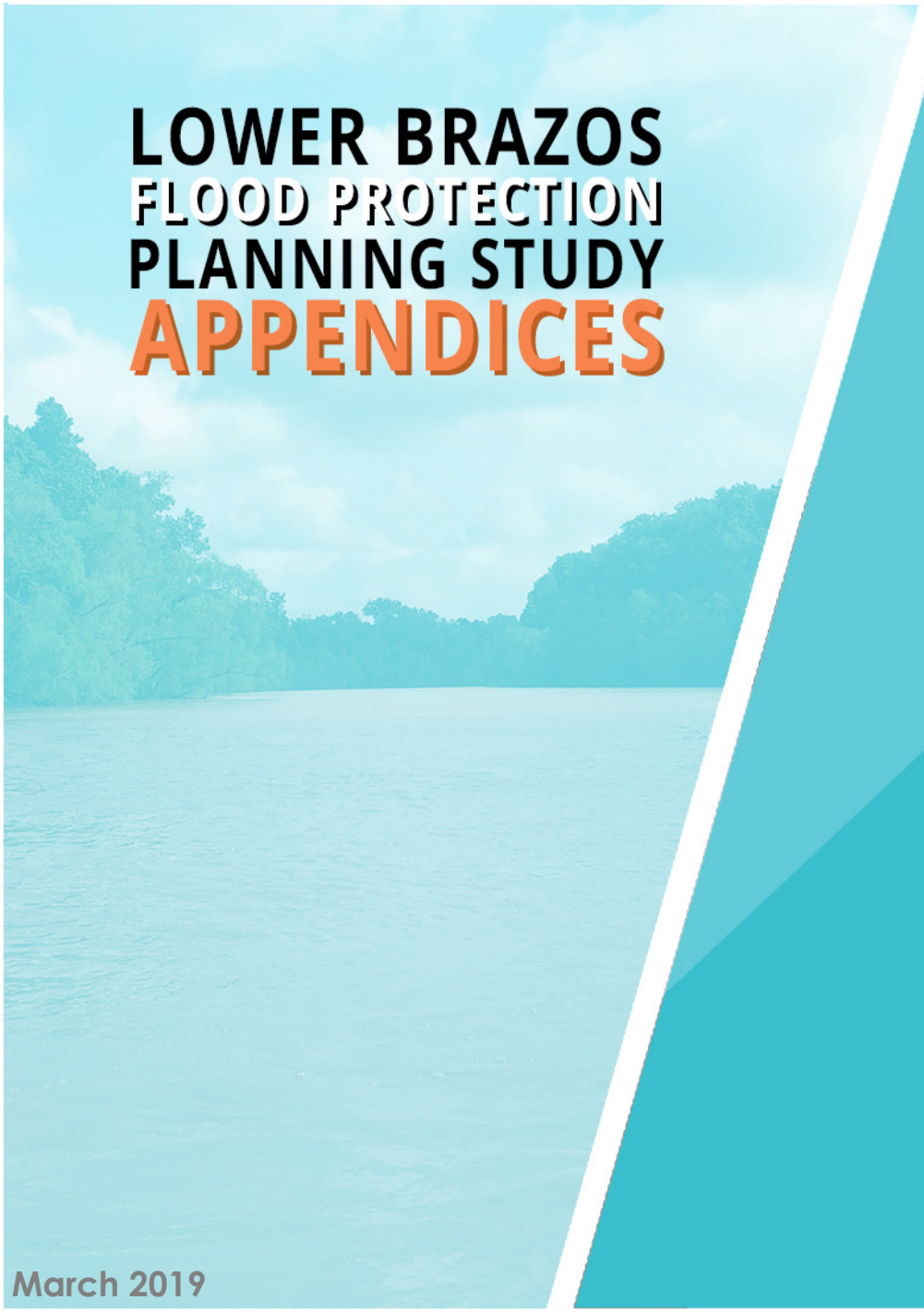
Appendix D:
Hydrologic Analysis



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Appendix D – Hydrologic Analysis

D.1.0 – Introduction

The total Brazos River Basin is approximately 44,620 square miles with 9,600 square miles classified as non-contributing according to the USGS. Exhibit D-1 presents the Lower Brazos River Basin project area. For the Lower Brazos Floodplain Protection Planning Study, the upper limits of the hydrologic model extended to the downstream face of the seven USACE projects (dams) as discussed in Appendix A. The upstream limit of the Brazos River mainstem is the downstream face of the Lake Whitney Dam. Major tributaries included in the hydrologic model study area include: the Navasota River, Little Brazos River, Brushy Creek, Big Elm Creek, Salado Creek, Davidson Creek, New Year Creek, Mill Creek, Big Creek, and Bessie's Creek Basins. Other major tributaries included in the study are Aquilla Creek downstream of Lake Aquilla, Leon River downstream of Lake Belton, Lampasas River downstream of Stillhouse Hollow Lake, San Gabriel River downstream of Lake Granger, and Yegua Creek downstream of Somerville Lake. The entire study drainage area is 9,766 square miles. The basin was divided into two study areas, shown below in Figure D-1. The upper portion (limited-detail study area) includes the 8,157 square mile area above the Hempstead Gauge (USGS Station ID 08111500). The lower portion (detailed study area) includes the 1,609 square miles below the Hempstead Gauge (USGS Station ID 08111500).

The hydrologic model calibration, period of record, and design storm were developed to produce inflow hydrographs for the unsteady HEC-RAS model. Figure D-2 provides the general workflow for the hydrologic and hydraulic analysis. The blue areas representing the hydrology modeling in Figure D-2 are discussed in this appendix. The red area representing the hydraulic modeling in Figure D-2 is discussed in Appendix E.

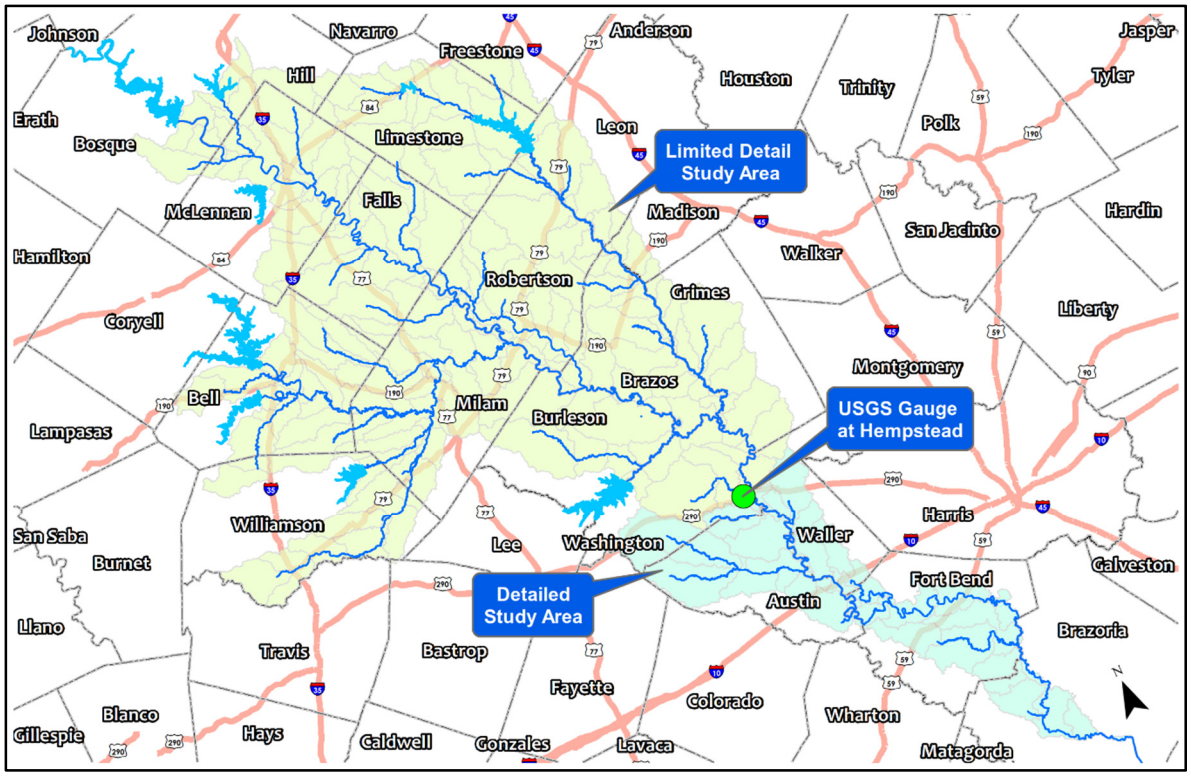


Figure D-1: Study Areas

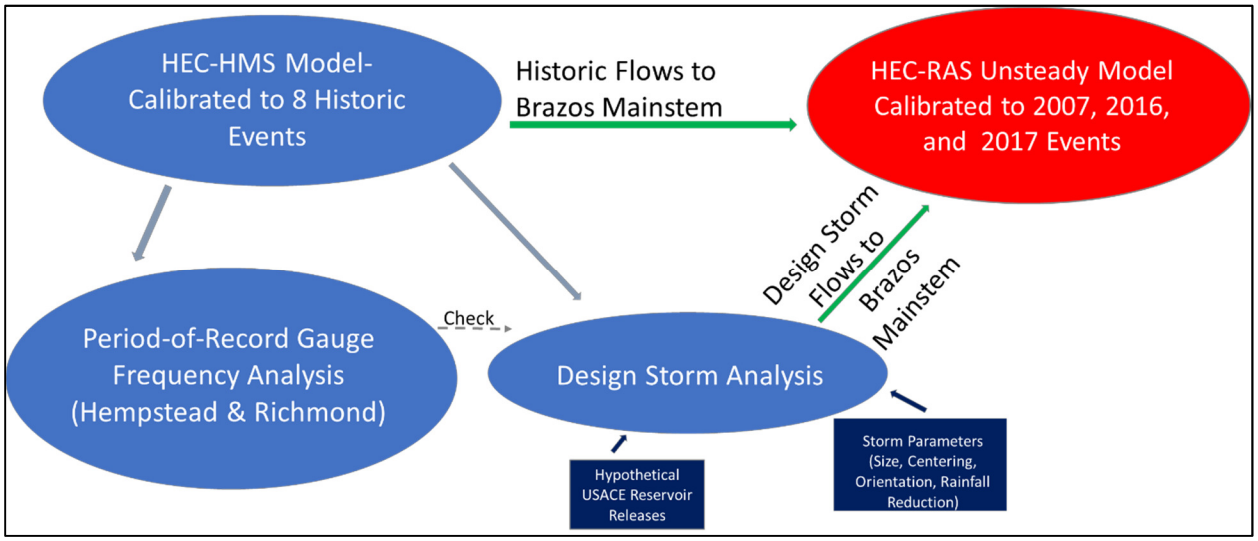


Figure D-2: Lower Brazos Workflow

D.2.0 Sub-Basin Delineation

Delineations of sub-basins for the hydrologic model were completed using HEC-GeoHMS Version 10.1, a GIS pre-processor for HEC-HMS. From LiDAR, 60-foot digital elevation model terrain data was generated and utilized for the sub-basin delineations. Stream centerlines were taken from

the National Hydrologic Dataset (NHD) and adjusted based on LiDAR and aerial photography. Basin boundaries were adjusted to coincide with major roads, NRCS dam locations, and USGS gauge locations. Overall, 154 sub-basins were delineated with areas ranging from 9.5 to 194 square miles and an average area of 63.4 square miles. The delineated sub-basins are shown in Exhibit D-2.

The sub-basin names are based on the creek and/or river names. A complete list of sub-basin abbreviations and corresponding creek/river name can be found in Table D-1. The sub-basins are numbered in increasing order generally from upstream to downstream per drainage basin name.

Table D-1: Sub-Basin Abbreviations and Corresponding Creek/River Names

Stream Code	Stream Name	Loss Method	Unit Hydrograph Method
BRA	Brazos River	Exponential	Clark
BIC	Big Creek	Exponential	Clark
BIG	Big Elm Creek	Initial & Constant	Snyder
BIN	Big Creek-North	Initial & Constant	Snyder
BRU	Brushy Creek	Initial & Constant	Snyder
DAV	Davidson Creek	Initial & Constant	Snyder
LAM	Lampasas River	Initial & Constant	Snyder
LEO	Leon River	Initial & Constant	Snyder
LIB	Little Brazos River	Initial & Constant	Snyder
LIT	Little River	Initial & Constant	Snyder
MIL	Mill Creek	Exponential	Clark
NAV	Navasota River	Initial & Constant	Snyder
NEW	New Year Creek	Initial & Constant	Snyder
NOL	Nolan Creek	Initial & Constant	Snyder
PON	Pond Creek	Initial & Constant	Snyder
SAL	Salado Creek	Initial & Constant	Snyder
SAN	San Gabriel River	Initial & Constant	Snyder
THE	Tehuacana Creek	Initial & Constant	Snyder
WAL	Walnut Creek	Initial & Constant	Snyder
YEG	Yegua Creek	Initial & Constant	Snyder

D.3.0 Initial Hydrologic Model Parameters

HEC-HMS Version 4.0 was utilized for the rainfall-runoff modeling for the Lower Brazos study area. Table D-1 above presents the selected loss method and unit hydrograph method for each study stream. Within the limited-detail study area, the initial and constant loss method was selected for the rainfall loss rate, and the Snyder's unit hydrograph method was selected for the unit hydrograph technique. Within the detailed study area, the exponential loss method was selected for the rainfall loss rate, and the Clark's unit hydrograph method was selected for the unit

hydrograph technique. The selected methods were chosen based on previous studies and successful application for other river basins near the Lower Brazos study area. Hydrologic routing for the mainstem Brazos and Navasota Rivers used Muskingum routing while all major tributaries in the limited-detail study area were developed using Modified Puls storage-outflow relationships computed with HEC-RAS Version 4.1. Major tributaries within the detailed study area utilize the Muskingum-Cunge Eight Point routing method. A complete summary of computed hydrologic parameters and calibrated parameters for each sub-basin is included at the end of Appendix D.

D.3.1 Initial and Constant Loss Rate Method

Initial weighted percent impervious values were determined by GIS methods for each sub-basin based on USGS Land Use Land Cover (LULC) maps (Exhibit D-3). The base initial loss (abstraction) was then assumed to be twenty percent of the storage for each sub-basin prior to calibration.

The constant loss rate represents the ultimate infiltration capacity of the soils. Constant (uniform) loss rates were based on soil type for each sub-basin using the NRCS Soil Survey Geographic (SSURGO) Database hydrologic soil group maps (Exhibit D-4). The range of constant loss rates for a given soil type are presented in Table D-2. Composite constant loss rates were computed using a weighted loss method based on the hydrologic soils within each sub-basin. Both the initial and constant loss rates were calibrated as part of the hydrologic model calibration efforts discussed later in this appendix.

Table D-2: Range of Constant Loss Rates Based on Soil Type

Soil Group	Description	Range of Constant Loss Rates [in/hr]	
		Min	Max
A	Deep sand, deep loess, aggregated silts	0.30	0.45
B	Shallow loess, sandy loam	0.15	0.30
C	Clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay	0.05	0.15
D	Soils that swell significantly when wet, heavy plastic clays, and certain saline soils	0.00	0.05

D.3.2 Exponential Loss Rate Method

The Exponential Loss Rate Method is an empirical method that relates loss rates to rainfall intensity and accumulated losses. This loss rate method requires calibration to determine the final model parameters. The five parameters associated with exponential loss are initial range, precipitation exponent, initial coefficient, coefficient ratio, and percent impervious (Source: Fort Bend Hydrology Manual).

1. Initial Range – the amount of initial accumulated infiltration during which the loss rate is increased. This parameter is a function primarily of antecedent soil moisture deficiency and is usually storm-dependent. An initial value of 0.0 was used for an initial range.
2. Initial Coefficient – specifies the starting loss rate coefficient on the exponential infiltration curve. It is assumed to be a function of infiltration characteristics and consequently may be correlated with soil type, land use, vegetation cover, and other properties of a sub-basin. A base value of 0.5 was used for the initial coefficient.
3. Coefficient Ratio – indicates the rate at which the exponential decrease in infiltration capability proceeds. It may be considered a function of the ability of the surface of a sub-basin to absorb precipitation and should be reasonably constant for large, homogenous areas. An initial value of 3.0 was used for the coefficient ratio.
4. Precipitation Exponent – reflects the influence of precipitation rate on sub-basin average loss characteristics. It reflects the way storms occur within an area and may be considered a characteristic of a region. The precipitation exponent varies from 0.0 to 1.0. An initial value of 0.6 was used for the Precipitation Exponent.
5. Percent Impervious – percentage of the sub-basin that is directly connected impervious area can be specified. No loss calculations are carried out on the impervious area. All precipitation on that portion of the sub-basin becomes excess precipitation and subject to direct runoff. Weighted percent impervious values were determined by GIS methods for each sub-basin based on USGS Land Use Land Cover (LULC) maps (Exhibit D-3).

D.3.3 Snyder's Unit Hydrograph Method

Snyder's unit hydrograph considers the time distribution of rainfall, the initial rainfall losses to interception and depression storage, and an infiltration rate that decreases during the storm (Source: USACE Engineering Manual (EM 1110-2-1405) *Flood-Hydrograph Analysis and Computations*). The two parameters associated with the Snyder's unit hydrograph are lag time and Snyder's peaking coefficient.

The Snyder's unit hydrograph utilizes the time to peak of the unit hydrograph in hours. The time to peak represents the lag time from the midpoint of the unit rainfall duration.

$$t_p = C_t\,(L\,L_{ca})^{0.3}$$

tp = Time to peak of unit hydrograph, hours

C_t = Snyder's peaking coefficients depending upon units and drainage basin characteristics derived by the USACE and others. Assumed to be 1.0 for the initial parameter estimation for this study.

L = River mileage from the given station to the upstream limits of the drainage area

L_{ca} = River mileage from the design point (basin discharge location) to the centroid of gravity of the drainage area

D.3.4 Clark's Unit Hydrograph Method

The three parameters associated with the Clark's unit hydrograph are time of concentration, storage coefficient, and a time-area curve. The time-area curve defines the cumulative area of the basin contributing to the design point as a function of time.

A statistical analysis of historical rainfall and runoff data taken from selected basins in the Fort Bend County vicinity was performed to correlate the time of concentration and storage coefficient to drainage area physiographic characteristics. These characteristics include the length, slope, and roughness of the basin's longest watercourse, the average basin slope, and the effective imperviousness of the basin.

$$TC = (TC + R) \times 0.38(\log S_o)$$

$$TC + R = (128\ (L/\sqrt{S})^{0.57}(N)^{0.8})/(S_o)^{0.11}(10)^{I}$$

$$R = (TC+R) - TC$$

TC = Clark's time of concentration, hours

R = Clark's storage coefficient, hours

L = Length of the longest watercourse within the drainage area, miles

S = Average slope along the area's longest watercourse, feet/mile

N = Manning's weighted roughness coefficient along the watercourse

S_o = Average basin slope of land draining overland into the longest watercourse, feet/mile

I = Effective impervious ratio

D.3.5 Modified Puls Routing

Modified Puls storage-outflow relationships were computed with HEC-RAS Version 4.1 for all major tributaries in the limited-detail study area. Limited-detail HEC-RAS Version 4.1 routing models were used to generate the storage-outflow relationships for major tributaries in the detailed study area.

LiDAR was used to generate hydraulic cross-sections for the Modified Puls routing reaches. HEC-GeoRAS, a GIS pre- and post-processor for HEC-RAS, was used along with the terrain data to generate cross-sections for over 900 miles of mainstem and tributary reaches in the routing models. Manning's n-values were assigned for the routing model cross-sections based on land use data (Exhibit D-3). Overbank n-values typically ranged from 0.023 for "ponded water" to 0.12 for "heavy industrial" land uses. Channel roughness coefficients ranged from 0.033 in wide developed channels to 0.055 in narrow, weedy channels. Bridges and culverts were not included in the routing models.

D.3.6 Muskingum Routing

Travel times along the Brazos and Navasota Rivers were found to be long when using Modified Puls Routing for historical storm calibration. These travel times were sometimes days behind the observed peaks. For historical storm calibration, observed travel times were utilized to develop Muskingum Routing parameters. Velocities along the Brazos River range from 2 to 5 feet per second while velocities along the Navasota River range from 1 to 2.5 feet per second. The Muskingum K value is a storage constant representing the ration between storage and discharge. The Muskingum X value is dimensionless and represents the importance of inflow and outflow to storage. A summary of Muskingum Routing parameters is shown in Table D-3, below.

Table D-3: Summary of Muskingum Parameters

Creek/River	HMS Element	Calibration Zone	K, hr	X	No. of Subreaches
Big Elm	R_BIG_020	BIG	8	0.1	1
Big Elm	R_BIG_040	BIG	4	0.1	1
Big Elm	R_BIG_050	BIG	5	0.1	1
Big Elm	R_BIG_070	BRY	2	0.1	1
Brazos River	R_BRA_010	AQU	13	0.35	10
Brazos River	R_BRA_020	WAC	6	0.3	6
Brazos River	R_BRA_040	WAC	4	0.3	4
Brazos River	R_BRA_050	WAC	6	0.3	6
Brazos River	R_BRA_060	WAC	4	0.3	4
Brazos River	R_BRA_070	HIG	8	0.1	1
Brazos River	R_BRA_080	HIG	10	0.1	1
Brazos River	R_BRA_100	HIG	10	0.1	1
Brazos River	R_BRA_110	HIG	10	0.1	1
Brazos River	R_BRA_120	HIG	8	0.1	1
Brazos River	R_BRA_140	HIG	11	0.1	1
Brazos River	R_BRA_150	HIG	4	0.1	1
Brazos River	R_BRA_160	BRY	4	0.1	1
Brazos River	R_BRA_170	BRY	6	0.1	1
Brazos River	R_BRA_180	BRY	3	0.1	1
Brazos River	R_BRA_190	BRY	4	0.1	1
Brazos River	R_BRA_200	HEM	8	0	1
Brazos River	R_BRA_210	HEM	11	0	1
Brazos River	R_BRA_220	HEM	13	0	1
Brazos River	R_BRA_230	HEM	13	0	1
Brazos River	R_BRA_240	HEM	8	0	2
Brazos River	R_BRA_250	HEM	8	0	2
Brazos River	R_BRA_260	HEM	17	0	1
Brazos River	R_BRA_270	RIC	5	0	1

Creek/River	HMS Element	Calibration Zone	K, hr	X	No. of Subreaches
Brazos River	R_BRA_290	RIC	5	0	1
Brazos River	R_BRA_310	RIC	11	0	1
Brazos River	R_BRA_320	RIC	20	0.5	1
Brazos River	R_BRA_330	RIC	1.54	0.2	2
Brazos River	R_BRA_340	RIC	7	0.2	6
Brazos River	R_BRA_360	RIC	7	0.2	7
Brazos River	R_BRA_370	RIC	9	0.2	9
Brazos River	R_BRA_380	ROS	14	0.4	1
Brazos River	R_BRA_390	ROS	11	0.4	1
Brazos River	R_BRA_BRY2NAV	HEM	120	0	1
Brazos River	R_BRA_HEM2MIL	SAN	60	0	1
Brazos River	R_BRA_MIL2SAM	RIC	13.5	0	1
Brazos River	R_BRA_NAV2HEM	HEM	80	0	1
Brazos River	R_BRA_RIC2ROS	ROS	90	0	1
Brazos River	R_BRA_SAN2RIC_1	RIC	20	0	1
Brazos River	R_BRA_SAN2RIC_2	RIC	25	0	1
Brazos River	R_BRA_SAN2RIC_3	RIC	11	0.1	1
Brazos River	R_BRA_SAN2RIC_4	RIC	13	0.1	1
Little River	R_LIT_090	BRY	2	0.1	1
Little River	R_LIT_100	BRY	2	0.1	1
Little River	R_LIT_110	BRY	2	0.1	1
Little River	R_LIT_120	BRY	2	0.1	1
Little River	R_LIT_130	BRY	3	0.1	1
Millcreek	R_MIL_030	BEL	10	0.3	12
Mill Creek	R_MIL_040	RIC	3.25	0.1	3
Navasota	R_NAV_100	EAS	30	0.4	12
Navasota	R_NAV_120	EAS	60	0.1	10
Navasota	R_NAV_140	OSR	9	0.4	9
Navasota	R_NAV_150	OSR	2.57	0.4	3
Navasota	R_NAV_160	OSR	7.38	0.4	8
Navasota	R_NAV_170	OSR	8.84	0.4	9
Navasota	R_NAV_180	HEM	5.42	0	5
Navasota	R_NAV_190	HEM	9	0	7
Navasota	R_NAV_200	HEM	13	0	11
Navasota	R_NAV_220	HEM	13	0	13
Navasota	R_NAV_230	HEM	13	0	12
Navasota	R_NAV_240	HEM	18	0	15
Navasota	R_NAV_260	HEM	7	0	5

Creek/River	HMS Element	Calibration Zone	K, hr	X	No. of Subreaches
Navasota	R_NAV_270	HEM	14	0	12
Navasota	R_NAV_300	HEM	9	0	8
Navasota	R_NAV_310	HEM	11	0	10
Navasota	R_NAV_320	HEM	20	0	20
New Year Creak	R_NEW_020	HEM	14	0.4	5

D.3.7 Muskingum-Cunge Eight Point Routing

Muskingum-Cunge routing was developed for Big Creek and Bessie's Creek within the detailed study area. Cross sections were generated from LiDAR and used to develop eight-point cross sections. Manning's n-values were assigned based on land use data. Channel length and slope were determined using GIS tools and LiDAR data.

D.4.0 Historical Storm Calibration

The calibration strategy for the Lower Brazos Basin was to simulate a wide range of storms that could be re-created with the most current rainfall, streamflow, and reservoir release data. The basin was separated into 18 calibration zones as discussed in this section. Each calibration zone has an observed data source at the downstream end, either streamflow or stage. When possible, observed data (flow) was used as a source at the upstream end of the zones. This allows the modeler to focus on the parameters of the zone being calibrated. In total, ten historical storm events were utilized for the hydrologic calibration. A summary of historical events that were utilized to determine the final calibration parameters is shown in Table D-4. Each calibration zone and observed data source is shown in Figure D-3. A detailed calibration zone map is provided in Exhibit D-5.

Table D-4: Summary of Historical Events per Calibration Zone

Stream Code	Downstream USGS Gauge	1991	1998	2002	2004	2007	2010	2013	2015	2016	2017
AQU	Brazos River near Aquilla (8093100)	X	X	X	X	X	X	X	X	X	
BEL	Mill Creek near Bellville (8111700)				X	X	X	X	X	X	X
BIG	Big Elm Creek near Cameron (8106500)						X	X	X		
BRY	Brazos River near Bryan (8108700)		X	X		X		X	X	X	X
CAM	Little River at Cameron (810500)		X		X	X		X	X	X	X
EAS	Navasota River near Easterly (8110500)		X	X	X	X		X	X	X	

Stream Code	Downstream USGS Gauge	1991	1998	2002	2004	2007	2010	2013	2015	2016	2017
FRE	Big Creek near Freestone (8110430)	X	X		X	X		X	X	X	
GRO	Navasota River above Groesbeck (8110325)		X		X	X		X	X	X	
HEM	Brazos River near Hempstead (8111500)	X	X	X	X	X	X	X	X	X	X
HIG	Brazos River near Highbank (8098290)	X	X			X		X	X	X	
LIM	Lake Limestone near Marquez (8110470)		X	X	X	X		X	X		
LIT	Little River near Little River (8104500)		X	X	X	X	X	X	X	X	X
LYO	Davidson Creek near Lyons (8110100)			X				X	X	X	X
OSR	Navasota River at OSR (8110800)		X			X		X		X	
RIC	Brazos River near Richmond (8114000)	X	X	X	X	X	X	X	X	X	X
ROS	Brazos River near Rosharon (8116650)	X	X	X	X	X	X	X	X	X	X
SAN	Brazos River near San Felipe (8111850)							X	X	X	X
WAC	Brazos River at Waco (8096500)			X	X	X	X	X	X	X	

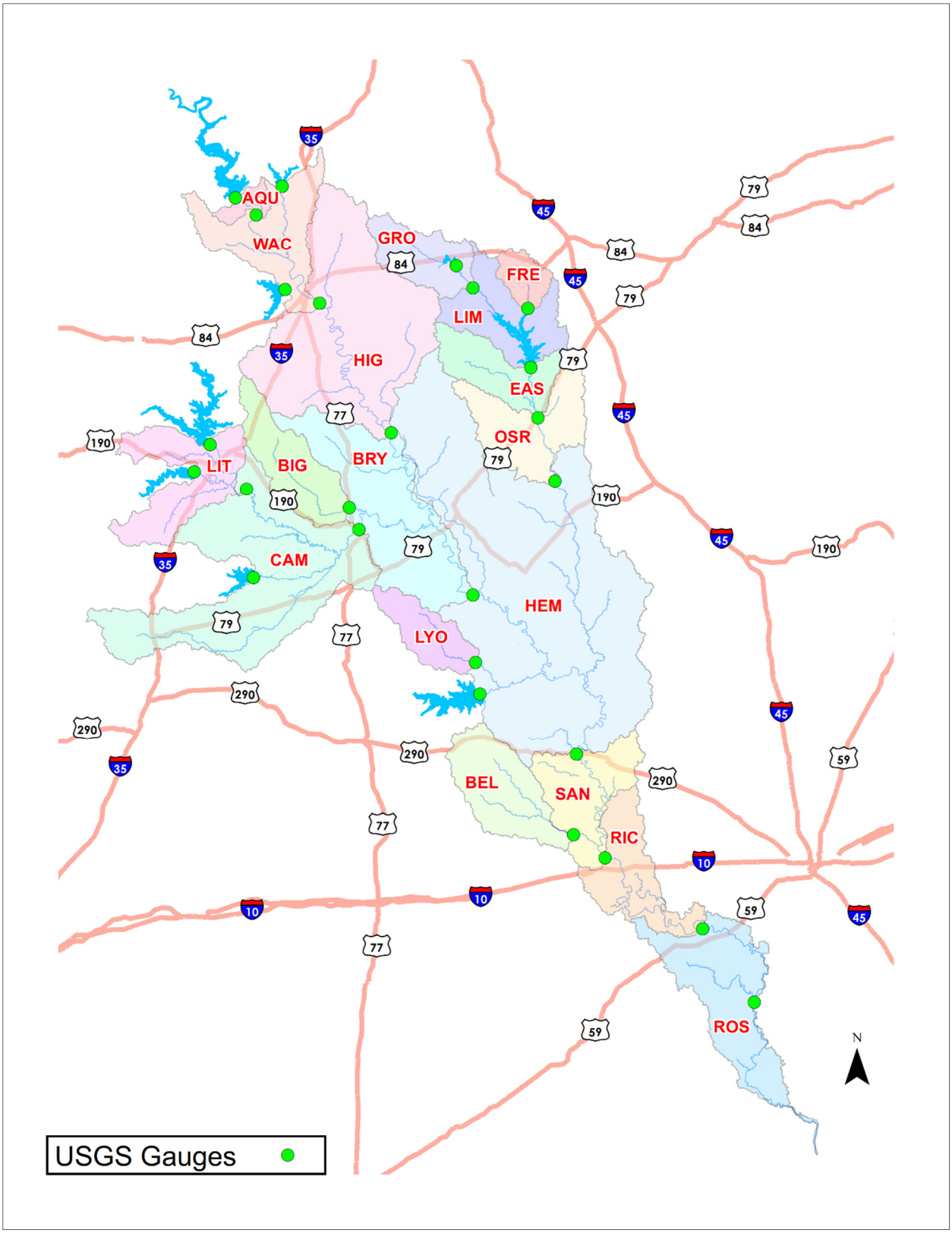


Figure D-3: Calibration Zones

Hourly rainfall data for all the events except the December 1991-Spring 1992 event were taken from the National Weather Service (NWS) multisensor precipitation estimator (MPE) rainfall product. The rainfall data are available on an approximate 4km x 4km grid in the Hydrologic Rainfall Analysis Project (HRAP) coordinate system and provide high-quality temporal and spatial distribution of the rainfall. In total, 1,938 HRAP grid cells were utilized to represent the 9,766 square mile basin in the Lower Brazos River Study area. Hourly mean areal precipitation hyetographs were developed for each of the 154 sub-basins for each of the calibration storm events.

The MPE data was not available for the December 1991-Spring 1992 or the 1957 events. The rainfall for these events were developed from National Climatic Data Center (NCDC) rainfall gauges. Rainfall depths were interpolated between the rainfall gauges in order to distribute the rainfall across the basin. The 1913 and 1957 events were simulated as part of the period-of-record analysis (see Section D.5.0). Basin-wide rainfall data for this event was developed from isohyetal maps created by the USACE Galveston office and published daily rainfall. Daily rainfall sources include "Excessive Rainfall in Texas", 1934 and "Flash Floods in Texas", 2008.

An initial pass was made through the calibration events for all storms. The focus of this initial pass was to calibrate transform and routing parameters for each sub-basin to be consistent across all calibration events. Loss parameters determined during the initial pass were found to vary by event due to changing antecedent moistures conditions prior to each historic calibration event. Once transform and routing parameters were set, intermediate gauge data were removed from the model and the December 1991, May 2015, May 2016, and August 2017 events were simulated for the entire Lower Brazos hydrologic study area.

D.4.1 Lake Whitney to Aquilla Gauge (AQU)

The AQU calibration zone consists of a single 56 square mile sub-basin and one reach along the Brazos River between Lake Whitney and the USGS Aquilla Gauge. The headwater area is largely range land. Approximately 75% of the soils are in Hydrological Soil Groups C and D, indicating slow infiltration with moderate to high runoff potential. Historic USACE releases from Lake Whitney are the upstream source of this calibration zone. The Muskingum Routing Method delivered the best calibration results when routing large releases from Lake Whitney. The 2002, 2004, and 2007 calibration events consisted largely of release data with little rainfall. For these events, the AQU zone was calibrated downstream in conjunction with the WAC zone. Table D-5 summarizes the results from calibration of the AQU Zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-5: Calibrated Hydrologic Parameter Summary – Zone AQU

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
1991, 1998, 2002, 2004, 2007, 2010, 2013, 2015, 2016	4.7	5.29	0.76

D.4.2 Aquilla to Waco Gauge (WAC)

The WAC calibration zone is a 397 square mile region divided into eight sub-basins with seven routing reaches. Four routing reaches are along the main stem of the Brazos River between the USGS Aquilla Gauge and the USGS Waco gauge. The remaining three routing reaches are along Aquilla Creek between Lake Aquilla and the confluence with the Brazos River. The headwater area is largely farm and range land, however, there is heavy urban development downstream near Waco. Approximately 85% of the soils are in Hydrological Soils Groups C and D, indicating slow to very slow infiltration rates and high runoff potential. Observed data at the USGS Aquilla Gauge is used as the upstream source along the Brazos River while USACE release data from Lake Aquilla is used as the upstream source along Aquilla Creek. The USACE release data from Lake Waco is applied just upstream of the last reach within the zone. Along the Brazos River, the Muskingum Routing Method delivered the best calibration results when routing releases from Lake Waco and upstream releases from Lake Whitney. Observed data at the USGS Waco Gauge was unavailable for the 1991 event. For this event, the WAC zone was calibrated downstream in conjunction with the HIG zone. The 2002, 2004, and 2007 calibration events at the USGS Aquilla gauge consisted largely of release data with little rainfall. The AQU zone was combined with the WAC zone during the calibration of the 2002, 2004, and 2007 events. Table D-6 summarizes the results from calibration of the WAC Zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-6: Calibrated Hydrologic Parameter Summary - Zone WAC

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
2002, 2004, 2007, 2010, 2013, 2015, 2016	9.0	5.87	0.51

D.4.3 Waco to Highbank Gauge (HIG)

The HIG calibration zone is a 1,092 square mile region divided into 15 sub-basins with 11 routing reaches. Seven routing reaches are along the Brazos River while Tehuacana Creek and Big Creek North each have two reaches. The headwater areas consist mostly of farm and rangeland with dense urban development near Waco. Approximately 86% of the soils are within Hydrological Soils Groups C and D, indicating slow to very slow infiltration rates and high runoff potential. The observed flows and USACE releases from the USGS Aquilla Gauge and Lake Waco are the upstream sources for this event. For all other events, the observed data at the USGS Waco Gauge is used as the upstream source. Due to large channel flows, the Muskingum Routing Method delivered the best calibration results along the Brazos River. Observed data at the USGS Highbank Gauge was incomplete for the 2010 event due to gauge failure. For this event, the HIG zone was calibrated downstream in conjunction with the BRY zone. Observed data at the USGS Waco Gauge was unavailable for the 1991 event. Therefore, the WAC zone was combined with the HIG zone during the calibration of the 1991 event. Table D-7 summarizes the results from calibration of

the HIG Zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-7: Calibrated Hydrologic Parameter Summary - Zone HIG

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
1991, 1998, 2007, 2013, 2015, 2016	9.5	8.6	0.39

D.4.4 Lake Belton and Stillhouse Hollow to Little River Gauge (LIT)

The LIT calibration zone is a 384 square mile zone divided into eight sub-basins and seven routing reaches. The Leon River has three routing reaches, Salado Creek has two, and both the Lampasas River and Nolan Creek each have a single routing reach. Stillhouse Hollow and Lake Belton USACE releases are used as upstream sources which contribute to the Lampasas and Leon Rivers, respectively. Headwater areas consist largely of pasture and farmland, however, there is significant urban development around Temple, Belton and Fort Hood. Approximately 90% of the soils are in Hydrological Soils Groups C and D, indicating very slow infiltration rates and high runoff potential. Observed data at the USGS Little River Gauge was incomplete for the 1991 event due to gauge failure. For this event, the LIT zone was calibrated downstream in conjunction with the CAM zone. Table D-8 summarizes the results from calibration of the LIT zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-8: Calibrated Hydrologic Parameter Summary - Zone LIT

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
1998, 2002, 2004, 2007, 2010, 2013, 2015, 2016, 2017	12.3	5.19	0.5

D.4.5 Little River and Lake Granger to Cameron Gauge (CAM)

The CAM calibration zone is a 1,107 square mile zone divided into 20 sub-basins and 15 routing reaches. The San Gabriel consists of three routing reaches while the Little River and Brushy Creek each have six reaches. Observed flows from the USGS Little River Gauge and USACE releases from Lake Granger are used as upstream sources for the Little River and San Gabriel River, respectively. Approximately 92% of the soils are in Hydrological Soils Groups C and D, indicating very slow infiltration rates and high runoff potential. Observed data at the USGS Little River Gauge was incomplete for the 1991 event due to gauge failure. Therefore, the LIT zone was combined with the CAM zone during the calibration of the 1991 event. Table D-9 summarizes the results from

calibration of the CAM zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-9: Calibrated Hydrologic Parameter Summary - Zone CAM

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
1998, 2004, 2007, 2013, 2015, 2016, 2017	5.28	8.07	0.49

D.4.6 Big Elm Gauge (BIG)

The BIG calibration zone is a 303 square mile zone divided into six sub-basins and four routing reaches. All routing reaches are along Big Elm Creek. There is no upstream data source for this zone. The headwater area is almost entirely farm land with a small portion of urban development near Temple. Approximately 99% of the soils are in Hydrological Soils Groups C and D, indicating very slow infiltration rates and very high runoff potential. There is no gauge data before 2010 or after 2015. The1998, 2002, 2004, 2007, 2016, and 2017 events are calibrated downstream in conjunction with the BRY Zone. The BRY Zone is calibrated at the USGS Bryan Gauge which was not available for the 1991 event and failed during the 2004 event. For these events, the BIG zone is calibrated downstream in conjunction with the HEM Zone. Table D-10 summarizes the results from calibration of the BIG zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-10: Calibrated Hydrologic Parameter Summary – Zone BIG

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
2010, 2013, 2015	3.8	8.44	0.5

D.4.7 Highbank to Bryan Gauge (BRY)

The BRY calibration Zone is a 722 square mile region divided into 12 sub-basins and 10 routing reaches. Four sub-reaches are along the Brazos River, the Little River has five sub-reaches, and Pond Creek has one sub-reach. Approximately 75% of the soils are in Hydrological Soil Groups C and D, indicating slow infiltration with moderate to high runoff potential. The headwater area transitions from farm and range land in the upper part of the zone to mixed and dense forest in the lower part of the zone. Observed flows from USGS Gauges at Highbank, Big Elm Creek and Little River are the upstream sources for this zone. Observed data at the USGS Bryan Gauge was not available for the 1991 event and was incomplete for the 2004 event due to gauge failure. For these events, the BRY zone was calibrated downstream in conjunction with the HEM Zone. Observed data at the USGS Highbank Gauge was incomplete for the 2010 event due to gauge

failure. Therefore, the HIG zone was combined with the BRY zone during the calibration of the 2010 event. There is no gauge data before 2010 or after 2015 at the USGS Big Elm Gauge. Therefore, the BIG zone was combined with the BRY zone during the calibration of the 1998, 2002, 2007, 2016, and 2017 events. Table D-11 summarizes the results from calibration of the BRY zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-11: Calibrated Hydrologic Parameter Summary - Zone BRY

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
1998, 2002, 2007, 2013, 2015, 2016, 2017	5.7	7.32	0.52

D.4.8 Davidson Creek near Lyons Gauge (LYO)

The LYO calibration zone is a 195 square mile area divided into two sub-basins with a single routing reach. The headwater area consists largely of pasture and farm land, however, there are large concentrations of mixed and dense forest upstream of SH 21. Both sub-basins vary in soil composition. Upstream, 58% of the soils are in Hydrologic Soils Group C and D. Downstream, 87% of the soils are in groups C and D. This indicates a moderate to fast infiltration rate with moderate to low runoff potential upstream and a very slow infiltration rate with high runoff potential downstream. Unlike other calibration zones which have observed data upstream, there are no observed inflows for this zone. Observed data at the USGS Lyons Gauge was unavailable for the 1991 event. Table D-12 summarizes the results from calibration of the LYO zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-12: Calibrated Hydrologic Parameter Summary - Zone LYO

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
2002, 2013, 2015, 2016, 2017	3.1	8.90	0.51

D.4.9 Navasota River at Groesbeck Gauge (GRO)

The GRO calibration zone is a 240 square mile area divided into five sub-basins and two routing reaches. Both reaches are along the Navasota River with Lake Mexia separating the routing reaches. There are no upstream data sources for this zone. The headwater area consists mostly of pasture and farm land. Approximately 90% of the soils are in Hydrological Soils Groups C and D, indicating very slow infiltration rates and high runoff potential. Calibration of the GRO zone considers observed pool elevations at Lake Mexia for all events except 1991 and 1998. For these

events, there are no observed pool elevations. Table D-13 summarizes the results from calibration of the GRO zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-13: Calibrated Hydrologic Parameter Summary - Zone GRO

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
1998, 2004, 2007, 2013, 2015, 2016	4.6	6.55	0.51

D.4.10 Big Creek near Freestone Gauge (FRE)

The FRE calibration zone is a single 97 square mile sub-basin. There are no upstream sources for this zone. The headwater area consists largely of pasture yet has a substantial amount of mixed forest in the southwestern region of the zone. Approximately 65% of the soils are in Hydrologic Soils Groups C and D and are primarily in the northwestern and southeastern portions of the zone. Between these two areas, there are higher concentrations of Hydrologic Soils Groups A and B. Overall, this indicates moderate infiltration rates and moderate runoff potential. Observed flows at the USGS Freestone Gauge were too low for calibration of the 2010 and 2017 events. For these events, the FRE zone is calibrated downstream in conjunction with the EAS and LIM Zones, respectively. Table D-14 summarizes the results from calibration of the FRE zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-14: Calibrated Hydrologic Parameter Summary - Zone FRE

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
1991, 1998, 2004, 2007, 2013, 2015, 2016	8.9	12.86	0.62

D.4.11 Groesbeck and Freestone to Limestone Gauge (LIM)

The LIM calibration zone is a 338 square mile area divided into three sub-basins and one routing reach. The headwater area consists mainly of pasture and farm land. Approximately 75% of the soils are in Hydrologic Soils Groups C and D, indicating moderate to slow infiltration and moderate to high runoff potential. Observed data from the USGS Groesbeck and Freestone Gauges are used as upstream sources. The LIM Zone is calibrated to observed pool elevations at the USGS Lake Limestone Gauge. Observed flows at the USGS Limestone Gauge were unavailable for the 1991 and 2010 events. For these events, the LIM zone is calibrated downstream in conjunction with the EAS Zone. Observed flows at the USGS Freestone Gauge were too low for calibration of the

2017 event. Therefore, the FRE zone was combined with the LIM zone during the calibration of the 2010 event. Table D-15 summarizes the results from calibration of the LIM Zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-15: Calibrated Hydrologic Parameter Summary - Zone LIM

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
1998, 2002, 2004, 2007, 2013, 2015	4.4	11.24	0.48

D.4.12 Lake Limestone to Easterly Gauge (EAS)

The EAS calibration zone is a 262 square mile area divided up into three sub-basins and two routing reaches. One routing reach is along the Navasota River while the other is along a tributary to the Navasota River. The headwater areas consist mainly of pasture and farmland with mixed to dense forest scattered throughout the zone. There is an even mix of hydrologic soils, with 60% belonging to groups C and D. This indicates moderate infiltration with a moderate runoff rate. Observed BRA release data from Lake Limestone is used as the upstream source for this zone. Since there is only one reach from LIM to EAS, BRA releases are difficult to route. Timing and attenuation is more consistent with observed data when using the Muskingum Routing Method as opposed to Modified Puls. Calibration zones upstream were combined with the EAS zone during the calibration of some events due to unavailable observed data and low flows that could not be used for calibration. These events included 1991 and 1998 at the USGS Groesbeck Gauge, 2010 and 2017 at the USGS Freestone Gauge, and 1991 and 2010 at the USGS Limestone Gauge. Therefore, the GRO and LIM zone was combined with the EAS zone during the calibration of the 1991 event, the GRO zone was combined with the EAS zone during the 1998 event, and the FRE and LIM zones were combined with the EAS zone during the calibration of the 2010 event. Table D-16, summarizes the results from calibration of the EAS Zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-16: Calibrated Hydrologic Parameter Summary - Zone EAS

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
1998, 2002, 2004, 2007, 2013, 2015, 2016	3.4	19.81	0.50

D.4.13 Easterly to OSR Gauge (OSR)

The OSR calibration zone is a 380 square mile area divided into five sub-basins with four routing reaches. There is an even mix of hydrologic soils, with 60% belonging to groups A and B. This indicates moderate to fast infiltration with moderate to low runoff rate. Observed data at the USGS Easterly Gauge is used as the upstream source for this zone except for the 2004 event, which has incomplete observed data due to gauge failure. For the 2004 event, the releases from Lake Limestone are used as the upstream source along with calibrated hydrologic parameters for the EAS zone. The 1991 event for this zone is calibrated downstream at the USGS Hempstead Gauge due to missing observed data. Muskingum routing is used along with a 5% channel loss to model the attenuation of Lake Limestone releases which occurs through the OSR zone. Results at the OSR gauge are much more consistent with observed data when using these two methods. Table D-17 summarizes the results from calibration of the OSR Zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-17: Calibrated Hydrologic Parameter Summary - Zone OSR

Calibration Events	Average Percent Impervious (%)	Average Snyder Ct (hr)	Average Snyder Cp
1998, 2004, 2013, 2016	3.3	11.17	0.49

D.4.14 Bryan to Hempstead Gauge (HEM)

The HEM calibration zone is a 2,470 square mile region divided into 38 sub-basins and 32 routing reaches. Eleven routing reaches run along the Navasota River while the Little Brazos and Brazos River have six and seven reaches, respectively. The smaller tributaries, Yegua and Walnut Creek, have two reaches while Davidson and New Year Creek each have one routing reach. Also, there are two "diversion" reaches along the Brazos River with long lag times which divert flows over 85,000 cubic feet per second and return this flow downstream. One reach is from the USGS Bryan Gauge to the confluence with the Navasota River. The second is from the confluence with the Navasota River to the USGS Hempstead Gauge. These reaches help maintain volume and decrease peak flows to be more consistent with observed flows. Muskingum routing is necessary along the Brazos, Navasota and "diversion" reaches to model travel times and attenuation. Most of the headwater area consists of range and farm land. There are dense urban developments at Bryan/College Station, Somerville, Hearne and Bremond. Mixed and dense forests are scattered throughout the zone, with heavier concentrations along the Brazos and Navasota Rivers.

The HEM zone is divided into three sub-areas due to having such a large zone with two large, ungauged tributaries. The first area consists of the sub-basins contributing to the Little Brazos River and Walnut Creek. The second area is 897 square miles of sub-basins along the lower Navasota River between the USGS OSR Gauge and the confluence with the Brazos River. The third area is the remaining sub-basins which contribute to the Brazos River, Yegua Creek, Davidson Creek and New Year Creek. Each sub-area has independent transforms and losses. A 2% constant channel loss is required along the Navasota to attenuate large releases from Lake Limestone. Some

calibrations at HEM included calibrations of upstream zones. These upstream zones were not calibrated upstream due to gauge failure or unavailable gauge data. The 1991 event includes calibrations of the BIG, CAM, BRY, DAV and OSR zones. The 2004 event includes calibrations of the BIG and BRY zones. The 2010 event includes calibration of the FRE, LIM, EAS and OSR zones. Table D-18 summarizes the results from calibration of the HEM Zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-18: Calibrated Hydrologic Parameter Summary - Zone HEM

Calibration Events	River	Percent Impervious (%)	Snyder Ct (hr)	Snyder Cp
1991, 1998, 2002, 2004, 2007, 2010, 2013, 2015, 2016, 2017	Brazos River & Tributary Rivers	6.9	7.8	0.50
1991, 1998, 2002, 2004, 2007, 2010, 2013, 2015, 2016, 2017	Little Brazos River Above Brazos River	6.0	7.2	0.40
1991, 1998, 2002, 2004, 2007, 2010, 2013, 2015, 2016, 2017	Navasota River Above Brazos River	9.5	7.6	0.40

D.4.15 Hempstead to San Felipe Gauge (SAN)

The SAN Calibration Zone is a 355 square mile area divided into seven sub-basins with five routing reaches. Four routing reaches run along the Brazos River, and Mill Creek has one routing reach. Also, there is one "diversion" routing reach with a long lag time to divert flows over 80,000 cfs and return this flow downstream. This reach helps maintain volume and decrease peak flows to be more consistent with observed flows. Observed data at the USGS Hempstead and Mill Creek at Bellville Gauges are used as the upstream sources for this zone. Due to the short life of the USGS San Felipe gauge, events before 2013 were calibrated downstream at the USGS Richmond Gauge. In HEC-HMS, Muskingum routing is used to calibrate within the zone. Ultimately, the routing was modeled within the unsteady HEC-RAS model described in Appendix E. Table D-19 summarizes the results from calibration of the SAN Zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-19: Calibrated Hydrologic Parameter Summary - Zone SAN

Calibration Events	River	Percent Impervious	Clark Tc (hr)	Clark R
2013, 2015, 2016, 2017	Brazos River	5.9	11.0	18.0
2013, 2015, 2016, 2017	Mill Creek	6.2	18.3	30.5

D.4.16 Mill Creek near Bellville Gauge (BEL)

The BEL Calibration Zone is a 362 square mile area divided into three sub-basins with one routing reach. Headwater areas consist largely of pasture and farmland. Unlike other calibration zones which have observed data upstream, there are no upstream data sources for this zone. Table D-20 summarizes the results from calibration of the BEL Zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-20: Calibrated Hydrologic Parameter Summary - Zone BEL

Calibration Events	Percent Impervious	Clark Tc (hr)	Clark R
2004, 2007, 2013, 2015, 2016, 2017	5.9	16.8	22.0

D.4.17 San Felipe to Richmond Gauge (RIC)

The RIC Calibration Zone is a 340 square mile area divided into seven sub-basins with five routing reaches. Four routing reaches run along the Brazos River while Bessie's Creek has one routing reach. Also, there is one "diversion" routing reach with a long lag time to divert flows over 80,000 cfs and return this flow downstream. This diversion simulates attenuation due to ponding in the overbanks and flow that spills into adjacent tributaries and returns downstream. The diversion reach helps maintain volume and decrease peak flows to be more consistent with observed flows. Observed data at the USGS San Felipe Gauge is used as the upstream source for this zone. Events prior to 2013 used the Hempstead and Mill Creek at Bellville Gauges as upstream sources. In HEC-HMS, Muskingum routing was used to calibrate within the zone. Ultimately, the routing was modeled within the unsteady HEC-RAS model described in Appendix E. Table D-21 summarizes the results from calibration of the RIC Zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-21: Calibrated Hydrologic Parameter Summary - Zone RIC

Calibration Events	Percent Impervious	Clark Tc (hr)	Clark R
1991, 1998, 2007, 2010, 2013, 2015, 2016, 2017	6.5	12.9	51.7

D.4.18 Richmond to Rosharon Gauge (ROS)

The ROS Calibration Zone is a 552 square mile area divided into ten sub-basins with eight routing reaches. Six routing reaches run along the Brazos River while Big Creek has two routing reaches. Observed data at the USGS Richmond Gauge is used as the upstream source for this zone. Because the Rosharon Gauge is the most downstream gauge along the Brazos River, the basins below the Rosharon Gauge were calibrated within the ROS calibration zone. In HEC-HMS,

Muskingum routing was used to calibrate within the zone. Ultimately, the routing was modeled within the unsteady HEC-RAS model described in Appendix E. Table D-22 summarizes the results from calibration of the ROS Zone. A detailed record of calibration results along with a summary of hydrologic parameters can be found at the end of Appendix D.

Table D-22: Calibrated Hydrologic Parameter Summary - Zone ROS

Calibration Events	Percent Impervious	Clark Tc (hr)	Clark R
1991, 1998, 2007, 2010, 2013, 2015, 2016, 2017	11.2	8.4	17.5

D.4.19 Historical Storm Calibration Summary

The Lower Brazos River Basin was divided into 18 calibration zones based on the location of USGS streamflow gauges, and each zone was calibrated to multiple historical storms. The upstream zones utilize USACE reservoir releases as inflows to the model. Other zones utilize USGS observed flows as the inflow to each zone. If the USGS gauge failed to read or was non-existent for an event, the event in question was calibrated in conjunction with the zone downstream. After each individual zone was calibrated, the intermediate boundary conditions (USGS gauges used to calibrate each zone) were removed to validate the calibration from a basin-wide perspective. Larger events (1991, 2015, 2016, and 2017) were run in the combined model and key USGS stream gauges were evaluated throughout the basin to confirm the historical storm calibration. The calibration resulted in consistent unit hydrograph and routing parameters. The HEC-HMS model accurately simulated the Lower Brazos River Basin for a range of rainfall depths, intensities, and durations.

D.5.0 Historical Gauge Frequency Analysis

Frequency flows at Hempstead and Richmond are needed to accurately define the 1% ACE (and other frequency) storm events. The Brazos River Basin within the Lower Brazos Floodplain Protection Planning Study area has several USGS flow gauges with significant periods-of-record. With the upper limits of the study area being USACE reservoirs, the difference between regulated and unregulated flows could be significant, especially for higher flows. This study utilizes methods from previous studies conducted in 1979 and 1984 by Espey, Huston & Associates, Inc. (EHA), and in 2006 by LJA Engineering and Surveying, Inc, with some minor modifications, to develop frequency discharges at the Hempstead and Richmond gauges.

D.5.1 Methodology

The historical gauge frequency analysis is based on a Log Pearson Type III Analysis as outlined in Bulletin 17B, "*Guidelines for Determining Flood Flow Frequency*", published by the United States Water Resources Council in 1981. The Bulletin 17B methodology is based on a homogeneous unregulated basin. The Lower Brazos River Basin today is a fully regulated basin. The historical

gauge flows at Hempstead and Richmond are also non-homogeneous, as early flood events (prior to 1952) were unregulated prior to the upstream reservoir construction and events after 1982 (construction of last upstream flood control reservoir) were fully regulated. Partial regulation existed between 1952 and 1982.

To complete the gauge frequency analysis, the entire period-of-record needed to be converted to "unregulated" conditions to utilize the Bulletin 17B methodology, and then those results translated into "regulated" conditions reflecting the basin today.

The first step in the process was assembling the period-of-record flows, including any historic events to be considered in the analysis outside of the systematic period-of-record. Peak flows from each water year (WY) recorded at the USGS streamflow gauges at Richmond and Hempstead were tabulated. For the Richmond Gauge, this record extends continuously from WY 1923 to 2017. Additionally, gauge records from 1903 to 1906 were also included. At the Hempstead Gauge, the period-of-record extends continuously from WY 1939 to 2017. Historic flow records were also estimated for the 1884, 1885, 1899, 1913, and 1915 events at both gauges and included in the analysis. The peak streamflow data were then sorted into 4 categories: historical (no actual gauge record), unregulated gauged (prior to 1952), partially regulated (1952-1982), and fully regulated (1983-2017).

Next, using the USGS flow records, an event volume vs. peak flow relationship was developed in Microsoft Excel for each of the peak events in each water year. Prior to 1952, the volume for the event was simply the computed gauge volume. For water years after 1952 when regulation began in the basin, the total volume was the volume recorded at the gauge plus the change in upstream reservoir storage (from event start to peak at the gauge). This is used as an approximation of the volume of water that would have passed the gauge during the event had the upstream reservoir(s) not been in place (i.e., a simulation of unregulated conditions). The total volume versus recorded annual peak flow relationships were then plotted for the unregulated and fully-regulated periods. An exponential trendline was developed from each plot with the unregulated trendline forced through the December 1913 (WY 1914) event. These equations are shown in Table D-23. These plots and trendline equations are shown in Figure D-4 and Figure D-5

Table D-23: Volume vs Flow Equations

	Hempstead	Richmond
Fully Unregulated	$Q = 5.077 * V^{0.6932}$ $R^2 = 0.9902$	$Q = 1.837 * V^{0.7540}$ $R^2 = 0.9958$
Fully Regulated	$Q = 11.316 * V^{0.6101}$ $R^2 = 0.8371$	$Q = 14.040 * V^{0.5843}$ $R^2 = 0.8719$

Notes : Q=Discharge (cfs) ; V=volume (ac-ft)

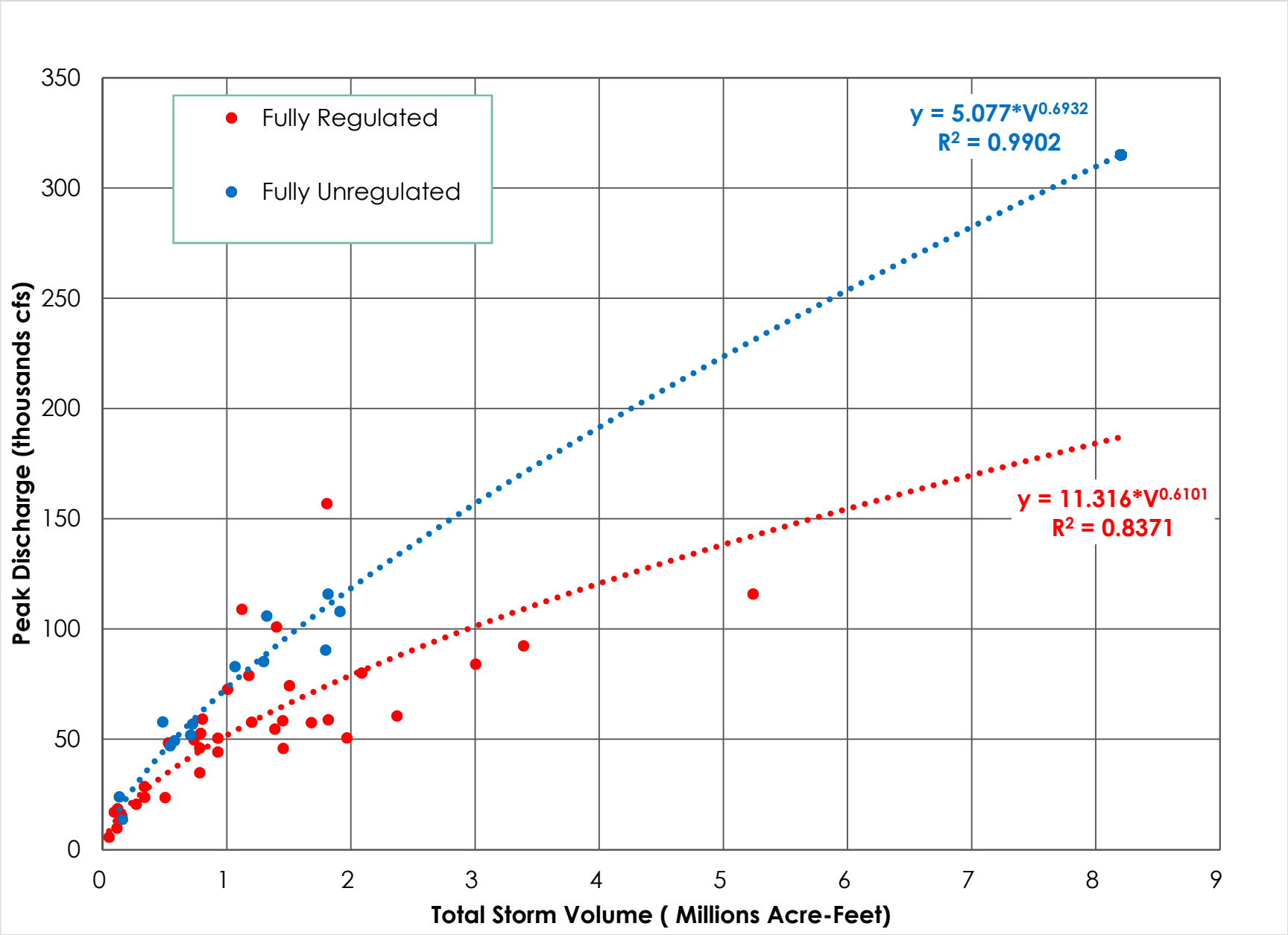


Figure D-4: Volume Versus Flow Analysis at Hempstead (Period-of-Record)

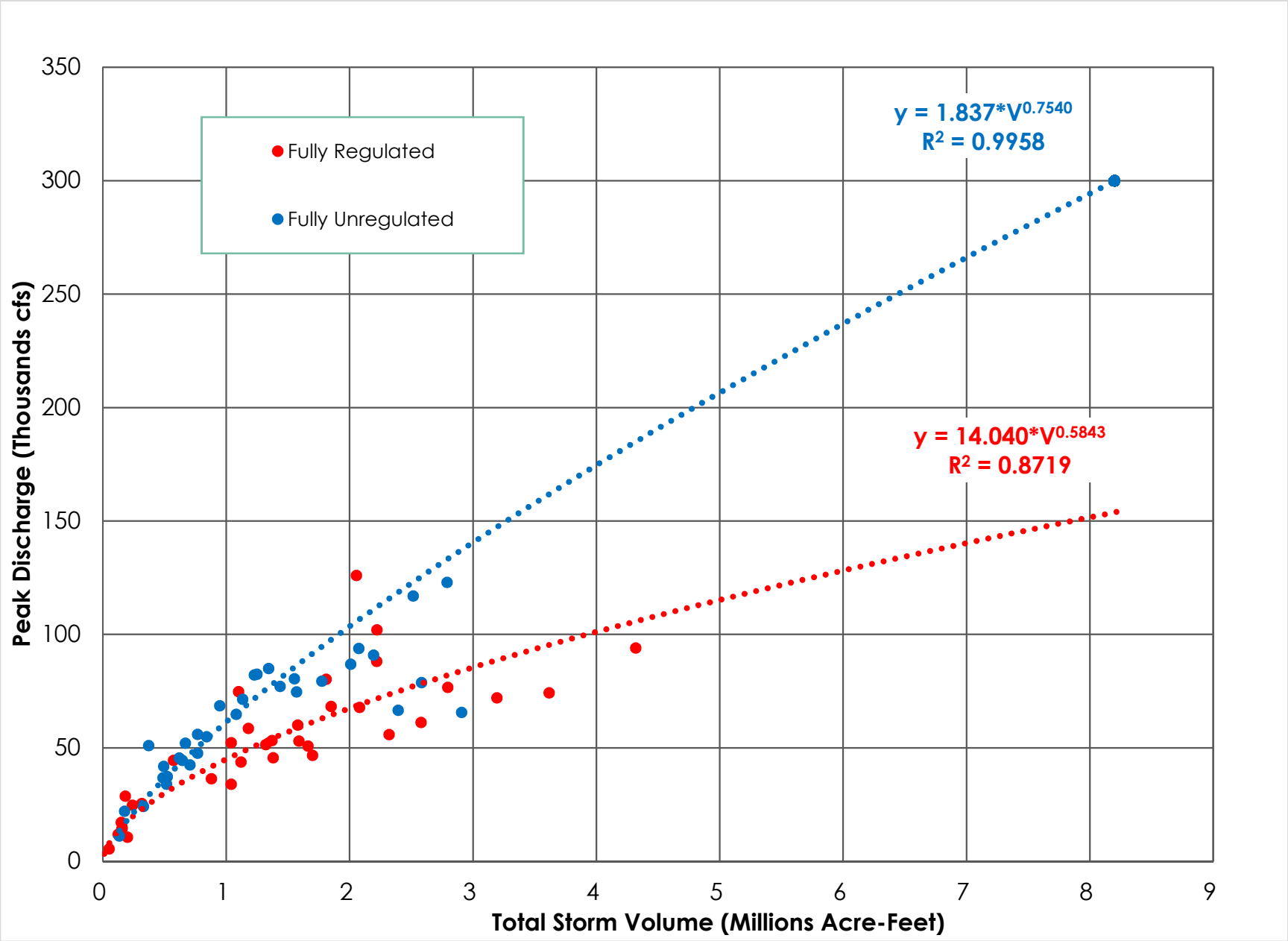


Figure D-5: Volume Versus Flow Analysis at Richmond (Period-of-Record)

With the volume of discharge for a given water year, the discharge for both fully regulated and unregulated conditions are computed with the trendlines. The ratio between the two-derived annual peak flows are used to adjust the regulated and partially regulated peaks to an unregulated condition. If the ratio is less than 1.0, then the annual peak discharge was not adjusted for that given water year. Since recorded gauge flows prior to 1952 were unregulated, no adjustments were made to the recorded discharge for water years prior to 1952.

For the partial regulation period (1952-1981), a further adjustment was made considering the available reservoir storage utilized and available each year. As new reservoirs came on-line during this period, the volume of available flood storage increased. Since the total flood storage available in the reservoirs has never been used, the maximum observed storage was used to determine the correction factor for the reservoirs. The reservoir correction factor was computed by taking the max observed storage of all the reservoirs in place at a given time divided by the total maximum observed storage for all 10 USACE multi-purpose upstream projects (4,179,010 ac-ft). To check the accuracy of this methodology used to simulate a complete unregulated period of record, the 1957 and 1991 (WY 1992) events were simulated with the HEC-HMS model developed for the lower basin as described in Section D.2 utilizing actual rainfall, reservoir operations, and hydrologic routing parameters. Table D-24 shows the peak unregulated flows computed at both Hempstead and Richmond for these events with the period-of-record method described in this section as well as the HEC-HMS model.

Table D-24: Unregulated Flows Results; Frequency Analysis vs Simulated

	Hempstead Discharge (cfs)		Richmond Discharge (cfs)	
Event	**Frequency Analysis**	**HEC-HMS**	**Frequency Analysis**	**HEC-HMS**
1957	190,600	188,500	179,900	161,000
1992 (Dec. 1991)	188,300	204,000	171,700	160,100

Once the adjusted unregulated flows were developed for each water year using the method outlined above, these systematic record data were input to HEC-SSP, along with the historical flow data to perform the Log Pearson Type III Analysis in accordance with Bulletin 17B. A simulation was also made without using the historical flow data.

Results from the HEC-SSP simulation for unregulated discharges are shown in Table D-25 and Table D-26 for the Hempstead and Richmond gauges, respectively. The tables summarize the results both with and without the inclusion of the historical flow data.

Table D-25: Unregulated Frequency Flows at Hempstead

Frequency	Unregulated Frequency Flows With Historical Flows (cfs)	Unregulated Frequency Flows Without Historical Flows (cfs)
50% ACE (2-YR)	64,614	33,133
20% ACE (5-YR)	114,228	63,117
10% ACE (10-YR)	149,056	140,534
5% ACE (20-YR)	182,791	169,909
2% ACE (50-YR)	226,213	206,552
1% ACE (100-YR)	258,311	232,842
0.5% ACE (200-YR)	289,801	258,007
0.2% ACE (500-YR)	330,500	289,651

Table D-26: Unregulated Frequency Flows at Richmond

Frequency	Unregulated Frequency Flows With Historical Flows (cfs)	Unregulated Frequency Flows Without Historical Flows (cfs)
50% ACE (2-YR)	66,078	64,490
20% ACE (5-YR)	113,496	108,167
10% ACE (10-YR)	144,981	135,810
5% ACE (20-YR)	174,196	160,527
2% ACE (50-YR)	210,089	189,698
1% ACE (100-YR)	235,467	209,541
0.5% ACE (200-YR)	259,464	227,717
0.2% ACE (500-YR)	289,227	249,465

With the results of the unregulated frequency discharge analysis, regulated frequency discharges needed to be computed to reflect conditions in the basin in 2017. In 2006, as part of the Fort Bend County FIS update, LJA utilized the method that Espey Huston Associates developed in 1984. For the Espey Huston Associates study, a rainfall-runoff model of the natural Brazos River basin below Possum Kingdom Dam was developed using HEC-1. The model was "calibrated" to produce a 1% ACE unregulated flow of 238,000 cfs to match the results of the flood frequency analysis at the Richmond gauge. Espey Huston Associates then added in the eight reservoirs (Whitney, Waco, Proctor, Belton, Georgetown, Granger, Stillhouse Hollow, and Somerville) to the HEC-1 model and routed the flows through each of the reservoirs using the Modified Puls method. The initial stage for each reservoir was set at the top of the conservation pool and only spillway flows at stages above the top of the flood control pools were modeled. The results of the Espey Huston Associates HEC-1 model with the reservoirs in place were compared against the unregulated "calibrated" HEC-1 model to determine a ratio of adjustment between unregulated and regulated conditions. These same ratios (summarized in Table D-27) were utilized by LJA in the 2006 Fort Bend County FIS update to convert the unregulated frequency discharges to regulated conditions.

Table D-27: Regulated to Unregulated Rations Used in Previous Studies

Frequency	Return Interval (Years)	Ratio of Regulated to Unregulated Discharges
10% ACE	10	0.771
2% ACE	50	0.766
1% ACE	100	0.761
0.2% ACE	500	0.766

For the current Lower Brazos Floodplain Protection Planning Study, the use of these ratios to convert from unregulated frequency discharges to regulated frequency discharges did not agree with modeled/observed results. A concern with the 1984 Espey Huston Associates Method is the design storm assumption of approximately 3" of rainfall in 24 hours over the entire basin for the 1% ACE event. Loss rates were adjusted to match the 238,000 cfs unregulated condition. This design storm assumption is not realistic for a basin of this size. Also, Muskingum routing was used throughout the 1984 HEC-1 model which resulted in very little attenuation along the Brazos River. As discussed in section D.3.0 there are very high rates of attenuation along the lower Brazos River especially below the Navasota River confluence. This has been observed through the gauge records over the years.

Therefore, for the current flood frequency analysis, the volume versus flow relationships developed from the gauge records (shown in Table D-23) were used to convert the unregulated discharges to regulated discharges. Table D-28 and Table D-29 show the regulated frequency discharges computed with the historical gauge frequency analysis at the Hempstead and Richmond gauges, respectively.

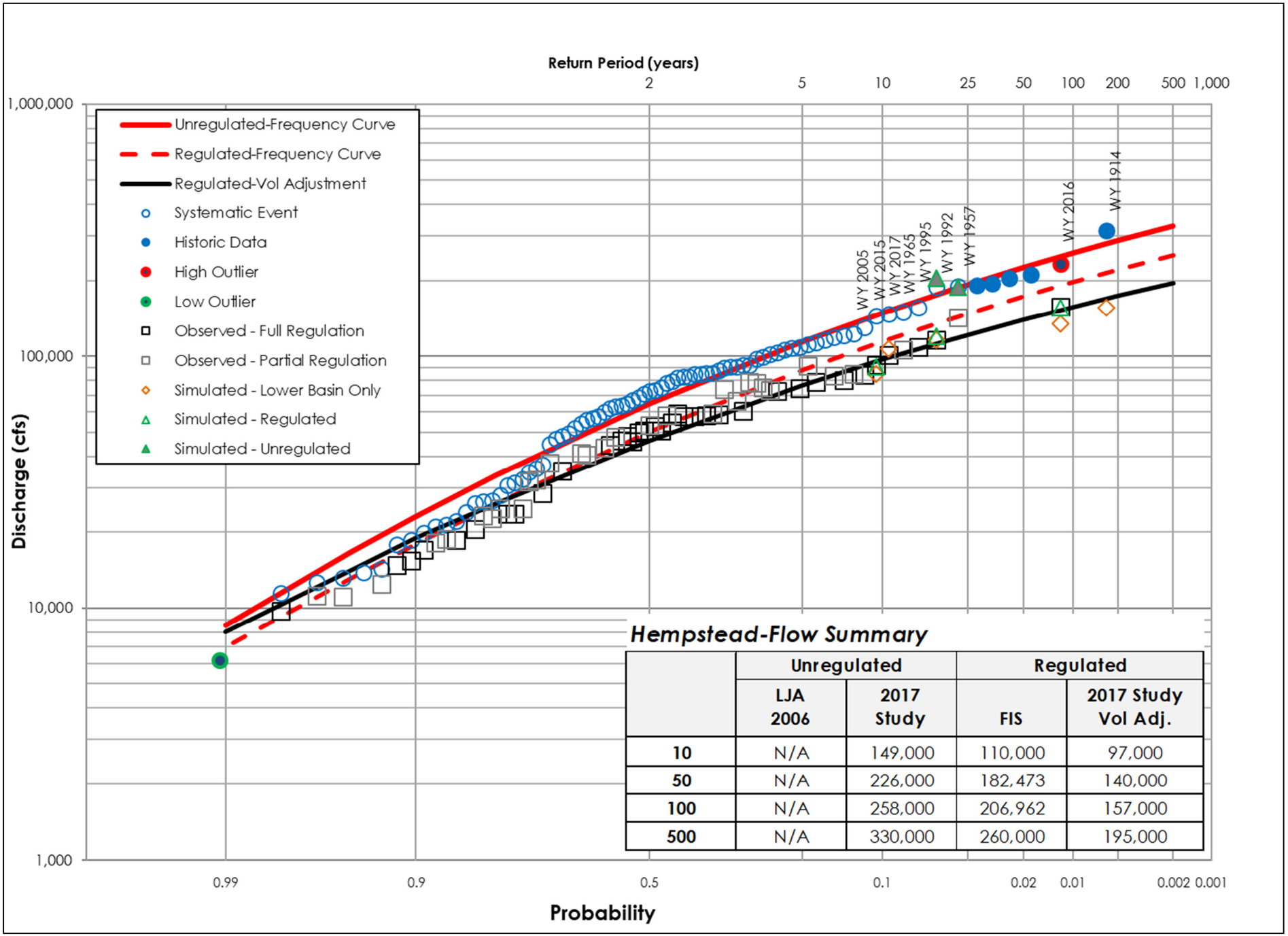
Table D-28: Hempstead Regulated Frequency Flows – Historical Gauge Frequency Analysis

Frequency	Regulated Frequency Flows With Historical Flows (cfs)	Regulated Frequency Flows Without Historical Flows (cfs)
50% ACE (2-YR)	46,000	26,000
20% ACE (5-YR)	77,000	45,000
10% ACE (10-YR)	97,000	92,000
5% ACE (20-YR)	116,000	109,000
2% ACE (50-YR)	140,000	129,000
1% ACE (100-YR)	157,000	143,000
0.5% ACE (200-YR)	174,000	157,000
0.2% ACE (500-YR)	195,000	174,000

Table D-29: Richmond Regulated Frequency Flows – Historical Gauge Frequency Analysis

Frequency	Regulated Frequency Flows With Historical Flows (cfs)	Regulated Frequency Flows Without Historical Flows (cfs)
50% ACE (2-YR)	48,000	47,000
20% ACE (5-YR)	72,000	70,000
10% ACE (10-YR)	88,000	83,000
5% ACE (20-YR)	101,000	95,000
2% ACE (50-YR)	117,000	108,000
1% ACE (100-YR)	127,000	116,000
0.5% ACE (200-YR)	137,000	124,000
0.2% ACE (500-YR)	149,000	133,000

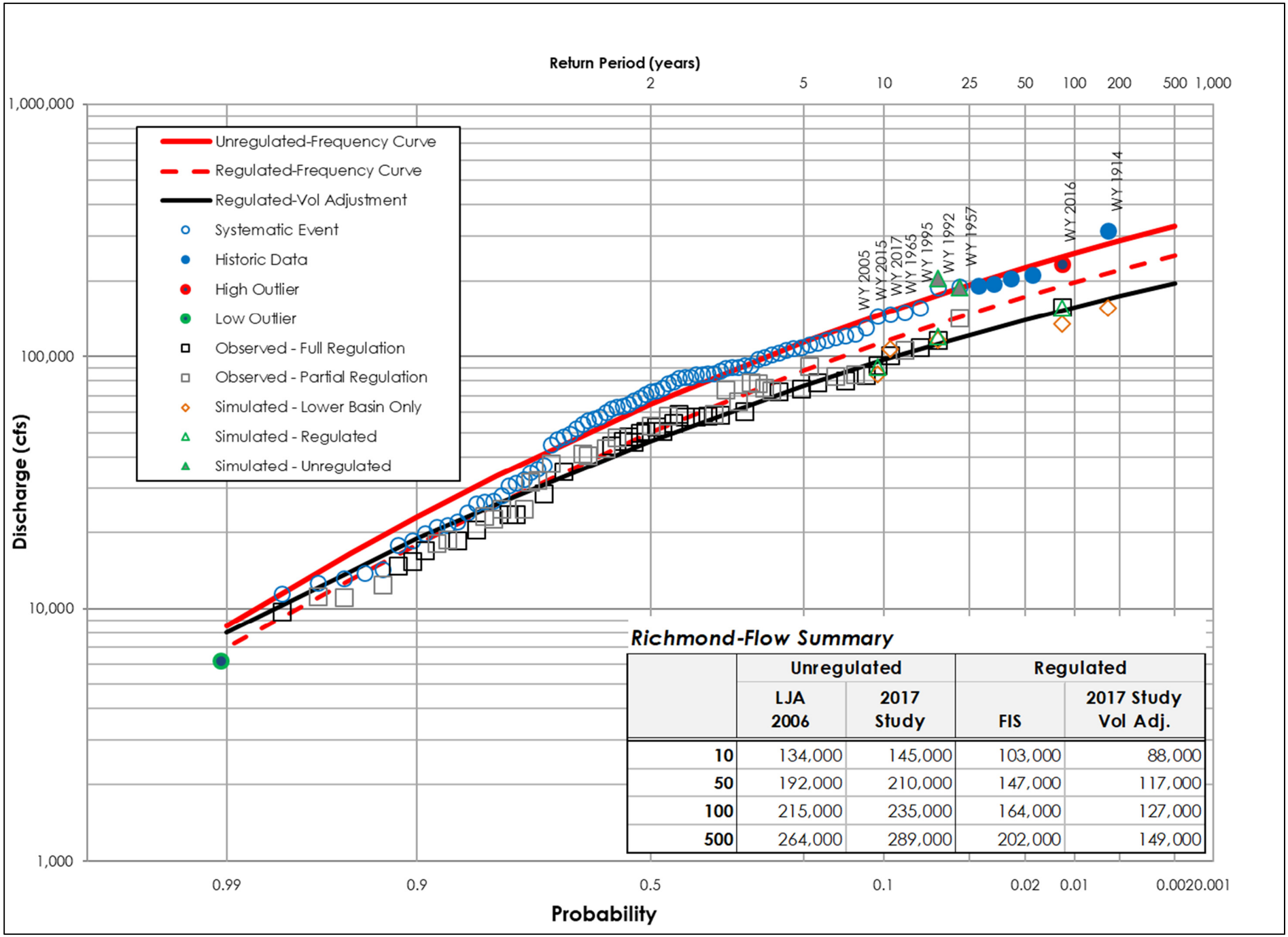
The regulated curve can be plotted on the unregulated frequency curve along with observed regulated events and hypothetical storms to ensure consistency for Hempstead and Richmond USGS gauges as shown in Figure D-6 and Figure -7, respectively. As a check, the December 1912, December 1991, 2015, and 2016 events were simulated with full regulation using the HEC-HMS model. This methodology agrees with modeled results and observed flows but reduces the 1% ACE flows at both Hempstead and Richmond compared to current FIS values.



Hempstead-Flow Summary

	Unregulated		Regulated	
	LJA 2006	2017 Study	FIS	2017 Study Vol Adj.
10	N/A	149,000	110,000	97,000
50	N/A	226,000	182,473	140,000
100	N/A	258,000	206,962	157,000
500	N/A	330,000	260,000	195,000

Figure D-6: Unregulated and Regulated Frequency Curves at the USGS Hempstead Gauge



Richmond-Flow Summary

	Unregulated		Regulated	
	LJA 2006	2017 Study	FIS	2017 Study Vol Adj.
10	134,000	145,000	103,000	88,000
50	192,000	210,000	147,000	117,000
100	215,000	235,000	164,000	127,000
500	264,000	289,000	202,000	149,000

Figure D-7: Unregulated and Regulated Frequency Curves at the USGS Richmond Gauge

D.6.0 Design Storm Rainfall

As discussed in Section D.3.0, a HEC-HMS hydrologic model was developed for the lower Brazos River Basin (9,766 square miles) below the USACE reservoirs. In addition to the historical gauge frequency analysis discussed in Section D.5.0, the HEC-HMS hydrologic model was used to develop a critically centered design storm to further assess peak frequency flows and volumes in the lower basin. Since the drainage area to Hempstead, Richmond, and other key locations along the Brazos River in the lower basin exceeds 400 square miles and the upper threshold for areal-storm reduction as outlined in TP-40 and in HEC-HMS, a design storm approach is needed.

A critical storm centering approach was used to derive the centering location that produced the highest peak flows at Hempstead and Richmond. This involved moving an elliptical shaped storm around the basin to various locations and computing corresponding peak runoff flow rates at the Hempstead and Richmond gauges with the HEC-HMS model.

The synthetic rainfall analysis and storm centering approach involved selection of storm duration, storm location, storm orientation, temporal rainfall distribution, and areal reduction. A GIS-based rainfall generator tool developed in-house was utilized to compute rainfall depths given various centering locations. Inputs to the rainfall generator included: rainfall depth, storm orientation, elliptical-shaped major to minor axis ratio, and an areal reduction curve.

The duration and orientation of historical Brazos River basin storms was researched to determine appropriate synthetic storm characteristics. Gauge rainfall records throughout the Lower Brazos River study area were researched for ten storm events from 1991 to 2017. The average duration of rainfall at the various gauges was just under four days for these fifteen historical storm events. A five-day (120-hour) synthetic storm duration was selected for the frequency storm rainfall.

The orientation of the historical storms varied between events. Many of the storm events had multiple storm centering locations across the basin. Some of the events were frontal in nature moving from west to east across the basin. Others were tropical in nature with rainfall moving up from the Texas Gulf Coast into the Brazos River Basin. Ultimately, a storm orientation more typical of a tropical storm was determined to be more critical, producing higher discharges at Hempstead and Richmond. An elliptical-shaped (2.5:1 major: minor axis ratio, typical for probable maximum storms) rainfall pattern was selected for the design storm analysis. Exhibit D-6 presents the design storm orientation map.

The areal reduction curve is used to reduce point rainfall depths moving away from the center of the storm. The curve used for the Lower Brazos Floodplain Protection Planning study was developed from a range of sources including: the Lower Colorado River (Texas) Flood Damage Evaluation Project, NOAA Technical Paper No. 40, NOAA Technical Paper No. 49, Hydrometeorological Report No. 51 (HMR-51), USACE SWF (Southwest Division – Fort Worth District) studies, and Areal Reduction Factors for Precipitation of the 1-Day Design Storm in Texas, published by the USGS in 1999. The areal reduction curve used for this study is at the end of Appendix D. The areal reduction for the Lower Brazos River hydrologic analysis utilized the USACE SWF curve up to

10,000 square miles and then followed the slope of the Hurricane Claudette (1979) curve out to 200,000 square miles.

The rainfall generator tool obtains frequency point rainfall depths from the *USGS Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas* published in 2004 for a given storm centering location based on the latitude and longitude of each storm center. The point rainfall is reduced away from the center based on the areal reduction curve and the corresponding elliptical ring area. The final product from the rainfall generator is a reduced point rainfall depth at each of the sub-basins for any given storm centering location.

Once the point rainfall depth for a given centering location was found (and reduced if located away from the centering), a temporal distribution of the rainfall was needed. An Alternating Block curve was selected for the rainfall distribution. The Alternating Block rainfall distribution is shown at the end of Appendix D. This time distribution and the point rainfall depths from the rainfall generator were input into HEC-HMS to create 1-hour synthetic storm hyetographs for each storm centering location.

The rainfall generator and HEC-HMS model were used in an iterative fashion for storm centering locations around the Brazos River Basin until the critical centering location was found for given points of interest (Hempstead and Richmond gauges). The initial center locations were chosen using a 20-mile grid around the centroid of the basin. Once a critical location and orientation was determined, a sensitivity analysis was conducted by adding additional locations using a ten-mile grid around the newly determined critical location. The sensitivity analysis was iterated until a true critical location and orientation was determined. For all frequency events, the critical synthetic storm centering location is near Bremond, between the Brazos and Little Brazos Rivers. Figure D-8, below, shows the synthetic storm's elliptical pattern and orientation. Table D-30 presents the storm centering ellipse areas, areal reduction, and rainfall depths for the 10%, 2%, 1%, and 0.2% annual chance storm events.

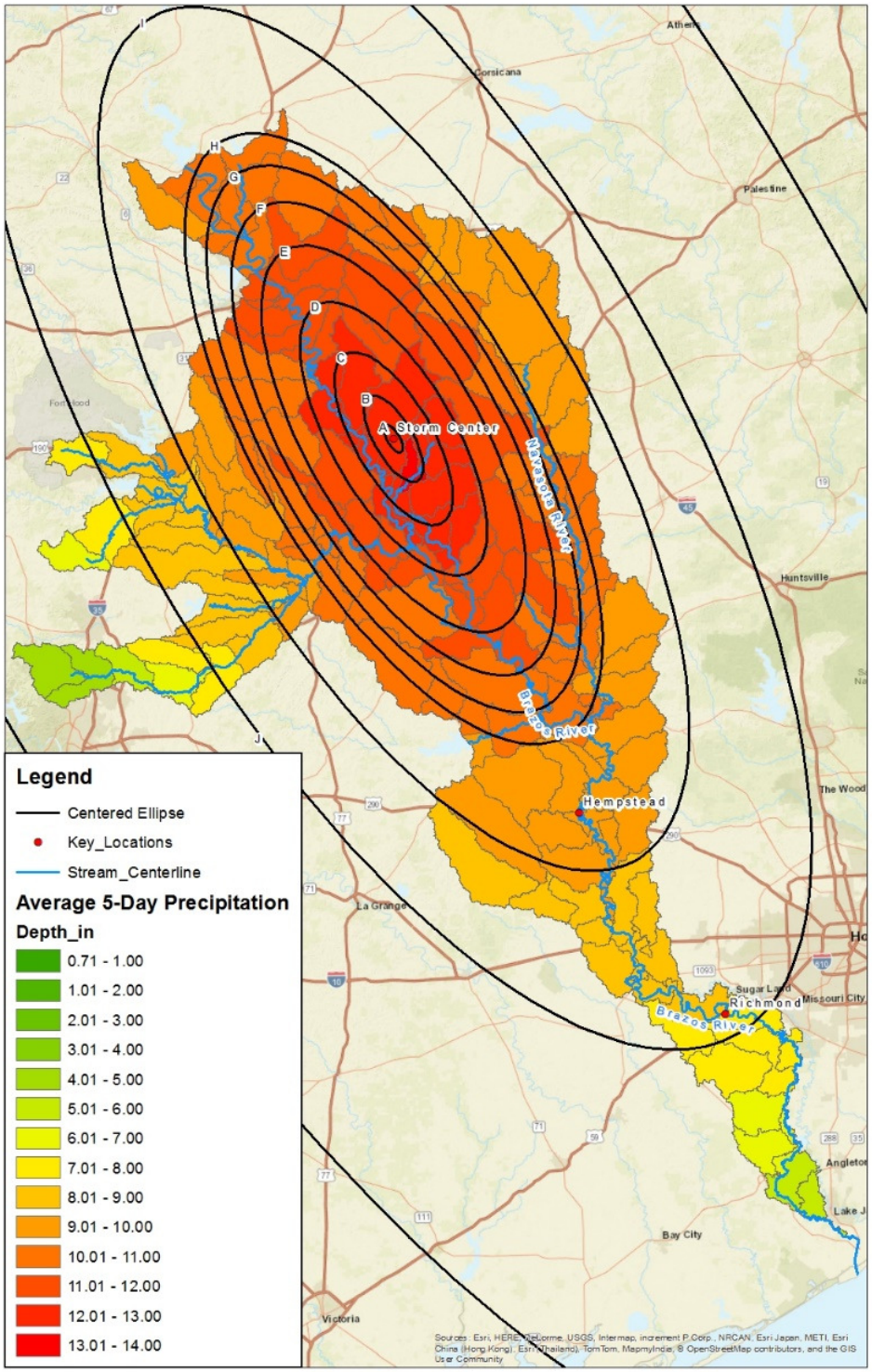


Figure D-8: Design Storm Orientation

Table D-30: Storm Centering Rainfall Depths

			Average 5-Day Rainfall Depth (in)			
Ellipse[1]	Area of Ellipse (sq mi)	Areal Reduction	10% ACE	2% ACE	1% ACE	0.2% ACE
A	10	1	8.42	11.97	13.61	17.74
B	100	0.96	8.08	11.49	13.07	17.03
C	400	0.92	7.75	11.01	12.52	16.32
D	1000	0.85	7.16	10.17	11.57	15.08
E	2000	0.82	6.9	9.82	11.16	14.55
F	3000	0.80	6.74	9.58	10.89	14.19
G	4000	0.77	6.48	9.22	10.48	13.66
H	5000	0.74	6.23	8.86	10.07	13.13
I	10000	0.68	5.73	8.14	9.25	12.06
J	20000	0.51	4.29	6.1	6.94	9.05
K	60000	0.35	2.95	4.19	4.76	6.21
L	100000	0.2	1.68	2.39	2.72	3.55
M	200000	0.05	0.42	0.6	0.68	0.89

Notes: [1]Ellipse is shown in Figure D-8: Design Storm Orientation

D.7.0 Frequency (Design) Storm Hydrologic Modeling

Large-basin synthetic storm distributions and rainfall generation is not well-documented. Historical storms on a large basin often have multiple storm centering locations and variable spatial and temporal distributions. Although the historical gauge frequency analyses provide a solid statistical analysis of peak flows and volumes based on historical weather patterns and basin conditions, there is uncertainty with how well this historical analysis will reflect future conditions due to climate variability and other basin changes. The regulation of the lower Brazos River Basin throughout the historical record adds another challenge and source of uncertainty with the statistically-based historical gauge frequency analysis.

Therefore, a hypothetical design storm provides another "check" on frequency flows beyond the historical gauge frequency analysis. Although the hypothetical design storm does not capture this future variability either, it does provide additional data beyond just a traditional gauge frequency analysis.

The frequency rainfall hyetographs discussed in the preceding section were input into the HEC-HMS model to generate runoff hydrographs for the various frequency events. The HEC-HMS model is set-up in a "regulated" mode since the upstream bounds of the study area are USACE reservoirs.

Simulated reservoir releases are also included in the model for the frequency storm events. In the study area, the USACE control points are at the Hempstead and Richmond gauge stations. The controlling flow at these two points is 60,000 cfs. The USACE will adjust operations at USACE projects to maintain flows at or below this 60,000 cfs threshold if possible. If existing flows exceed or are anticipated to exceed 60,000 cfs at these two points due to inflow from the uncontrolled drainage area below the USACE projects, the USACE will hold water within the flood control pools in accordance with the Water Control Plans at each project. Once the flow at Hempstead and Richmond has receded to less than 60,000 cfs, the USACE will begin to evacuate flood control storage. The simulated reservoir releases in the Lower Brazos River HEC-HMS model were initially set at a release of 60,000 cfs before the storm moved onto the basin. The releases were shut down as local runoff increased in the lower basin.

Initial HEC-HMS design simulations with the calibrated loss rate parameters produced peak flows at the Hempstead and Richmond gauges that were considerably lower than the historical gauge frequency analysis, especially for the more frequent storm events. Since the 2015 event was similar to a 10% ACE event, loss rates for the 10% ACE were set equal to the losses determined by the 2015 historical storm calibration. Due to drought conditions preceding the 2015 event, initial losses were set to 1.5 inches. The loss rates were reduced for less frequent events.

The overall weighted basin loss rate average range is relatively small between the 50% ACE and 0.2% ACE event. Table D-311 and Table D-322 show the computed regulated frequency flows with the calibrated HEC-HMS model at the Hempstead gauge and Richmond gauge, respectively, compared to the historical gauge frequency analysis results.

Table D-311: HEC-HMS Peak Flows at the Hempstead Gauge

	Regulated Peak Flow (cfs)		
Frequency	Frequency Analysis	Calibrated HEC-HMS	Percent Difference
10% ACE	97,000	98,000	1%
2% ACE	140,000	143,200	2%
1% ACE	157,000	160,600	2%
0.2% ACE	195,000	226,700	16%

Table D-322: HEC-HMS Peak Flows at Richmond Gauge

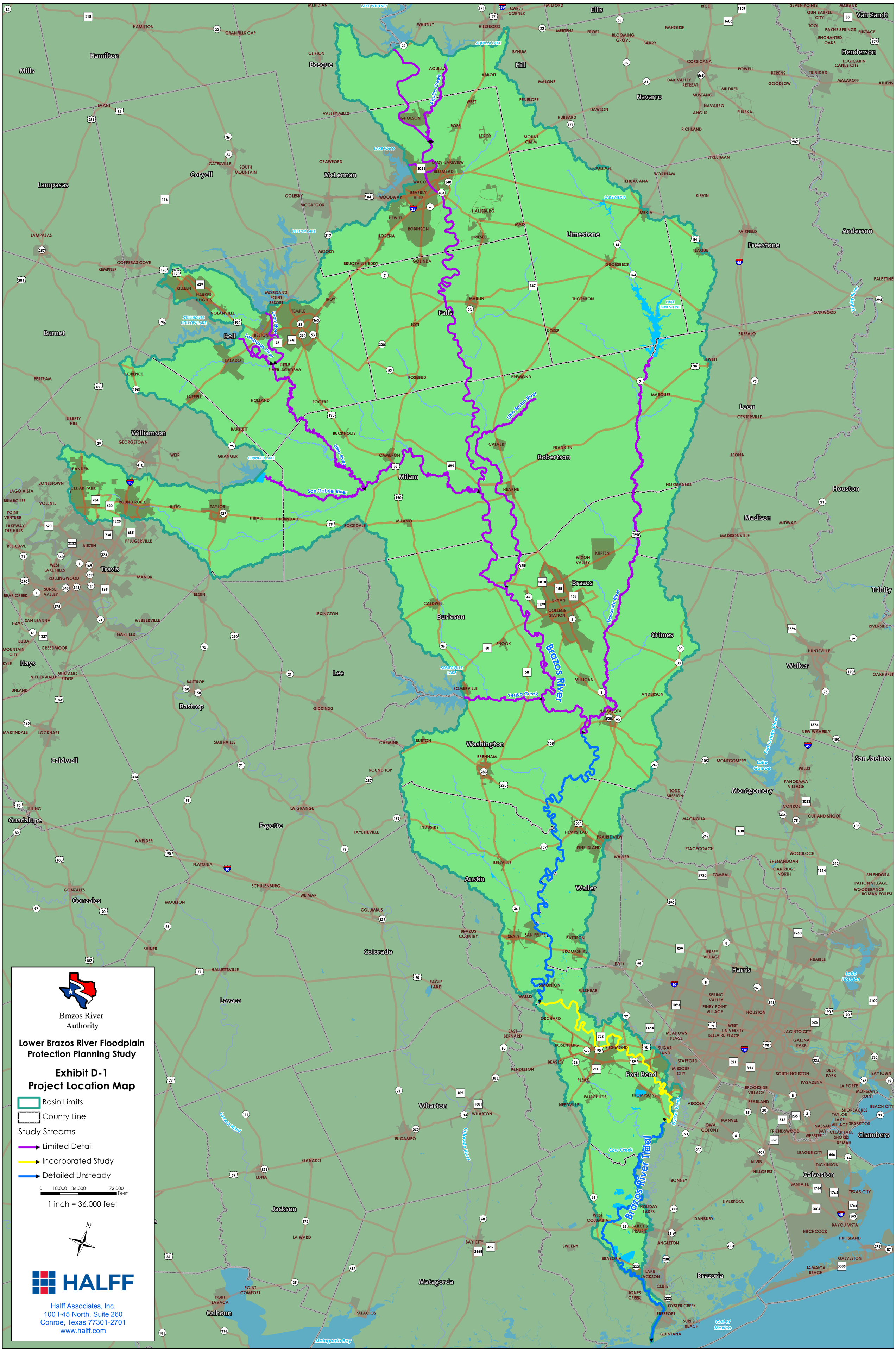
	Regulated Peak Flow (cfs)		
Frequency	Frequency Analysis	Calibrated HEC-HMS	Percent Difference
10% ACE	88,000	95,300	8%
2% ACE	117,000	115,300	-1%
1% ACE	127,000	124,600	-2%
0.2% ACE	149,000	175,600	18%

D.8.0 Hydrologic Analysis Conclusions

The goal of the hydrologic analysis was to generate synthetic frequency flow hydrographs to be used for unsteady HEC-RAS hydraulic analyses. A historical gauge frequency analysis was made to establish peak flow conditions (both unregulated and regulated) at key locations within the basin. The HEC-HMS model was also calibrated using rainfall data from historical flood events in the Lower Brazos River basin. The HEC-HMS modeling tool was used to generate runoff hydrographs for various frequency storm events in conjunction with a synthetic rainfall generator. The HEC-HMS model generated peak flows that were consistent with the peak flows established with the historical gauge frequency analysis at Hempstead and Richmond. In conclusion, the hydrologic analysis was successful in generating calibrated frequency flow hydrographs for use with the other modeling tools associated with the Lower Brazos Floodplain Protection Planning Study.

Appendix D: Hydrologic Analysis

Exhibits


Brazos River Authority
Lower Brazos River Floodplain Protection Planning Study
Exhibit D-1
Project Location Map
Basin Limits
County Line
Study Streams
Limited Detail
Incorporated Study
Detailed Unsteady
0 18,000 36,000 72,000 Feet
1 inch = 36,000 feet
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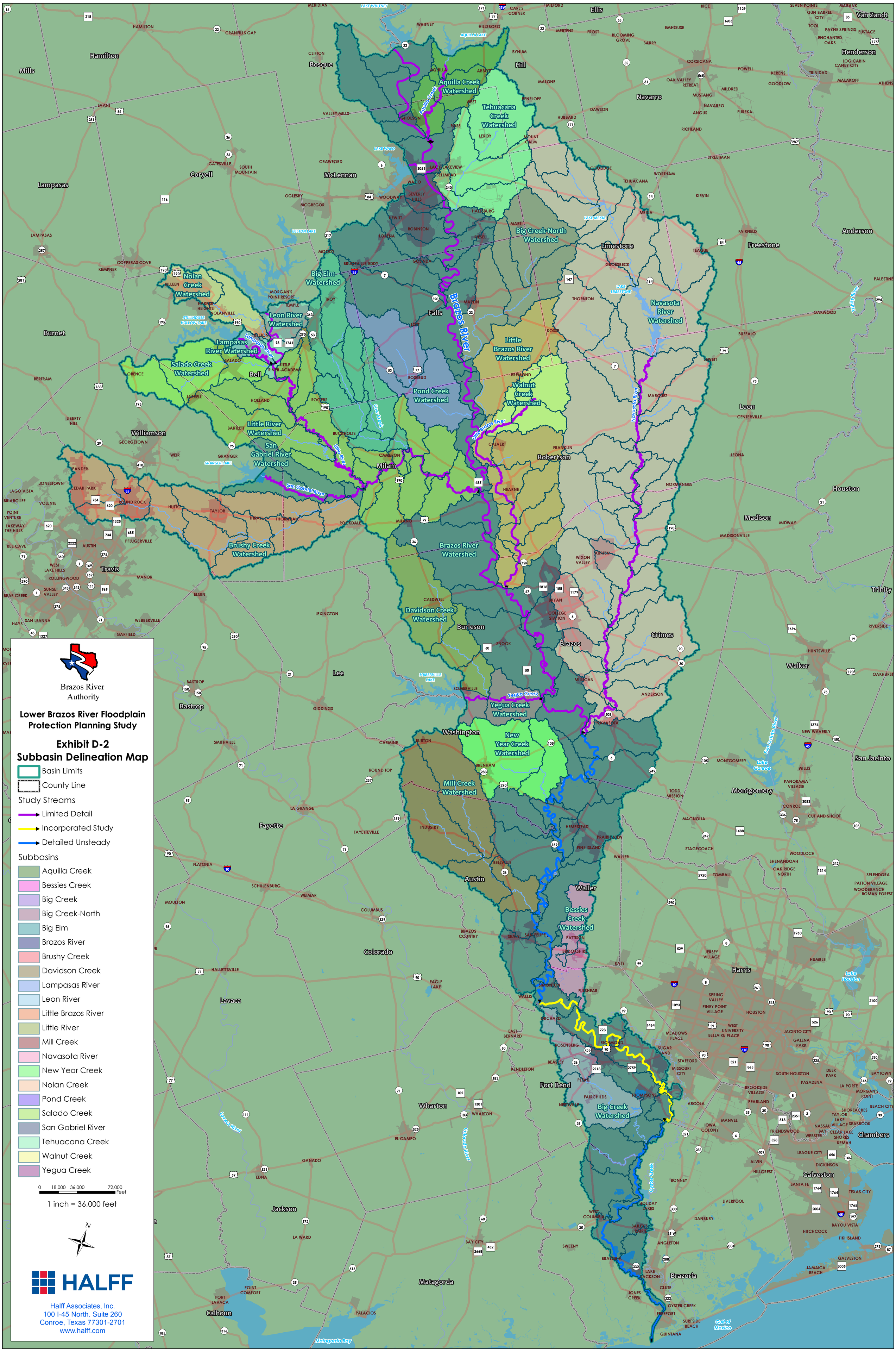
Leon River
Lampasas River
Little Brazos River
Little River
San Gabriel River
Navasota River
Yegua Creek
Cow Creek
Oyster Creek
Colorado River
Lavaca River
Trinity River
San Jacinto River
Lake Whitney
Aquilla Lake
Lake Waco
Belton Lake
Lake Mexia
Lake Limestone
Stillhouse Hollow Lake
Granger Lake
Somerville Lake
Lake Conroe
Lake Houston
Gulf of Mexico
Matagorda Bay
Mills
Hamilton
Bosque
Hill
Ellis
Van Zandt
Henderson
Navarro
Coryell
McLennan
Limestone
Freestone
Anderson
Lampasas
Burnet
Bell
Falls
Leon
Williamson
Milam
Robertson
Houston
Madison
Travis
Brazos
Trinity
Burleson
Grimes
Hays
Lee
Walker
Bastrop
Washington
San Jacinto
Caldwell
Montgomery
Guadalupe
Fayette
Austin
Waller
Gonzales
Colorado
Harris
Lavaca
Fort Bend
Wharton
Chambers
Jackson
Galveston
Matagorda
Brazoria
Calhoun


Brazos River Authority
Lower Brazos River Floodplain Protection Planning Study
Exhibit D-2
Subbasin Delineation Map
Basin Limits
County Line
Study Streams
Limited Detail
Incorporated Study
Detailed Unsteady
Subbasins
Aquilla Creek
Bessies Creek
Big Creek
Big Creek-North
Big Elm
Brazos River
Brushy Creek
Davidson Creek
Lampasas River
Leon River
Little Brazos River
Little River
Mill Creek
Navasota River
New Year Creek
Nolan Creek
Pond Creek
Salado Creek
San Gabriel River
Tehuacana Creek
Walnut Creek
Yegua Creek
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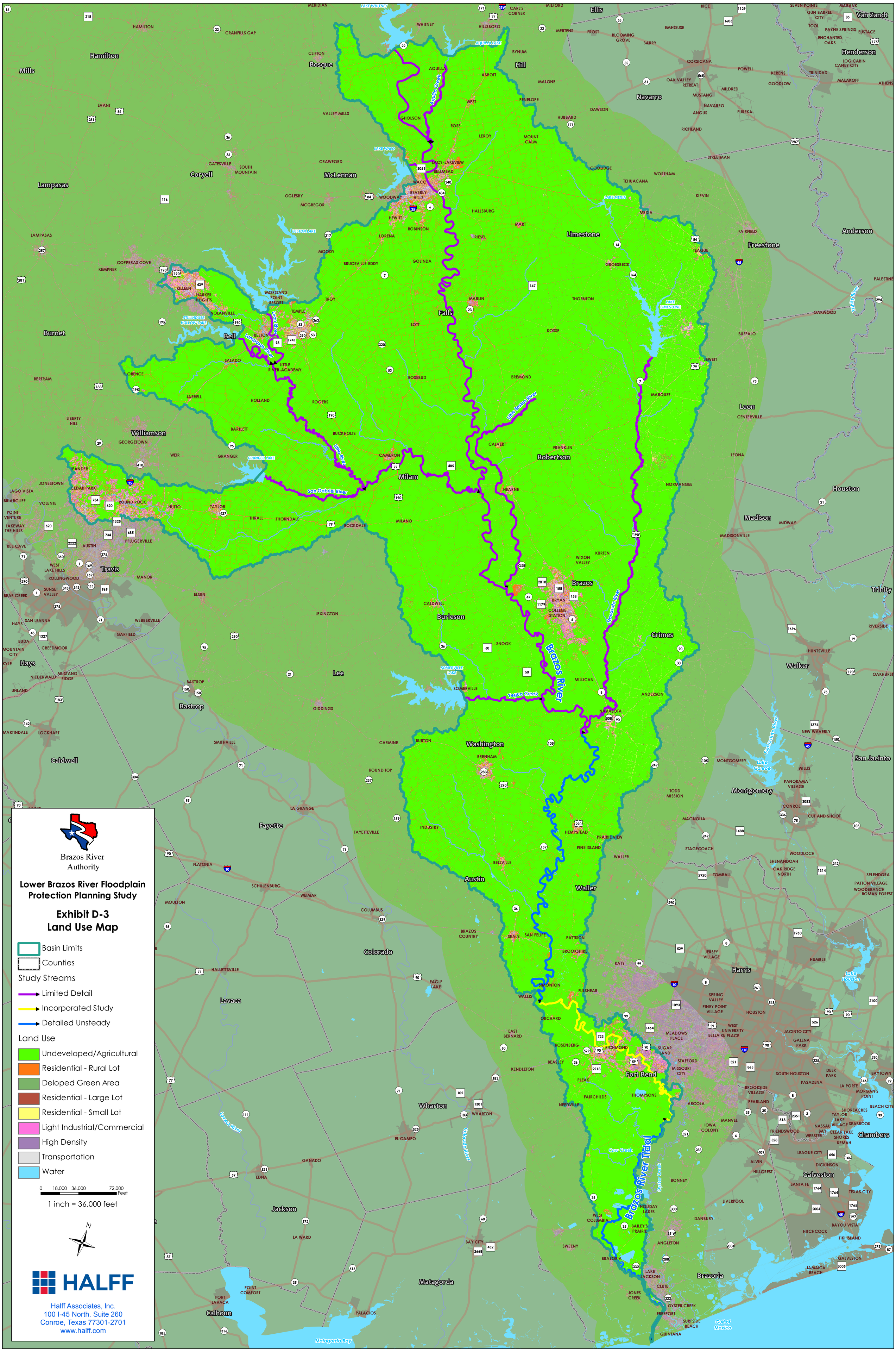
Brazos River Authority
Lower Brazos River Floodplain Protection Planning Study
Exhibit D-3
Land Use Map
Basin Limits
Counties
Study Streams
Limited Detail
Incorporated Study
Detailed Unsteady
Land Use
Undeveloped/Agricultural
Residential - Rural Lot
Deloped Green Area
Residential - Large Lot
Residential - Small Lot
Light Industrial/Commercial
High Density
Transportation
Water
0 18,000 36,000 72,000 Feet
1 inch = 36,000 feet
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Aquilla Creek
Leon River
Lampasas River
Little Brazos River
Little River
San Gabriel River
Navasota River
Yegua Creek
Cow Creek
Oyster Creek
Lake Waco
Belton Lake
Aquilla Lake
Lake Mexia
Lake Limestone
Granger Lake
Stillhouse Hollow Lake
Somerville Lake
Lake Conroe
San Jacinto River
Lake Houston
Trinity River
Colorado River
Lavaca River
Gulf of Mexico
Matagorda Bay
Mills
Hamilton
Bosque
Hill
Ellis
Van Zandt
Henderson
Navarro
Coryell
McLennan
Limestone
Freestone
Anderson
Lampasas
Falls
Burnet
Bell
Leon
Williamson
Robertson
Milam
Houston
Madison
Travis
Brazos
Trinity
Grimes
Burleson
Hays
Lee
Walker
Bastrop
Washington
San Jacinto
Caldwell
Montgomery
Fayette
Austin
Waller
Colorado
Harris
Lavaca
Fort Bend
Wharton
Jackson
Chambers
Galveston
Matagorda
Brazoria
Calhoun

Brazos River Authority

Lower Brazos River Floodplain Protection Planning Study

Exhibit D-4
Soils Map

Basin Limits
Counties
Study Streams
Limited Detail
Incorporated Study
Detailed Unsteady
Hydrologic Soil Group
A
B
C
D

0 18,000 36,000 72,000 Feet
1 inch = 36,000 feet

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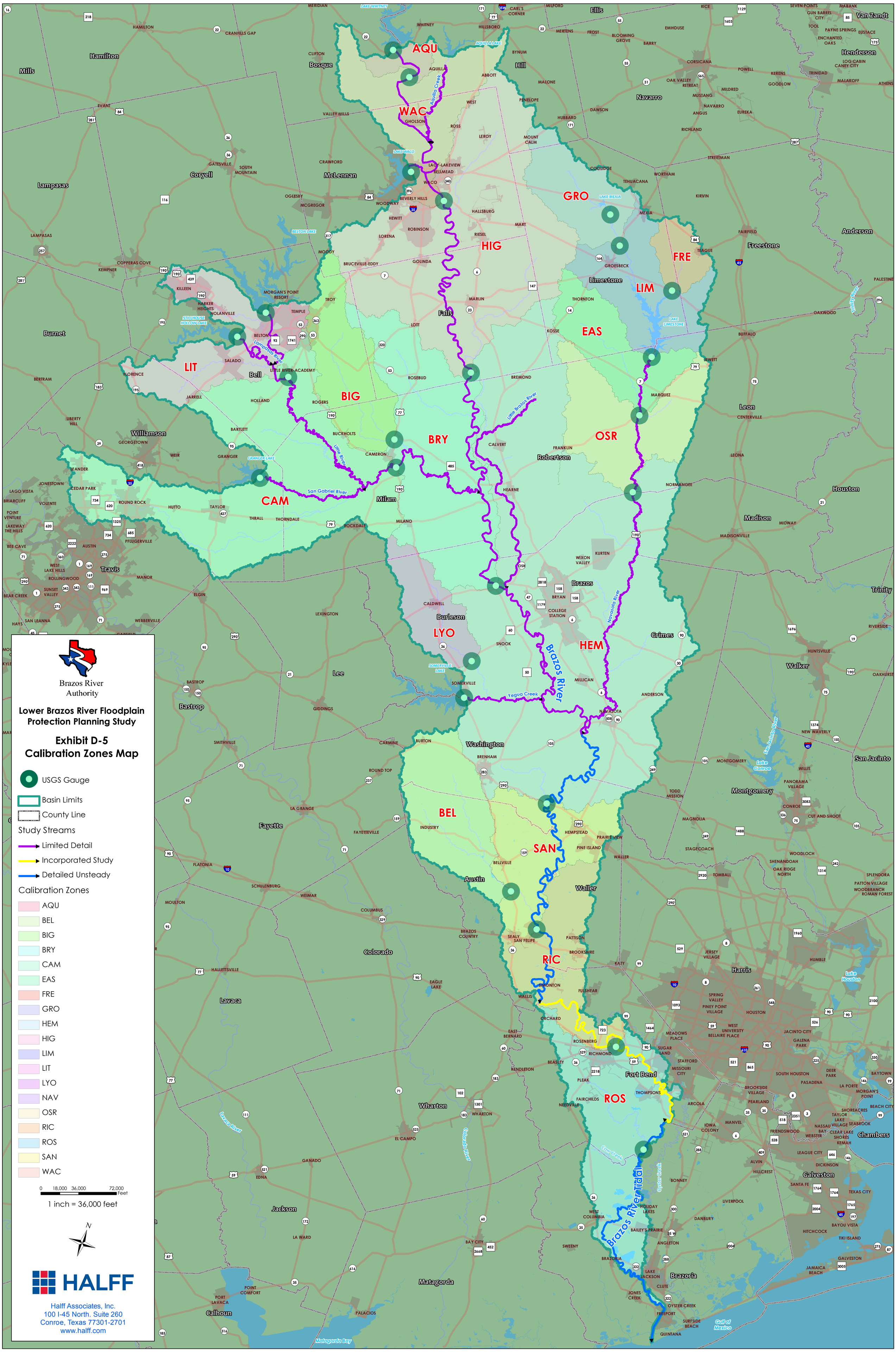
Brazos River Authority
Lower Brazos River Floodplain Protection Planning Study
Exhibit D-5
Calibration Zones Map
USGS Gauge
Basin Limits
County Line
Study Streams
Limited Detail
Incorporated Study
Detailed Unsteady
Calibration Zones
AQU
BEL
BIG
BRY
CAM
EAS
FRE
GRO
HEM
HIG
LIM
LIT
LYO
NAV
OSR
RIC
ROS
SAN
WAC
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1 inch = 36,000 feet
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Little Brazos River
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Brazos River Tidal
Colorado River
Lavaca River
Trinity River
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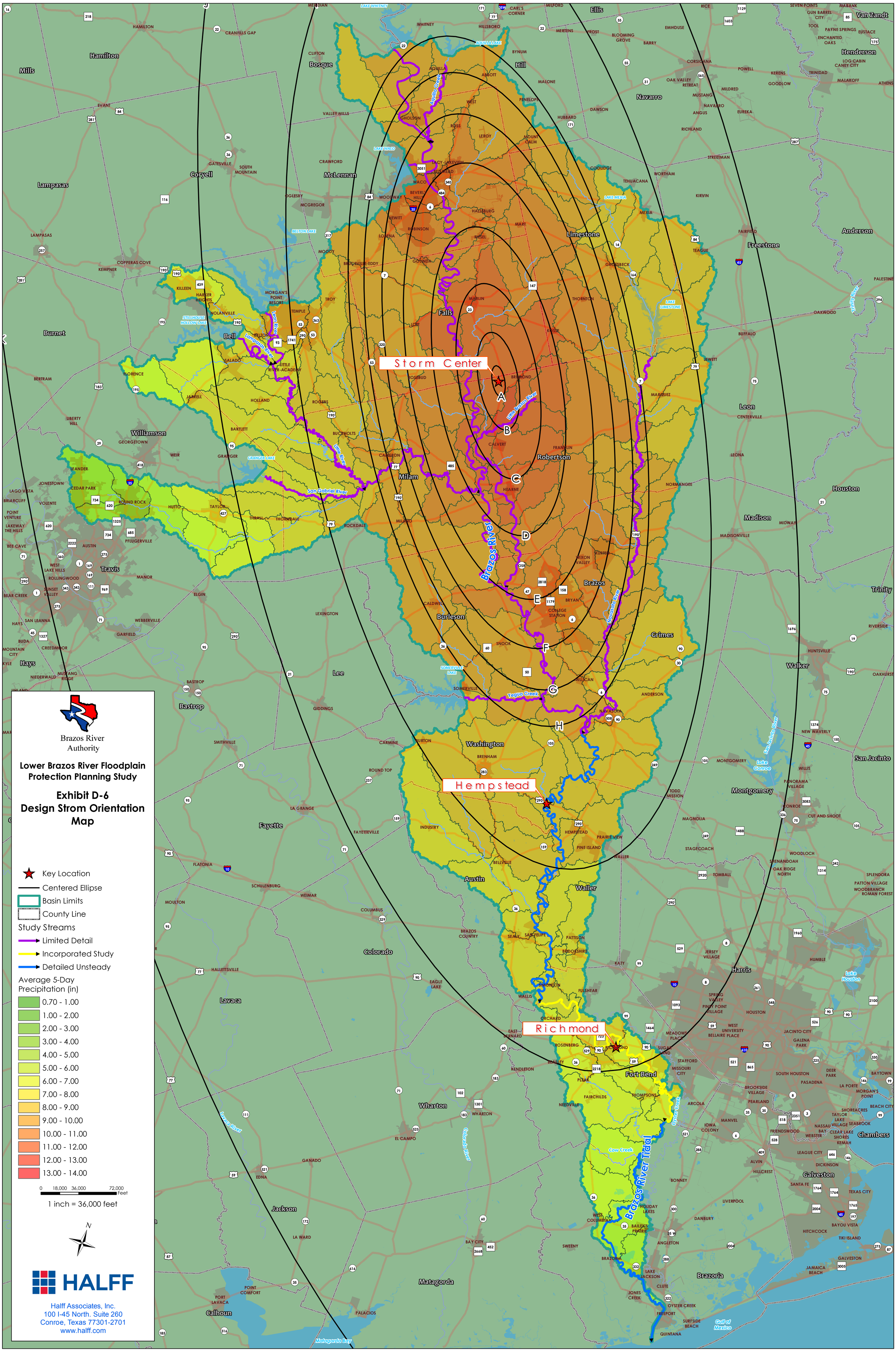
Lake Houston
Gulf of Mexico
Matagorda Bay
Mills
Hamilton
Bosque
Coryell
McLennan
Lampasas
Burnet
Williamson
Bell
Travis
Falls
Limestone
Freestone
Navarro
Ellis
Hill
Henderson
Van Zandt
Anderson
Leon
Houston
Madison
Trinity
Walker
San Jacinto
Montgomery
Brazos
Grimes
Robertson
Milam
Lee
Bastrop
Burleson
Washington
Fayette
Austin
Waller
Colorado
Fort Bend
Harris
Chambers
Galveston
Brazoria
Wharton
Lavaca
Jackson
Matagorda
Calhoun


Brazos River Authority
Lower Brazos River Floodplain Protection Planning Study
Exhibit D-6
Design Strom Orientation Map
Key Location
Centered Ellipse
Basin Limits
County Line
Study Streams
Limited Detail
Incorporated Study
Detailed Unsteady
Average 5-Day Precipitation (in)
0.70 - 1.00
1.00 - 2.00
2.00 - 3.00
3.00 - 4.00
4.00 - 5.00
5.00 - 6.00
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0 18,000 36,000 72,000 Feet
1 inch = 36,000 feet
N
HALFF
Halff Associates, Inc.
100 I-45 North. Suite 260
Conroe, Texas 77301-2701
www.halff.com
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Hempstead
Richmond
A
B
C
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H
Hamilton
Mills
Bosque
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Ellis
Navarro
Van Zandt
Henderson
Coryell
McLennan
Lampasas
Limestone
Freestone
Anderson
Falls
Burnet
Bell
Williamson
Travis
Milam
Robertson
Leon
Houston
Madison
Brazos
Trinity
Burleson
Grimes
Hays
Lee
Bastrop
Washington
San Jacinto
Montgomery
Fayette
Austin
Waller
Colorado
Harris
Fort Bend
Lavaca
Wharton
Chambers
Galveston
Jackson
Matagorda
Brazoria
Calhoun
Brazos River
Little Brazos River
Navasota River
Yegua Creek
Cow Creek
Brazos River Tidal
Oyster Creek
Colorado River
Lavaca River
Little River
San Gabriel River
Lampasas River
Leon River
Aquilla Creek
San Jacinto River
Trinity River
Lake Whitney
Aquilla Lake
Lake Waco
Belton Lake
Lake Mexia
Lake Limestone
Stillhouse Hollow Lake
Granger Lake
Somerville Lake
Lake Conroe
Lake Houston
Matagorda Bay
Gulf of Mexico

Appendix D: Hydrologic Analysis

Initial and Constant Loss Calculations

Initial and Constant Loss Calculations

Sub-basin	Area [Mi²]	Calibration Zone	Hydrologic Soil Group Distribution				Maximum Storage [in]	Weighted ConstantLoss [in/hr]	Initial Loss [in]	Impervious Area [%]
			A	B	C	D				
B_AQU_010	53.65	WAC	0.00%	12.33%	11.82%	75.86%	10.60	0.06	2.12	6.77
B_AQU_020	55.32	WAC	0.00%	16.47%	16.23%	67.30%	10.60	0.07	2.12	8.85
B_AQU_030	44.00	WAC	2.11%	20.62%	21.62%	55.65%	9.57	0.09	1.91	5.97
B_BIG_010	72.15	BIG	0.00%	2.81%	26.73%	70.46%	9.93	0.05	1.99	7.43
B_BIG_020	54.29	BIG	0.00%	0.88%	22.14%	76.98%	9.93	0.05	1.99	13.34
B_BIG_030	39.89	BIG	0.00%	0.17%	1.17%	98.67%	10.05	0.03	2.01	5.47
B_BIG_040	62.32	BIG	0.00%	0.08%	13.16%	86.76%	9.44	0.04	1.89	6.23
B_BIG_050	20.09	BIG	0.00%	0.00%	6.03%	93.97%	9.14	0.03	1.83	7.29
B_BIG_060	64.53	BIG	0.00%	0.54%	2.37%	97.09%	10.05	0.03	2.01	6.06
B_BIG_070	10.57	BRY	0.00%	0.28%	10.36%	89.36%	9.44	0.03	1.89	10.61
B_BIN_010	119.63	HIG	0.00%	2.57%	0.33%	97.10%	10.05	0.03	2.01	5.32
B_BIN_020	113.25	HIG	0.03%	6.06%	1.63%	92.28%	10.05	0.04	2.01	4.26
B_BIN_030	102.19	HIG	0.74%	12.02%	6.84%	80.40%	10.47	0.06	2.09	9.24
B_BRA_010	55.91	AQU	3.85%	20.18%	15.28%	60.70%	10.57	0.09	2.11	7.14
B_BRA_020	40.03	WAC	4.47%	28.70%	9.62%	57.22%	10.05	0.11	2.01	5.02
B_BRA_030	87.68	WAC	0.00%	3.77%	20.44%	75.80%	10.05	0.05	2.01	4.68
B_BRA_040	25.42	WAC	12.95%	26.76%	13.91%	46.37%	9.04	0.13	1.81	6.58
B_BRA_050	64.55	WAC	3.85%	21.08%	17.95%	57.12%	9.04	0.09	1.81	14.19
B_BRA_060	28.62	WAC	4.70%	21.74%	20.12%	53.43%	8.54	0.10	1.71	77.82
B_BRA_070	9.88	HIG	9.13%	8.80%	9.78%	72.29%	8.81	0.08	1.76	41.69
B_BRA_080	30.78	HIG	15.31%	13.17%	7.07%	64.45%	9.04	0.11	1.81	4.94
B_BRA_090	52.11	HIG	1.86%	6.45%	18.90%	72.79%	9.04	0.06	1.81	28.18
B_BRA_100	76.02	HIG	6.52%	12.94%	7.97%	72.56%	10.05	0.08	2.01	7.61
B_BRA_110	47.49	HIG	9.13%	23.39%	4.78%	62.71%	10.47	0.11	2.09	7.44
B_BRA_120	122.33	HIG	0.61%	12.11%	20.01%	67.28%	10.47	0.07	2.09	7.55
B_BRA_130	115.25	HIG	0.18%	11.48%	13.08%	75.26%	10.05	0.06	2.01	8.46
B_BRA_140	85.34	HIG	13.13%	34.22%	4.56%	48.10%	10.47	0.14	2.09	9.36
B_BRA_150	10.76	HIG	41.71%	23.77%	6.12%	28.40%	10.47	0.22	2.09	7.84
B_BRA_160	24.51	BRY	16.99%	23.05%	5.24%	54.72%	10.47	0.13	2.09	5.12
B_BRA_170	39.56	BRY	22.38%	17.01%	10.84%	49.76%	9.74	0.15	1.95	3.64
B_BRA_180	51.18	BRY	11.88%	14.90%	41.15%	32.06%	9.44	0.13	1.89	4.72

B_BRA_190	162.61	BRY	40.66%	18.04%	24.36%	16.93%	9.65	0.22	1.93	3.38
B_BRA_200	108.75	HEM	8.72%	9.27%	20.13%	61.88%	9.65	0.09	1.93	13.65
B_BRA_210	45.31	HEM	3.82%	9.57%	11.32%	75.28%	9.65	0.07	1.93	22.07
B_BRA_220	150.15	HEM	4.32%	14.00%	8.26%	73.42%	11.42	0.07	2.28	4.29
B_BRA_230	79.43	HEM	6.29%	20.96%	16.88%	55.87%	9.76	0.10	1.95	3.50
B_BRA_240	83.67	HEM	16.25%	15.68%	8.73%	59.33%	11.39	0.12	2.28	9.00
B_BRA_250	82.33	HEM	26.81%	10.75%	12.71%	49.72%	11.23	0.15	2.25	5.76
B_BRA_260	61.02	HEM	14.53%	26.94%	12.57%	45.97%	9.96	0.14	1.99	3.84
B_BRU_010	73.25	CAM	0.00%	4.12%	0.00%	95.88%	10.05	0.03	2.01	51.21
B_BRU_020	65.58	CAM	0.00%	3.05%	8.61%	88.34%	10.05	0.04	2.01	54.72
B_BRU_030	50.81	CAM	0.00%	9.86%	19.53%	70.61%	10.05	0.06	2.01	25.93
B_BRU_040	54.61	CAM	0.00%	8.32%	7.80%	83.88%	10.05	0.05	2.01	6.93
B_BRU_050	55.59	CAM	0.00%	4.25%	7.41%	88.34%	10.05	0.04	2.01	17.60
B_BRU_060	66.36	CAM	0.00%	1.24%	21.15%	77.60%	10.11	0.04	2.02	7.46
B_BRU_070	54.01	CAM	3.47%	4.87%	21.81%	69.84%	10.05	0.06	2.01	8.00
B_BRU_080	65.54	CAM	0.00%	3.82%	4.00%	92.18%	10.05	0.04	2.01	7.47
B_BRU_090	32.27	CAM	11.22%	5.64%	31.82%	51.32%	9.74	0.10	1.95	8.34
B_DAV_010	142.02	LYO	32.20%	10.09%	27.98%	29.74%	9.07	0.18	1.81	6.38
B_DAV_020	52.76	LYO	11.37%	1.95%	15.14%	71.54%	9.07	0.08	1.81	4.26
B_DAV_030	31.73	HEM	9.79%	0.49%	14.52%	75.21%	7.98	0.07	1.60	6.56
B_LAM_010	26.41	LIT	0.00%	24.58%	17.03%	58.40%	9.93	0.09	1.99	10.43
B_LEO_010	46.82	LIT	0.00%	11.17%	22.51%	66.32%	9.93	0.06	1.99	40.81
B_LEO_020	23.15	LIT	0.00%	28.06%	24.56%	47.38%	9.57	0.10	1.91	21.05
B_LIB_010	168.09	HEM	5.47%	19.32%	7.20%	68.01%	10.47	0.09	2.09	5.34
B_LIB_020	22.56	HEM	10.72%	27.60%	5.32%	56.37%	8.97	0.12	1.79	3.49
B_LIB_030	78.49	HEM	24.61%	27.42%	11.42%	36.54%	8.83	0.18	1.77	7.44
B_LIB_040	40.70	HEM	14.13%	30.37%	7.89%	47.61%	8.97	0.14	1.79	13.66
B_LIB_050	55.94	HEM	33.97%	27.33%	15.84%	22.86%	8.97	0.21	1.79	3.84
B_LIB_060	48.15	HEM	33.87%	28.70%	15.24%	22.19%	8.97	0.21	1.79	4.08
B_LIB_070	44.39	HEM	1.52%	18.56%	26.60%	53.32%	8.97	0.09	1.79	5.47
B_LIB_080	30.84	HEM	5.83%	27.60%	5.95%	60.62%	9.26	0.11	1.85	7.54
B_LIT_010	43.17	CAM	0.00%	13.49%	27.26%	59.25%	9.93	0.07	1.99	6.57
B_LIT_020	36.45	CAM	0.00%	2.10%	13.22%	84.68%	9.93	0.04	1.99	12.50
B_LIT_030	57.53	CAM	0.00%	5.89%	29.19%	64.93%	9.93	0.06	1.99	4.85
B_LIT_040	46.28	CAM	0.00%	5.78%	11.53%	82.69%	9.44	0.05	1.89	7.51
B_LIT_050	130.20	CAM	0.00%	5.44%	20.63%	73.93%	10.05	0.05	2.01	7.32
B_LIT_060	50.01	CAM	0.00%	6.71%	29.71%	63.58%	9.74	0.06	1.95	7.73
B_LIT_070	28.56	CAM	2.81%	7.24%	29.73%	60.22%	9.74	0.07	1.95	7.99
B_LIT_080	78.35	CAM	11.37%	5.13%	27.92%	55.58%	9.74	0.10	1.95	8.44
B_LIT_090	10.32	BRY	2.55%	8.36%	45.86%	43.22%	9.74	0.09	1.95	16.02

B_LIT_100	37.96	BRY	0.44%	2.99%	15.59%	80.98%	9.74	0.04	1.95	5.67
B_LIT_110	41.15	BRY	22.60%	3.68%	28.34%	45.37%	9.31	0.13	1.86	3.51
B_LIT_120	48.78	BRY	0.37%	4.71%	64.60%	30.33%	9.74	0.08	1.95	3.70
B_LIT_130	64.97	BRY	18.66%	3.69%	55.29%	22.36%	9.74	0.14	1.95	3.13
B_NAV_010	50.56	GRO	0.00%	10.12%	1.67%	88.22%	9.57	0.05	1.91	4.96
B_NAV_020	53.11	GRO	0.00%	4.01%	0.00%	95.99%	9.33	0.03	1.87	4.82
B_NAV_030	53.99	GRO	0.00%	5.90%	0.08%	94.01%	9.33	0.04	1.87	4.43
B_NAV_040	39.51	GRO	0.11%	14.75%	9.45%	75.69%	9.04	0.06	1.81	5.43
B_NAV_050	43.26	GRO	1.77%	18.92%	19.42%	59.89%	9.04	0.08	1.81	5.86
B_NAV_060	72.99	LIM	0.00%	16.54%	9.92%	73.54%	9.54	0.07	1.91	8.55
B_NAV_070	71.07	LIM	0.89%	19.40%	4.68%	75.04%	9.12	0.07	1.82	5.48
B_NAV_080	97.37	FRE	9.00%	25.20%	2.13%	63.67%	10.58	0.11	2.12	9.93
B_NAV_090	193.96	LIM	12.51%	29.51%	9.17%	48.81%	9.54	0.13	1.91	9.63
B_NAV_100	74.13	EAS	30.20%	22.19%	13.77%	33.83%	10.11	0.19	2.02	6.00
B_NAV_110	105.27	EAS	6.96%	26.83%	7.41%	58.79%	9.54	0.11	1.91	4.33
B_NAV_120	82.30	EAS	13.38%	16.54%	11.21%	58.87%	10.11	0.11	2.02	4.33
B_NAV_130	73.59	OSR	46.86%	14.32%	19.52%	19.30%	10.11	0.23	2.02	6.46
B_NAV_140	170.08	OSR	19.87%	27.27%	13.77%	39.09%	10.11	0.16	2.02	5.10
B_NAV_150	64.60	OSR	59.83%	6.96%	21.20%	12.01%	10.11	0.26	2.02	5.53
B_NAV_160	49.51	OSR	29.73%	35.02%	14.36%	20.90%	10.11	0.21	2.02	5.36
B_NAV_170	22.14	OSR	28.69%	30.05%	13.16%	28.10%	10.11	0.20	2.02	3.64
B_NAV_180	28.45	NAV	52.73%	5.95%	12.98%	28.34%	10.11	0.23	2.02	11.91
B_NAV_190	63.80	NAV	10.35%	19.53%	29.62%	40.50%	9.61	0.12	1.92	4.83
B_NAV_200	50.32	NAV	9.70%	19.43%	18.45%	52.42%	9.61	0.11	1.92	3.34
B_NAV_210	120.02	NAV	19.82%	14.57%	32.42%	33.19%	8.83	0.15	1.77	3.70
B_NAV_220	41.20	NAV	10.02%	2.77%	18.38%	68.83%	9.61	0.08	1.92	3.03
B_NAV_230	51.36	NAV	8.01%	2.66%	16.64%	72.70%	9.11	0.07	1.82	4.20
B_NAV_240	36.78	NAV	8.18%	1.81%	5.80%	84.22%	9.46	0.06	1.89	4.50
B_NAV_250	89.75	NAV	4.26%	4.11%	22.50%	69.13%	8.78	0.06	1.76	6.17
B_NAV_260	66.78	NAV	3.15%	1.30%	18.36%	77.19%	9.11	0.05	1.82	49.11
B_NAV_270	52.95	NAV	8.49%	0.51%	10.61%	80.39%	9.11	0.06	1.82	16.75
B_NAV_280	117.72	NAV	12.69%	1.33%	11.72%	74.26%	9.11	0.08	1.82	5.65
B_NAV_290	30.23	NAV	3.06%	0.23%	15.27%	81.44%	9.11	0.05	1.82	10.72
B_NAV_300	62.82	NAV	8.29%	0.79%	10.83%	80.09%	10.50	0.06	2.10	5.40
B_NAV_310	59.00	NAV	3.70%	8.14%	8.87%	79.29%	10.50	0.06	2.10	5.74
B_NAV_320	25.91	NAV	2.72%	21.45%	8.89%	66.94%	11.23	0.08	2.25	15.19
B_NEW_010	146.89	HEM	3.84%	21.73%	20.48%	53.95%	9.76	0.10	1.95	11.52
B_NEW_020	69.01	HEM	6.69%	24.22%	10.77%	58.32%	9.76	0.11	1.95	5.00
B_NOL_010	52.69	LIT	0.00%	10.21%	35.08%	54.71%	9.93	0.07	1.99	68.38
B_NOL_020	61.25	LIT	0.00%	13.58%	16.36%	70.06%	9.93	0.06	1.99	16.53

B_PON_010	100.54	BRY	0.00%	6.06%	0.31%	93.63%	10.05	0.04	2.01	7.28
B_PON_020	129.62	BRY	1.86%	7.36%	4.30%	86.48%	10.05	0.05	2.01	5.59
B_SAL_010	51.15	LIT	0.00%	1.67%	0.32%	98.01%	9.17	0.03	1.83	6.82
B_SAL_020	84.89	LIT	0.00%	1.84%	11.72%	86.44%	9.93	0.04	1.99	5.78
B_SAL_030	37.20	LIT	0.00%	7.77%	39.22%	53.01%	9.93	0.07	1.99	8.13
B_SAN_010	50.82	CAM	0.00%	18.20%	19.36%	62.44%	10.05	0.08	2.01	8.94
B_SAN_020	58.37	CAM	0.00%	4.01%	11.50%	84.49%	10.05	0.04	2.01	6.95
B_SAN_030	9.52	CAM	0.32%	13.40%	30.76%	55.53%	9.74	0.08	1.95	6.58
B_TEH_010	131.33	HIG	0.00%	2.43%	1.62%	95.95%	10.60	0.03	2.12	6.01
B_TEH_020	111.52	HIG	0.05%	7.07%	4.49%	88.40%	9.57	0.04	1.91	12.10
B_TEH_030	66.07	HIG	0.11%	13.07%	2.11%	84.71%	9.33	0.05	1.87	13.69
B_WAL_010	53.35	HEM	23.68%	20.38%	14.54%	41.40%	8.83	0.16	1.77	3.09
B_WAL_020	57.72	HEM	12.02%	18.01%	18.28%	51.69%	9.10	0.12	1.82	5.09
B_WAL_030	25.47	HEM	12.19%	26.85%	16.44%	44.52%	9.14	0.13	1.83	5.80
B_YEG_010	21.73	HEM	9.31%	8.10%	4.51%	78.08%	9.76	0.08	1.95	7.29
B_YEG_020	66.56	HEM	4.10%	5.77%	9.03%	81.10%	9.76	0.06	1.95	3.70

Appendix D: Hydrologic Analysis

Snyder Unit Hydrograph

Snyder Unit Hydrograph										
Sub-basin	Basin Area (sq mi)	Calibration Zone	River Mileage, L (mi)	Centroidal Length, Lca (mi)	Elevation Upstream (ft)	Elevation Downstream (ft)	Basin Coefficient, Ct	Slope S (ft/mi)	Time to Peak tp (hr)	Time of Concentration, tc (hr)
B_AQU_010	54	WAC	22.9	10.1	818.56	450.07	1.0	16.1	3.8	2.9
B_AQU_020	55	WAC	15.9	8.0	717.99	429.63	1.0	18.2	3.1	2.3
B_AQU_030	44	WAC	15.4	8.9	575.71	384.28	1.0	12.4	3.3	2.5
B_BIG_010	72	CAM	26.5	17.0	797.67	458.54	1.0	12.8	4.9	3.7
B_BIG_020	54	CAM	28.5	15.6	828.02	394.90	1.0	15.2	4.8	3.6
B_BIG_030	40	CAM	19.7	11.0	595.19	394.90	1.0	10.1	4.0	3.0
B_BIG_040	62	CAM	17.4	7.7	580.39	350.14	1.0	13.2	3.3	2.5
B_BIG_050	20	CAM	11.3	4.9	505.39	301.62	1.0	18.0	2.3	1.8
B_BIG_060	65	CAM	25.2	11.3	593.37	307.50	1.0	11.3	4.3	3.2
B_BIG_070	11	BRY	7.5	4.0	411.10	280.08	1.0	17.4	1.9	1.4
B_BIN_010	120	HIG	23.6	12.3	621.53	372.89	1.0	10.5	4.4	3.3
B_BIN_020	113	HIG	24.2	11.7	621.99	340.16	1.0	11.7	4.3	3.2
B_BIN_030	102	HIG	33.0	17.9	562.92	283.74	1.0	8.5	5.8	4.3
B_BRA_010	56	AQU	17.6	6.4	812.88	415.5	1.0	22.6	2.8	2.1
B_BRA_020	40	WAC	17.01	7.07	701.41	388.68	1.0	18.4	3.0	2.3
B_BRA_030	88	WAC	27.7	13.52	942.8	399.68	1.0	19.6	4.3	3.2
B_BRA_040	25	WAC	12.7	5.9	654.78	384.6	1.0	21.3	2.5	1.9
B_BRA_050	65	WAC	18.89	6.1	629.8	379.9	1.0	13.2	3.1	2.3
B_BRA_060	29	WAC	11.42	5.1	625.2	369.34	1.0	22.4	2.3	1.7
B_BRA_070	10	HIG	11.6	6.4	627.2	354.1	1.0	23.5	2.5	1.8
B_BRA_080	31	HIG	16.7	6.9	544.76	338.72	1.0	12.3	3.2	2.4
B_BRA_090	52	HIG	20.3	10.4	730.16	339.46	1.0	19.2	3.6	2.7
B_BRA_100	76	HIG	21.9	4.8	742	343.38	1.0	18.2	2.9	2.2
B_BRA_110	47	HIG	25.7	14.8	575.32	320.99	1.0	9.9	4.9	3.6
B_BRA_120	122	HIG	35.8	20.2	861.62	324.15	1.0	15.0	5.6	4.2
B_BRA_130	115	HIG	32.9	13.3	875.37	325.55	1.0	16.7	4.7	3.5
B_BRA_140	85	HIG	25.4	10.1	490.78	286.54	1.0	8.0	4.4	3.3
B_BRA_150	11	HIG	7.2	3.5	450.19	282.09	1.0	23.4	1.7	1.3
B_BRA_160	25	BRY	15.6	10.4	315.50	265.00	1.0	3.2	4.4	3.3
B_BRA_170	40	BRY	28.0	15.8	465.90	244.42	1.0	7.9	5.3	4.0

B_BRA_180	51	BRY	15.4	7.2	499.89	212.81	1.0	18.7	2.9	2.2
B_BRA_190	163	BRY	29.5	14.7	559.77	202.43	1.0	12.1	4.9	3.7
B_BRA_200	109	HEM	22.1	6.9	454.74	193.91	1.0	11.8	3.5	2.6
B_BRA_210	45	HEM	21.1	5.3	352.66	183.22	1.0	8.0	3.4	2.5
B_BRA_220	150	HEM	39.4	21.5	238.75	182.51	1.0	1.4	8.7	6.5
B_BRA_230	79	HEM	21.7	12.1	311.43	152.76	1.0	7.3	4.5	3.4
B_BRA_240	84	HEM	18.1	7.0	410.33	132.88	1.0	15.4	3.2	2.4
B_BRA_250	82	HEM	19.7	8.4	419.95	131.35	1.0	14.7	3.5	2.6
B_BRA_260	61	HEM	25.3	11.7	370.46	123.54	1.0	9.7	4.5	3.4
B_BRU_010	73	ROC	20.3	8.2	1130.74	706.62	1.0	20.9	3.3	2.5
B_BRU_020	66	ROC	18.7	6.2	1025.86	618.45	1.0	21.8	2.9	2.2
B_BRU_030	51	ROC	21.0	10.5	906.30	518.62	1.0	18.5	3.7	2.7
B_BRU_040	55	ROC	20.5	12.0	669.92	433.19	1.0	11.5	4.1	3.1
B_BRU_050	56	ROC	22.8	11.7	781.66	433.19	1.0	15.3	4.0	3.0
B_BRU_060	66	ROC	19.6	7.5	609.38	401.47	1.0	10.6	3.5	2.6
B_BRU_070	54	ROC	18.1	8.9	557.92	350.78	1.0	11.5	3.6	2.7
B_BRU_080	66	ROC	27.6	13.2	641.62	350.95	1.0	10.5	4.7	3.6
B_BRU_090	32	ROC	11.2	5.1	545.76	321.25	1.0	20.1	2.3	1.7
B_DAV_010	142	LYO	31.1	16.5	639.68	260.26	1.0	12.2	5.2	3.9
B_DAV_020	53	LYO	15.4	6.0	421.94	231.61	1.0	12.3	2.9	2.2
B_DAV_030	32	HEM	12.4	2.6	342.68	195.39	1.0	11.9	2.1	1.6
B_LAM_010	26	LIT	20.1	10.0	740.24	427.28	1.0	15.6	3.7	2.7
B_LEO_010	47	LIT	15.0	8.6	784.48	446.79	1.0	22.5	3.0	2.2
B_LEO_020	23	LIT	18.0	9.6	725.64	405.50	1.0	17.8	3.4	2.6
B_WAL_010	53	HEM	12.5	5.1	570.52	347.05	1.0	17.9	2.4	1.8
B_WAL_020	58	HEM	16.4	5.7	522.39	309.82	1.0	13.0	2.9	2.2
B_WAL_030	48	HEM	25.8	13.6	461.66	284.50	1.0	6.9	5.0	3.8
B_LIB_010	168	HEM	37.4	19.8	537.17	294.00	1.0	6.5	6.5	4.9
B_LIB_020	23	HEM	14.6	7.4	385.50	269.57	1.0	7.9	3.3	2.5
B_LIB_030	78	HEM	17.9	7.2	577.91	269.72	1.0	17.2	3.1	2.3
B_LIB_040	41	HEM	13.6	5.7	465.39	251.84	1.0	15.6	2.7	2.0
B_LIB_050	56	HEM	19.5	10.6	541.17	247.08	1.0	15.1	3.7	2.8
B_LIB_060	48	HEM	17.2	7.2	522.65	241.06	1.0	16.4	3.1	2.3
B_LIB_070	44	HEM	14.3	6.7	454.57	237.47	1.0	15.2	2.9	2.2
B_LIB_080	31	HEM	14.1	6.2	260.22	203.55	1.0	4.0	3.5	2.6

B_LIT_010	43	ROC	22.5	14.1	681.39	377.55	1.0	13.5	4.4	3.3
B_LIT_020	36	ROC	20.1	8.8	747.90	377.55	1.0	18.4	3.4	2.6
B_LIT_030	58	ROC	24.1	11.7	868.53	380.90	1.0	20.3	3.9	2.9
B_LIT_040	46	ROC	20.3	10.3	551.04	352.12	1.0	9.8	4.0	3.0
B_LIT_050	130	ROC	54.4	31.4	902.27	349.90	1.0	10.1	8.0	6.0
B_LIT_060	50	ROC	28.9	17.9	552.04	307.34	1.0	8.5	5.5	4.1
B_LIT_070	29	CAM	14.1	5.6	524.02	301.73	1.0	15.7	2.7	2.0
B_LIT_080	78	CAM	19.7	8.9	590.43	292.14	1.0	15.2	3.5	2.6
B_LIT_090	10	BRY	8.0	4.3	476.71	280.08	1.0	24.6	1.9	1.4
B_LIT_100	38	BRY	17.2	7.9	469.24	296.85	1.0	10.0	3.4	2.6
B_LIT_110	41	BRY	13.7	5.8	580.74	270.84	1.0	22.6	2.5	1.9
B_LIT_120	49	BRY	14.6	9.7	445.02	257.51	1.0	12.9	3.4	2.5
B_LIT_130	65	BRY	18.8	9.3	603.44	244.77	1.0	19.1	3.4	2.5
B_NAV_010	51	GRO	13.0	6.2	654.93	500.40	1.0	11.9	2.8	2.1
B_NAV_020	53	GRO	15.4	8.1	642.94	446.97	1.0	12.8	3.2	2.4
B_NAV_030	54	GRO	23.7	12.2	669.04	446.97	1.0	9.4	4.5	3.4
B_NAV_040	40	GRO	10.8	3.1	568.18	430.49	1.0	12.7	2.1	1.6
B_NAV_050	43	GRO	15.0	5.3	635.06	398.54	1.0	15.7	2.7	2.0
B_NAV_060	73	LIM	22.6	10.6	574.05	362.32	1.0	9.4	4.2	3.2
B_NAV_070	71	LIM	18.9	8.9	610.01	362.32	1.0	13.1	3.6	2.7
B_NAV_080	97	FRE	18.6	8.3	553.20	368.50	1.0	10.0	3.6	2.7
B_NAV_090	194	LIM	25.9	8.6	540.80	347.60	1.0	7.5	4.3	3.2
B_NAV_100	74	EAS	29.1	21.7	525.77	299.30	1.0	7.8	6.0	4.5
B_NAV_110	105	EAS	20.5	9.4	583.28	360.20	1.0	10.9	3.8	2.9
B_NAV_120	82	EAS	24.4	11.6	515.80	299.30	1.0	8.9	4.5	3.4
B_NAV_130	74	OSR	25.2	14.5	527.21	283.59	1.0	9.7	4.8	3.6
B_NAV_140	170	OSR	31.8	5.3	556.12	280.33	1.0	8.7	3.8	2.9
B_NAV_150	65	OSR	16.9	7.8	573.10	273.03	1.0	17.7	3.1	2.3
B_NAV_160	50	OSR	17.3	10.0	480.29	262.51	1.0	12.6	3.6	2.7
B_NAV_170	22	OSR	11.9	6.6	479.75	254.09	1.0	19.0	2.6	1.9
B_NAV_180	28	NAV	14.5	8.1	478.98	245.70	1.0	16.1	3.0	2.3
B_NAV_190	64	NAV	20.6	6.8	570.89	241.49	1.0	16.0	3.2	2.4
B_NAV_200	50	NAV	14.5	5.4	395.97	233.13	1.0	11.2	2.8	2.1
B_NAV_210	120	NAV	30.1	16.7	497.37	232.77	1.0	8.8	5.4	4.1
B_NAV_220	41	NAV	15.2	5.8	365.87	211.66	1.0	10.2	3.0	2.2

B_NAV_230	51	NAV	14.5	4.1	380.86	206.50	1.0	12.0	2.6	1.9
B_NAV_240	37	NAV	19.8	10.0	361.67	187.15	1.0	8.8	4.0	3.0
B_NAV_250	90	NAV	29.6	18.0	431.25	185.11	1.0	8.3	5.6	4.2
B_NAV_260	67	NAV	20.6	11.0	370.67	187.80	1.0	8.9	4.2	3.1
B_NAV_270	53	NAV	18.8	8.4	324.59	174.07	1.0	8.0	3.8	2.8
B_NAV_280	118	NAV	27.4	16.4	391.59	174.85	1.0	7.9	5.3	4.0
B_NAV_290	30	NAV	15.3	7.7	361.41	179.87	1.0	11.9	3.2	2.4
B_NAV_300	63	NAV	25.1	12.0	394.47	175.07	1.0	8.7	4.6	3.5
B_NAV_310	59	NAV	14.7	5.8	444.81	159.15	1.0	19.4	2.7	2.0
B_NAV_320	26	NAV	16.0	8.7	323.30	148.46	1.0	10.9	3.4	2.6
B_NEW_010	147	HEM	23.5	11.5	501.46	165.57	1.0	14.3	4.1	3.1
B_NEW_020	69	HEM	22.4	8.8	414.07	122.95	1.0	13.0	3.8	2.8
B_NOL_010	53	LIT	14.8	6.4	1032.53	688.25	1.0	23.3	2.7	2.0
B_NOL_020	61	LIT	25.7	12.9	1011.06	446.83	1.0	21.9	4.1	3.1
B_PON_010	101	BRY	24.6	10.6	641.14	349.39	1.0	11.9	4.2	3.1
B_PON_020	130	BRY	32.8	18.0	592.98	273.00	1.0	9.7	5.6	4.2
B_SAL_010	51	LIT	16.7	7.5	1095.37	756.41	1.0	20.3	3.0	2.3
B_SAL_020	85	LIT	16.6	7.2	975.74	562.14	1.0	24.9	2.9	2.1
B_SAL_030	37	LIT	15.1	8.3	802.16	428.96	1.0	24.7	2.9	2.2
B_SAN_010	51	ROC	25.0	12.9	614.63	349.82	1.0	10.6	4.6	3.4
B_SAN_020	58	ROC	30.2	15.6	592.35	329.02	1.0	8.7	5.3	4.0
B_SAN_030	10	ROC	7.7	3.6	465.98	307.34	1.0	20.5	1.8	1.4
B_TEH_010	131	HIG	23.6	12.5	719.96	427.08	1.0	12.4	4.3	3.2
B_TEH_020	112	HIG	26.4	10.6	666.54	363.77	1.0	11.5	4.3	3.2
B_TEH_030	66	HIG	21.8	8.8	640.51	354.07	1.0	13.1	3.7	2.8
B_YEG_010	22	HEM	7.6	3.1	492.00	200.00	1.0	38.4	1.6	1.2
B_YEG_020	67	HEM	18.9	8.8	417.04	187.27	1.0	12.2	3.6	2.7

Notes:

1. Ct - Coefficient depending upon unit and drainage basin characteristics
2. L - The river mileage from the given station to the upstream limits of the drainage area
3. Lca - The river mileage from the design point to the centroid of gravity of the drainage area.

Appendix D: Hydrologic Analysis

Clark Unit Hydrograph

Clark Unit Hydrograph Calculations

Sub-basin	Basin Area (sq mi)	Longest Flow Path Length, L (mi)	River Elevation Upstream (ft)	River Elevation Downstream (ft)	Channel Slope, S (ft/mi)	Mannings Roughness Coefficient, n	Longest Flow Path Elevation Upstream (ft)	Longest Flow Path Elevation Downstream (ft)	Average Basin Slope, S_0 (ft/mi)	% Impervious, C	% of Developable Subarea, D	Effective Impervious Ratio, I	Time of Concentration + Storage Coefficient, TC + R	Time of Concentration, TC (hr)	Storage Coefficient, R (hr)
B_BES_010	51	29.79	173.07	110.13	2.82	0.049	248.7	123.4	4.21	5.93	75	0.044	45.53	10.79	34.74
B_BES_020	49	24.39	113.95	78.81	1.92	0.059	128.26	59.25	2.83	11.34	75	0.085	50.01	8.58	41.43
B_BIC_010	60	24.83	123.96	81.62	2.27	0.048	134.05	72.03	2.50	10.56	75	0.079	41.95	6.34	35.61
B_BIC_020	97	27.84	83.79	34.25	2.37	0.056	101.2	38.38	2.26	5.06	75	0.038	55.65	7.47	48.17
B_BIC_030	77	39.86	89.65	18.5	2.38	0.068	105.8	5.36	2.52	14.46	75	0.108	66.93	10.21	56.72
B_BRA_270	25	13.4	203.11	115.75	8.69	0.069	308.14	115.08	14.41	6.39	75	0.048	23.86	10.51	13.36
B_BRA_280	62	19.83	247	132.43	7.70	0.063	396.5	114.65	14.21	4.43	75	0.033	29.75	13.03	16.72
B_BRA_290	23	14.11	198.97	106.17	8.77	0.068	257.51	108.12	10.59	13.58	75	0.102	22.14	8.62	13.52
B_BRA_300	74	24.16	259.95	126.94	7.34	0.058	344.24	108.12	9.77	8.74	75	0.066	30.56	11.50	19.06
B_BRA_310	96	34.11	237.13	94.68	5.57	0.054	407.17	93.82	9.19	5.46	75	0.041	40.50	14.82	25.68
B_BRA_320	26	10.14	203.82	100.55	13.58	0.055	251.84	93.2	15.64	9.98	75	0.075	13.93	6.32	7.61
B_BRA_330	72	28.96	181.71	104.92	3.54	0.065	262.68	84.3	6.16	5.14	75	0.039	51.18	15.35	35.82
B_BRA_340	18	22.18	116.91	69.22	2.87	0.057	128.87	69.39	2.68	10.47	75	0.079	41.99	6.84	35.15
B_BRA_350	62	19.36	186.66	97.39	6.15	0.066	220.62	69.39	7.81	9.06	75	0.068	32.02	10.86	21.16
B_BRA_360	32	18.07	67.48	59.97	0.55	0.048	109.06	83.53	1.41	8.20	75	0.062	58.04	3.31	54.73
B_BRA_370	56	28.96	102.57	38.81	2.94	0.064	130.51	36.12	3.26	15.61	75	0.117	47.71	9.30	38.40
B_BRA_380	64	25.94	32.72	15.21	0.90	0.078	92.75	14.25	3.03	51.05	75	0.383	40.19	7.34	32.85
B_BRA_390	21	15.99	55.02	4.85	4.18	0.08	67.85	6.47	3.84	2.02	75	0.015	45.64	10.13	35.51
B_BRA_400	67	18.6	66.89	29.6	2.67	0.055	76.2	4.17	3.87	3.38	75	0.025	40.87	9.13	31.74
B_BRA_410	20	23.65	15.23	3.22	0.68	0.08	53.56	0	2.26	2.37	75	0.018	100.97	13.62	87.35
B_BRA_420	56	16.39	53.46	14.96	3.13	0.076	121.62	22.06	6.07	3.77	75	0.028	44.50	13.25	31.25
B_BRA_430	52	16.15	27.27	9.16	1.50	0.075	32.96	0.2	2.03	6.03	75	0.045	58.49	6.83	51.67
B_BRA_440	38	18.57	23.62	9.79	0.99	0.057	30.44	4.5	1.40	7.71	75	0.058	57.84	3.19	54.65
B_MIL_010	156	40.43	333.24	169.38	5.40	0.075	525.91	158.17	9.10	5.65	75	0.042	58.40	21.28	37.12
B_MIL_020	159	37.51	319.67	177.63	5.05	0.071	551.96	158.17	10.50	5.48	75	0.041	53.91	20.92	32.99
B_MIL_030	48	18.29	276.08	133.94	10.36	0.063	390.34	133.29	14.05	4.82	75	0.036	25.96	11.32	14.64
B_MIL_040	49	18.99	158.46	102.57	3.92	0.075	308.58	93.82	11.31	8.46	75	0.063	38.68	15.48	23.20

Notes:

1. L - Length of stream within sub-basin.
2. S- Average slope of the stream * 75% of stream length.
3. S_0 - Average slope of longest flowpath within sub-basin.
4. I - Impervious ratio of each sub-basin. Found by converting % impervious to a ratio. (%/100)

Appendix D: Hydrologic Analysis

Routing Steps

Routing Steps

Creek/River	HMS Element	Calibration Zone	US Station	DS Station	Length	Average Channel Velocity	Steps	Rounded Steps
Aquilla Creek	R_AQU_010	WAC	116497	88661	27,836	2.92	15.89	16.0
Aquilla Creek	R_AQU_020	WAC	88661	57587	31,074	2.84	18.24	19.0
Aquilla Creek	R_AQU_030	WAC	57587	5604	51,983	2.83	30.61	31.0
Big_Creek_North	R_BIN_020	HIG	141647	91534	50,113	2.59	32.25	33.0
Big_Creek_North	R_BIN_030	HIG	91534	216	91,318	1.1	138.36	139.0
Big Elm	R_BIG_020	BIG	194139.9	112618.9	81,521	1.69	80.40	81.0
Big Elm	R_BIG_040	BIG	112618.9	71219.81	41,399	1.6	43.12	44.0
Big Elm	R_BIG_050	BIG	71219.81	28828.2	42,392	1.39	50.83	51.0
Big Elm	R_BIG_070	BRY	28828.2	5730.77	23,097	2.76	13.95	14.0
Brushy Creek	R_BRU_020	CAM	342506	314634	27,872	3.03	15.33	16.0
Brushy Creek	R_BRU_030	CAM	314389	242486	71,903	4.41	27.17	28.0
Brushy Creek	R_BRU_040	CAM	242486	146773.9	95,712	4.01	39.78	40.0
Brushy Creek	R_BRU_060	CAM	146773.9	111268.8	35,505	4.11	14.40	15.0
Brushy Creek	R_BRU_070	CAM	111268.8	38243.96	73,025	2.59	46.99	47.0
Brushy Creek	R_BRU_090	CAM	38243.96	869.5212	37,374	3.56	17.50	18.0
Brazos River	R_BRA_010	AQU	1164735	1120337	44,398	2.91	25.43	26.0
Brazos River	R_BRA_020	WAC	1120337	1064755	55,582	4.02	23.04	24.0
Brazos River	R_BRA_040	WAC	1064755	1032731	32,024	2.42	22.06	23.0
Brazos River	R_BRA_050	WAC	1032731	971427	61,304	2.45	41.70	42.0
Brazos River	R_BRA_060	WAC	971427	939969	31,458	4.41	11.89	12.0
Brazos River	R_BRA_070	HIG	939969	924176	15,793	3.84	6.85	7.0
Brazos River	R_BRA_080	HIG	924176	872599	51,577	2.44	35.23	36.0
Brazos River	R_BRA_100	HIG	872599	820000	52,599	1.99	44.05	45.0
Brazos River	R_BRA_110	HIG	820000	754581	65,419	1.84	59.26	60.0
Brazos River	R_BRA_120	HIG	754581	737324	17,257	2.6	11.06	12.0
Brazos River	R_BRA_140	HIG	737324	657240	80,084	2.86	46.67	47.0
Brazos River	R_BRA_150	HIG	657240	642118	15,122	3.35	7.52	8.0
Brazos River	R_BRA_160	BRY	642118	570967	71,151	2.63	45.09	46.0
Brazos River	R_BRA_170	BRY	570967	450008	120,959	3.39	59.47	60.0
Brazos River	R_BRA_180	BRY	450008	390000	60,008	3.73	26.81	27.0
Brazos River	R_BRA_190	BRY	390000	311026	78,974	3.71	35.48	36.0
Brazos River	R_BRA_200	HEM	311026	245363	65,663	3.24	33.78	34.0
Brazos River	R_BRA_210	HEM	245363	177760	67,603	3.91	28.82	29.0
Brazos River	R_BRA_220	HEM	177760	87517	90,243	2.71	55.50	56.0
Brazos River	R_BRA_230	HEM	87517	1431	86,086	4.04	35.51	36.0
Davidson Creek	R_DAV_020	LYO	109632	59298	50,334	1.59	52.76	53.0
Davidson Creek	R_DAV_030	LYO	59298	3709	55,589	1.05	88.24	89.0
Lampasas	R_LAM_010	LIT	88783.63	937.1243	87,847	2.78	52.67	53.0
Little Brazos	R_LIB_020	HEM	223552	158116	65,436	1.13	96.51	97.0
Little Brazos	R_LIB_040	HEM	158116	103316	54,800	1.18	77.40	78.0
Little Brazos	R_LIB_050	HEM	103316	80871	22,445	1.08	34.64	35.0
Little Brazos	R_LIB_060	HEM	80871	54882	25,989	0.9	48.13	49.0
Little Brazos	R_LIB_070	HEM	54882	34658	20,224	1.88	17.93	18.0
Little Brazos	R_LIB_080	HEM	34658	1953	32,705	1.96	27.81	28.0

Leon_River	R_LEO_010	LIT	89292.69	44137.69	45,155	2.7	27.87	28.0
Leon_River	R_LEO_020	LIT	44137.69	1361.017	42,777	3.19	22.35	23.0
Little_River	R_LEO_021	CAM	562084	533765.8	28,318	4.17	11.32	12.0
Little_River	R_LIT_010	CAM	533765.8	453616.3	80,150	3.99	33.48	34.0
Little_River	R_LIT_030	CAM	453616.3	444020.5	2,000	2	1.67	2.0
Little_River	R_LIT_040	CAM	440020.5	343592.6	96,428	3.5	45.92	46.0
Little_River	R_LIT_060	CAM	343592.6	241797	101,796	2.79	60.81	61.0
Little_River	R_LIT_070	CAM	241797	208039.5	33,758	2.95	19.07	20.0
Little_River	R_LIT_080	CAM	208039.5	180330	27,710	2.62	17.63	18.0
Little_River	R_LIT_090	BRY	180330	147764.1	32,566	3.25	16.70	17.0
Little_River	R_LIT_100	BRY	147764.1	130192.3	17,572	2.61	11.22	12.0
Little_River	R_LIT_110	BRY	130192.3	100640.4	29,552	3.24	15.20	16.0
Little_River	R_LIT_120	BRY	100640.4	69788.02	30,852	3.36	15.30	16.0
Little_River	R_LIT_130	BRY	69788.02	1519.445	68,269	2.33	48.83	49.0
Mill_Creek	R_MIL_030	BEL	95068.1	48213.59	46,855	1.9	41.10	42.0
Mill Creek	R_MIL_040	BEL	48213.59	5596.59	42,617	2.5	28.41	29.0
Navasota	R_NAV_020	GRO	62573	3539	59,034	1.95	50.46	51.0
Navasota	R_NAV_050	GRO	897037	852192	44,845	11.5	6.50	7.0
Navasota	R_NAV_060	LIM	852192	770312	81,880	3.67	37.18	38.0
Navasota	R_NAV_100	EAS	654515	559331	95,184	4.48	35.41	36.0
Navasota	R_NAV_140	OSR	559331	518846	40,485	5.58	12.09	13.0
Navasota	R_NAV_150	OSR	518846	507282	11,564	5.94	3.24	4.0
Navasota	R_NAV_160	OSR	507282	474050	33,232	5.01	11.06	12.0
Navasota	R_NAV_170	OSR	474050	434292	39,758	4.02	16.48	17.0
Navasota	R_NAV_180	NAV	434292	414779	19,513	3.85	8.45	9.0
Navasota	R_NAV_190	NAV	414779	389246	25,533	4.87	8.74	9.0
Navasota	R_NAV_200	NAV	389246	349623	39,623	3.2	20.64	21.0
Navasota	R_NAV_220	NAV	349623	304428	45,195	3.38	22.29	23.0
Navasota	R_NAV_230	NAV	304428	263818	40,610	3.22	21.02	22.0
Navasota	R_NAV_240	NAV	263818	206930	56,888	3.87	24.50	25.0
Navasota	R_NAV_260	NAV	206930	187783	19,147	3.47	9.20	10.0
Navasota	R_NAV_270	NAV	187783	144042	43,741	1.99	36.63	37.0
Navasota	R_NAV_300	NAV	144042	113273	30,769	0.73	70.25	71.0
Navasota	R_NAV_310	NAV	113273	75836	37,437	0.61	102.29	103.0
Navasota	R_NAV_320	NAV	75836	1380	74,456	1.82	68.18	69.0
Navasota	R_NAV_120	NAV	105069	22105	82,964	1.29	107.19	108.0
New Year Creak	R_NEW_020	HEM	50451	5039	45,412	2.69	28.14	29.0
Nolan_Creek	R_NOL_020	LIT	107212	2176	105,036	4.18	41.88	42.0
Pond Creek	R_PON_020	BRY	89135	3446	85,689	1.91	74.77	75.0
Salado_Creek	R_SAL_020	LIT	121685	52341	69,344	3.53	32.74	33.0
Salado_Creek	R_SAL_030	LIT	52341	236	52,105	3.96	21.93	22.0
SanGabriel	R_SAN_010	CAM	171647	70507	101,140	3.05	55.27	56.0
SanGabriel	R_SAN_020	CAM	70507	28324.06	42,183	2.71	25.94	26.0
SanGabriel	R_SAN_030	CAM	28324.06	3567.929	24,756	2.21	18.67	19.0
Yegua	R_YEG_010	HEM	103121.9	71833.52	31,288	1.11	46.98	47.0
Yegua	R_YEG_020	HEM	71833.52	3685.776	68,148	1.76	64.53	65.0
Tehuacana	R_TEH_020	HIG	85393	28141	57,252	2.16	44.18	45.0
Tehuacana	R_TEH_030	HIG	28141	5556	22,585	3.18	11.84	12.0

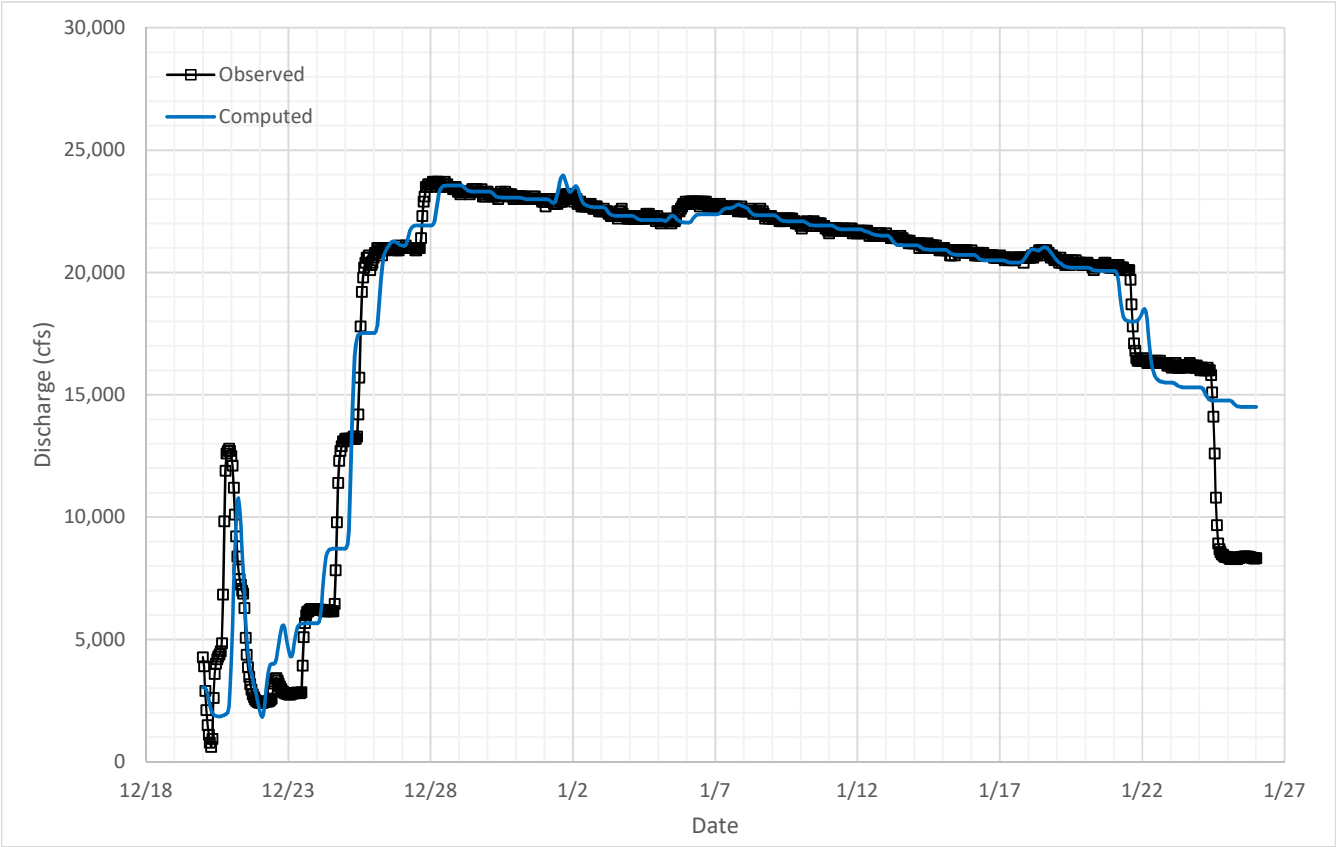
Wanut Creek	R_WAL_020	HEM	78012	38907	39,105	0.9	72.42	73.0
Walnut Creek	R_WAL_030	HEM	38907	4486	34,421	0.87	65.94	66.0

Appendix D: Hydrologic Analysis

Calibration Results

BRA Calibration
Brazos River Near Aquilla, TX
USGS 08093100

1991 Calibration Event

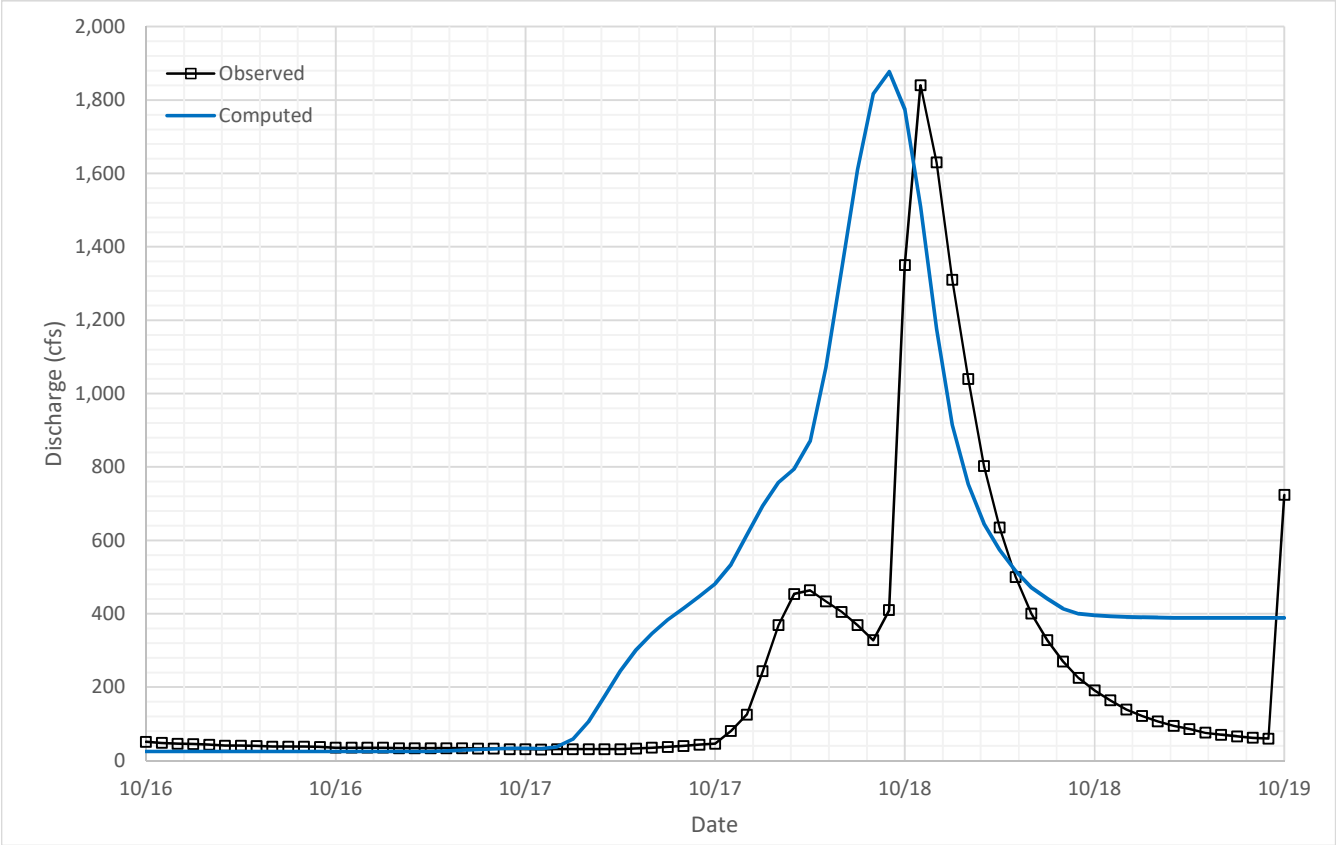


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.9	0.06	5.0	2.22	0.80

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	23,700	1,359,300
Computed	23,966	1,365,268
Residual	266	5,968
Error	1%	0%

BRA Calibration
Brazos River Near Aquilla, TX
USGS 08093100

1998 Calibration Event

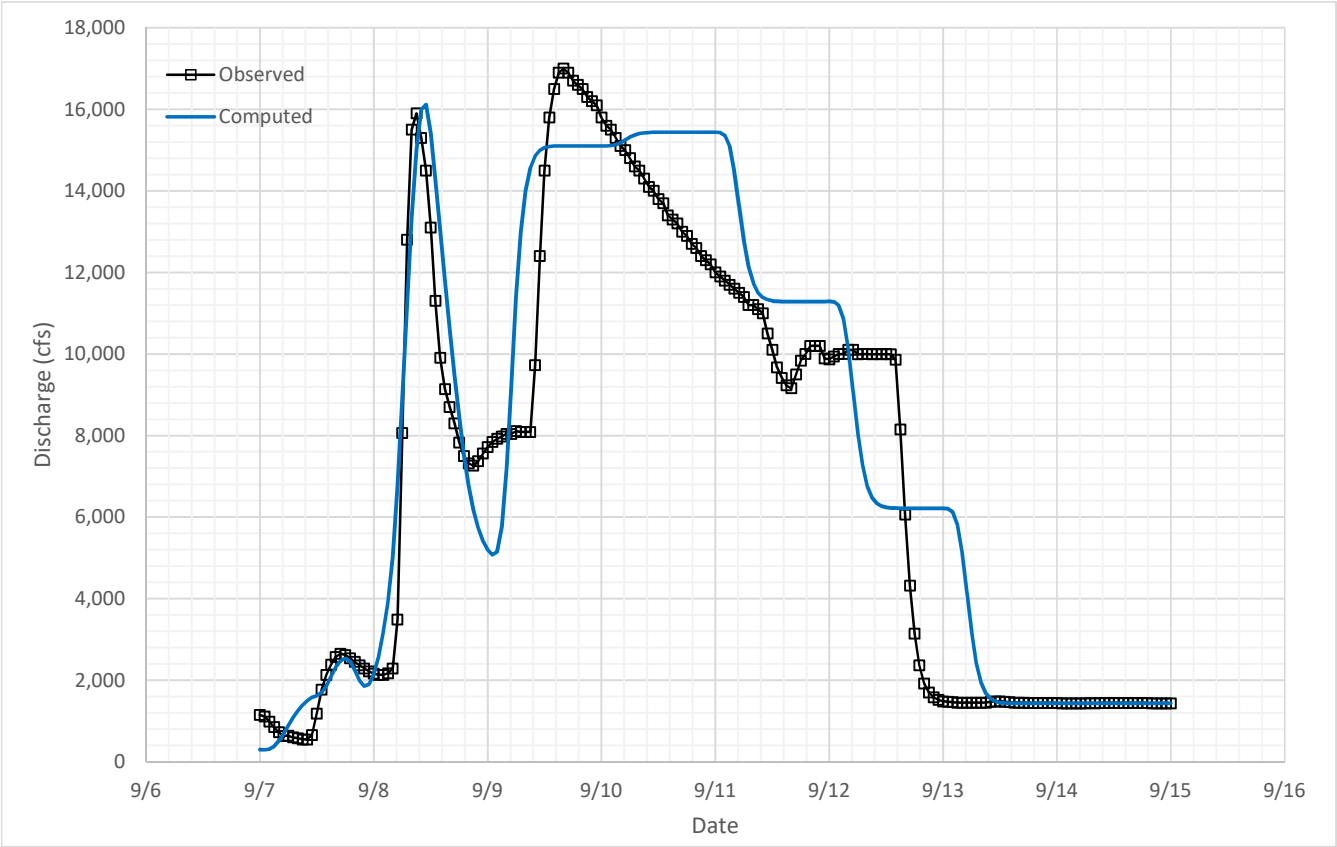


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.7	0.06	5.0	1.80	0.80

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	1,840	1,401
Computed	1,877	2,490
Residual	37	1,089
Error	2%	78%

BRA Calibration
Brazos River Near Aquilla, TX
USGS 08093100

2010 Calibration Event

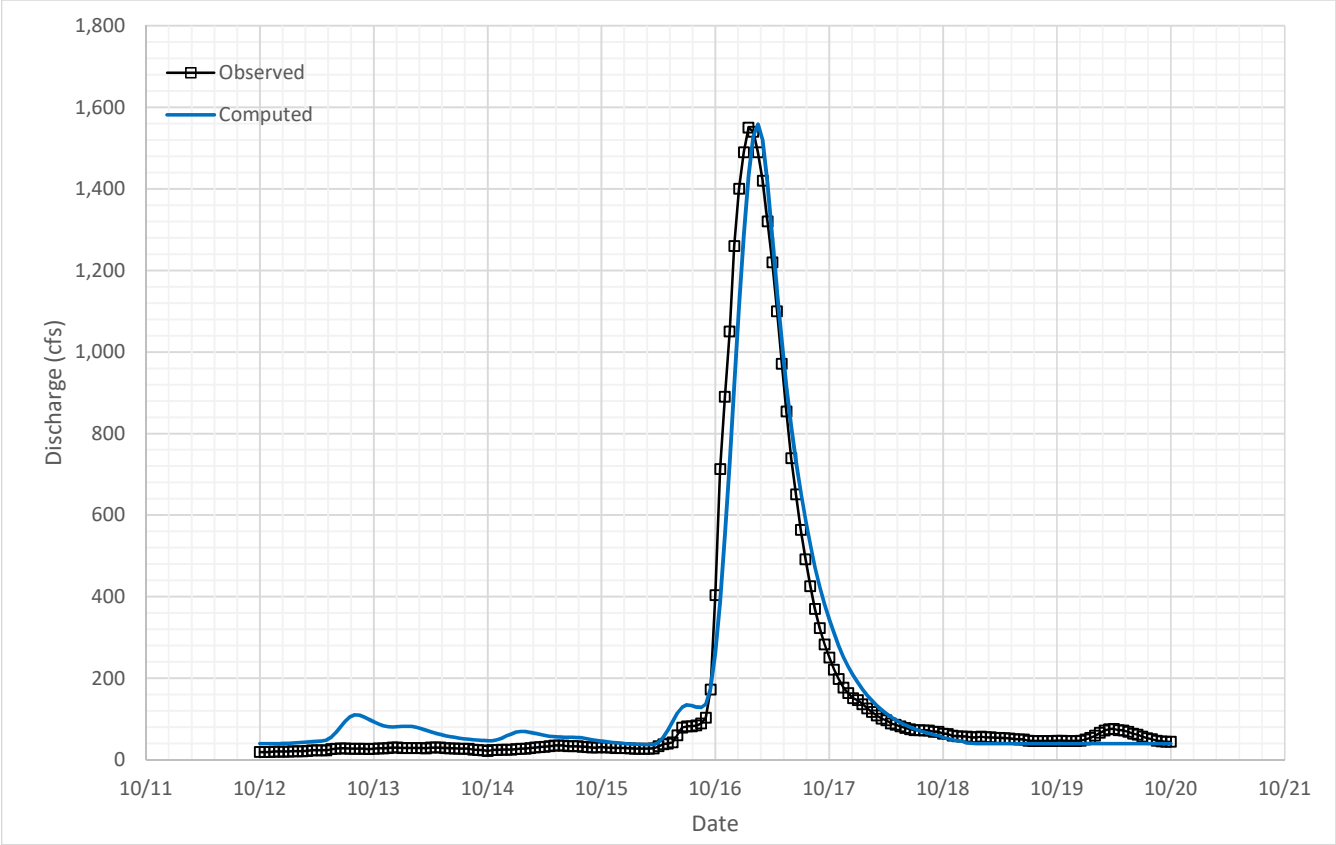


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.1	0.06	5.0	2.00	0.80

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	17,000	113,590
Computed	16,115	123,793
Residual	-885	10,203
Error	-5%	9%

BRA Calibration
Brazos River Near Aquilla, TX
USGS 08093100

2013 Calibration Event

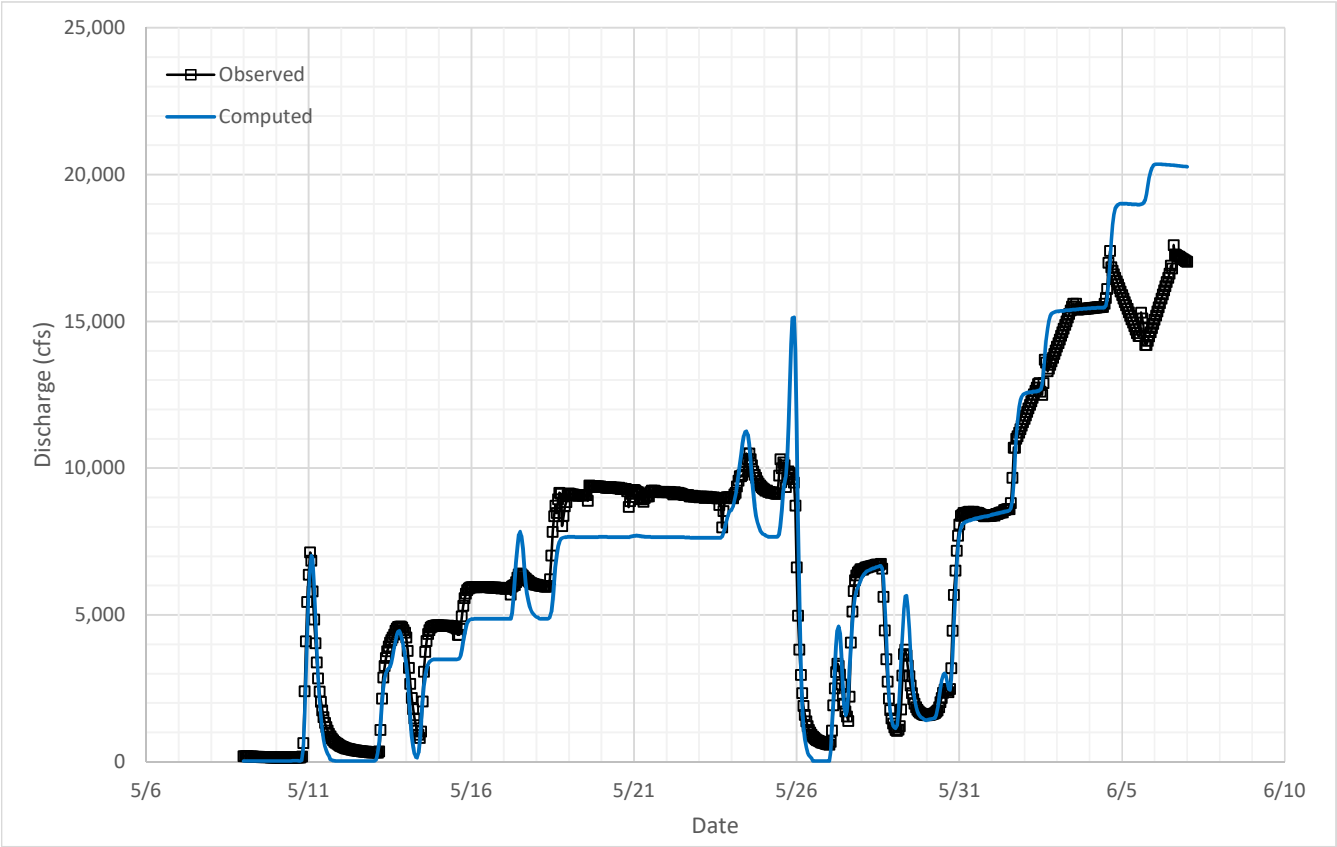


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.2	0.07	3.6	2.20	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	1,550	2,578
Computed	1,558	2,767
Residual	8	189
Error	1%	7%

BRA Calibration
Brazos River Near Aquilla, TX
USGS 08093100

2015 Calibration Event

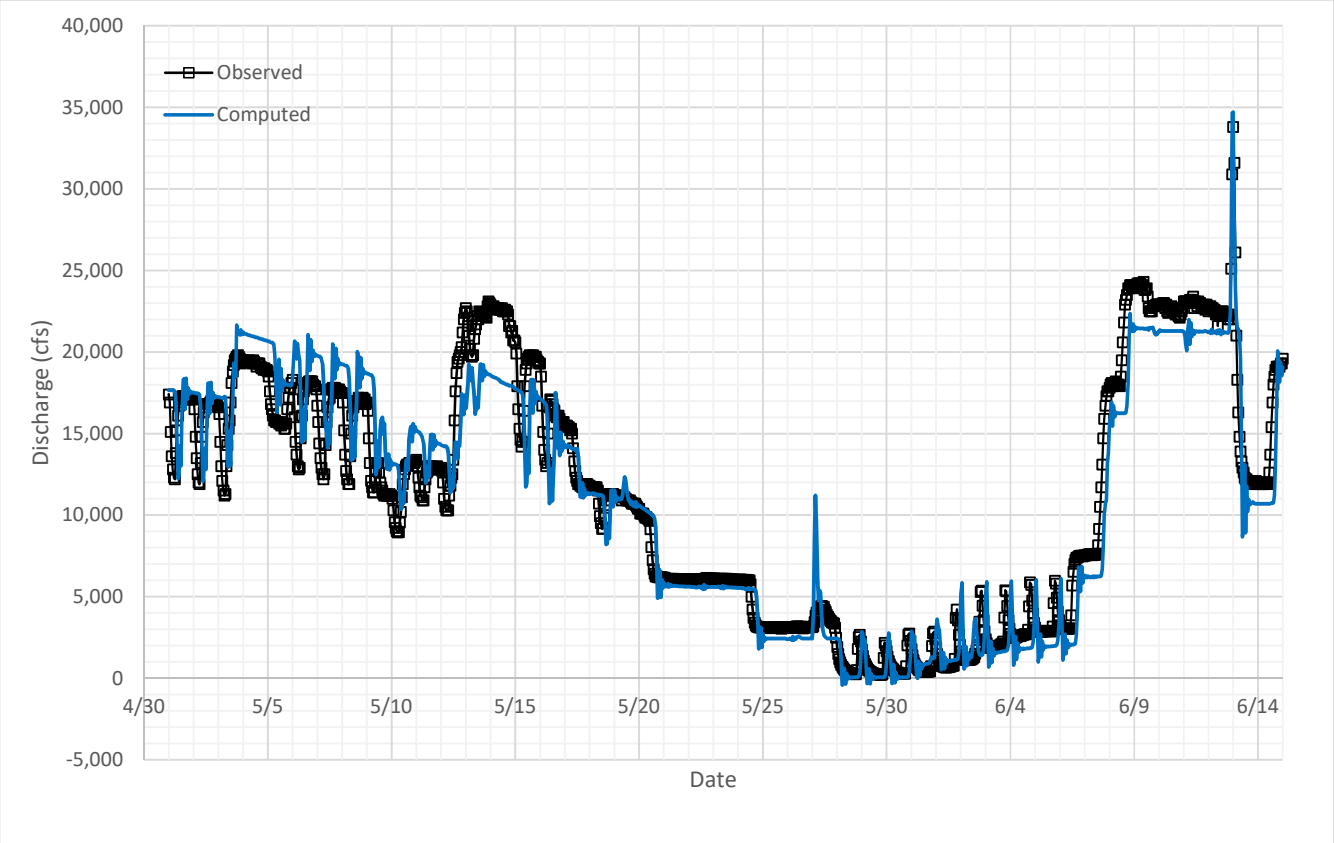


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.0	0.06	5.0	2.22	0.80

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	17,600	412,509
Computed	20,351	406,175
Residual	2,751	-6,334
Error	16%	-2%

BRA Calibration
Brazos River Near Aquilla, TX
USGS 08093100

2016 Calibration Event

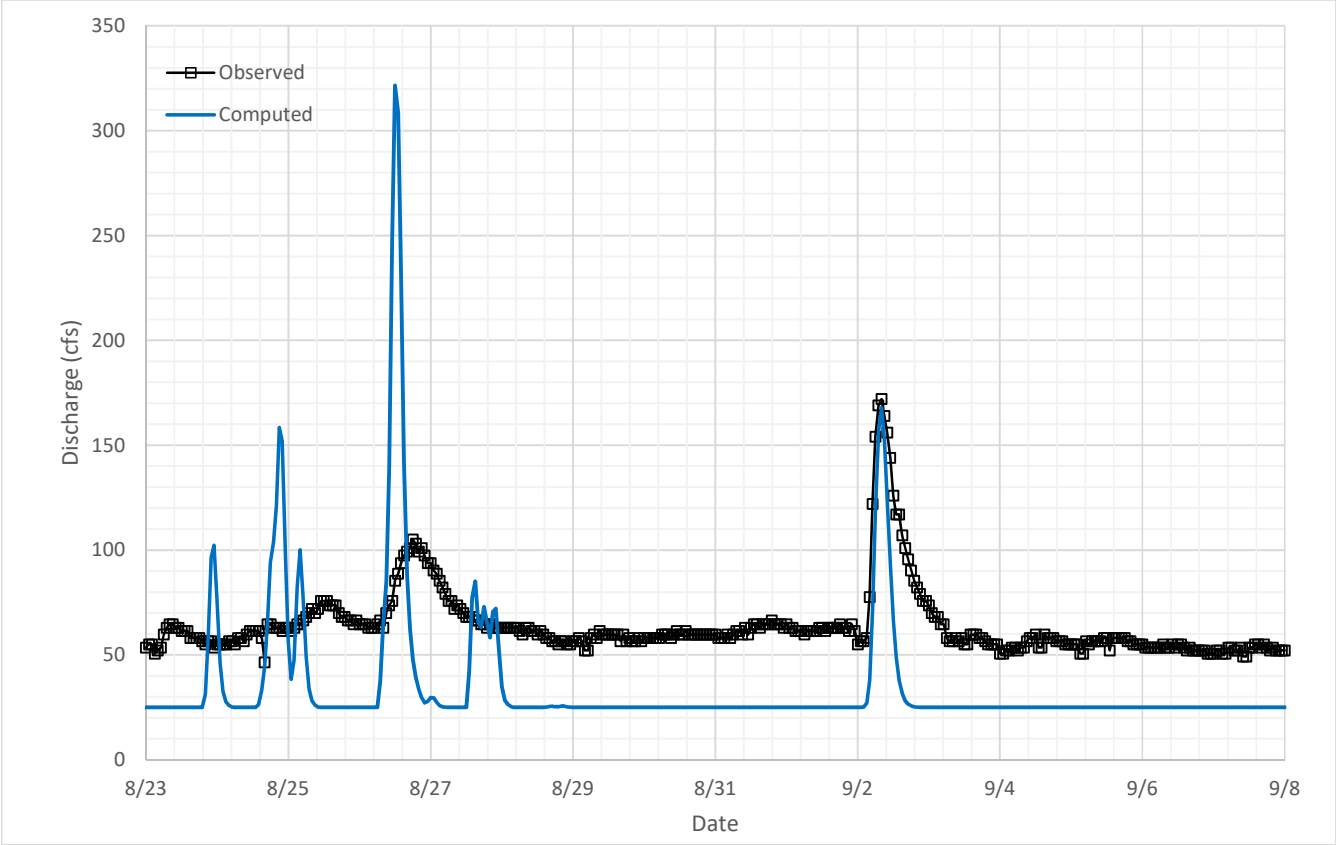


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.1	0.19	5.0	1.99	0.70

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	33,800	1,018,267
Computed	34,702	991,080
Residual	902	-27,187
Error	3%	-3%

BRA Calibration
Brazos River Near Aquilla, TX
USGS 08093100

2017 Calibration Event

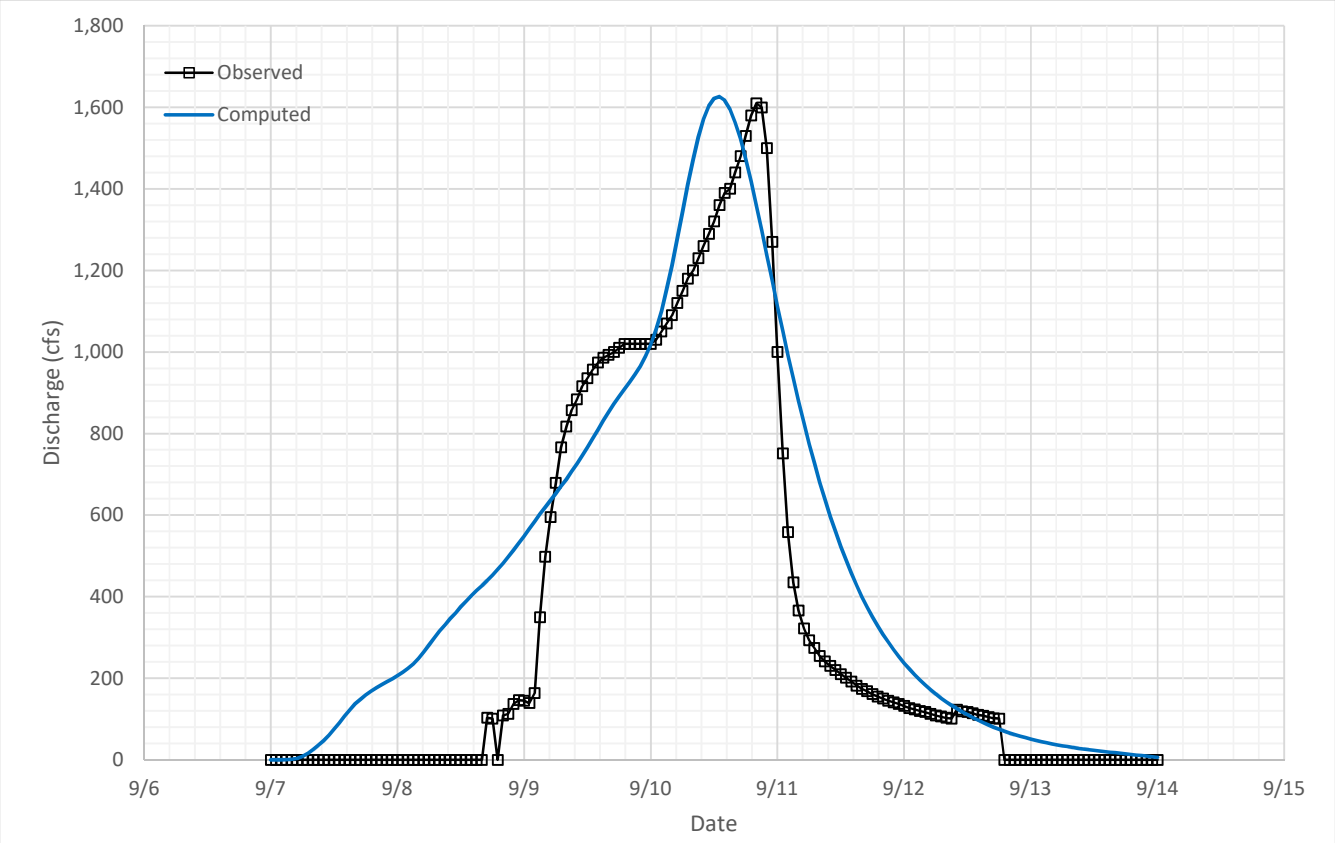


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
5.3	0.08	5.0	1.99	0.70

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	172	2,031
Computed	322	1,125
Residual	150	-906
Error	87%	-45%

BRA Calibration
Big Elm Creek at SH 77 near Cameron, TX
USGS 08108250

2010 Calibration Event

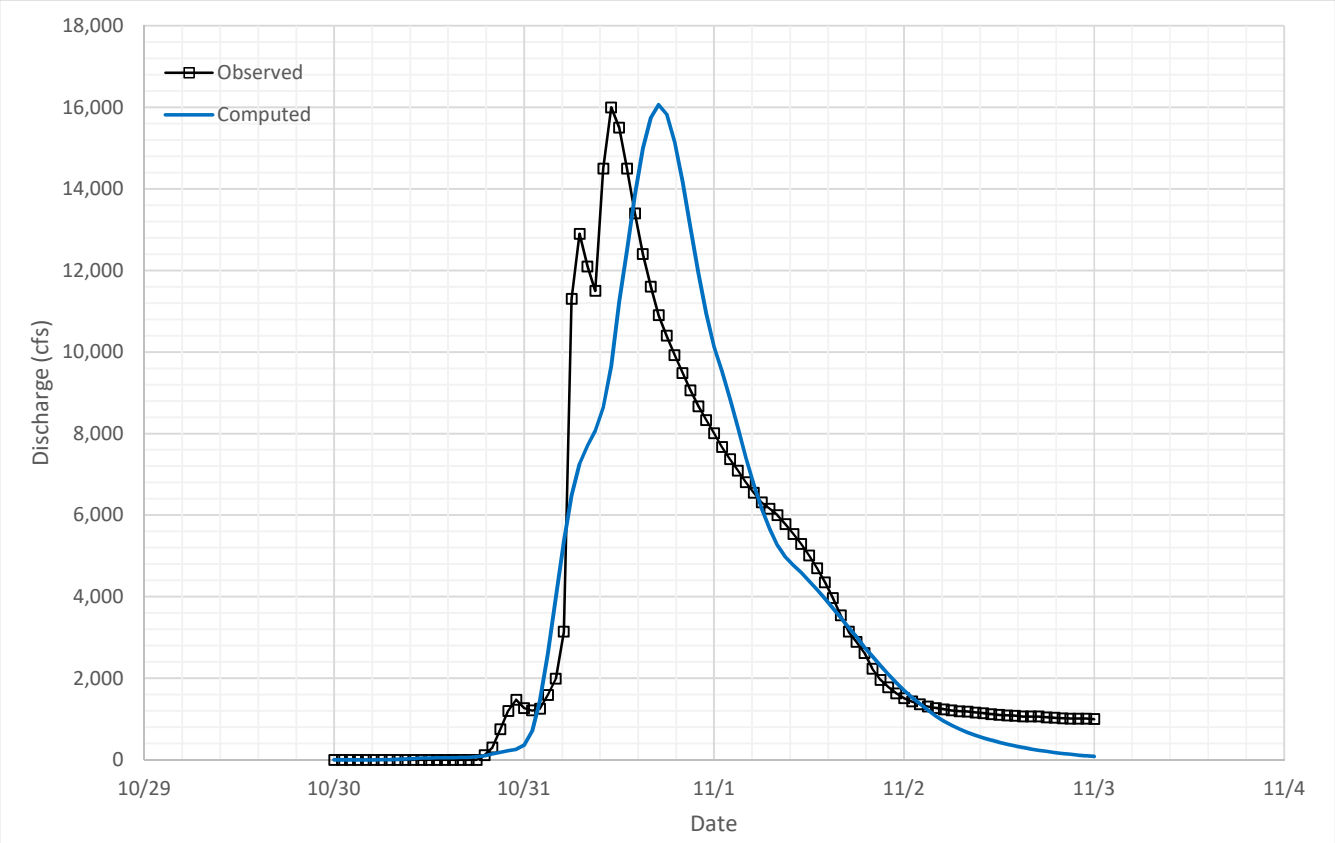


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.1	0.10	7.1	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	1,610	4,939
Computed	1,626	6,619
Residual	16	1,680
Error	1%	34%

BRA Calibration
Big Elm Creek at SH 77 near Cameron, TX
USGS 08108250

2013 Calibration Event

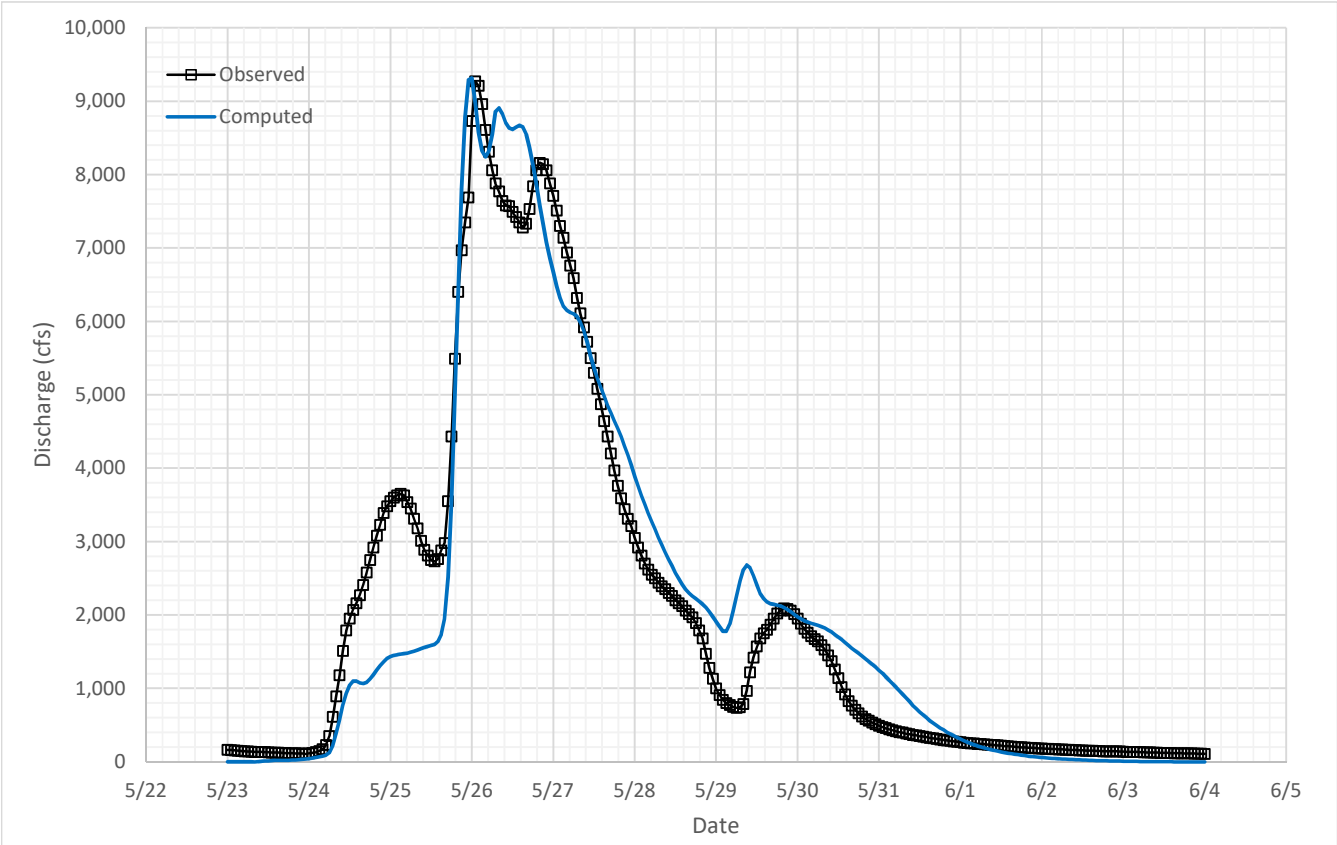


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.1	0.10	7.1	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	16,000	30,689
Computed	16,063	30,046
Residual	63	-643
Error	0%	-2%

BRA Calibration
Big Elm Creek at SH 77 near Cameron, TX
USGS 08108250

2015 Calibration Event

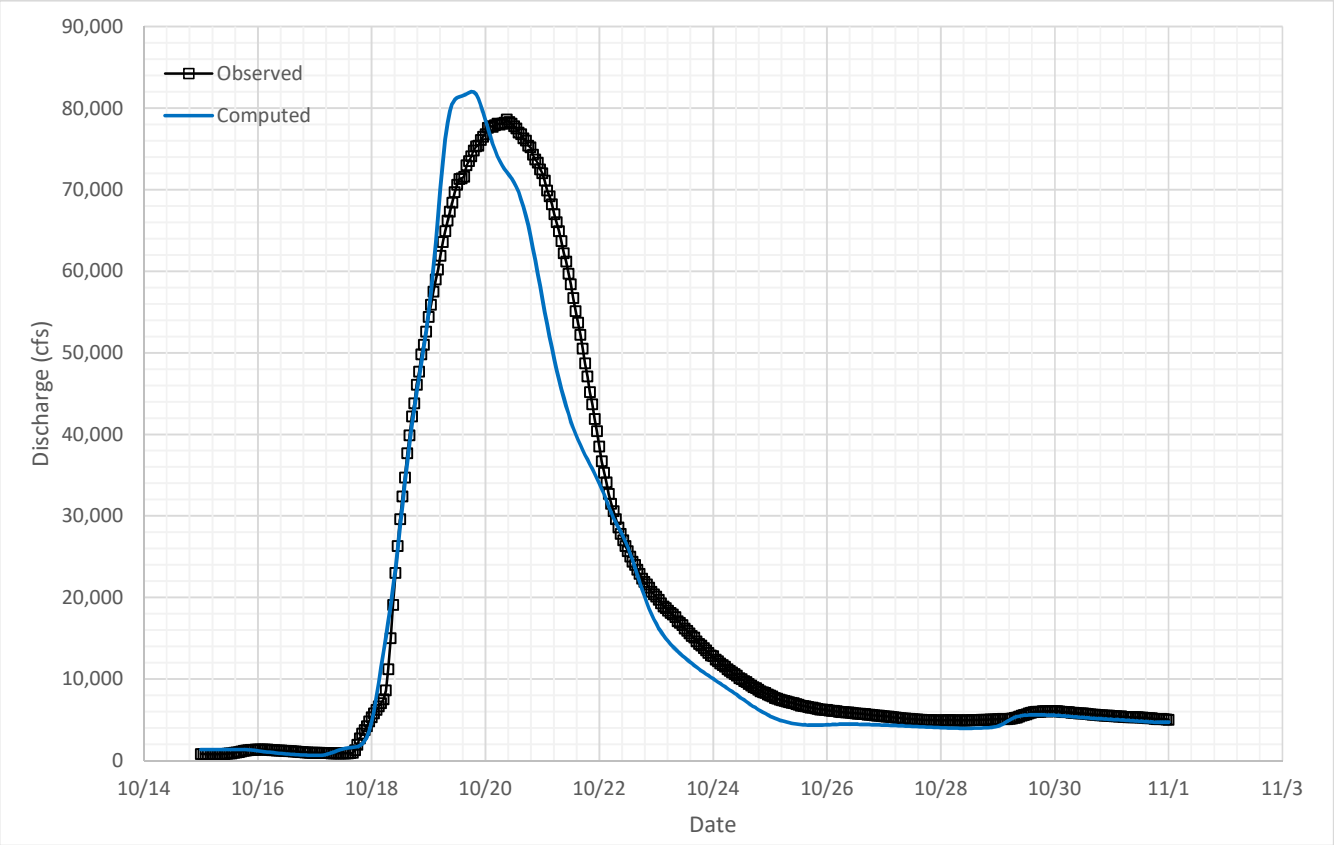


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.1	0.09	7.1	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	9,270	49,262
Computed	9,316	49,486
Residual	46	224
Error	0%	0%

BRA Calibration
Brazos River at SH 21 Near Bryan, TX
USGS 08108700

1998 Calibration Event

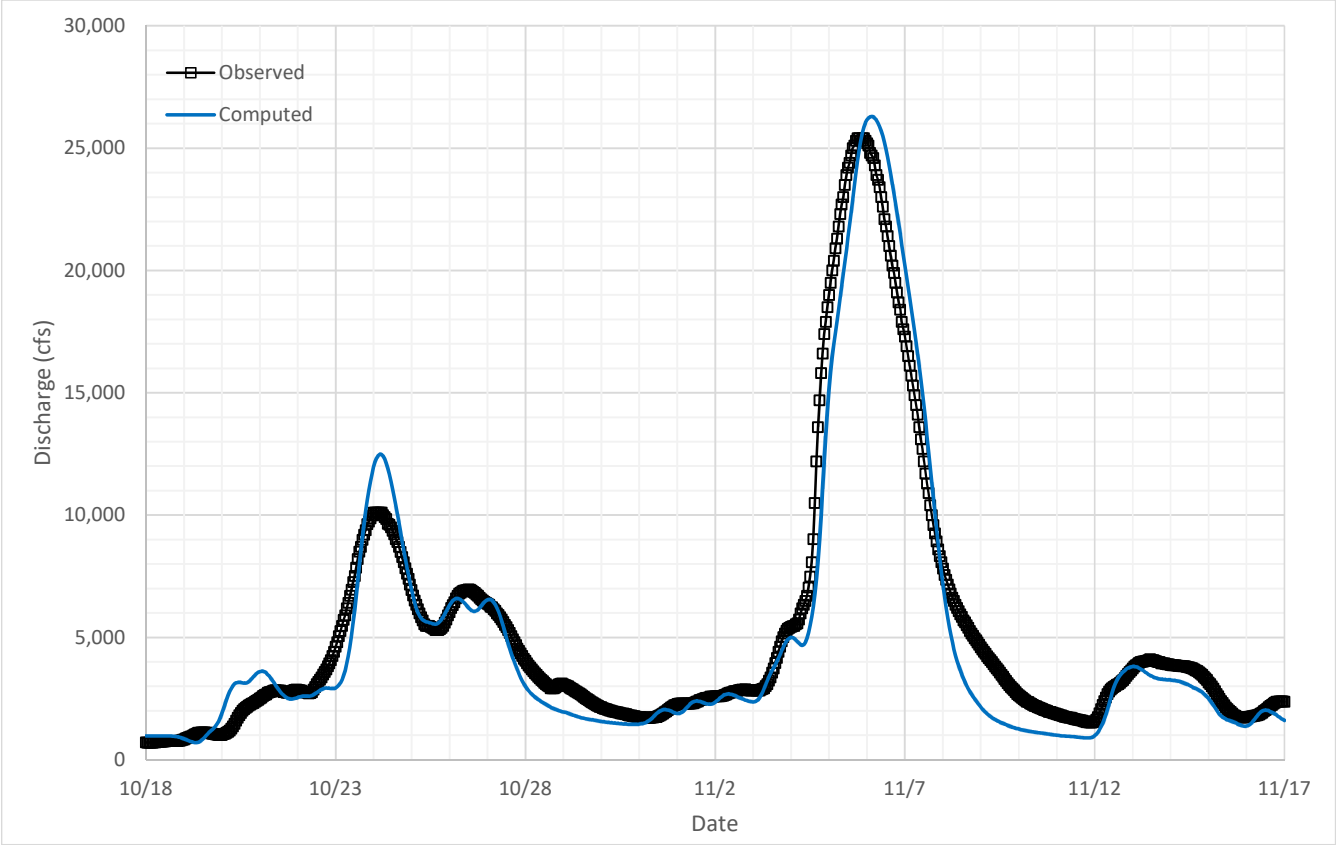


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.9	0.13	6.0	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	78,600	648,012
Computed	82,030	595,676
Residual	3,430	-52,336
Error	4%	-8%

BRA Calibration
Brazos River at SH 21 Near Bryan, TX
USGS 08108700

2002 Calibration Event

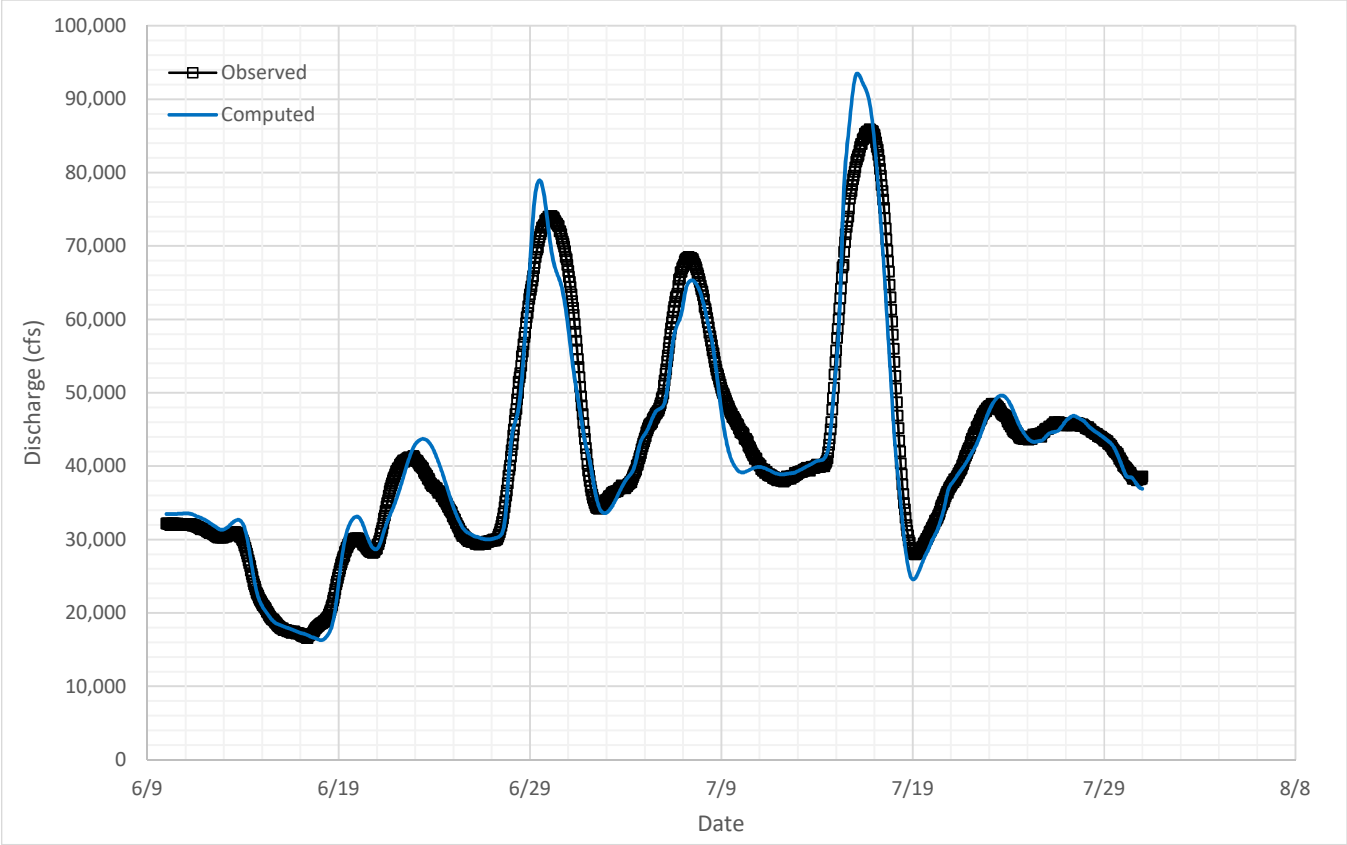


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
4.9	0.13	6.0	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	25,400	313,808
Computed	26,295	293,667
Residual	895	-20,141
Error	4%	-6%

BRA Calibration
Brazos River at SH 21 Near Bryan, TX
USGS 08108700

2007 Calibration Event

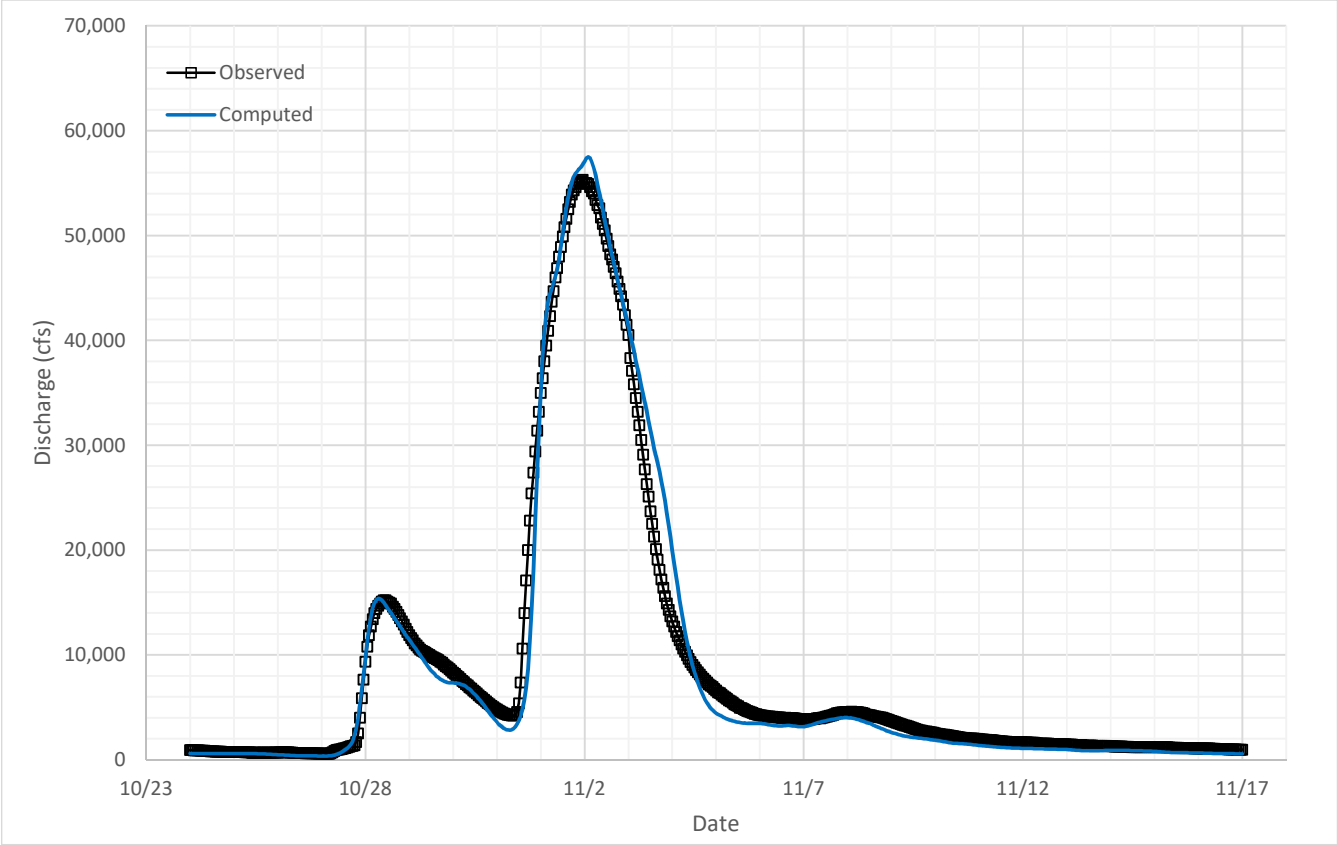


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.9	0.10	6.0	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	85,900	4,240,149
Computed	93,500	4,219,078
Residual	7,600	-21,071
Error	9%	0%

BRA Calibration
Brazos River at SH 21 Near Bryan, TX
USGS 08108700

2013 Calibration Event

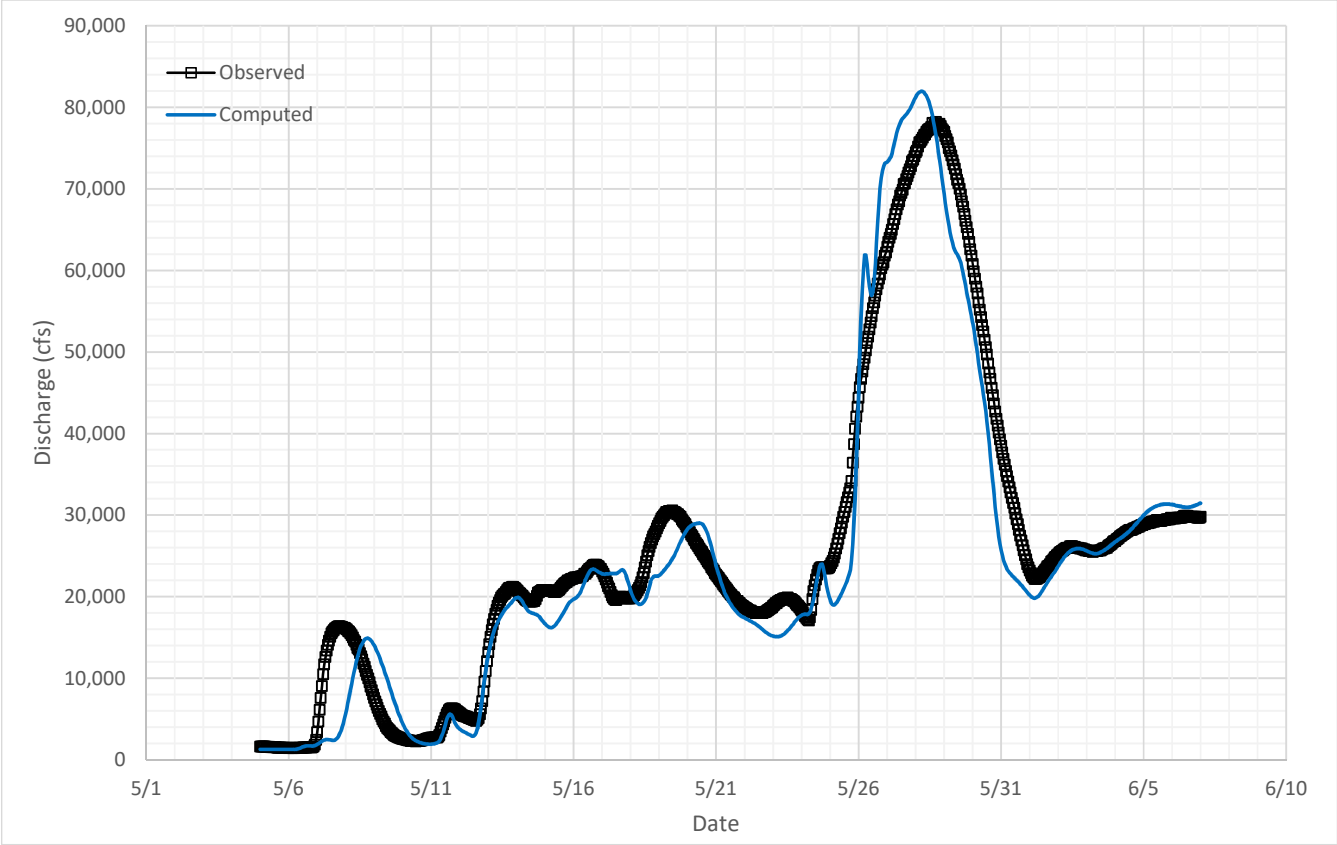


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.2	0.23	6.0	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	55,300	416,053
Computed	57,493	406,969
Residual	2,193	-9,084
Error	4%	-2%

BRA Calibration
Brazos River at SH 21 Near Bryan, TX
USGS 08108700

2015 Calibration Event

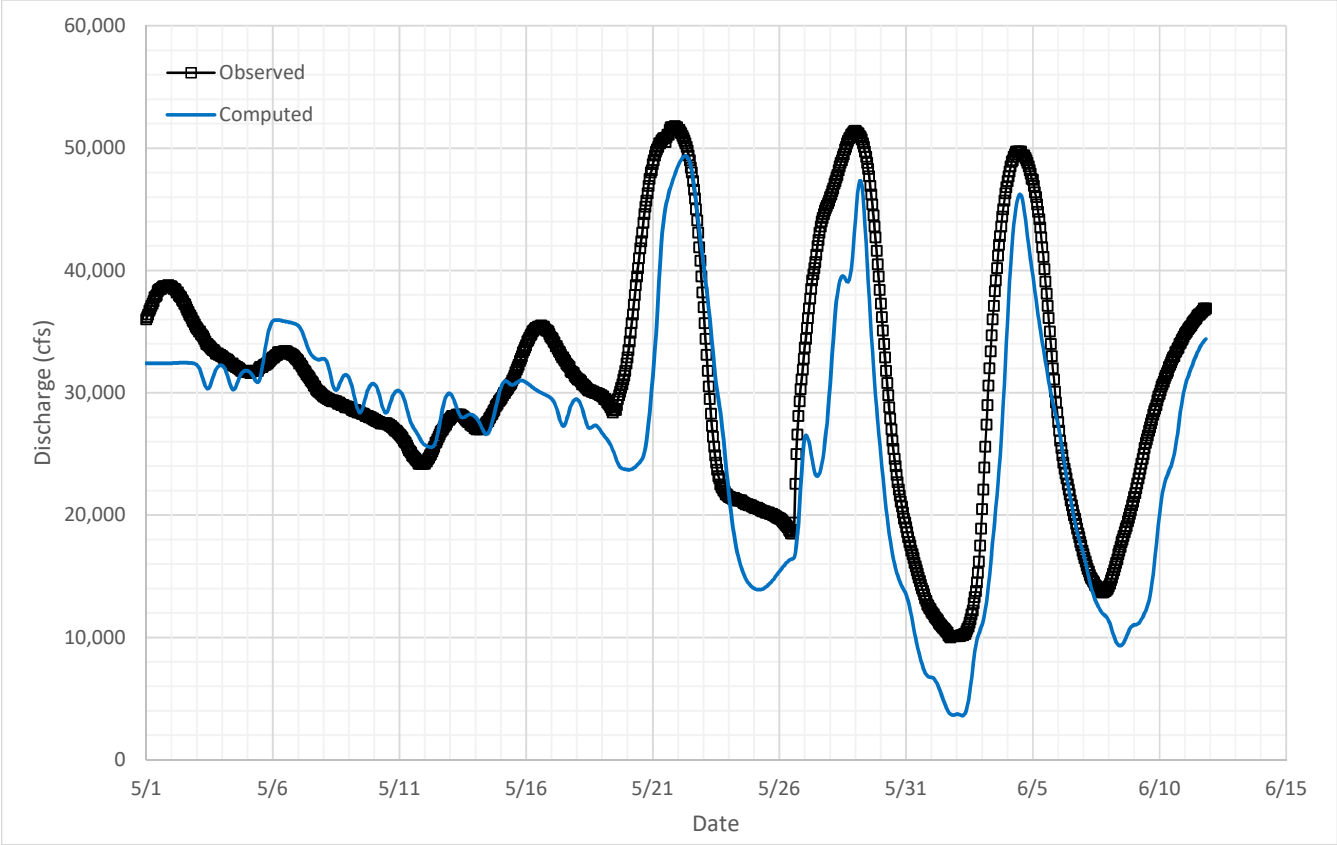


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.9	0.14	6.0	2.00	0.80

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	78,200	1,693,257
Computed	81,979	1,609,639
Residual	3,779	-83,618
Error	5%	-5%

BRA Calibration
Brazos River at SH 21 Near Bryan, TX
USGS 08108700

2016 Calibration Event

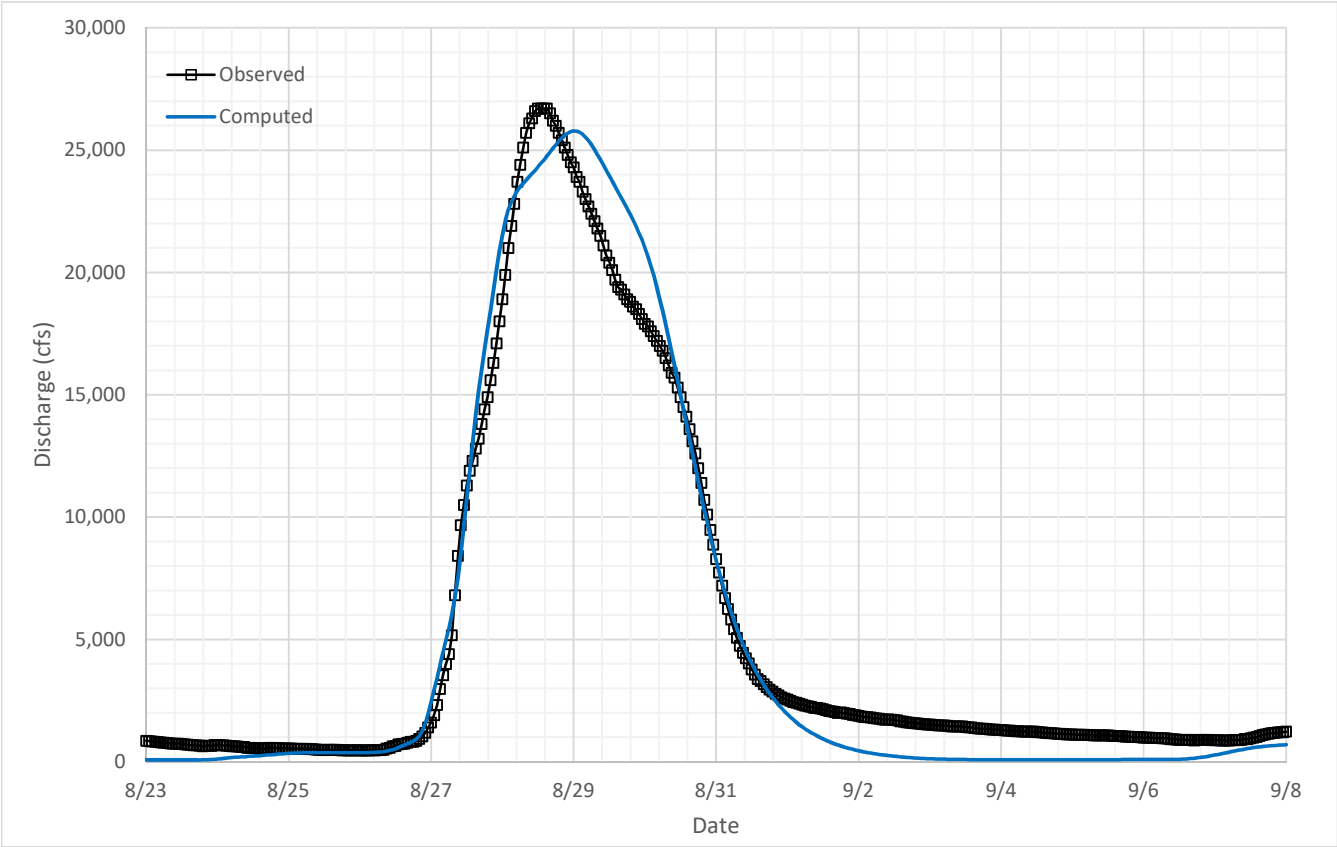


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.7	0.14	5.3	7.84	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	51,800	2,975,880
Computed	51,700	2,476,923
Residual	-100	-498,957
Error	0%	-17%

BRA Calibration
Brazos River at SH 21 Near Bryan, TX
USGS 08108700

2017 Calibration Event

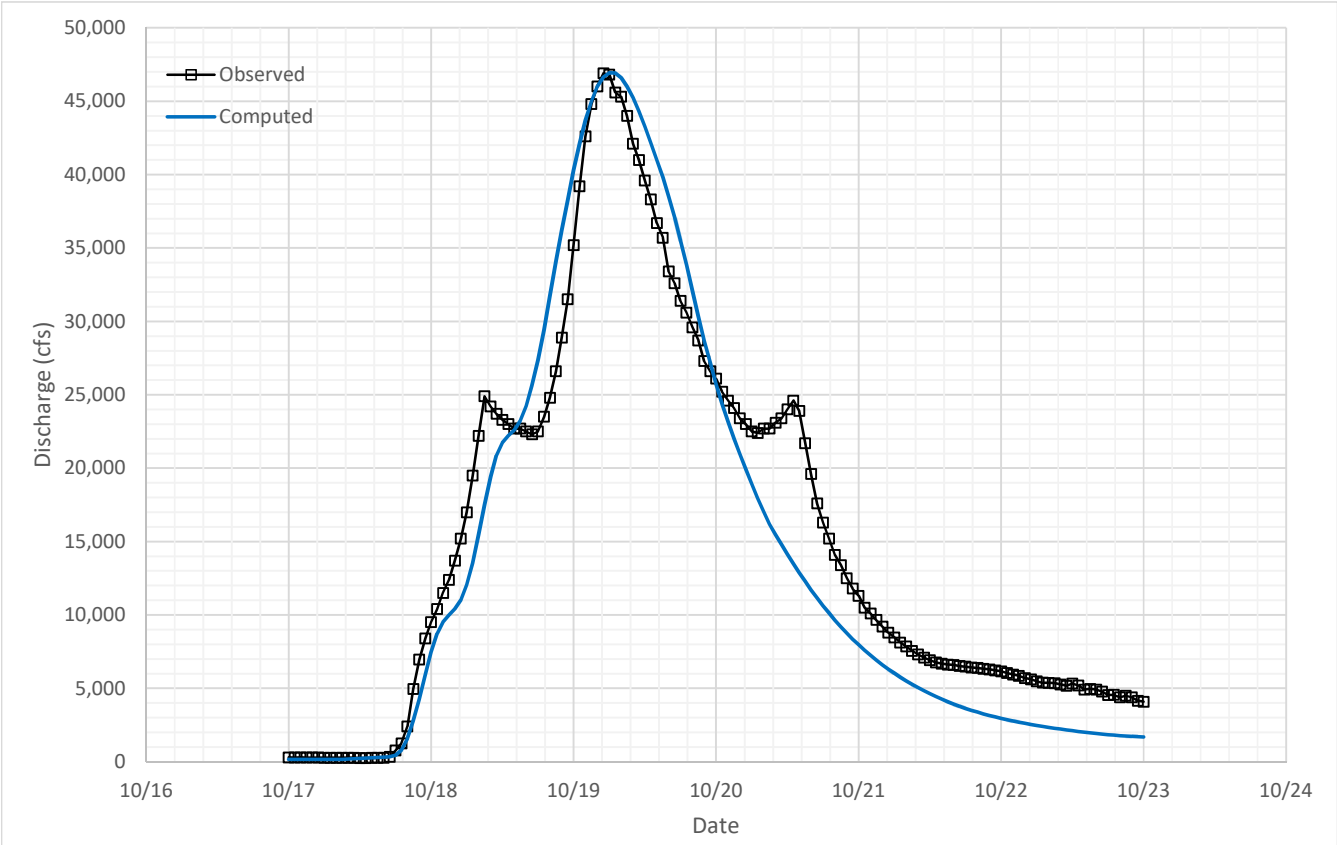


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.9	0.09	3.3	8.17	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	26,700	17,082
Computed	25,783	163,107
Residual	-917	146,025
Error	-3%	855%

BRA Calibration
Little River near Cameron, TX
USGS 08106500

1998 Calibration Event

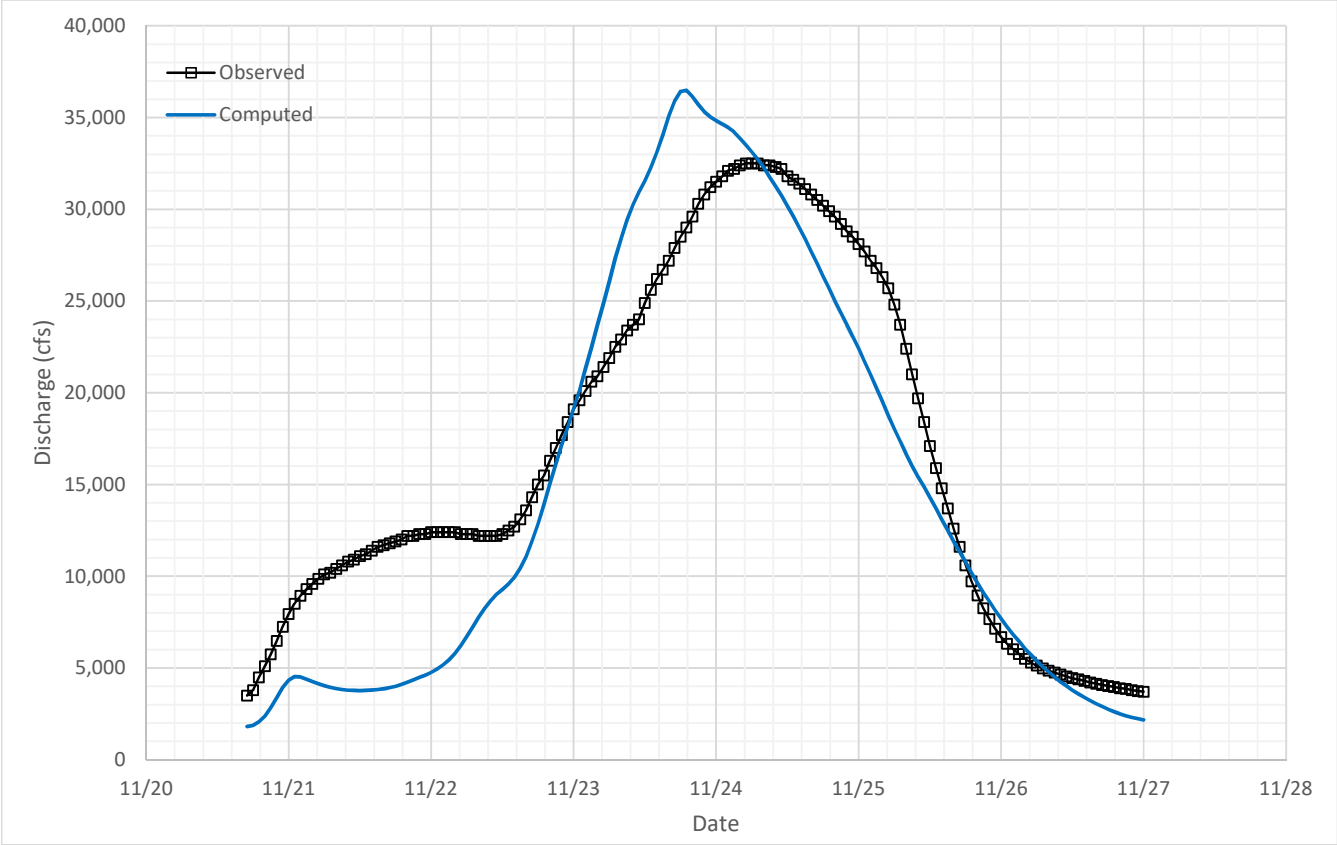


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.0	0.10	4.5	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	46,900	185,659
Computed	46,929	167,322
Residual	29	-18,337
Error	0%	-10%

BRA Calibration
Little River near Cameron, TX
USGS 08106500

2004 Calibration Event

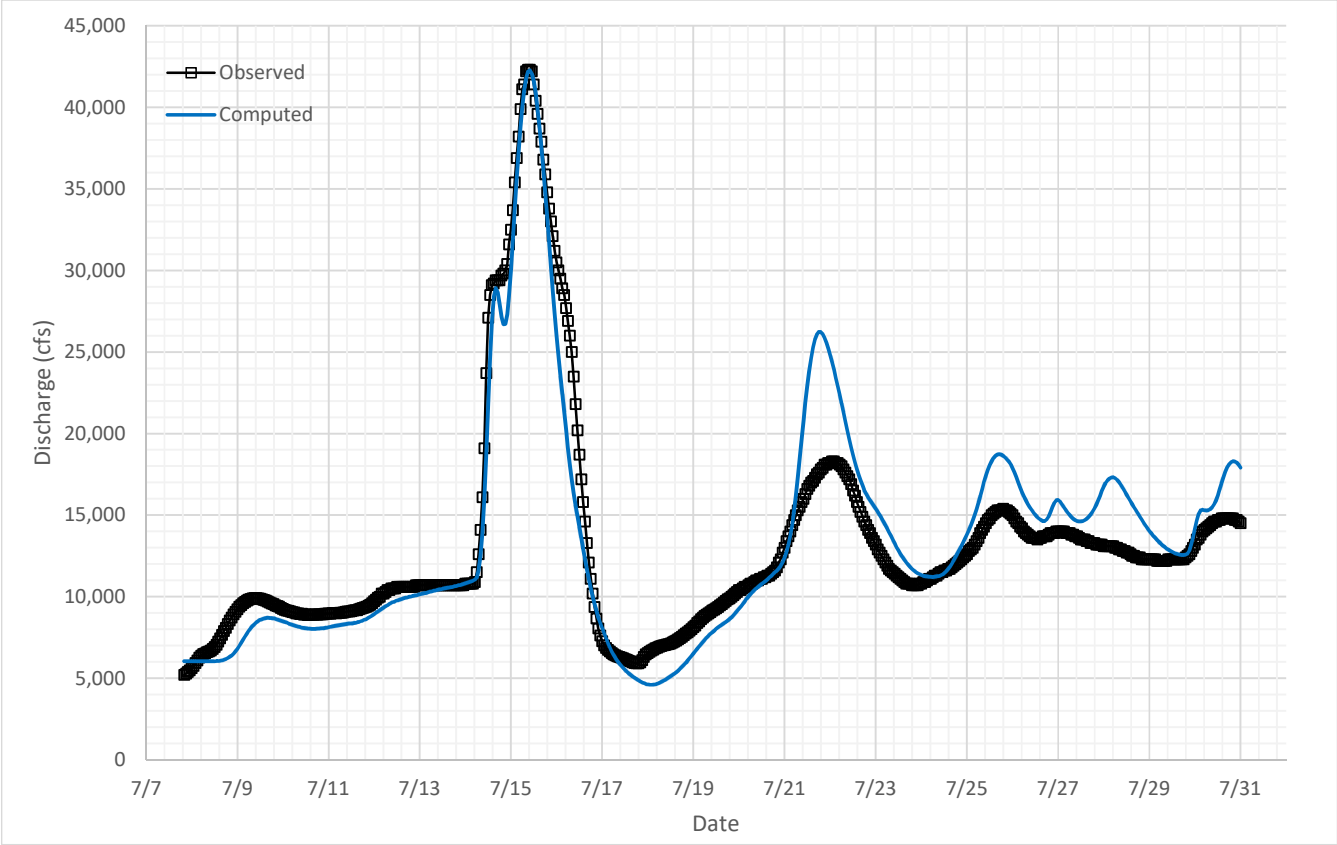


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.10	0.00	6.4	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	32,500	207,672
Computed	36,478	185,891
Residual	3,978	-21,781
Error	12%	-10%

BRA Calibration
Little River near Cameron, TX
USGS 08106500

2007 Calibration Event

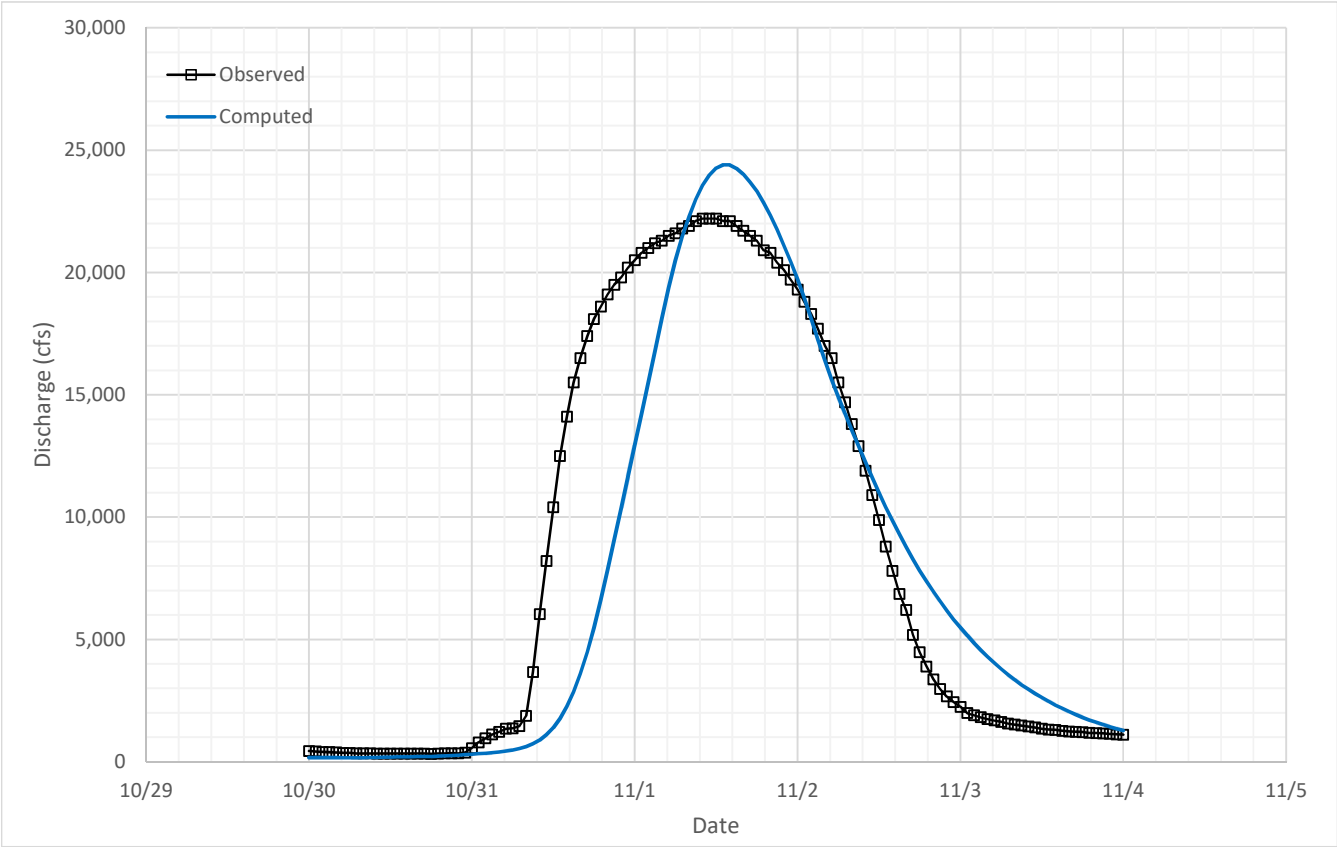


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.7	0.10	4.5	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	42,300	608,116
Computed	42,272	619,881
Residual	-28	11,765
Error	0%	2%

BRA Calibration
Little River near Cameron, TX
USGS 08106500

2013 Calibration Event

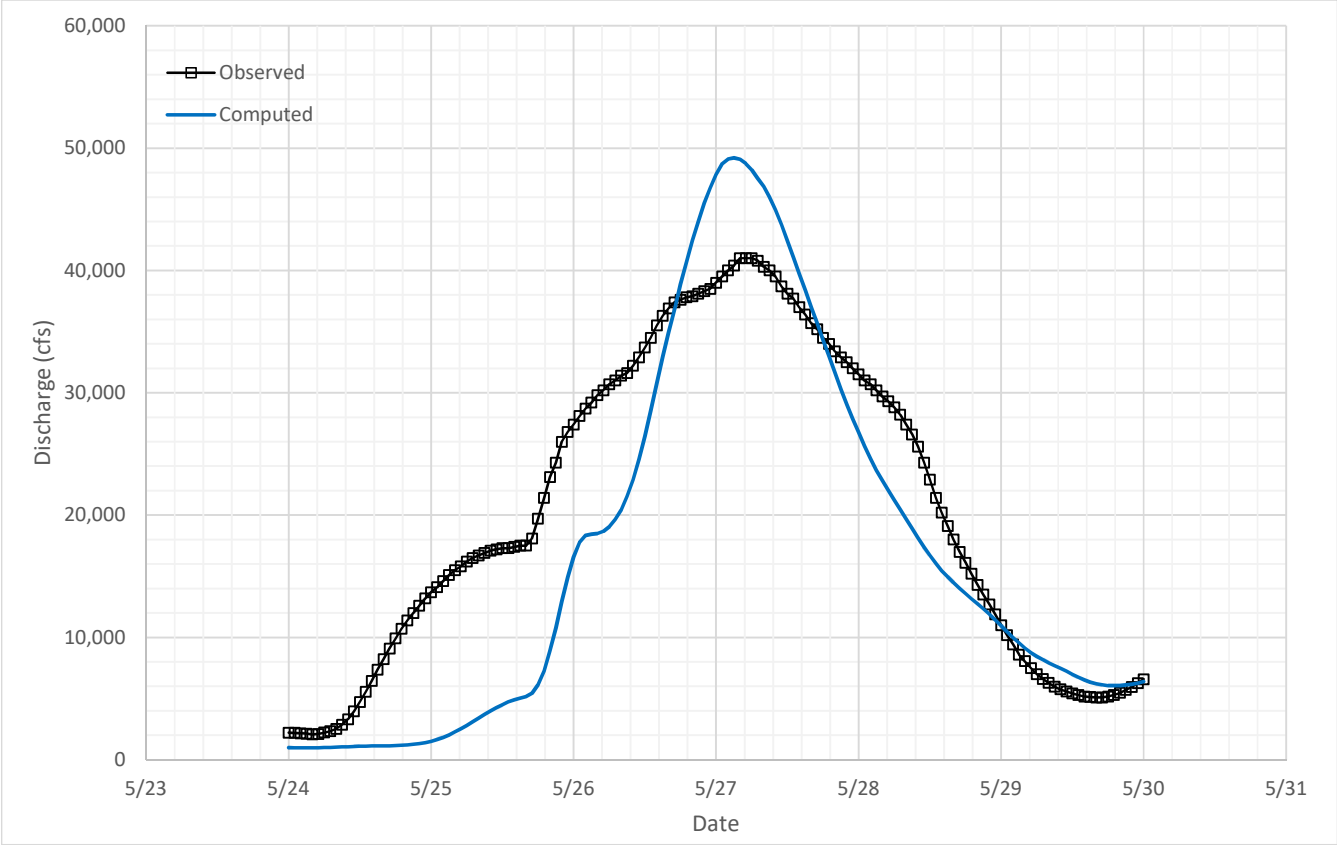


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.2	0.07	3.6	2.20	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	22,200	85,866
Computed	24,399	77,913
Residual	2,199	-7,953
Error	10%	-9%

BRA Calibration
Little River near Cameron, TX
USGS 08106500

2015 Calibration Event

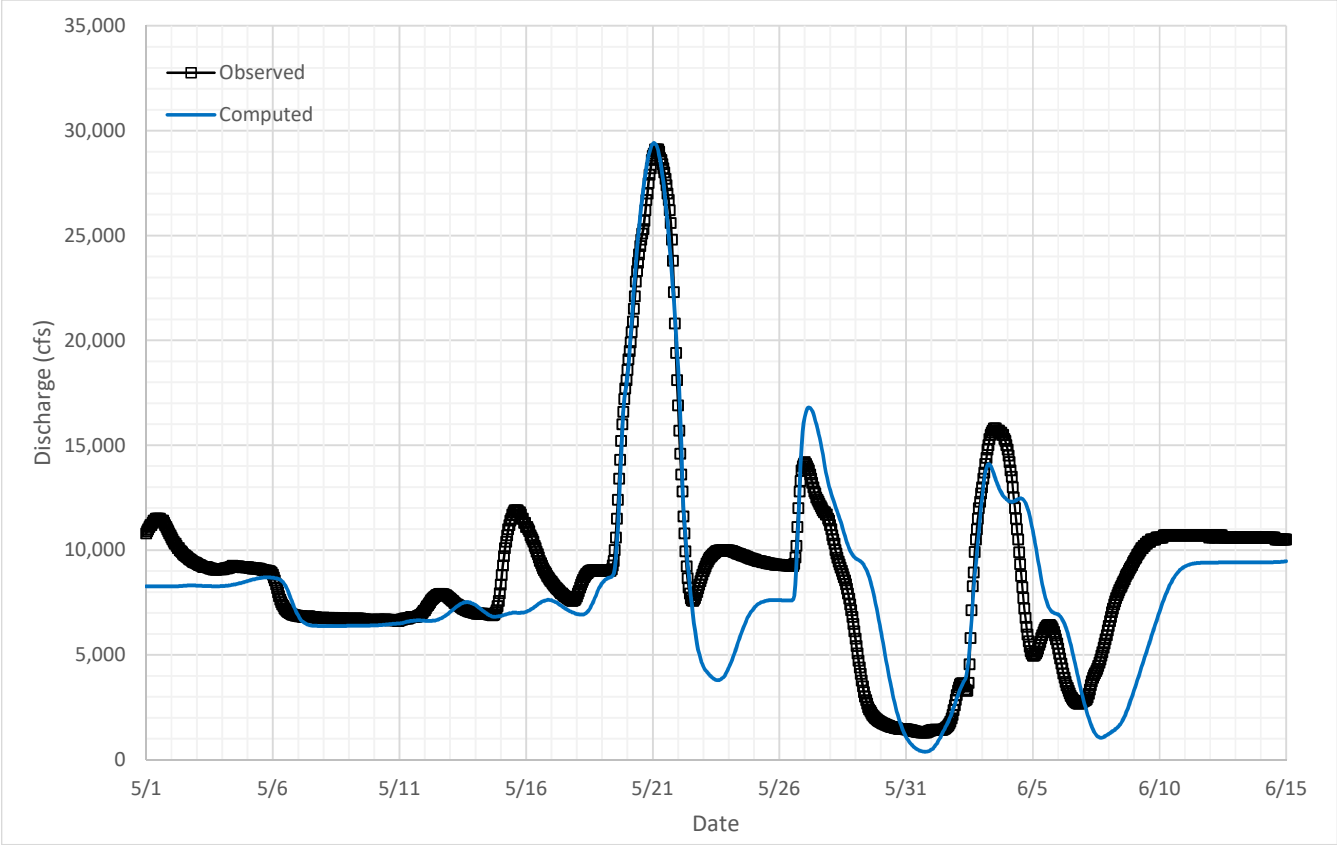


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.3	0.00	4.5	2.50	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	41,000	246,974
Computed	49,202	201,525
Residual	8,202	-45,449
Error	20%	-18%

BRA Calibration
Little River near Cameron, TX
USGS 08106500

2016 Calibration Event

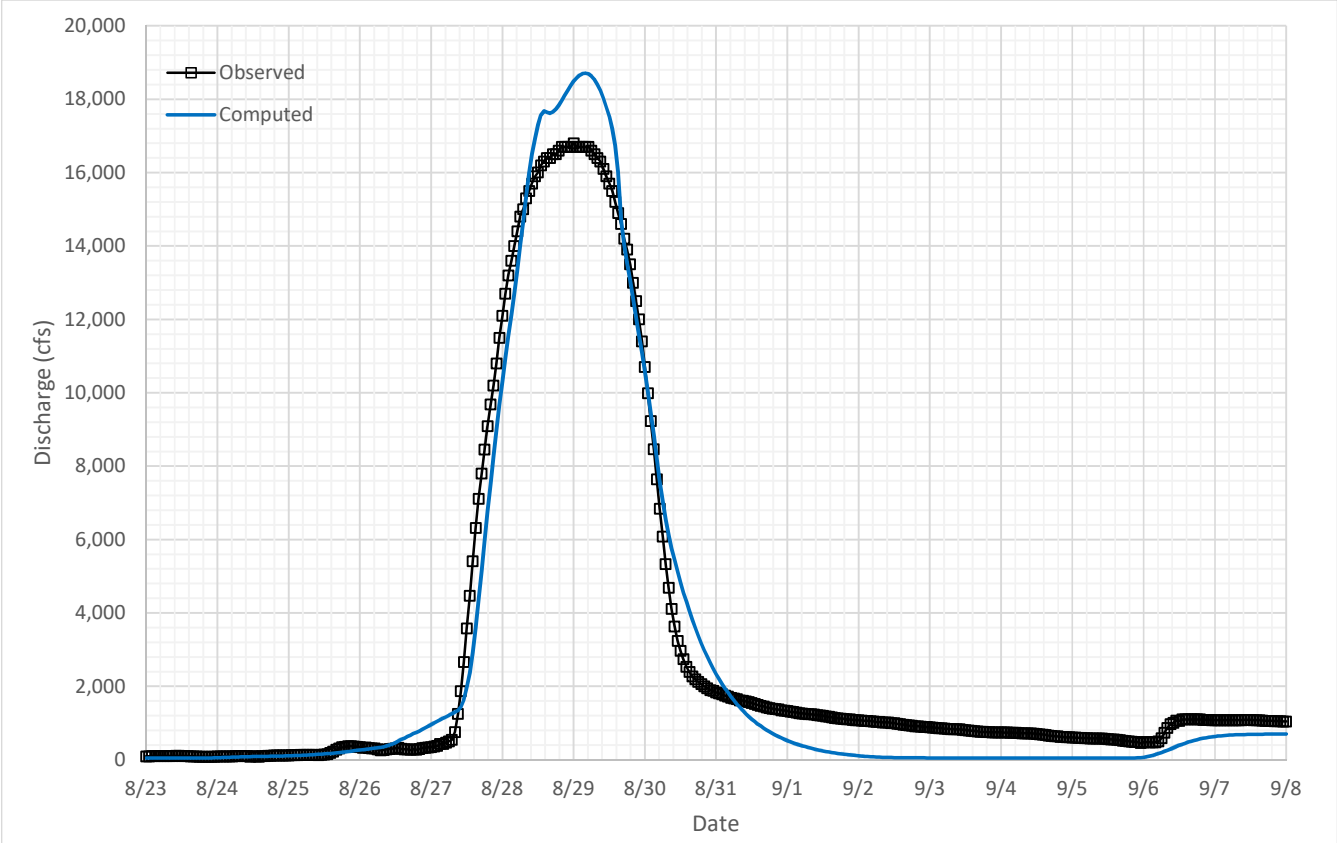


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.3	0.09	4.5	8.32	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	29,100	805,309
Computed	29,415	736,056
Residual	315	-69,253
Error	1%	-9%

BRA Calibration
Little River near Cameron, TX
USGS 08106500

2016 Calibration Event

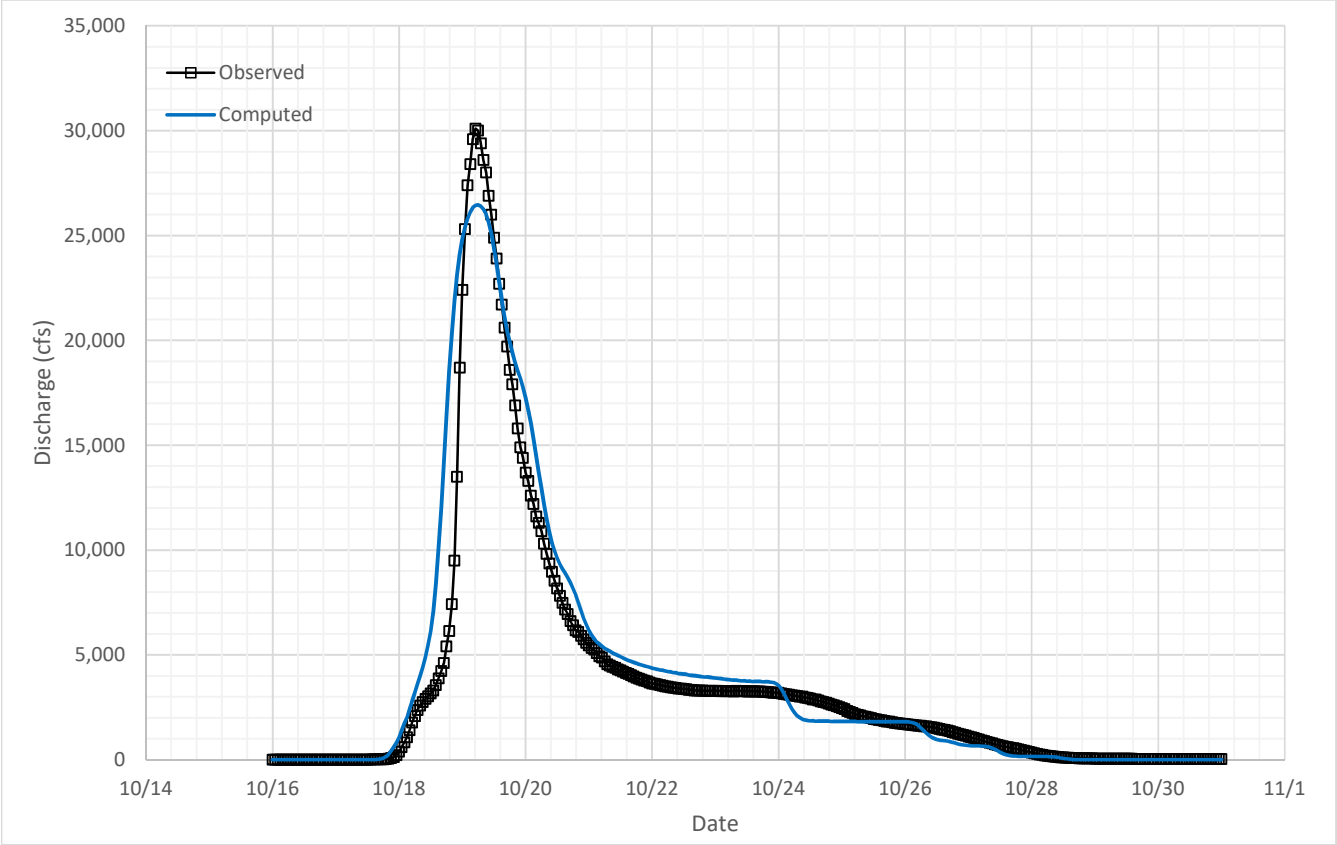


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
6.0	0.03	4.5	8.32	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	16,800	94,987
Computed	18,709	88,615
Residual	1,909	-6,373
Error	11%	-7%

BRA Calibration
Navasota River near Easterly, TX
USGS 08110500

1998 Calibration Event

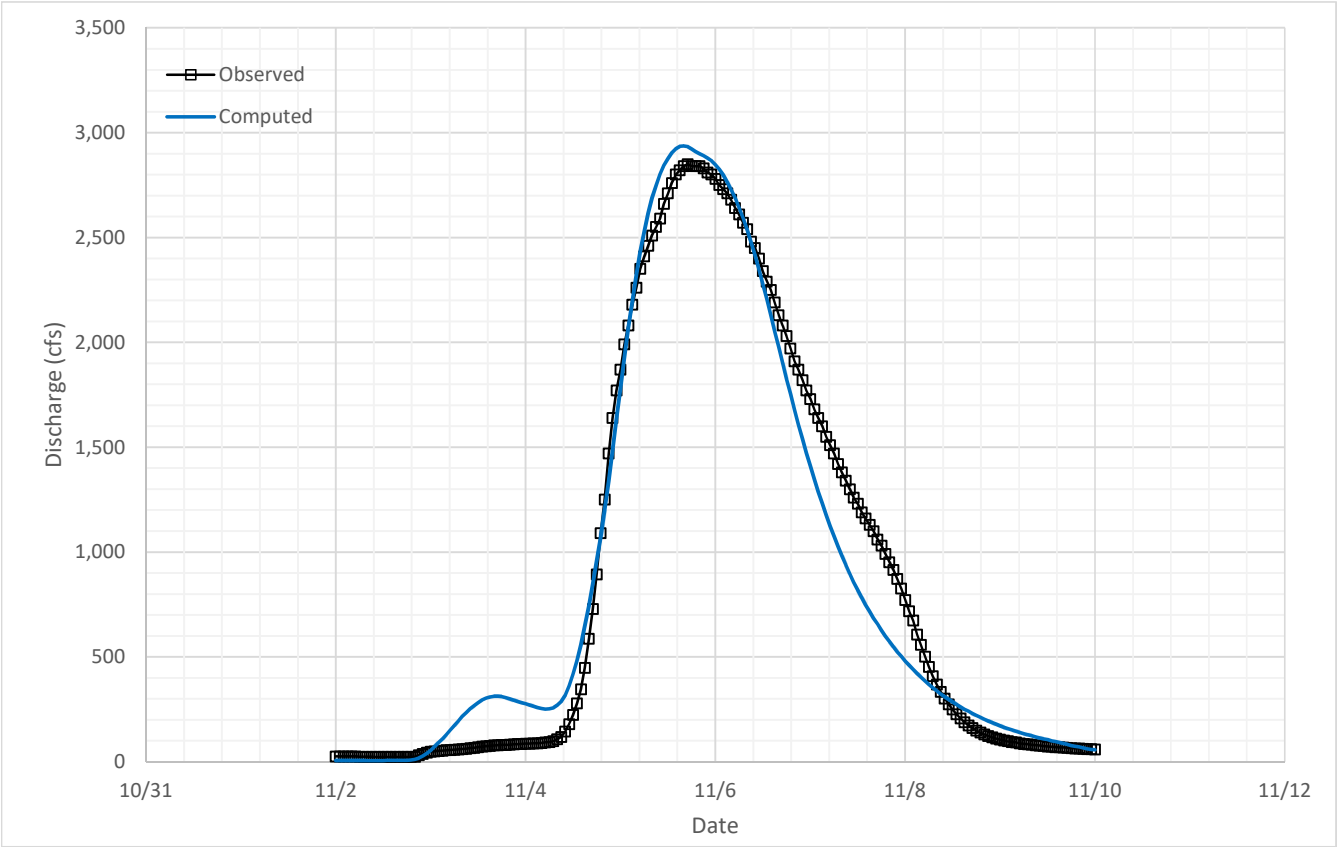


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.3	0.20	3.4	4.5	0.6

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	30,100	109,488
Computed	16,462	122,771
Residual	-13,638	13,283
Error	-45%	12%

BRA Calibration
Navasota River near Easterly, TX
USGS 08110500

2002 Calibration Event

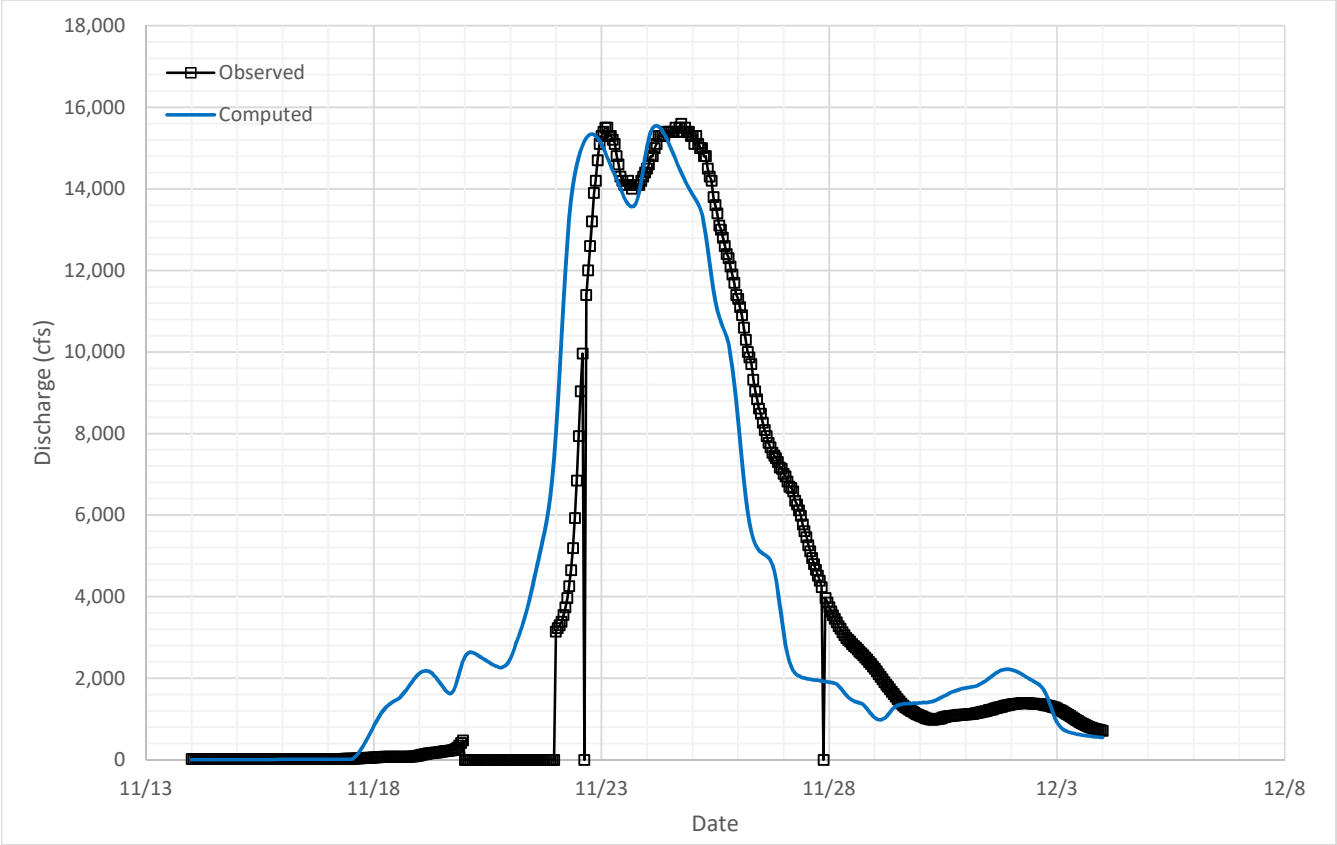


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.0	0.10	3.4	4.5	0.6

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	2,850	14,217
Computed	2,937	14,010
Residual	87	-207
Error	3%	-1%

BRA Calibration
Navasota River near Easterly, TX
USGS 08110500

2004 Calibration Event

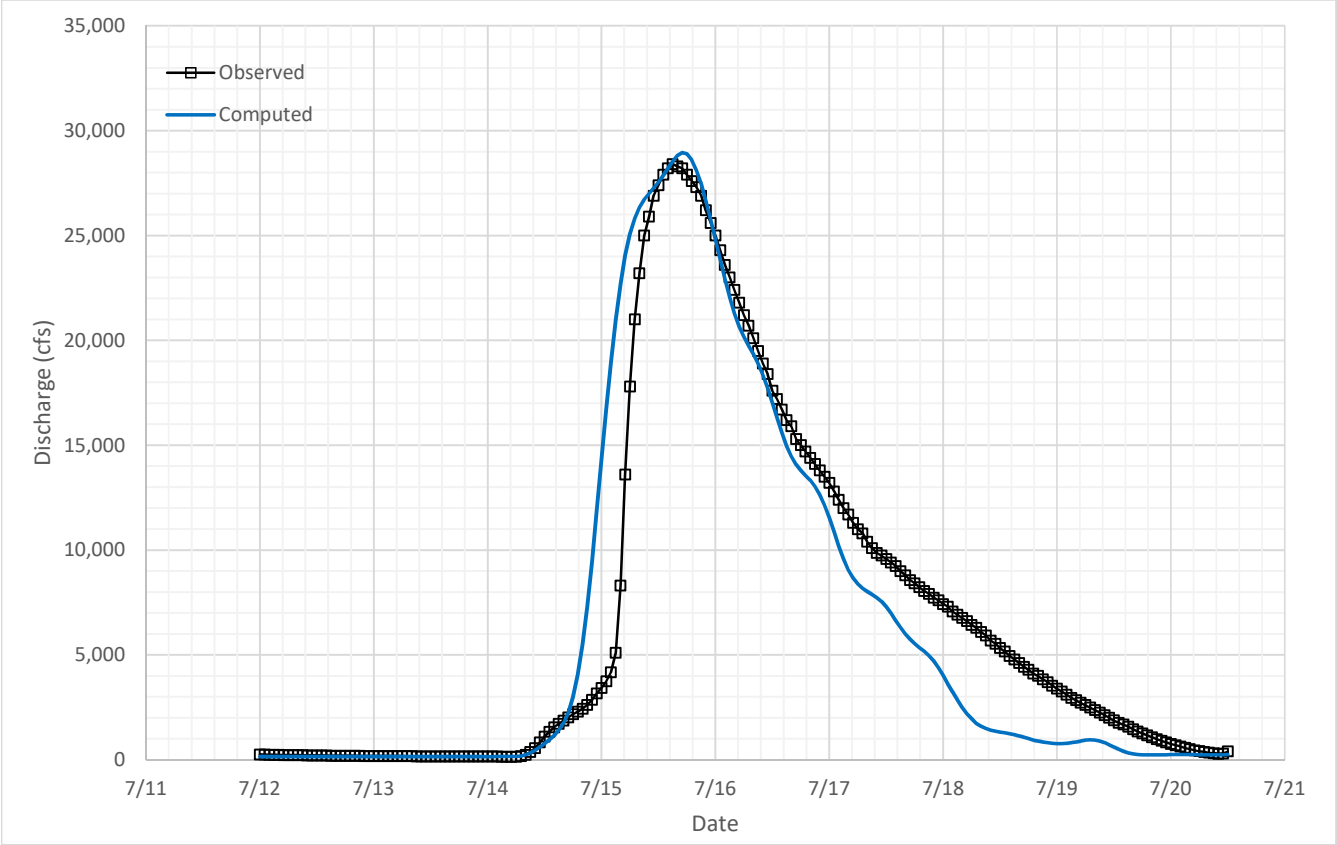


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.2	0.10	3.4	4.5	0.6

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	15,600	148,472
Computed	15,552	160,982
Residual	-48	12,510
Error	0%	8%

BRA Calibration
Navasota River near Easterly, TX
USGS 08110500

2007 Calibration Event

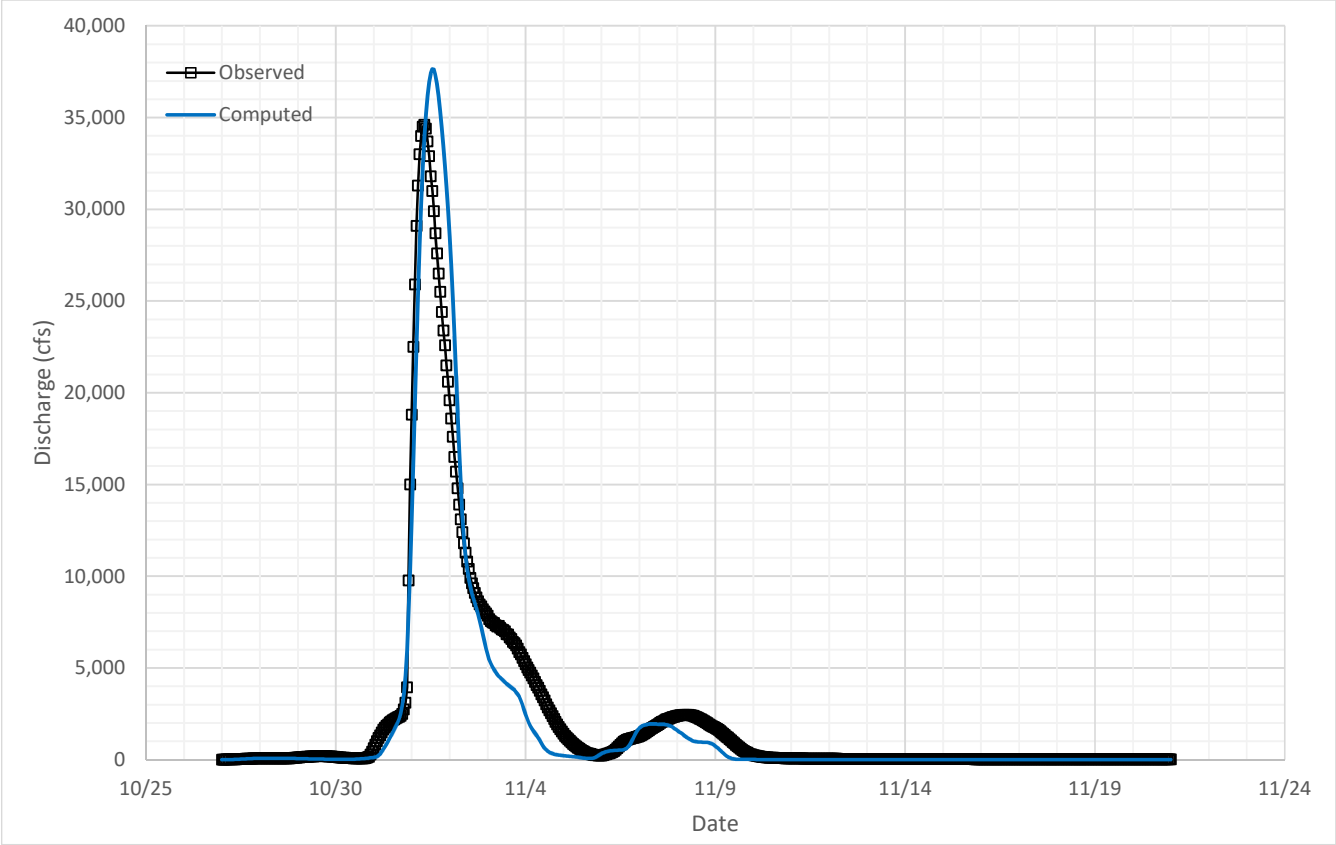


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.0	0.10	3.4	4.5	0.6

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	28,400	116,636
Computed	28,946	109,601
Residual	546	-7,035
Error	2%	-6%

BRA Calibration
Navasota River near Easterly, TX
USGS 08110500

2013 Calibration Event

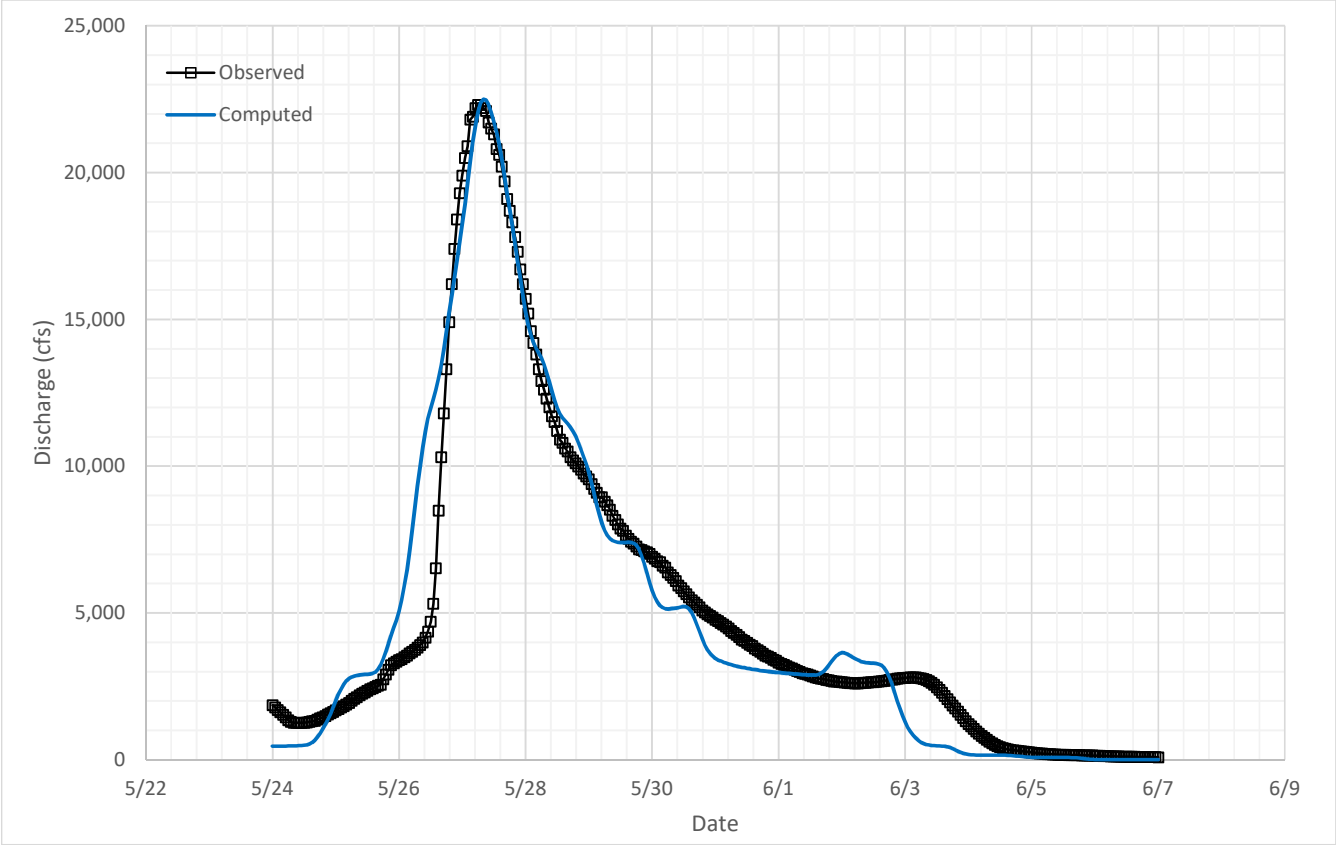


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
4.0	0.20	3.4	4.5	0.6

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	34,600	119,943
Computed	37,643	111,522
Residual	3,043	-8,421
Error	9%	-7%

BRA Calibration
Navasota River near Easterly, TX
USGS 08110500

2015 Calibration Event

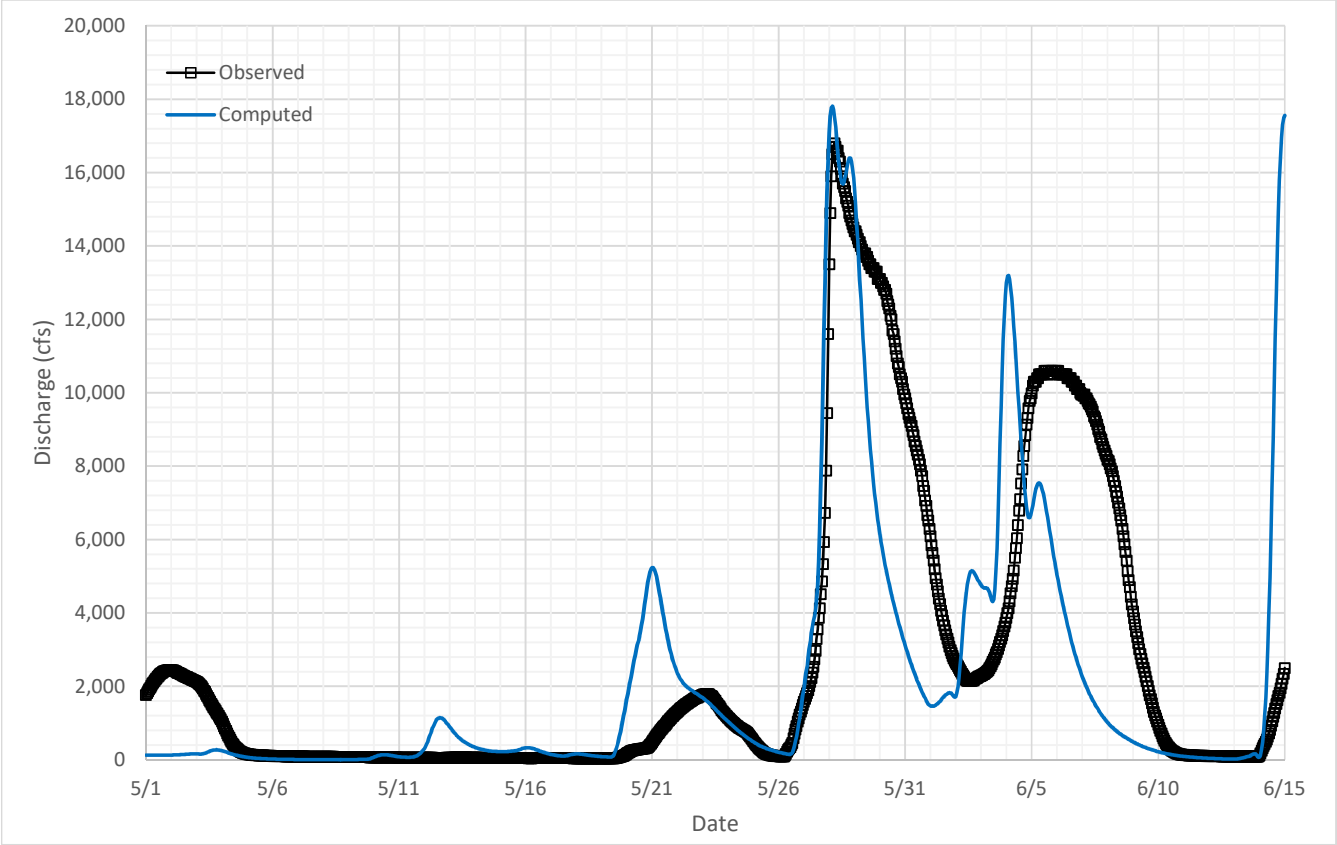


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.0	0.20	3.4	4.5	0.6

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	22,300	139,959
Computed	22,496	139,237
Residual	196	-722
Error	1%	-1%

BRA Calibration
Navasota River near Easterly, TX
USGS 08110500

2016 Calibration Event

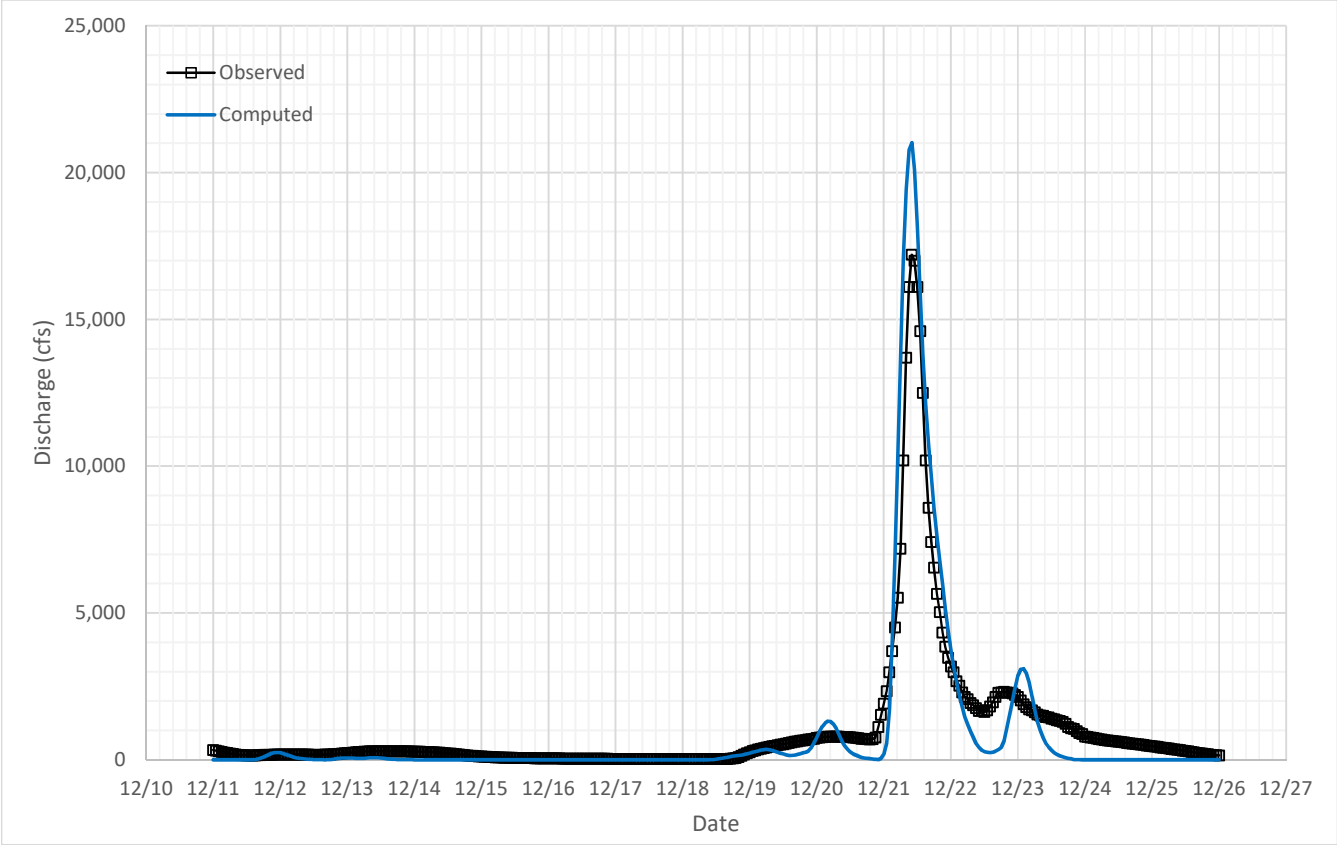


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.7	0.08	4.8	16.1	0.6

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	16,800	245,214
Computed	17,808	197,420
Residual	1,008	-47,793
Error	6%	-19%

BRA Calibration
Big Creek near Freestone, TX
USGS 08110430

1991 Calibration Event

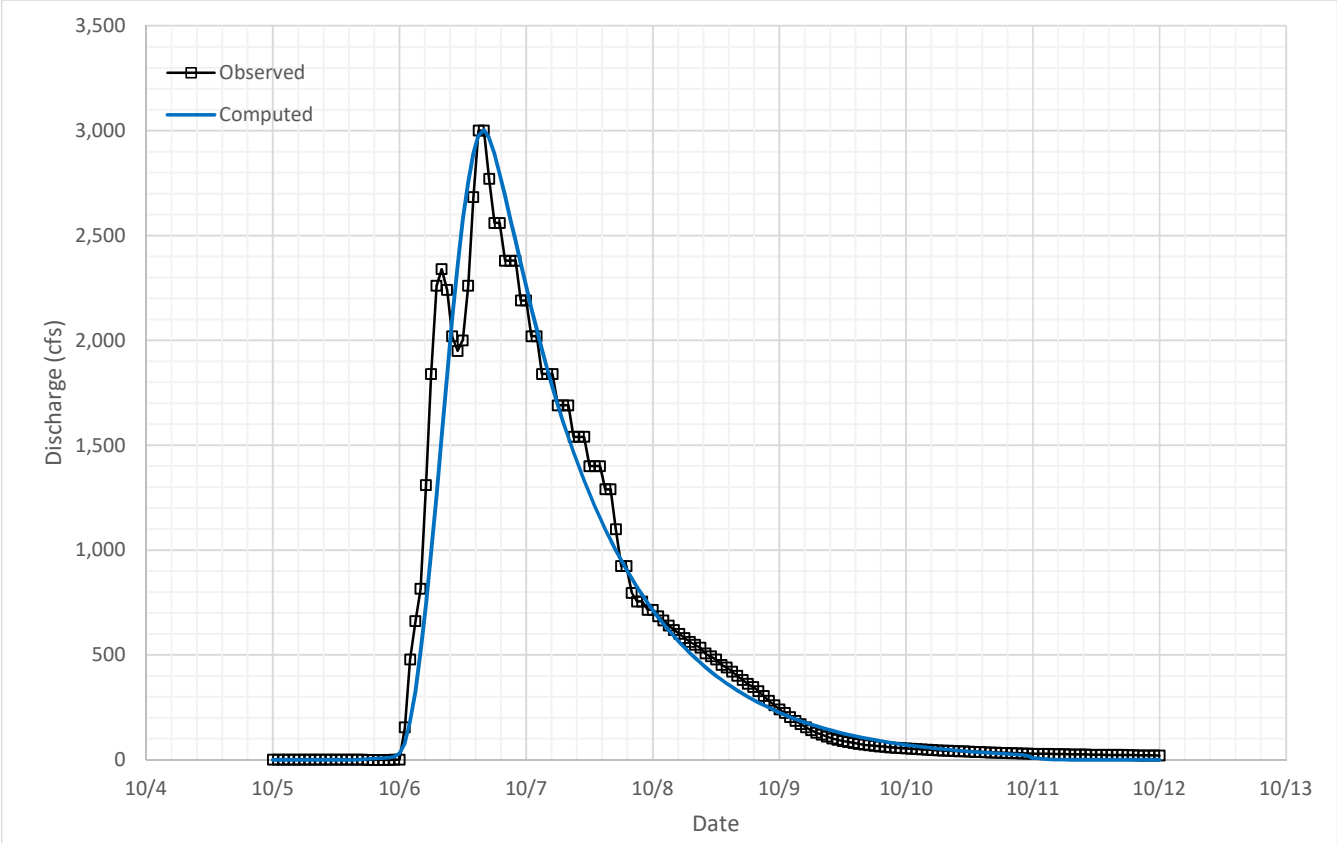


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.1	0.07	9.9	2.10	0.80

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	17,200	30,267
Computed	21,017	27,422
Residual	3,817	-2,845
Error	22%	-9%

BRA Calibration
Big Creek near Freestone, TX
USGS 08110430

1998 Calibration Event

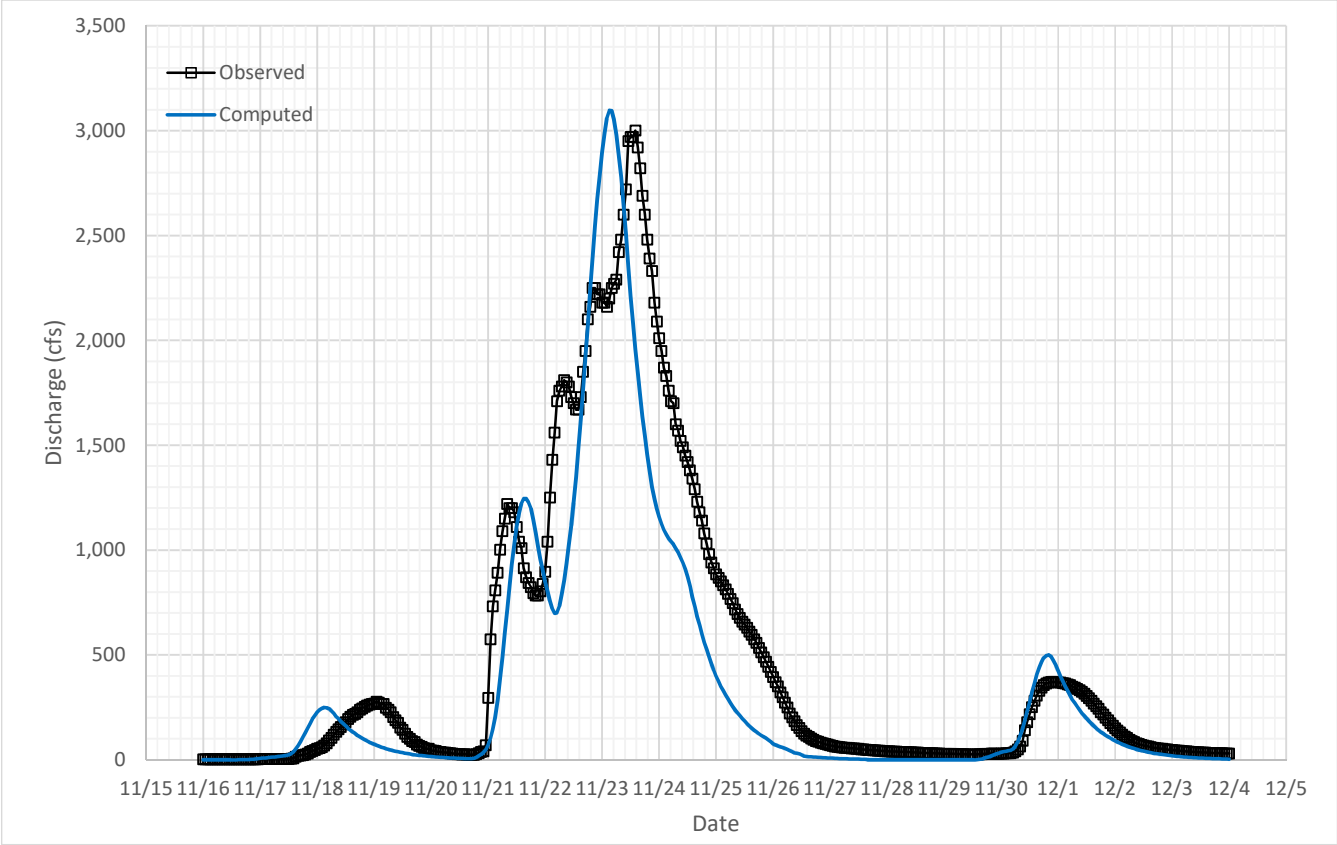


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.8	0.11	9.9	4.20	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	3,000	7,959
Computed	3,003	7,663
Residual	3	-296
Error	0%	-4%

BRA Calibration
Big Creek near Freestone, TX
USGS 08110430

2004 Calibration Event

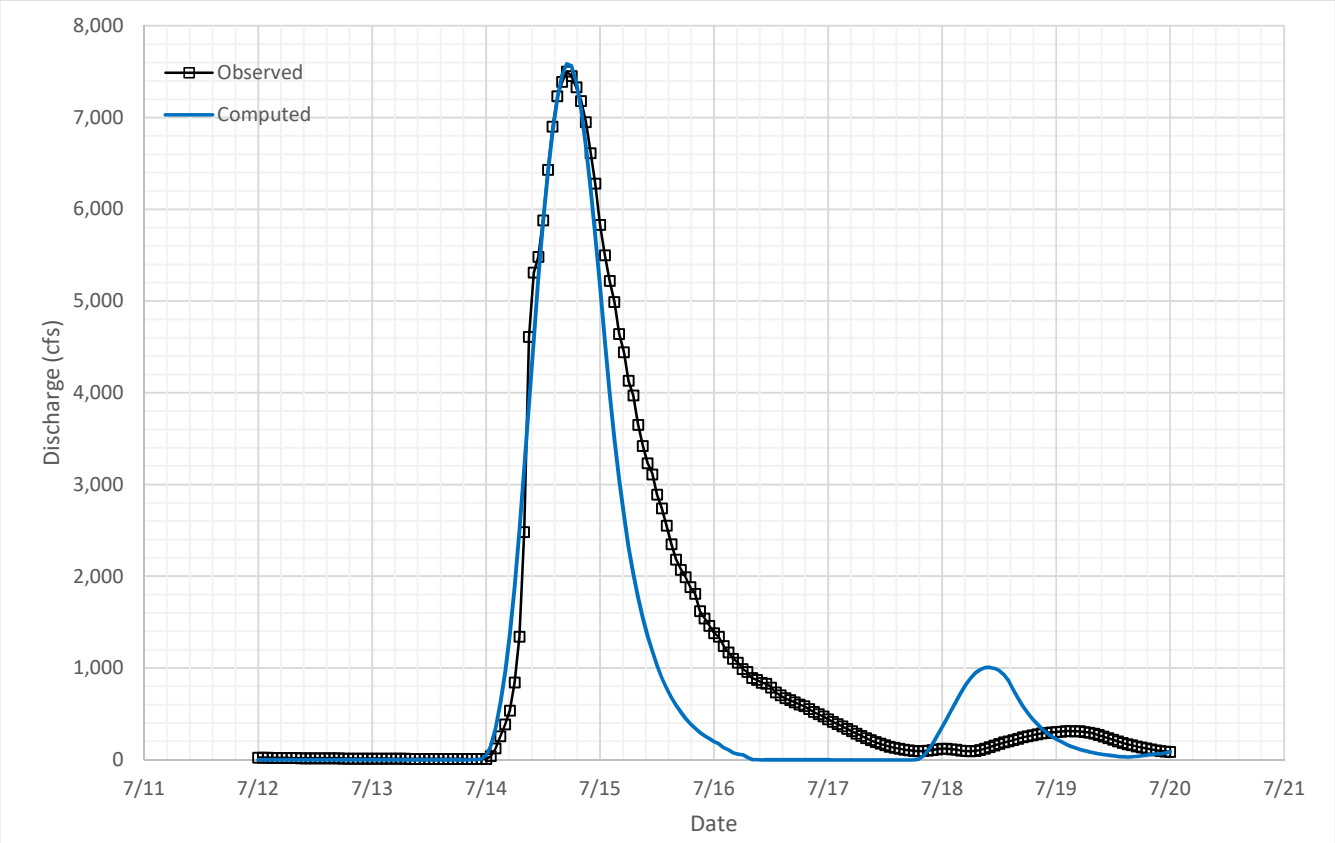


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.8	0.11	9.9	4.20	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	3,000	16,957
Computed	3,097	12,652
Residual	97	-4,305
Error	3%	-25%

BRA Calibration
Big Creek near Freestone, TX
USGS 08110430

2007 Calibration Event

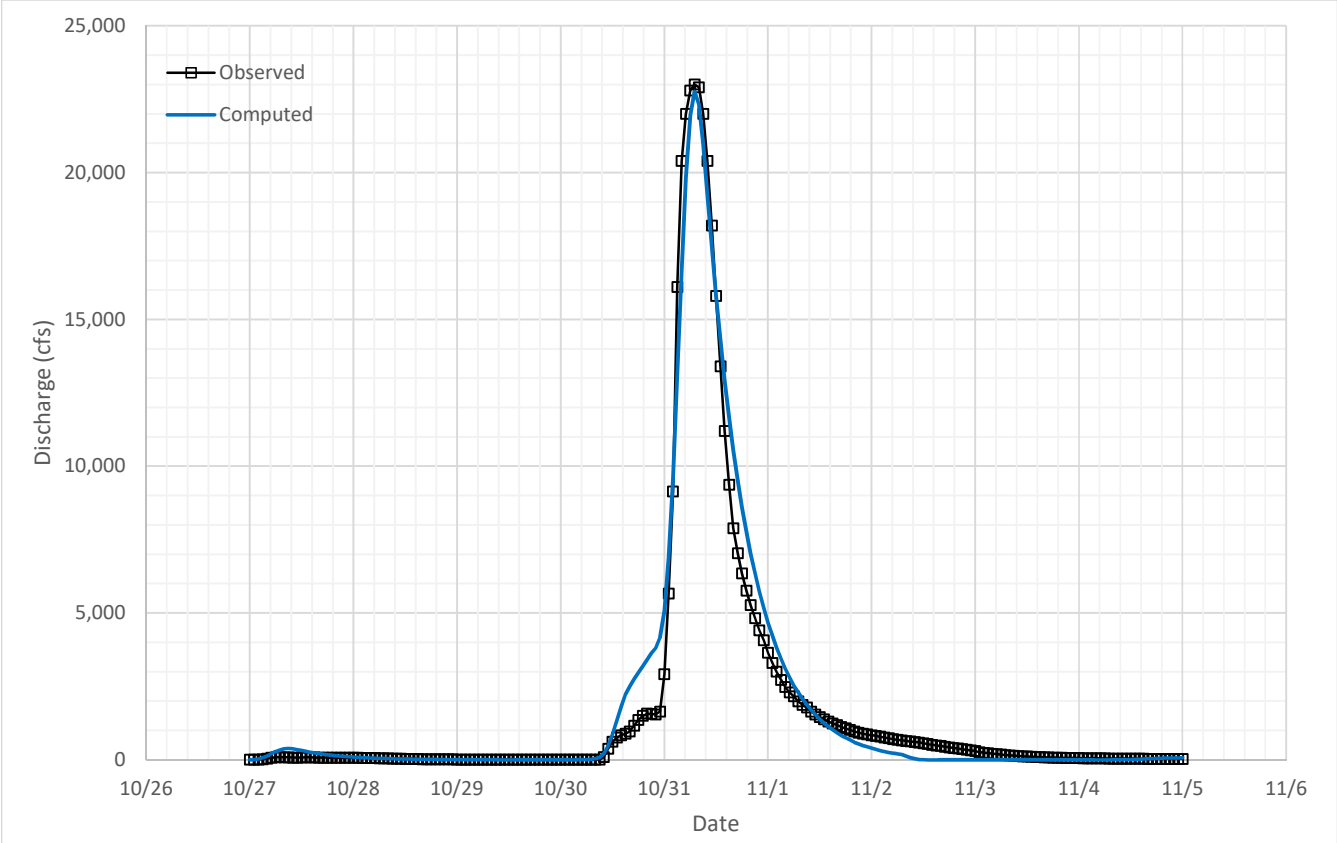


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.0	0.07	9.9	4.20	0.80

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	7,500	17,936
Computed	7,585	13,735
Residual	85	-4,201
Error	1%	-23%

BRA Calibration
Big Creek near Freestone, TX
USGS 08110430

2013 Calibration Event

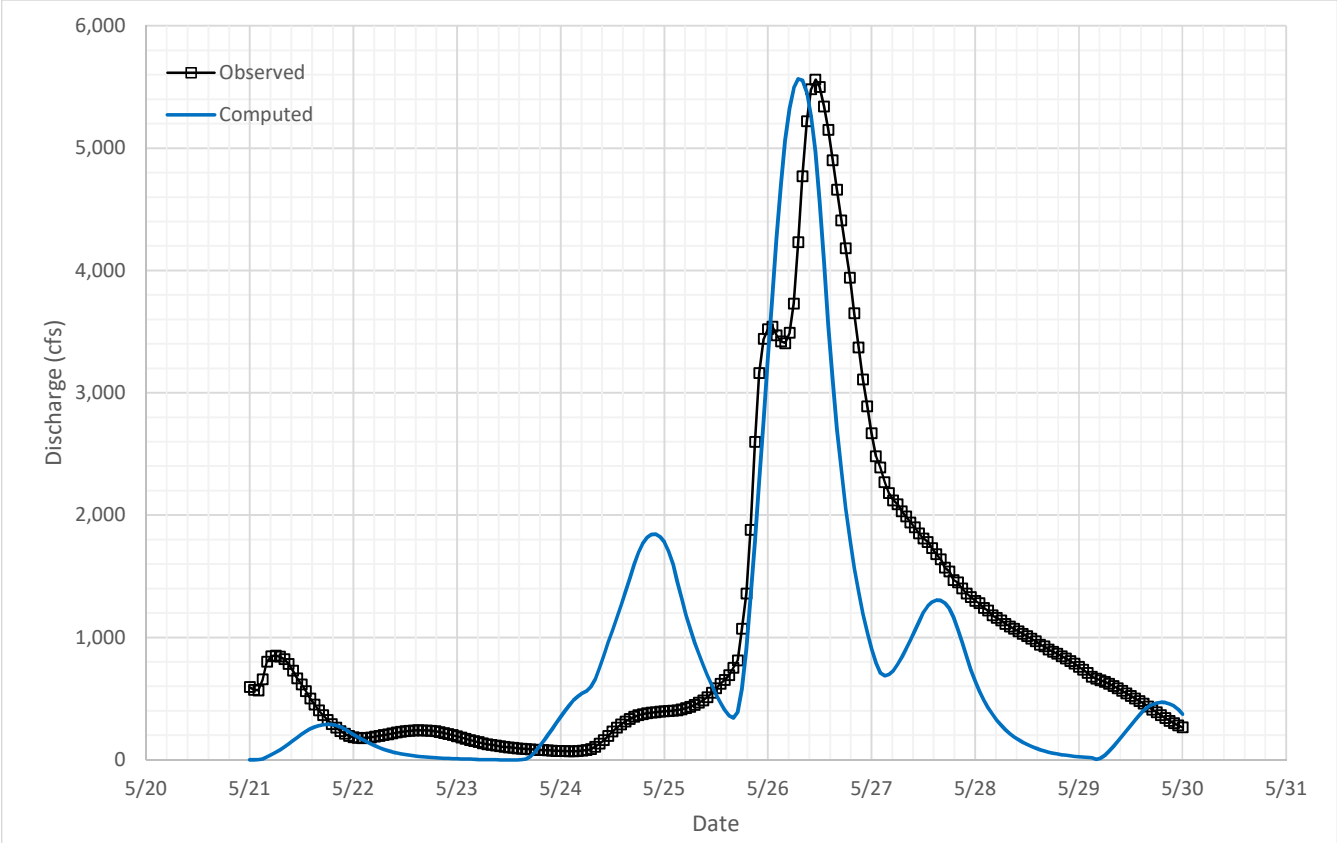


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.1	0.11	9.9	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	23,000	31,239
Computed	22,758	32,885
Residual	-242	1,646
Error	-1%	5%

BRA Calibration
Big Creek near Freestone, TX
USGS 08110430

2015 Calibration Event

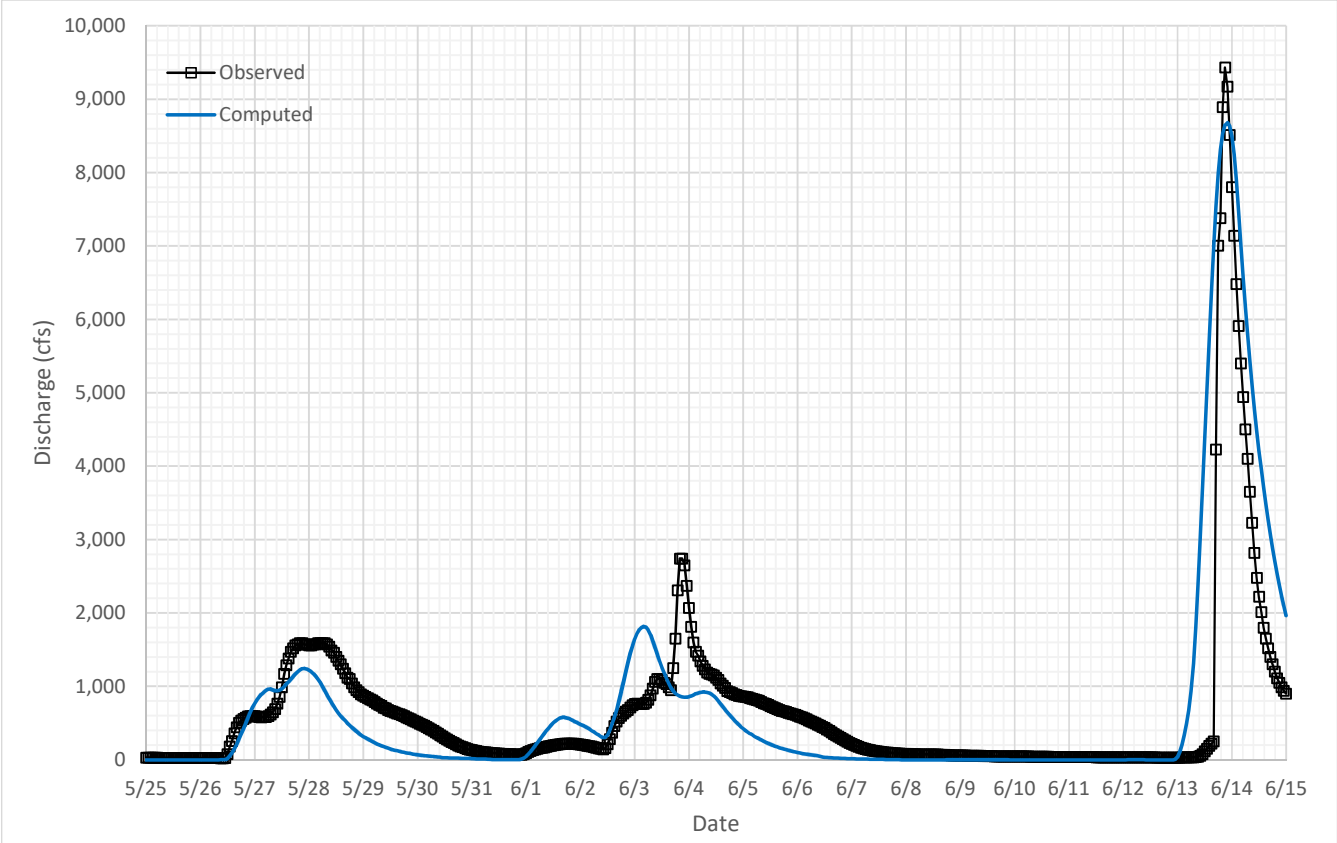


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.1	0.07	9.9	4.20	0.80

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	5,560	20,123
Computed	5,566	15,278
Residual	6	-4,845
Error	0%	-24%

BRA Calibration
Big Creek near Freestone, TX
USGS 08110430

2016 Calibration Event

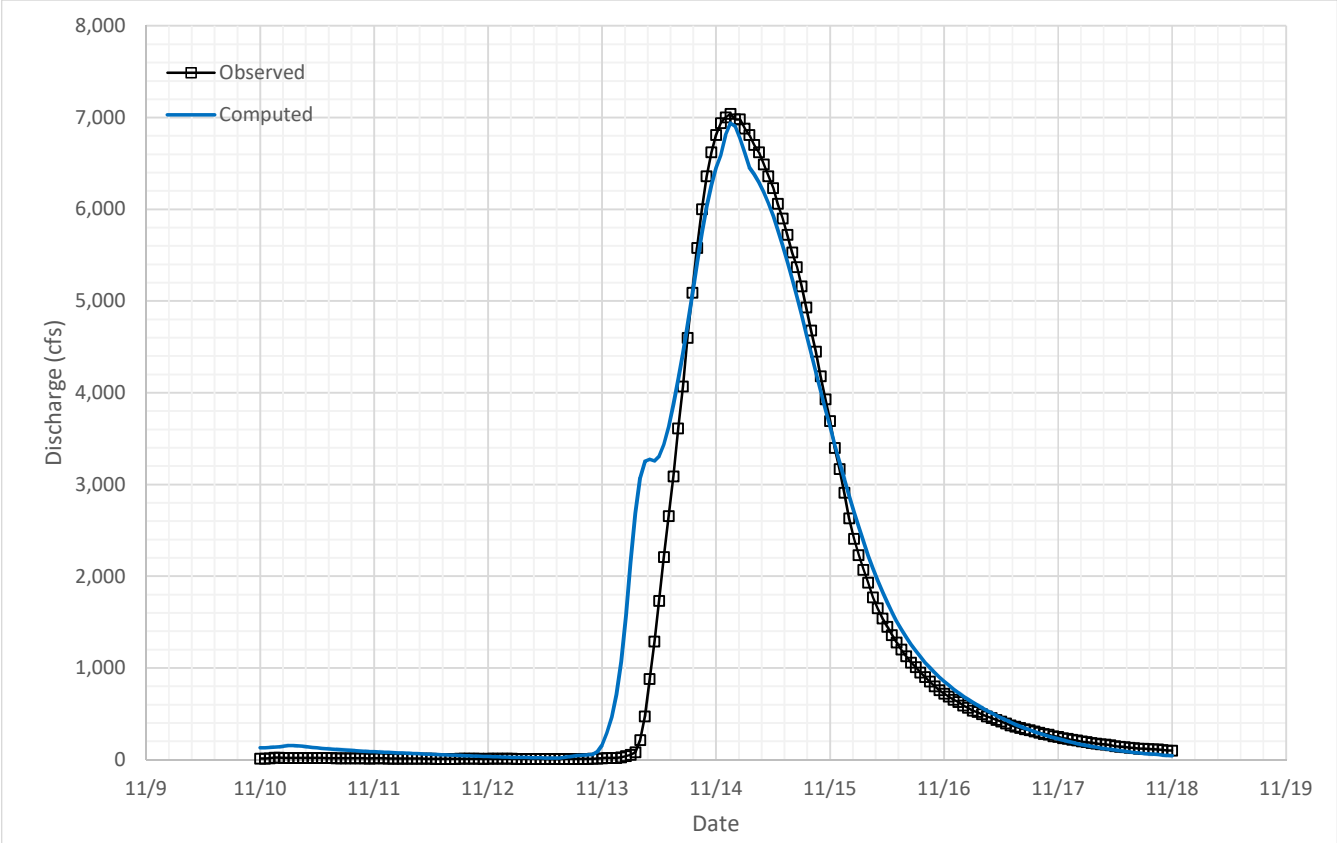


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
4.2	0.11	9.9	18.07	0.65

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	9,430	29,759
Computed	8,680	30,557
Residual	-750	798
Error	-8%	3%

BRA Calibration
Navasota River above Groesbeck, TX
USGS 08110325

1998 Calibration Event

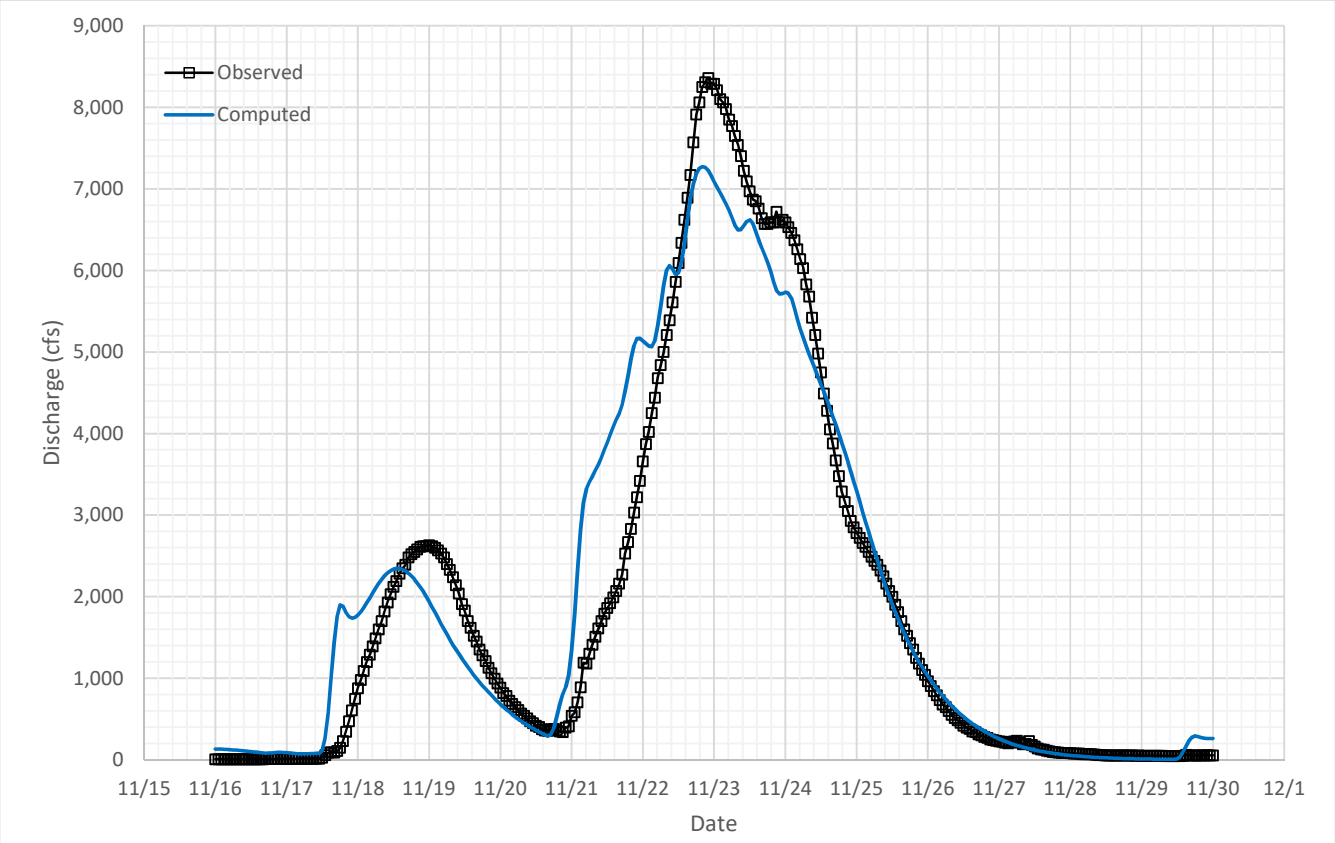


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.5	0.05	5.1	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	7,040	21,179
Computed	6,939	23,353
Residual	-101	2,174
Error	-1%	10%

BRA Calibration
Navasota River above Groesbeck, TX
USGS 08110325

2004 Calibration Event

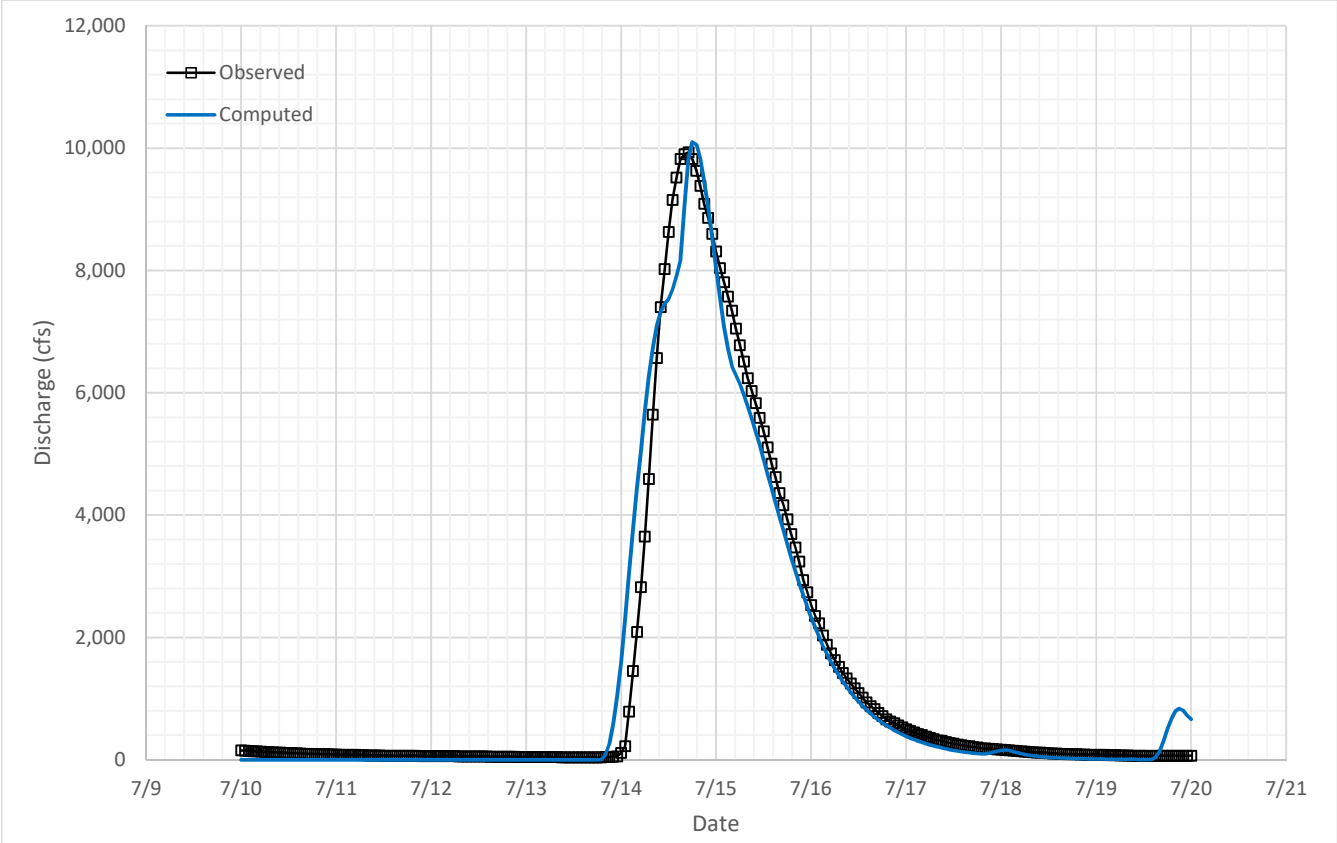


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.7	0.02	5.1	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	8,360	53,931
Computed	7,274	56,888
Residual	-1,086	2,957
Error	-13%	5%

BRA Calibration
Navasota River above Groesbeck, TX
USGS 08110325

2007 Calibration Event

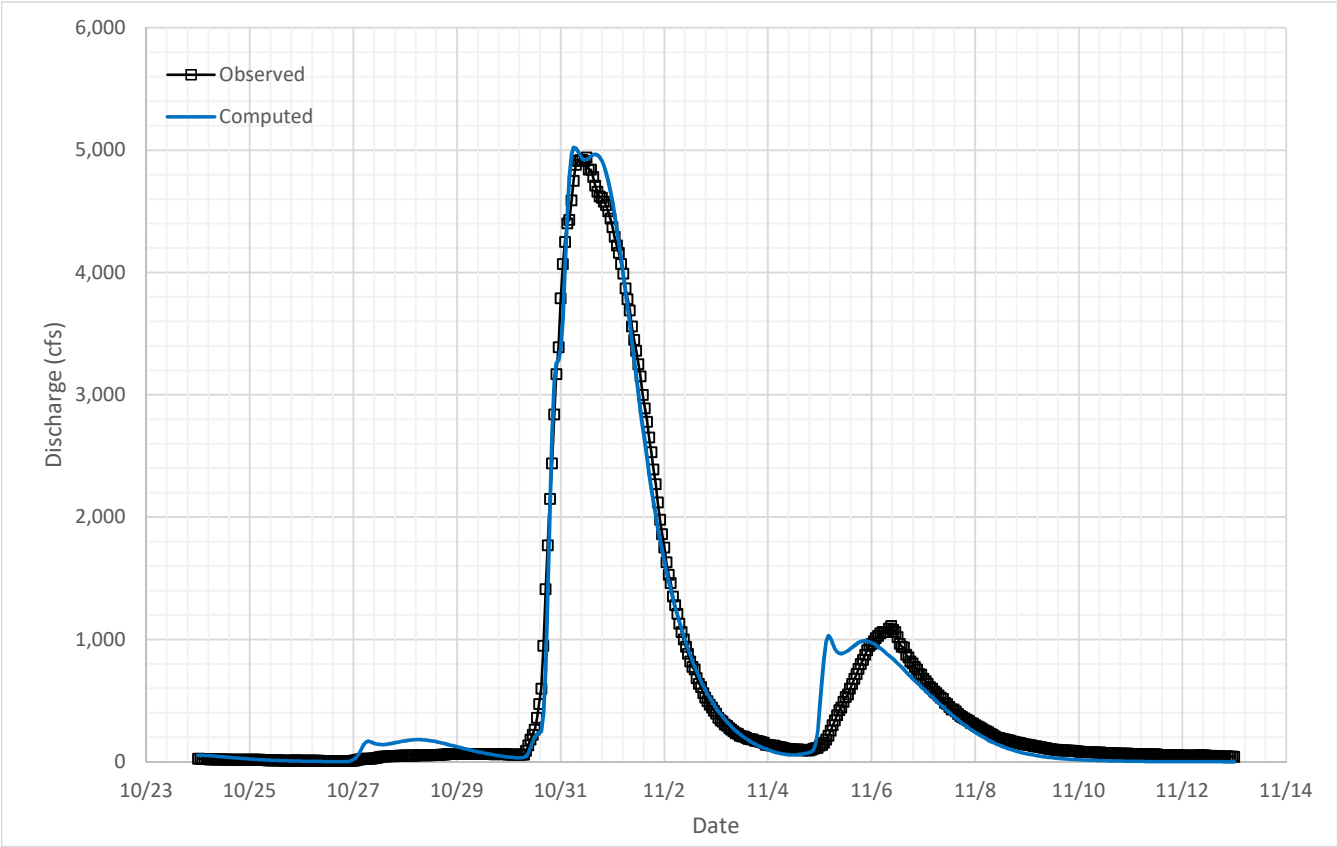


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.1	0.02	5.1	2.22	0.65

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	9,930	27,753
Computed	10,099	27,133
Residual	169	-620
Error	2%	-2%

BRA Calibration
Navasota River above Groesbeck, TX
USGS 08110325

2013 Calibration Event

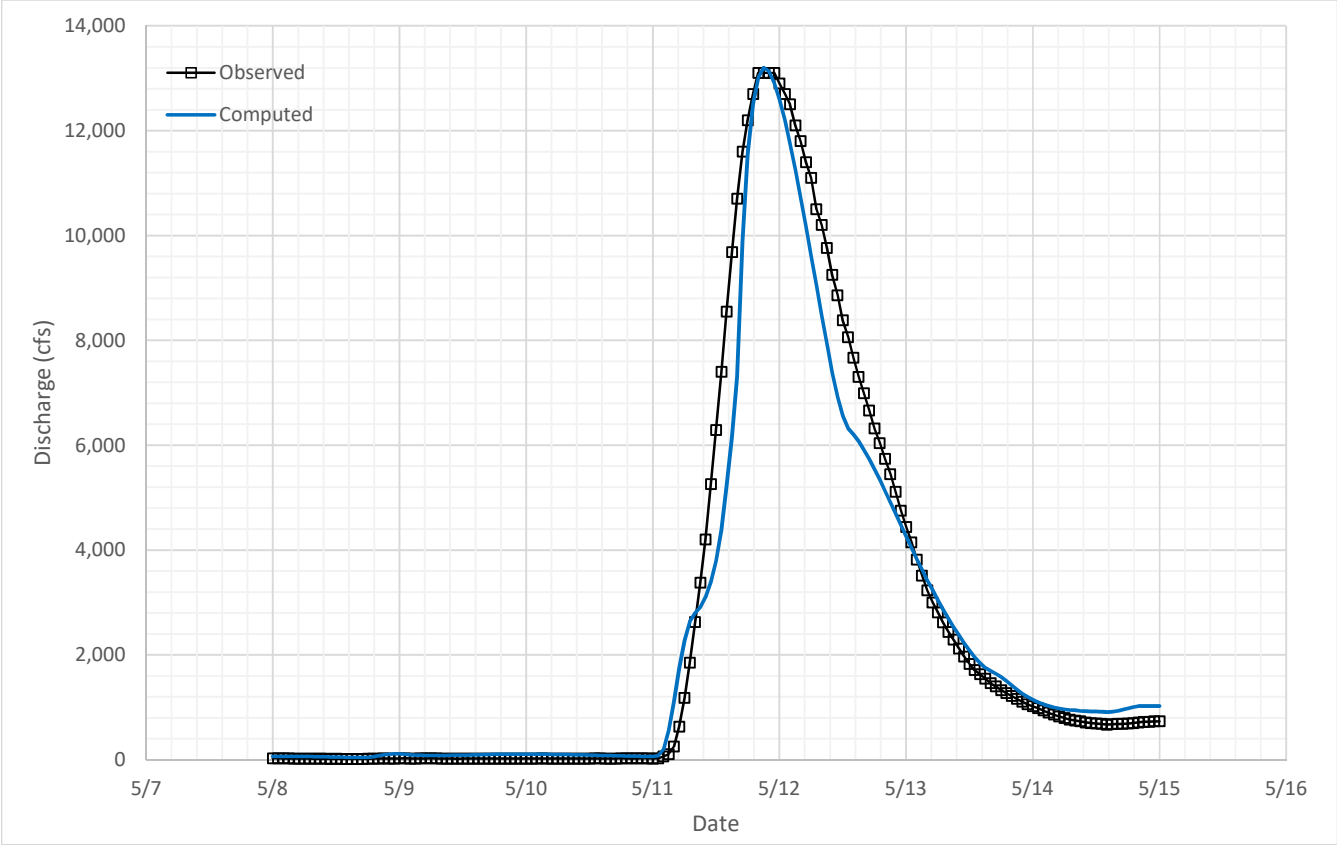


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.8	0.04	5.1	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	4,940	25,045
Computed	5,022	25,089
Residual	82	44
Error	2%	0%

BRA Calibration
Navasota River above Groesbeck, TX
USGS 08110325

2015 Calibration Event

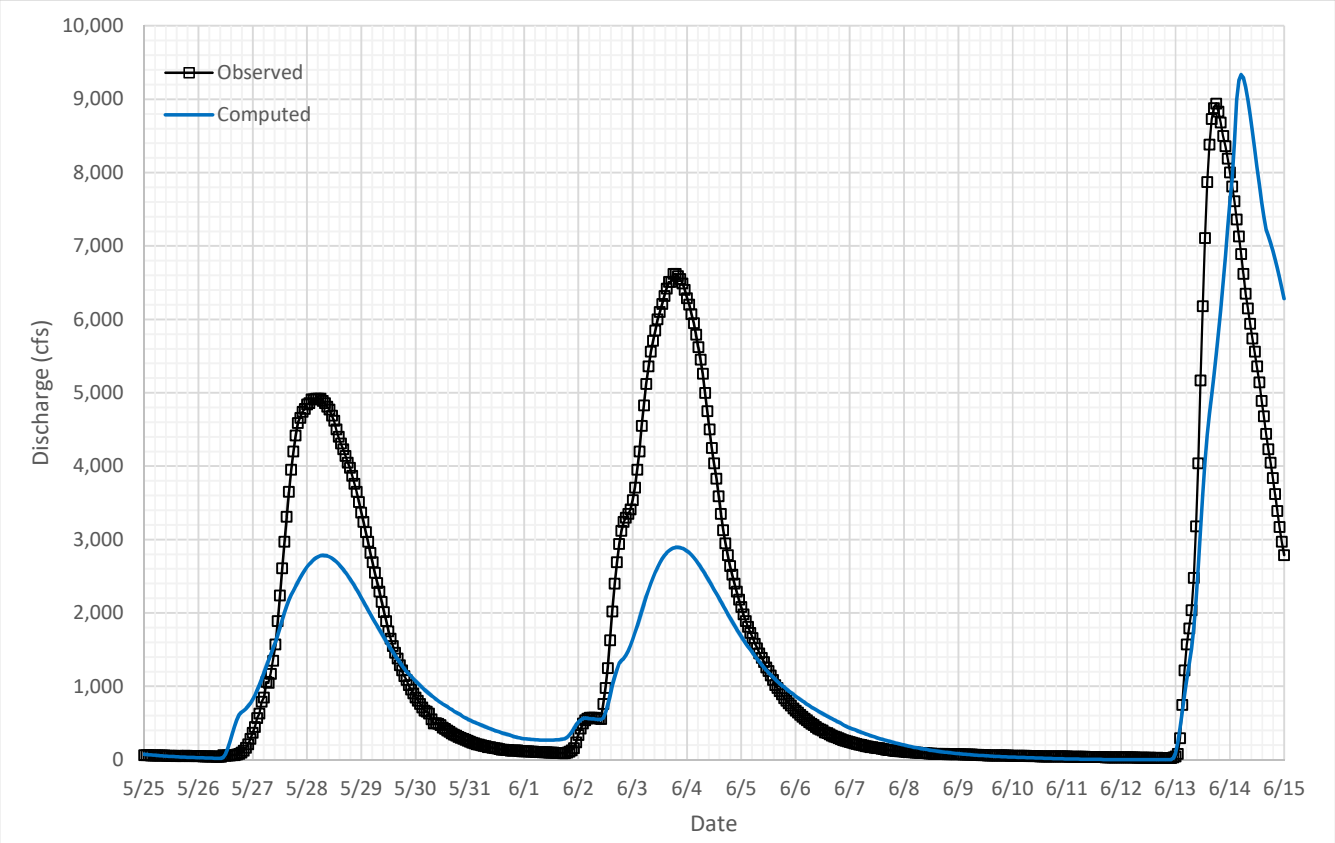


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.8	0.04	5.1	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	4,940	25,045
Computed	5,022	25,089
Residual	82	44
Error	2%	0%

BRA Calibration
Navasota River above Groesbeck, TX
USGS 08110325

2016 Calibration Event

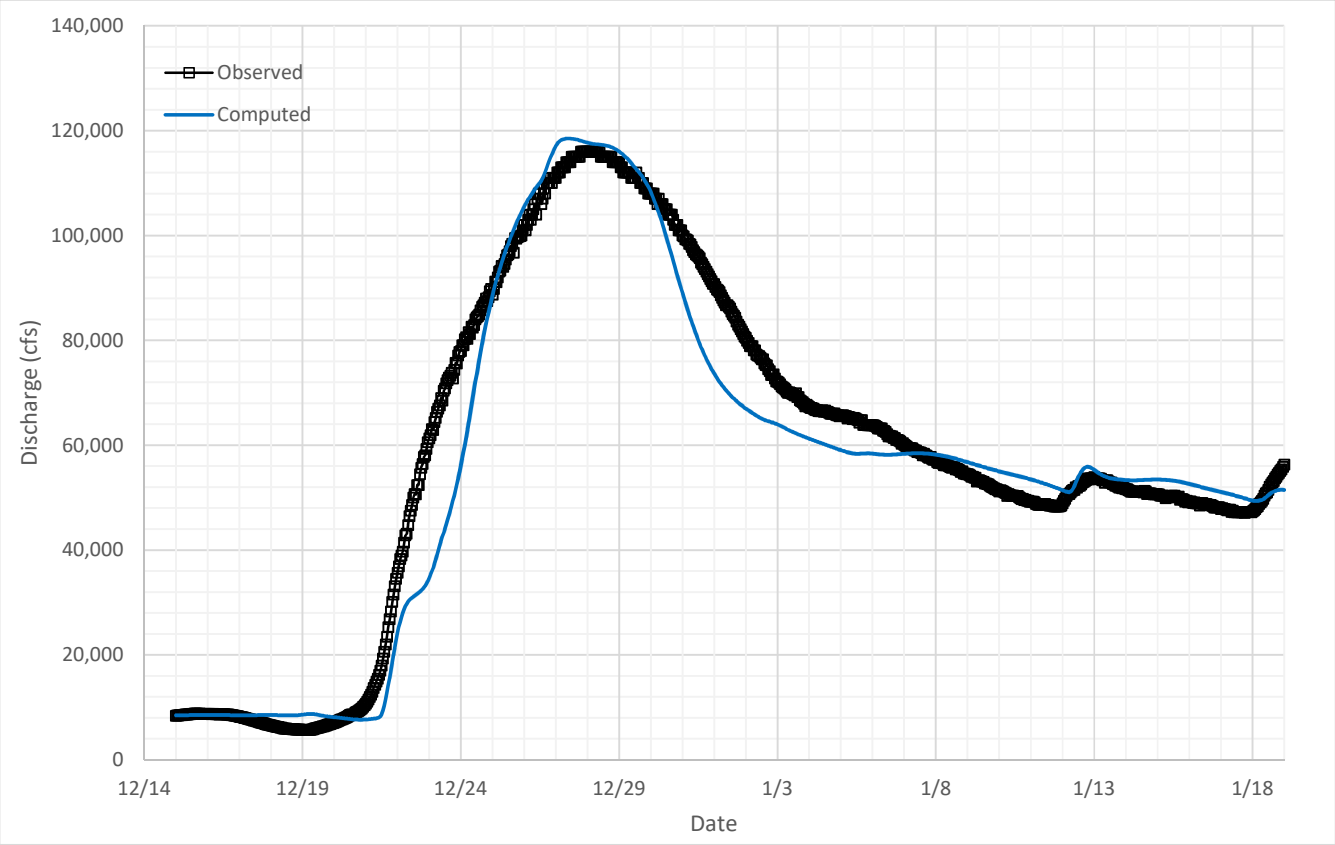


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.3	0.12	5.1	9.20	0.30

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	8,940	73,471
Computed	9,334	61,782
Residual	394	-11,689
Error	4%	-16%

BRA Calibration
Brazos River Near Hempsted, TX
USGS 08111500

1991 Calibration Event

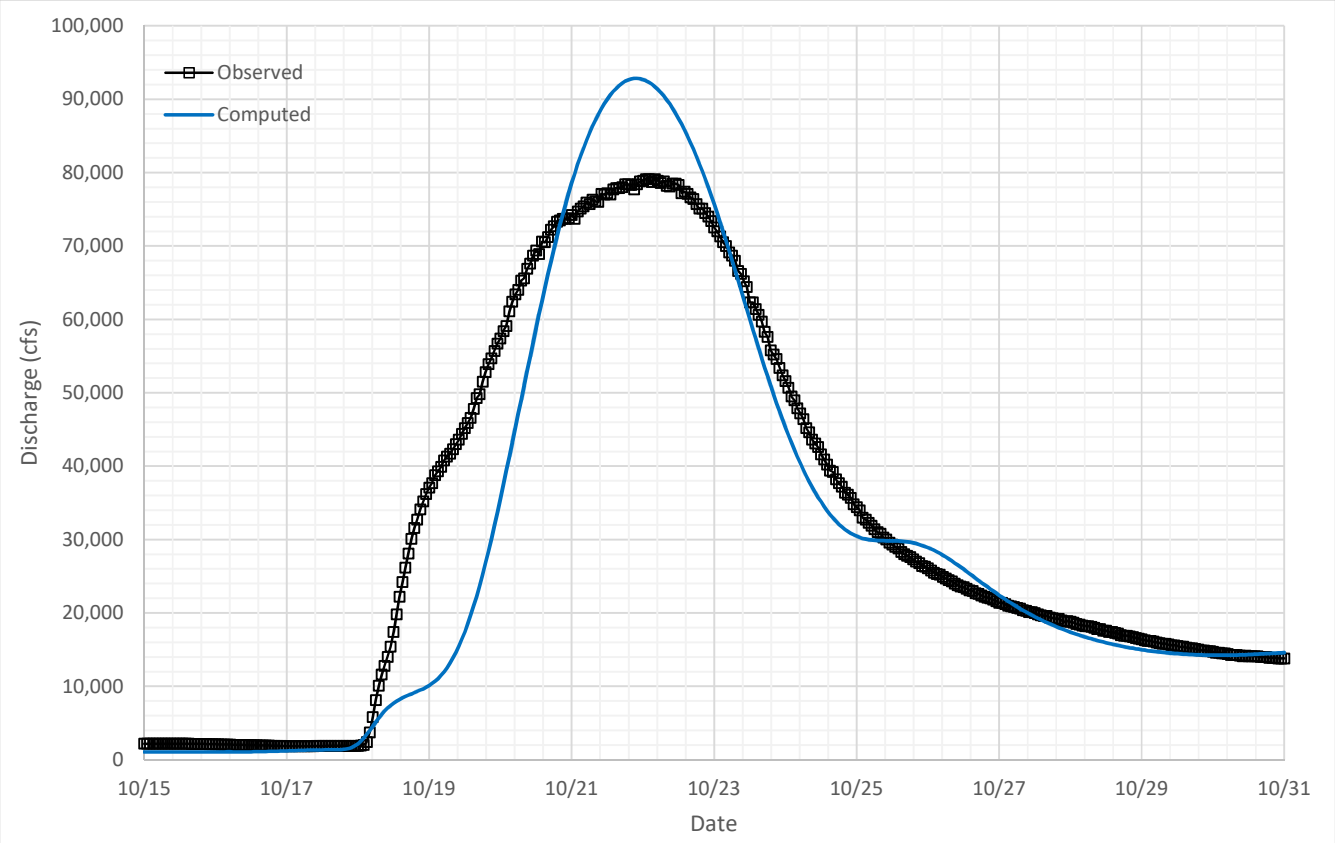


Parameter Summary					
River	Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
	(in)	(iph)	(%)		
Brazos River & Tributary Rivers	2.9	0.12	7.3	2.00	0.50
Little Brazos River Above Brazos River	2.8	0.16	6.4	2.00	0.40
Navasota River Above Brazos River	2.9	0.12	10.0	2.00	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	116,000	4,079,584
Computed	118,494	3,899,971
Residual	2,494	-179,613
Error	2%	-4%

BRA Calibration
Brazos River Near Hempsted, TX
USGS 08111500

1998 Calibration Event

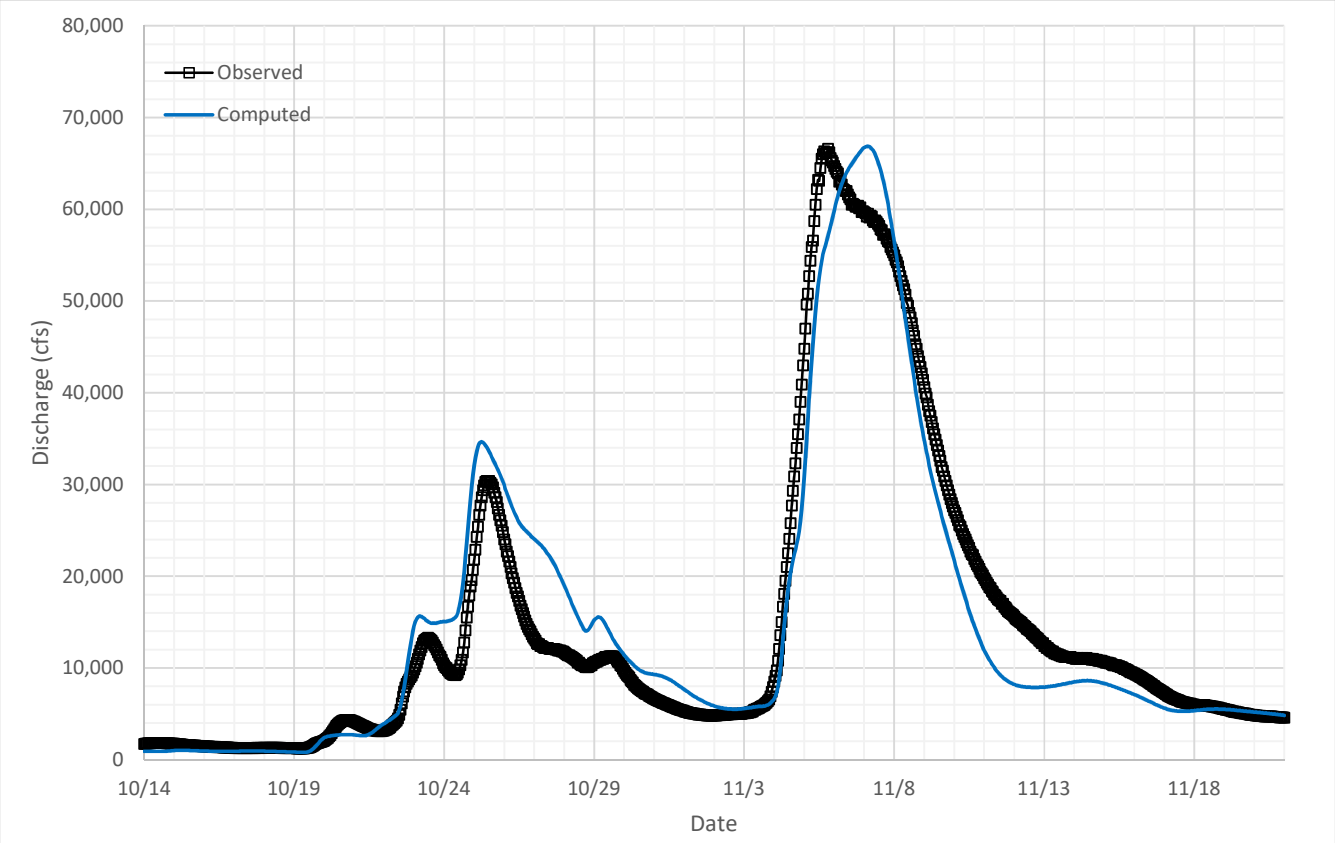


Parameter Summary					
River	Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
	(in)	(iph)	(%)		
Brazos River & Tributary Rivers	7.8	0.16	7.3	2.00	0.50
Little Brazos River Above Brazos River	7.3	0.21	6.4	2.00	0.40
Navasota River Above Brazos River	7.7	0.14	10.0	2.00	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	79,100	1,027,811
Computed	92,826	950,594
Residual	13,726	-77,217
Error	17%	-8%

BRA Calibration
Brazos River Near Hempsted, TX
USGS 08111500

2002 Calibration Event

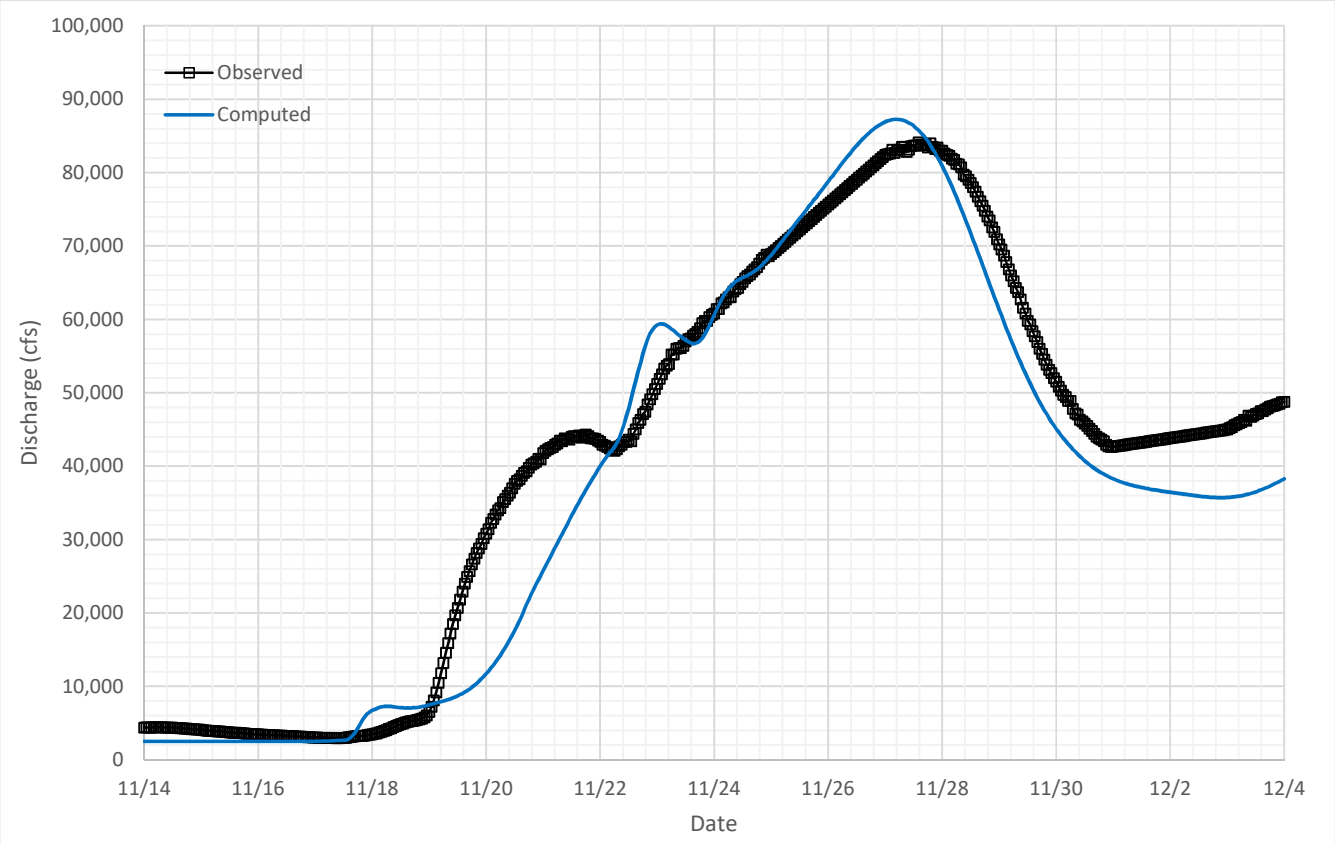


Parameter Summary					
River	Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
	(in)	(iph)	(%)		
Brazos River & Tributary Rivers	2.9	0.10	7.3	2.00	0.50
Little Brazos River Above Brazos River	0.9	0.13	6.4	2.00	0.40
Navasota River Above Brazos River	2.9	0.09	10.0	2.00	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	66,600	1,110,059
Computed	66,854	1,102,618
Residual	254	-7,441
Error	0%	-1%

BRA Calibration
Brazos River Near Hempsted, TX
USGS 08111500

2004 Calibration Event

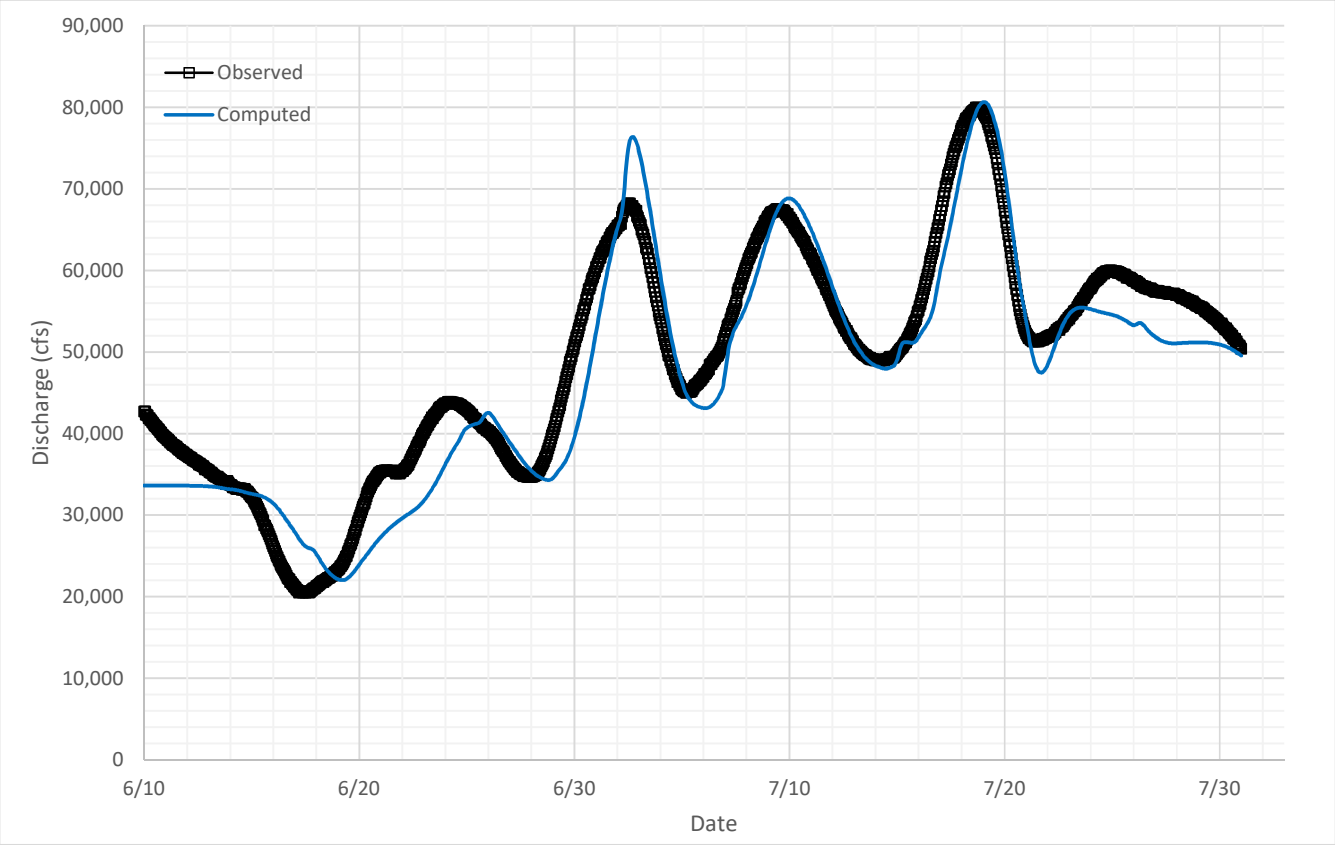


Parameter Summary					
River	Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
	(in)	(iph)	(%)		
Brazos River & Tributary Rivers	0.8	0.11	7.3	2.00	0.50
Little Brazos River Above Brazos River	0.9	0.11	6.4	2.00	0.40
Navasota River Above Brazos River	0.5	0.08	10.0	2.00	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	84,100	1,665,712
Computed	87,244	1,524,117
Residual	3,144	-141,595
Error	4%	-9%

BRA Calibration
Brazos River Near Hempsted, TX
USGS 08111500

2007 Calibration Event

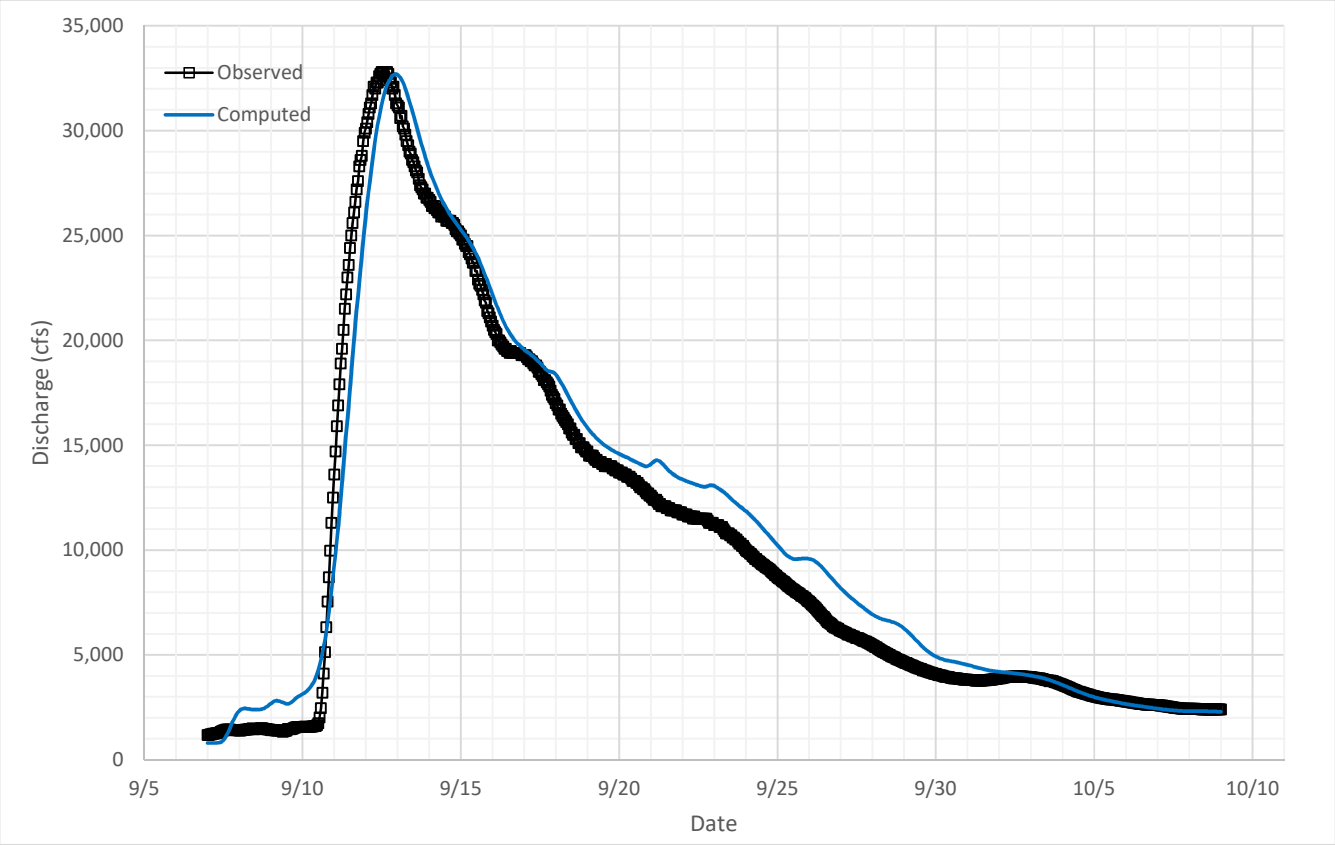


Parameter Summary					
River	Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
	(in)	(iph)	(%)		
Brazos River & Tributary Rivers	2.9	0.16	7.3	2.00	0.50
Little Brazos River Above Brazos River	2.8	0.21	6.4	2.00	0.40
Navasota River Above Brazos River	2.9	0.14	10.0	2.00	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	80,000	4,964,849
Computed	80,652	4,772,685
Residual	652	-192,164
Error	1%	-4%

BRA Calibration
Brazos River Near Hempsted, TX
USGS 08111500

2010 Calibration Event

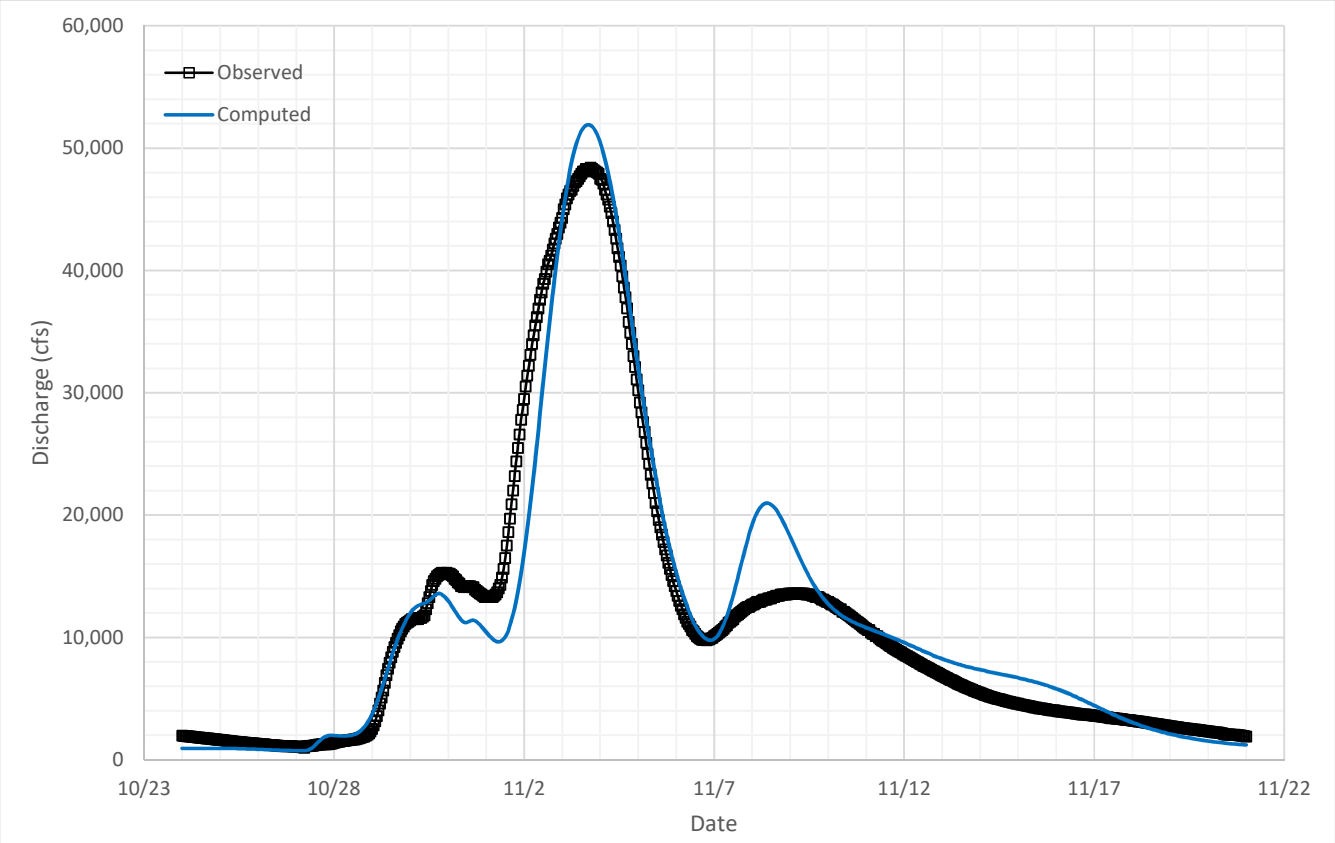


Parameter Summary					
River	Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
	(in)	(iph)	(%)		
Brazos River & Tributary Rivers	2.9	0.10	7.3	2.00	0.50
Little Brazos River Above Brazos River	3.2	0.14	6.4	2.00	0.40
Navasota River Above Brazos River	2.9	0.09	10.0	2.00	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	32,800	645,700
Computed	32,696	686,225
Residual	-104	40,525
Error	0%	6%

BRA Calibration
Brazos River Near Hempsted, TX
USGS 08111500

2013 Calibration Event

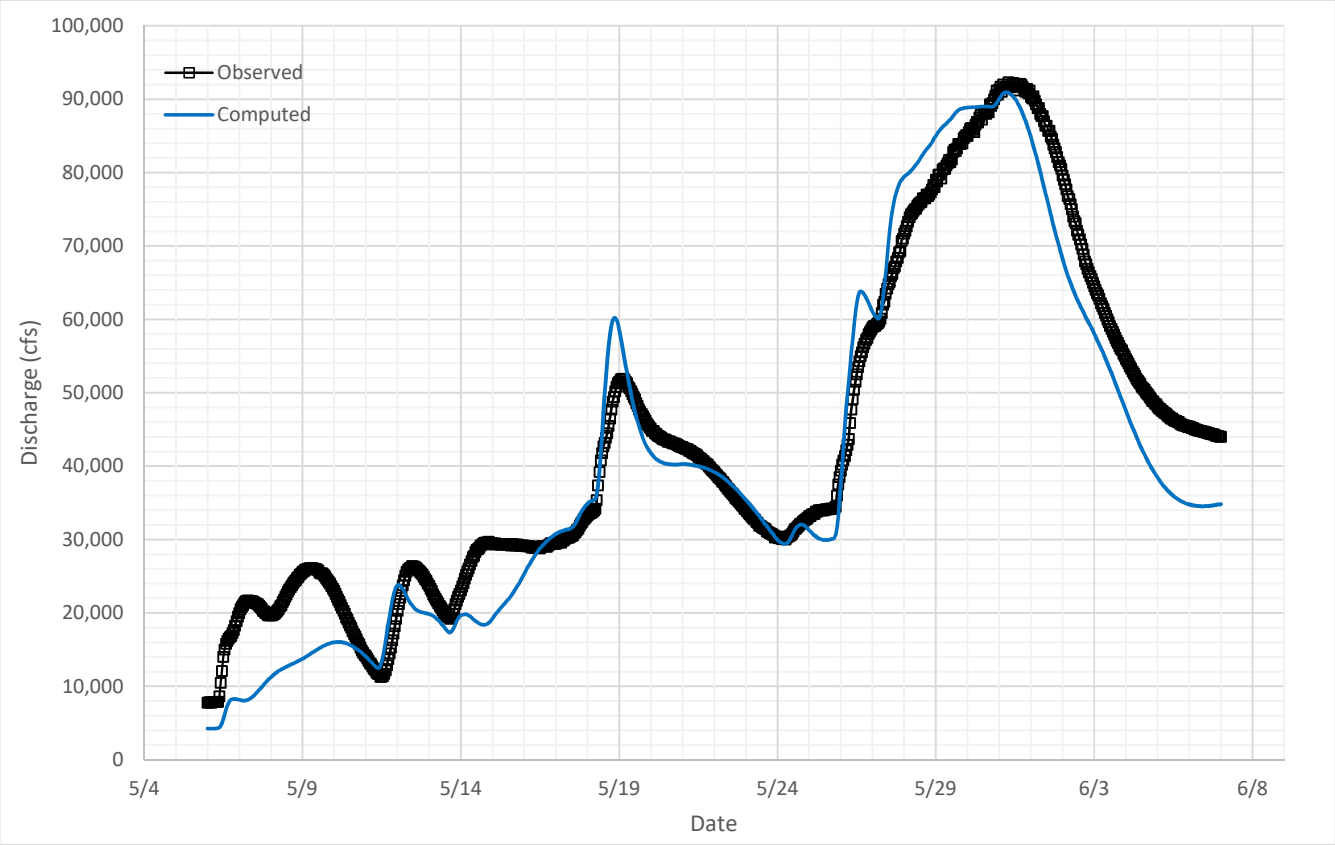


Parameter Summary					
River	Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
	(in)	(iph)	(%)		
Brazos River & Tributary Rivers	2.9	0.12	7.3	2.00	0.50
Little Brazos River Above Brazos River	3.2	0.18	6.4	2.00	0.40
Navasota River Above Brazos River	2.9	0.10	10.0	2.00	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	48,400	627,242
Computed	51,904	641,118
Residual	3,504	13,876
Error	7%	2%

BRA Calibration
Brazos River Near Hempsted, TX
USGS 08111500

2015 Calibration Event

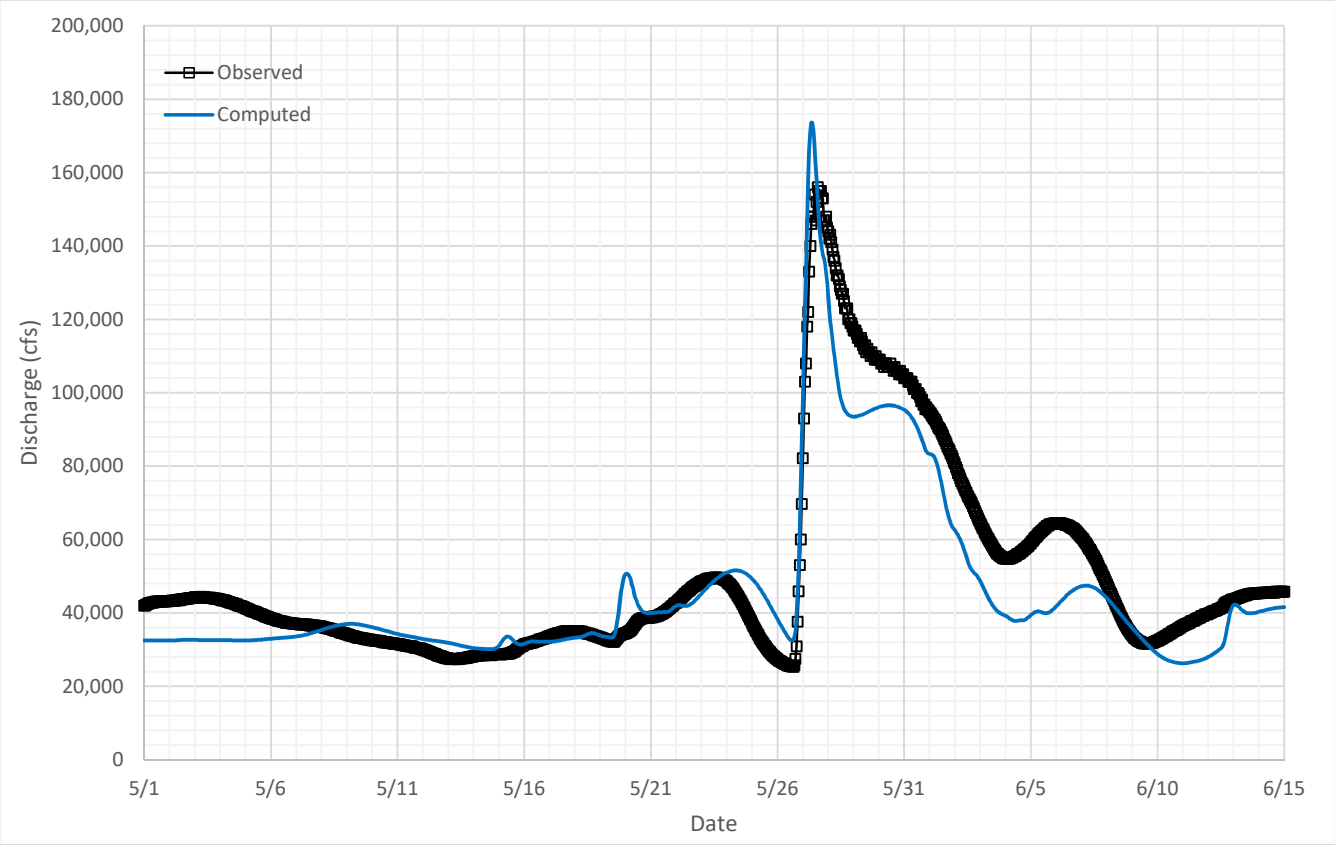


Parameter Summary					
River	Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
	(in)	(iph)	(%)		
Brazos River & Tributary Rivers	2.0	0.12	7.3	2.00	0.50
Little Brazos River Above Brazos River	1.8	0.16	6.4	2.00	0.40
Navasota River Above Brazos River	1.9	0.10	10.0	2.00	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	92,300	2,772,947
Computed	90,931	2,586,497
Residual	-1,369	-186,450
Error	-1%	-7%

BRA Calibration
Brazos River Near Hempsted, TX
USGS 08111500

2016 Calibration Event

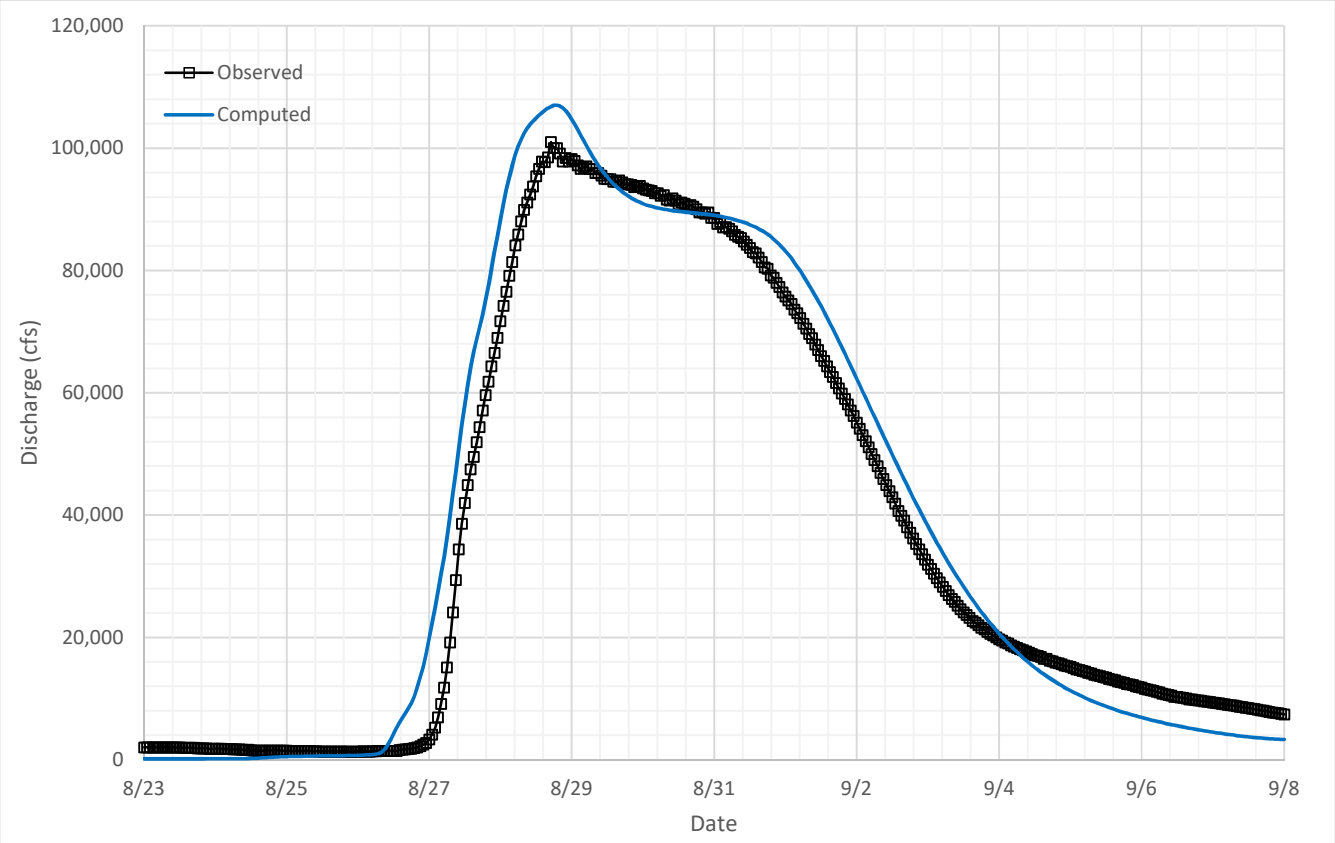


Parameter Summary					
River	Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
	(in)	(iph)	(%)		
Brazos River & Tributary Rivers	1.7	0.09	7.8	8.19	0.58
Little Brazos River Above Brazos River	1.9	0.16	6.4	7.20	0.40
Navasota River Above Brazos River	2.1	0.12	8.8	8.83	0.43

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	156,000	4,502,690
Computed	173,612	4,087,723
Residual	17,612	-414,967
Error	11%	-9%

BRA Calibration
Brazos River Near Hempsted, TX
USGS 08111500

2017 Calibration Event

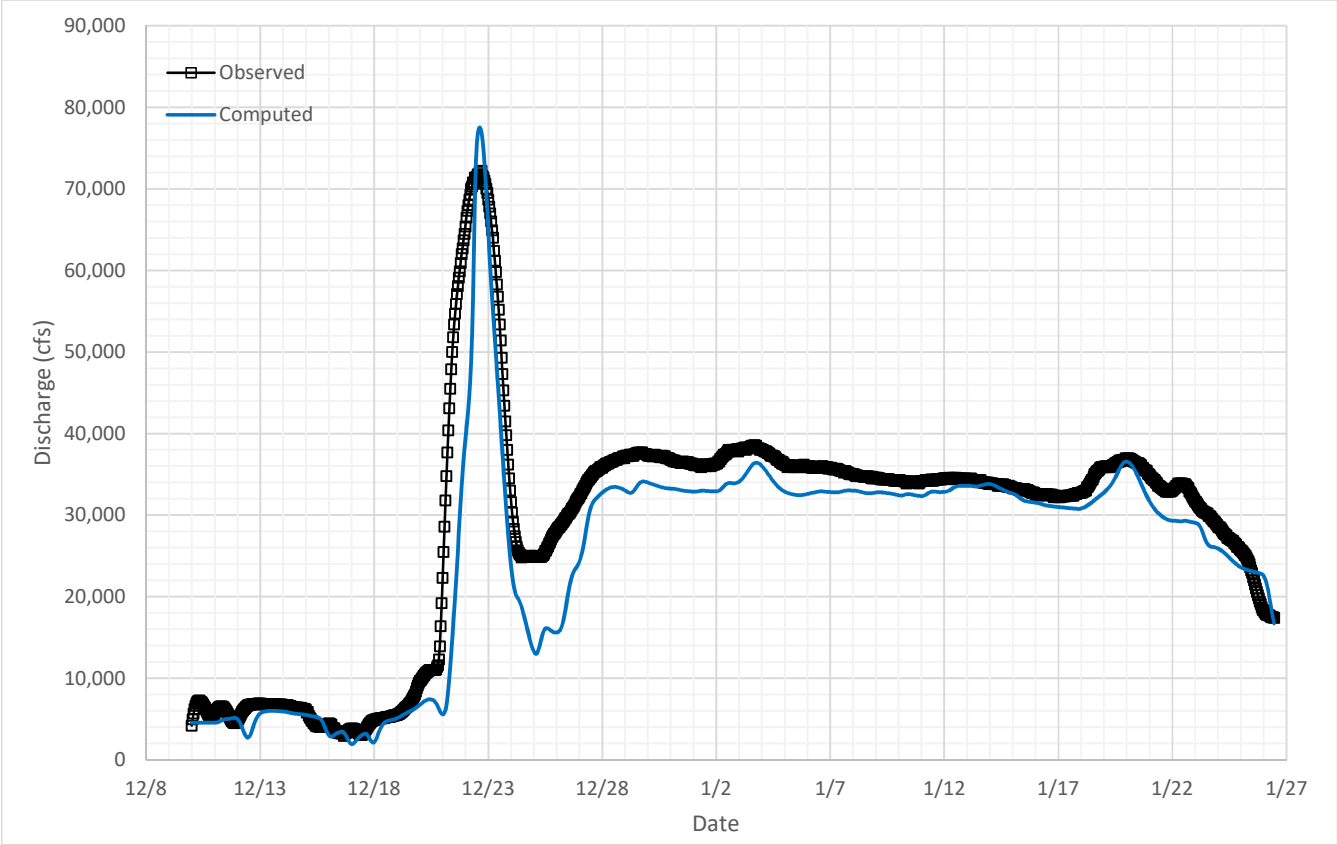


Parameter Summary					
River	Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
	(in)	(iph)	(%)		
Brazos River & Tributary Rivers	2.1	0.10	5.7	6.05	0.51
Little Brazos River Above Brazos River	3.7	0.09	3.2	7.20	0.40
Navasota River Above Brazos River	6.2	0.11	4.2	9.28	0.43

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	101,000	1,167,846
Computed	107,014	1,237,693
Residual	6,014	69,848
Error	6%	6%

BRA Calibration
Brazos River Near Highbank, TX
USGS 08098290

1991 Calibration Event

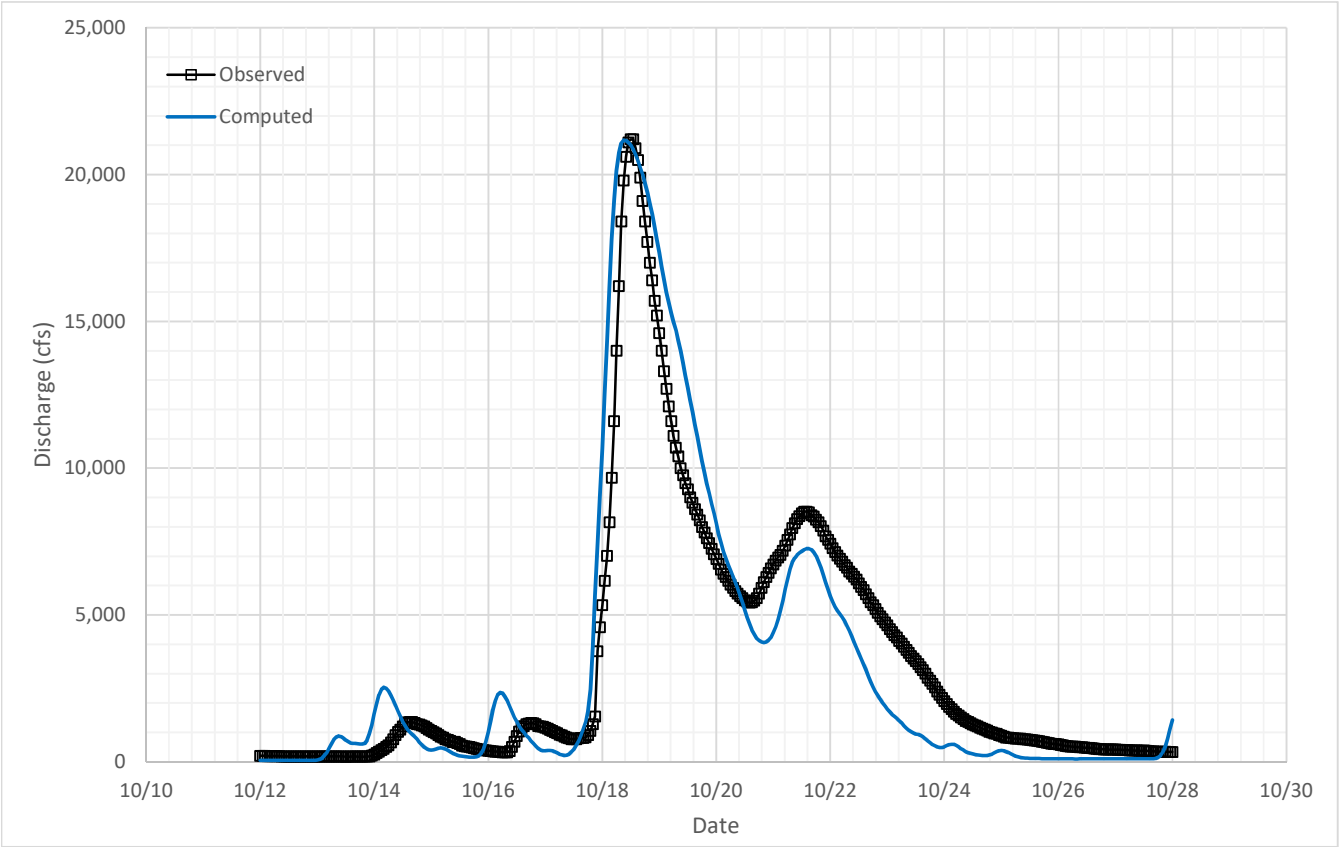


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.7	0.09	11.6	2.00	0.60

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	72,200	2,696,415
Computed	77,545	2,378,137
Residual	5,345	-318,278
Error	7%	-12%

BRA Calibration
Brazos River Near Highbank, TX
USGS 08098290

1998 Calibration Event

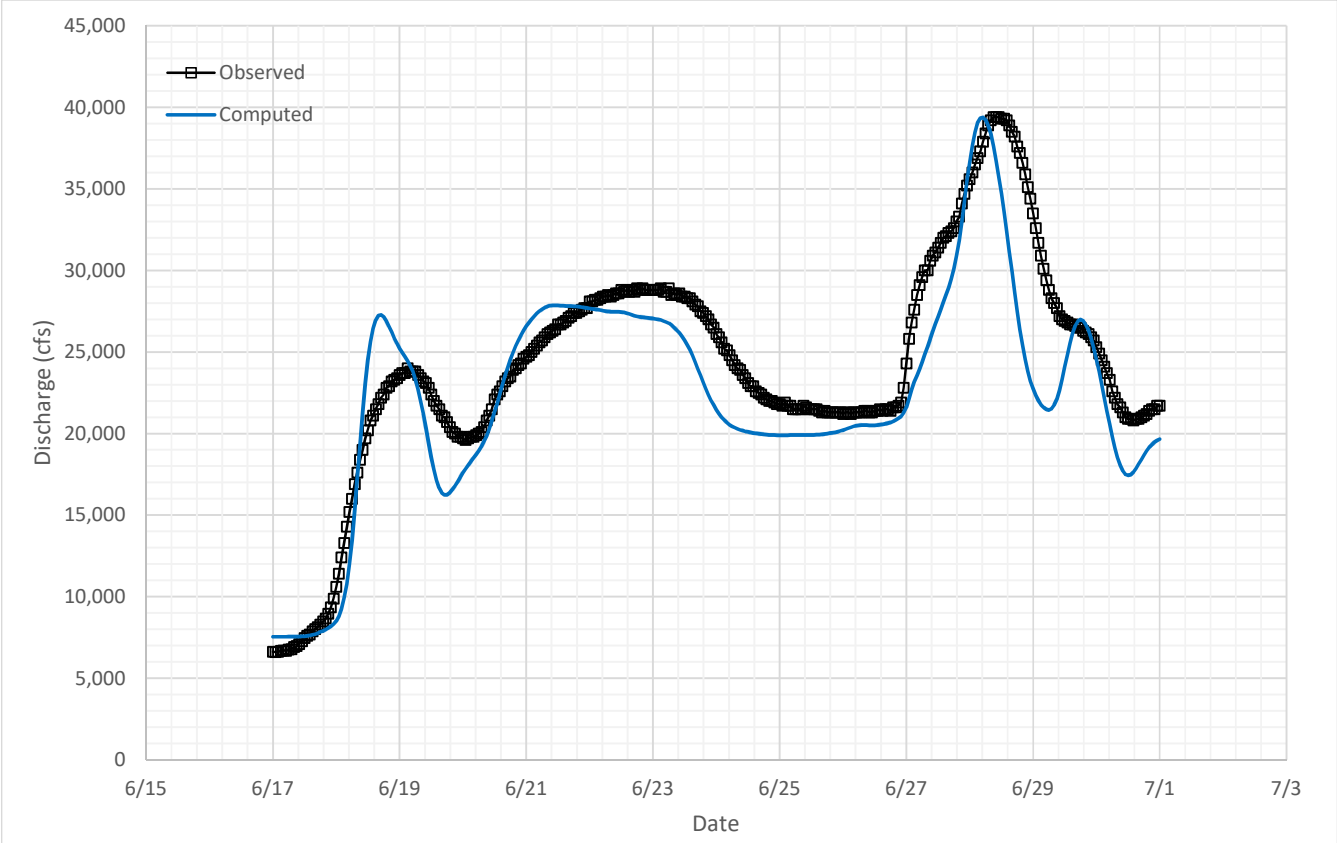


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
5.1	0.09	11.6	2.22	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	21,200	111,221
Computed	21,175	108,436
Residual	-25	-2,785
Error	0%	-3%

BRA Calibration
Brazos River Near Highbank, TX
USGS 08098290

2007 Calibration Event

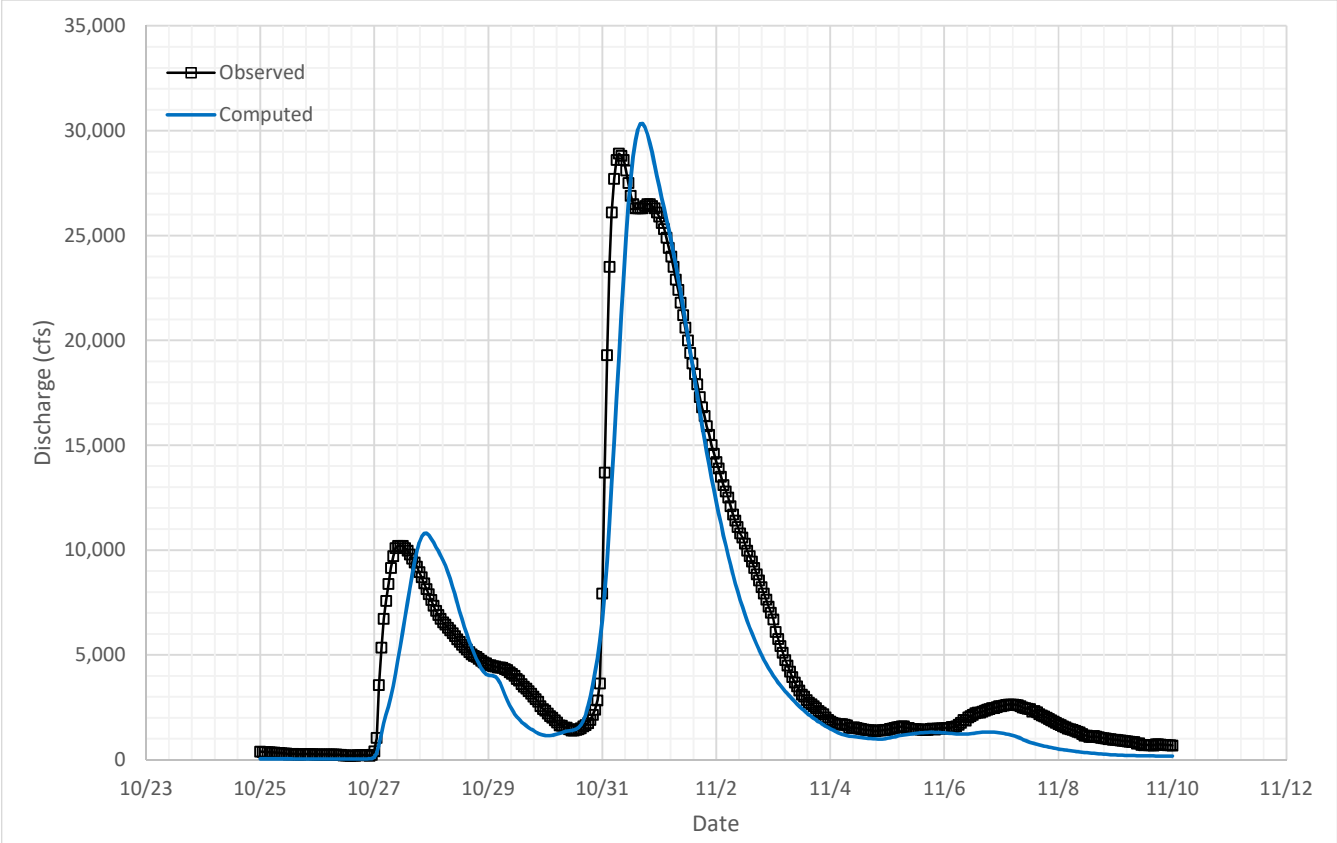


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.6	0.06	11.6	2.22	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	39,400	672,232
Computed	39,388	624,529
Residual	-12	-47,704
Error	0%	-7%

BRA Calibration
Brazos River Near Highbank, TX
USGS 08098290

2013 Calibration Event

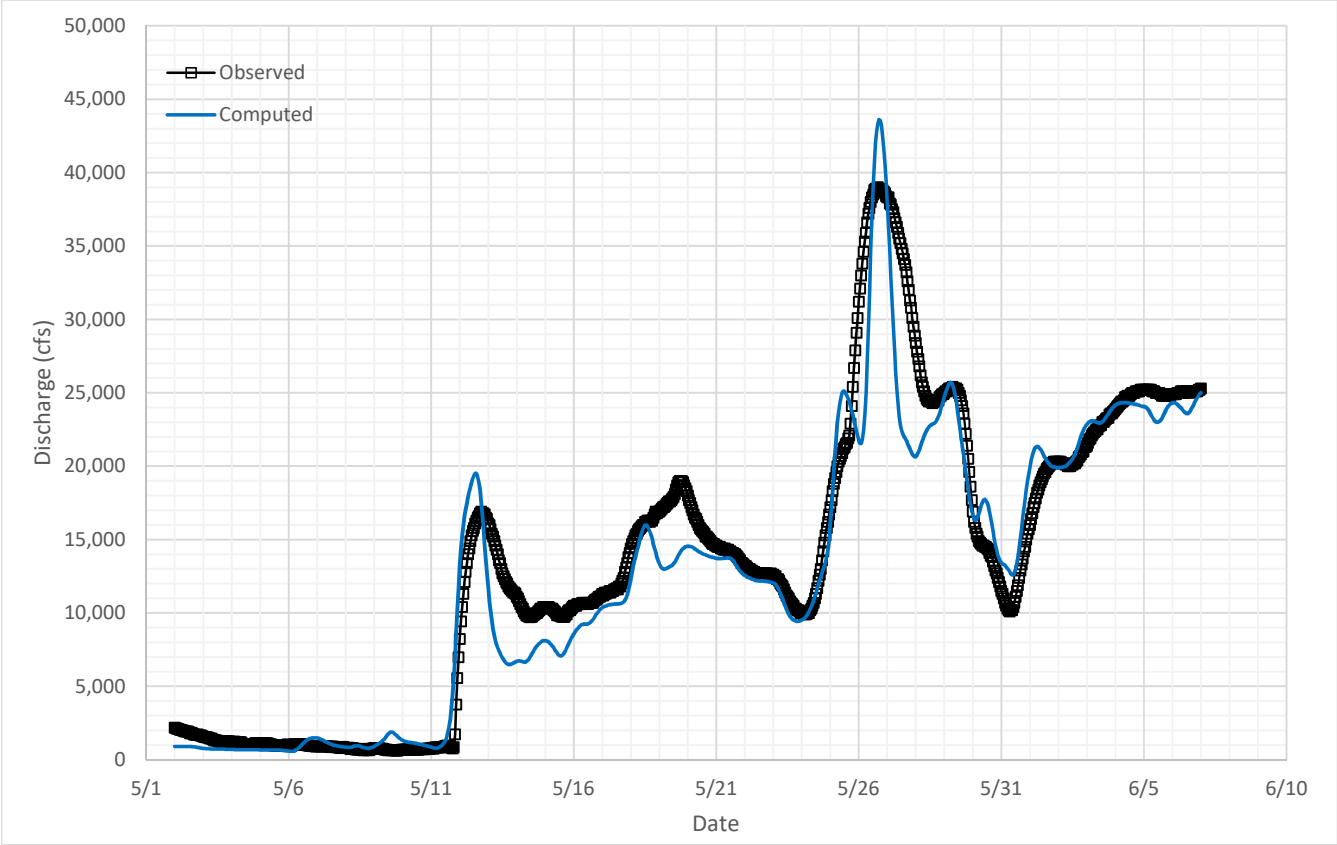


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.6	0.12	11.6	2.50	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	28,900	176,823
Computed	30,336	150,854
Residual	1,436	-25,969
Error	5%	-15%

BRA Calibration
Brazos River Near Highbank, TX
USGS 08098290

2015 Calibration Event

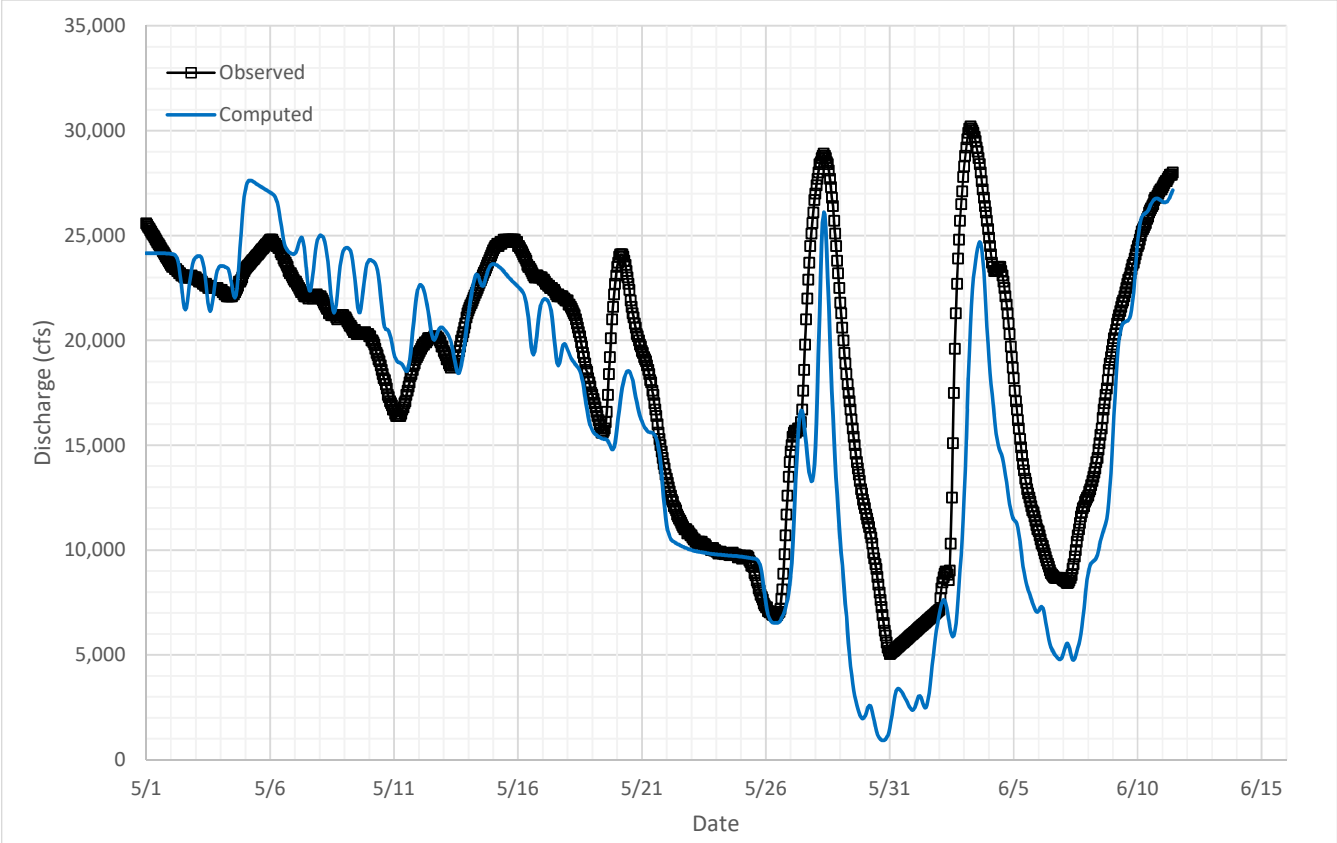


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
8.4	0.08	11.6	1.80	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	39,000	967,803
Computed	43,608	905,554
Residual	4,608	-62,249
Error	12%	-6%

BRA Calibration
Brazos River Near Highbank, TX
USGS 08098290

2016 Calibration Event

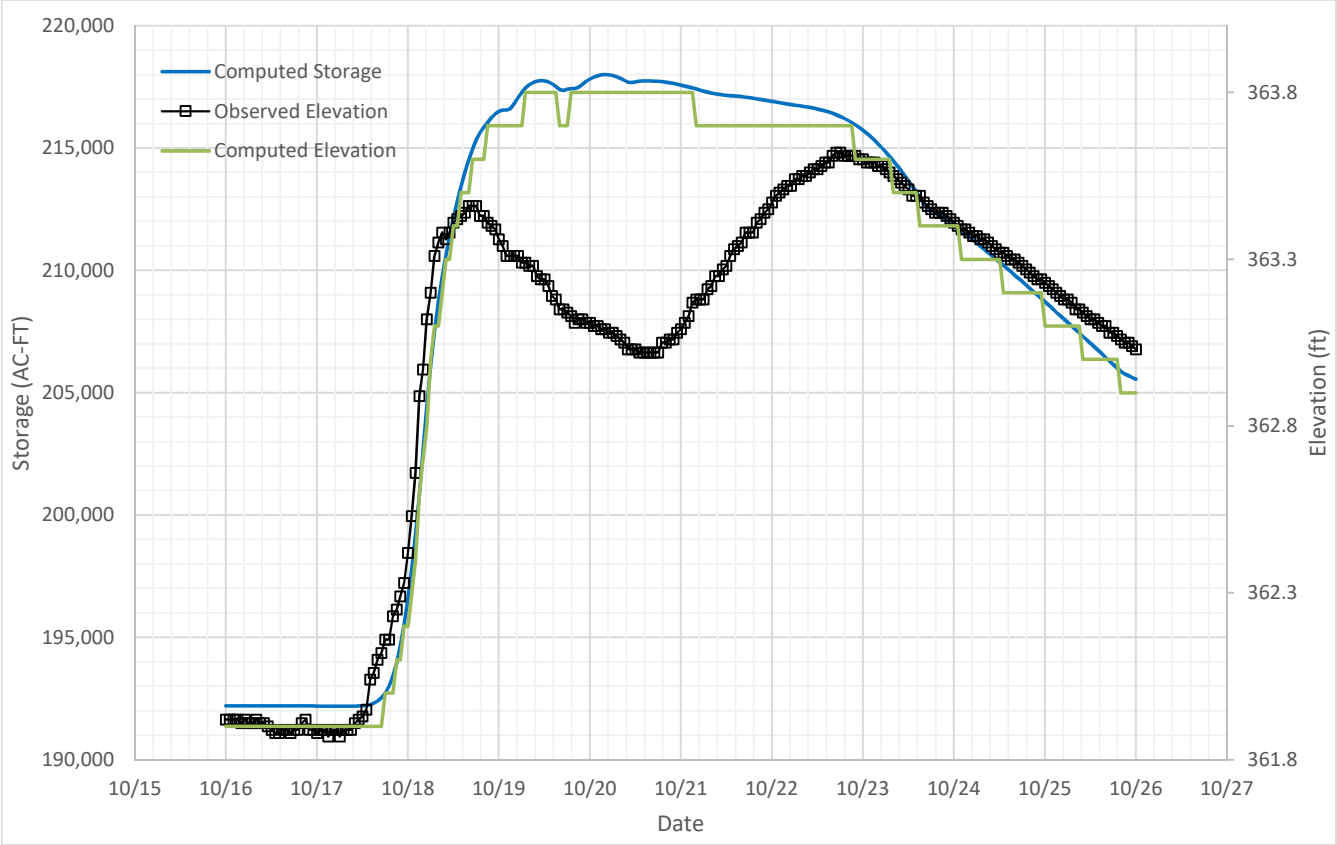


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
8.4	0.08	11.6	8.91	0.40

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	30,200	1,505,249
Computed	27,626	1,344,688
Residual	-2,574	-160,561
Error	-9%	-11%

BRA Calibration
Lake Limestone near Marquez, TX
USGS 081104700

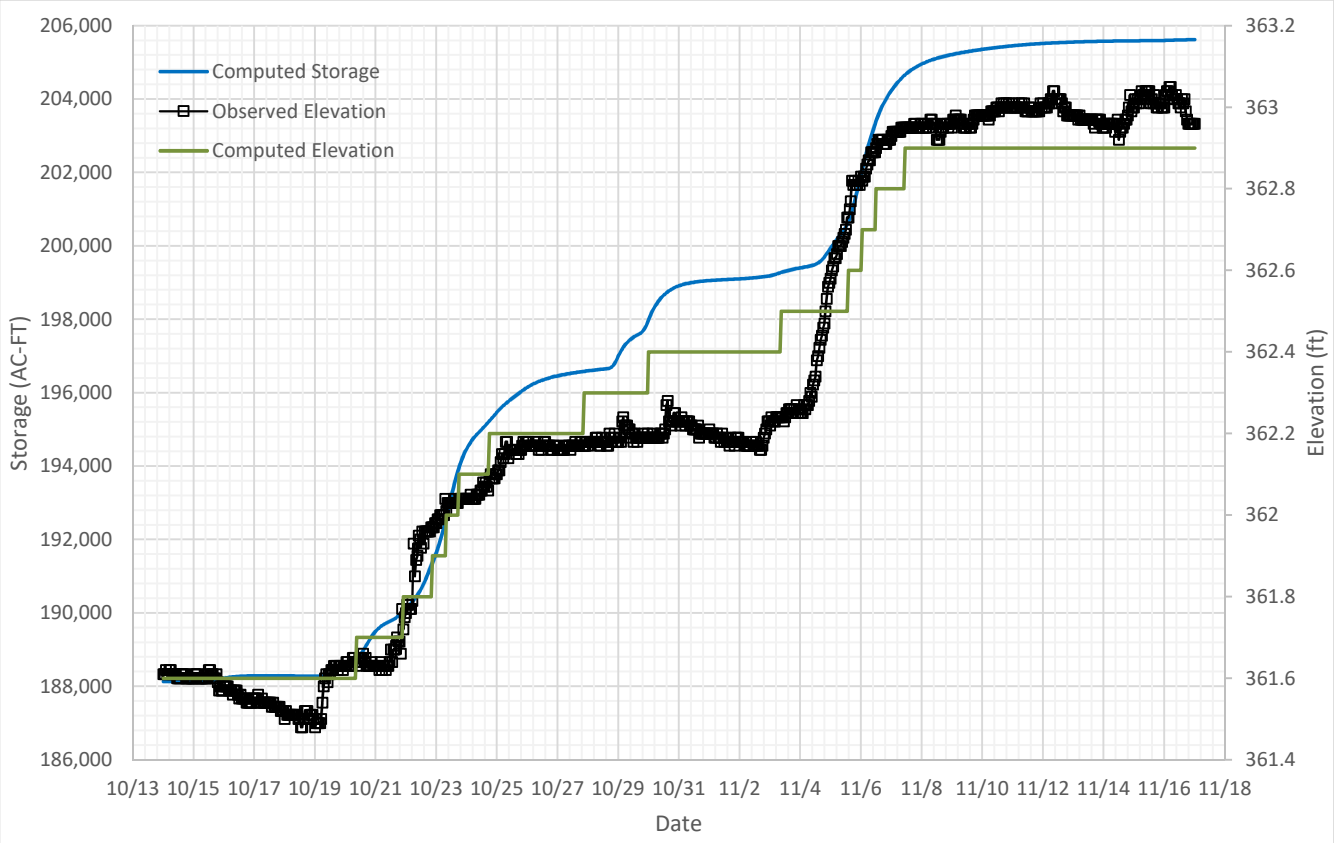
1998 Calibration Event



Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.9	0.10	4.7	3.0	0.5

BRA Calibration
Lake Limestone near Marquez, TX
USGS 081104700

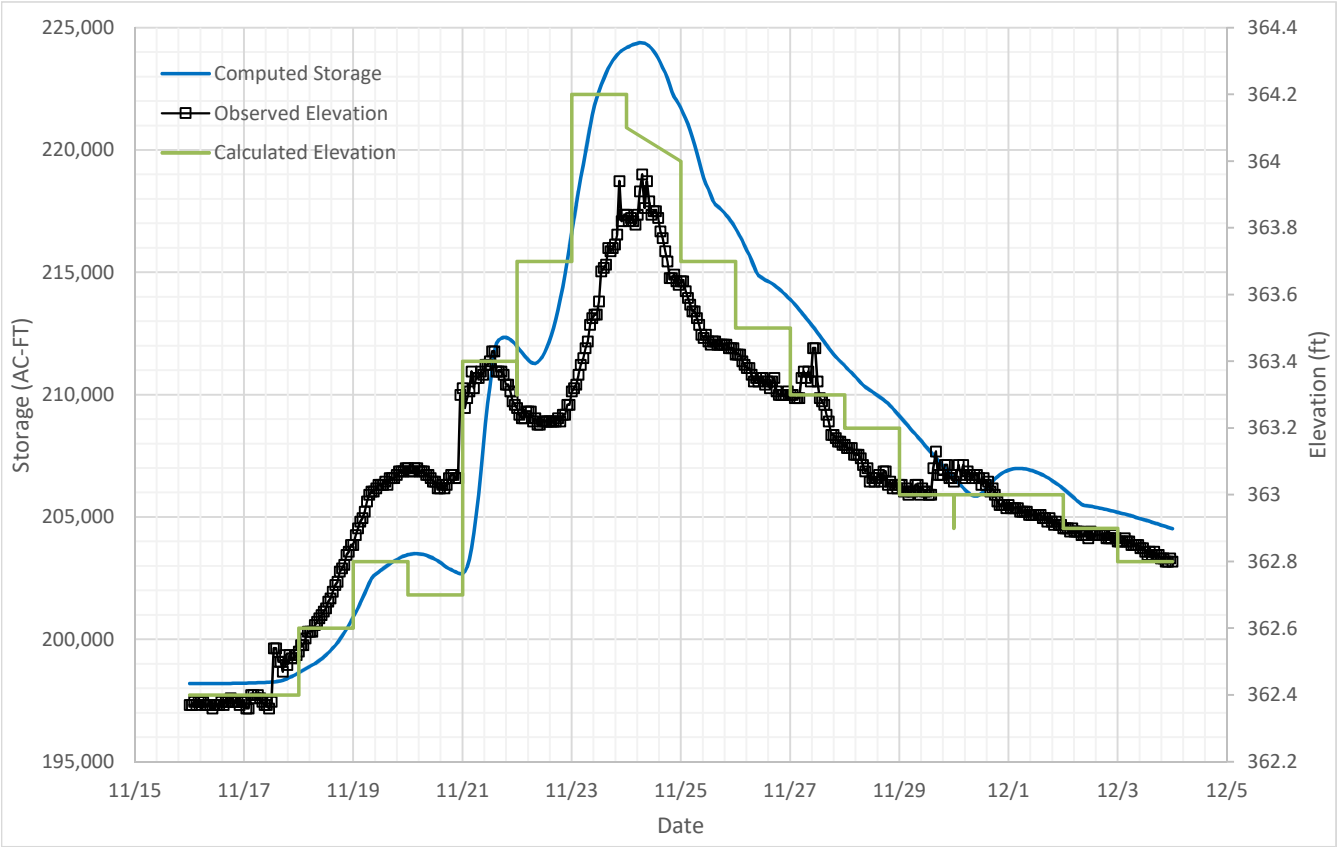
2002 Calibration Event



Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
4.4	0.10	4.7	2.0	0.5

BRA Calibration
Lake Limestone near Marquez, TX
USGS 081104700

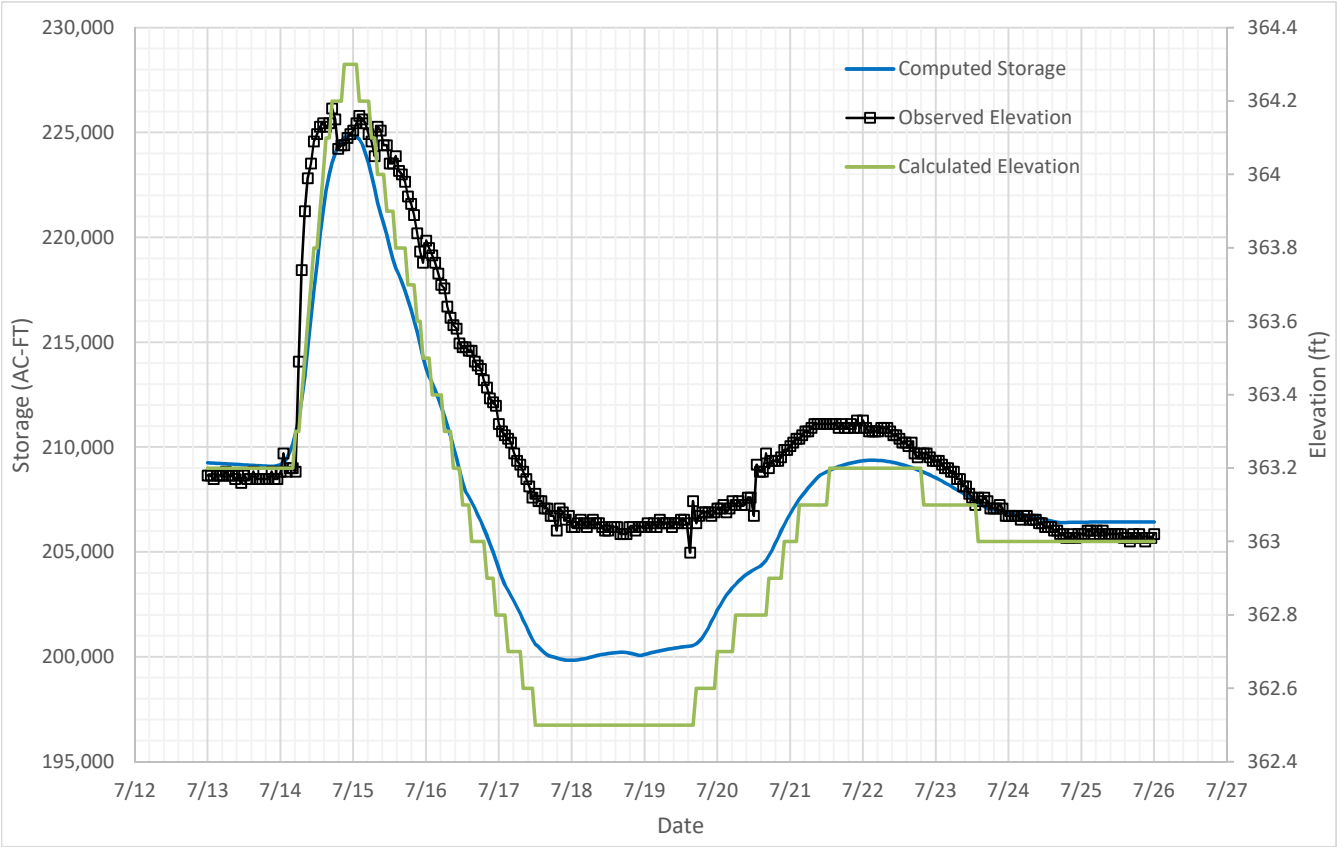
2004 Calibration Event



Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.1	0.10	4.7	2.5	0.5

BRA Calibration
Lake Limestone near Marquez, TX
USGS 081104700

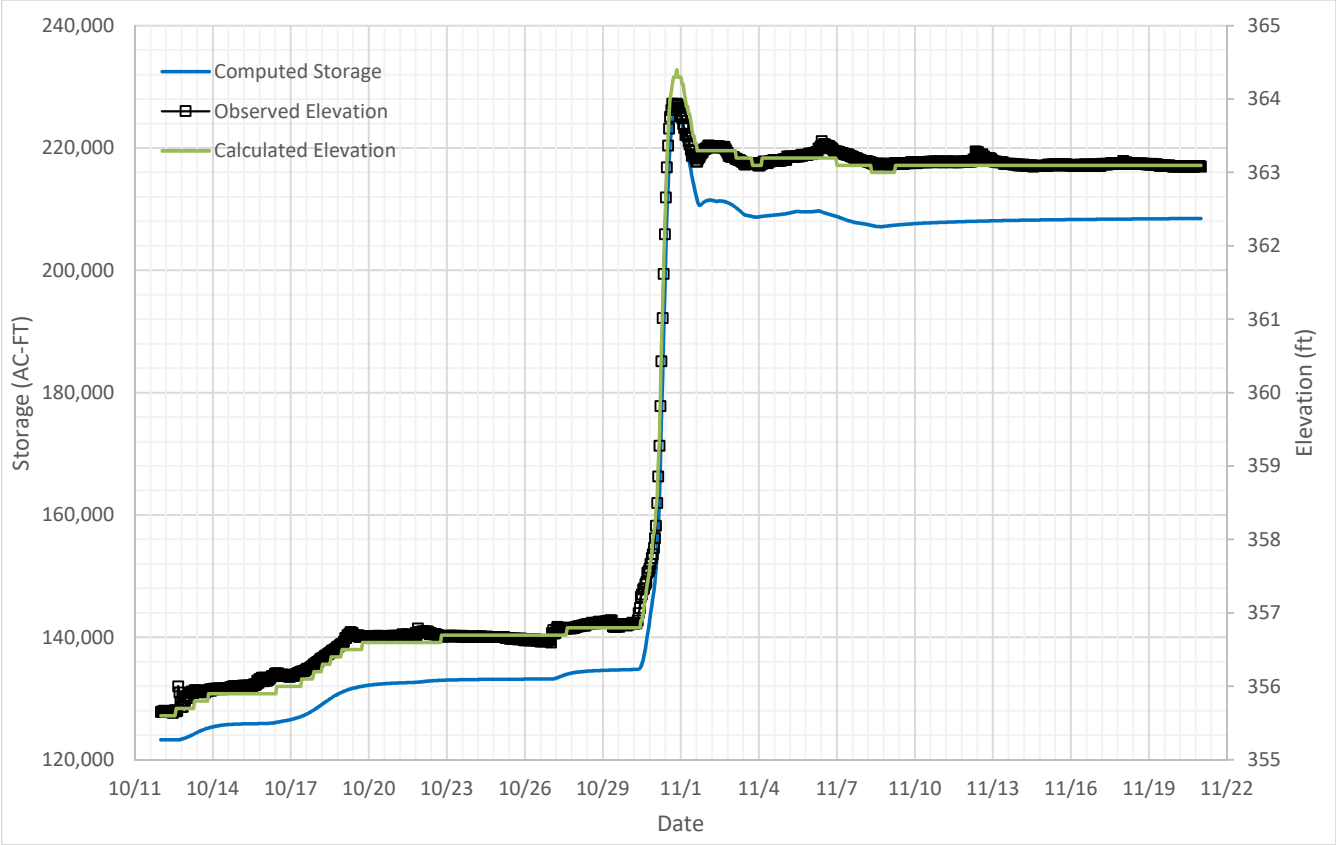
2007 Calibration Event



Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.2	0.10	4.7	2.0	0.5

BRA Calibration
Lake Limestone near Marquez, TX
USGS 081104700

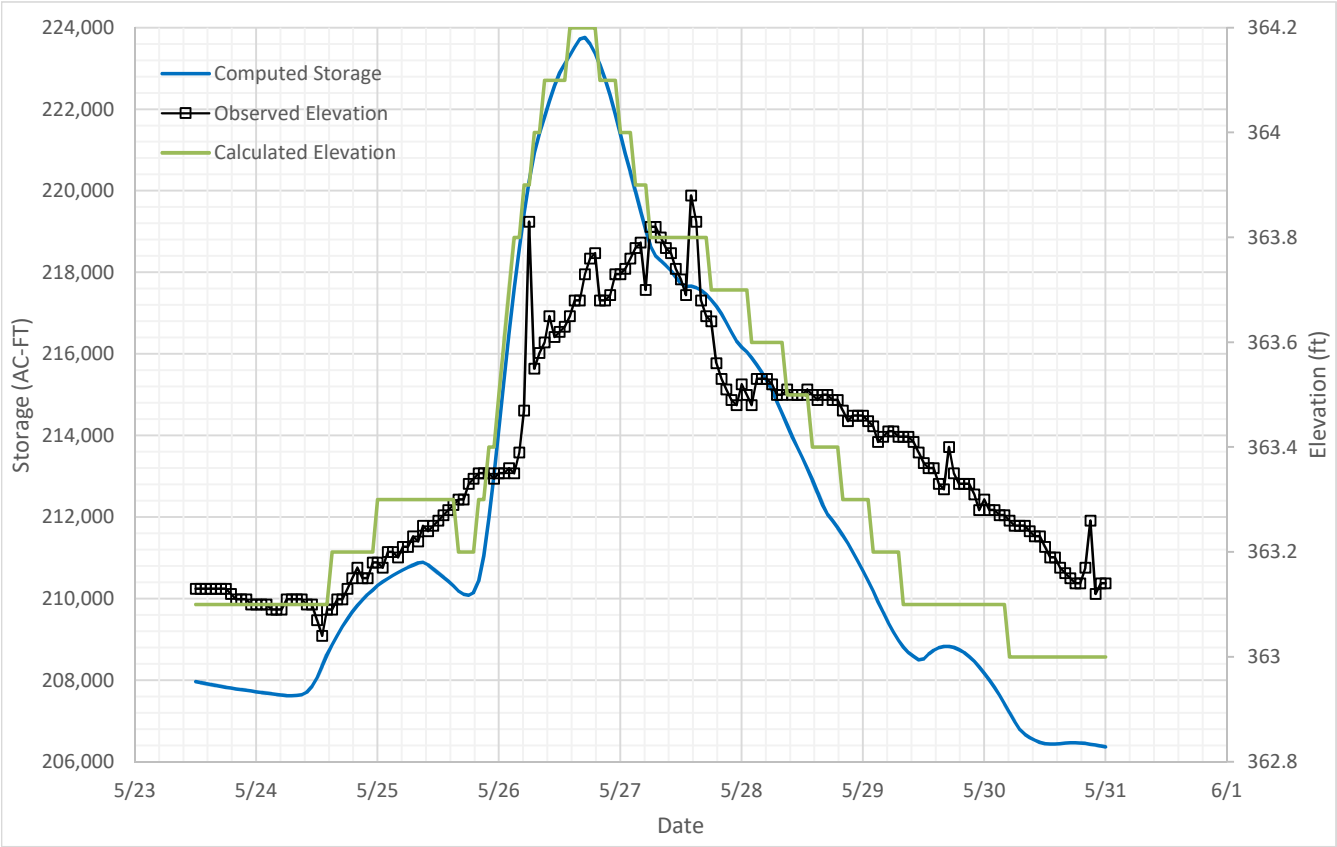
2013 Calibration Event



Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
4.7	0.10	4.7	1.7	0.5

BRA Calibration
Lake Limestone near Marquez, TX
USGS 081104700

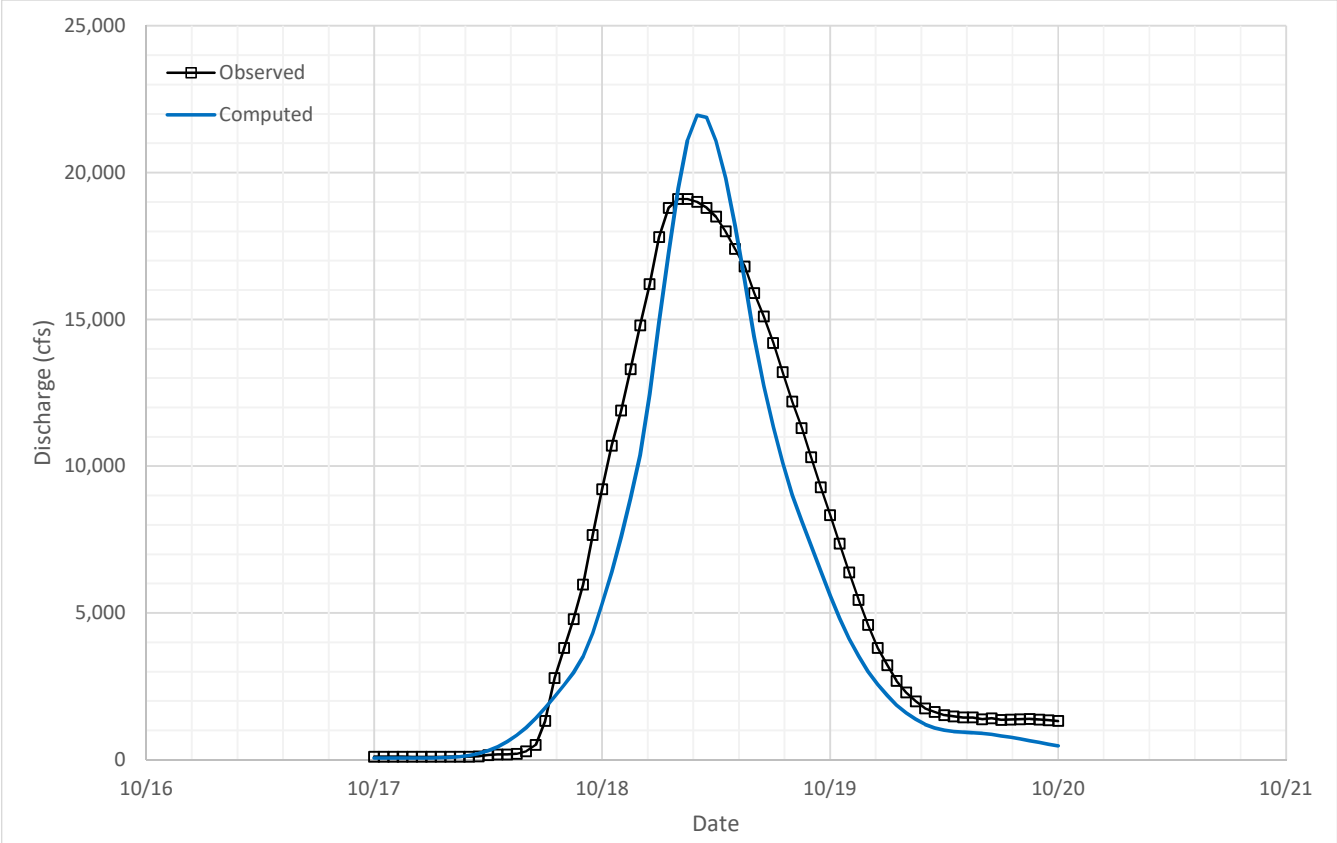
2015 Calibration Event



Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
4.7	0.10	4.7	1.7	0.5

BRA Calibration
Little River near Little River, TX
USGS 08104500

1998 Calibration Event

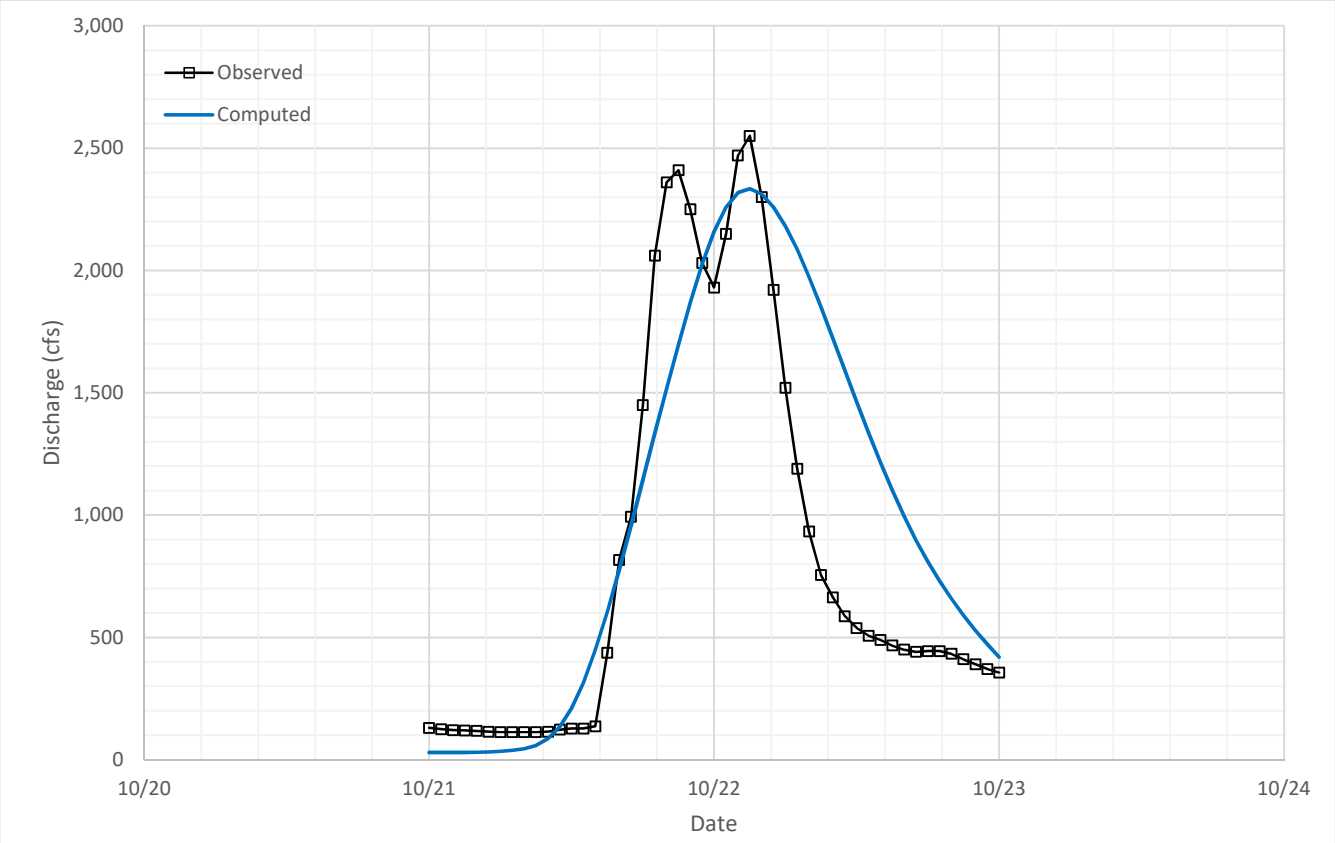


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
4.2	0.07	10.0	1.50	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	19,100	37,769
Computed	21,952	32,096
Residual	2,852	-5,673
Error	15%	-15%

BRA Calibration
Little River near Little River, TX
USGS 08104500

2002 Calibration Event

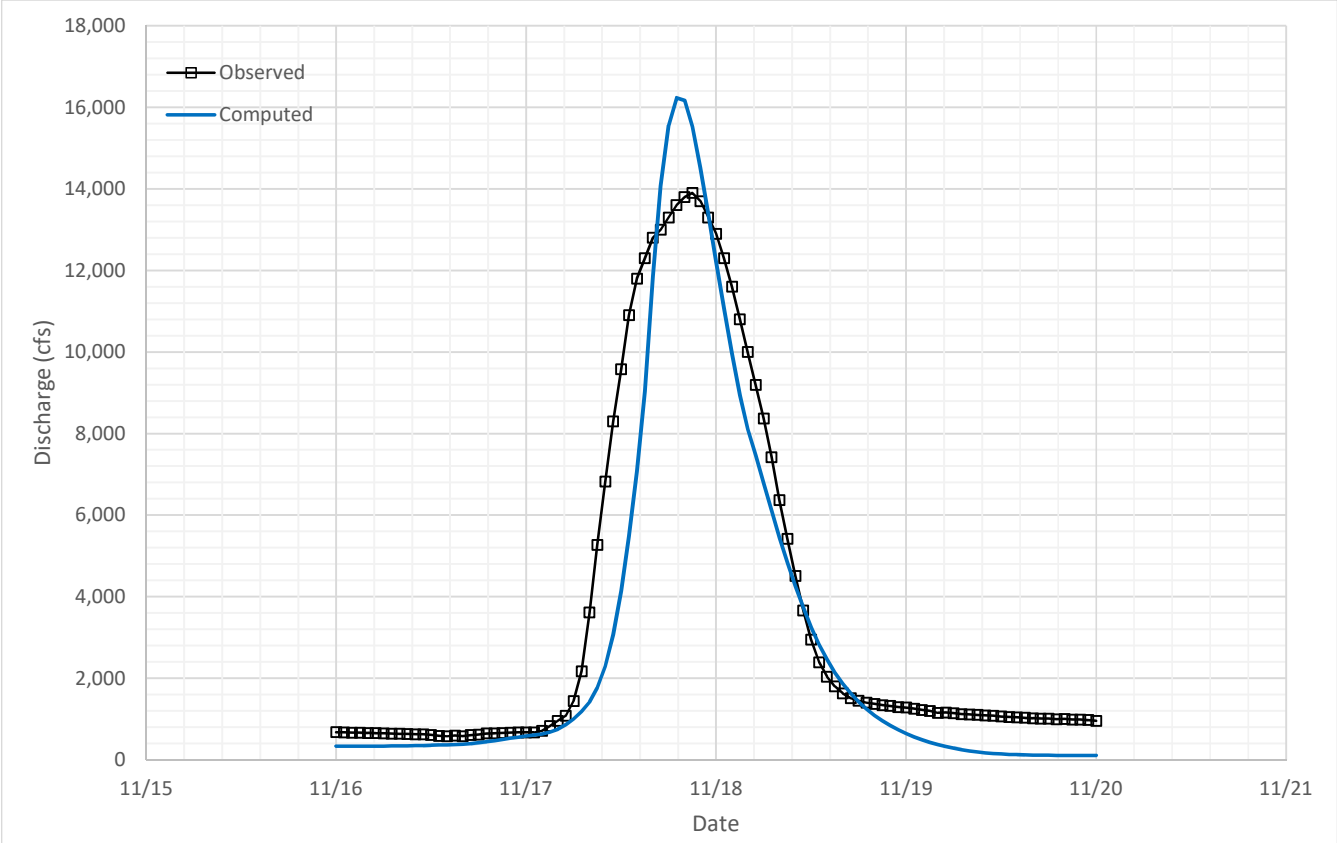


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.6	0.05	8.9	1.70	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	2,550	3,396
Computed	2,334	4,093
Residual	-216	697
Error	-8%	21%

BRA Calibration
Little River near Little River, TX
USGS 08104500

2004 Calibration Event

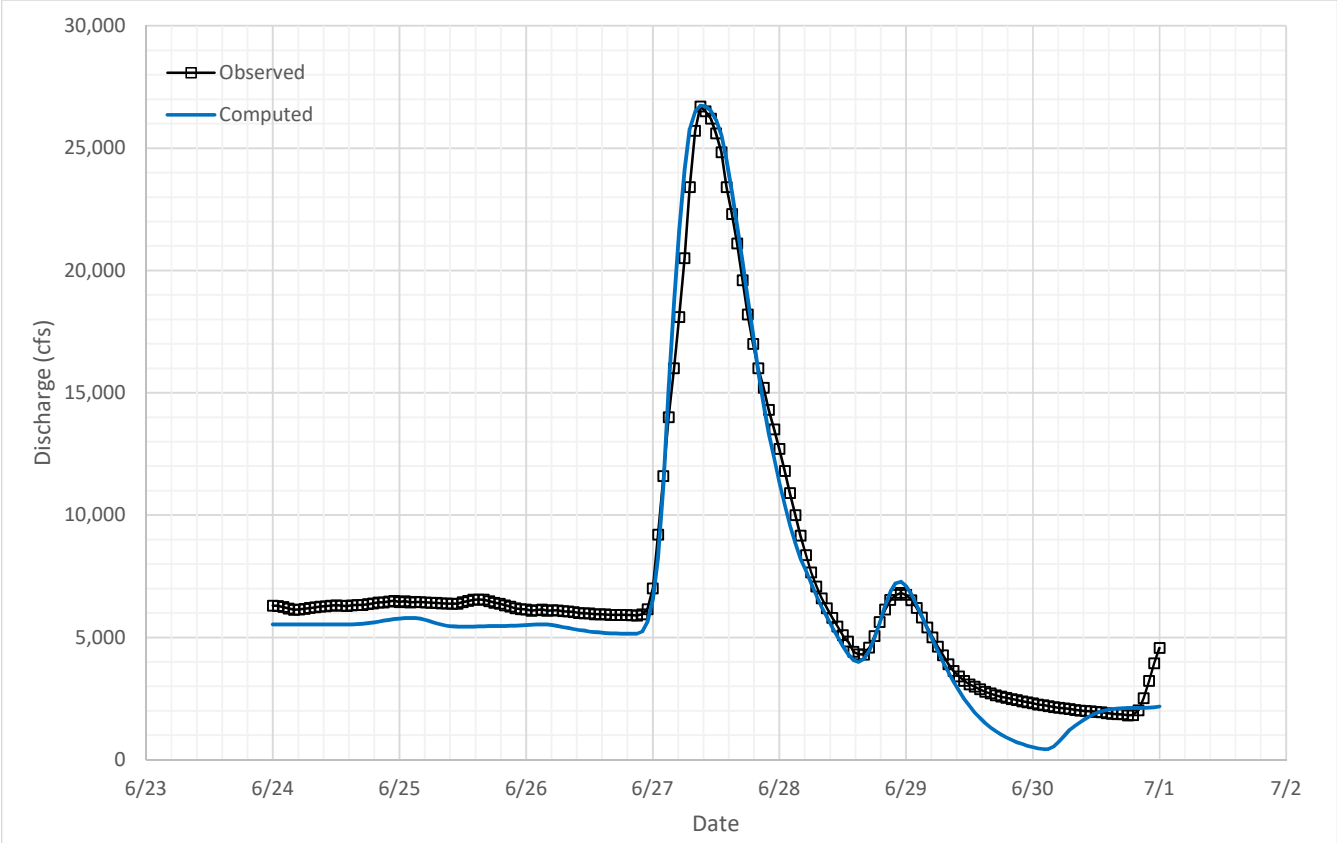


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.1	0.05	10.0	1.70	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	13,900	28,843
Computed	16,235	23,301
Residual	2,335	-5,542
Error	17%	-19%

BRA Calibration
Little River near Little River, TX
USGS 08104500

2007 Calibration Event

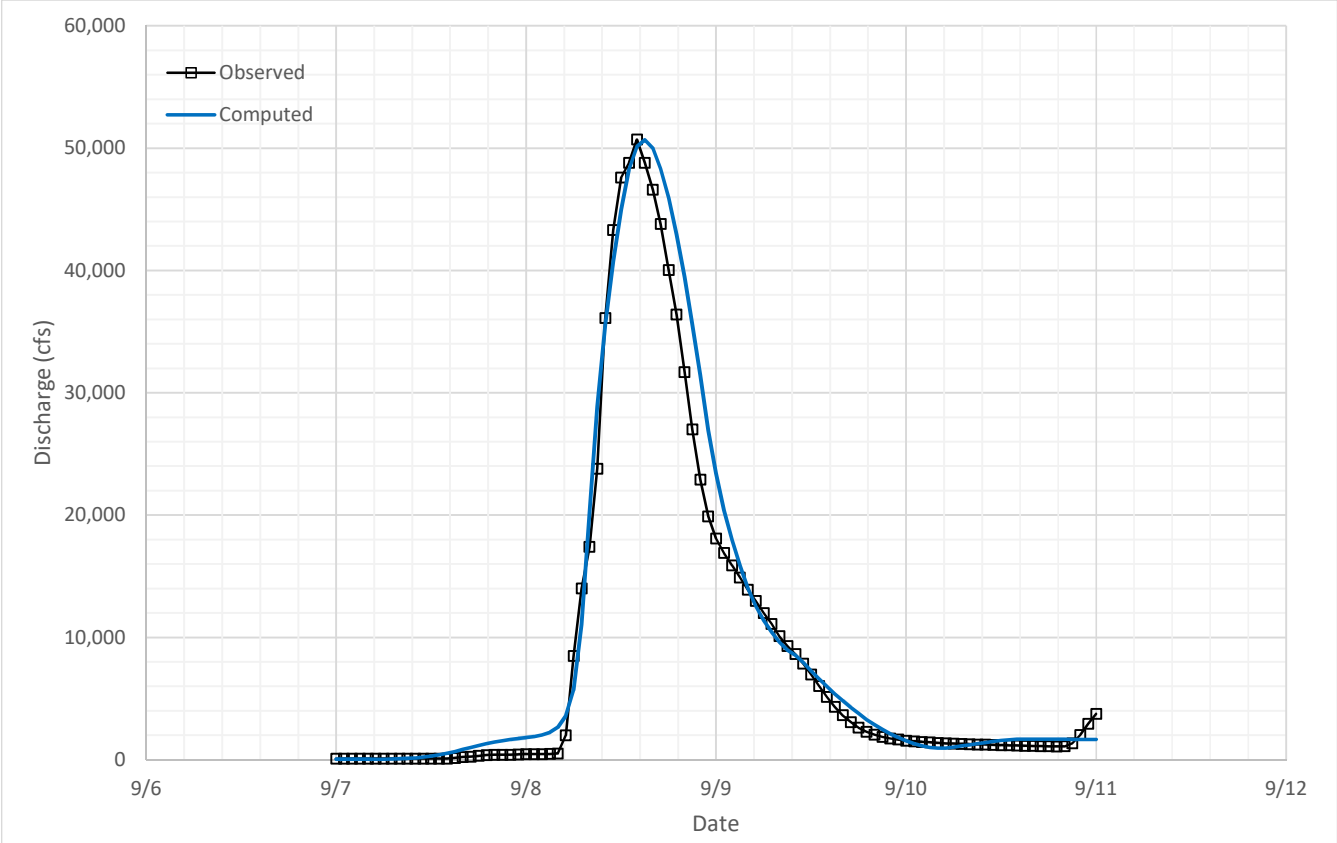


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.5	0.04	10.0	1.70	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	26,700	100,279
Computed	26,737	93,347
Residual	37	-6,932
Error	0%	-7%

BRA Calibration
Little River near Little River, TX
USGS 08104500

2010 Calibration Event

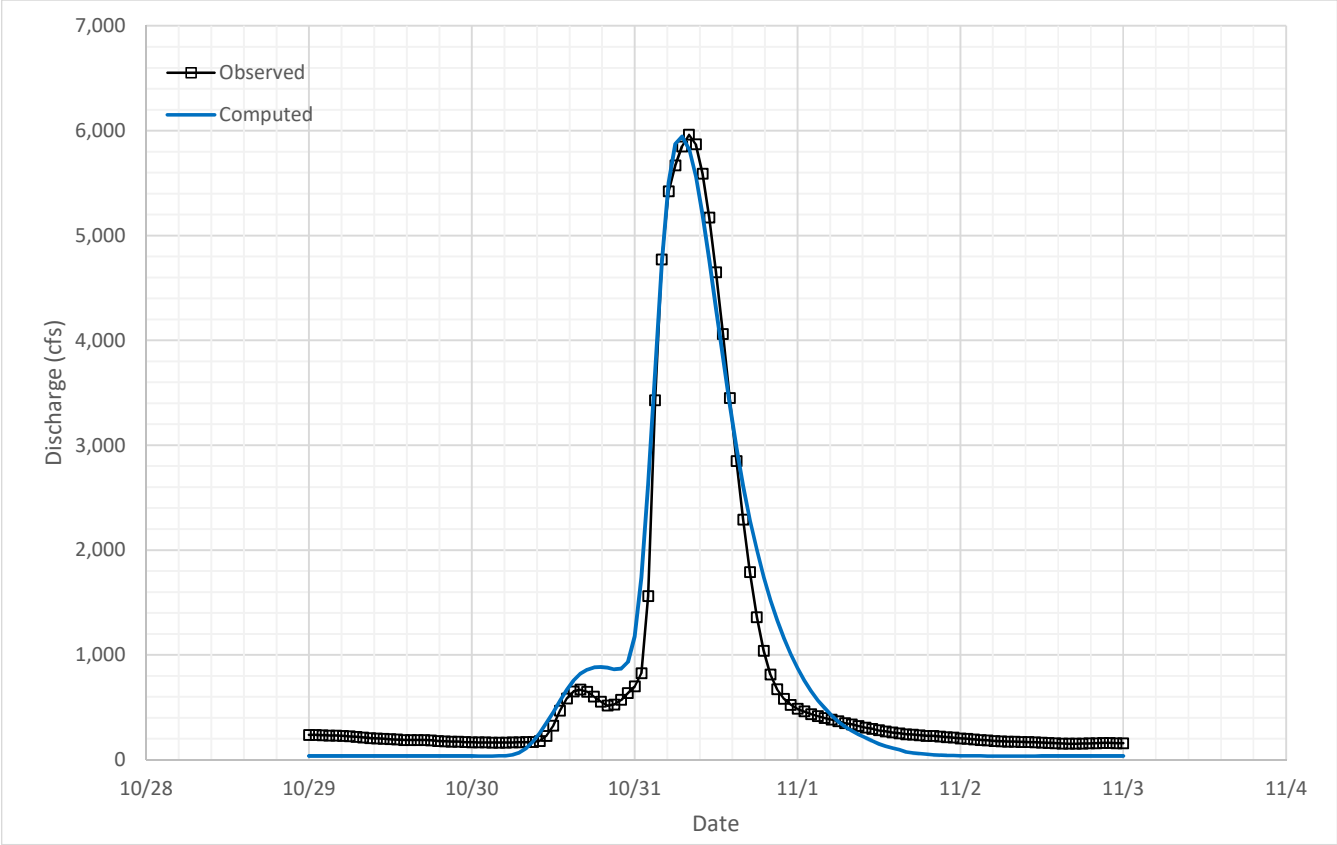


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
6.3	0.07	10.0	1.70	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	50,700	69,741
Computed	50,670	77,046
Residual	-30	7,305
Error	0%	10%

BRA Calibration
Little River near Little River, TX
USGS 08104500

2013 Calibration Event

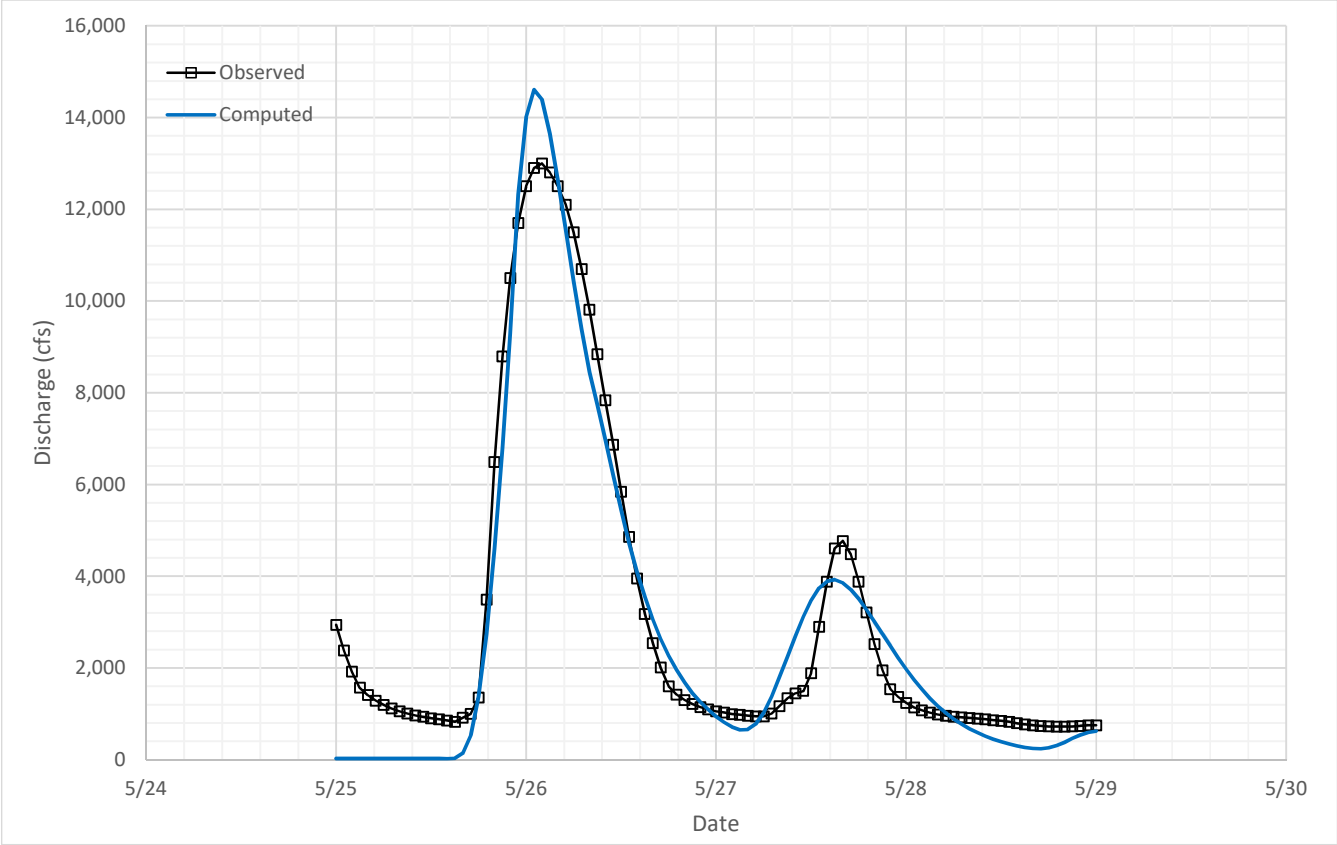


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.6	0.05	10.0	1.50	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	5,960	8,258
Computed	5,977	8,223
Residual	17	-35
Error	0%	0%

BRA Calibration
Little River near Little River, TX
USGS 08104500

2015 Calibration Event

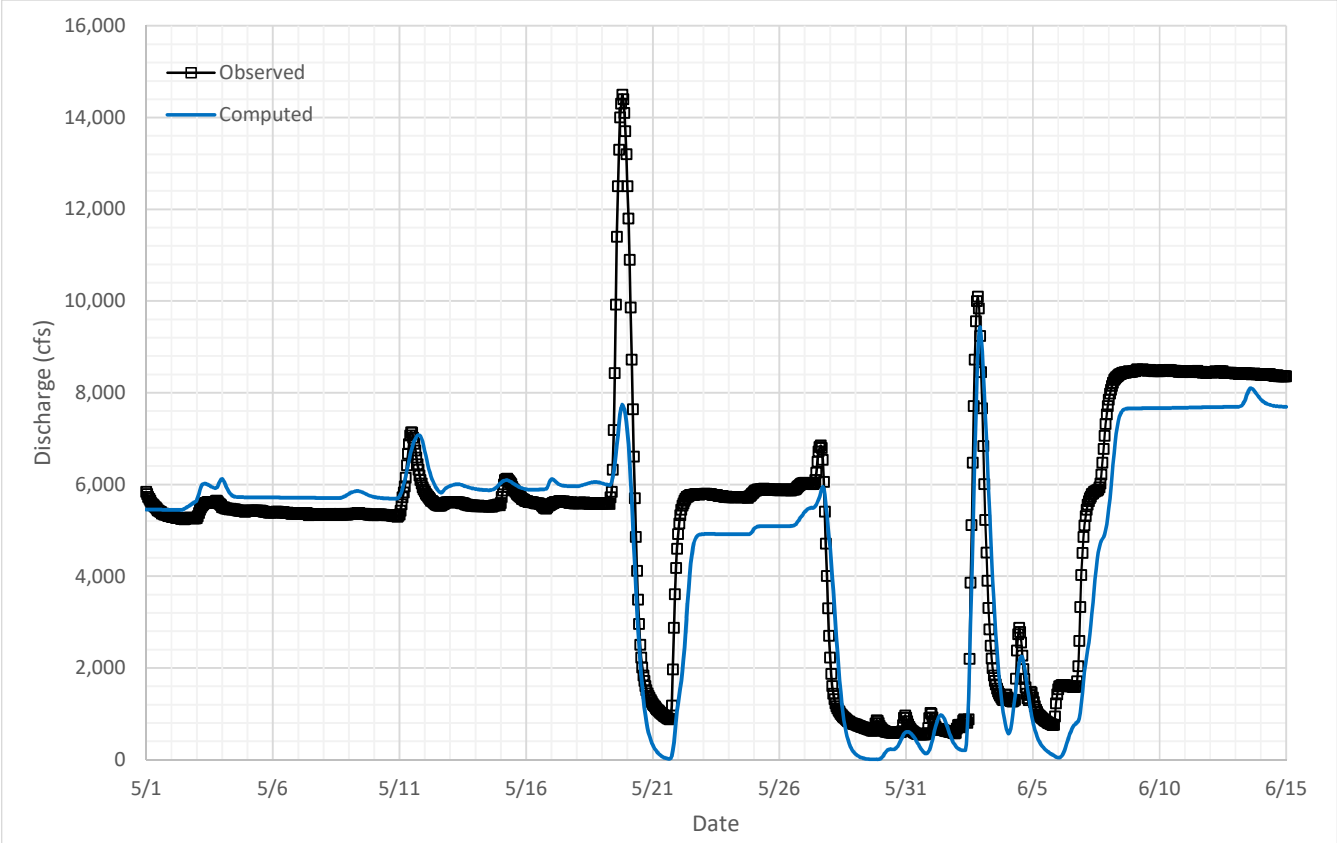


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.8	0.03	10.0	1.50	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	13,000	24,573
Computed	14,606	22,776
Residual	1,606	-1,797
Error	12%	-7%

BRA Calibration
Little River near Little River, TX
USGS 08104500

2016 Calibration Event

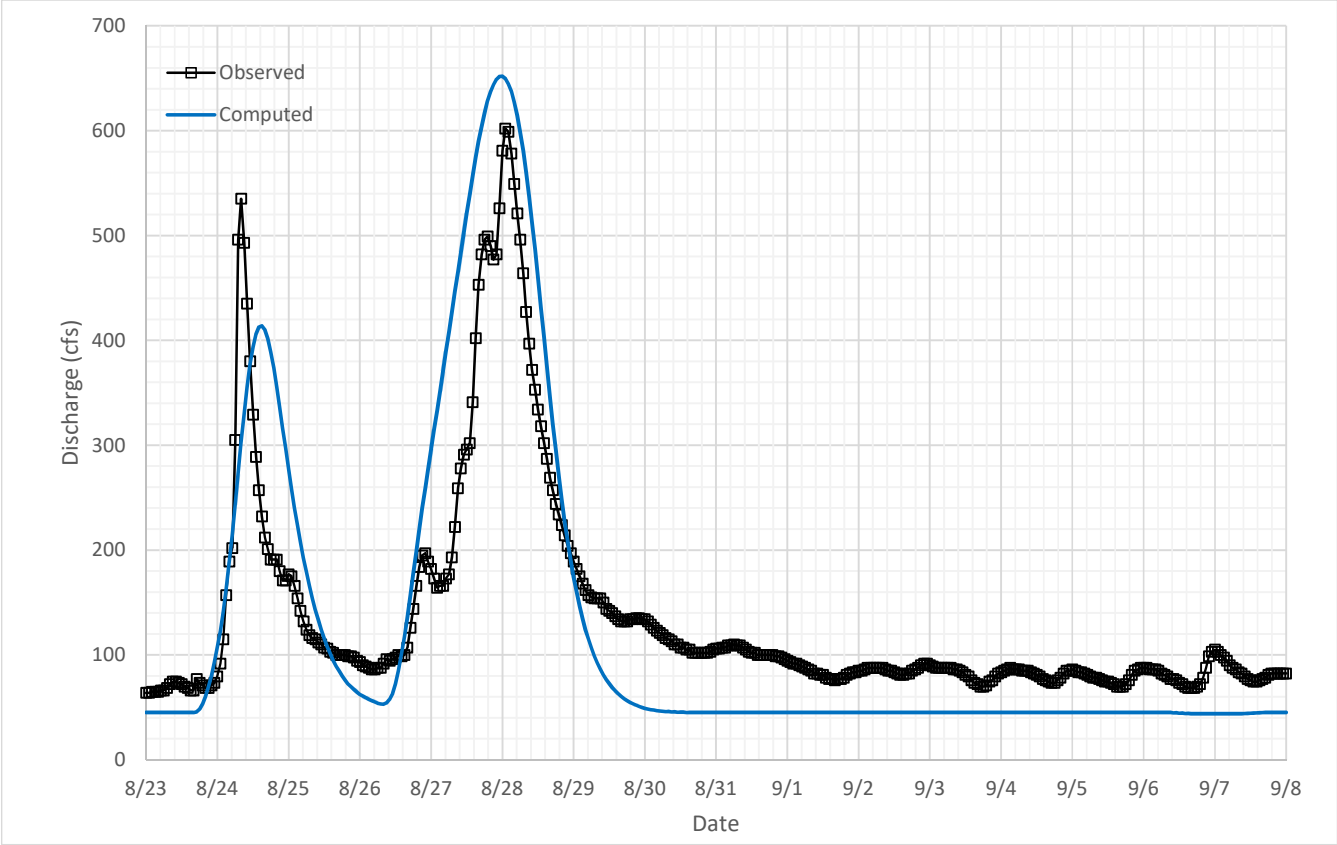


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
6.9	0.14	10.0	5.08	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	14,500	456,908
Computed	9,433	425,714
Residual	-5,067	-31,194
Error	-35%	-7%

BRA Calibration
Little River near Little River, TX
USGS 08104500

2017 Calibration Event

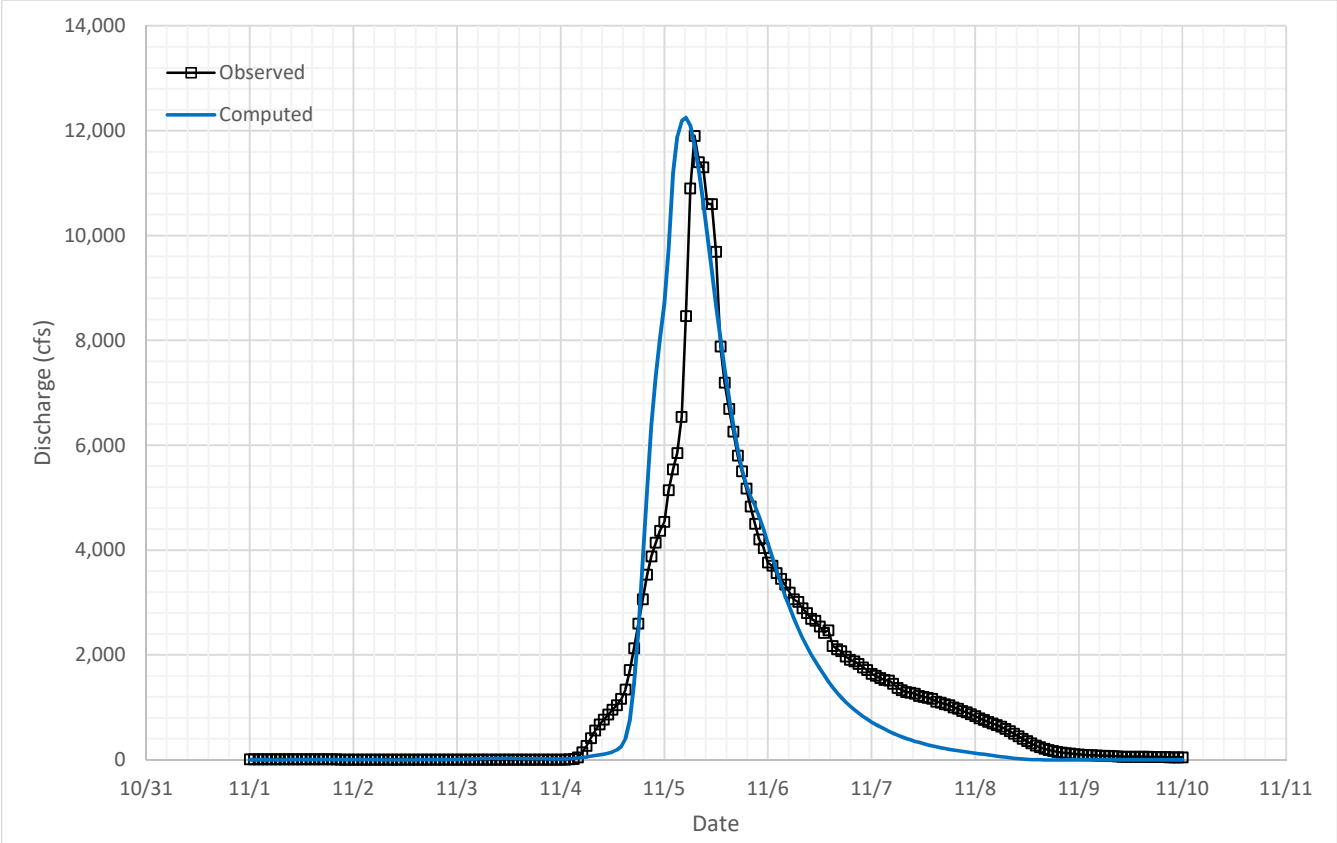


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
8.8	0.15	4.5	6.39	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	602	4,353
Computed	652	4,073
Residual	50	-280
Error	8%	-6%

BRA Calibration
Davdidson Creek near Lyons, TX
USGS 08110100

2002 Calibration Event

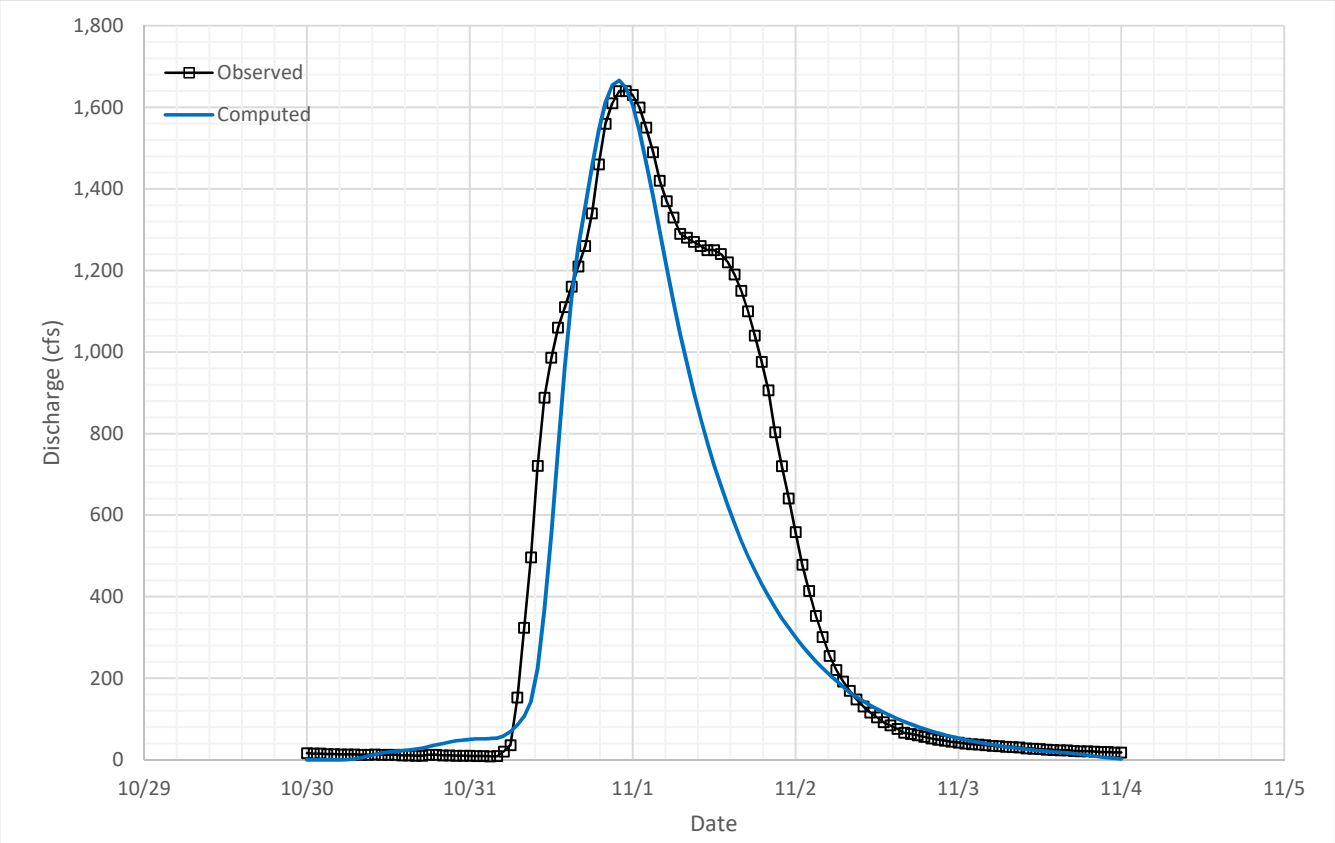


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.8	0.10	3.2	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	11,900	25,839
Computed	12,249	24,790
Residual	349	-1,049
Error	3%	-4%

BRA Calibration
Davidson Creek near Lyons, TX
USGS 08110100

2013 Calibration Event

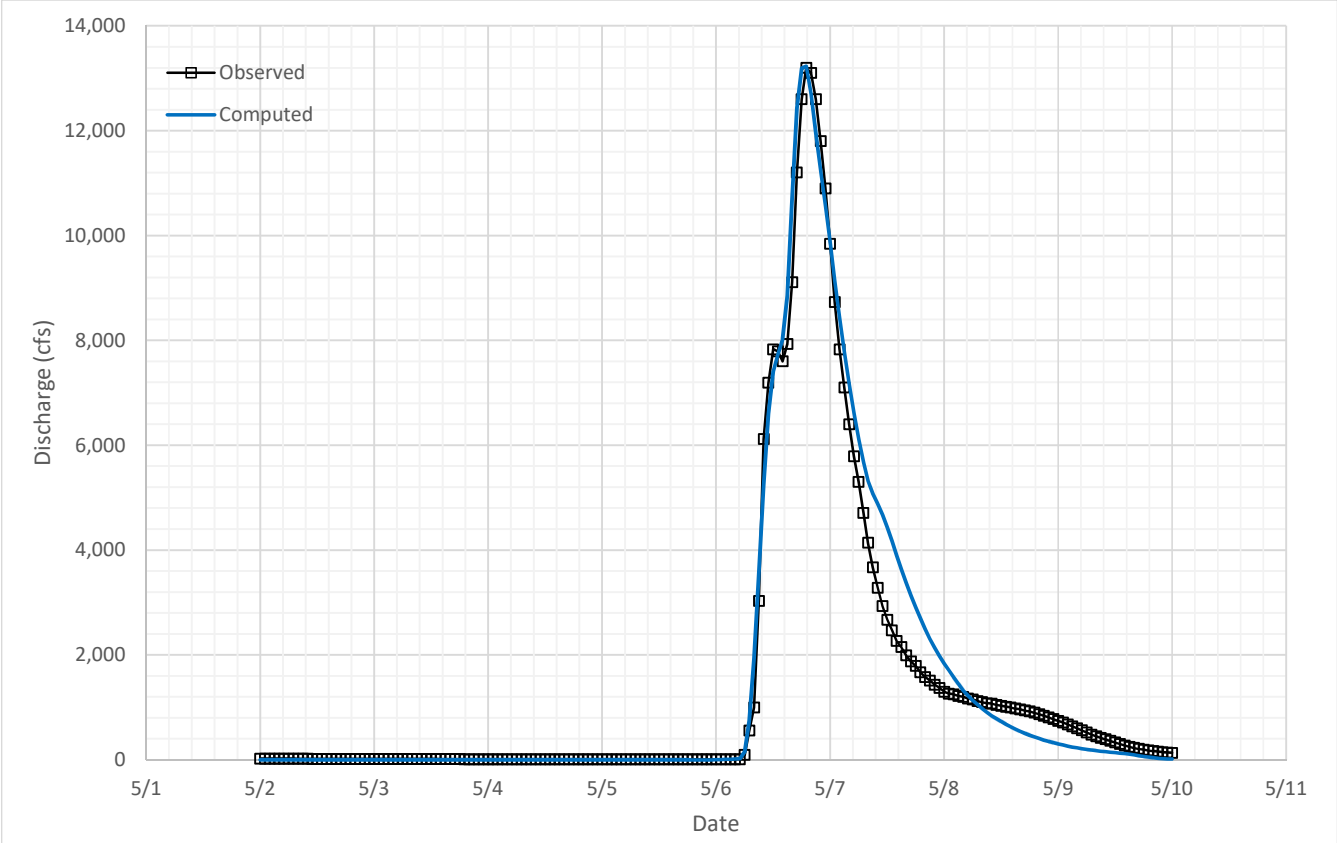


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.2	0.10	3.2	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	1,640	4,363
Computed	1,666	3,440
Residual	26	-923
Error	2%	-21%

BRA Calibration
Davidson Creek near Lyons, TX
USGS 08110100

2015 Calibration Event

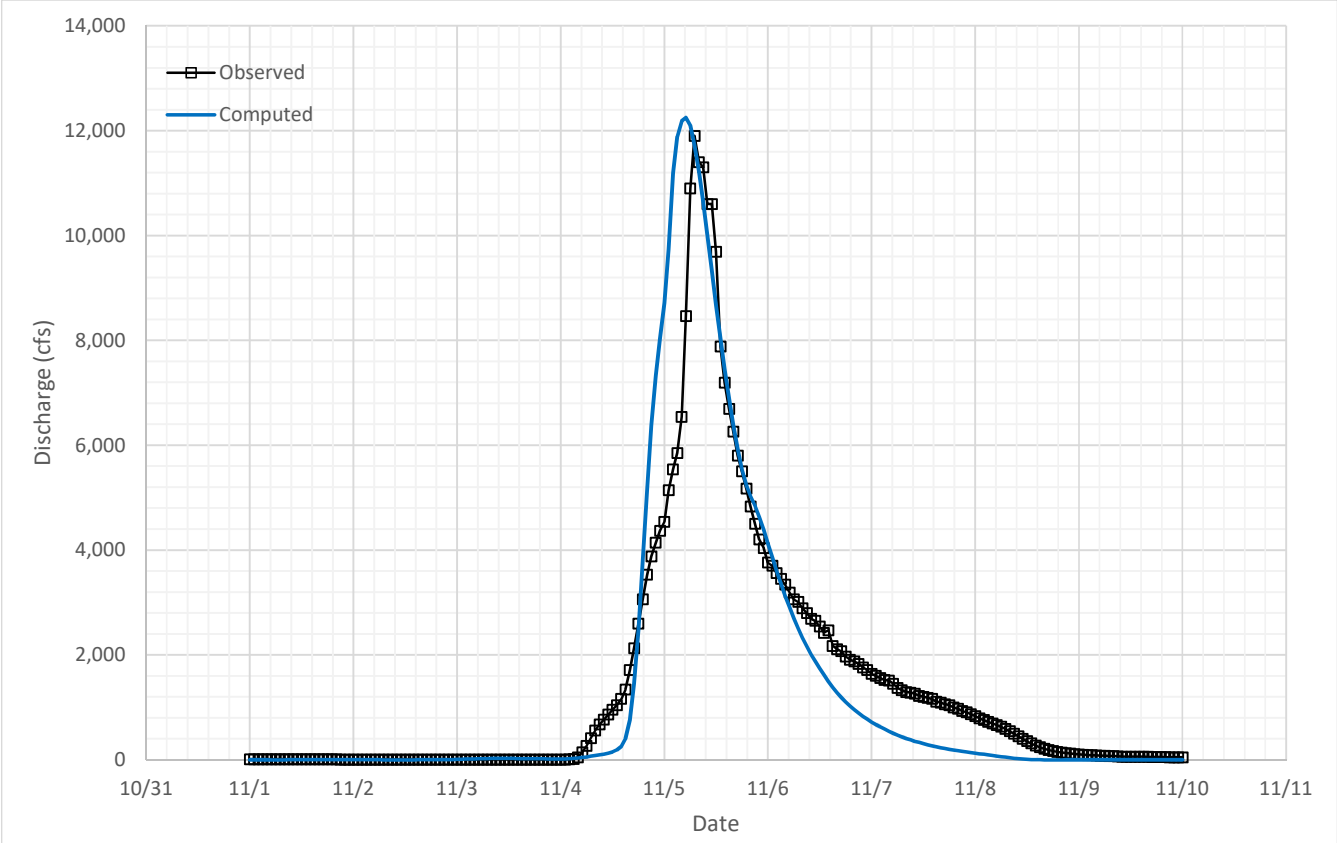


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.1	0.10	3.2	1.90	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	13,200	22,446
Computed	13,227	23,837
Residual	27	1,391
Error	0%	6%

BRA Calibration
Davdidson Creek near Lyons, TX
USGS 08110100

2002 Calibration Event

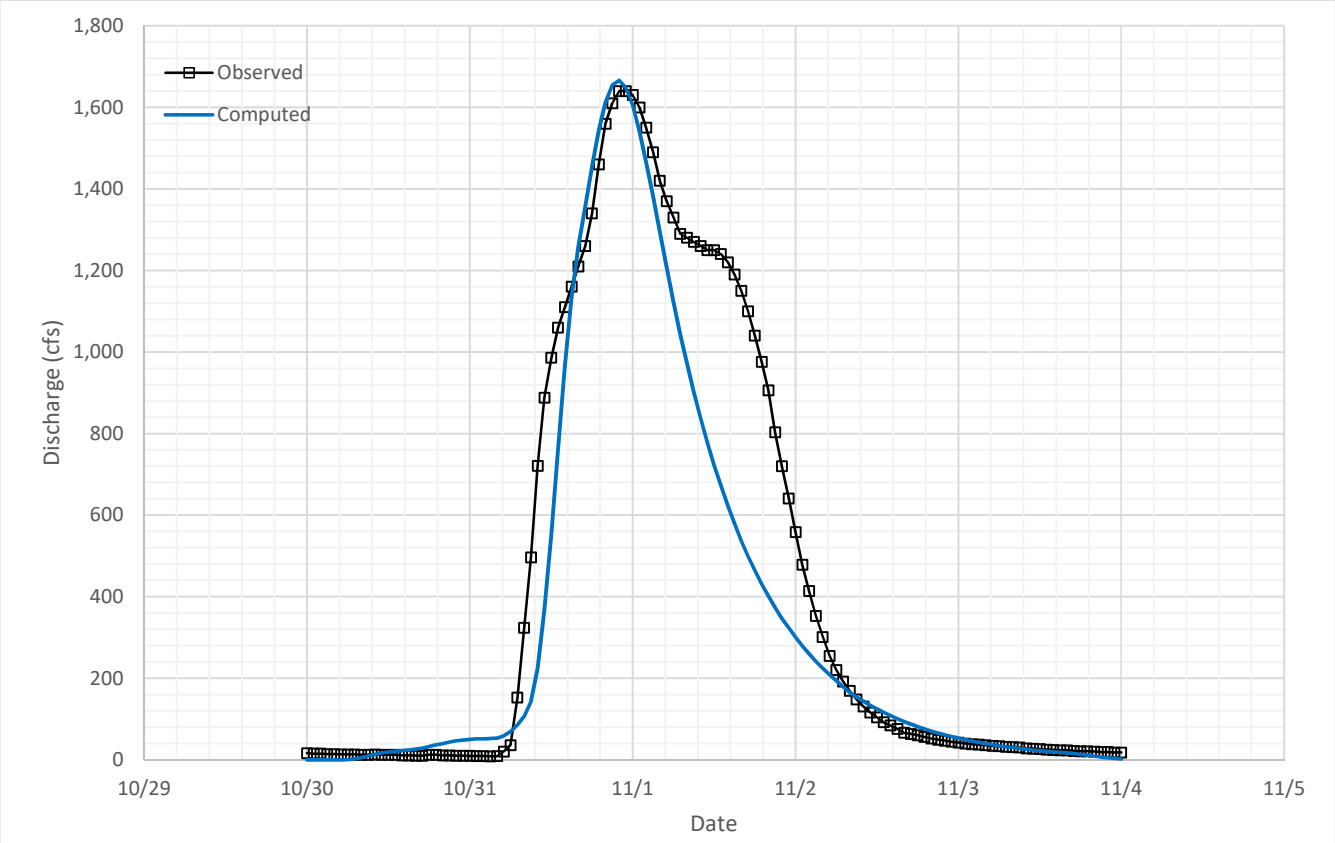


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.8	0.10	3.2	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	11,900	25,839
Computed	12,249	24,790
Residual	349	-1,049
Error	3%	-4%

BRA Calibration
Davidson Creek near Lyons, TX
USGS 08110100

2013 Calibration Event

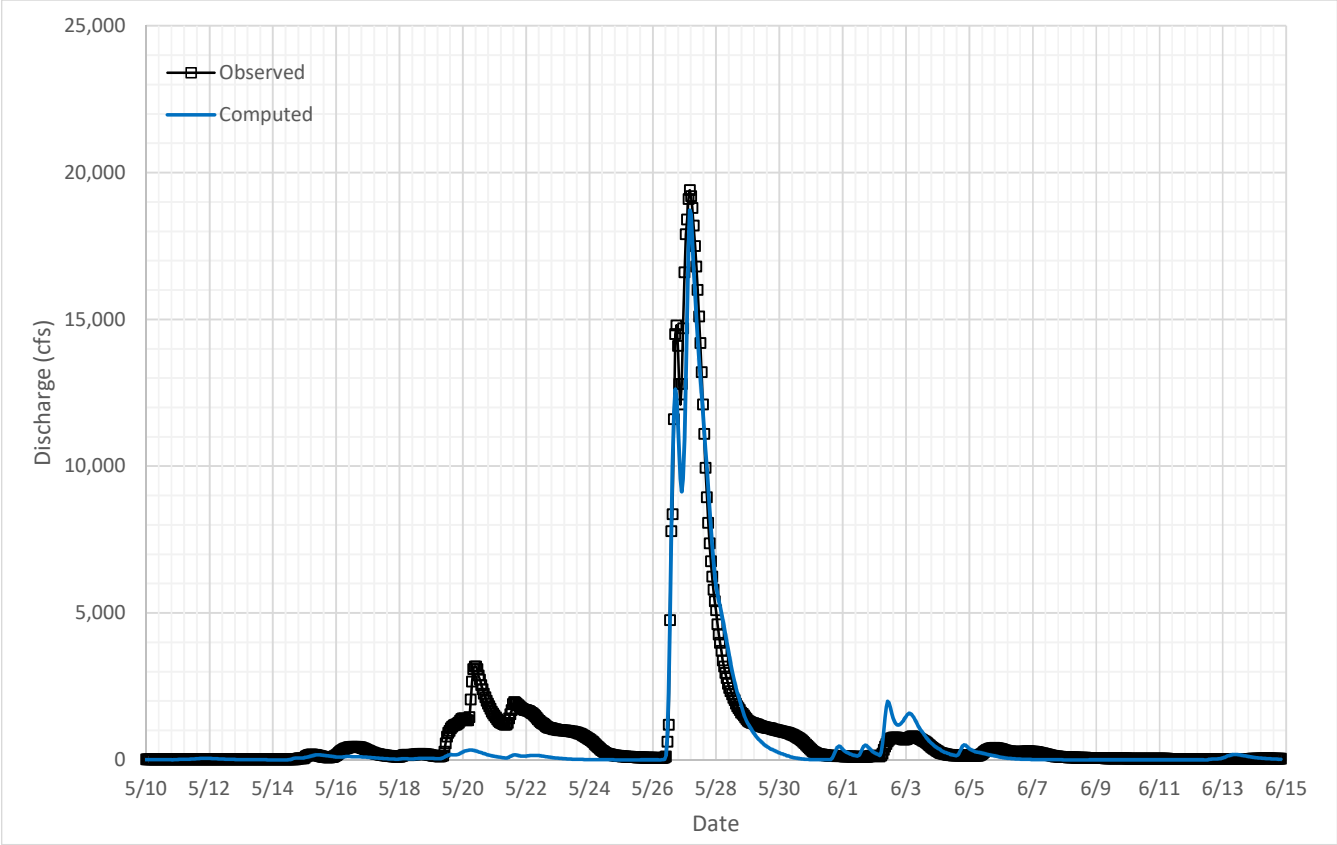


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.2	0.10	3.2	2.00	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	1,640	4,363
Computed	1,666	3,440
Residual	26	-923
Error	2%	-21%

BRA Calibration
Davidson Creek near Lyons, TX
USGS 08110100

2016 Calibration Event

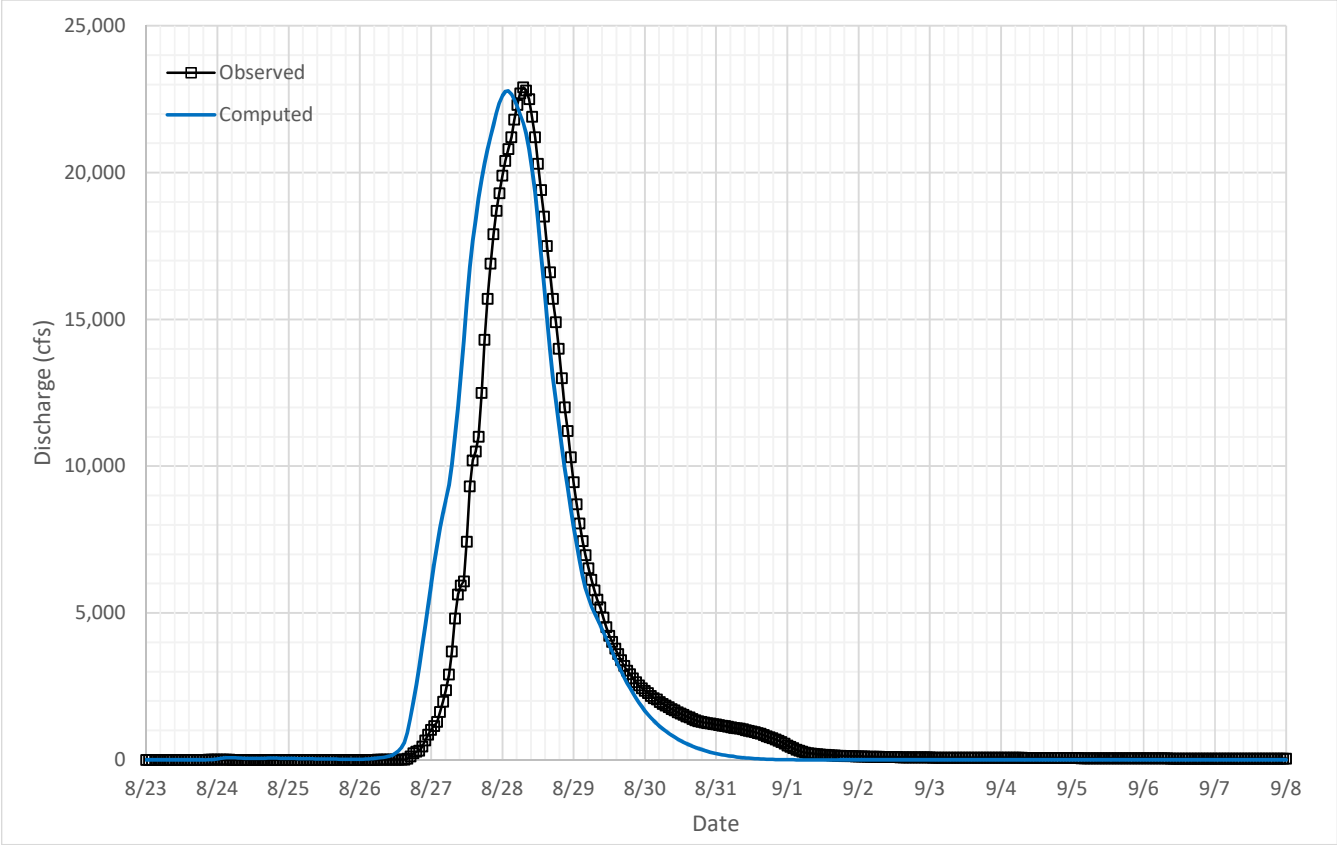


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
7.3	0.12	3.2	8.13	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	19,400	71,109
Computed	18,720	50,996
Residual	-680	-20,113
Error	-4%	-28%

BRA Calibration
Davidson Creek near Lyons, TX
USGS 08110100

2017 Calibration Event

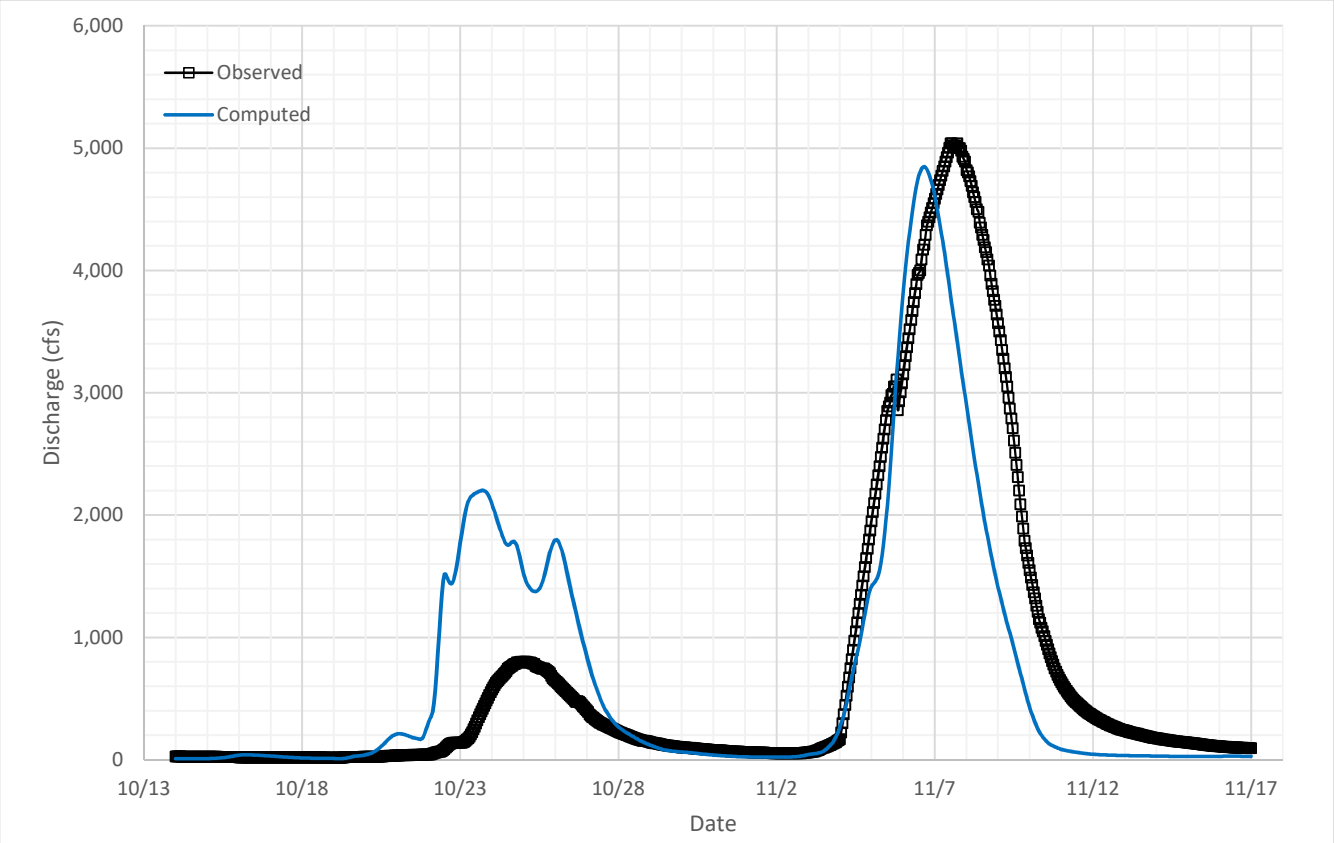


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.7	0.09	4.8	10.16	0.60

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	22,900	69,656
Computed	22,783	75,796
Residual	-117	6,140
Error	-1%	9%

BRA Calibration
Navasota River at Old Spanish Road, TX
USGS 08110800

2002 Calibration Event

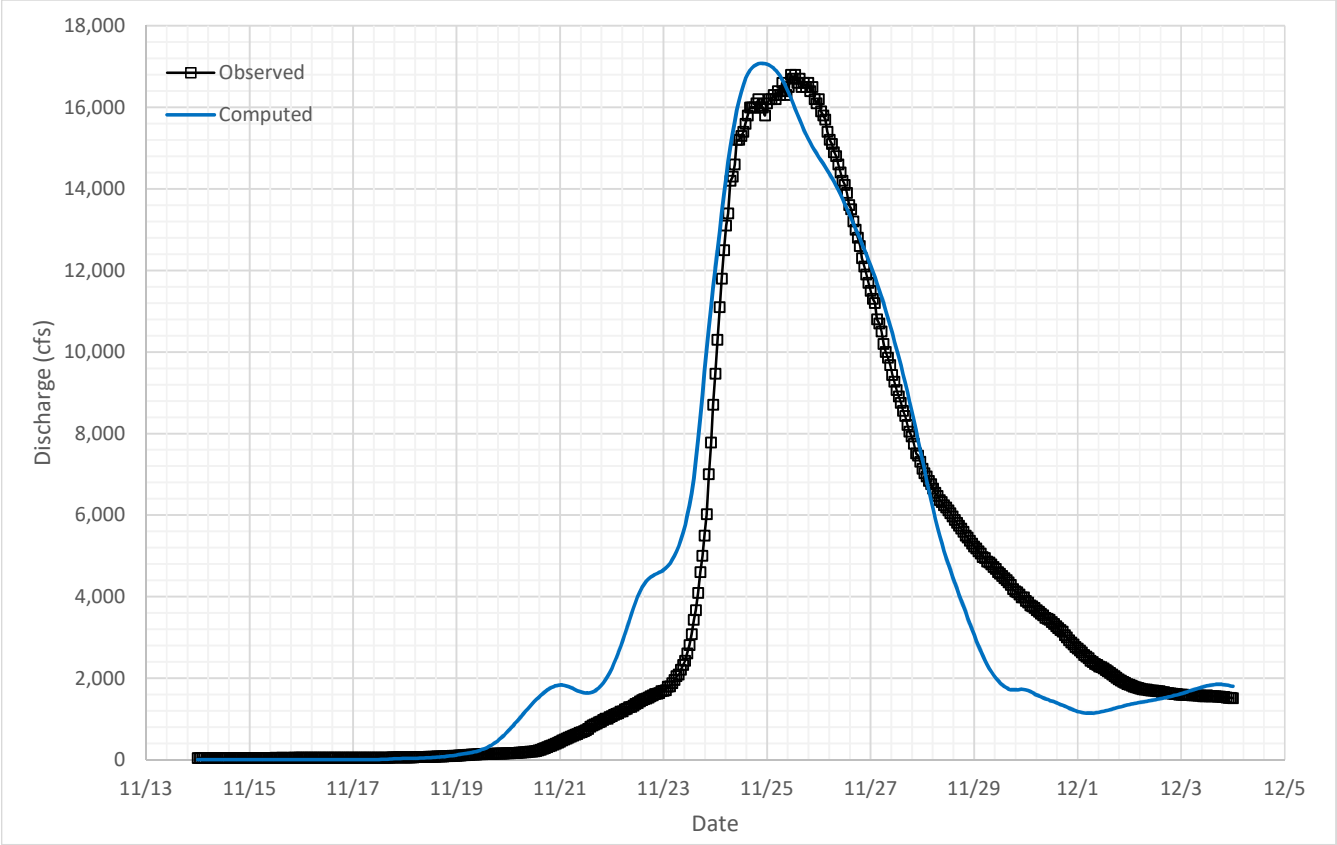


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.0	0.20	3.7	3.50	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	5,040	50,338
Computed	4,848	48,253
Residual	-192	-2,085
Error	-4%	-4%

BRA Calibration
Navasota River at Old Spanish Road, TX
USGS 08110800

2004 Calibration Event

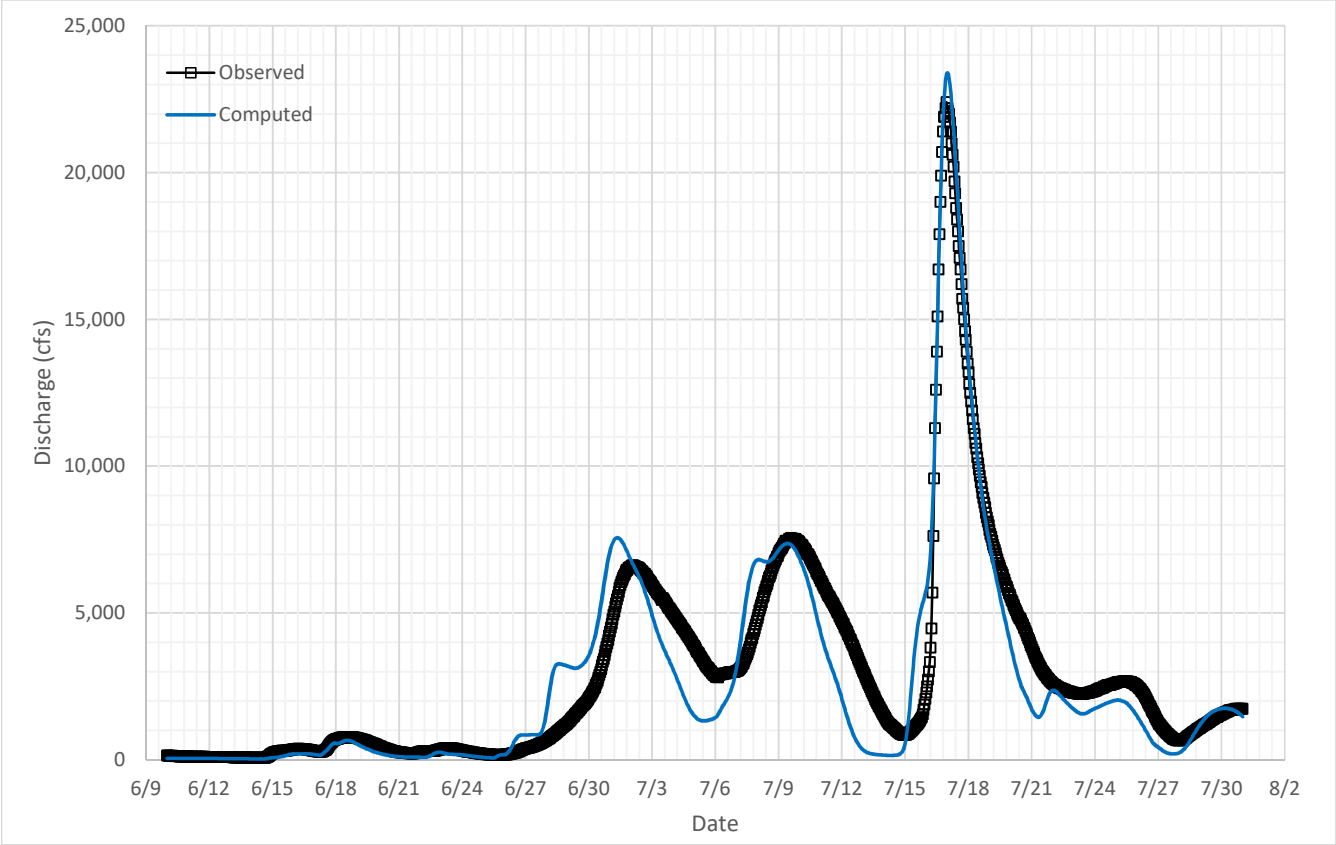


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.0	0.20	3.7	3.50	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	16,800	158,986
Computed	17,077	163,906
Residual	277	4,920
Error	2%	3%

BRA Calibration
Navasota River at Old Spanish Road, TX
USGS 08110800

2007 Calibration Event

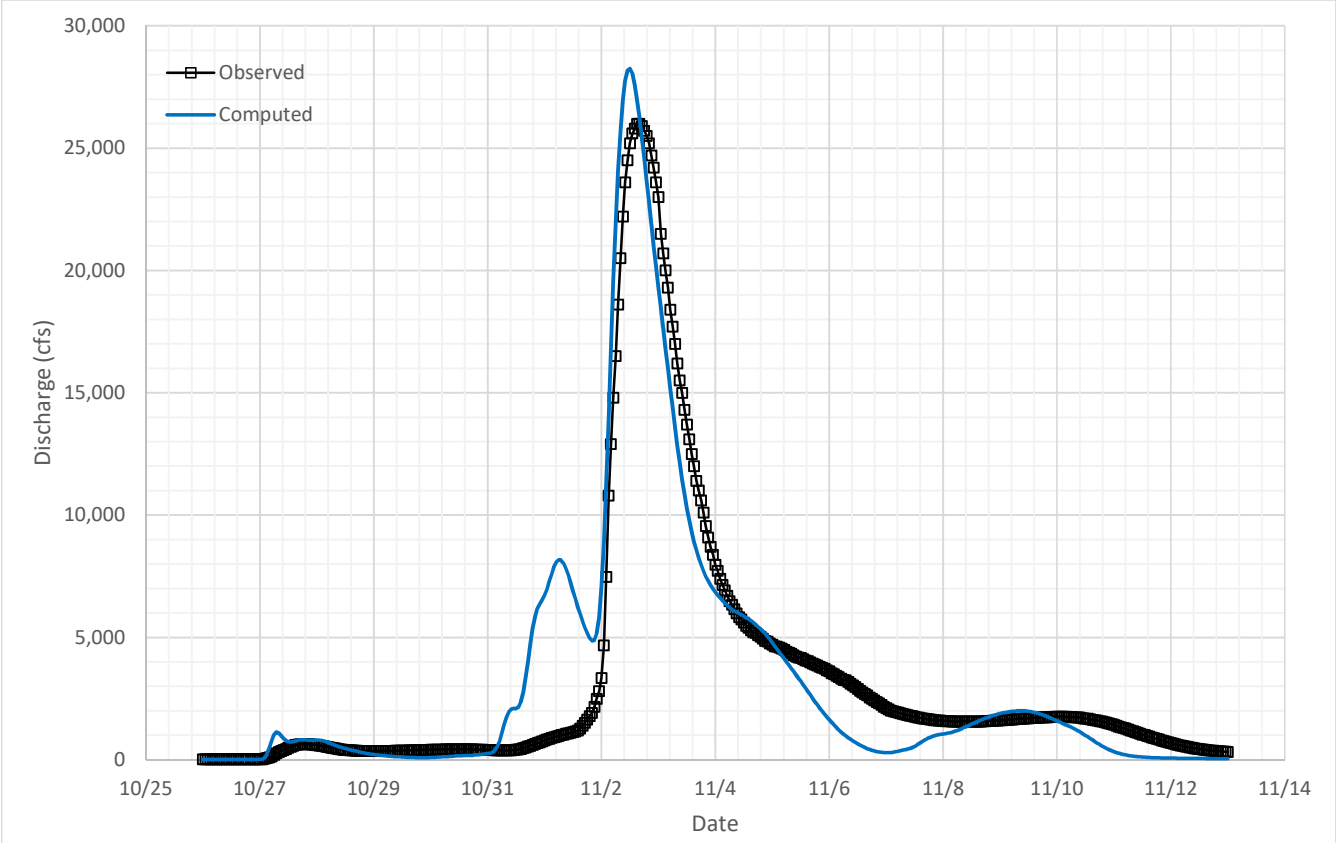


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.0	0.20	3.7	3.50	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	22,400	295,906
Computed	23,396	272,891
Residual	996	-23,015
Error	4%	-8%

BRA Calibration
Navasota River at Old Spanish Road, TX
USGS 08110800

2013 Calibration Event

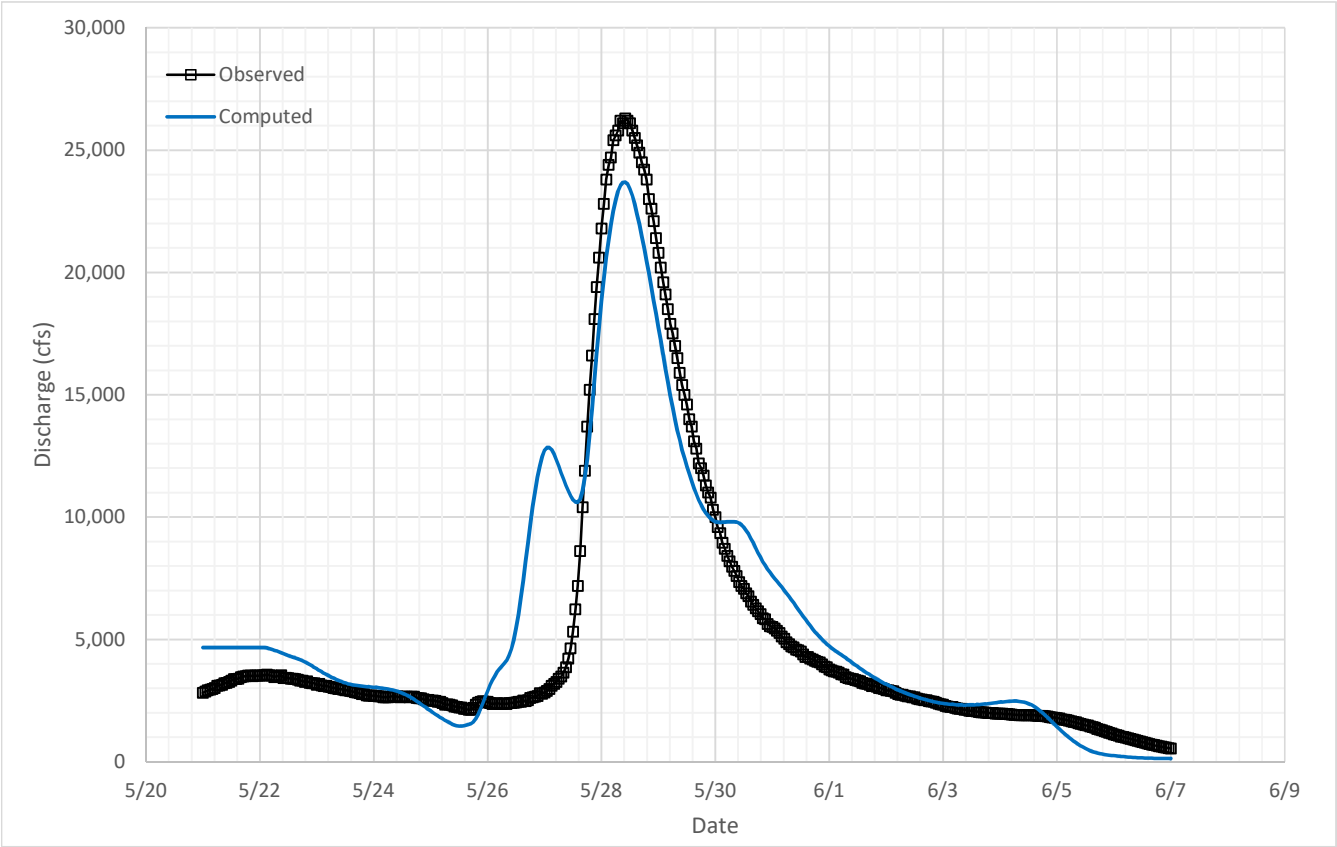


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.0	0.20	3.7	3.50	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	26,000	117,815
Computed	28,248	118,192
Residual	2,248	377
Error	9%	0%

BRA Calibration
Navasota River at Old Spanish Road, TX
USGS 08110800

2015 Calibration Event

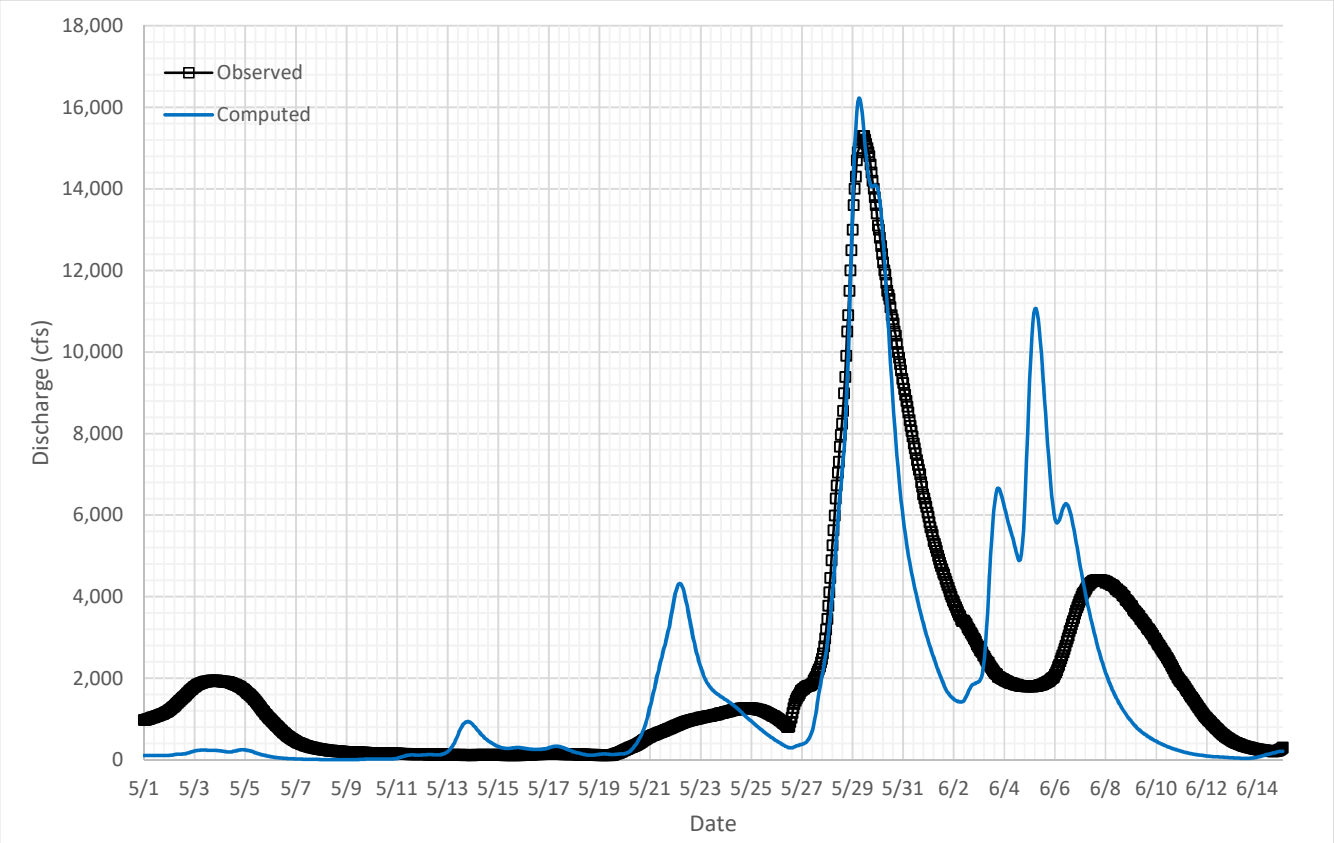


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.5	0.10	3.7	4.00	0.60

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	26,300	176,335
Computed	23,696	193,796
Residual	-2,604	17,461
Error	-10%	10%

BRA Calibration
Navasota River at Old Spanish Road, TX
USGS 08110800

2016 Calibration Event

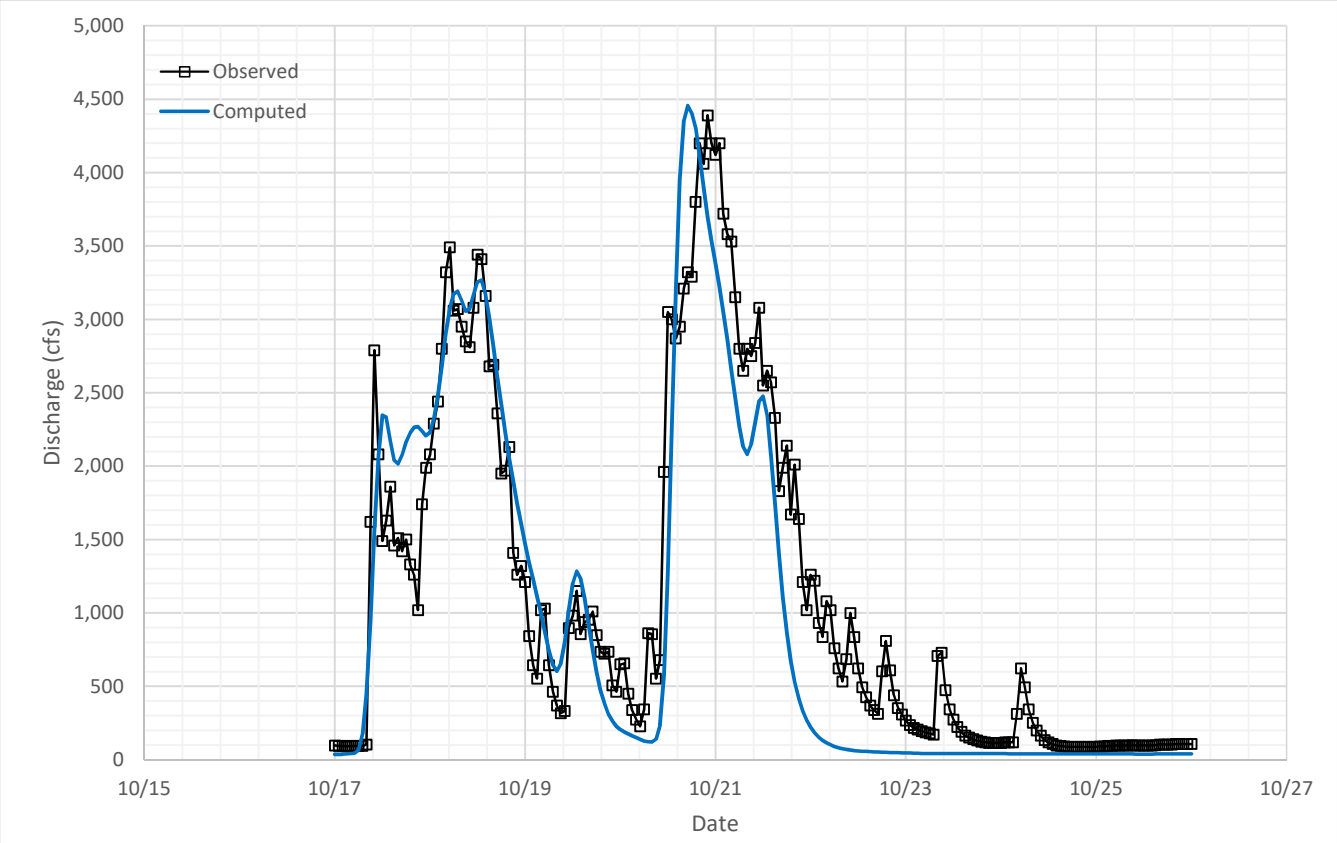


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
7.1	0.17	5.2	12.57	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	15,300	187,136
Computed	16,226	171,667
Residual	926	-15,469
Error	6%	-8%

BRA Calibration
Brazos River at Waco, TX
USGS 08096500

1998 Calibration Event

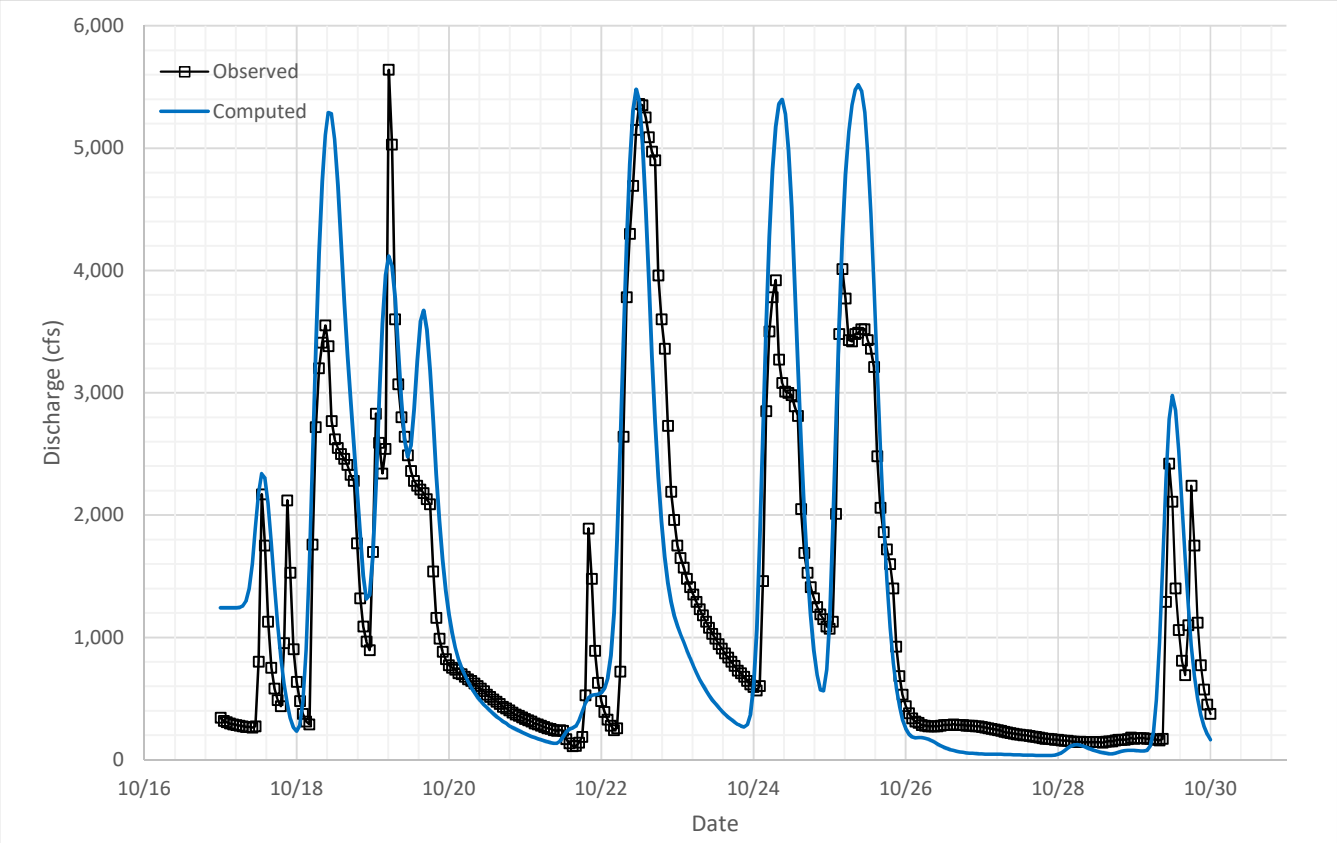


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
2.4	0.09	11.4	1.80	0.80

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	4,390	20,460
Computed	4,456	17,579
Residual	66	-2,881
Error	1%	-14%

BRA Calibration
Brazos River at Waco, TX
USGS 08096500

2002 Calibration Event

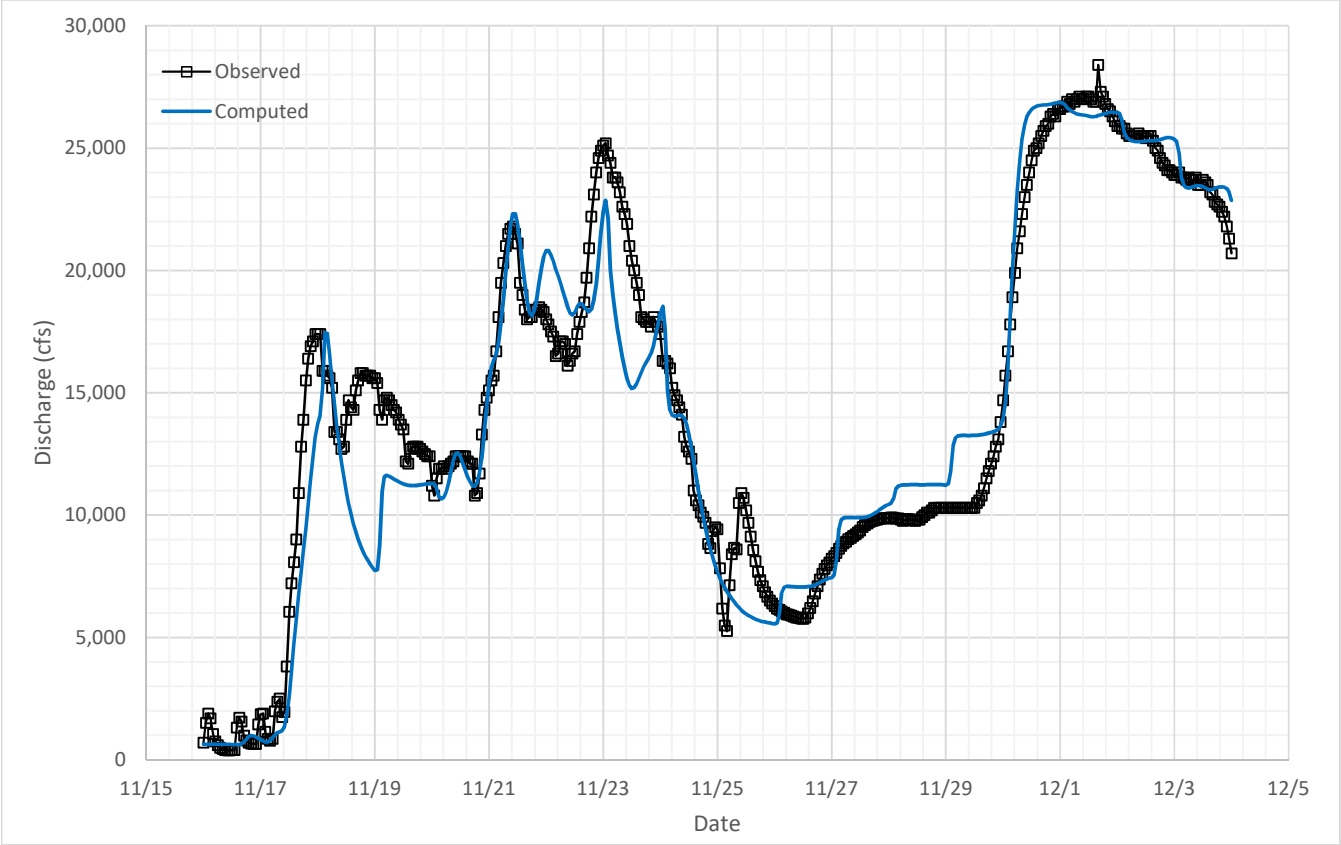


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.9	0.09	9.8	2.00	0.30

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	5,640	32,061
Computed	5,516	36,629
Residual	-124	4,568
Error	-2%	14%

BRA Calibration
Brazos River at Waco, TX
USGS 08096500

2004 Calibration Event

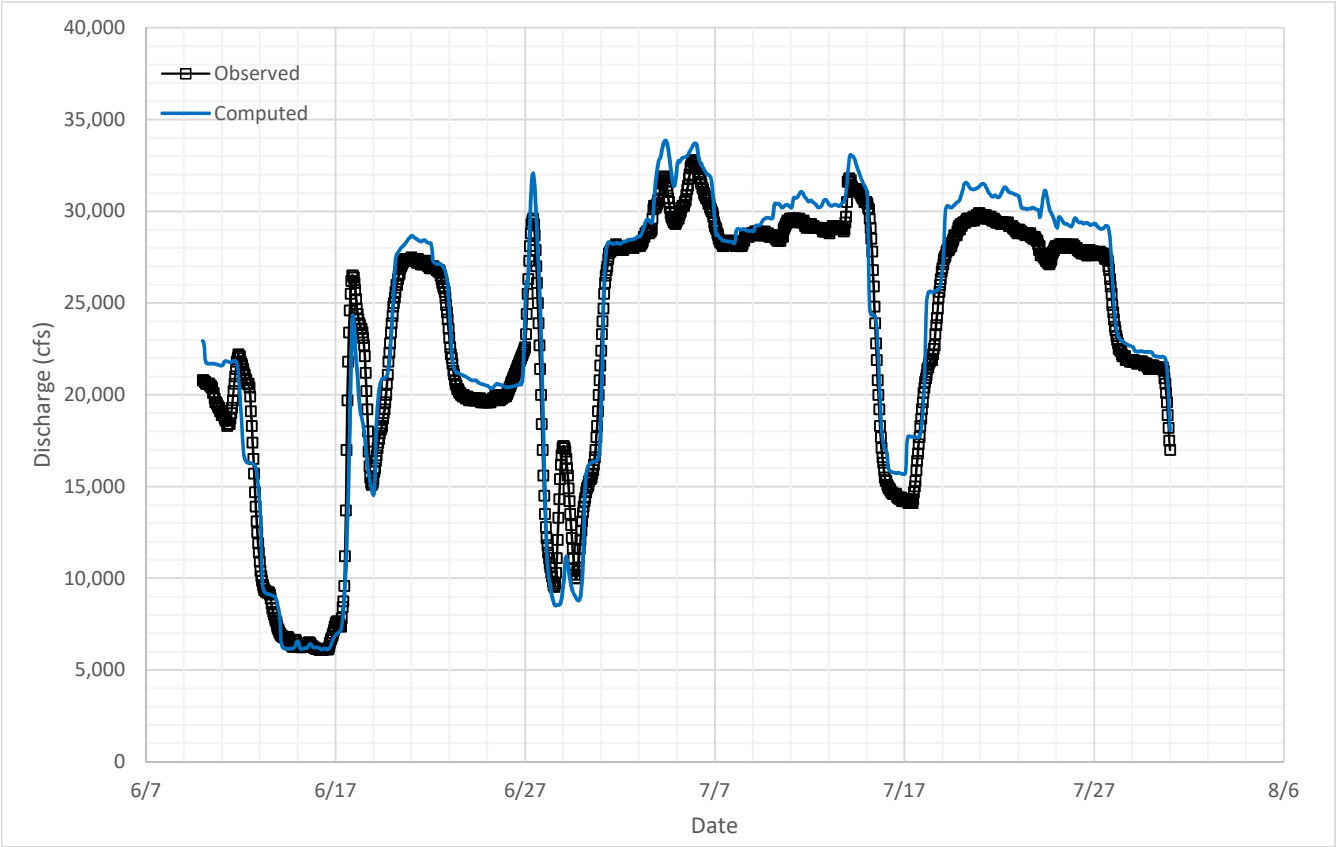


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
1.4	0.10	9.7	1.80	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	28,400	522,791
Computed	26,862	506,791
Residual	-1,538	-16,000
Error	-5%	-3%

BRA Calibration
Brazos River at Waco, TX
USGS 08096500

2007 Calibration Event

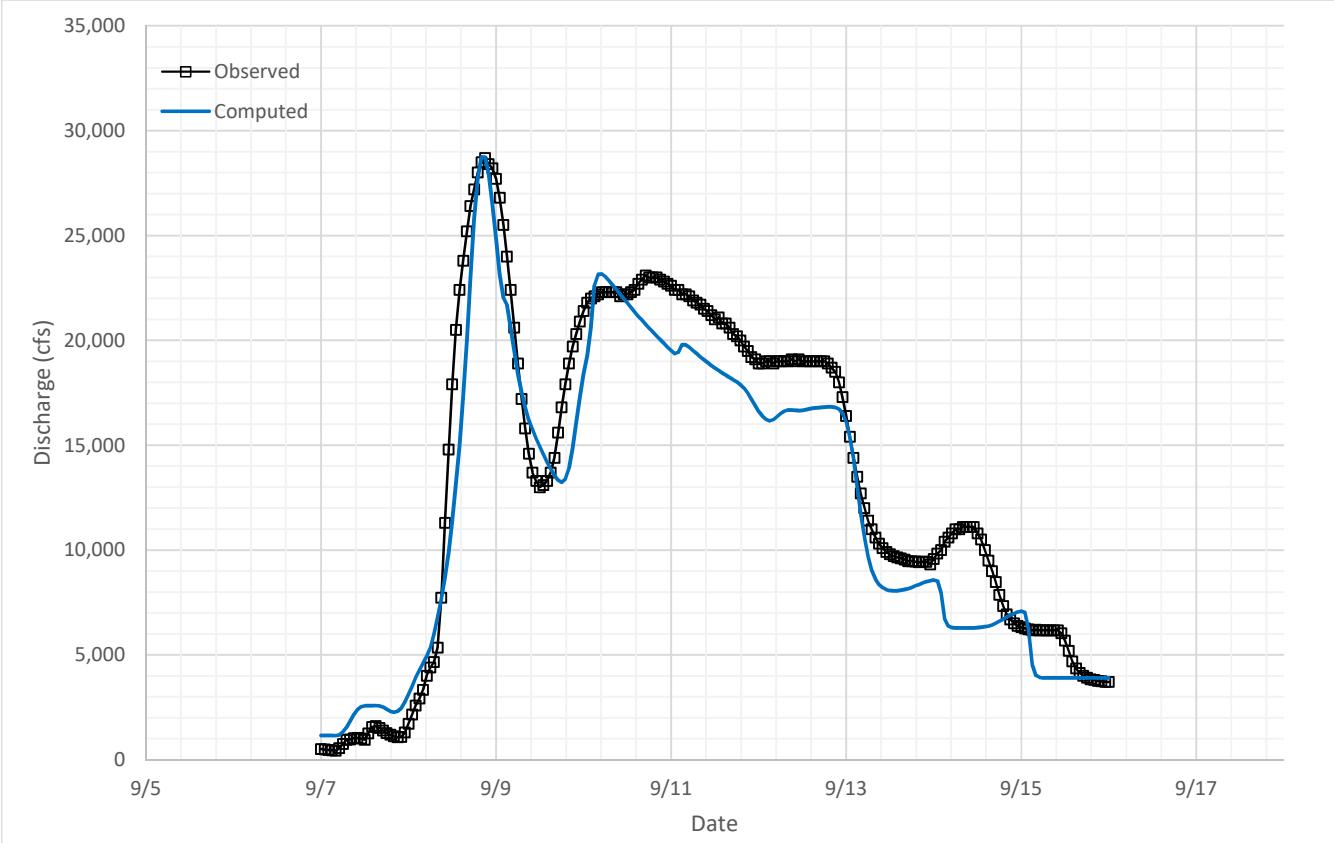


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
0.5	0.17	9.7	1.80	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	32,800	2,334,627
Computed	33,860	2,404,846
Residual	1,060	70,219
Error	3%	3%

BRA Calibration
Brazos River at Waco, TX
USGS 08096500

2010 Calibration Event

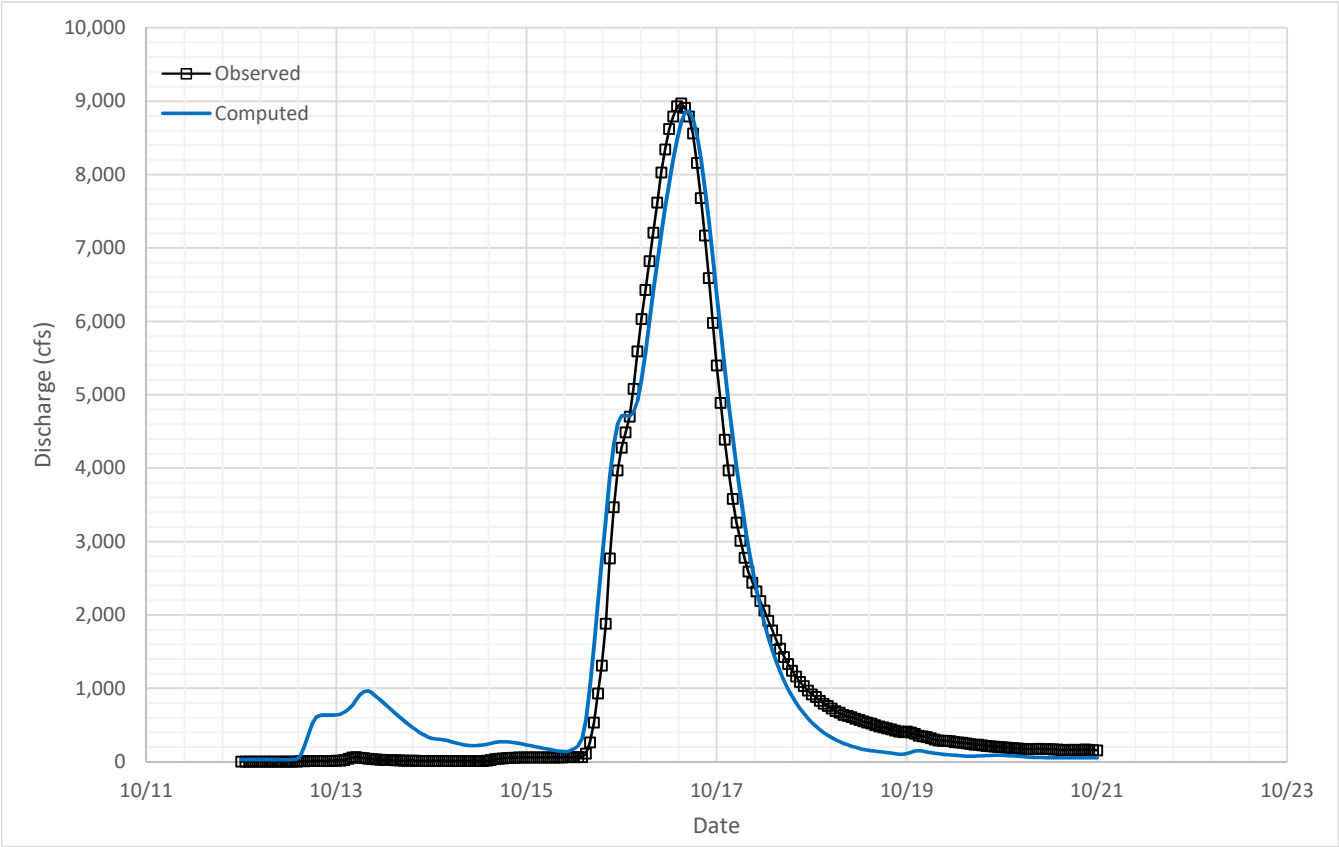


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
4.2	0.11	9.7	1.80	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	28,700	243,392
Computed	28,745	218,473
Residual	45	-24,919
Error	0%	-10%

BRA Calibration
Brazos River at Waco, TX
USGS 08096500

2013 Calibration Event

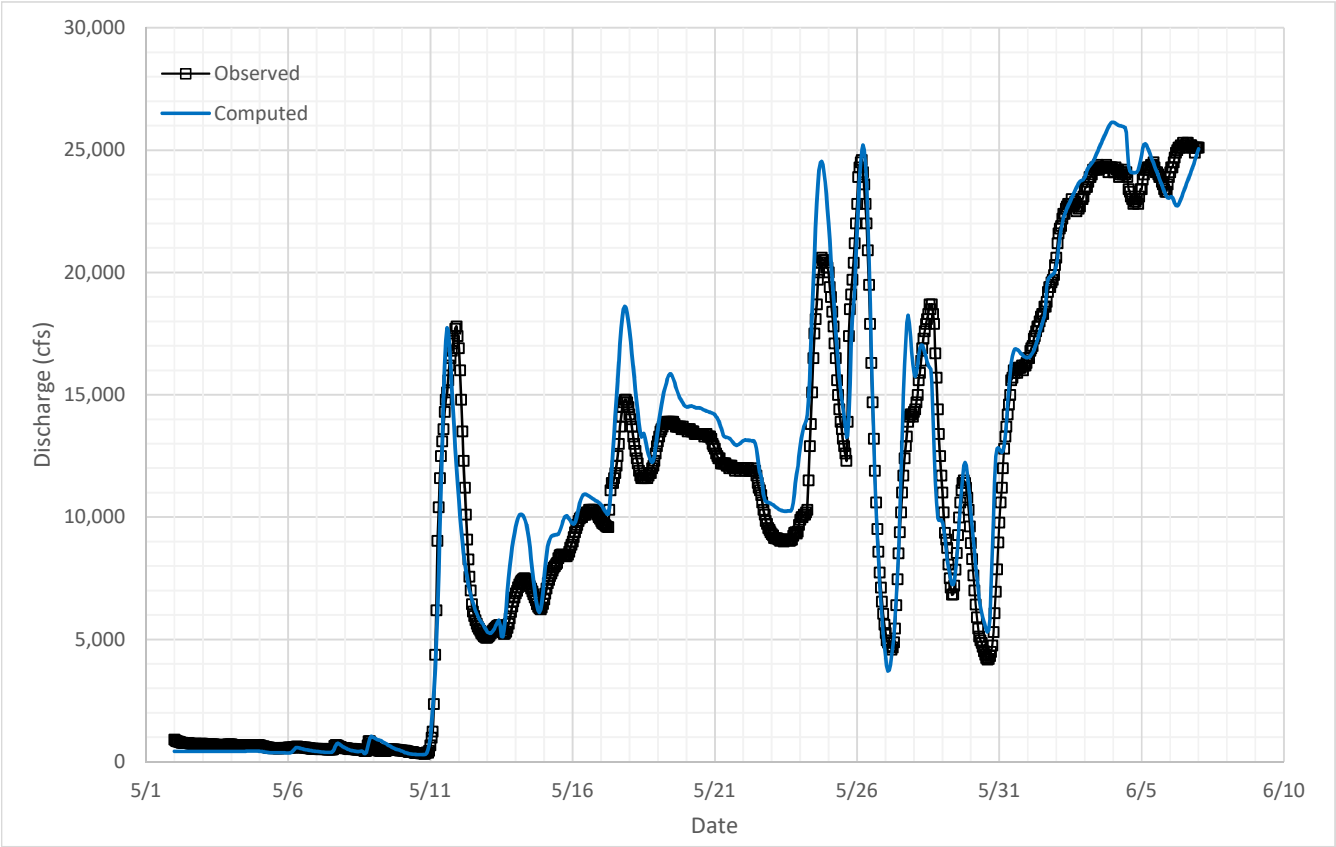


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.3	0.12	9.7	1.80	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	8,970	22,551
Computed	8,862	24,188
Residual	-108	1,637
Error	-1%	7%

BRA Calibration
Brazos River at Waco, TX
USGS 08096500

2015 Calibration Event

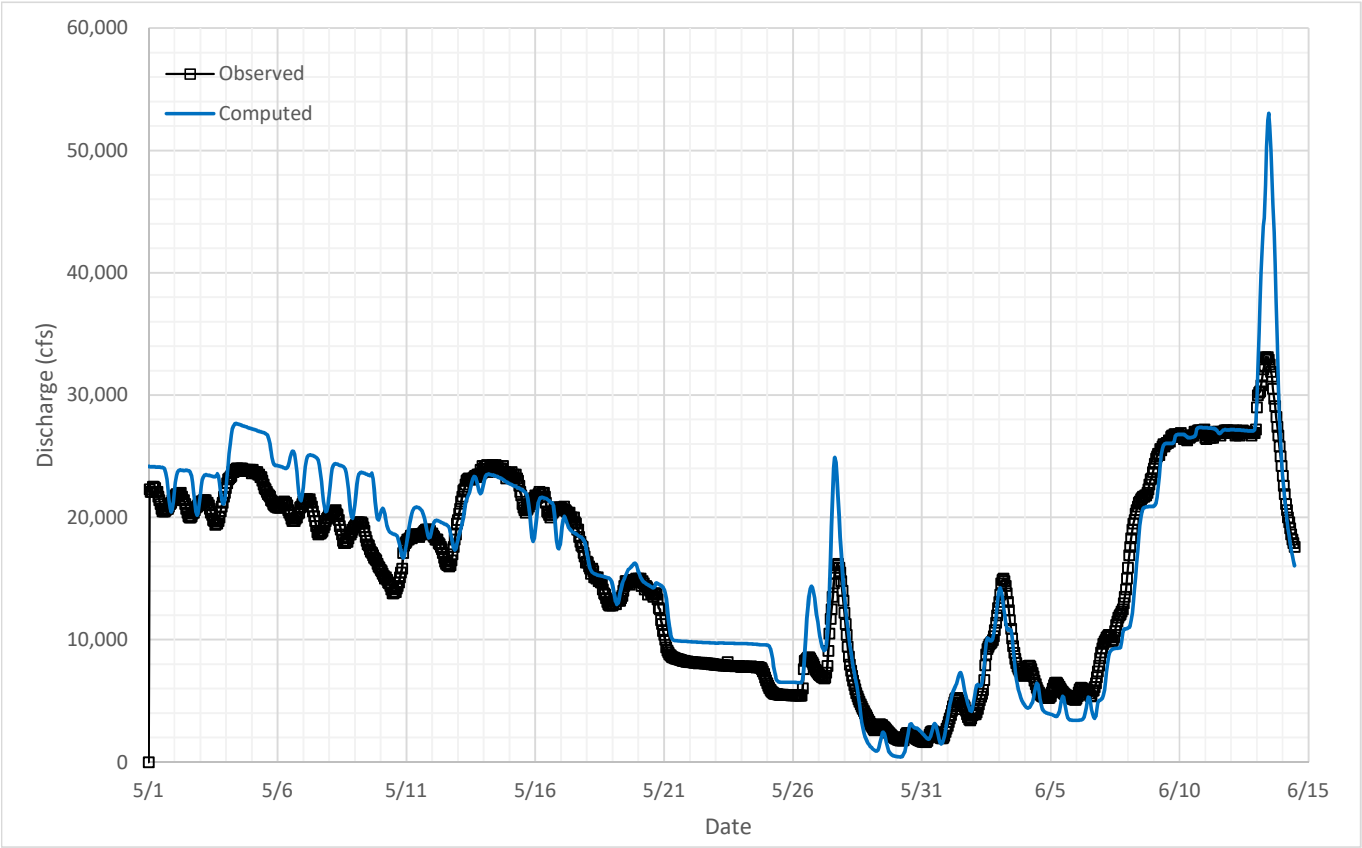


Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.2	0.12	9.7	1.80	0.50

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	25,300	756,792
Computed	26,136	793,706
Residual	836	36,914
Error	3%	5%

BRA Calibration
Brazos River at Waco, TX
USGS 08096500

2016 Calibration Event



Parameter Summary				
Initial Loss	Constant Loss	Percent Impervious	Snyder Ct	Snyder Cp
(in)	(iph)	(%)		
3.4	0.1	3.3	5.7	0.5

Results Summary		
	Peak (cfs)	Volume (acre-ft)
Observed	33,100	1,361,684
Computed	53,029	1,439,677
Residual	19,929	77,993
Error	60%	6%

Appendix D: Hydrologic Analysis

Final HMS Calibrated Parameters 1991

Final HMS Calibrated Parameters, 1991													
Sub-Basin	Area, (sq. mi.)	Initial and Constant Losses			Snyder's Unit Hydrograph		Exponential Losses					Clark Unit Hydrograph	
		Initial Loss, (hr)	Constant Loss, (in/hr)	Percent Impervious	Lag Time, (hr)	Peaking Cefficient	Initial Range, (in)	Initial Coefficient, ((in/hr)^(1-x))	Coefficient Ratio	Exponent	Percent Impervious	Time of Concentration (hr)	Storage Coefficient (hr)
B_AQU_010	53.6	2.1	0.09	4.1	6.86	0.5	-	-	-	-	-	-	-
B_AQU_020	55.3	2.1	0.11	5.3	5.53	0.5	-	-	-	-	-	-	-
B_AQU_030	44	1.9	0.13	3.6	6.02	0.5	-	-	-	-	-	-	-
B_BES_010	51.3	-	-	-	-	-	0	0.5	3	0.6	3.6	14.93	48.05
B_BES_020	49.4	-	-	-	-	-	0	0.5	3	0.6	6.8	11.87	57.3
B_BIC_010	60.4	-	-	-	-	-	0	0.5	3	0.6	10.6	6.34	35.61
B_BIC_020	96.9	-	-	-	-	-	0	0.5	3	0.6	5.1	7.47	48.17
B_BIC_030	76.6	-	-	-	-	-	0	0.5	3	0.6	14.5	10.21	56.72
B_BIG_010	72.1	2	0.02	3.7	11.08	0.5	-	-	-	-	-	-	-
B_BIG_020	54.3	2	0.01	6.7	10.75	0.5	-	-	-	-	-	-	-
B_BIG_030	39.9	2	0	2.7	9.08	0.5	-	-	-	-	-	-	-
B_BIG_040	62.3	1.9	0.01	3.1	7.39	0.5	-	-	-	-	-	-	-
B_BIG_050	20.1	1.8	0	3.6	5.26	0.5	-	-	-	-	-	-	-
B_BIG_060	64.5	2	0	3	9.73	0.5	-	-	-	-	-	-	-
B_BIG_070	10.6	1.9	0.02	10.6	3.84	0.5	-	-	-	-	-	-	-
B_BIN_010	119.6	2	0.06	5.3	9.79	0.4	-	-	-	-	-	-	-
B_BIN_020	113.2	2	0.07	4.3	9.54	0.4	-	-	-	-	-	-	-
B_BIN_030	102.2	2.1	0.09	9.2	12.83	0.4	-	-	-	-	-	-	-
B_BRA_010	55.9	2.1	0.05	5	5.68	0.8	-	-	-	-	-	-	-
B_BRA_020	40	2	0.15	3	5.41	0.5	-	-	-	-	-	-	-
B_BRA_030	87.7	2	0.08	2.8	7.79	0.5	-	-	-	-	-	-	-
B_BRA_040	25.4	1.8	0.18	3.9	4.52	0.5	-	-	-	-	-	-	-
B_BRA_050	64.5	1.8	0.14	8.5	5.63	0.5	-	-	-	-	-	-	-
B_BRA_060	28.6	1.7	0.14	46.7	4.12	0.5	-	-	-	-	-	-	-
B_BRA_070	9.9	1.8	0.12	41.7	5.46	0.4	-	-	-	-	-	-	-
B_BRA_080	30.8	1.8	0.15	4.9	7.02	0.4	-	-	-	-	-	-	-
B_BRA_090	52.1	1.8	0.09	28.2	7.97	0.4	-	-	-	-	-	-	-
B_BRA_100	76	2	0.12	7.6	6.39	0.4	-	-	-	-	-	-	-
B_BRA_110	47.5	2.1	0.15	7.4	10.8	0.4	-	-	-	-	-	-	-
B_BRA_120	122.3	2.1	0.1	7.5	12.45	0.4	-	-	-	-	-	-	-
B_BRA_130	115.2	2	0.09	8.5	10.39	0.4	-	-	-	-	-	-	-
B_BRA_140	85.3	2.1	0.19	9.4	9.83	0.4	-	-	-	-	-	-	-
B_BRA_150	10.8	2.1	0.28	7.8	3.82	0.4	-	-	-	-	-	-	-
B_BRA_160	24.5	2.1	0.11	5.1	8.83	0.5	-	-	-	-	-	-	-
B_BRA_170	39.6	1.9	0.12	3.6	10.61	0.5	-	-	-	-	-	-	-
B_BRA_180	51.2	1.9	0.1	4.7	5.84	0.5	-	-	-	-	-	-	-
B_BRA_190	162.6	1.9	0.19	3.4	9.81	0.5	-	-	-	-	-	-	-
B_BRA_200	108.8	1.9	0.06	13.7	6.99	0.5	-	-	-	-	-	-	-
B_BRA_210	45.3	1.9	0.04	22.1	6.75	0.5	-	-	-	-	-	-	-
B_BRA_220	150.2	2.3	0.05	4.3	17.45	0.5	-	-	-	-	-	-	-
B_BRA_230	79.4	2	0.07	3.5	9.04	0.5	-	-	-	-	-	-	-
B_BRA_240	83.7	2.3	0.09	9	6.31	0.5	-	-	-	-	-	-	-
B_BRA_250	82.3	2.2	0.11	5.8	6.94	0.5	-	-	-	-	-	-	-
B_BRA_260	61	2	0.1	3.8	9	0.5	-	-	-	-	-	-	-
B_BRA_270	24.6	-	-	-	-	-	0	0.5	3	0.6	6.4	14.53	18.47
B_BRA_280	62.1	-	-	-	-	-	0	0.5	3	0.6	4.4	18.02	23.12
B_BRA_290	23.1	-	-	-	-	-	0	0.5	3	0.6	13.6	11.92	18.7
B_BRA_300	74.1	-	-	-	-	-	0	0.5	3	0.6	8.7	15.9	26.37
B_BRA_310	95.8	-	-	-	-	-	0	0.5	3	0.6	5.5	20.5	35.51
B_BRA_320	26.3	-	-	-	-	-	0	0.5	3	0.6	10	8.74	10.52
B_BRA_330	71.8	-	-	-	-	-	0	0.5	3	0.6	3.1	21.24	49.55
B_BRA_340	17.9	-	-	-	-	-	0	0.5	3	0.6	6.3	9.45	48.62
B_BRA_350	62.3	-	-	-	-	-	0	0.5	3	0.6	5.4	15.03	29.27
B_BRA_360	31.8	-	-	-	-	-	0	0.5	3	0.6	4.9	4.58	75.7
B_BRA_370	55.5	-	-	-	-	-	0	0.5	3	0.6	9.4	12.87	53.12
B_BRA_380	63.6	-	-	-	-	-	0	0.5	3	0.6	51.1	7.34	32.85
B_BRA_390	21.1	-	-	-	-	-	0	0.5	3	0.6	2	10.13	35.51
B_BRA_400	66.9	-	-	-	-	-	0	0.5	3	0.6	3.4	9.13	31.74

B_BRA_410	20.3	-	-	-	-	-	0	0.5	3	0.6	2.4	13.62	87.35
B_BRA_420	56.2	-	-	-	-	-	0	0.5	3	0.6	3.8	13.25	31.25
B_BRA_430	52	-	-	-	-	-	0	0.5	3	0.6	6	6.83	51.67
B_BRA_440	38.2	-	-	-	-	-	0	0.5	3	0.6	7.7	3.19	54.65
B_BRU_010	73.2	2	0.01	16.9	6.88	0.5	-	-	-	-	-	-	-
B_BRU_020	65.6	2	0.01	18.1	6.05	0.5	-	-	-	-	-	-	-
B_BRU_030	50.8	2	0.02	8.6	7.69	0.5	-	-	-	-	-	-	-
B_BRU_040	54.6	2	0.02	2.3	8.62	0.5	-	-	-	-	-	-	-
B_BRU_050	55.6	2	0.01	5.8	8.47	0.5	-	-	-	-	-	-	-
B_BRU_060	66.4	2	0.01	2.5	7.38	0.5	-	-	-	-	-	-	-
B_BRU_070	54	2	0.03	2.6	7.51	0.5	-	-	-	-	-	-	-
B_BRU_080	65.5	2	0.01	2.5	9.97	0.5	-	-	-	-	-	-	-
B_BRU_090	32.3	1.9	0.06	2.8	4.85	0.5	-	-	-	-	-	-	-
B_DAV_010	142	1.8	0.13	3.8	10.37	0.5	-	-	-	-	-	-	-
B_DAV_020	52.8	1.8	0.04	2.6	5.89	0.5	-	-	-	-	-	-	-
B_DAV_030	31.7	1.6	0.04	6.6	4.18	0.5	-	-	-	-	-	-	-
B_LAM_010	26.4	2	0.05	4.7	5.82	0.5	-	-	-	-	-	-	-
B_LEO_010	46.8	2	0.03	18.4	4.73	0.5	-	-	-	-	-	-	-
B_LEO_020	23.1	1.9	0.05	9.5	5.41	0.5	-	-	-	-	-	-	-
B_LIB_010	168.1	2.1	0.05	5.3	13	0.4	-	-	-	-	-	-	-
B_LIB_020	22.6	1.8	0.08	3.5	6.67	0.4	-	-	-	-	-	-	-
B_LIB_030	78.5	1.8	0.12	7.4	6.21	0.4	-	-	-	-	-	-	-
B_LIB_040	40.7	1.8	0.09	13.7	5.35	0.4	-	-	-	-	-	-	-
B_LIB_050	55.9	1.8	0.15	3.8	7.43	0.4	-	-	-	-	-	-	-
B_LIB_060	48.1	1.8	0.15	4.1	6.19	0.4	-	-	-	-	-	-	-
B_LIB_070	44.4	1.8	0.05	5.5	5.76	0.4	-	-	-	-	-	-	-
B_LIB_080	30.8	1.9	0.06	7.5	6.96	0.4	-	-	-	-	-	-	-
B_LIT_010	43.2	2	0.03	2.2	9.15	0.5	-	-	-	-	-	-	-
B_LIT_020	36.5	2	0.01	4.1	7.17	0.5	-	-	-	-	-	-	-
B_LIT_030	57.5	2	0.02	1.6	8.22	0.5	-	-	-	-	-	-	-
B_LIT_040	46.3	1.9	0.01	2.5	8.4	0.5	-	-	-	-	-	-	-
B_LIT_050	130.2	2	0.02	2.4	16.71	0.5	-	-	-	-	-	-	-
B_LIT_060	50	1.9	0.02	2.6	11.6	0.5	-	-	-	-	-	-	-
B_LIT_070	28.6	1.9	0.03	2.6	5.65	0.5	-	-	-	-	-	-	-
B_LIT_080	78.4	1.9	0.06	2.8	7.37	0.5	-	-	-	-	-	-	-
B_LIT_090	10.3	1.9	0.06	16	3.79	0.5	-	-	-	-	-	-	-
B_LIT_100	38	1.9	0.03	5.7	6.9	0.5	-	-	-	-	-	-	-
B_LIT_110	41.2	1.9	0.11	3.5	5.06	0.5	-	-	-	-	-	-	-
B_LIT_120	48.8	1.9	0.06	3.7	6.73	0.5	-	-	-	-	-	-	-
B_LIT_130	65	1.9	0.11	3.1	6.75	0.5	-	-	-	-	-	-	-
B_MIL_010	155.7	-	-	-	-	-	4	0.1	10	1	4.5	21.28	9.28
B_MIL_020	158.9	-	-	-	-	-	4	0.1	10	1	4.4	20.92	8.25
B_MIL_030	47.6	-	-	-	-	-	4	0.1	6	1	4.8	11.32	14.64
B_MIL_040	48.9	-	-	-	-	-	0	0.5	3	0.6	8.46	21.42	32.08
B_NAV_010	50.6	1.9	0.02	5	5.67	0.5	-	-	-	-	-	-	-
B_NAV_020	53.1	1.9	0.01	4.8	6.45	0.5	-	-	-	-	-	-	-
B_NAV_030	54	1.9	0.01	4.4	8.97	0.5	-	-	-	-	-	-	-
B_NAV_040	39.5	1.8	0.03	5.4	4.2	0.5	-	-	-	-	-	-	-
B_NAV_050	43.3	1.8	0.04	5.9	5.37	0.5	-	-	-	-	-	-	-
B_NAV_060	73	1.9	0.07	5.1	8.86	0.5	-	-	-	-	-	-	-
B_NAV_070	71.1	1.8	0.07	3.3	7.46	0.5	-	-	-	-	-	-	-
B_NAV_080	97.4	2.1	0.11	9.9	15.18	0.8	-	-	-	-	-	-	-
B_NAV_090	194	1.9	0.13	5.8	8.96	0.5	-	-	-	-	-	-	-
B_NAV_100	74.1	2	0.13	4.2	26.93	0.5	-	-	-	-	-	-	-
B_NAV_110	105.3	1.9	0.06	3	17.2	0.5	-	-	-	-	-	-	-
B_NAV_120	82.3	2	0.07	3	20.25	0.5	-	-	-	-	-	-	-
B_NAV_130	73.6	2	0.17	6.5	16.9	0.5	-	-	-	-	-	-	-
B_NAV_140	170.1	2	0.11	5.1	13.31	0.5	-	-	-	-	-	-	-
B_NAV_150	64.6	2	0.2	5.5	10.92	0.5	-	-	-	-	-	-	-
B_NAV_160	49.5	2	0.15	5.4	12.63	0.5	-	-	-	-	-	-	-
B_NAV_170	22.1	2	0.14	3.6	9.09	0.5	-	-	-	-	-	-	-

B_NAV_180	28.4	2	0.29	11.9	6.1	0.4	-	-	-	-	-	-	-
B_NAV_190	63.8	1.9	0.17	4.8	6.46	0.4	-	-	-	-	-	-	-
B_NAV_200	50.3	1.9	0.16	3.3	5.68	0.4	-	-	-	-	-	-	-
B_NAV_210	120	1.8	0.2	3.7	10.89	0.4	-	-	-	-	-	-	-
B_NAV_220	41.2	1.9	0.12	3	5.97	0.4	-	-	-	-	-	-	-
B_NAV_230	51.4	1.8	0.11	4.2	5.11	0.4	-	-	-	-	-	-	-
B_NAV_240	36.8	1.9	0.09	4.5	7.99	0.4	-	-	-	-	-	-	-
B_NAV_250	89.7	1.8	0.1	6.2	11.19	0.4	-	-	-	-	-	-	-
B_NAV_260	66.8	1.8	0.08	49.1	8.37	0.4	-	-	-	-	-	-	-
B_NAV_270	53	1.8	0.1	16.8	7.55	0.4	-	-	-	-	-	-	-
B_NAV_280	117.7	1.8	0.12	5.6	10.68	0.4	-	-	-	-	-	-	-
B_NAV_290	30.2	1.8	0.08	10.7	6.42	0.4	-	-	-	-	-	-	-
B_NAV_300	62.8	2.1	0.1	5.4	9.2	0.4	-	-	-	-	-	-	-
B_NAV_310	59	2.1	0.09	5.7	5.31	0.4	-	-	-	-	-	-	-
B_NAV_320	25.9	2.2	0.12	15.2	6.86	0.4	-	-	-	-	-	-	-
B_NEW_010	146.9	2	0.06	11.5	8.19	0.5	-	-	-	-	-	-	-
B_NEW_020	69	2	0.07	5	7.51	0.5	-	-	-	-	-	-	-
B_NOL_010	52.7	2	0.03	30.8	4.24	0.5	-	-	-	-	-	-	-
B_NOL_020	61.3	2	0.03	7.4	6.49	0.5	-	-	-	-	-	-	-
B_PON_010	100.5	2	0.02	7.3	8.35	0.5	-	-	-	-	-	-	-
B_PON_020	129.6	2	0.03	5.6	11.29	0.5	-	-	-	-	-	-	-
B_SAL_010	51.2	1.8	0	3.1	4.78	0.5	-	-	-	-	-	-	-
B_SAL_020	84.9	2	0.01	2.6	4.54	0.5	-	-	-	-	-	-	-
B_SAL_030	37.2	2	0.03	3.7	4.61	0.5	-	-	-	-	-	-	-
B_SAN_010	50.8	2	0.04	3	9.57	0.5	-	-	-	-	-	-	-
B_SAN_020	58.4	2	0.01	2.3	11.21	0.5	-	-	-	-	-	-	-
B_SAN_030	9.5	1.9	0.04	2.2	3.83	0.5	-	-	-	-	-	-	-
B_TEH_010	131.3	2.1	0.06	6	9.57	0.4	-	-	-	-	-	-	-
B_TEH_020	111.5	1.9	0.07	12.1	9.52	0.4	-	-	-	-	-	-	-
B_TEH_030	66.1	1.9	0.09	13.7	8.23	0.4	-	-	-	-	-	-	-
B_WAL_010	53.3	1.8	0.12	3.1	4.88	0.5	-	-	-	-	-	-	-
B_WAL_020	57.7	1.8	0.08	5.1	5.86	0.5	-	-	-	-	-	-	-

Appendix D: Hydrologic Analysis

Final HMS Calibrated Parameters 2007

Final HMS Calibrated Parameters, 2007													
Sub-Basin	Area, (sq. mi.)	Initial and Constant Losses			Snyder's Unit Hydrograph		Exponential Losses					Clark Unit Hydrograph	
		Initial Loss, (hr)	Constant Loss, (in/hr)	Percent Impervious	Lag Time, (hr)	Peaking Cefficient	Initial Range, (in)	Initial Coefficient, ((in/hr)^(1-x))	Coefficient Ratio	Exponent	Percent Impervious	Time of Concentration (hr)	Storage Coefficient (hr)
B_AQU_010	53.6	0.5	0.13	4.1	6.86	0.5	-	-	-	-	-	-	-
B_AQU_020	55.3	0.5	0.14	5.3	5.53	0.5	-	-	-	-	-	-	-
B_AQU_030	44	0.5	0.17	3.6	6.02	0.5	-	-	-	-	-	-	-
B_BES_010	51.3	-	-	-	-	-	0	0.5	3	0.6	3.6	14.93	48.05
B_BES_020	49.4	-	-	-	-	-	0	0.5	3	0.6	6.8	11.87	57.3
B_BIC_010	60.4	-	-	-	-	-	0	0.5	3	0.6	10.6	6.34	35.61
B_BIC_020	96.9	-	-	-	-	-	0	0.5	3	0.6	5.1	7.47	48.17
B_BIC_030	76.6	-	-	-	-	-	0	0.5	3	0.6	14.5	10.21	56.72
B_BIG_010	72.1	3.5	0.08	3.7	9.85	0.5	-	-	-	-	-	-	-
B_BIG_020	54.3	3.5	0.07	6.7	9.55	0.5	-	-	-	-	-	-	-
B_BIG_030	39.9	3.5	0.05	2.7	8.07	0.5	-	-	-	-	-	-	-
B_BIG_040	62.3	3.3	0.06	3.1	6.57	0.5	-	-	-	-	-	-	-
B_BIG_050	20.1	3.2	0.05	3.6	4.67	0.5	-	-	-	-	-	-	-
B_BIG_060	64.5	3.5	0.05	3	8.65	0.5	-	-	-	-	-	-	-
B_BIG_070	10.6	3.8	0.03	10.6	3.84	0.5	-	-	-	-	-	-	-
B_BIN_010	119.6	3.6	0.02	5.3	9.79	0.4	-	-	-	-	-	-	-
B_BIN_020	113.2	3.6	0.03	4.3	9.54	0.4	-	-	-	-	-	-	-
B_BIN_030	102.2	3.8	0.04	9.2	12.83	0.4	-	-	-	-	-	-	-
B_BRA_010	55.9	5.4	0.06	5	5.68	0.8	-	-	-	-	-	-	-
B_BRA_020	40	0.5	0.19	3	5.41	0.5	-	-	-	-	-	-	-
B_BRA_030	87.7	0.5	0.11	2.8	7.79	0.5	-	-	-	-	-	-	-
B_BRA_040	25.4	0.5	0.23	3.9	4.52	0.5	-	-	-	-	-	-	-
B_BRA_050	64.5	0.5	0.18	8.5	5.63	0.5	-	-	-	-	-	-	-
B_BRA_060	28.6	0.4	0.19	46.7	4.12	0.5	-	-	-	-	-	-	-
B_BRA_070	9.9	3.2	0.07	41.7	5.46	0.4	-	-	-	-	-	-	-
B_BRA_080	30.8	3.3	0.09	4.9	7.02	0.4	-	-	-	-	-	-	-
B_BRA_090	52.1	3.3	0.05	28.2	7.97	0.4	-	-	-	-	-	-	-
B_BRA_100	76	3.6	0.07	7.6	6.39	0.4	-	-	-	-	-	-	-
B_BRA_110	47.5	3.8	0.09	7.4	10.8	0.4	-	-	-	-	-	-	-
B_BRA_120	122.3	3.8	0.05	7.5	12.45	0.4	-	-	-	-	-	-	-
B_BRA_130	115.2	3.6	0.04	8.5	10.39	0.4	-	-	-	-	-	-	-
B_BRA_140	85.3	3.8	0.12	9.4	9.83	0.4	-	-	-	-	-	-	-
B_BRA_150	10.8	3.8	0.2	7.8	3.82	0.4	-	-	-	-	-	-	-
B_BRA_160	24.5	4.2	0.13	5.1	8.83	0.5	-	-	-	-	-	-	-
B_BRA_170	39.6	3.9	0.15	3.6	10.61	0.5	-	-	-	-	-	-	-
B_BRA_180	51.2	3.8	0.13	4.7	5.84	0.5	-	-	-	-	-	-	-
B_BRA_190	162.6	3.9	0.22	3.4	9.81	0.5	-	-	-	-	-	-	-
B_BRA_200	108.8	4.8	0.14	6.8	6.99	0.5	-	-	-	-	-	-	-
B_BRA_210	45.3	4.8	0.11	11	6.75	0.5	-	-	-	-	-	-	-
B_BRA_220	150.2	5.7	0.13	2.1	17.45	0.5	-	-	-	-	-	-	-
B_BRA_230	79.4	4.9	0.16	1.8	9.04	0.5	-	-	-	-	-	-	-
B_BRA_240	83.7	5.7	0.18	4.5	6.31	0.5	-	-	-	-	-	-	-
B_BRA_250	82.3	5.6	0.22	2.9	6.94	0.5	-	-	-	-	-	-	-
B_BRA_260	61	5	0.21	1.9	9	0.5	-	-	-	-	-	-	-
B_BRA_270	24.6	-	-	-	-	-	0	0.5	3	0.6	3.8	14.53	18.47
B_BRA_280	62.1	-	-	-	-	-	0	0.5	3	0.6	2.7	18.02	23.12
B_BRA_290	23.1	-	-	-	-	-	0	0.5	3	0.6	8.1	11.92	18.7
B_BRA_300	74.1	-	-	-	-	-	0	0.5	3	0.6	5.2	15.9	26.37
B_BRA_310	95.8	-	-	-	-	-	0	0.5	3	0.6	3.3	20.5	35.51
B_BRA_320	26.3	-	-	-	-	-	0	0.5	3	0.6	6	8.74	10.52
B_BRA_330	71.8	-	-	-	-	-	0	0.5	3	0.6	3.1	21.24	49.55
B_BRA_340	17.9	-	-	-	-	-	0	0.5	3	0.6	6.3	9.45	48.62
B_BRA_350	62.3	-	-	-	-	-	0	0.5	3	0.6	5.4	15.03	29.27
B_BRA_360	31.8	-	-	-	-	-	0	0.5	3	0.6	4.9	4.58	75.7
B_BRA_370	55.5	-	-	-	-	-	0	0.5	3	0.6	9.4	12.87	53.12
B_BRA_380	63.6	-	-	-	-	-	0	0.5	3	0.6	51.1	7.34	32.85
B_BRA_390	21.1	-	-	-	-	-	0	0.5	3	0.6	2	10.13	35.51
B_BRA_400	66.9	-	-	-	-	-	0	0.5	3	0.6	3.4	9.13	31.74

B_BRA_410	20.3	-	-	-	-	-	0	0.5	3	0.6	2.4	13.62	87.35
B_BRA_420	56.2	-	-	-	-	-	0	0.5	3	0.6	3.8	13.25	31.25
B_BRA_430	52	-	-	-	-	-	0	0.5	3	0.6	6	6.83	51.67
B_BRA_440	38.2	-	-	-	-	-	0	0.5	3	0.6	7.7	3.19	54.65
B_BRU_010	73.2	0.7	0.03	16.9	6.55	0.5	-	-	-	-	-	-	-
B_BRU_020	65.6	0.7	0.04	18.1	5.76	0.5	-	-	-	-	-	-	-
B_BRU_030	50.8	0.7	0.06	8.6	7.33	0.5	-	-	-	-	-	-	-
B_BRU_040	54.6	0.7	0.05	2.3	8.21	0.5	-	-	-	-	-	-	-
B_BRU_050	55.6	0.7	0.04	5.8	8.06	0.5	-	-	-	-	-	-	-
B_BRU_060	66.4	0.7	0.05	2.5	7.02	0.5	-	-	-	-	-	-	-
B_BRU_070	54	0.7	0.07	2.6	7.15	0.5	-	-	-	-	-	-	-
B_BRU_080	65.5	0.7	0.04	2.5	9.5	0.5	-	-	-	-	-	-	-
B_BRU_090	32.3	0.7	0.1	2.8	4.62	0.5	-	-	-	-	-	-	-
B_DAV_010	142	0.7	0.2	3.8	15.55	0.45	-	-	-	-	-	-	-
B_DAV_020	52.8	0.7	0.1	2.5	8.84	0.45	-	-	-	-	-	-	-
B_DAV_030	31.7	4	0.12	3.3	4.18	0.5	-	-	-	-	-	-	-
B_LAM_010	26.4	1.5	0.06	4.7	6.23	0.5	-	-	-	-	-	-	-
B_LEO_010	46.8	1.5	0.04	18.4	5.05	0.5	-	-	-	-	-	-	-
B_LEO_020	23.1	1.4	0.07	9.5	5.78	0.5	-	-	-	-	-	-	-
B_LIB_010	168.1	3.1	0.14	5.3	13	0.4	-	-	-	-	-	-	-
B_LIB_020	22.6	2.7	0.19	3.5	6.67	0.4	-	-	-	-	-	-	-
B_LIB_030	78.5	2.6	0.25	7.4	6.21	0.4	-	-	-	-	-	-	-
B_LIB_040	40.7	2.7	0.21	13.7	5.35	0.4	-	-	-	-	-	-	-
B_LIB_050	55.9	2.7	0.29	3.8	7.43	0.4	-	-	-	-	-	-	-
B_LIB_060	48.1	2.7	0.3	4.1	6.19	0.4	-	-	-	-	-	-	-
B_LIB_070	44.4	2.7	0.15	5.5	5.76	0.4	-	-	-	-	-	-	-
B_LIB_080	30.8	2.8	0.17	7.5	6.96	0.4	-	-	-	-	-	-	-
B_LIT_010	43.2	0.7	0.07	2.2	8.72	0.5	-	-	-	-	-	-	-
B_LIT_020	36.5	0.7	0.04	4.1	6.83	0.5	-	-	-	-	-	-	-
B_LIT_030	57.5	0.7	0.06	1.6	7.82	0.5	-	-	-	-	-	-	-
B_LIT_040	46.3	0.7	0.05	2.5	8	0.5	-	-	-	-	-	-	-
B_LIT_050	130.2	0.7	0.05	2.4	15.92	0.5	-	-	-	-	-	-	-
B_LIT_060	50	0.7	0.06	2.6	11.05	0.5	-	-	-	-	-	-	-
B_LIT_070	28.6	0.7	0.07	2.6	5.38	0.5	-	-	-	-	-	-	-
B_LIT_080	78.4	0.7	0.1	2.8	7.02	0.5	-	-	-	-	-	-	-
B_LIT_090	10.3	3.9	0.09	16	3.79	0.5	-	-	-	-	-	-	-
B_LIT_100	38	3.9	0.04	5.7	6.9	0.5	-	-	-	-	-	-	-
B_LIT_110	41.2	3.7	0.13	3.5	5.06	0.5	-	-	-	-	-	-	-
B_LIT_120	48.8	3.9	0.08	3.7	6.73	0.5	-	-	-	-	-	-	-
B_LIT_130	65	3.9	0.14	3.1	6.75	0.5	-	-	-	-	-	-	-
B_MIL_010	155.7	-	-	-	-	-	3	0.5	1	0.6	5.7	14.14	27.14
B_MIL_020	158.9	-	-	-	-	-	3	0.5	1	0.6	5.5	13.9	24.12
B_MIL_030	47.6	-	-	-	-	-	3	0.5	1	0.6	4.8	11.32	16.1
B_MIL_040	48.9	-	-	-	-	-	0	0.5	3	0.6	5.1	21.42	32.08
B_NAV_010	50.6	0.1	0.02	5	6.29	0.65	-	-	-	-	-	-	-
B_NAV_020	53.1	0.1	0.01	4.8	7.16	0.65	-	-	-	-	-	-	-
B_NAV_030	54	0.1	0.01	4.4	9.95	0.65	-	-	-	-	-	-	-
B_NAV_040	39.5	0.1	0.03	5.4	4.66	0.65	-	-	-	-	-	-	-
B_NAV_050	43.3	0.1	0.05	5.9	5.96	0.65	-	-	-	-	-	-	-
B_NAV_060	73	0.2	0.03	5.1	8.44	0.5	-	-	-	-	-	-	-
B_NAV_070	71.1	0.2	0.03	3.3	7.11	0.5	-	-	-	-	-	-	-
B_NAV_080	97.4	0	0.07	9.9	15.18	0.8	-	-	-	-	-	-	-
B_NAV_090	194	0.2	0.09	5.8	8.54	0.5	-	-	-	-	-	-	-
B_NAV_100	74.1	1	0.16	4.2	26.93	0.5	-	-	-	-	-	-	-
B_NAV_110	105.3	1	0.09	3	17.2	0.5	-	-	-	-	-	-	-
B_NAV_120	82.3	1	0.09	3	20.25	0.5	-	-	-	-	-	-	-
B_NAV_130	73.6	2	0.21	4.5	16.9	0.5	-	-	-	-	-	-	-
B_NAV_140	170.1	2	0.14	3.6	13.31	0.5	-	-	-	-	-	-	-
B_NAV_150	64.6	2	0.25	3.9	10.92	0.5	-	-	-	-	-	-	-
B_NAV_160	49.5	2	0.19	3.8	12.63	0.5	-	-	-	-	-	-	-
B_NAV_170	22.1	2	0.18	2.5	9.09	0.5	-	-	-	-	-	-	-

B_NAV_180	28.4	3	0.31	11.9	6.1	0.4	-	-	-	-	-	-	-
B_NAV_190	63.8	2.9	0.19	4.8	6.46	0.4	-	-	-	-	-	-	-
B_NAV_200	50.3	2.9	0.17	3.3	5.68	0.4	-	-	-	-	-	-	-
B_NAV_210	120	2.6	0.22	3.7	10.89	0.4	-	-	-	-	-	-	-
B_NAV_220	41.2	2.9	0.13	3	5.97	0.4	-	-	-	-	-	-	-
B_NAV_230	51.4	2.7	0.12	4.2	5.11	0.4	-	-	-	-	-	-	-
B_NAV_240	36.8	2.8	0.11	4.5	7.99	0.4	-	-	-	-	-	-	-
B_NAV_250	89.7	2.6	0.11	6.2	11.19	0.4	-	-	-	-	-	-	-
B_NAV_260	66.8	2.7	0.1	49.1	8.37	0.4	-	-	-	-	-	-	-
B_NAV_270	53	2.7	0.11	16.8	7.55	0.4	-	-	-	-	-	-	-
B_NAV_280	117.7	2.7	0.13	5.6	10.68	0.4	-	-	-	-	-	-	-
B_NAV_290	30.2	2.7	0.09	10.7	6.42	0.4	-	-	-	-	-	-	-
B_NAV_300	62.8	3.1	0.11	5.4	9.2	0.4	-	-	-	-	-	-	-
B_NAV_310	59	3.1	0.11	5.7	5.31	0.4	-	-	-	-	-	-	-
B_NAV_320	25.9	3.4	0.14	15.2	6.86	0.4	-	-	-	-	-	-	-
B_NEW_010	146.9	4.9	0.16	5.8	8.19	0.5	-	-	-	-	-	-	-
B_NEW_020	69	4.9	0.17	2.5	7.51	0.5	-	-	-	-	-	-	-
B_NOL_010	52.7	1.5	0.05	30.8	4.53	0.5	-	-	-	-	-	-	-
B_NOL_020	61.3	1.5	0.04	7.4	6.94	0.5	-	-	-	-	-	-	-
B_PON_010	100.5	4	0.04	7.3	8.35	0.5	-	-	-	-	-	-	-
B_PON_020	129.6	4	0.05	5.6	11.29	0.5	-	-	-	-	-	-	-
B_SAL_010	51.2	1.4	0.01	3.1	5.11	0.5	-	-	-	-	-	-	-
B_SAL_020	84.9	1.5	0.02	2.6	4.86	0.5	-	-	-	-	-	-	-
B_SAL_030	37.2	1.5	0.04	3.7	4.93	0.5	-	-	-	-	-	-	-
B_SAN_010	50.8	0.7	0.08	3	9.11	0.5	-	-	-	-	-	-	-
B_SAN_020	58.4	0.7	0.04	2.3	10.68	0.5	-	-	-	-	-	-	-
B_SAN_030	9.5	0.7	0.08	2.2	3.64	0.5	-	-	-	-	-	-	-
B_TEH_010	131.3	3.8	0.02	6	9.57	0.4	-	-	-	-	-	-	-
B_TEH_020	111.5	3.4	0.03	12.1	9.52	0.4	-	-	-	-	-	-	-
B_TEH_030	66.1	1.9	0.09	13.7	8.23	0.4	-	-	-	-	-	-	-
B_WAL_010	53.3	4.4	0.23	1.5	4.88	0.5	-	-	-	-	-	-	-
B_WAL_020	57.7	4.6	0.18	2.5	5.86	0.5	-	-	-	-	-	-	-

Appendix D: Hydrologic Analysis

Final HMS Calibrated Parameters 2015

Final HMS Calibrated Parameters, 2015													
Sub-Basin	Area, (sq. mi.)	Initial and Constant Losses			Snyder's Unit Hydrograph		Exponential Losses					Clark Unit Hydrograph	
		Initial Loss, (hr)	Constant Loss, (in/hr)	Percent Impervious	Lag Time, (hr)	Peaking Cefficient	Initial Range, (in)	Initial Coefficient, ((in/hr)^(1-x))	Coefficient Ratio	Exponent	Percent Impervious	Time of Concentration (hr)	Storage Coefficient (hr)
B_AQU_010	53.6	3.4	0.09	4.1	6.86	0.5	-	-	-	-	-	-	-
B_AQU_020	55.3	3.4	0.11	5.3	5.53	0.5	-	-	-	-	-	-	-
B_AQU_030	44	3.1	0.13	3.6	6.02	0.5	-	-	-	-	-	-	-
B_BES_010	51.3	-	-	-	-	-	0	0.5	3	0.6	3.6	14.93	48.05
B_BES_020	49.4	-	-	-	-	-	0	0.5	3	0.6	6.8	11.87	57.3
B_BIC_010	60.4	-	-	-	-	-	0	0.5	3	0.6	10.6	6.34	35.61
B_BIC_020	96.9	-	-	-	-	-	0	0.5	3	0.6	5.1	7.47	48.17
B_BIC_030	76.6	-	-	-	-	-	0	0.5	3	0.6	14.5	10.21	56.72
B_BIG_010	72.1	0.7	0.08	3.7	11.08	0.5	-	-	-	-	-	-	-
B_BIG_020	54.3	0.7	0.07	6.7	10.75	0.5	-	-	-	-	-	-	-
B_BIG_030	39.9	0.7	0.05	2.7	9.08	0.5	-	-	-	-	-	-	-
B_BIG_040	62.3	0.7	0.06	3.1	7.39	0.5	-	-	-	-	-	-	-
B_BIG_050	20.1	0.6	0.06	3.6	5.26	0.5	-	-	-	-	-	-	-
B_BIG_060	64.5	0.7	0.05	3	9.73	0.5	-	-	-	-	-	-	-
B_BIG_070	10.6	3.6	0.09	10.6	3.84	0.5	-	-	-	-	-	-	-
B_BIN_010	119.6	8.5	0.03	5.3	9.79	0.4	-	-	-	-	-	-	-
B_BIN_020	113.2	8.5	0.04	4.3	9.54	0.4	-	-	-	-	-	-	-
B_BIN_030	102.2	8.9	0.06	9.2	12.83	0.4	-	-	-	-	-	-	-
B_BRA_010	55.9	2.7	0.19	5	5.68	0.8	-	-	-	-	-	-	-
B_BRA_020	40	3.2	0.15	3	5.41	0.5	-	-	-	-	-	-	-
B_BRA_030	87.7	3.2	0.08	2.8	7.79	0.5	-	-	-	-	-	-	-
B_BRA_040	25.4	2.9	0.18	3.9	4.52	0.5	-	-	-	-	-	-	-
B_BRA_050	64.5	2.9	0.14	8.5	5.63	0.5	-	-	-	-	-	-	-
B_BRA_060	28.6	2.7	0.14	46.7	4.12	0.5	-	-	-	-	-	-	-
B_BRA_070	9.9	7.5	0.08	41.7	5.46	0.4	-	-	-	-	-	-	-
B_BRA_080	30.8	7.7	0.11	4.9	7.02	0.4	-	-	-	-	-	-	-
B_BRA_090	52.1	7.7	0.06	28.2	7.97	0.4	-	-	-	-	-	-	-
B_BRA_100	76	8.5	0.08	7.6	6.39	0.4	-	-	-	-	-	-	-
B_BRA_110	47.5	8.9	0.11	7.4	10.8	0.4	-	-	-	-	-	-	-
B_BRA_120	122.3	8.9	0.07	7.5	12.45	0.4	-	-	-	-	-	-	-
B_BRA_130	115.2	8.5	0.06	8.5	10.39	0.4	-	-	-	-	-	-	-
B_BRA_140	85.3	8.9	0.14	9.4	9.83	0.4	-	-	-	-	-	-	-
B_BRA_150	10.8	8.9	0.22	7.8	3.82	0.4	-	-	-	-	-	-	-
B_BRA_160	24.5	4	0.23	5.1	8.83	0.5	-	-	-	-	-	-	-
B_BRA_170	39.6	3.7	0.24	3.6	10.61	0.5	-	-	-	-	-	-	-
B_BRA_180	51.2	3.6	0.22	4.7	5.84	0.5	-	-	-	-	-	-	-
B_BRA_190	162.6	3.7	0.34	3.4	9.81	0.5	-	-	-	-	-	-	-
B_BRA_200	108.8	1.4	0.06	13.7	6.99	0.5	-	-	-	-	-	-	-
B_BRA_210	45.3	1.4	0.04	22.1	6.75	0.5	-	-	-	-	-	-	-
B_BRA_220	150.2	1.7	0.05	4.3	17.45	0.5	-	-	-	-	-	-	-
B_BRA_230	79.4	1.5	0.07	3.5	9.04	0.5	-	-	-	-	-	-	-
B_BRA_240	83.7	1.7	0.09	9	6.31	0.5	-	-	-	-	-	-	-
B_BRA_250	82.3	1.7	0.11	5.8	6.94	0.5	-	-	-	-	-	-	-
B_BRA_260	61	1.5	0.1	3.8	9	0.5	-	-	-	-	-	-	-
B_BRA_270	24.6	-	-	-	-	-	0	0.7	1	0.6	5.1	6.98	17.75
B_BRA_280	62.1	-	-	-	-	-	0	0.7	1	0.6	3.5	8.66	22.22
B_BRA_290	23.1	-	-	-	-	-	0	0.7	1	0.6	10.9	5.73	17.96
B_BRA_300	74.1	-	-	-	-	-	0	0.7	1	0.6	7	7.64	25.33
B_BRA_310	95.8	-	-	-	-	-	0	0.7	1	0.6	4.4	9.85	34.13
B_BRA_320	26.3	-	-	-	-	-	0	0.7	1	0.6	8	4.2	10.11
B_BRA_330	71.8	-	-	-	-	-	0	0.5	3	0.6	3.1	21.24	49.55
B_BRA_340	17.9	-	-	-	-	-	0	0.5	3	0.6	6.3	9.45	48.62
B_BRA_350	62.3	-	-	-	-	-	0	0.5	3	0.6	5.4	15.03	29.27
B_BRA_360	31.8	-	-	-	-	-	0	0.5	3	0.6	4.9	4.58	75.7
B_BRA_370	55.5	-	-	-	-	-	0	0.5	3	0.6	9.4	12.87	53.12
B_BRA_380	63.6	-	-	-	-	-	0	0.5	3	0.6	51.1	7.34	32.85
B_BRA_390	21.1	-	-	-	-	-	0	0.5	3	0.6	2	10.13	35.51
B_BRA_400	66.9	-	-	-	-	-	0	0.5	3	0.6	3.4	9.13	31.74

B_BRA_410	20.3	-	-	-	-	-	0	0.5	3	0.6	2.4	13.62	87.35
B_BRA_420	56.2	-	-	-	-	-	0	0.5	3	0.6	3.8	13.25	31.25
B_BRA_430	52	-	-	-	-	-	0	0.5	3	0.6	6	6.83	51.67
B_BRA_440	38.2	-	-	-	-	-	0	0.5	3	0.6	7.7	3.19	54.65
B_BRU_010	73.2	2	0.06	16.9	6.88	0.5	-	-	-	-	-	-	-
B_BRU_020	65.6	2	0.07	18.1	6.05	0.5	-	-	-	-	-	-	-
B_BRU_030	50.8	2	0.09	8.6	7.69	0.5	-	-	-	-	-	-	-
B_BRU_040	54.6	2	0.08	2.3	8.62	0.5	-	-	-	-	-	-	-
B_BRU_050	55.6	2	0.07	5.8	8.47	0.5	-	-	-	-	-	-	-
B_BRU_060	66.4	2	0.07	2.5	7.38	0.5	-	-	-	-	-	-	-
B_BRU_070	54	2	0.1	2.6	7.51	0.5	-	-	-	-	-	-	-
B_BRU_080	65.5	2	0.06	2.5	9.97	0.5	-	-	-	-	-	-	-
B_BRU_090	32.3	1.9	0.14	2.8	4.85	0.5	-	-	-	-	-	-	-
B_DAV_010	142	0.2	0.15	3.8	10.37	0.5	-	-	-	-	-	-	-
B_DAV_020	52.8	0.2	0.06	2.6	5.89	0.5	-	-	-	-	-	-	-
B_DAV_030	31.7	1.2	0.04	6.6	4.18	0.5	-	-	-	-	-	-	-
B_LAM_010	26.4	3	0.17	4.7	5.82	0.5	-	-	-	-	-	-	-
B_LEO_010	46.8	3	0.14	18.4	4.73	0.5	-	-	-	-	-	-	-
B_LEO_020	23.1	2.9	0.19	9.5	5.41	0.5	-	-	-	-	-	-	-
B_LIB_010	168.1	2.1	0.1	5.3	13	0.4	-	-	-	-	-	-	-
B_LIB_020	22.6	1.8	0.14	3.5	6.67	0.4	-	-	-	-	-	-	-
B_LIB_030	78.5	1.8	0.2	7.4	6.21	0.4	-	-	-	-	-	-	-
B_LIB_040	40.7	1.8	0.16	13.7	5.35	0.4	-	-	-	-	-	-	-
B_LIB_050	55.9	1.8	0.23	3.8	7.43	0.4	-	-	-	-	-	-	-
B_LIB_060	48.1	1.8	0.24	4.1	6.19	0.4	-	-	-	-	-	-	-
B_LIB_070	44.4	1.8	0.1	5.5	5.76	0.4	-	-	-	-	-	-	-
B_LIB_080	30.8	1.9	0.12	7.5	6.96	0.4	-	-	-	-	-	-	-
B_LIT_010	43.2	2	0.11	2.2	9.15	0.5	-	-	-	-	-	-	-
B_LIT_020	36.5	2	0.07	4.1	7.17	0.5	-	-	-	-	-	-	-
B_LIT_030	57.5	2	0.09	1.6	8.22	0.5	-	-	-	-	-	-	-
B_LIT_040	46.3	1.9	0.08	2.5	8.4	0.5	-	-	-	-	-	-	-
B_LIT_050	130.2	2	0.08	2.4	16.71	0.5	-	-	-	-	-	-	-
B_LIT_060	50	1.9	0.1	2.6	11.6	0.5	-	-	-	-	-	-	-
B_LIT_070	28.6	1.9	0.11	2.6	5.65	0.5	-	-	-	-	-	-	-
B_LIT_080	78.4	1.9	0.14	2.8	7.37	0.5	-	-	-	-	-	-	-
B_LIT_090	10.3	3.7	0.17	16	3.79	0.5	-	-	-	-	-	-	-
B_LIT_100	38	3.7	0.11	5.7	6.9	0.5	-	-	-	-	-	-	-
B_LIT_110	41.2	3.5	0.22	3.5	5.06	0.5	-	-	-	-	-	-	-
B_LIT_120	48.8	3.7	0.17	3.7	6.73	0.5	-	-	-	-	-	-	-
B_LIT_130	65	3.7	0.24	3.1	6.75	0.5	-	-	-	-	-	-	-
B_MIL_010	155.7	-	-	-	-	-	0	0.18	1	0	13	21.28	18.56
B_MIL_020	158.9	-	-	-	-	-	0	0.18	1	0	13	20.92	16.49
B_MIL_030	47.6	-	-	-	-	-	2	0.1	1	0	11.5	6.5	8.41
B_MIL_040	48.9	-	-	-	-	-	0	0.7	1	0.6	6.8	10.29	30.83
B_NAV_010	50.6	1.9	0.06	5	5.67	0.5	-	-	-	-	-	-	-
B_NAV_020	53.1	1.9	0.04	4.8	6.45	0.5	-	-	-	-	-	-	-
B_NAV_030	54	1.9	0.05	4.4	8.97	0.5	-	-	-	-	-	-	-
B_NAV_040	39.5	1.8	0.08	5.4	4.2	0.5	-	-	-	-	-	-	-
B_NAV_050	43.3	1.8	0.1	5.9	5.37	0.5	-	-	-	-	-	-	-
B_NAV_060	73	2.9	0.05	5.1	8.86	0.5	-	-	-	-	-	-	-
B_NAV_070	71.1	2.7	0.06	3.3	7.46	0.5	-	-	-	-	-	-	-
B_NAV_080	97.4	1.8	0.07	9.9	15.18	0.8	-	-	-	-	-	-	-
B_NAV_090	194	2.9	0.12	5.8	8.96	0.5	-	-	-	-	-	-	-
B_NAV_100	74.1	4	0.22	4.2	26.93	0.5	-	-	-	-	-	-	-
B_NAV_110	105.3	3.8	0.13	3	17.2	0.5	-	-	-	-	-	-	-
B_NAV_120	82.3	4	0.14	3	20.25	0.5	-	-	-	-	-	-	-
B_NAV_130	73.6	0	0.17	6.5	16.9	0.5	-	-	-	-	-	-	-
B_NAV_140	170.1	0	0.11	5.1	13.31	0.5	-	-	-	-	-	-	-
B_NAV_150	64.6	0	0.2	5.5	10.92	0.5	-	-	-	-	-	-	-
B_NAV_160	49.5	0	0.15	5.4	12.63	0.5	-	-	-	-	-	-	-
B_NAV_170	22.1	0	0.14	3.6	9.09	0.5	-	-	-	-	-	-	-

B_NAV_180	28.4	3	0.25	11.9	6.1	0.4	-	-	-	-	-	-	-
B_NAV_190	63.8	2.9	0.14	4.8	6.46	0.4	-	-	-	-	-	-	-
B_NAV_200	50.3	2.9	0.13	3.3	5.68	0.4	-	-	-	-	-	-	-
B_NAV_210	120	2.6	0.17	3.7	10.89	0.4	-	-	-	-	-	-	-
B_NAV_220	41.2	2.9	0.09	3	5.97	0.4	-	-	-	-	-	-	-
B_NAV_230	51.4	2.7	0.08	4.2	5.11	0.4	-	-	-	-	-	-	-
B_NAV_240	36.8	2.8	0.07	4.5	7.99	0.4	-	-	-	-	-	-	-
B_NAV_250	89.7	2.6	0.08	6.2	11.19	0.4	-	-	-	-	-	-	-
B_NAV_260	66.8	2.7	0.07	49.1	8.37	0.4	-	-	-	-	-	-	-
B_NAV_270	53	2.7	0.08	16.8	7.55	0.4	-	-	-	-	-	-	-
B_NAV_280	117.7	2.7	0.09	5.6	10.68	0.4	-	-	-	-	-	-	-
B_NAV_290	30.2	2.7	0.06	10.7	6.42	0.4	-	-	-	-	-	-	-
B_NAV_300	62.8	3.1	0.08	5.4	9.2	0.4	-	-	-	-	-	-	-
B_NAV_310	59	3.1	0.07	5.7	5.31	0.4	-	-	-	-	-	-	-
B_NAV_320	25.9	3.4	0.1	15.2	6.86	0.4	-	-	-	-	-	-	-
B_NEW_010	146.9	1.5	0.06	11.5	8.19	0.5	-	-	-	-	-	-	-
B_NEW_020	69	1.5	0.07	5	7.51	0.5	-	-	-	-	-	-	-
B_NOL_010	52.7	3	0.15	30.8	4.24	0.5	-	-	-	-	-	-	-
B_NOL_020	61.3	3	0.14	7.4	6.49	0.5	-	-	-	-	-	-	-
B_PON_010	100.5	3.8	0.09	7.3	8.35	0.5	-	-	-	-	-	-	-
B_PON_020	129.6	3.8	0.11	5.6	11.29	0.5	-	-	-	-	-	-	-
B_SAL_010	51.2	2.8	0.08	3.1	4.78	0.5	-	-	-	-	-	-	-
B_SAL_020	84.9	3	0.1	2.6	4.54	0.5	-	-	-	-	-	-	-
B_SAL_030	37.2	3	0.15	3.7	4.61	0.5	-	-	-	-	-	-	-
B_SAN_010	50.8	2	0.11	3	9.57	0.5	-	-	-	-	-	-	-
B_SAN_020	58.4	2	0.07	2.3	11.21	0.5	-	-	-	-	-	-	-
B_SAN_030	9.5	1.9	0.12	2.2	3.83	0.5	-	-	-	-	-	-	-
B_TEH_010	131.3	9	0.03	6	9.57	0.4	-	-	-	-	-	-	-
B_TEH_020	111.5	8.1	0.04	12.1	9.52	0.4	-	-	-	-	-	-	-
B_TEH_030	66.1	7.9	0.05	13.7	8.23	0.4	-	-	-	-	-	-	-
B_WAL_010	53.3	1.3	0.12	3.1	4.88	0.5	-	-	-	-	-	-	-
B_WAL_020	57.7	1.4	0.08	5.1	5.86	0.5	-	-	-	-	-	-	-

Appendix D: Hydrologic Analysis

Final HMS Calibrated Parameters 2016

Final HMS Calibrated Parameters, 2016													
Sub-Basin	Area, (sq. mi.)	Initial and Constant Losses			Snyder's Unit Hydrograph		Exponential Losses					Clark Unit Hydrograph	
		Initial Loss, (hr)	Constant Loss, (in/hr)	Percent Impervious	Lag Time, (hr)	Peaking Cefficient	Initial Range, (in)	Initial Coefficient, ((in/hr)^(1-x))	Coefficient Ratio	Exponent	Percent Impervious	Time of Concentration (hr)	Storage Coefficient (hr)
B_AQU_010	53.6	3.7	0.03	1.4	6.86	0.5	-	-	-	-	-	-	-
B_AQU_020	55.3	3.7	0.04	1.8	5.53	0.5	-	-	-	-	-	-	-
B_AQU_030	44	3.4	0.06	1.2	6.02	0.5	-	-	-	-	-	-	-
B_BES_010	51.3	-	-	-	-	-	0	0.5	3	0.6	3.6	14.93	48.05
B_BES_020	49.4	-	-	-	-	-	0	0.5	3	0.6	6.8	11.87	57.3
B_BIC_010	60.4	-	-	-	-	-	0	0.05	3	0.6	12.7	5.3	23.83
B_BIC_020	96.9	-	-	-	-	-	0	0.05	3	0.6	6.1	6.25	32.24
B_BIC_030	76.6	-	-	-	-	-	0	0.05	3	0.6	17.3	8.54	37.96
B_BIG_010	72.1	0.7	0.08	3.7	11.08	0.5	-	-	-	-	-	-	-
B_BIG_020	54.3	0.7	0.07	6.7	10.75	0.5	-	-	-	-	-	-	-
B_BIG_030	39.9	0.7	0.05	2.7	9.08	0.5	-	-	-	-	-	-	-
B_BIG_040	62.3	0.7	0.06	3.1	7.39	0.5	-	-	-	-	-	-	-
B_BIG_050	20.1	0.6	0.06	3.6	5.26	0.5	-	-	-	-	-	-	-
B_BIG_060	64.5	0.7	0.05	3	9.73	0.5	-	-	-	-	-	-	-
B_BIG_070	10.6	3.6	0.09	10.6	3.84	0.5	-	-	-	-	-	-	-
B_BIN_010	119.6	8.5	0.03	5.3	9.79	0.4	-	-	-	-	-	-	-
B_BIN_020	113.2	8.5	0.04	4.3	9.54	0.4	-	-	-	-	-	-	-
B_BIN_030	102.2	8.9	0.06	9.2	12.83	0.4	-	-	-	-	-	-	-
B_BRA_010	55.9	2.1	0.19	5	1.99	0.7	-	-	-	-	-	-	-
B_BRA_020	40	3.5	0.07	1	5.41	0.5	-	-	-	-	-	-	-
B_BRA_030	87.7	3.5	0.03	0.9	7.79	0.5	-	-	-	-	-	-	-
B_BRA_040	25.4	3.2	0.1	1.3	4.52	0.5	-	-	-	-	-	-	-
B_BRA_050	64.5	3.2	0.06	2.8	5.63	0.5	-	-	-	-	-	-	-
B_BRA_060	28.6	3	0.07	15.6	4.12	0.5	-	-	-	-	-	-	-
B_BRA_070	9.9	7.5	0.08	41.7	5.46	0.4	-	-	-	-	-	-	-
B_BRA_080	30.8	7.7	0.11	4.9	7.02	0.4	-	-	-	-	-	-	-
B_BRA_090	52.1	7.7	0.06	28.2	7.97	0.4	-	-	-	-	-	-	-
B_BRA_100	76	8.5	0.08	7.6	6.39	0.4	-	-	-	-	-	-	-
B_BRA_110	47.5	8.9	0.11	7.4	10.8	0.4	-	-	-	-	-	-	-
B_BRA_120	122.3	8.9	0.07	7.5	12.45	0.4	-	-	-	-	-	-	-
B_BRA_130	115.2	8.5	0.06	8.5	10.39	0.4	-	-	-	-	-	-	-
B_BRA_140	85.3	8.9	0.14	9.4	9.83	0.4	-	-	-	-	-	-	-
B_BRA_150	10.8	8.9	0.22	7.8	3.82	0.4	-	-	-	-	-	-	-
B_BRA_160	24.5	4	0.23	5.1	8.83	0.5	-	-	-	-	-	-	-
B_BRA_170	39.6	3.7	0.24	3.6	10.61	0.5	-	-	-	-	-	-	-
B_BRA_180	51.2	3.6	0.22	4.7	5.84	0.5	-	-	-	-	-	-	-
B_BRA_190	162.6	3.7	0.34	3.4	9.81	0.5	-	-	-	-	-	-	-
B_BRA_200	108.8	1.4	0.06	13.7	6.99	0.5	-	-	-	-	-	-	-
B_BRA_210	45.3	1.4	0.04	22.1	6.75	0.5	-	-	-	-	-	-	-
B_BRA_220	150.2	1.7	0.05	4.3	17.45	0.5	-	-	-	-	-	-	-
B_BRA_230	79.4	1.5	0.07	3.5	9.04	0.5	-	-	-	-	-	-	-
B_BRA_240	83.7	1.7	0.09	9	6.31	0.5	-	-	-	-	-	-	-
B_BRA_250	82.3	1.7	0.11	5.8	6.94	0.7	-	-	-	-	-	-	-
B_BRA_260	61	1.5	0.1	3.8	9	0.7	-	-	-	-	-	-	-
B_BRA_270	24.6	-	-	-	-	-	0	0.7	1	0.6	5.1	6.98	17.75
B_BRA_280	62.1	-	-	-	-	-	0	0.7	1	0.6	3.5	8.66	22.22
B_BRA_290	23.1	-	-	-	-	-	0	0.7	1	0.6	10.9	5.73	17.96
B_BRA_300	74.1	-	-	-	-	-	0	0.7	1	0.6	7	7.64	25.33
B_BRA_310	95.8	-	-	-	-	-	0	0.7	1	0.6	4.4	9.85	34.13
B_BRA_320	26.3	-	-	-	-	-	0	0.7	1	0.6	8	4.2	10.11
B_BRA_330	71.8	-	-	-	-	-	0	0.5	3	0.6	3.1	21.24	49.55
B_BRA_340	17.9	-	-	-	-	-	0	0.5	3	0.6	6.3	9.45	48.62
B_BRA_350	62.3	-	-	-	-	-	0	0.5	3	0.6	5.4	15.03	29.27
B_BRA_360	31.8	-	-	-	-	-	0	0.5	3	0.6	4.9	4.58	75.7
B_BRA_370	55.5	-	-	-	-	-	0	0.5	3	0.6	9.4	12.87	53.12
B_BRA_380	63.6	-	-	-	-	-	0	0	1	0	51.1	7.34	8.21
B_BRA_390	21.1	-	-	-	-	-	0	0	1	0	2	10.13	8.88
B_BRA_400	66.9	-	-	-	-	-	0	0	1	0	3.4	9.13	7.93

B_BRA_410	20.3	-	-	-	-	-	0	0	1	0	2.4	13.62	21.84
B_BRA_420	56.2	-	-	-	-	-	0	0	1	0	3.8	13.25	7.81
B_BRA_430	52	-	-	-	-	-	0	0	1	0	6	6.83	12.92
B_BRA_440	38.2	-	-	-	-	-	0	0	1	0	7.7	3.19	13.66
B_BRU_010	73.2	3.3	0.06	16.9	6.88	0.5	-	-	-	-	-	-	-
B_BRU_020	65.6	3.3	0.07	18.1	6.05	0.5	-	-	-	-	-	-	-
B_BRU_030	50.8	3.3	0.09	8.6	7.69	0.5	-	-	-	-	-	-	-
B_BRU_040	54.6	3.3	0.08	2.3	8.62	0.5	-	-	-	-	-	-	-
B_BRU_050	55.6	3.3	0.07	5.8	8.47	0.5	-	-	-	-	-	-	-
B_BRU_060	66.4	3.3	0.07	2.5	7.38	0.5	-	-	-	-	-	-	-
B_BRU_070	54	3.3	0.1	2.6	7.51	0.5	-	-	-	-	-	-	-
B_BRU_080	65.5	3.3	0.06	2.5	9.97	0.5	-	-	-	-	-	-	-
B_BRU_090	32.3	3.2	0.14	2.8	4.85	0.5	-	-	-	-	-	-	-
B_DAV_010	142	7.3	0.17	3.8	10.37	0.5	-	-	-	-	-	-	-
B_DAV_020	52.8	7.3	0.07	2.6	5.89	0.5	-	-	-	-	-	-	-
B_DAV_030	31.7	1.2	0.04	6.6	4.18	0.5	-	-	-	-	-	-	-
B_LAM_010	26.4	7	0.17	4.7	5.82	0.5	-	-	-	-	-	-	-
B_LEO_010	46.8	7	0.14	18.4	4.73	0.5	-	-	-	-	-	-	-
B_LEO_020	23.1	6.7	0.19	9.5	5.41	0.5	-	-	-	-	-	-	-
B_LIB_010	168.1	2.1	0.1	5.3	13	0.4	-	-	-	-	-	-	-
B_LIB_020	22.6	1.8	0.14	3.5	6.67	0.4	-	-	-	-	-	-	-
B_LIB_030	78.5	1.8	0.2	7.4	6.21	0.4	-	-	-	-	-	-	-
B_LIB_040	40.7	1.8	0.16	13.7	5.35	0.4	-	-	-	-	-	-	-
B_LIB_050	55.9	1.8	0.23	3.8	7.43	0.4	-	-	-	-	-	-	-
B_LIB_060	48.1	1.8	0.24	4.1	6.19	0.4	-	-	-	-	-	-	-
B_LIB_070	44.4	1.8	0.1	5.5	5.76	0.4	-	-	-	-	-	-	-
B_LIB_080	30.8	1.9	0.12	7.5	6.96	0.4	-	-	-	-	-	-	-
B_LIT_010	43.2	3.3	0.11	2.2	9.15	0.5	-	-	-	-	-	-	-
B_LIT_020	36.5	3.3	0.07	4.1	7.17	0.5	-	-	-	-	-	-	-
B_LIT_030	57.5	3.3	0.09	1.6	8.22	0.5	-	-	-	-	-	-	-
B_LIT_040	46.3	3.1	0.08	2.5	8.4	0.5	-	-	-	-	-	-	-
B_LIT_050	130.2	3.3	0.08	2.4	16.71	0.5	-	-	-	-	-	-	-
B_LIT_060	50	3.2	0.1	2.6	11.6	0.5	-	-	-	-	-	-	-
B_LIT_070	28.6	3.2	0.11	2.6	5.65	0.5	-	-	-	-	-	-	-
B_LIT_080	78.4	3.2	0.14	2.8	7.37	0.5	-	-	-	-	-	-	-
B_LIT_090	10.3	3.7	0.17	16	3.79	0.5	-	-	-	-	-	-	-
B_LIT_100	38	3.7	0.11	5.7	6.9	0.5	-	-	-	-	-	-	-
B_LIT_110	41.2	3.5	0.22	3.5	5.06	0.5	-	-	-	-	-	-	-
B_LIT_120	48.8	3.7	0.17	3.7	6.73	0.5	-	-	-	-	-	-	-
B_LIT_130	65	3.7	0.24	3.1	6.75	0.5	-	-	-	-	-	-	-
B_MIL_010	155.7	-	-	-	-	-	0	0.01	1	0	16.4	8.12	14.17
B_MIL_020	158.9	-	-	-	-	-	0	0.01	1	0	17	7.98	12.59
B_MIL_030	47.6	-	-	-	-	-	0	0.01	1	0	14.5	4.32	5.59
B_MIL_040	48.9	-	-	-	-	-	0	0.7	1	0.6	6.8	10.29	30.83
B_NAV_010	50.6	2.4	0.11	5	13.45	0.3	-	-	-	-	-	-	-
B_NAV_020	53.1	2.3	0.09	4.8	9.68	0.3	-	-	-	-	-	-	-
B_NAV_030	54	2.3	0.1	4.4	8.51	0.3	-	-	-	-	-	-	-
B_NAV_040	39.5	2.3	0.14	5.4	6.3	0.3	-	-	-	-	-	-	-
B_NAV_050	43.3	2.3	0.17	5.9	8.06	0.3	-	-	-	-	-	-	-
B_NAV_060	73	2.9	0.05	5.1	8.86	0.5	-	-	-	-	-	-	-
B_NAV_070	71.1	2.7	0.06	3.3	7.46	0.5	-	-	-	-	-	-	-
B_NAV_080	97.4	4.2	0.11	9.9	18.07	0.65	-	-	-	-	-	-	-
B_NAV_090	194	2.9	0.12	5.8	8.96	0.5	-	-	-	-	-	-	-
B_NAV_100	74.1	0.5	0.13	6	29.92	0.6	-	-	-	-	-	-	-
B_NAV_110	105.3	0.5	0.06	4.3	19.11	0.6	-	-	-	-	-	-	-
B_NAV_120	82.3	0.5	0.07	4.3	22.5	0.6	-	-	-	-	-	-	-
B_NAV_130	73.6	0	0.17	6.5	16.9	0.5	-	-	-	-	-	-	-
B_NAV_140	170.1	0	0.11	5.1	13.31	0.5	-	-	-	-	-	-	-
B_NAV_150	64.6	0	0.2	5.5	10.92	0.5	-	-	-	-	-	-	-
B_NAV_160	49.5	0	0.15	5.4	12.63	0.5	-	-	-	-	-	-	-
B_NAV_170	22.1	0	0.14	3.6	9.09	0.5	-	-	-	-	-	-	-

B_NAV_180	28.4	3	0.25	11.9	6.1	0.4	-	-	-	-	-	-	-
B_NAV_190	63.8	2.9	0.14	4.8	6.46	0.4	-	-	-	-	-	-	-
B_NAV_200	50.3	2.9	0.13	3.3	5.68	0.4	-	-	-	-	-	-	-
B_NAV_210	120	2.6	0.17	3.7	10.89	0.4	-	-	-	-	-	-	-
B_NAV_220	41.2	2.9	0.09	3	5.97	0.4	-	-	-	-	-	-	-
B_NAV_230	51.4	2.7	0.08	4.2	5.11	0.4	-	-	-	-	-	-	-
B_NAV_240	36.8	2.8	0.07	4.5	7.99	0.4	-	-	-	-	-	-	-
B_NAV_250	89.7	2.6	0.08	6.2	11.19	0.4	-	-	-	-	-	-	-
B_NAV_260	66.8	2.7	0.07	49.1	8.37	0.4	-	-	-	-	-	-	-
B_NAV_270	53	2.7	0.08	16.8	7.55	0.4	-	-	-	-	-	-	-
B_NAV_280	117.7	2.7	0.09	5.6	10.68	0.4	-	-	-	-	-	-	-
B_NAV_290	30.2	2.7	0.06	10.7	6.42	0.4	-	-	-	-	-	-	-
B_NAV_300	62.8	3.1	0.08	5.4	9.2	0.4	-	-	-	-	-	-	-
B_NAV_310	59	3.1	0.07	5.7	5.31	0.4	-	-	-	-	-	-	-
B_NAV_320	25.9	3.4	0.1	15.2	6.86	0.4	-	-	-	-	-	-	-
B_NEW_010	146.9	1.5	0.06	11.5	8.19	0.75	-	-	-	-	-	-	-
B_NEW_020	69	1.5	0.07	5	7.51	0.75	-	-	-	-	-	-	-
B_NOL_010	52.7	7	0.15	30.8	4.24	0.5	-	-	-	-	-	-	-
B_NOL_020	61.3	7	0.14	7.4	6.49	0.5	-	-	-	-	-	-	-
B_PON_010	100.5	3.8	0.09	7.3	8.35	0.5	-	-	-	-	-	-	-
B_PON_020	129.6	3.8	0.11	5.6	11.29	0.5	-	-	-	-	-	-	-
B_SAL_010	51.2	6.4	0.08	3.1	4.78	0.5	-	-	-	-	-	-	-
B_SAL_020	84.9	7	0.1	2.6	4.54	0.5	-	-	-	-	-	-	-
B_SAL_030	37.2	7	0.15	3.7	4.61	0.5	-	-	-	-	-	-	-
B_SAN_010	50.8	3.3	0.11	3	9.57	0.5	-	-	-	-	-	-	-
B_SAN_020	58.4	3.3	0.07	2.3	11.21	0.5	-	-	-	-	-	-	-
B_SAN_030	9.5	3.2	0.12	2.2	3.83	0.5	-	-	-	-	-	-	-
B_TEH_010	131.3	9	0.03	6	9.57	0.4	-	-	-	-	-	-	-
B_TEH_020	111.5	8.1	0.04	12.1	9.52	0.4	-	-	-	-	-	-	-
B_TEH_030	66.1	7.9	0.05	13.7	8.23	0.4	-	-	-	-	-	-	-
B_WAL_010	53.3	1.3	0.12	3.1	4.88	0.5	-	-	-	-	-	-	-
B_WAL_020	57.7	1.4	0.08	5.1	5.86	0.5	-	-	-	-	-	-	-

Appendix D: Hydrologic Analysis

Final HMS Calibrated Parameters 2017

Final HMS Calibrated Parameters, 2017													
Sub-Basin	Area, (sq. mi.)	Initial and Constant Losses			Snyder's Unit Hydrograph		Exponential Losses					Clark Unit Hydrograph	
		Initial Loss, (hr)	Constant Loss, (in/hr)	Percent Impervious	Lag Time, (hr)	Peaking Coefficient	Initial Range, (in)	Initial Coefficient, ((in/hr)^(1-x))	Coefficient Ratio	Exponent	Percent Impervious	Time of Concentration (hr)	Storage Coefficient
		(hr)											
B_AQU_010	53.6	7.4	0.09	0.7	6.86	0.5	-	-	-	-	-	-	-
B_AQU_020	55.3	7.4	0.11	0.9	5.53	0.5	-	-	-	-	-	-	-
B_AQU_030	44	6.7	0.13	0.6	6.02	0.5	-	-	-	-	-	-	-
B_BES_010	51.3	-	-	-	-	-	0	0.2	3	0.6	5.9	10.79	26.05
B_BES_020	49.4	-	-	-	-	-	0	0.2	3	0.6	11.3	8.58	31.07
B_BIC_010	60.4	-	-	-	-	-	0	0.05	3	0.6	12.7	5.3	23.83
B_BIC_020	96.9	-	-	-	-	-	0	0.05	3	0.6	6.1	6.25	32.24
B_BIC_030	76.6	-	-	-	-	-	0	0.05	3	0.6	17.3	8.54	37.96
B_BIG_010	72.1	3	0.06	3.7	12.31	0.5	-	-	-	-	-	-	-
B_BIG_020	54.3	3	0.05	6.7	11.94	0.5	-	-	-	-	-	-	-
B_BIG_030	39.9	3	0.03	2.7	10.08	0.5	-	-	-	-	-	-	-
B_BIG_040	62.3	2.8	0.04	3.1	8.22	0.5	-	-	-	-	-	-	-
B_BIG_050	20.1	2.7	0.03	3.6	5.84	0.5	-	-	-	-	-	-	-
B_BIG_060	64.5	3	0.03	3	10.82	0.5	-	-	-	-	-	-	-
B_BIG_070	10.6	2.8	0.04	5.3	3.84	0.5	-	-	-	-	-	-	-
B_BIN_010	119.6	10	0.06	1.1	7.94	0.4	-	-	-	-	-	-	-
B_BIN_020	113.2	10	0.07	0.9	7.74	0.4	-	-	-	-	-	-	-
B_BIN_030	102.2	10.5	0.09	1.8	10.4	0.4	-	-	-	-	-	-	-
B_BRA_010	55.9	5.3	0.08	5	1.99	0.7	-	-	-	-	-	-	-
B_BRA_020	40	7	0.15	0.5	5.41	0.5	-	-	-	-	-	-	-
B_BRA_030	87.7	7	0.08	0.5	7.79	0.5	-	-	-	-	-	-	-
B_BRA_040	25.4	6.3	0.18	0.7	4.52	0.5	-	-	-	-	-	-	-
B_BRA_050	64.5	6.3	0.14	1.4	5.63	0.5	-	-	-	-	-	-	-
B_BRA_060	28.6	6	0.14	7.8	4.12	0.5	-	-	-	-	-	-	-
B_BRA_070	9.9	8.8	0.12	8.3	4.43	0.4	-	-	-	-	-	-	-
B_BRA_080	30.8	9	0.15	1	5.7	0.4	-	-	-	-	-	-	-
B_BRA_090	52.1	9	0.09	5.6	6.46	0.4	-	-	-	-	-	-	-
B_BRA_100	76	10	0.12	1.5	5.18	0.4	-	-	-	-	-	-	-
B_BRA_110	47.5	10.5	0.15	1.5	8.76	0.4	-	-	-	-	-	-	-
B_BRA_120	122.3	10.5	0.1	1.5	10.1	0.4	-	-	-	-	-	-	-
B_BRA_130	115.2	10	0.09	1.7	8.42	0.4	-	-	-	-	-	-	-
B_BRA_140	85.3	10.5	0.19	1.9	7.97	0.4	-	-	-	-	-	-	-
B_BRA_150	10.8	10.5	0.28	1.6	3.09	0.4	-	-	-	-	-	-	-
B_BRA_160	24.5	3.1	0.14	2.6	8.83	0.5	-	-	-	-	-	-	-
B_BRA_170	39.6	2.9	0.15	1.8	10.61	0.5	-	-	-	-	-	-	-
B_BRA_180	51.2	2.8	0.14	2.4	5.84	0.5	-	-	-	-	-	-	-
B_BRA_190	162.6	2.9	0.23	1.7	9.81	0.5	-	-	-	-	-	-	-
B_BRA_200	108.8	1.9	0.08	10.2	3.5	0.55	-	-	-	-	-	-	-
B_BRA_210	45.3	1.9	0.06	16.6	3.37	0.55	-	-	-	-	-	-	-
B_BRA_220	150.2	2.3	0.07	3.2	8.72	0.55	-	-	-	-	-	-	-
B_BRA_230	79.4	2	0.09	2.6	4.52	0.55	-	-	-	-	-	-	-
B_BRA_240	83.7	2.3	0.11	6.7	3.15	0.55	-	-	-	-	-	-	-
B_BRA_250	82.3	2.2	0.14	4.3	3.47	0.55	-	-	-	-	-	-	-
B_BRA_260	61	2	0.13	2.9	11.25	0.4	-	-	-	-	-	-	-
B_BRA_270	24.6	-	-	-	-	-	0	1.5	3	0.4	6.4	10.51	23.37
B_BRA_280	62.1	-	-	-	-	-	0	1.5	3	0.4	4.4	13.03	29.25
B_BRA_290	23.1	-	-	-	-	-	0	1.5	3	0.4	13.6	8.62	23.65
B_BRA_300	74.1	-	-	-	-	-	0	1.5	3	0.4	8.7	11.5	33.36
B_BRA_310	95.8	-	-	-	-	-	0	1.5	3	0.4	5.5	14.82	44.93
B_BRA_320	26.3	-	-	-	-	-	0	1.5	3	0.4	10	6.32	13.31
B_BRA_330	71.8	-	-	-	-	-	0	0.2	3	0.6	5.1	15.35	26.87
B_BRA_340	17.9	-	-	-	-	-	0	0.2	3	0.6	10.5	6.84	26.36
B_BRA_350	62.3	-	-	-	-	-	0	0.2	3	0.6	9.1	10.86	15.87
B_BRA_360	31.8	-	-	-	-	-	0	0.2	3	0.6	8.2	3.31	41.05
B_BRA_370	55.5	-	-	-	-	-	0	0.2	3	0.6	15.6	9.3	28.8
B_BRA_380	63.6	-	-	-	-	-	0	0.05	3	0.6	61.3	6.14	21.98
B_BRA_390	21.1	-	-	-	-	-	0	0.05	3	0.6	2.4	8.47	23.76
B_BRA_400	66.9	-	-	-	-	-	0	0.05	3	0.6	4.1	7.64	21.24

B_BRA_410	20.3	-	-	-	-	-	0	0.05	3	0.6	2.8	11.39	58.46
B_BRA_420	56.2	-	-	-	-	-	0	0.05	3	0.6	4.5	11.08	20.92
B_BRA_430	52	-	-	-	-	-	0	0.05	3	0.6	7.2	5.71	34.58
B_BRA_440	38.2	-	-	-	-	-	0	0.05	3	0.6	9.2	2.67	36.57
B_BRU_010	73.2	6.2	0.01	16.9	6.88	0.4	-	-	-	-	-	-	-
B_BRU_020	65.6	6.2	0.01	18.1	6.05	0.4	-	-	-	-	-	-	-
B_BRU_030	50.8	6.2	0.02	8.6	7.69	0.4	-	-	-	-	-	-	-
B_BRU_040	54.6	6.2	0.02	2.3	8.62	0.4	-	-	-	-	-	-	-
B_BRU_050	55.6	6.2	0.01	5.8	8.47	0.4	-	-	-	-	-	-	-
B_BRU_060	66.4	6.3	0.01	2.5	7.38	0.4	-	-	-	-	-	-	-
B_BRU_070	54	6.2	0.03	2.6	7.51	0.4	-	-	-	-	-	-	-
B_BRU_080	65.5	6.2	0.01	2.5	9.97	0.4	-	-	-	-	-	-	-
B_BRU_090	32.3	6	0.06	2.8	4.85	0.4	-	-	-	-	-	-	-
B_DAV_010	142	2.7	0.13	5.7	12.96	0.6	-	-	-	-	-	-	-
B_DAV_020	52.8	2.7	0.04	3.8	7.36	0.6	-	-	-	-	-	-	-
B_DAV_030	31.7	1.6	0.06	4.9	2.09	0.55	-	-	-	-	-	-	-
B_LAM_010	26.4	8.9	0.18	2.1	7.33	0.5	-	-	-	-	-	-	-
B_LEO_010	46.8	8.9	0.14	8.2	5.94	0.5	-	-	-	-	-	-	-
B_LEO_020	23.1	8.6	0.2	4.2	6.8	0.5	-	-	-	-	-	-	-
B_LIB_010	168.1	4.2	0.05	2.7	13	0.4	-	-	-	-	-	-	-
B_LIB_020	22.6	3.6	0.08	1.7	6.67	0.4	-	-	-	-	-	-	-
B_LIB_030	78.5	3.5	0.12	3.7	6.21	0.4	-	-	-	-	-	-	-
B_LIB_040	40.7	3.6	0.09	6.8	5.35	0.4	-	-	-	-	-	-	-
B_LIB_050	55.9	3.6	0.15	1.9	7.43	0.4	-	-	-	-	-	-	-
B_LIB_060	48.1	3.6	0.15	2	6.19	0.4	-	-	-	-	-	-	-
B_LIB_070	44.4	3.6	0.05	2.7	5.76	0.4	-	-	-	-	-	-	-
B_LIB_080	30.8	3.7	0.06	3.8	6.96	0.4	-	-	-	-	-	-	-
B_LIT_010	43.2	6.2	0.03	2.2	9.15	0.4	-	-	-	-	-	-	-
B_LIT_020	36.5	6.2	0.01	4.1	7.17	0.4	-	-	-	-	-	-	-
B_LIT_030	57.5	6.2	0.02	1.6	8.22	0.4	-	-	-	-	-	-	-
B_LIT_040	46.3	5.9	0.01	2.5	8.4	0.4	-	-	-	-	-	-	-
B_LIT_050	130.2	6.2	0.02	2.4	16.71	0.4	-	-	-	-	-	-	-
B_LIT_060	50	6	0.02	2.6	11.6	0.4	-	-	-	-	-	-	-
B_LIT_070	28.6	6	0.03	2.6	5.65	0.4	-	-	-	-	-	-	-
B_LIT_080	78.4	6	0.06	2.8	7.37	0.4	-	-	-	-	-	-	-
B_LIT_090	10.3	2.9	0.09	8	3.79	0.5	-	-	-	-	-	-	-
B_LIT_100	38	2.9	0.05	2.8	6.9	0.5	-	-	-	-	-	-	-
B_LIT_110	41.2	2.8	0.14	1.8	5.06	0.5	-	-	-	-	-	-	-
B_LIT_120	48.8	2.9	0.09	1.9	6.73	0.5	-	-	-	-	-	-	-
B_LIT_130	65	2.9	0.15	1.6	6.75	0.5	-	-	-	-	-	-	-
B_MIL_010	155.7	-	-	-	-	-	0	0.1	3	0.6	17	8.12	4.25
B_MIL_020	158.9	-	-	-	-	-	0	0.1	3	0.6	16.4	7.98	3.78
B_MIL_030	47.6	-	-	-	-	-	0	0.1	3	0.6	14.5	25	20.25
B_MIL_040	48.9	-	-	-	-	-	0	1.5	3	0.4	8.5	15.48	40.59
B_NAV_010	50.6	9.6	0.11	1	8.51	0.3	-	-	-	-	-	-	-
B_NAV_020	53.1	9.3	0.09	1	9.68	0.3	-	-	-	-	-	-	-
B_NAV_030	54	9.3	0.1	0.9	13.45	0.3	-	-	-	-	-	-	-
B_NAV_040	39.5	9	0.14	1.1	6.3	0.3	-	-	-	-	-	-	-
B_NAV_050	43.3	9	0.17	1.2	8.06	0.3	-	-	-	-	-	-	-
B_NAV_060	73	1.9	0.07	2.6	8.44	0.5	-	-	-	-	-	-	-
B_NAV_070	71.1	1.8	0.07	1.6	7.11	0.5	-	-	-	-	-	-	-
B_NAV_080	97.4	9.5	0.11	9.9	18.07	0.65	-	-	-	-	-	-	-
B_NAV_090	194	1.9	0.13	2.9	8.54	0.5	-	-	-	-	-	-	-
B_NAV_100	74.1	10.1	0.17	0.9	26.93	0.5	-	-	-	-	-	-	-
B_NAV_110	105.3	9.5	0.1	0.6	17.2	0.5	-	-	-	-	-	-	-
B_NAV_120	82.3	10.1	0.1	0.6	20.25	0.5	-	-	-	-	-	-	-
B_NAV_130	73.6	7.6	0.25	2.3	19.32	0.5	-	-	-	-	-	-	-
B_NAV_140	170.1	7.6	0.18	1.8	15.21	0.5	-	-	-	-	-	-	-
B_NAV_150	64.6	7.6	0.28	1.9	12.48	0.5	-	-	-	-	-	-	-
B_NAV_160	49.5	7.6	0.23	1.9	14.43	0.5	-	-	-	-	-	-	-
B_NAV_170	22.1	7.6	0.21	1.3	10.39	0.5	-	-	-	-	-	-	-

B_NAV_180	28.4	6.1	0.2	6	6.1	0.4	-	-	-	-	-	-	-
B_NAV_190	63.8	5.8	0.1	2.4	6.46	0.4	-	-	-	-	-	-	-
B_NAV_200	50.3	5.8	0.09	1.7	5.68	0.4	-	-	-	-	-	-	-
B_NAV_210	120	5.3	0.12	1.9	10.89	0.4	-	-	-	-	-	-	-
B_NAV_220	41.2	5.8	0.06	1.5	5.97	0.4	-	-	-	-	-	-	-
B_NAV_230	51.4	5.5	0.05	2.1	5.11	0.4	-	-	-	-	-	-	-
B_NAV_240	36.8	5.7	0.05	2.2	7.99	0.4	-	-	-	-	-	-	-
B_NAV_250	89.7	5.3	0.05	3.1	11.19	0.4	-	-	-	-	-	-	-
B_NAV_260	66.8	5.5	0.04	24.6	8.37	0.4	-	-	-	-	-	-	-
B_NAV_270	53	5.5	0.05	8.4	7.55	0.4	-	-	-	-	-	-	-
B_NAV_280	117.7	5.5	0.06	2.8	10.68	0.4	-	-	-	-	-	-	-
B_NAV_290	30.2	5.5	0.03	5.4	6.42	0.4	-	-	-	-	-	-	-
B_NAV_300	62.8	6.3	0.05	2.7	9.2	0.4	-	-	-	-	-	-	-
B_NAV_310	59	6.3	0.04	2.9	5.31	0.4	-	-	-	-	-	-	-
B_NAV_320	25.9	6.7	0.06	7.6	6.86	0.4	-	-	-	-	-	-	-
B_NEW_010	146.9	2	0.09	8.6	10.23	0.4	-	-	-	-	-	-	-
B_NEW_020	69	2	0.1	3.8	9.39	0.4	-	-	-	-	-	-	-
B_NOL_010	52.7	8.9	0.16	13.7	5.33	0.5	-	-	-	-	-	-	-
B_NOL_020	61.3	8.9	0.14	3.3	8.16	0.5	-	-	-	-	-	-	-
B_PON_010	100.5	3	0.04	3.6	8.35	0.5	-	-	-	-	-	-	-
B_PON_020	129.6	3	0.06	2.8	11.29	0.5	-	-	-	-	-	-	-
B_SAL_010	51.2	8.3	0.09	1.4	6.01	0.5	-	-	-	-	-	-	-
B_SAL_020	84.9	8.9	0.1	1.2	5.71	0.5	-	-	-	-	-	-	-
B_SAL_030	37.2	8.9	0.16	1.6	5.8	0.5	-	-	-	-	-	-	-
B_SAN_010	50.8	6.2	0.04	3	9.57	0.4	-	-	-	-	-	-	-
B_SAN_020	58.4	6.2	0.01	2.3	11.21	0.4	-	-	-	-	-	-	-
B_SAN_030	9.5	6	0.04	2.2	3.83	0.4	-	-	-	-	-	-	-
B_TEH_010	131.3	10.6	0.06	1.2	7.76	0.4	-	-	-	-	-	-	-
B_TEH_020	111.5	9.6	0.07	2.4	7.72	0.4	-	-	-	-	-	-	-
B_TEH_030	66.1	9.3	0.09	2.7	6.67	0.4	-	-	-	-	-	-	-
B_WAL_010	53.3	1.8	0.15	2.3	2.44	0.55	-	-	-	-	-	-	-
B_WAL_020	57.7	1.8	0.11	3.8	2.93	0.55	-	-	-	-	-	-	-