the watershed and may possibly be used as a base for analyzing the effectiveness of various flood mitigation efforts. This study is expected to be complete in the Fall of 2020.

Sincerely,

Ryan Londeen, PE
Hydrology & Hydraulics Design Engineer
Bleyl Engineering

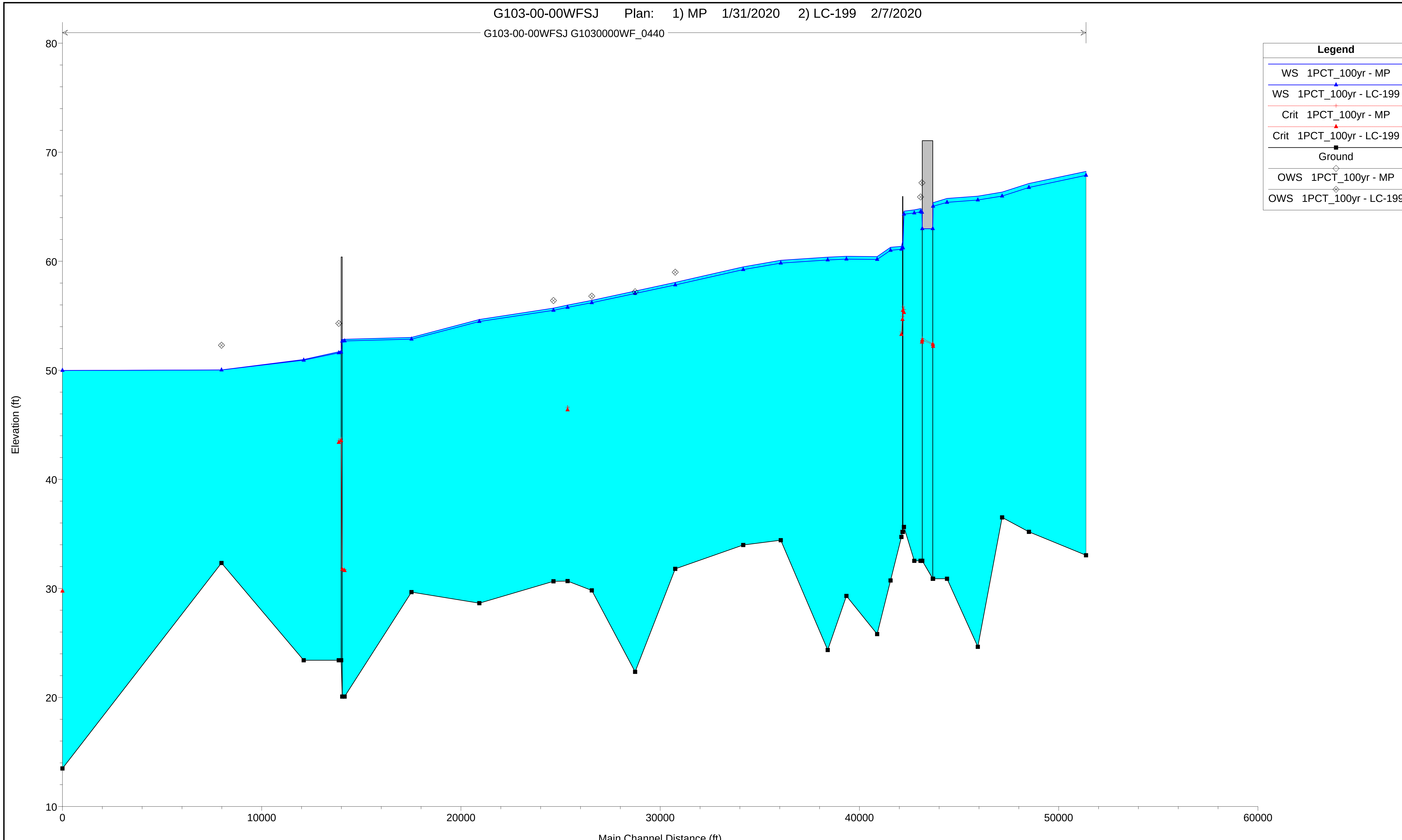
STATE OF TEXAS
RYAN J. LONDEEN
127074
LICENSED PROFESSIONAL ENGINEER
2-14-2020

Attachment A
West Fork Overall



F:\12500\12584 Lake Conroe Lowering Analysis\04 CAD\GIS\Master_Exhibit (11x17).mxd - 2/14/2020 12:27:37 AM

Attachment B
Supporting Calculations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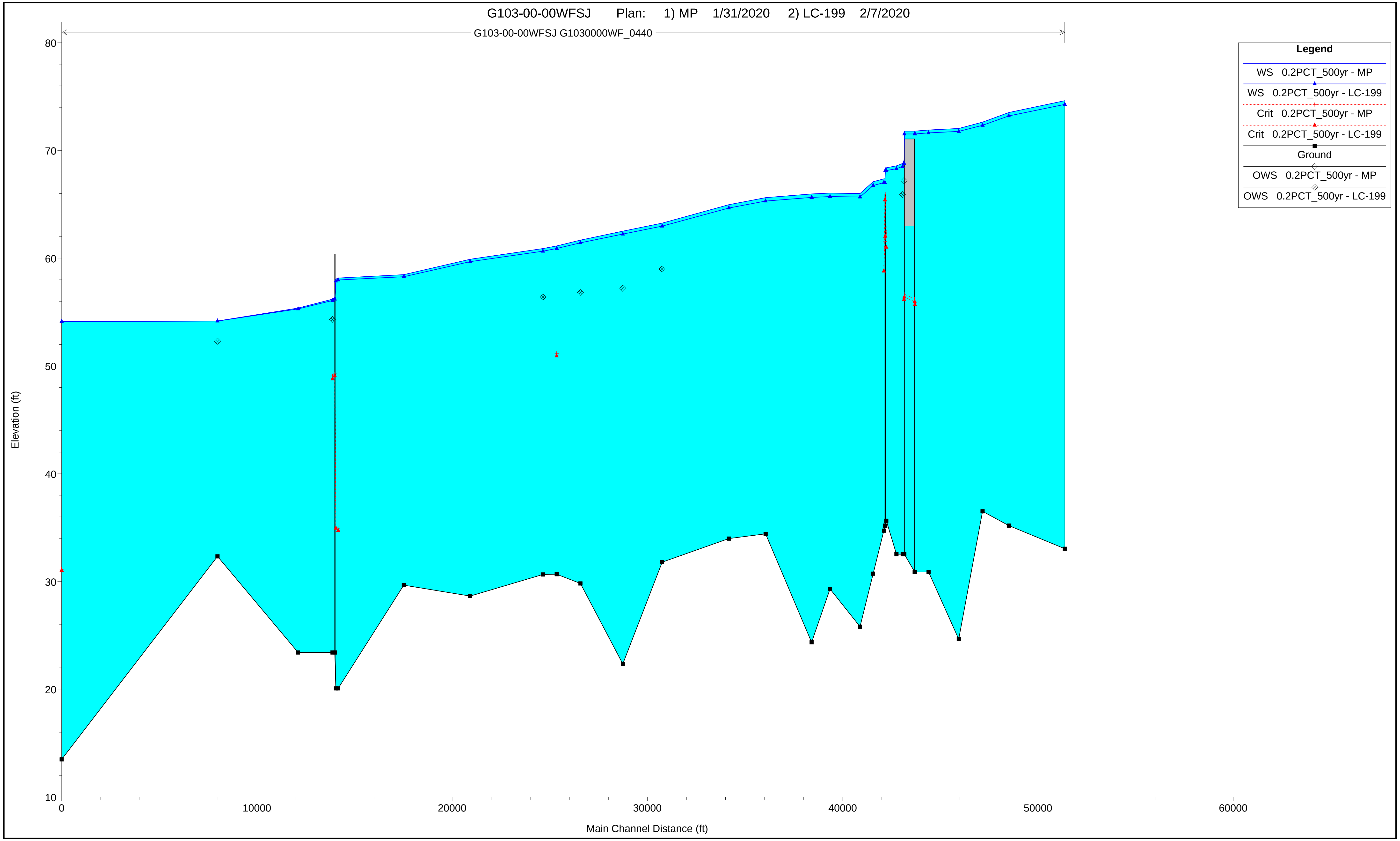
G103-00-00WFSJ G1030000WF_0440
Legend
WS 1PCT_100yr - MP
WS 1PCT_100yr - LC-199
Crit 1PCT_100yr - MP
Crit 1PCT_100yr - LC-199
Ground
OWS 1PCT_100yr - MP
OWS 1PCT_100yr - LC-199
Elevation (ft)
Main Channel Distance (ft)
80
70
60
50
40
30
20
10
0
10000
20000
30000
40000
50000
60000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G103-00-00WFSJ G1030000WF_0440
Legend
WS 0.2PCT_500yr - MP
WS 0.2PCT_500yr - LC-199
Crit 0.2PCT_500yr - MP
Crit 0.2PCT_500yr - LC-199
Ground
OWS 0.2PCT_500yr - MP
OWS 0.2PCT_500yr - LC-199
Elevation (ft)
Main Channel Distance (ft)
10
20
30
40
50
60
70
80
0
10000
20000
30000
40000
50000
60000

HEC-RAS River: G103-00-00WFSJ Reach: G1030000WF_0440 Profile: 1PCT_100yr

Reach	River Sta	Profile	Plan	Q Total	W.S. Elev	Top Width
				(cfs)	(ft)	(ft)
G1030000WF_0440	95419.06	1PCT_100yr	MP	165730.00	68.24	6280.01
G1030000WF_0440	95419.06	1PCT_100yr	LC-199	159903.00	67.88	6127.64
G1030000WF_0440	92550.84	1PCT_100yr	MP	165730.00	67.13	6980.07
G1030000WF_0440	92550.84	1PCT_100yr	LC-199	159903.00	66.77	6931.68
G1030000WF_0440	91206.56	1PCT_100yr	MP	165730.00	66.35	6409.01
G1030000WF_0440	91206.56	1PCT_100yr	LC-199	159903.00	65.98	6384.78
G1030000WF_0440	89987.87	1PCT_100yr	MP	165730.00	65.97	6861.80
G1030000WF_0440	89987.87	1PCT_100yr	LC-199	159903.00	65.62	6500.47
G1030000WF_0440	88441.26	1PCT_100yr	MP	167500.00	65.76	7689.79
G1030000WF_0440	88441.26	1PCT_100yr	LC-199	161673.00	65.40	7660.56
G1030000WF_0440	87742.76	1PCT_100yr	MP	167500.00	65.38	7995.03
G1030000WF_0440	87742.76	1PCT_100yr	LC-199	161673.00	65.04	7912.98
G1030000WF_0440	87463.61			Bridge		
G1030000WF_0440	87184.46	1PCT_100yr	MP	167500.00	64.77	7358.02
G1030000WF_0440	87184.46	1PCT_100yr	LC-199	161673.00	64.49	6771.39
G1030000WF_0440	87112.78	1PCT_100yr	MP	167560.00	64.83	7890.56
G1030000WF_0440	87112.78	1PCT_100yr	LC-199	161733.00	64.54	7717.50
G1030000WF_0440	86799.31	1PCT_100yr	MP	167670.00	64.71	8107.54
G1030000WF_0440	86799.31	1PCT_100yr	LC-199	161843.00	64.42	7931.03
G1030000WF_0440	86280.02	1PCT_100yr	MP	167670.00	64.60	8952.25
G1030000WF_0440	86280.02	1PCT_100yr	LC-199	161843.00	64.32	8645.36
G1030000WF_0440	86216.96			Bridge		
G1030000WF_0440	86153.91	1PCT_100yr	MP	167670.00	61.37	7131.44
G1030000WF_0440	86153.91	1PCT_100yr	LC-199	161843.00	61.10	7071.86
G1030000WF_0440	85606.07	1PCT_100yr	MP	167890.00	61.28	6805.81
G1030000WF_0440	85606.07	1PCT_100yr	LC-199	162063.00	61.00	6770.66
G1030000WF_0440	84932.06	1PCT_100yr	MP	168090.00	60.43	6280.85
G1030000WF_0440	84932.06	1PCT_100yr	LC-199	162263.00	60.17	6202.56
G1030000WF_0440	83393.67	1PCT_100yr	MP	168330.00	60.46	7556.28
G1030000WF_0440	83393.67	1PCT_100yr	LC-199	162503.00	60.20	7438.29
G1030000WF_0440	82452.94	1PCT_100yr	MP	169330.00	60.38	8254.64
G1030000WF_0440	82452.94	1PCT_100yr	LC-199	163503.00	60.12	8180.77
G1030000WF_0440	80095.81	1PCT_100yr	MP	169330.00	60.09	9942.01
G1030000WF_0440	80095.81	1PCT_100yr	LC-199	163503.00	59.83	9936.89

HEC-RAS River: G103-00-00WFSJ Reach: G1030000WF_0440 Profile: 1PCT_100yr (Continued)

Reach	River Sta	Profile	Plan	Q Total	W.S. Elev	Top Width
				(cfs)	(ft)	(ft)
G1030000WF_0440	78212.09	1PCT_100yr	MP	169330.00	59.49	8637.69
G1030000WF_0440	78212.09	1PCT_100yr	LC-199	163503.00	59.24	8590.91
G1030000WF_0440	74800.67	1PCT_100yr	MP	169770.00	58.06	6366.98
G1030000WF_0440	74800.67	1PCT_100yr	LC-199	163943.00	57.83	6355.38
G1030000WF_0440	72784.57	1PCT_100yr	MP	169770.00	57.27	10728.80
G1030000WF_0440	72784.57	1PCT_100yr	LC-199	163943.00	57.05	10532.76
G1030000WF_0440	70613.72	1PCT_100yr	MP	171000.00	56.41	10976.22
G1030000WF_0440	70613.72	1PCT_100yr	LC-199	165173.00	56.19	10776.65
G1030000WF_0440	69395.08	1PCT_100yr	MP	171000.00	55.98	13817.40
G1030000WF_0440	69395.08	1PCT_100yr	LC-199	165173.00	55.78	13531.57
G1030000WF_0440	68690.36	1PCT_100yr	MP	171000.00	55.71	12258.87
G1030000WF_0440	68690.36	1PCT_100yr	LC-199	165173.00	55.50	11671.12
G1030000WF_0440	64969.45	1PCT_100yr	MP	171320.00	54.66	8163.83
G1030000WF_0440	64969.45	1PCT_100yr	LC-199	165493.00	54.47	8049.30
G1030000WF_0440	61563.42	1PCT_100yr	MP	172610.00	53.01	8613.42
G1030000WF_0440	61563.42	1PCT_100yr	LC-199	166783.00	52.86	8603.51
G1030000WF_0440	58206.30	1PCT_100yr	MP	172610.00	52.84	7591.46
G1030000WF_0440	58206.30	1PCT_100yr	LC-199	166783.00	52.70	7230.43
G1030000WF_0440	58060.89			Bridge		
G1030000WF_0440	57915.48	1PCT_100yr	MP	172610.00	51.70	6584.26
G1030000WF_0440	57915.48	1PCT_100yr	LC-199	166783.00	51.60	6543.01
G1030000WF_0440	56153.38	1PCT_100yr	MP	173330.00	50.99	5669.12
G1030000WF_0440	56153.38	1PCT_100yr	LC-199	167503.00	50.93	5626.14
G1030000WF_0440	52026.90	1PCT_100yr	MP	174300.00	50.03	8229.66
G1030000WF_0440	52026.90	1PCT_100yr	LC-199	168473.00	50.03	8225.65
G1030000WF_0440	44044.71	1PCT_100yr	MP	214619.00	49.99	8768.77
G1030000WF_0440	44044.71	1PCT_100yr	LC-199	208792.00	49.99	8768.77

HEC-RAS River: G103-00-00WFSJ Reach: G1030000WF_0440 Profile: 0.2PCT_500yr

Reach	River Sta	Profile	Plan	Q Total	W.S. Elev	Top Width
				(cfs)	(ft)	(ft)
G1030000WF_0440	95419.06	0.2PCT_500yr	MP	299930.00	74.61	7487.62
G1030000WF_0440	95419.06	0.2PCT_500yr	LC-199	288747.00	74.27	7476.49
G1030000WF_0440	92550.84	0.2PCT_500yr	MP	299930.00	73.52	7961.72
G1030000WF_0440	92550.84	0.2PCT_500yr	LC-199	288747.00	73.20	7947.88
G1030000WF_0440	91206.56	0.2PCT_500yr	MP	299930.00	72.62	8214.36
G1030000WF_0440	91206.56	0.2PCT_500yr	LC-199	288747.00	72.33	8202.50
G1030000WF_0440	89987.87	0.2PCT_500yr	MP	299930.00	72.03	9087.36
G1030000WF_0440	89987.87	0.2PCT_500yr	LC-199	288747.00	71.77	8997.35
G1030000WF_0440	88441.26	0.2PCT_500yr	MP	306000.00	71.89	9651.81
G1030000WF_0440	88441.26	0.2PCT_500yr	LC-199	294817.00	71.63	9640.84
G1030000WF_0440	87742.76	0.2PCT_500yr	MP	306000.00	71.79	10098.84
G1030000WF_0440	87742.76	0.2PCT_500yr	LC-199	294817.00	71.53	10073.83
G1030000WF_0440	87463.61			Bridge		
G1030000WF_0440	87184.46	0.2PCT_500yr	MP	306000.00	69.09	9292.35
G1030000WF_0440	87184.46	0.2PCT_500yr	LC-199	294817.00	68.80	9217.65
G1030000WF_0440	87112.78	0.2PCT_500yr	MP	307140.00	68.79	9114.77
G1030000WF_0440	87112.78	0.2PCT_500yr	LC-199	295957.00	68.52	9085.02
G1030000WF_0440	86799.31	0.2PCT_500yr	MP	307570.00	68.57	9839.33
G1030000WF_0440	86799.31	0.2PCT_500yr	LC-199	296387.00	68.30	9734.31
G1030000WF_0440	86280.02	0.2PCT_500yr	MP	307570.00	68.39	10058.31
G1030000WF_0440	86280.02	0.2PCT_500yr	LC-199	296387.00	68.13	10048.89
G1030000WF_0440	86216.96			Bridge		
G1030000WF_0440	86153.91	0.2PCT_500yr	MP	307570.00	67.36	10031.06
G1030000WF_0440	86153.91	0.2PCT_500yr	LC-199	296387.00	67.01	10027.20
G1030000WF_0440	85606.07	0.2PCT_500yr	MP	308450.00	67.10	11117.28
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G1030000WF_0440	84932.06	0.2PCT_500yr	MP	310160.00	66.00	10476.97
G1030000WF_0440	84932.06	0.2PCT_500yr	LC-199	298977.00	65.68	10332.45
G1030000WF_0440	83393.67	0.2PCT_500yr	MP	309220.00	66.04	10269.39
G1030000WF_0440	83393.67	0.2PCT_500yr	LC-199	298037.00	65.72	10235.07
G1030000WF_0440	82452.94	0.2PCT_500yr	MP	314100.00	65.96	10502.30
G1030000WF_0440	82452.94	0.2PCT_500yr	LC-199	302917.00	65.64	10495.65
G1030000WF_0440	80095.81	0.2PCT_500yr	MP	314100.00	65.62	10727.99
G1030000WF_0440	80095.81	0.2PCT_500yr	LC-199	302917.00	65.30	10714.34

HEC-RAS River: G103-00-00WFSJ Reach: G1030000WF_0440 Profile: 0.2PCT_500yr (Continued)

Reach	River Sta	Profile	Plan	Q Total	W.S. Elev	Top Width
				(cfs)	(ft)	(ft)
G1030000WF_0440	78212.09	0.2PCT_500yr	MP	314100.00	64.96	9233.12
G1030000WF_0440	78212.09	0.2PCT_500yr	LC-199	302917.00	64.66	9223.71
G1030000WF_0440	74800.67	0.2PCT_500yr	MP	315820.00	63.25	7345.74
G1030000WF_0440	74800.67	0.2PCT_500yr	LC-199	304637.00	62.98	7338.58
G1030000WF_0440	72784.57	0.2PCT_500yr	MP	315820.00	62.51	12191.19
G1030000WF_0440	72784.57	0.2PCT_500yr	LC-199	304637.00	62.24	12159.66
G1030000WF_0440	70613.72	0.2PCT_500yr	MP	320030.00	61.68	14223.19
G1030000WF_0440	70613.72	0.2PCT_500yr	LC-199	308847.00	61.42	14116.60
G1030000WF_0440	69395.08	0.2PCT_500yr	MP	320030.00	61.14	17745.11
G1030000WF_0440	69395.08	0.2PCT_500yr	LC-199	308847.00	60.90	17736.10
G1030000WF_0440	68690.36	0.2PCT_500yr	MP	320030.00	60.89	17708.62
G1030000WF_0440	68690.36	0.2PCT_500yr	LC-199	308847.00	60.65	17679.12
G1030000WF_0440	64969.45	0.2PCT_500yr	MP	321900.00	59.91	11168.15
G1030000WF_0440	64969.45	0.2PCT_500yr	LC-199	310717.00	59.68	11090.35
G1030000WF_0440	61563.42	0.2PCT_500yr	MP	326970.00	58.47	10337.61
G1030000WF_0440	61563.42	0.2PCT_500yr	LC-199	315787.00	58.28	10306.40
G1030000WF_0440	58206.30	0.2PCT_500yr	MP	326970.00	58.15	13590.69
G1030000WF_0440	58206.30	0.2PCT_500yr	LC-199	315787.00	57.98	13565.07
G1030000WF_0440	58060.89			Bridge		
G1030000WF_0440	57915.48	0.2PCT_500yr	MP	326970.00	56.20	13741.19
G1030000WF_0440	57915.48	0.2PCT_500yr	LC-199	315787.00	56.08	13734.60
G1030000WF_0440	56153.38	0.2PCT_500yr	MP	329800.00	55.37	13374.56
G1030000WF_0440	56153.38	0.2PCT_500yr	LC-199	318617.00	55.29	13346.40
G1030000WF_0440	52026.90	0.2PCT_500yr	MP	333600.00	54.17	11145.26
G1030000WF_0440	52026.90	0.2PCT_500yr	LC-199	322417.00	54.17	11143.92
G1030000WF_0440	44044.71	0.2PCT_500yr	MP	369116.00	54.12	8926.61
G1030000WF_0440	44044.71	0.2PCT_500yr	LC-199	357933.00	54.12	8926.61

Peak Flow Rates for West Fork Between US-59 and Lake Conroe

1% Chance Return Event		
201 ft-msl	199 ft-msl	Reduction (%)
165,730	159,903	3.52%
167,500	161,673	3.48%
167,560	161,733	3.48%
167,670	161,843	3.48%
167,890	162,063	3.47%
168,090	162,263	3.47%
168,330	162,503	3.46%
169,330	163,503	3.44%
169,770	163,943	3.43%
171,000	165,173	3.41%
171,320	165,493	3.40%
172,610	166,783	3.38%
173,330	167,503	3.36%
174,300	168,473	3.34%
214,619	208,792	2.72%

0.2% Chance Return Event		
201 ft-msl	199 ft-msl	Reduction (%)
299,930	288,747	1.94%
306,000	294,817	1.90%
307,140	295,957	1.90%
307,570	296,387	1.89%
308,450	297,267	1.89%
310,160	298,977	1.88%
309,220	298,037	1.88%
314,100	302,917	1.86%
315,820	304,637	1.85%
320,030	308,847	1.82%
321,900	310,717	1.81%
326,970	315,787	1.78%
329,800	318,617	1.77%
333,600	322,417	1.75%
369,116	357,933	1.58%

*Base flows from HCFCD hydraulic model

Water Surface Elevations for West Fork Between US-59 and Lake Conroe

1% Chance Return Event		
Base Model (ft)	199 ft-msl (ft)	Reduction (in)
68.24	67.88	4.32
67.13	66.77	4.32
66.35	65.98	4.44
65.97	65.62	4.2
65.76	65.4	4.32
65.38	65.04	4.08
64.77	64.49	3.36
64.83	64.54	3.48
64.71	64.42	3.48
64.6	64.32	3.36
61.37	61.1	3.24
61.28	61	3.36
60.43	60.17	3.12
60.46	60.2	3.12
60.38	60.12	3.12
60.09	59.83	3.12
59.49	59.24	3
58.06	57.83	2.76
57.27	57.05	2.64
56.41	56.19	2.64
55.98	55.78	2.4
55.71	55.5	2.52
54.66	54.47	2.28
53.01	52.86	1.8
52.84	52.7	1.68
51.7	51.6	1.2
50.99	50.93	0.72
50.03	50.03	0
49.99	49.99	0

0.2% Chance Return Event		
Base Model (ft)	199 ft-msl (ft)	Reduction (in)
74.61	74.27	4.08
73.52	73.2	3.84
72.62	72.33	3.48
72.03	71.77	3.12
71.89	71.63	3.12
71.79	71.53	3.12
69.09	68.8	3.48
68.79	68.52	3.24
68.57	68.3	3.24
68.39	68.13	3.12
67.36	67.01	4.2
67.1	66.75	4.2
66	65.68	3.84
66.04	65.72	3.84
65.96	65.64	3.84
65.62	65.3	3.84
64.96	64.66	3.6
63.25	62.98	3.24
62.51	62.24	3.24
61.68	61.42	3.12
61.14	60.9	2.88
60.89	60.65	2.88
59.91	59.68	2.76
58.47	58.28	2.28
58.15	57.98	2.04
56.2	56.08	1.44
55.37	55.29	0.96
54.17	54.17	0
54.12	54.12	0

Max	68.24	67.88	4.44	0.54%
Min	49.99	49.99	0	0.00%
Avg	59.6	59.3	2.8	0.39%

Max	74.61	74.27	4.2	0.47%
Min	54.12	54.12	0	0.00%
Avg	64.8	64.6	3	0.39%

*Base water surface elevations from HCFCD hydraulic model

Flood Extents for West Fork Between US-59 and Lake Conroe

1% Chance Return Event		
Base Model (ft)	199 ft-msl (ft)	Reduction (in)
6280.01	6127.64	152.37
6980.07	6931.68	48.39
6409.01	6384.78	24.23
6861.8	6500.47	361.33
7689.79	7660.56	29.23
7995.03	7912.98	82.05
7358.02	6771.39	586.63
7890.56	7717.5	173.06
8107.54	7931.03	176.51
8952.25	8645.36	306.89
7131.44	7071.86	59.58
6805.81	6770.66	35.15
6280.85	6202.56	78.29
7556.28	7438.29	117.99
8254.64	8180.77	73.87
9942.01	9936.89	5.12
8637.69	8590.91	46.78
6366.98	6355.38	11.6
10728.8	10532.76	196.04
10976.22	10776.65	199.57
13817.4	13531.57	285.83
12258.87	11671.12	587.75
8163.83	8049.3	114.53
8613.42	8603.51	9.91
7591.46	7230.43	361.03
6584.26	6543.01	41.25
5669.12	5626.14	42.98
8229.66	8225.65	4.01
8768.77	8768.77	0

Max	13817.4	13531.57	587.75	0.35%
Min	5669.12	5626.14	0	0.00%
Avg	8169	8023.8	145.2	0.15%

0.2% Chance Return Event		
Base Model (ft)	199 ft-msl (ft)	Reduction (in)
7487.62	7476.49	11.13
7961.72	7947.88	13.84
8214.36	8202.5	11.86
9087.36	8997.35	90.01
9651.81	9640.84	10.97
10098.84	10073.83	25.01
9292.35	9217.65	74.7
9114.77	9085.02	29.75
9839.33	9734.31	105.02
10058.31	10048.89	9.42
10031.06	10027.2	3.86
11117.28	11100.34	16.94
10476.97	10332.45	144.52
10269.39	10235.07	34.32
10502.3	10495.65	6.65
10727.99	10714.34	13.65
9233.12	9223.71	9.41
7345.74	7338.58	7.16
12191.19	12159.66	31.53
14223.19	14116.6	106.59
17745.11	17736.1	9.01
17708.62	17679.12	29.5
11168.15	11090.35	77.8
10337.61	10306.4	31.21
13590.69	13565.07	25.62
13741.19	13734.6	6.59
13374.56	13346.4	28.16
11145.26	11143.92	1.34
8926.61	8926.61	0

Max	17745.11	17736.1	144.52	0.07%
Min	7345.74	7338.58	0	0.00%
Avg	10850.4	10817.1	33.3	0.03%

*Base flood extents from HCFCD hydraulic model