GZA

Proactive by Design

Study 1: Hydrologic and Hydraulic Planning Study of Eight Major Streams

Town of Westport, Connecticut

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PREPARED FOR:
Town of Westport

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1.0 EXECUTIVE SUMMARY

GZA GeoEnvironmental, Inc. (GZA) performed a hydrologic and hydraulic analysis of eight streams within the Town of Westport to estimate the flooding resulting from various design storms, up to and including the 500-year flood. The results obtained from the analysis were used by GZA to develop flood maps and hydraulic profiles. Under a separate report, GZA used the results to propose drainage improvement recommendations. The work was performed by GZA for the Town of Westport (Town) pursuant to GZA's proposal dated October 12, 2016 and the Town's Notice to Proceed, dated November 28, 2016. The results presented within this report are estimations based upon the hydrologic and hydraulic analysis. This report is subject to the Limitations in **Appendix A**.

GZA performed the hydrologic and hydraulic analysis of Indian River, Muddy Brook, New Creek, Poplar Plains Brook, Pussy Willow Brook, Silver Brook, Stony Brook, and Willow Brook (see **Figure 1**). GZA estimated flooding for the 24-hour 10-, 25-, 50-, 100-, and 500-year storms. GZA conducted field assessments of conveyance structures, delineated watershed boundaries, and collected relevant data for each of the eight watercourses that were used as input into hydrologic and hydraulic simulation software. The results of the analysis are shown in the form of hydraulic profiles in **Appendix G** and Flood Maps in **Appendix H**.

2.0 INTRODUCTION TO STUDY

This report presents the results of the hydrologic and hydraulic (H&H) analysis performed by GZA GeoEnvironmental, Inc. (GZA) on behalf of the Town of Westport (Town) for eight of the major streams located in Westport (see **Figure 1**). The report is one of two studies that GZA is performing for the Town. The purpose of this study (Study 1) is to provide an analysis of the watersheds of eight major streams in Westport, map the major stream's current flood lines for the 24-hour 10-, 25-, 50-, 100-, and 500-year precipitation events, and to recommend drainage improvements to the streams. The drainage improvements are presented in a separate memorandum. A separate evaluation (Study 2) focuses on the vulnerability and resiliency of Westport's Downtown area relative to coastal and stormwater-induced flooding. The eight streams and their respective drainage area are listed below:

- Indian River (0.9 square miles);
- Muddy Brook (2.7 square miles);
- New Creek (0.9 square miles);
- Poplar Plains Brook (1.1. square miles);
- Pussy Willow Brook (1.3 square miles);
- Silver Brook (1.1 square miles);
- Stony Brook (3.3 square miles); and
- Willow Brook (0.9 square miles).

A discussion of flood-prone areas within the Town of Westport is described in the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for Fairfield County (last revised October 16, 2013). The FIS lists Compo Beach and Sherwood Island State Park along Long Island Sound, and areas adjacent to the Saugatuck River near confluences of Silver Brook, Willow Brook, and Stony Brook as flood-prone areas in Westport.

The FIS states that Muddy Brook, Poplar Plains Brook, Stony Brook, and Willow Brook were studied by detailed methods during the 1970's and 1980's. The Town also has a study of the streams which was performed in the 1970's. The Town is interested in the updating the studies on the streams due to development in Westport as well as changing weather patterns since the previous studies.

For our hydrologic evaluation, GZA used the Army Corps of Engineers' HEC-HMS (version 4.1,) computer program and Snyder Unit Hydrograph methodology to simulate the rainfall/runoff processes. Unit hydrographs are the main tool for converting rainfall excess into runoff for gauged watersheds. GZA used a neighboring watershed's gauged stream to calibrate Snyder parameters, and translated these parameters to the eight stream's watersheds (which are ungauged). The simulated hydrologic response is output as hydrographs, which were then used as inputs into GZA's HEC-RAS hydraulic model. GZA used the US Army Corps of Engineers (USACE) Hydrological Engineering Center – River

Analysis System (HEC-RAS) Version 5.0.3 model to simulate the transient and maximum extent of flooding along these eight stream systems. GZA developed a transient, unsteady, two-dimensional flow model for each stream. The flood mapping for each stream was limited to the boundaries for the Town of Westport.

It is noted that the limits of flooding developed through the HEC-RAS modeling effort and presented on the inundation maps are approximate. The HEC-RAS and HEC-HMS results are a function of the methods, procedures, and assumptions employed by GZA for the models. Actual inundation areas may vary from the areas shown on GZA's maps.

2.1 DATUMS

Elevations in this report reference the vertical datum NAVD88.

2.2 REFERENCES

References used in this report are summarized in Section 3.0.

2.3 RIVERINE DESCRIPTION

The upstream and downstream study limits of each stream, for the purpose of conducting the hydraulic analysis for this report, are described below and graphically presented in **Figure 1**.

Indian River

Indian River discharges into Burritt Cove of the Long Island Sound along the southwestern Town boundary. The approximate upstream terminus of Indian River is at the northern inlet of the Kings Highway South culvert. The downstream terminus is at the confluence of Indian River and Burritt Cove near the outlet of the culvert beneath Saugatuck Avenue/State Highway 136. The distance between the upstream and downstream limits of Indian River is approximately 0.9 miles.

Muddy Brook

Muddy Brook discharges into Sherwood Millpond in the Compo Cove of the Long Island Sound along the southern Town boundary. The approximate upstream terminus of Muddy Brook is at the northern inlet of the Merritt Parkway culvert. The downstream terminus is at the confluence of Muddy Brook and Sherwood Millpond near the outlet of the culvert beneath Interstate 95 and the railroad. The distance between the upstream and downstream limits of Muddy Brook is approximately 4.5 miles.

New Creek

New Creek discharges into the Long Island Sound along the southeastern Town boundary. The approximate upstream terminus of New Creek is in a residential neighborhood south of Post Road East. The downstream terminus is at the confluence of New Creek and Long Island Sound. The distance between the upstream and downstream limits of New Creek is approximately 2 miles.

Poplar Plains Brook

Poplar Plains Brook discharges directly into the Saugatuck River just upstream of Lee Pond. The approximate upstream terminus of Poplar Plains Brook is approximately 120 feet southwest of Cross Brook Lane. The downstream terminus is at the confluence of Poplar Plains Brook and the Saugatuck River approximately 440 feet downstream of the Merritt Parkway crossing over the Saugatuck River. The distance between the upstream and downstream limits of Poplar Plains Brook is approximately 2 miles.

Pussy Willow Brook

Pussy Willow Brook (PWB) discharges into the Sherwood Millpond, which discharges into Compo Cove of the Long Island Sound within the south-central region of the Town. The approximate upstream terminus of PWB is approximately 115 feet southwest of Whitney Street. The downstream terminus is at the confluence of PWB and Sherwood Millpond, where the stream flows parallel to the Metro-North Railroad at Grove Point. The distance between the upstream and downstream limits of PWB is approximately 2.4 miles.

Silver Brook

Silver Brook discharges into the Aspetuck River, which discharges into the Saugatuck River within the northeastern region of the Town. The approximate upstream terminus of Silver Brook is approximately 270 feet northwest of Cardinal Lane. The downstream terminus is at the confluence of Silver Brook and the Aspetuck River near the outlet of the culvert beneath Lyons Plains Road. The distance between the upstream and downstream limits of Silver Brook is approximately 2.2 miles.

Stony Brook

Stony Brook discharges into the Saugatuck River within the south-central region of the Town. Stony Brook flows through the Towns of Wilton, Norwalk, and Westport. For the purposes of this study, the flooding extents were evaluated only within the Town of Westport's boundaries. The approximate upstream terminus of Stony Brook is at the Westport and Norwalk Town boundary near Patrick Road. The downstream terminus is at the confluence of Stony Brook and the Saugatuck River, where State Highway 33 (Riverside Avenue) crosses over Stony Brook. The distance between the upstream and downstream limits of Stony Brook is approximately 2.1 miles.

Willow Brook

Willow Brook discharges into a branch of the Saugatuck River. The approximate upstream terminus of the brook is approximately 780 feet upstream of North Avenue at the start of Willow Brook. The downstream terminus is at the confluence of Willow Brook and the Saugatuck River, approximately 470 feet downstream of where Richmondville Avenue crosses over Willow Brook. The distance between the upstream and downstream limits of Willow Brook is approximately 2 miles.

3.0 DATA COLLECTION AND SOURCES

3.1 DIGITAL DATA

Several sources of digital data were used for this analysis and are summarized below.

Aerial Imagery: The Town provided GZA with a series of raster files with a ¼-foot resolution of aerial imagery of the Town.

Westport Terrain Data: The Town provided GZA with a raster file with a 4-foot resolution titled "BareEarth ALL.tif". The raster was developed from LiDAR points and the elevations are in feet, NAVD88.

Land Cover: Land cover was obtained as a raster file with a 100-foot resolution titled "area_2010_v2-03.img". The file was published in 2012 by the Center for Land-use Education and Research (CLEAR). The data was captured in 2010.

Pavement: The Town provided GZA with a shapefile called "Street Pavement (2013).shp", part of a geodatabase called Westport_Kucera_Data.gdb.

Buildings: The Town provided GZA with a shapefile called "Building (2013).shp", part of a geodatabase called Westport_Kucera_Data.gdb.

Watershed Delineation: Preliminary watershed delineations for the streams were obtained from the StreamStats, an interactive online tool hosted by the United States Geological Survey.

Tide Elevation in Long Island Sound: GZA obtained the Mean Higher-High tide elevation at National Oceanic Atmospheric Administration's (NOAA) Tidal Gauge 9468191, Saugatuck River.

Historic Flooding in the Town of Westport and Water Surface Elevations in Downstream Rivers: GZA obtained the 10-, 50-, 100-, and 500-year water surface elevations in the Aspetuck River and Saugatuck River from the FEMA Flood Insurance Study for Fairfield County, Connecticut, which was revised in October 2013.

Stream Gauge Data: Stream gauge data was obtained from USGS Gauge 01208950, Sasco Brook Near Southport, CT.

Hydrologic Soil Groups: Hydrologic soils groups were downloaded from the NRCS Web Soil Survey, an interactive website hosted by the United State Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS).

Precipitation Data: Precipitation depths and distributions for design return periods (e.g., 2-year, 5-year, 10-year, 100-year, 500-year) were obtained from NOAA Atlas 14, Volume 10 for New England. Historic precipitation data was obtained from the following sources:

- one-hour Digital Precipitation Array (DPA) and the one-hour Digital Accumulation Array (DAA) radar-rainfall products from the National Weather Service's NEXRAD Radar Station in Upton, NY (Station ID: KOKX.)
- hourly rainfall observations from the rain gauge at the Igor Sikorsky Memorial Airport's (COOP:060806,)
- daily rainfall accumulation records from Saugatuck Reservoir (GHCND: USC00067157.)

3.2 FIELD DATA

Details about the conveyance structures were required to set-up the hydraulic models. GZA used aerial imagery provided by the Town to locate conveyance structures (i.e. bridges, culverts, and dams) which traversed the eight study streams within the Town (study) boundaries. The locations of the conveyance structures are shown on the flood maps in **Appendix H**. On February 1 and 2, 2017, GZA staff performed a visual field inspection and assessment of the identified conveyance structures, as well as of additional structures encountered in the field. Measurements and photos were collected in the field. Some of the structures identified with the aerial imagery were not accessible due to safety concerns or private property access. GZA did not gather information at small footbridges, as these were considered as having insignificant hydraulic profile impact, in our opinion. Field notes and data were recorded using the GZA's Web Collector App. GZA's field inspection was limited to only those structures traversing the eight project streams.

4.0 HYDROLOGIC ANALYSIS

GZA developed a detailed hydrologic model of the contributing watersheds to the eight major streams in the Westport study area. The rainfall/runoff processes were simulated by GZA using the Army Corps of Engineers' HEC-HMS (version 4.1,) computer program and Snyder Unit Hydrograph methodology. Unit hydrographs are the main tool for converting rainfall excess into runoff for gauged or ungauged watershed. The Snyder Method is one of many unit hydrograph methods. The simulated hydrologic response was output as hydrographs, which were then used as inputs into GZA's HEC-RAS hydraulic model.

The watersheds for the eight streams in Westport are ungauged. GZA calibrated and verified Snyder Unit Hydrograph parameters to the streamflow gauge (USGS 01208950) on Sasco Brook near Southport, CT. The Saco gauge was used by GZA as a surrogate for the determination of the Snyder parameters for the ungauged study watersheds. Sasco Brook is hydrologically similar to the study watersheds and, as such, assists in the appropriate estimation of Snyder parameters for the eight study watersheds, in GZA's opinion. These parameters were then used to simulate the hydrologic response of each of the eight study streams, and the sub-watersheds therein, for the 24-hour 10-, 25-, 50-, 100-, and 500-year precipitation events. Our use of actual stream gauge data and the development of site-specific unit hydrographs increased the reliability of the rainfall/runoff characteristics developed for the HEC-HMS model for the Westport, CT study area, in GZA's opinion. A map of the watershed delineations, including the location of the USGS gauge, is provided as **Figure 2**.

4.1 METHODOLOGY OVERVIEW

Rainfall/runoff processes were modeled utilizing the Snyder Unit Hydrograph processes native to the HEC-HMS software. Snyder's Unit Hydrograph method uses two Snyder parameters and two loss/infiltration parameters to model the unit hydrograph response of the watershed given a rainfall event.

The steps in the modelling procedure are as follows:

1. Estimate initial Snyder Unit Hydrograph parameters to develop a unit hydrograph using Snyder's method for the gauged (USGS 01208950) Sasco Brook watershed. These parameters are the watershed lag (t_p) and peaking coefficient (C_p). The acceptable range for peaking coefficient is between 0.4 and 0.8 (Bedient, 1992). A peaking coefficient of 0.6 was chosen as an initial estimate for model calibration (described below). The initial estimate for lag time was calculated by:

$$t_p = C_t(L * L_c)^{0.3} \qquad \text{Equation 1}$$

where:

t_p : Watershed Lag (hr),

L : Length of the main stream from the outlet to the divide (mi), (see **Figure 3)**

L_c : Length along the main stream to the point nearest the watershed centroid (mi), (see **Figure 3)**

C_t : Basin coefficient, usually ranging from 1.8 to 2.2. Assume a value of 2.0 to begin iterative procedure. This coefficient is best found via calibration, as it is not a physically based parameter.

The Snyder peak discharge equation is internal to the HEC-HMS, where the peak discharge is solved as follows:

$$Q_p = \frac{640\, C_p * A}{t_p} \qquad \text{Equation 2}$$

where:

Q_p : Peak Discharge (cfs)

C_p : Peaking Coefficient (dimensionless). This coefficient is best found via calibration, as it is not a physically based parameter.

A : Watershed Size (mi^2)

T_p : Lag Time (hr)

2. Estimate initial conditions for constant and initial losses. Constant loss is estimated using published[1] infiltration rates of the hydrologic soil groups within the watershed (see **Figure 3**). The initial loss is estimated, based on engineering judgment, from the watershed's antecedent conditions prior to each storm.
3. Obtain historic flood information for the USGS streamflow and staff gauge. Additionally, obtain rainfall data corresponding to selected candidate floods.
4. Import these data into the HEC-HMS environment and perform the calibration by iteratively adjusting the Snyder parameters (i.e. peaking coefficient and lag time,) and the loss parameters (i.e. initial and constant loss,) until the simulated runoff response reflects the observed response to the historic floods. The model is calibrated when the calculated hydrograph approximately reflects the observed hydrograph for the watershed's stream gauge.
5. Verify model parameters using historic floods not used in calibration. This is done by comparing the observed response to the model simulated runoff response (maintaining the calibrated Snyder parameters and constant loss parameter) while adjusting the initial loss parameter. The model, for the gauged watershed, is verified when an acceptable comparison of simulated results versus observed streamflow data is achieved for the verification storms.
6. Apply the calibrated and verified Snyder Unit Hydrograph parameters (C_p and C_t) from the gauged watershed to the ungauged watersheds in the HEC-HMS model. Use the calibrated and verified C_t, and physical estimates of (L) and (L_c) for the ungauged watershed, to estimate the lag time (t_p), from Equation 1 above, for the ungauged watersheds. Apply the calibrated and verified C_p to the ungauged watersheds directly.
7. Simulate response of the ungauged watersheds in HEC-HMS for the 10-, 25-, 50-, 100-, 500-year flood events using the applied Snyder Unit Hydrograph parameters and the NOAA Atlas 14 precipitation depths for Westport, CT. HEC-HMS calculate the full runoff hydrograph for each storm. The hydrograph's peak ordinate is calculated with Equations 1 and 2 listed above. The other ordinates on the hydrograph are calculated in HEC-HMS with Clark's unit hydrograph model.

4.2 WATERSHED DELINEATION

GZA initially delineated the watersheds for the eight streams in Westport and Sasco Brook using the StreamStats tool, for a total of nine watersheds. The Westport streams were delineated at their downstream limit, and Sasco Brook was delineated at the location of the gauge. The watershed delineations created using StreamStats were visually evaluated using the topographic data (Lidar) and manually adjusted.

GZA then used the terrain data provided by the Town to sub-divide the eight Westport watersheds into sub-watersheds. This was performed because GZA is modeling the entirety of each stream, not just the downstream end. The streams begin near the upstream limit of each watershed, and the hydrograph for the downstream end cannot be realistically routed through the entirety of the stream. Therefore, each of the eight project watersheds were subdivided to between four to seven sub-watersheds for a total of 49 sub-watersheds.

4.3 STREAM GAUGE DATA

Hourly and 15-minute stream flow measurements for Sasco Brook were obtained from USGS gauge 01208950.

[1] 1955 USDA Reference: Musgrave, G.W. 1955. How much of the rain enters the soil? In Water: U.S. Department of Agriculture. Yearbook. Washington, DC. pp. 151–159.

4.4 PRECIPITATION DATA

This section describes the historical rainfall data used in the calibration and verification procedure and the rainfall depths and synthetic rainfall distribution used in the simulation of 10-, 25-, 50-, 100-, 500-year return period events.

4.4.1 Historical Rainfall Data

Local rainfall estimates for historical flood events are required to calibrate the gauged watershed's response. Accordingly, GZA used four rainfall products as the basis for a quantitative precipitation estimate (QPE) for each of the calibration and verification storms within the HEC-HMS model. GZA used the one-hour Digital Precipitation Array (DPA) and the one-hour Digital Accumulation Array (DAA) radar-rainfall products from the National Weather Service's NEXRAD Radar Station in Upton, NY (Station ID: KOKX.). GZA also used hourly rainfall observations from the rain gauge at the Igor Sikorsky Memorial Airport's (COOP:060806,) and daily rainfall accumulation records from Saugatuck Reservoir (GHCND: USC00067157). These rainfall products were analyzed and assimilated into a single QPE for the land area associated with Sasco Brook's watershed for each storm. GZA used these QPEs as input into the calibration and verification process. Historical data were accessed through the National Centers for Environmental Information (NCEI) (formerly the National Climatic Data Center – NCDC)[2]. The location of the rainfall gauges in relation to the study basin can be found on **Figure 4**.

4.4.2 Synthetic Rainfall Events for Different Return Periods

GZA simulated the hydrologic response of the eight study watersheds for the 24-hour duration 10-, 25-, 50-, 100-, and 500-year rainfall events. Rainfall depths for these events were generated using NOAA Atlas 14 for the Town of Westport, Connecticut. **Table 1** shows the rainfall depths for the respective storms for the Town of Westport, CT. In conjunction with the NOAA Atlas 14 rainfall depths, GZA used the SCS Type III synthetic rainfall distribution native to the HEC-HMS program.

Table 1: NOAA Atlas 14 Rainfall Depths for 24-hour Duration Storm at Westport, CT

Return Period	10-year	25-year	50-year	100-year	500-year
Depth (inches)	5.35	6.51	7.41	8.30	11.20

4.5 CALIBRATION STORMS

Based on period of record and the observed peak flows, GZA selected four floods to use in the calibration process. Each calibration flood is summarized below.

4.5.1 Calibration Flood: April 1996

The April 1996 event was the result of a spring storm delivering approximately 3.2 inches of rainfall to the Sasco Brook watershed on April 16, 1996. The storm took place over an approximately 19-hour period. Records show a peak streamflow on Sasco Brook (USGS 01208950,) of 480 cfs. Regional precipitation records suggest moist antecedent conditions, with over three inches of rain in the previous two weeks.

[2] National Centers for Environmental Information; https://www.ncdc.noaa.gov/, accessed January 2017.

4.5.2 Calibration Flood: September 2004

The September 2004 event was the result of a convective storm delivering approximately 1.9 inches of rainfall to the Sasco Brook watershed on September 18, 2004. The storm took place over approximately six hours, with the majority of rain falling within a two-hour window. Records show a peak stream flow on Sasco Brook (USGS 01208950,) of 425 cfs. Regional precipitation records suggest average to dry conditions, with only two rainfall events in the previous 17 days resulting in less than two inches of rainfall.

4.5.3 Calibration Flood: April 2007

The April 2007 event was the result of a spring storm delivering approximately 5.2 inches of rainfall to the Sasco Brook watershed on April 15 and 16, 2007. The storm took place over an approximately 32-hour period. Records show a peak stream flow on Sasco Brook (USGS 01208950,) of 1,300 cfs. Regional precipitation records suggest average antecedent moisture conditions, with approximately two inches of rain fall in the previous two weeks.

4.5.4 Calibration Flood: March 2010

The March 2010 flood was the result of a nor'easter that impacted the Northeastern United States from March 12 to March 16 of 2010. The slow-moving storm produced approximately 4.6 inches of rainfall in the Sasco Brook watershed. Records show a peak stream flow on Sasco Brook (USGS 01208950,) of 603 cfs. Regional precipitation records suggest moist antecedent conditions.

4.6 VERIFICATION STORMS

Based on period of record and the observed peak flows and stage heights, GZA selected three floods to verify the Sasco Brook's watershed response and the calibrated Snyder Unit Hydrograph Parameters. Each verification flood is summarized below.

4.6.1 Verification Flood: April 2006

The April 2006 event was the result of a spring storm delivering approximately 5.8 inches of rainfall to the Sasco Brook watershed on April 22 and 23, 2006. Most rain was observed to fall at a steady rate from the morning of April 23rd until the early afternoon of the same day. Records show a peak streamflow on Sasco Brook (USGS 01208950,) of 1,140 cfs. Regional precipitation records suggest average antecedent moisture conditions.

4.6.2 Verification Flood: March 2010

This March 2010 flood was the result of a spring storm delivering approximately 3.75 inches of rainfall to the Sasco Brook watershed on March 29 and 30, 2010. The storm took place over an approximately 36-hour period. Precipitation rates oscillated through the 36 hours, with rainfall intensities peaking approximately every 12 hours. Records show a peak streamflow on Sasco Brook (USGS 01208950,) of 560 cfs. This event was the last of many large precipitation events that occurred in New England during the month of March 2010, contributing to the record rainfall and record flooding. The frequent rainfall early in the month produced overly moist antecedent conditions, setting up conditions for significant flooding during the middle and end of March[3].

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[3] "The March 2010 Floods in Southern New England", WFO Taunton Storm Series Report # 2013-01, NOAA, National Weather Service, January, 2013.

4.6.3 Verification Flood: May 2014

The May 2014 event was the result of a spring storm delivering approximately 2.9 inches of rainfall to the Sasco Brook watershed on April 30 and May 1, 2014. The storm took place over a 24-hour period starting in the morning of April 30 and ending the morning of May 1, 2014. Records show a peak streamflow on Sasco Brook (USGS 01208950,) of 550 cfs. Regional precipitation records suggest moist antecedent conditions.

Table 2: Historic Floods Used for Sasco Brook Calibration and Verification

Historic Flood	Observed Peak Streamflow (cfs)	Flood Modeling Use
April 1996	480	Calibration
September 2004	425	Calibration
April 2006	1,140	Verification
April 2007	1,300	Calibration
March 14, 2010	603	Calibration
March 29, 2010	560	Verification
May 2014	550	Verification

4.7 MODEL SET UP

The following sections describe the HEC-HMS runoff model setup for the calibration/verification procedure and the simulations of the 24-hour 10-, 25-, 50-, 100-, 500-year precipitation events for each of the study watersheds.

4.7.1 Calibration, Verification Model Setup

Throughout the calibration and verification process, GZA simulated the watershed response of Sasco Brook's watershed as a single basin element in HEC-HMS. Simulated streamflow at this outlet was compared to the observed streamflow data, as discussed above.

As described in Section 4.1 Methodology Overview, the modeling procedure GZA employed requires initial and constant loss estimates and the Snyder unit hydrograph parameters of peaking coefficient, C_p, and lag time, t_p. Initial losses were estimated for each storm using engineering judgement while considering recorded antecedent moisture conditions for Sasco Brook region. Seasonal drought reports and daily precipitation records were consulted. GZA estimated constant losses for the basin element based on the SCS hydrologic soil group classifications for the soils within each basin. The soil database for the Sasco Brook watershed was obtained from the NRCS Web Soil Survey. The SCS hydrologic soil group (HSG) classification[4] (A, B, C, or D, from lowest runoff potential to highest runoff potential,) was determined from the soil database. When a soil type is assigned with a dual-classification (e.g., B/D), the soil group with the higher runoff potential conservatively was used (e.g., D). For some soils, the HSG classification was not in the database. For these cases, the HSG classification is communicated as 'Null'. Null soils were conservatively assumed to have the same runoff as HSG D classification soils. **Figure 3** shows the HSG classifications for the Sasco Brook study area.

[4] 1955 USDA Reference: Musgrave, G.W. 1955. How much of the rain enters the soil? In Water: U.S. Department of Agriculture. Yearbook. Washington, DC. pp. 151–159.

The initial condition of the peaking coefficient for the calibration process was 0.6 – the middle of the range of acceptable peaking coefficient values (0.4 to 0.8). To estimate lag time, GZA used the Geographic Information System (GIS) ArcMap 10.2.2 to estimate physical parameters of the watersheds including the length, *L*, of the main stream from the outlet to the divide (mi) and the length, L_c, along the main stream to the point nearest the watershed centroid (mi).

4.7.2 Study Watersheds Model Setup

GZA simulated the rainfall/runoff processes for the 8 study watersheds, which collectively include a total of 49 sub-watersheds. GZA accomplished this using the Snyder Unit Hydrograph method and NOAA Atlas 14 precipitation data within the HEC-HMS 4.1 software. For each sub-watershed, GZA estimated the area, Snyder *L* and L_c, and the infiltration rate (see **Figure 5**). Using the Snyder *L* and L_c along with the calibrated and verified Snyder parameters, GZA transcribed Snyder model parameters to each sub-watershed. Each sub-watershed was modeled as an individual basin element in HEC-HMS using the Snyder Unit Hydrograph method.

A figure for the study watershed model setup is provided in **Appendix B**. A table summarizing the input Snyder parameters for each sub-watershed is also provided in **Appendix B**.

4.8 HYDROLOGIC RESULTS

This section describes the results of the calibration and verification runs for the Sasco Brook surrogate watershed as well as the results of the hydrologic simulations for the 10-, 25-, 50-, 100-, and 500-year storms for each of the 49 sub-watersheds.

4.8.1 Calibration Results

The calibrated Snyder parameters are summarized in **Table 3.**

Table 3: Summary of Calibration Results for Sasco Brook

Unit Hydrograph Input Parameters	April 1996	September 2004	April 2007	March 2010
Initial Loss [in]	0.0	0.5	1.0	0.0
Constant Loss Rate [in/hr]	0.1	0.105	0.05	0.05
Snyder Peaking Coefficient	0.4	0.4	0.8	0.4
Lag Time [hr]	5.3	5.0	4.75	7.5
Observed Peak Streamflow [cfs]	480	425	1,300	603
GZA Model Peak Streamflow [cfs]	477	434	1,256	578

In GZA's opinion, the parameters resulted in a reasonable fit to the observed streamflow of the gauge at Sasco Brook. Graphical calibration results can be found in **Appendix C**. The April 1996, September 2004, April 2007, and March 2010 flood hydrographs were different in shape and volume due to varying antecedent moisture conditions and the total amount and distribution of rainfall. As expected, initial losses for September 2004 and April 2007 storms were greater than the April 1996 and March 2010 storm. This was expected due to observed antecedent conditions.

Based on the results for the four calibration storms and using engineering judgment, GZA applied the following calibrated Snyder Unit Hydrograph parameters for Sasco Brook: lag time is 5 hours and peaking coefficient is 0.40. GZA estimated that the calibrated value for constant loss rate is 0.05 inches per hour.

4.8.2 Verification Results

Holding the above Snyder Unit Hydrograph parameters constant (Lag, Peaking Coefficient, and Constant Loss Rate), GZA simulated the runoff process for the three candidate storms: April 2006, March 2010, and May 2014. To verify the modeled watershed response, GZA compared the simulated results of each flood to the observed streamflow and overall configuration at Sasco Brook (USGS 01208950). GZA's HEC-HMS model simulated the observed peak streamflow within 45 cfs for the April 2006 storm event, one of the largest on record. Verification results are shown in **Table 4**.

Table 4: Summary of Verification Results to Streamflow from Sasco Brook

Unit Hydrograph Input Parameters	April 2006	March 2010	May 2014
Initial Loss [in]	0.5	0.0	0.2
Constant Loss Rate [in/hr]	0.05	0.05	0.05
Snyder Peaking Coefficient	0.4	0.4	0.4
Lag Time	5.0	5.0	5.0
Observed Peak Streamflow [cfs]	1,140	560	550
GZA Model Peak Streamflow [cfs]	1,185	335	480

As **Table 4** shows, there is relatively good agreement between the observed peak streamflow and the GZA HEC-HMS model peak streamflow. Further, for all simulated events, GZA's model simulated the timing and shape of the observed hydrographs appropriately (see **Appendix C**). These results give GZA confidence that the Snyder Unit Hydrograph parameters, Standard Lag (hr) and Peaking Coefficient, were properly chosen in the calibration process. Deviations in observed and simulated peak streamflow can be mainly attributed to antecedent moisture conditions, which could contribute to deviations from the estimated constant loss, in GZA's opinion. For example, prior to the March 31, 2010 event used for verification the region had received heavy rainfall throughout the month of March (as evidence by using one such event for the calibration stage.) It is possible that, due to the significant precipitation events prior, the moisture conditions in the soils would be such that the soils would reject any infiltration either in the form of initial losses or constant losses. In fact, when using zero initial losses and zero constant losses for the late March 2010 event, GZA's model suggests outputs a peak streamflow of 550 cfs, only 10 cfs less than the observed.

Nonetheless the verification results are satisfactory, in GZA's opinion.

4.8.3 Westport sub-watershed hydrologic results

The sub-watershed areas ranged from 0.02 square miles to 1.99 square miles. The smallest sub-watershed is the 2nd most upstream watershed for Willow Brook (called Willow Brook 2). The largest sub-watershed is the most upstream watershed for Stony Brook (called Stony Brook 1). The sub-watersheds are identified by their stream name and a number. The number represents their chronological order from upstream to downstream.

The calculated lag time for the sub-watersheds ranged from 0.8 hours to 3.1 hours. The sub-watershed with smallest lag time is Willow Brook 1. The sub-watershed with the longest lag time is Stony Brook 1.

The calculated constant loss rates for the sub-watersheds ranged from 0.04 to 0.18. The sub-watershed with the lowest constant loss is Silver Brook 1. Three sub-watersheds have constant loss rates equal to 0.18: Silver Brook 3, Willow Brook 4, and Willow Brook 5.

The smallest peak flow for each design storm was observed from the Willow Brook 2 sub-watershed. The largest peak flow for each design storm was observed from the Stony Brook 1 sub-watershed. The 10-year peak flows at these two watersheds, rounded to the nearest 10 cfs, was 10 cfs and 520 cfs. The 25-year peak flows at these watersheds was 20 cfs and 650 cfs. The 50-year peak flows at these watersheds was 20 cfs and 750 cfs. The 100-year peak flows at these watersheds was 20 cfs and 850 cfs. The 500-year peak flows at these watersheds was 30 cfs and 1,180 cfs.

A summary of the Snyder input parameters for each sub-watershed is in **Appendix B**. The peak flow from each sub-watershed is included in a table in **Appendix C**. The time series hydrograph output from each sub-watershed is used as an input to the HEC-RAS hydraulic model.

5.0 HYDRAULIC ANALYSIS

To estimate the water surface profile and flooding extents of each stream, GZA performed hydraulic simulations. Using our results from the aforementioned hydrologic analysis, the hydraulic simulations were performed using USACE's HEC-RAS computer program. The eight streams were modeled using the two-dimensional (2-D), unsteady, mixed flow regimes. GZA set up the models in the following general sequence:

1. Imported digital terrain data and land cover data.
2. Defined the model extents (2-D Flow Area) with a polygon.
3. Assigned grid size resolution and HEC-RAS then generated a grid within the model extents.
4. Added dams and other hydraulic conveyance structures within the model extents.
5. GZA modified the grid using breaklines, which are used to align grid cells with significant topographic features, such as high points (i.e. ridges).
6. Added boundary conditions along the edge of the model extents. Boundary conditions can be locations of incoming or outgoing flow.

The HEC-RAS software utilized the terrain and land cover to generate cross sections at each grid face and storage-elevation curves for each grid cell. After the grid and boundary conditions were established, flow was routed through the model extents.

GZA added the HEC-HMS output incremental hydrographs for each sub-watershed, as boundary conditions. Subsequently, HEC-RAS routes the hydrographs through the downstream channel and floodplain. Each hydrograph is typically translated and attenuated as it progresses downstream due to variations in channel valley geometry/storage, roughness, lateral inflows/outflows, acceleration effects, and hydraulic structures such as dams and bridges.

GZA then developed flood mapping by using the results from the HEC-RAS analysis. The flood area is calculated by HEC-RAS and can be exported to ArcMap (GIS). The flood areas are calculated by comparing the ground surface elevation to the maximum water surface elevations. Water surface elevations are linearly interpolated between grid faces. In those areas where the water surface elevation is greater than the ground surface elevation, the area is considered inundated.

5.1 2-D FLOW AREA

The HEC-RAS model 2-D flow areas were comprised of a grid with an average cell size of about 30 feet by 30 feet (see **Appendix D**). Breaklines were created by GZA to align grid cell edges with high ground, such as roadways and ridges. Each stream had the following number of cells in their respective 2-D flow area:

Table 5: Number of Grid Cells in 2-D Flow Areas

Riverine 2-D Model	Number of Grid Cells	Riverine 2-D Model	Number of Grid Cells
Indian River	7,679	Pussy Willow Brook	21,215
Muddy Brook	36,126	Silver Brook	44,788
New Creek	12,896	Stony Brook	22,449
Poplar Plains Brook	11,163	Willow Brook	15,634

The 2-D flow areas were linked with the terrain data provided by the Town. GZA modified the terrain to include a trapezoidal channel representing each stream's bathymetry (i.e. stream bank elevations below the water). The terrain data does not directly include ground elevations under water. The thalweg of the trapezoidal channel was set equal to the streams' channel invert as measured during GZA's field assessment in February 2017.

The 2-D flow area was also linked with spatial land use data. The Town of Westport provided shapefiles to GZA of buildings and pavements within the Town of Westport. Additional land use data was obtained from a statewide dataset based on imagery captured in 2010. The land use dataset was downloaded from the Center for Land-use Education and Research (CLEAR) and imported to HEC-RAS. GZA developed a shapefile for each stream's extent, as well. GZA assigned a Manning's n value to each land use type[5]. The Manning's n values ranged from .03 to 0.10 and are summarized in the table below:

Table 6: Manning's n Values for Different Land Uses

Land Use	Manning's n	Land Use	Manning's n
Stream	0.035	Developed	0.2
Building	0.5	Turf and Grass	0.04
Pavement	0.025	Other Grass	0.04
Ag. Field	0.03	Deciduous Forest	0.1
Water	0.035	Coniferous Forest	0.1
Non-Forested Wetland	0.05	Barren	0.03
Forested Wetland	0.08	Utility	0.1
Tidal Wetland	0.08		

5.2 BRIDGES/CULVERTS/DAMS

GZA collected field measurements for selected conveyance structures accessible on February 1 and 2, 2017. Structure dimensions and the vertical distance from road to streambed were measured and recorded. GZA took photographs of structures, if they were accessible. Field measurements were utilized as input parameters in the HEC-RAS models unless otherwise stated. A photo log of the structures is included in **Appendix E.** In addition, GZA was able to obtain inspection reports for some interstates, railroads, and major roadway crossings from the Connecticut Department of Transportation (CT DOT) ProjectWise website. For interstates and railroads that were not provided in inspection reports and not assessed in the field, the Town provided structure type, dimensions, and length.

For conveyance structures located on private property, GZA went door-to-door to gain permission to access the structures. If no one was present at the time of the visit, an informative letter was attached to the door prior to GZA taking measurements.

For the structures that were not accessible during GZA's visit, they were approximated to the best extent possible. For conveyance structures that have two different upstream and downstream dimensions, GZA utilized the most

[5] Australian Rainfall & Runoff Revision Projects, Project 15: Two Dimensional Modelling in Urban and Rural Floodplains, November 2012.

constricting structure dimension in the HEC-RAS model. Structure type and size that are in the HEC-RAS models are summarized in **Appendix E**. GZA included footnotes in the appendix if unique situations were encountered, assumptions were made, or data other than field measurements were utilized in the HEC-RAS models. Additionally, all conveyance structures were confirmed to be or assumed to be straight unless otherwise noted.

GZA modeled the bridges, culverts, and dams as hydraulic structures within the 2D grid. The bridges and culverts were modeled using the HEC-RAS culvert equations. The dams were modeled using the weir equation.

5.3 DOWNSTREAM BOUNDARY CONDITIONS

A stage hydrograph was assigned as a downstream boundary condition for each stream. Poplar Plains Brook, Silver Brook, and Willow Brook discharge into a larger river (either the Aspetuck River or the Saugatuck River). The downstream water surface elevations were based on the water surface profiles for the larger river, as presented in the current FEMA FIS. The remaining five streams flow into the Long Island Sound or the lower Saugatuck River and are affected by the tidal elevations of the Long Island Sound. The streams affected by tidal water surface elevations were given a downstream boundary condition equal to the Mean Higher-High Water level[6] of 3.67 feet, as reported by NOAA gauge 8468191. The stage hydrograph inputs for all eight study streams are listed in the table below.

Table 7: Stage Hydrograph Inputs at Downstream Boundaries

Stream Name	Water Surface Elevation (feet)	Model Storm Event(s)
Indian River	3.67	10-, 25-, 50-, 100-, and 500-year
Muddy Brook	3.67	10-, 25-, 50-, 100-, and 500-year
New Creek	3.67	10-, 25-, 50-, 100-, and 500-year
Poplar Plains Brook	21.2	10-year
	22.03	25-year
	23.4	50-year
	24.9	100-year
	28.5	500-year
Pussy Willow Brook	3.67	10-, 25-, 50-, 100-, and 500-year
Silver Brook	34.25	10-year
	35.09	25-year
	36.5	50-year
	39	100-year
	41.5	500-year
Stony Brook	3.67	10-, 25-, 50-, 100-, and 500-year
Willow Brook	9.2	10-year
	10	25-year
	10.8	50-year
	11.4	100-year
	12.7	500-year

[6] The FEMA document titled "Guidance for Flood Risk Analysis and Mapping – Hydraulics: One-Dimensional Analysis" (November 2016) states that tidal boundaries should be assigned the Mean Higher High Water (MHHW) level.

5.4 INFLOW HYDROGRAPHS

The results from the HEC-HMS model are used to represent the inflow hydrographs at the sub-watersheds of the eight study streams. These hydrographs represent runoff from each sub-watershed, which are routed through the downstream channel and floodplain. The peak flow for the HEC-HMS hydrographs are summarized in **Appendix C**.

5.5 SIMULATION PARAMETERS

HEC-RAS can perform two-dimensional unsteady flow routing with either the Full Saint Venant equations or the Diffusion Wave equations. GZA performed the simulations using the Diffusion Wave equations. The HEC-RAS User's Manual states this equation can model most modeling situations accurately at a faster rate with greater stability properties[7]. The Full Saint Venant equations should be used for modeling dam breaches, flash floods, models with a time-varying downstream boundary condition, and other unique conditions.

The manual also gives guidance on selecting a computational time step. The time step should be selected such that the Courant Number (a function of flood wave celerity, time step, and average cell size) is less than or equal to 2.0. The Courant Number can be calculated with the following equation:

$$C = \frac{V\Delta T}{\Delta X} \leq 2.0 \qquad \text{Equation 3}$$

Where:

C : Courant Number (dimensionless),

V : Flood Wave Celerity (ft/s),

ΔT : Computational Time Step (s),

ΔX : Average cell size (ft).

The HEC-RAS manual states the maximum velocity in the 2D flow area can be used for V. The maximum velocities that GZA observed in the model are approximately 12 ft/s. The HEC-RAS model cell size is 30 feet. Based on this guidance, GZA assigned a time step equal to 5 seconds for the simulation. GZA also performed a sensitivity test by iteratively decreasing the time step to observe the change in water surface elevations. GZA found that with smaller time steps than 5 seconds, the water surface elevations did not appreciably change.

5.6 HYDRAULIC RESULTS

The results were observed using the HEC-RAS Mapper program. The program is a feature in HEC-RAS which maps water surface elevations, depths, velocities, and flow paths over time. The program can be used to view animations of the progression of flooding. The animations were used to evaluate causes of flooding. For example, the animation can show how water backs up at a culvert and eventually floods a building located on the culvert's upstream side.

The results of the analysis are shown in in the form of hydrographs for each stream's downstream limit in **Appendix F**, hydraulic profiles in **Appendix G**, and flood maps in **Appendix H**. A summary of the results of GZA's HEC-RAS modelling is presented below.

The result summaries include three tables. The first table is a summary of the peak discharges at the stream's downstream limit. The second table is a list of roadways that are flooded by the stream's 10-year or 100-year floods.

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[7] "HEC-RAS River Analysis System 2D Modeling User's Manual," Version 5.0, USACE, February 2016.

Note that some of the roadways do not traverse the stream, but are located near the stream's overbank. The maximum depth of water, rounded to the nearest half foot, along the roadway is reported as well.

The third table presents the number of buildings for which at least 25 percent of the building's footprint is within the 10-year and 100-year flood zone. The causes of flooding at the buildings, as observed using the HEC-RAS animation, are listed. Note that in some cases, there may be multiple causes. The counted buildings include residences, detached garages, commercial buildings, etc., and are highlighted in orange on the flood maps. GZA counted buildings with 25 percent in the flood zone as opposed all buildings in the flood zone for two reasons. First, it is more likely that buildings with 25 percent in the flood zone remain in the flood zone when regarding the model's uncertainty. Second, it puts priority on buildings which will likely experience more significant damage from flooding.

GZA understands that for insurance purposes, the percentage of a building in the flood zone is irrelevant. In Table 8 below, the total number of buildings in the 100-year flood zone for each stream is listed. The counted buildings include residences, detached garages, commercial buildings, etc. The buildings which have 25 percent in the flood zone are highlighted in orange on the flood maps, and the rest of the buildings are highlighted in grey.

Note that GZA did not count buildings nor identify overtopped roadways if the structure was flooded due to the model's downstream boundary condition (i.e. mean-higher-high tide, or the water surface elevation in the Saugatuck River or Aspetuck River).

Table 8: Buildings within the 100-year Flood Zone for Each Stream

Stream	Number of Buildings With 25% in 100-Year Flood Zone	Total Number of Buildings in 100-Year Flood Zone
Indian River	46	61
Muddy Brook	36	63
New Creek	13	22
Poplar Plains Brook	8	13
Pussy Willow Brook	92	112
Silver Brook	40	65
Stony Brook	54	77
Willow Brook	21	42

5.6.1 Indian River

Indian River primarily travels through residential development and coastal wetlands. The stream's corridor is relatively narrow and travels a length of approximately 0.9 river miles within the Town of Westport. The peak discharge for the five storm events were near the downstream limit, on the upstream side of Indian River Green Road. The results at the downstream limit are shown below:

Table 9: Peak Discharge near Indian River's Downstream Limit

24-Hour Storm Event	Peak Discharge (cfs)
10-year	110
25-year	150
50-year	180
100-year	200
500-year	270

Table 10: Roadways Overtopped by Indian River's 10-Year and 100-Year Floods

Roadway (Upstream to Downstream)	Maximum Depth Over Roadway for 10-Year Flood (feet)	Maximum Depth Over Roadway for 100-Year Flood (feet)
Kings Highway S/County St.	Dry	1.0
Tarone Drive	Dry	1.0
Hogan Trail	0.5	1.5
Cricket Lane	0.5	3.0
Robert Lane	1.0	4.5
Hiawatha Lane	0.5	1.5
Dr. Gillette Circle	1.0	1.0
Saugatuck Avenue/State Highway 136	1.0	1.0
Great March Road*	1.0	1.0

** Backwater at the railroad results in Indian River floodwaters traveling through a railroad culvert slightly west of Indian River. These floodwaters travel to Long Island Sound. Note that GZA did not model culverts/bridges along this flow path, which are Saugatuck Avenue and Great Marsh Road. Therefore, the model may be overestimating flooding along this flow path.*

Table 11: Buildings with 25% of Footprint within Indian River's 10-Year and 100-Year Floods

Cause of Flooding	# of Buildings within the 10-Year Floodplain	# of Buildings within the 100-Year Floodplain
Backwater from Kings Highway S Culvert	1	1
Backwater from Tarone Drive	1	1
Backwater from Hogan Trail	2	4
Backwater from I-95	10	22
Backwater from Railroad	10	18

5.6.2 Muddy Brook

Muddy Brook primarily travels through residential development and some commercial development. The stream's corridor is relatively narrow and travels a length of approximately 4.5 river miles. The peak discharge for the five storm events were taken from a stream cross section between Sherwood Island Connector and Interstate 95. The results are shown below:

Table 12: Peak Discharge near Muddy Brook's Downstream Limit

24-Hour Storm Event	Peak Discharge (cfs)
10-year	680
25-year	950
50-year	1,170
100-year	1,260
500-year	1,830

Table 13: Roadways Overtopped by Muddy Brook's 10-Year and 100-Year Floods

Roadway (Upstream to Downstream)	Maximum Depth Over Roadway for 10-Year Flood (feet)	Maximum Depth Over Roadway for 100-Year Flood (feet)
Cross Highway	0.5	0.5
Bayberry Lane	1.0	1.5
High Pond Road	< 0.5	0.5
Meadowbrook Lane	1.0	1.5
Ambler Road	1.0	1.5
North Turkey Hill Road	1.0	1.5
US Highway 1	< 0.5	0.5
Morningside Drive	1.5	2.0
Hillandale Road	0.5	1.0
Center Street Road	0.5	1.5
Green Farms Road	4.5	7.5
Nyala Farm Road	1.5	4.0
Sherwood Island Connector	Dry	2.5
I-95	Dry	4.5
Railroad	Dry	1.0

Table 14: Buildings with 25% of Footprint within Muddy Brook's 10-Year and 100-Year Floods

Cause of Flooding	# of Buildings within the 10-Year Floodplain	# of Buildings within the 100-Year Floodplain
Insufficient Channel Capacity upstream of High Point Road	1	1
Backwater from Long Lots Road	2	2
Backwater from driveways downstream of Meadowbrook Lane	0	2
Backwater from Turkey Hill Road	4	4
Backwater from US Highway 1	5	6
Backwater from Hillandale Road	4	4
Backwater from Center Street	5	6
Backwater from Green Farms Road	4	6
Backwater from Nyala Farm Road	0	2
Backwater from I-95	2	3

Besides buildings, the some of the parking lots around US Highway 1 and Morningside Drive exhibit shallow flooding.

5.6.3 <u>New Creek</u>

New Creek travels through residential development and upland and coastal wetlands. The stream's corridor is narrow and expands horizontally through wetlands. The length of New Creek is approximately 2 river miles. The peak discharge for the five storm events were taken from a stream location downstream of Beachside Avenue. The results are shown below:

Table 15: Peak Discharge near New Creek's Downstream Limit

24-Hour Storm Event	Peak Discharge (cfs)
10-year	210
25-year	240
50-year	300
100-year	350
500-year	550

Table 16: Roadways Overtopped by New Creek's 10-Year and 100-Year Floods

Roadway (Upstream to Downstream)	Maximum Depth Over Roadway for 10-Year Flood (feet)	Maximum Depth Over Roadway for 100-Year Flood (feet)
Green Farms Road	2.5	4.0
New Creek Road (roadway passes under I-95)	3.5	4.0

Table 17: Buildings with 25% of Footprint within New Creek's 10-Year and 100-Year Floods

Cause of Flooding	# of Buildings within the 10-Year Floodplain	# of Buildings within the 100-Year Floodplain
Insufficient channel capacity about 1,000 feet upstream of Clapboard Hill Road	1	1
Backwater from Green Farms Road	3	5
Backwater from I-95	2	2
Backwater from Railroad	2	2
Backwater from Maple Lane	2	3

5.6.4 Poplar Plains Brook

Poplar Plains Brook travels through residential development and wetlands. The stream's corridor is narrow and expands horizontally through wetlands. The length of Poplar Plains Brook is approximately 2 river miles. The peak discharge for the five storm events were taken from a stream location downstream of Rices Lane. The results are shown below:

Table 18: Peak Discharge near Poplar Plains Brook's Downstream Limit

24-Hour Storm Event	Peak Discharge (cfs)
10-year	330
25-year	370
50-year	440
100-year	500
500-year	720

Table 19: Roadways Overtopped by Poplar Plains Brook's 10-Year and 100-Year Floods

Roadway (Upstream to Downstream)	Maximum Depth Over Roadway for 10-Year Flood (feet)	Maximum Depth Over Roadway for 100-Year Flood (feet)
Newtown Turnpike	< 0.5	< 0.5
State Highway 33 (Wilton Rd)	1.0	1.0

Table 20: Buildings with 25% of Footprint within Poplar Plains Brook's 10-Year and 100-Year Floods

Cause of Flooding	# of Buildings within the 10-Year Floodplain	# of Buildings within the 100-Year Floodplain
Backwater from Merritt Parkway	3	4
Building Close to Wetland near Lowlyn Road	0	1
Overtopping of State Highway 33	2	2
Small Dams; Insufficient Channel Capacity; model instability*	1	1

** GZA observed the hydraulic profile in **Appendix G** shows a model instability at Dam 2, which is adjacent to this building. The hydraulic profile shows a spike in water surface elevation. The model may be over-estimating flooding in this location.*

5.6.5 <u>Pussy Willow Brook</u>

Pussy Willow Brook primarily travels through residential development, limited commercial development, and wetlands. The stream's corridor is relatively narrow and expands horizontally through wetlands. The length of Pussy Willow Brook is approximately 2.4 river miles. The peak discharge for the five storm events were taken from a stream cross section between Hillspoint Road and Interstate 95. The results are shown below:

Table 21: Peak Discharge near Pussy Willow Brook's Downstream Limit

24-Hour Storm Event	Peak Discharge (cfs)
10-year	100
25-year	110
50-year	110
100-year	120
500-year	160

Table 22: Roadways Overtopped by Pussy Willow Brook's 10-Year and 100-Year Floods

Roadway (Upstream to Downstream)	Maximum Depth Over Roadway for 10-Year Flood (feet)	Maximum Depth Over Roadway for 100-Year Flood (feet)
Webb Road	0.5	1.0
Sue Terrace	1.0	1.0
Crescent Road	1.5	3.0
Spicer Road	0.5	0.5
Beechwood Lane	1.0	1.0
Valley Road	0.5	1.0
Guyer Road	0.5	1.0
Lakeview Road	0.5	2.0
High Street	1.0	3.5
Hale Street	<0.5	2.0
I-95	Dry	<0.5
Railroad	<0.5	0.5

Table 23: Buildings with 25% of Footprint within Pussy Willow Brook's 10-Year and 100-Year Floods

Cause of Flooding	# of Buildings within the 10-Year Floodplain	# of Buildings within the 100-Year Floodplain
Backwater from driveway culverts along Sue Terrace/Insufficient channel capacity	4	6
Backwater from North Avenue/Yard Culvert upstream of Crescent Road and Culvert under Crescent Road/Post Road	4	8
Backwater from Spicer Road	2	3
Overtopping of Spicer Road	1	1
Backwater from Office Park Culvert and Green Farms Road	23	73
Backwater from I-95	1	1

5.6.6 Silver Brook

Silver Brook travels through residential development and wetlands. The stream's corridor is relatively narrow and expands horizontally through wetlands and ponds. The length of Silver Brook is approximately 2 river miles. The peak discharge for the five storm events were taken from a stream cross section between Bonnie Brook Road and Lyons Plains Road. The results are shown below:

Table 24: Peak Discharge near Silver Brook's Downstream Limit

24-Hour Storm Event	Peak Discharge (cfs)
10-year	130
25-year	170
50-year	210
100-year	260
500-year	390

Table 25: Roadways Overtopped by Silver Brook's 10-Year and 100-Year Floods

Roadway (Upstream to Downstream)	Maximum Depth Over Roadway for 10-Year Flood (feet)	Maximum Depth Over Roadway for 100-Year Flood (feet)
Bayberry Lane	1.0	1.0
Charcoal Hill Commons	<0.5	0.5
Charcoal Hill Road*	<0.5	0.5
North Avenue**	<0.5	0.5
Easton Road	1.0	1.0
Brooklawn Drive	1.5	1.5
Meadow View Drive South	Dry	0.5
Pony Lane	1.5	2.0
Town Crier Lane	0.5	1.0
Rockyfield Road	1.0	1.5
Warnock Drive	2.5	3.0
Bonnie Brook Road	<0.5	1.5
Bonnie Brook Lane	0.5	1.0
Lyon's Plain Road	Dry	***

**Please note that several unique circumstances may have influenced select flooding areas. Charcoal Hill Road is overtopped in the HEC-RAS model; however, field observations suggest that overtopping would be an unlikely situation due to the very steep grade of the road and several stormwater inlet structures along the road. Additionally, the flooding of Charcoal Hill Road appears to be the cause of flooding for one adjacent building. GZA does not have a clear understanding of the stormwater catchment system in this area, but it is likely that the inlets would alleviate the pooling of rainfall on this steep road and flooding of the adjacent residence.*

***Based on aerial imagery, there is likely an additional culvert crossing beneath North Avenue and north of Silver Brook's main channel, which was assessed in the field because it is not along Silver Brook. It was not modeled in HEC-RAS. If the culvert were added to the HEC-RAS model, it would likely alleviate the flooding of North Avenue in this area. GZA's inflow hydrograph is positioned north of North Avenue, and is contributing to some of the flooding along the road. The location of the inflow hydrograph may also be resulting in an over-estimation of flooding along the road.*

****Lyon's Plain Road is overtopped. However, the road is overtopped from flooding in the Aspetuck River before floodwaters from Silver Brook reach it.*

Table 26: Buildings with 25% of Footprint within Silver Brook's 10-Year and 100-Year Floods

Cause of Flooding	# of Buildings within the 10-Year Floodplain	# of Buildings within the 100-Year Floodplain
Channel Split Diverting Flow (600 feet east of North Avenue)*	1	1
Overtopped Charcoal Hill Road*	1	1
Backwater from Pony Lane Culvert	4	5
Overtopped Easton Road from backwater from Pony Lane Culvert (floodwater travels southwest)	8	17
Floodwaters from overtopping of Easton Road pass under Merritt Parkway and towards Willow Brook**	2	5
Backwater from Town Crier Road	4	4
Overtopping of Town Crier Road	2	2
Insufficient Channel Capacity/Overtopped Bonnie Brook Road	2	2
Insufficient Channel Capacity Between Bonnie Brook Road and Lyons Plains Road	0	3

**A steep and sudden channel grade change (i.e. waterfall feature) was observed in the field upstream of the "North Avenue Culvert" inlet within the backyard of a residence off of Charcoal Hill Road. The HEC-RAS model appears to have interpreted the terrain data in a way that creates a split/fork in the channel flow path. The secondary flow path traveled southwest and inundated a building on its way toward North Avenue. Although, the terrain may allow the channel flow to overflow as the HEC-RAS model projects; it is also possible that the program misinterpreted the terrain data in this very steep area.*

***The flooding caused by the backwater from Pony Lane and subsequent overtopping of Easton Road, appears to be the primary contributor to excess flow entering the Willow Brook watershed south of Merritt Parkway through the Easton Road underpass. Note that aerial imagery suggests there may be a culvert along this flow path, between Merritt Parkway and Willow Brook. The culvert was not assessed in the field because it does not traverse one of the eight study streams, and therefore, it was not modeled in HEC-RAS.*

Note that roadways and buildings which are flooded as a result of the downstream boundary condition (i.e. water level in the Aspetuck River or tide elevation) are not listed in the above tables. Four buildings and four roads at the downstream end of Silver Brook are inundated by the flooding of the Aspetuck River.

Besides buildings, a parking lot between Bonnie Brook Road and Lyons Plains Road exhibited flooding.

5.6.7 Stony Brook

Stony Brook travels through residential development, wetlands, and some commercial development. The stream's corridor expands horizontally through wetlands and floods downstream development during high flow storms. The length of Stony Brook that GZA modeled is approximately 2 river miles. The peak discharge for the five storm events were taken from a stream location downstream of US Post Road 1. The results are shown below:

Table 27: Peak Discharge near Stony Brook's Downstream Limit

24-Hour Storm Event	Peak Discharge (cfs)
10-year	830
25-year	1,030
50-year	1,180
100-year	1,520
500-year	1,750

Table 28: Roadways Overtopped by Stony Brook's 10-Year and 100-Year Floods

Roadway (Upstream to Downstream)	Maximum Depth Over Roadway for 10-Year Flood (feet)	Maximum Depth Over Roadway for 100-Year Flood (feet)
Patrick Road	Dry	1
Stony Brook Road	Dry	1
Blind Brook Road	< 0.5	1
South Blind Brook Road	2	3
Kings Highway	1.5	2.5
US Highway 1 (Post Road)	0.5	1
Sylvan Road	1	1.5
Riverside Avenue	0.5	1.5

Table 29: Buildings with 25% of Footprint within Stony Brook's 10-Year and 100-Year Floods

Cause of Flooding	# of Buildings within the 10-Year Floodplain	# of Buildings within the 100-Year Floodplain
Backwater from Patrick Road	3	3
Insufficient channel capacity and overtopping of Patrick Road	1	1
Insufficient channel capacity north of dam near Woodside Lane	2	3
Backwater from driveway and dam near Woodside Lane	1	2
Backwater from Stony Brook Road	1	1
Overtopping of Stony Brook Road	0	1
Backwater from Blind Brook Road	2	6
Backwater from Nash Pond Dam	13	21
Backwater from Kings Highway	3	3

Cause of Flooding	# of Buildings within the 10-Year Floodplain	# of Buildings within the 100-Year Floodplain
Overtopping of Kings Highway/Post Road and insufficient Channel Capacity	0	2
Insufficient channel capacity near downstream limit and backwater from Sylvan Road	7	11*

**Many of the buildings in this area are commercial buildings.*

Besides buildings, the baseball field, tennis courts and some of the parking lots around Sylvan Road and Riverside Avenue exhibit flooding during the 10-year and/or 100-year flood.

5.6.8 Willow Brook

Willow Brook travels through residential development and wetlands. The stream's corridor expands horizontally through wetlands. The length of Willow Brook that GZA modeled is approximately 2 river miles. The peak discharge for the five storm events were taken from a stream location downstream of US Post Road 1. The results are shown below:

Table 30: Peak Discharge near Willow Brook's Downstream Limit

24-Hour Storm Event	Peak Discharge (cfs)
10-year	240
25-year	340
50-year	420
100-year	490
500-year	770

Table 31: Roadways Overtopped by Willow Brook's 10-Year and 100-Year Floods

Roadway (Upstream to Downstream)	Maximum Depth Over Roadway for 10-Year Flood (feet)	Maximum Depth Over Roadway for 100-Year Flood (feet)
North Avenue	Dry	<0.5
Bushy Ridge Road	<0.5	0.5
The Glen	Dry	0.5
Punch Bowl Drive	1.0	1.5
Gault Park Drive*	0.5	0.5
Coach Lane	0.5	0.5
Hockanum Road	0.5	1.0
Weston Road	Dry	0.5
Daybreak Lane	1.5	2.0
Campo Road	Dry	1.0
Main Street	2.0	2.5
Richmondville Ave	1.0	**

** Some flooding along Gault Park Drive is a result of floodwaters from Silver Brook, which overtopped Silver Brook's banks and flowed under the Merritt Parkways into Willow Brook's watershed.*

*** Richmondville Avenue is overtopped. However, the road is overtopped at the beginning of the simulation, and therefore the flooding is a result of the downstream boundary condition (i.e. water surface elevation in the Saugatuck River).*

Table 32: Buildings with 25% of Footprint within Willow Brook's 10-Year and 100-Year Floods

Cause of Flooding	# of Buildings within the 10-Year Floodplain	# of Buildings within the 100-Year Floodplain
Insufficient channel capacity downstream of Bushy Ridge Road	0	1
Backwater from Punch Bowl Drive	2	2
Overtopping of Punch Bowl Drive and backwater from Gault Park Drive	5	5
Backwater from Hockanum Road and insufficient channel capacity	0	1
Backwater from Weston Road	0	1
Overtopping of Weston Road	0	2
Insufficient channel capacity downstream of Weston Road	3	4
Backwater from Campo Road N	1	1
Overtopping of Main Street	0	3
Insufficient channel capacity upstream of Richmondville Ave.	0	1
Backwater from Richmondville Avenue	2	*
Overtopping of Richmondville Avenue	16	*

**Buildings inundated as a result of the downstream boundary condition.*

Note that roadways and buildings which are flooded as a result of the downstream boundary condition (i.e. water level in the Saugatuck River or tide elevation) are not listed in the above tables. 44 buildings and 4 roads at the downstream end of Willow Brook are inundated by the flooding of the Saugatuck River.

5.7 COMPARISON TO FEMA

The results of Study 1 are not intended to be used for insurance purposes. Nonetheless, GZA compared the results to those presented in the FEMA FIS and FEMA Flood Insurance Rate Maps (FIRMs) for informational purposes. The FEMA FIS only includes those streams that were studied with detailed studies, which are Muddy Brook, Poplar Plains Brook, Stony Brook, and Willow Brook. These streams are mapped as Zone A on FEMA FIRMs. The FEMA FIRMs also include Pussy Willow Brook and New Creek, which are Zone AE, signifying they were studied by approximate methods.

In **Table 33** below, the peak flows GZA calculated at each stream's downstream limit is compared to those presented in the FEMA FIS. The peak flows GZA calculated are generally higher than those presented by FEMA. The discrepancy can be due to multiple reasons, such as increased precipitation, increased development, and different methodologies used in the calculation.

Table 33: Comparison of 100-Year GZA Peak Flow with FEMA Peak Flow

24-Hour Storm Event	GZA Peak Discharge (cfs)	FEMA Peak Discharge (cfs)	FEMA's % Difference From GZA
Muddy Brook	1,260	1,100	-13
Poplar Plains Brook	500	245	-51
Stony Brook	1,520	1,700	12
Willow Brook	490	250	-49

Below is a summary of how the 100-year flood zone GZA calculated compares to the 100-year flood zones presented on FEMA's FIRMs. The 100-year flood zone that GZA calculated is referred to as the "GZA flood zone" and the 100-year flood zone presented on FEMA's FIRMs is referred to as the "FEMA flood zone".

The GZA flood zone for Muddy Brook is larger than the FEMA flood zone between the railroad and Green Farms Road, near the model's downstream limit. It encompasses approximately 8 structures that appear to not be within FEMA's flood zone. Upstream of Green Farms Road, the flood zones are similar with one exception. The GZA flood zone is slightly less than the FEMA flood zone upstream of US Highway 1, and as a result, a couple of buildings are removed from the flood zone limits. Further upstream, GZA's flood zone is generally equal to or less than FEMA's flood zone.

FEMA has mapping for only a short section of Poplar Plains Brook, from Route 33 until the confluence of Poplar Plains Brook and the Saugatuck River. Along this stretch, GZA's flood zone are greater in some locations, and less in others. GZA's flood zone includes 3 structures within its limits, as the FEMA flood zone includes 2.

At Stony Brook's downstream limit, GZA's flood zone is greater than FEMA's and includes approximately 5 additional structures. Also, near Post Road West, GZA's flood zone is greater and includes approximately 3 additional structures. Upstream of Nash Pond Dam, GZA's flood zone is slightly less than FEMA's and removes one structure. A wetland northwest of the Stony Brook, near Woodside Avenue, is included in the FEMA mapping but not reflected in GZA's results. Most likely, a culvert exists under Woodside Avenue which connects the wetland with Stony Brook. GZA's model does not include this culvert. Upstream of Stony Brook Road, GZA's flood zone includes 2 less structures than FEMA's flood zone. Near the Town's border, the 2 flood zones are very similar and the number of houses in the flood zone similar as well.

FEMA has mapping for only a short section of Willow Brook, from the brook's downstream limit up to Main Street. Along this reach, FEMA's mapping is generally similar to GZA's results. There does not appear to be a significant difference in the number of structure in the flood zone.

FEMA's flood zone for Pussy Willow Brook is very similar to GZA's flood zone directly upstream of Green Farms Road, where a significant number of structures are in the flood zone. Further upstream, the flood zones continue to compare well until Spicer Road. Near Spicer Road, GZA's flood zone is greater and encompasses approximately 4 more structures. However, upstream of US Highway 1, GZA's flood zone is less than FEMA's flood zone, removing approximately 25 structures.

FEMA's flood zone for New Creek is slightly greater than GZA's flood zone downstream of the railroad and includes approximately 10 structures not within GZA's flood extent. However, upstream of I-95, GZA's flood zone is slightly greater and includes 6 additional residences. Further upstream, GZA's flood zone is less than FEMA's and encompasses 3 less structures.

Overall, based on this preliminary analysis of GZA's maps compared with FEMA's FIRMs, GZA's results show slightly less structures in the eight stream's flood zones.

6.0 CONCLUSIONS

6.1 SIGNIFICANT FLOOD HAZARDS

The results in this study can be used to estimate where significant flood hazards exist within the Town of Westport. All eight streams show some buildings in the flood zone and overtopped roads; however, some streams show greater impacts than others. GZA has identified the 15 locations which show a large number of buildings in the flood zone, significant overtopping of a critical road, or both. Critical roads are considered major roads or roads which cannot be avoided via alternative routes.

Based on the modeling results, the location with the largest number of impacted buildings (Location 1) is along Pussy Willow Brook, upstream of Green Farms Road. The model indicates that during the 100-year storm, 73 buildings have 25% of the building's footprint in the flood zone. This area includes a residential neighborhood as well as an office park. This area is directly upstream of a series of culverts passing under Green Farms Road, Hillspoint Road, I-95, and the railroad.

The worst flooding among the 8 streams along a major highway or railway is along Muddy Brook (Location 2). The model results indicate overtopping of 4.5 feet at I-95 and 1 foot along the railroad. In this area, Muddy Brook is overtopping the Sherwood Island Connector, which appears to be a major route leading to I-95. In addition, Nyala Farms Road and Green Farms Road are significantly overtopped. The roads, however, do not appear to be a major means of access and may be avoided by taking alternative routes.

Other locations with significant flooding are as follows:

- Along Indian River, upstream of I-95, where a large number of buildings are in the flood zone. (Location 3)
- Along Indian River, upstream of the railroad, where a large number of buildings are in the flood zone and Hiawatha Lane is overtopped. Hiawatha Lane leads to a group of residences, and the residences cannot be accessed from an alternative route. (Location 4)
- Along Muddy Brook, at US Highway 1 (Post Road) and Morningside Drive. US Highway 1 is a major road. (Location 5)
- Along New Creek, upstream of I-95, where Green Farms Road and New Creek Road are overtopped. These roads appear to be important connector roads. (Location 6)
- Along Poplar Plains Brook, where State Highway 33 is overtopped. State Highway 33 is a major road. (Location 7)
- Along Stony Brook, upstream of Nash Pond Dam, where a large number of buildings are in the flood zone. (Location 8)
- Along Stony Brook, downstream of Nash Pond Dam, where two major roads (Post Road and Kings Highway) are overtopped. (Location 9)
- Along Stony Brook, near the river's downstream end, where flooding impacts a commercial area and the Saugatuck Elementary School, and overtops a major road (Riverside Avenue). (Location 10)
- Along Silver Brook, near Pony Lane, where Easton road is overtopped. Easton Road is a major road. The overtopping of Easton Road results in floodwaters traveling southwest, through the Merritt Parkway, and into the Willow Brook watershed. Along this path, 17 buildings have 25% of their footprint in the 100-year flood zone. (Location 11)
- Along Silver Brook, where the stream crosses Bonnie Brooks road twice. Flooding in the stream is expected to overtop both crossings of the road, which would trap residents along the road. (Location 12)

- Along Willow Brook, between Punch Bowl Drive and Weston Road, where floodwaters from both Willow Brook and Silver Brook may trap residents along Gault Park Drive and Punch Bowl Drive. (Location 13)
- Along Willow Brook, where Main Street is overtopped. Main Street is a major road. (Location 14)
- Along Willow Brook, near the downstream end, where 16 buildings have 25% of their footprint in the 10-year flood zone. (Location 15)

To compare these locations, the results from each location is summarized in **Table 34** below.

Proposed drainage improvements to alleviate these flood hazards are listed in a separate memorandum titled "Drainage Improvement Recommendations for 8 Streams in Westport, CT".

As a general observation, the models show the significant impacts that large embankments, such as highways and railroads, can make on a watershed's drainage. The location of I-95 and the railroad at the downstream end of some watersheds impedes the rivers' abilities to drain to the Long Island Sound. While these man-made structures can benefit a community against storm surge, they unfortunately block flow in both directions.

6.2 FURTHER STUDIES

The HEC-RAS model has been developed with the best data GZA was able to obtain under the scope of this project. Calibration can be performed if members of the town or property owners can recall historic flood events. GZA can simulate historical rainfall events in HEC-HMS, and input these hydrographs to the HEC-RAS model. The simulation results can be compared to historic flooding, and the model can be refined as necessary.

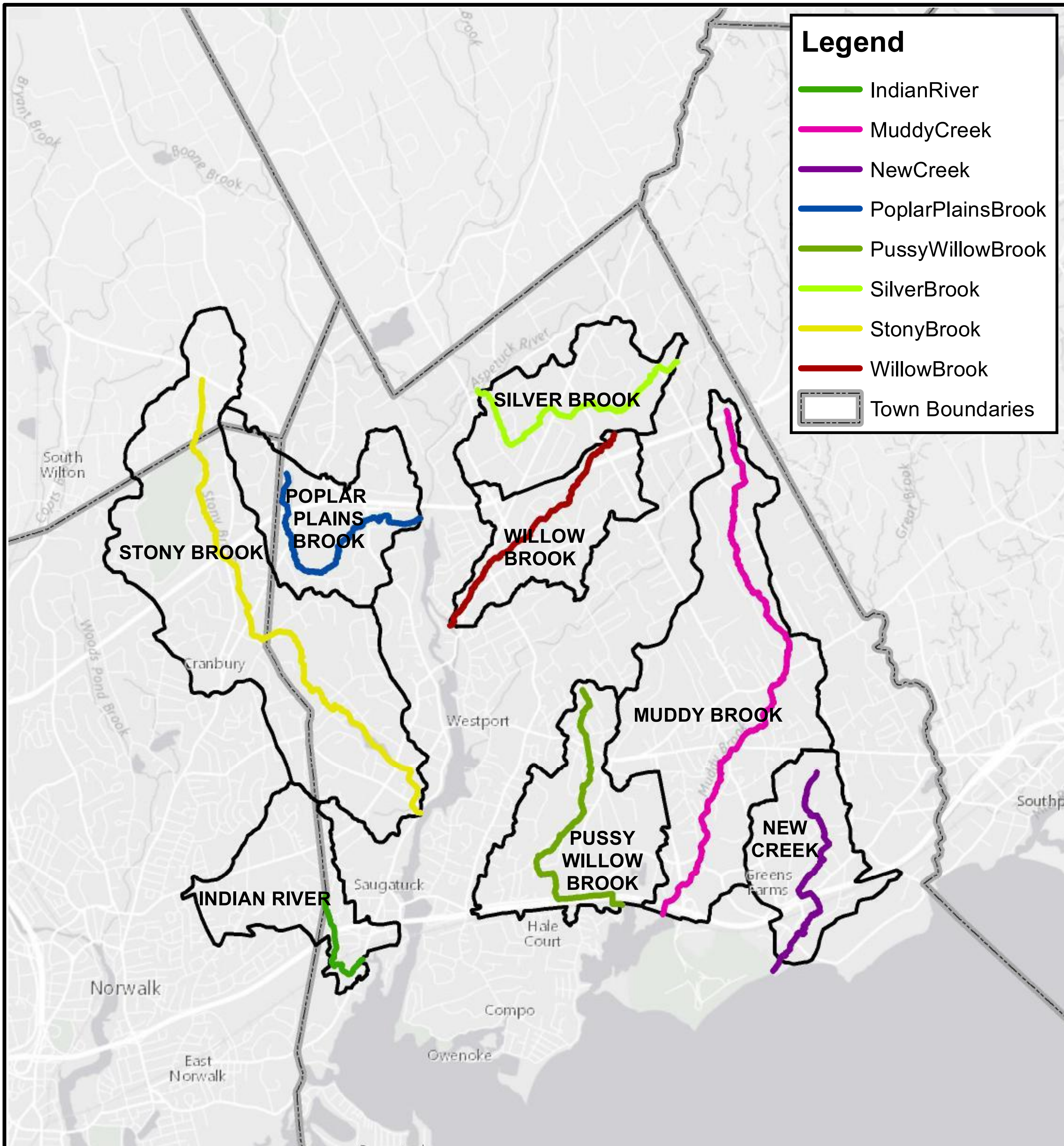
The HEC-RAS model can provide a useful tool for evaluating drainage improvements. Altering the capacity of a bridge/culvert/dam may affect peak flows downstream of the structure. The HEC-RAS model can be used to evaluate these effects. In addition, the HEC-RAS model can be used to assess the effects of dredging channels, building structures in the flood zone, altering land use, removing or adding dams, building levees, and adding additional culverts. The model can also be used to generate animations of the progression of flooding, as well as animations that show the flow paths of the water.

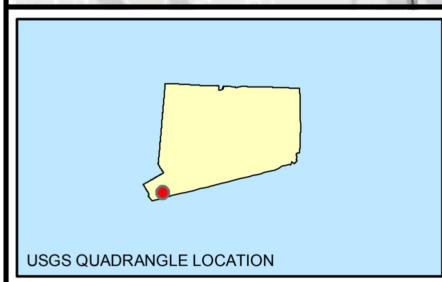
Table 34: Summary of Results for 15 Locations with Flood Hazards

Location # - River	Roadway	Maximum Depth Over Roadway for 10-Year Flood (feet)	Maximum Depth Over Roadway for 100-Year Flood (feet)
2 - Muddy Brook	Sherwood Island Connector	Dry	2.5
	I-95	Dry	4.5
4 - Indian River	Hiawatha Lane	0.5	1.5
5 - Muddy Brook	US Highway 1	< 0.5	0.5
	Morningside Drive	1.5	2.0
6 - New Creek	Green Farms Road	2.5	4.0
	New Creek Road (roadway passes under I-95)	3.5	4.0
7 - Poplar Plains Road	State Highway 33 (Wilton Rd)	1.0	1.0
9 - Stony Brook	Kings Highway	1.5	2.5
	US Highway 1 (Post Road)	0.5	1.0
10 - Stony Brook	Riverside Avenue	0.5	1.5
11 - Silver Brook	Easton Road	1.0	1.0
12 - Silver Brook	Bonnie Brook Road	<0.5	1.5
13 - Willow Brook	Punch Bowl Drive	1.0	1.5
	Gault Park Drive	0.5	0.5
14 - Willow Brook	Main Street	2.0	2.5

Location # - River	Cause of Flooding	# of Buildings within the 10-Year Floodplain	# of Buildings within the 100-Year Floodplain
1 - Pussy Willow Brook	Backwater from Office Park Culvert and Green Farms Road	23	73
3 - Indian River	Backwater from I-95	10	22
4 - Indian River	Backwater from Railroad	10	18
8 - Stony Brook	Backwater from Nash Pond Dam	13	21
10 - Stony Brook	Insufficient channel capacity near downstream limit and backwater from Sylvan Road	7	11
11 - Silver Brook	Overtopped Easton Road from backwater from Pony Lane Culvert (floodwater travels southwest)	8	17
15 - Willow Brook	Overtopping of Richmondville Avenue	16	NA

Figures





SOURCE : THIS MAP CONTAINS THE ESRI ARCGIS ONLINE USA TOPOGRAPHIC MAP SERVICE, PUBLISHED DECEMBER 12, 2009 BY ESRI ARCIMS SERVICES AND UPDATED AS NEEDED. THIS SERVICE USES UNIFORM NATIONALLY RECOGNIZED DATUM AND CARTOGRAPHY STANDARDS AND A VARIETY OF AVAILABLE SOURCES FROM SEVERAL DATA PROVIDERS.

Data Supplied by : esri

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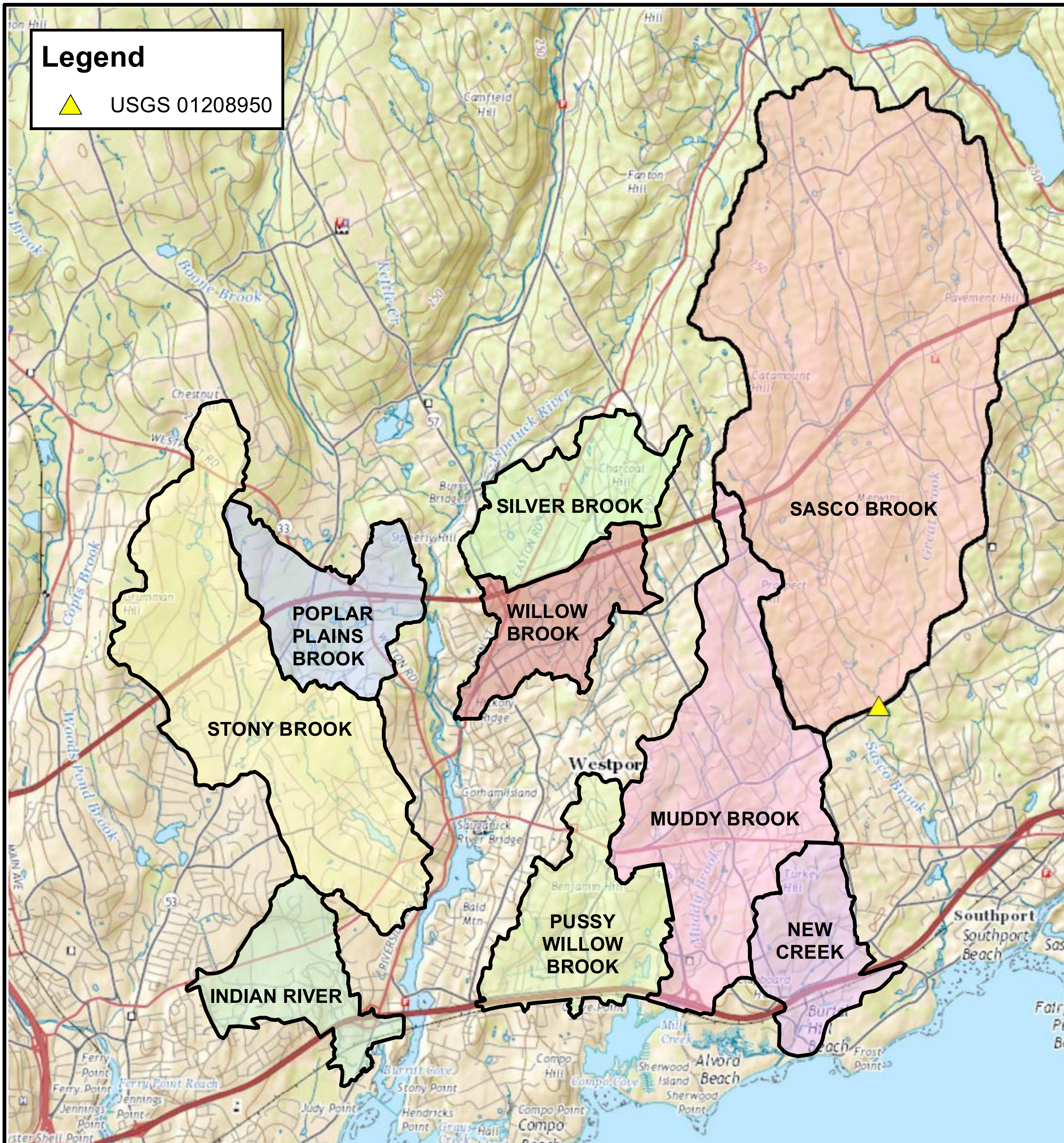
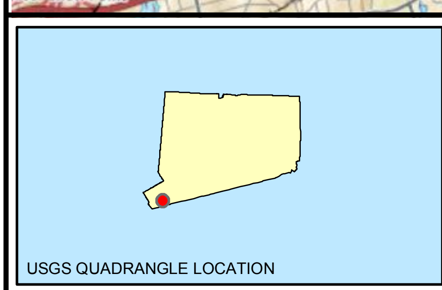
Miles

N W E S

GZA	PROJ. MGR.: SJB DESIGNED BY: KLK REVIEWED BY: CES OPERATOR: KLK DATE: 06-14-2017	STREAM COURSES	JOB NO. 01.0173028.00
		WESTPORT, CT	FIGURE NO. **1**





SOURCE : THIS MAP CONTAINS THE ESRI ARCGIS ONLINE USA TOPOGRAPHIC MAP SERVICE, PUBLISHED DECEMBER 12, 2009 BY ESRI ARCIMS SERVICES AND UPDATED AS NEEDED. THIS SERVICE USES UNIFORM NATIONALLY RECOGNIZED DATUM AND CARTOGRAPHY STANDARDS AND A VARIETY OF AVAILABLE SOURCES FROM SEVERAL DATA PROVIDERS.

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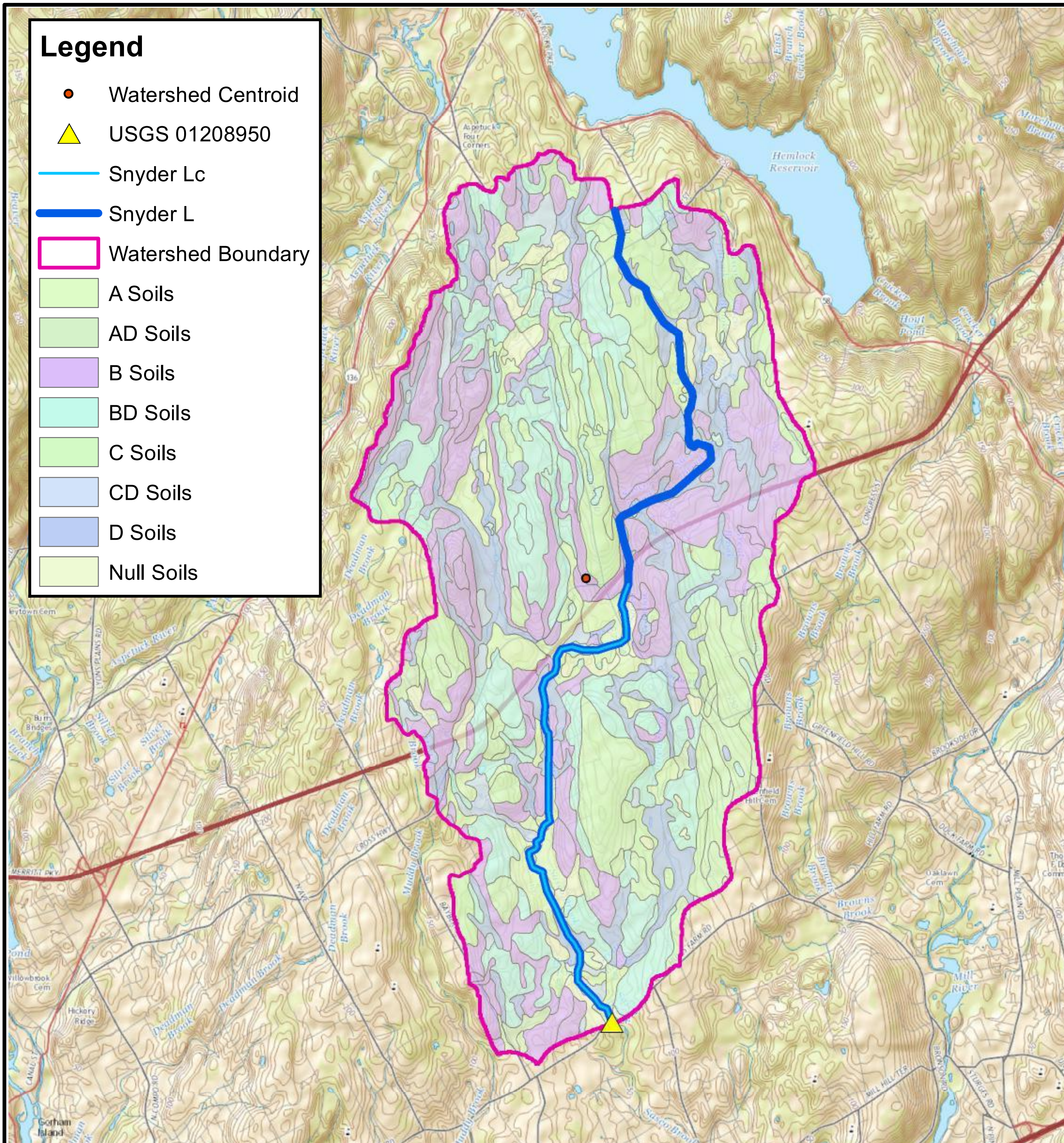
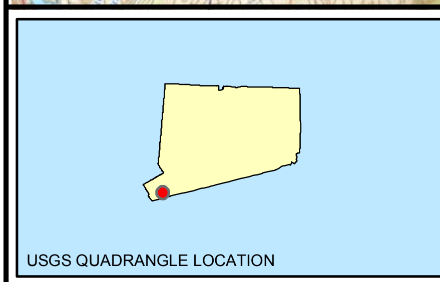
Data Supplied by : esri

N W E S

PROJ. MGR.: DESIGNED BY: GJE REVIEWED BY: OPERATOR: GJE DATE: 06-21-2017	WATERSHED DELINEATIONS	JOB NO. 01.0173028.00
	WESTPORT, CT	FIGURE NO. 2





SOURCE : THIS MAP CONTAINS THE ESRI ARCGIS ONLINE USA TOPOGRAPHIC MAP SERVICE, PUBLISHED DECEMBER 12, 2009 BY ESRI ARCIMS SERVICES AND UPDATED AS NEEDED. THIS SERVICE USES UNIFORM NATIONALLY RECOGNIZED DATUM AND CARTOGRAPHY STANDARDS AND A VARIETY OF AVAILABLE SOURCES FROM SEVERAL DATA PROVIDERS.

Data Supplied by : esri

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N W E S

PROJ. MGR.:
DESIGNED BY: GJE
REVIEWED BY:
OPERATOR: GJE

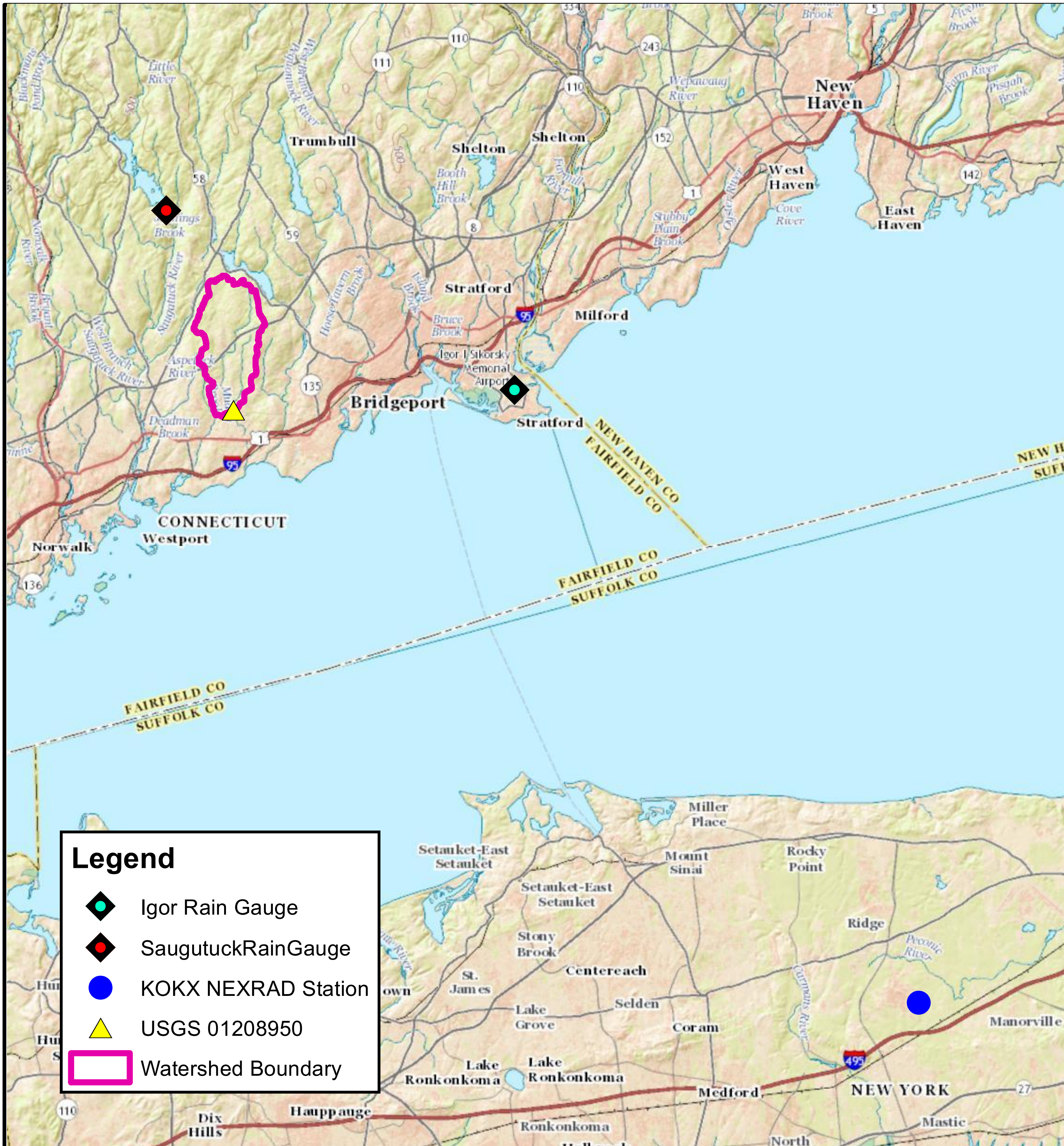
DATE: 06-13-2017

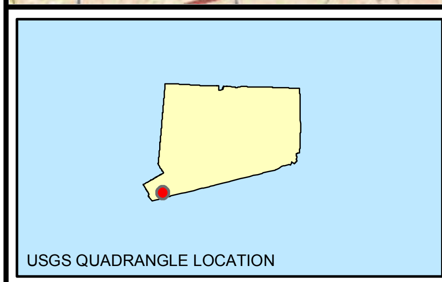
SNYDER PARAMETER CALCULATIONS INPUTS
SASCO BROOK

USGS 01208950, SASCO BROOK
NEAR SOUTHPORT, CT

JOB NO.
01.0173028.00

FIGURE NO.
3





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Data Supplied by : esri

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PROJ. MGR.:
DESIGNED BY: GJE
REVIEWED BY:
OPERATOR: GJE

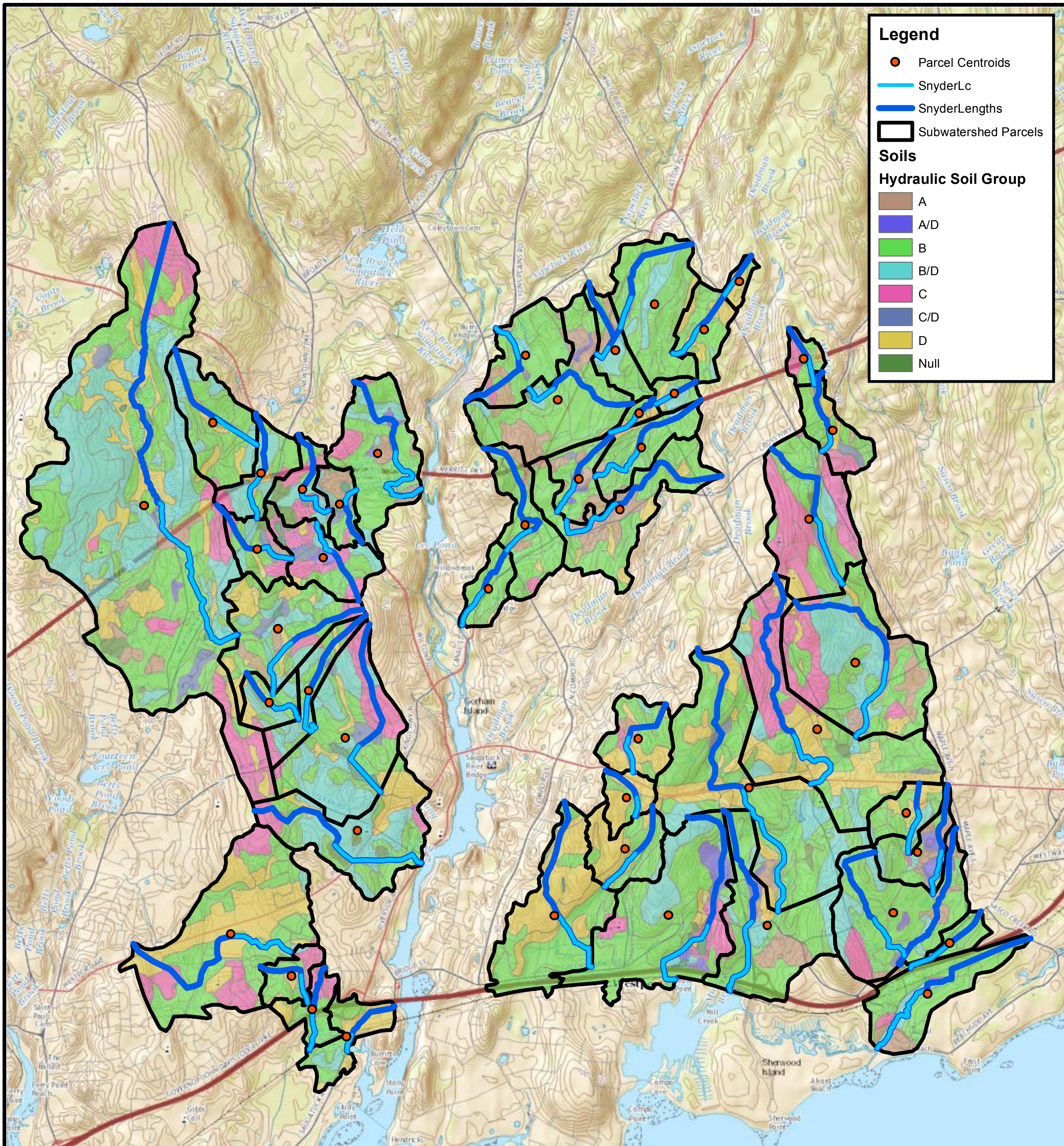
DATE: 06-13-2017

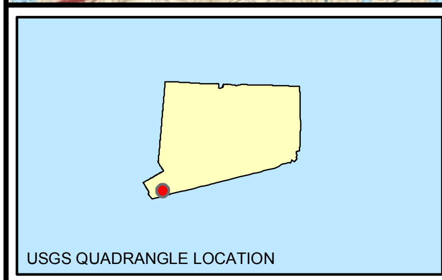
RAINFALL DATA COLLECTION LOCATIONS

USGS 01208950, SASCO BROOK NEAR SOUTHPORT, CT

JOB NO. 01.0173028.00

FIGURE NO. 4





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Data Supplied by : esri

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GZA	PROJ. MGR.: DESIGNED BY: GJE REVIEWED BY: OPERATOR: GJE DATE: 06-21-2017	SNYDER PARAMETER CALCULATION INPUTS WESTPORT STUDY AREAS TOWN OF WESTPORT, CT	JOB NO. 01.0173028.00 FIGURE NO. 5

Appendix A - Limitations

USE OF REPORT

1. GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of the Town of Westport (Client) for the stated purpose(s) and location(s) identified in the Report. Use of this Report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

STANDARD OF CARE

2. Our findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the Report and/or proposal, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. Conditions other than described in this report may be found at the subject location(s).

3. The interpretations and conclusions presented in the Report were based solely upon the services described therein, and not on scientific tasks or procedures beyond the scope of the described services. The work described in this report was carried out in accordance with the agreed upon Terms and Conditions of Engagement.

4. GZA's flood evaluation was performed in accordance with generally accepted practices of qualified professionals performing the same type of services at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made. The findings of the risk characterization are dependent on numerous assumptions and uncertainties inherent in the risk assessment process. The findings of the flood evaluation are not an absolute characterization of actual risks, but rather serve to highlight potential sources of risk at the site(s).

5. The study included analysis of information from Federal Agencies, including NOAA Precipitation Data and FEMA Reports, developed using the data and methodologies available when the study was completed. The development of recurrence interval precipitation depths by NOAA relied on readably available historical flow data. Future precipitation events that impact the project area may result in changes to the precipitation estimates.

6. Unless specifically stated otherwise, the flood evaluations performed by GZA and associated results and conclusions are based upon evaluation of existing and historic data, trends, references, and guidance with respect to the current climate. Future climate change may result in alterations to inputs which influence flooding at the site (*e.g*. rainfall totals, storm intensities, *etc*.). Such changes may have implications on the estimated peak flows, flood elevations, and/or other parameters contained in this report.

RELIANCE ON INFORMATION BY OTHERS

7. In conducting our work, GZA has relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Any inconsistencies in this information which we have noted are discussed in the Report.

GENERAL

8. Observations were made of the site and of structures on the site as indicated within the report. Where access to portions of the site, or to structures on the site was unavailable or limited, GZA renders no opinion as to the condition of that portion of the site or structure.

9. In reviewing this Report, it should be realized that the reported condition of stormwater infrastructure is based on observations of field conditions during the course of this study along with data made available to GZA. It is important to note that the condition of stormwater systems depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the stormwater systems will continue to represent the condition of the stormwater systems at some point in the future. Only through continued inspection and care can there be any chance that unsafe conditions be detected.

ADDITIONAL INFORMATION

10. In the event that the Client or others authorized to use this report obtain information on conditions at the site(s) not contained in this report, such information shall be brought to GZA's attention forthwith. GZA will evaluate such information and, on the basis of this evaluation, may modify the opinions stated in this report.

11. Additional analyses are required to refine the analysis of the stormwater systems on and adjacent to the project site(s) to evaluate system capacity to convey stormwater flows and inlet capacity to capture stormwater.

ADDITIONAL SERVICES

12. GZA recommends that we be retained to provide services during any future investigations, design, implementation activities, construction, and/or property development/ redevelopment at the Site. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

Appendix B - HEC-HMS Input Calculations

HEC-HMS

Project : StudyWatershedsOutputs

Basin Model : Sub_45

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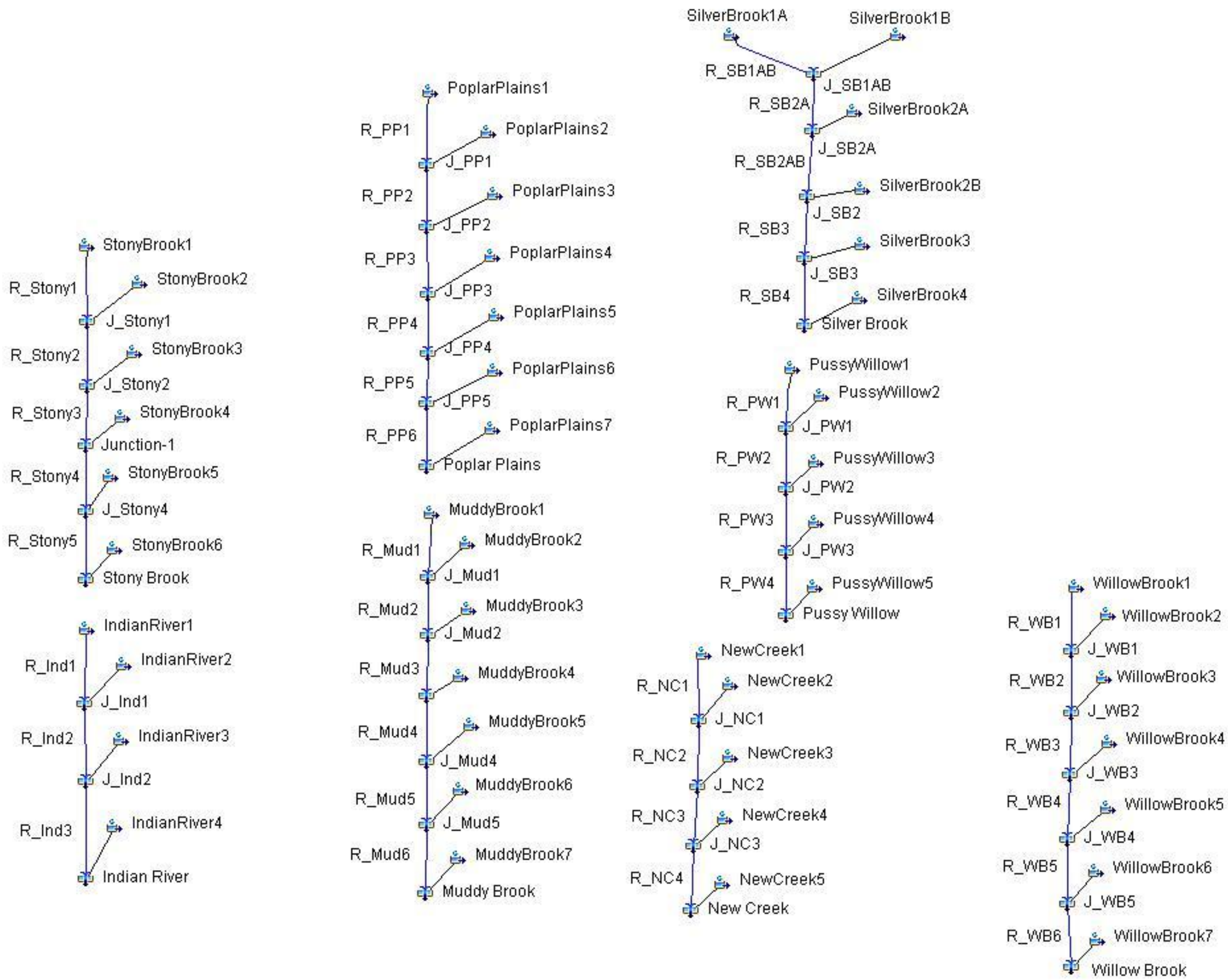


Basin Name	Peaking Coefficient, Cp	Calibrated Lag Time, tp [hr]	Length of Main Stem, L [mi]	Length of Main Stem nearest to centroid, Lc [mi]	Lag Factor, Ct	Calculated Lag Time, tp [hr]
Calibration / Verification Watershed						
Sasco (Calibration)	0.4	5	5.33	2.86	2.2	5
Town of Westport, Study Watersheds						
Indian River 1	0.4	-	1.24	0.39	2.2	1.78
Indian River 2	0.4	-	0.43	0.16	2.2	0.99
Indian River 3	0.4	-	0.50	0.24	2.2	1.17
Indian River 4	0.4	-	0.41	0.10	2.2	0.85
Muddy Brook 1	0.4	-	0.35	0.16	2.2	0.92
Muddy Brook 2	0.4	-	0.50	0.14	2.2	0.99
Muddy Brook 3	0.4	-	0.97	0.40	2.2	1.67
Muddy Brook 4	0.4	-	1.23	0.49	2.2	1.90
Muddy Brook 5	0.4	-	1.57	0.49	2.2	2.05
Muddy Brook 6	0.4	-	1.95	0.81	2.2	2.54
Muddy Brook 7	0.4	-	1.16	0.46	2.2	1.83
New Creek 1	0.4	-	0.41	0.25	2.2	1.11
New Creek 2	0.4	-	0.65	0.27	2.2	1.30
New Creek 3	0.4	-	0.93	0.31	2.2	1.52
New Creek 4	0.4	-	0.52	0.27	2.2	1.22
New Creek 5	0.4	-	1.20	0.49	2.2	1.88
Poplar Plains 1	0.4	-	0.75	0.27	2.2	1.38
Poplar Plains 2	0.4	-	0.65	0.29	2.2	1.33
Poplar Plains 3	0.4	-	0.58	0.22	2.2	1.20
Poplar Plains 4	0.4	-	0.52	0.19	2.2	1.11
Poplar Plains 5	0.4	-	0.62	0.26	2.2	1.28
Poplar Plains 6	0.4	-	0.36	0.11	2.2	0.83
Poplar Plains 7	0.4	-	1.16	0.61	2.2	1.99
Pussy Willow 1	0.4	-	0.55	0.22	2.2	1.16
Pussy Willow 2	0.4	-	0.37	0.10	2.2	0.83
Pussy Willow 3	0.4	-	0.57	0.26	2.2	1.25
Pussy Willow 4	0.4	-	1.08	0.39	2.2	1.70
Pussy Willow 5	0.4	-	1.28	0.49	2.2	1.92
Silver Brook 1A	0.4	-	0.51	0.11	2.2	0.93
Silver Brook 1B	0.4	-	0.46	1.22	2.2	1.86
Silver Brook 2A	0.4	-	0.27	0.18	2.2	0.89
Silver Brook 2B	0.4	-	0.71	0.11	2.2	1.02
Silver Brook 3	0.4	-	0.77	0.20	2.2	1.27
Silver Brook 4	0.4	-	0.66	0.23	2.2	1.26
Stony Brook 1	0.4	-	2.83	1.07	2.2	3.08
Stony Brook 2	0.4	-	0.80	0.35	2.2	1.50
Stony Brook 3	0.4	-	0.45	0.23	2.2	1.12
Stony Brook 4	0.4	-	0.86	0.31	2.2	1.49
Stony Brook 5	0.4	-	1.11	0.34	2.2	1.65
Stony Brook 6	0.4	-	1.19	0.55	2.2	1.94
Willow Brook 1	0.4	-	0.26	0.12	2.2	0.78
Willow Brook 2	0.4	-	0.33	0.21	2.2	0.99
Willow Brook 3	0.4	-	0.84	0.37	2.2	1.56
Willow Brook 4	0.4	-	0.55	0.23	2.2	1.18
Willow Brook 5	0.4	-	1.18	0.42	2.2	1.79
Willow Brook 6	0.4	-	0.87	0.18	2.2	1.26
Willow Brook 7	0.4	-	0.51	0.23	2.2	1.16

Table 8-8.1 Minimum Infiltration Rates for Hydrologic Soil Groups [USDA 1955]

Hydrologic Group	Minimum* Infiltration Rates (in./hr)	Soil Description
A	0.30 to 0.45	Deep sand, deep loess, aggregated silts
B	0.15 to 0.30	Shallow loess, sandy loam
C	0.05 to 0.15	Clay loams, shallow loam, soils low in organic content, soils usually high in clay
D	0 to 0.05	Soils that swell significantly when wet, heavy plastic clays, certain saline soils
* For each hydrologic group, use lowest value unless a higher value can be justified.		

Note: Soils A/D, B/D, and C/D were approximated to have IR equal to that of D soils. Null soil type was also considered D type soil.

Reference:

1) Soil infiltration rates are based on Chapter 5 of Handbook of Hydrology (Maidment, 1993).

Sasco Watershed Initial Calculation			
Soil Type	Area (acres)	Infiltration Rate (IR)	IR*Area
A	330.44	0.30	99.13
B	1,223.98	0.15	183.60
C	1,088.58	0.05	54.43
D	2,061.40	0.00	0.00
W	0.00	0.00	0.00
Total	4,704.39	0.05	337.16

Indian River 1 Subwatershed Constant Loss Calculation

Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.3	0.30	0.1
B	174.2	0.16	27.9
C	64.6	0.06	3.9
D	162.1	0.01	1.6
Null	1.0	0.01	0.0
Total	402.2	0.08	33.5

Indian River 2 Subwatershed Constant Loss Calculation

Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	28.0	0.16	4.5
C	12.6	0.06	0.8
D	7.6	0.01	0.1
Null	0.8	0.01	0.0
Total	48.9	0.11	5.3

Indian River 3 Subwatershed Constant Loss Calculation

Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	32.2	0.16	5.2
C	14.8	0.06	0.9
D	6.9	0.01	0.1
Null	0.1	0.01	0.0
Total	54.0	0.11	6.1

Indian River 4 Subwatershed Constant Loss Calculation

Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	36.2	0.16	5.8
C	1.0	0.06	0.1
D	39.3	0.01	0.4
Null	0.0	0.01	0.0
Total	76.5	0.08	6.2

Muddy Brook 1 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	10.7	0.16	1.7
C	13.0	0.06	0.8
D	6.1	0.01	0.1
Null	0.0	0.01	0.0
Total	29.8	0.09	2.6

Muddy Brook 2 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	3.4	0.30	1.0
B	40.8	0.16	6.5
C	12.1	0.06	0.7
D	17.6	0.01	0.2
Null	0.0	0.01	0.0
Total	74.0	0.11	8.5

Muddy Brook 3 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	2.4	0.30	0.7
B	86.9	0.16	13.9
C	106.0	0.06	6.4
D	32.6	0.01	0.3
Null	5.2	0.01	0.1
Total	233.2	0.09	21.4

Muddy Brook 4 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	42.4	0.30	12.7
B	128.2	0.16	20.5
C	58.6	0.06	3.5
D	112.8	0.01	1.1
Null	0.0	0.01	0.0
Total	342.0	0.11	37.9

Muddy Brook 5 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	114.2	0.16	18.3
C	80.6	0.06	4.8
D	186.6	0.01	1.9
Null	3.0	0.01	0.0
Total	384.3	0.07	25.0

Muddy Brook 6 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	7.4	0.30	2.2
B	123.1	0.16	19.7
C	0.0	0.06	0.0
D	65.2	0.01	0.7
Null	3.2	0.01	0.0
Total	198.9	0.11	22.6

Muddy Brook 7 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	29.1	0.30	8.7
B	293.2	0.16	46.9
C	8.1	0.06	0.5
D	147.2	0.01	1.5
Null	0.7	0.01	0.0
Total	478.3	0.12	57.6

New Creek 1 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.7	0.30	0.2
B	34.7	0.16	5.6
C	0.0	0.06	0.0
D	28.3	0.01	0.3
Null	0.0	0.01	0.0
Total	63.7	0.09	6.0

New Creek 2 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	14.7	0.30	4.4
B	35.9	0.16	5.7
C	1.1	0.06	0.1
D	25.1	0.01	0.3
Null	0.0	0.01	0.0
Total	76.8	0.14	10.5

New Creek 3 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	21.4	0.30	6.4
B	153.7	0.16	24.6
C	18.9	0.06	1.1
D	48.9	0.01	0.5
Null	0.0	0.01	0.0
Total	242.9	0.13	32.6

New Creek 4 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	3.3	0.30	1.0
B	33.5	0.16	5.4
C	0.0	0.06	0.0
D	0.4	0.01	0.0
Null	0.0	0.01	0.0
Total	37.3	0.17	6.4

New Creek 5 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	14.2	0.30	4.3
B	108.5	0.16	17.4
C	4.0	0.06	0.2
D	18.2	0.01	0.2
Null	1.5	0.01	0.0
Total	146.4	0.15	22.1

Poplar Plains 1 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	84.6	0.16	13.5
c	1.7	0.06	0.1
D	60.8	0.01	0.6
Null	0.0	0.01	0.0
Total	147.0	0.10	14.2

Poplar Plains 2 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	25.1	0.16	4.0
c	8.8	0.06	0.5
D	42.2	0.01	0.4
Null	1.0	0.01	0.0
Total	77.1	0.06	5.0

Poplar Plains 3 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	2.5	0.30	0.7
B	23.6	0.16	3.8
c	14.6	0.06	0.9
D	20.5	0.01	0.2
Null	1.9	0.01	0.0
Total	63.1	0.09	5.6

Poplar Plains 4 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.2	0.30	0.1
B	29.2	0.16	4.7
c	38.0	0.06	2.3
D	34.2	0.01	0.3
Null	7.1	0.01	0.1
Total	108.7	0.07	7.4

Poplar Plains 5 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	1.8	0.30	0.5
B	14.1	0.16	2.3
c	18.9	0.06	1.1
D	18.6	0.01	0.2
Null	13.3	0.01	0.1
Total	66.6	0.06	4.2

Poplar Plains 6 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	15.9	0.30	4.8
B	16.7	0.16	2.7
c	3.0	0.06	0.2
D	10.4	0.01	0.1
Null	2.7	0.01	0.0
Total	48.7	0.16	7.8

Poplar Plains 7 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	17.9	0.30	5.4
B	124.8	0.16	20.0
c	15.0	0.06	0.9
D	30.8	0.01	0.3
Null	0.0	0.01	0.0
Total	188.4	0.14	26.5

Pussy Willow 1 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	6.0	0.30	1.8
B	44.1	0.16	7.1
C	2.6	0.06	0.2
D	38.8	0.01	0.4
Null	0.0	0.01	0.0
Total	91.5	0.10	9.4

Pussy Willow 2 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	12.7	0.16	2.0
C	0.0	0.06	0.0
D	35.4	0.01	0.4
Null	0.0	0.01	0.0
Total	48.1	0.05	2.4

Pussy Willow 3 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	44.6	0.16	7.1
C	0.0	0.06	0.0
D	53.5	0.01	0.5
Null	0.0	0.01	0.0
Total	98.1	0.08	7.7

PussyWillow4 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	130.8	0.16	20.9
C	1.5	0.06	0.1
D	120.8	0.01	1.2
Null	0.5	0.01	0.0
Total	253.5	0.09	22.2

Pussy Willow 5 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	210.8	0.16	33.7
C	36.1	0.06	2.2
D	93.2	0.01	0.9
Null	6.9	0.01	0.1
Total	346.9	0.11	36.9

Silver Brook 1A Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	3.70	0.16	0.6
C	0.0	0.06	0.0
D	13.9	0.01	0.1
Null	0.0	0.01	0.0
Total	17.6	0.04	0.7

Silver Brook 1B Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	46.3	0.16	7.4
C	0.0	0.06	0.0
D	26.2	0.01	0.3
Null	0.0	0.01	0.0
Total	72.5	0.11	7.7

Silver Brook 2A Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.5	0.30	0.1
B	147.9	0.16	23.7
C	0.0	0.06	0.0
D	35.7	0.01	0.4
Null	0.0	0.01	0.0
Total	184.1	0.13	24.2

Silver Brook 2B Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	9.9	0.30	3.0
B	40.5	0.16	6.5
C	0.0	0.06	0.0
D	15.7	0.01	0.2
Null	0.0	0.01	0.0
Total	66.1	0.15	9.6

SilverBrook3 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	42.8	0.30	12.8
B	166.1	0.16	26.6
C	0.2	0.06	0.0
D	14.8	0.01	0.1
Null	1.2	0.01	0.0
Total	225.1	0.18	39.6

SilverBrook4 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	17.9	0.30	5.4
B	87.8	0.16	14.0
C	4.3	0.06	0.3
D	12.0	0.01	0.1
Null	0.0	0.01	0.0
Total	122.0	0.16	19.8

Stony Brook 1 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	33.6	0.30	10.1
B	469.7	0.16	75.2
C	147.0	0.06	8.8
D	607.8	0.01	6.1
Null	17.8	0.01	0.2
Total	1275.8	0.08	100.3

Stony Brook 2 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	12.0	0.30	3.6
B	85.8	0.16	13.7
C	13.1	0.06	0.8
D	84.8	0.01	0.8
Null	1.2	0.01	0.0
Total	196.9	0.10	19.0

Stony Brook 3 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	24.7	0.16	3.9
C	2.0	0.06	0.1
D	25.3	0.01	0.3
Null	0.0	0.01	0.0
Total	51.9	0.08	4.3

Stony Brook 4 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	35.0	0.16	5.6
C	14.0	0.06	0.8
D	26.8	0.01	0.3
Null	0.0	0.01	0.0
Total	75.8	0.09	6.7

Stony Brook 5 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	85.9	0.16	13.7
C	53.7	0.06	3.2
D	127.5	0.01	1.3
Null	11.4	0.01	0.1
Total	278.5	0.07	18.4

Stony Brook 6 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	77.7	0.16	12.4
C	19.1	0.06	1.1
D	116.9	0.01	1.2
Null	11.4	0.01	0.1
Total	225.1	0.07	14.9

Willow Brook 1 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	11.1	0.16	1.8
c	0.0	0.06	0.0
D	15.0	0.01	0.2
Null	0.0	0.01	0.0
Total	26.1	0.07	1.9

Willow Brook 2 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	25.5	0.16	4.1
c	0.0	0.06	0.0
D	6.6	0.01	0.1
Null	0.0	0.01	0.0
Total	32.1	0.13	4.1

Willow Brook 3 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	6.7	0.30	2.0
B	59.5	0.16	9.5
c	0.0	0.06	0.0
D	6.7	0.01	0.1
Null	0.0	0.01	0.0
Total	72.9	0.16	11.6

Willow Brook 4 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	20.7	0.30	6.2
B	40.6	0.16	6.5
c	0.0	0.06	0.0
D	8.8	0.01	0.1
Null	0.0	0.01	0.0
Total	70.1	0.18	12.8

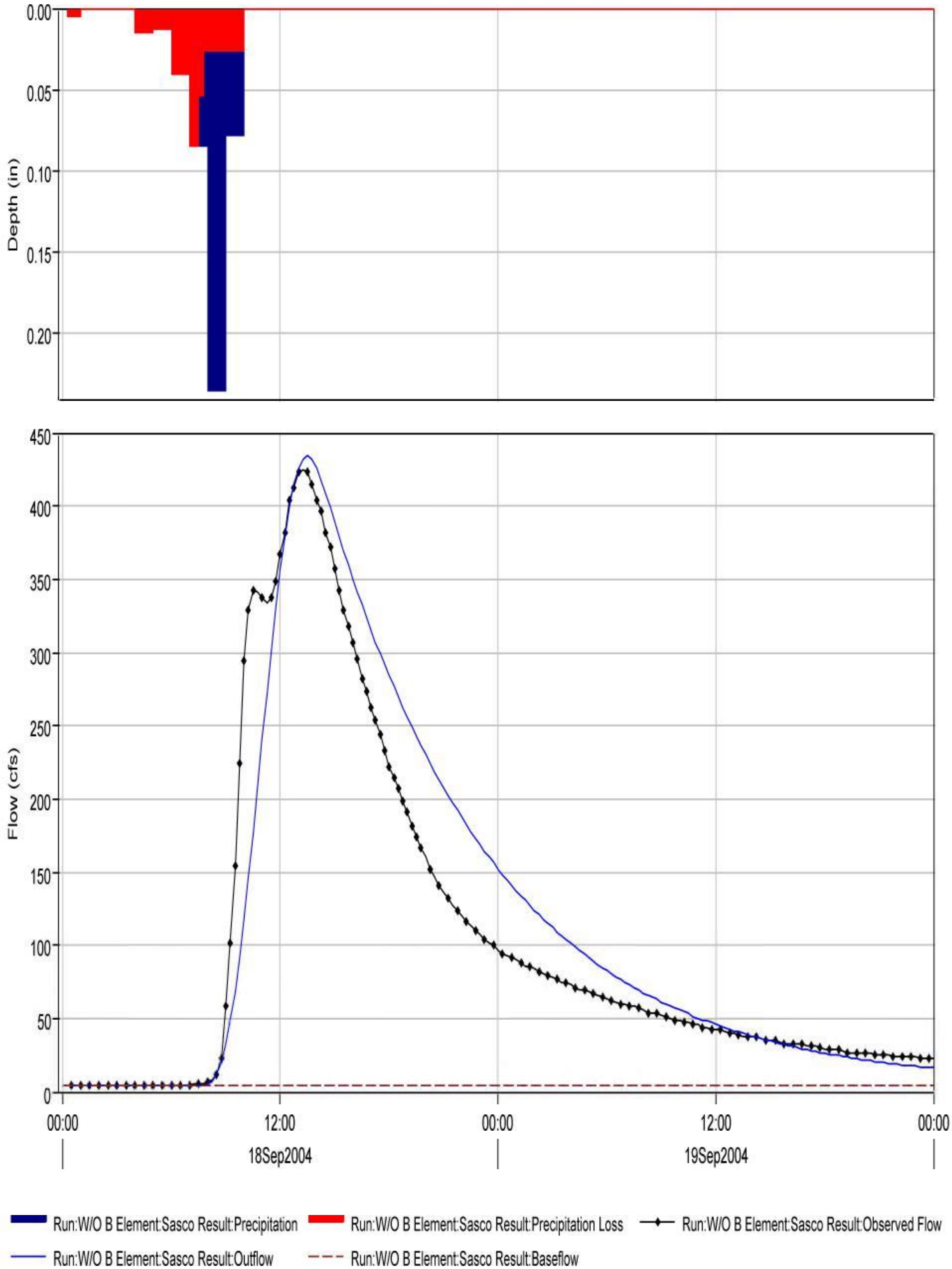
Willow Brook 5 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	45.4	0.30	13.6
B	131.0	0.16	21.0
c	0.0	0.06	0.0
D	20.8	0.01	0.2
Null	0.0	0.01	0.0
Total	197.1	0.18	34.8

Willow Brook 6 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	10.3	0.30	3.1
B	99.5	0.16	15.9
c	3.4	0.06	0.2
D	5.5	0.01	0.1
Null	0.0	0.01	0.0
Total	118.7	0.16	19.3

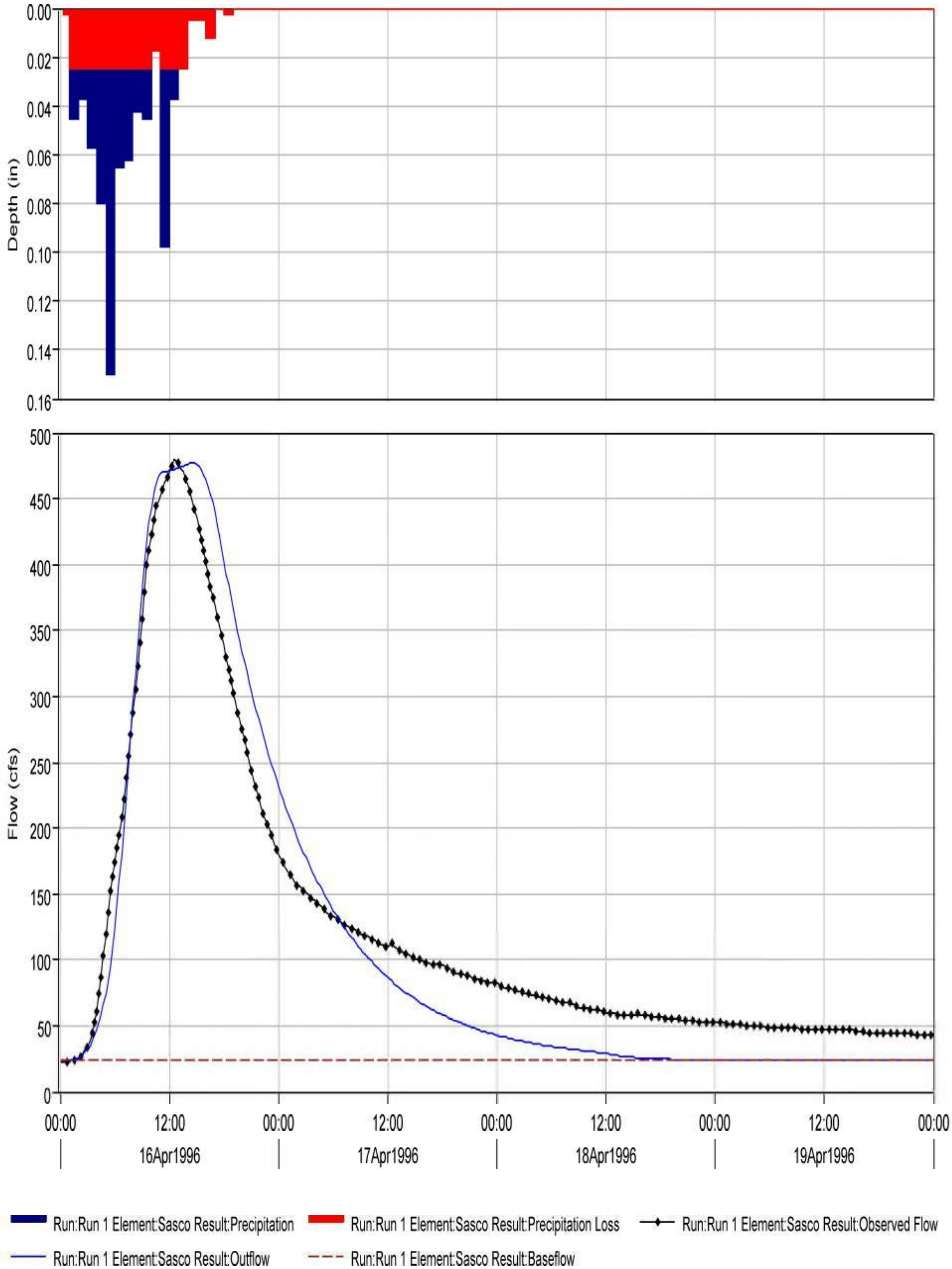
Willow Brook 7 Subwatershed Constant Loss Calculation			
Soil Type	Area [acre]	Infiltration Rate (IR)	IR x Area
A	0.0	0.30	0.0
B	51.8	0.16	8.3
c	0.0	0.06	0.0
D	2.2	0.01	0.0
Null	0.0	0.01	0.0
Total	54.0	0.15	8.3

Appendix C - HEC-HMS Outputs

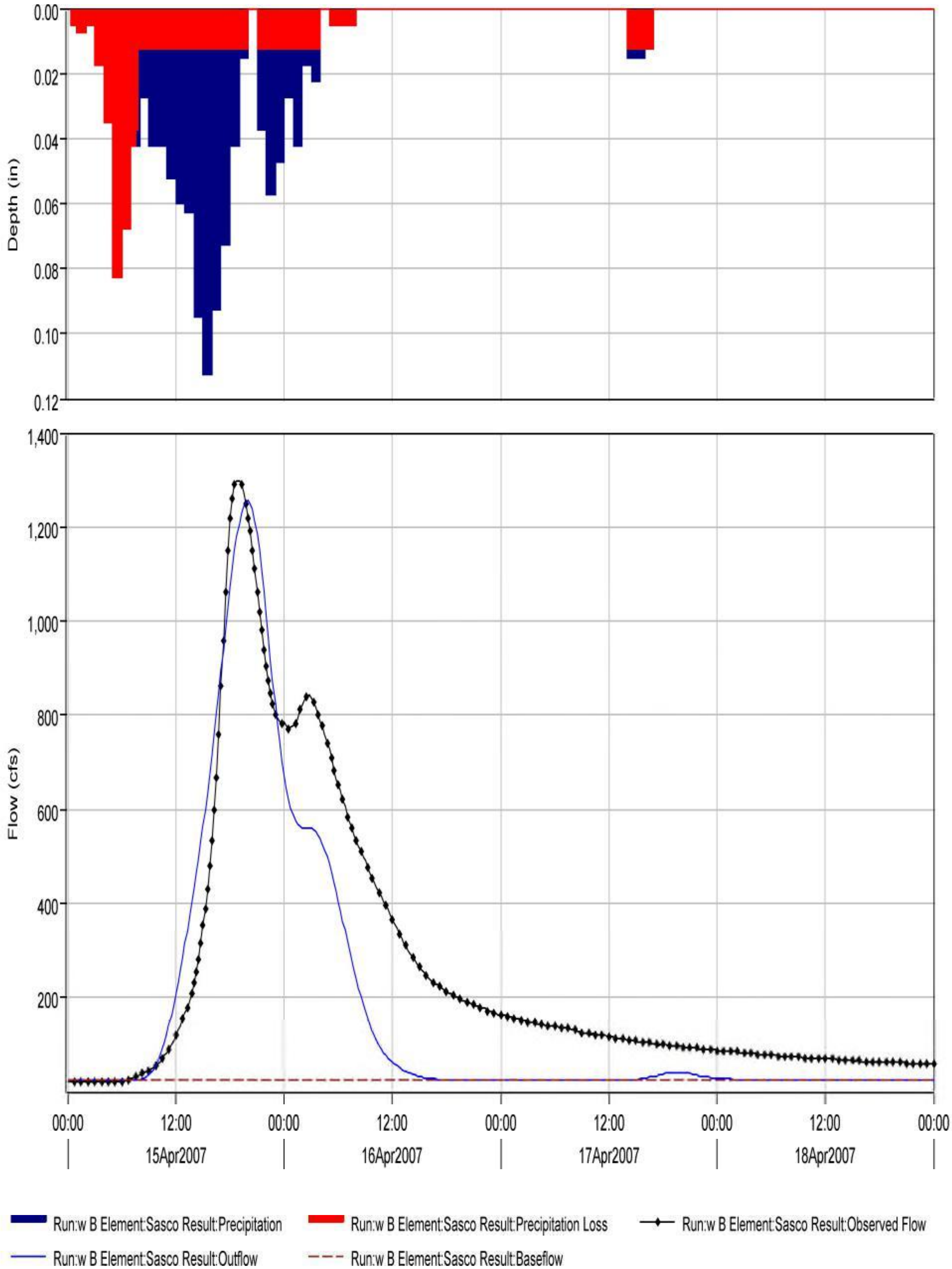
Sasco Brook Calibration Run, September 2004



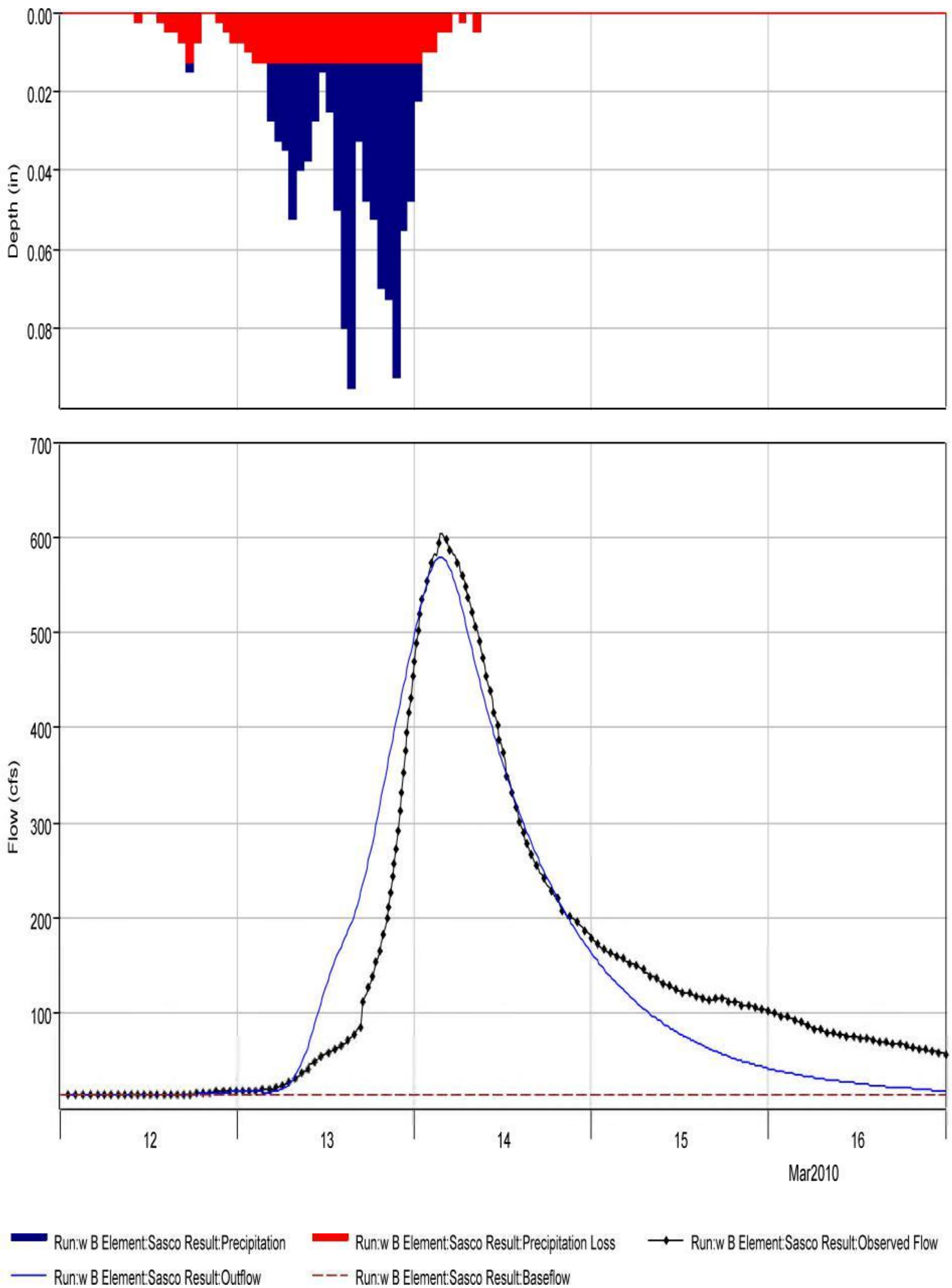
Sasco Brook Calibration Run, April 1996



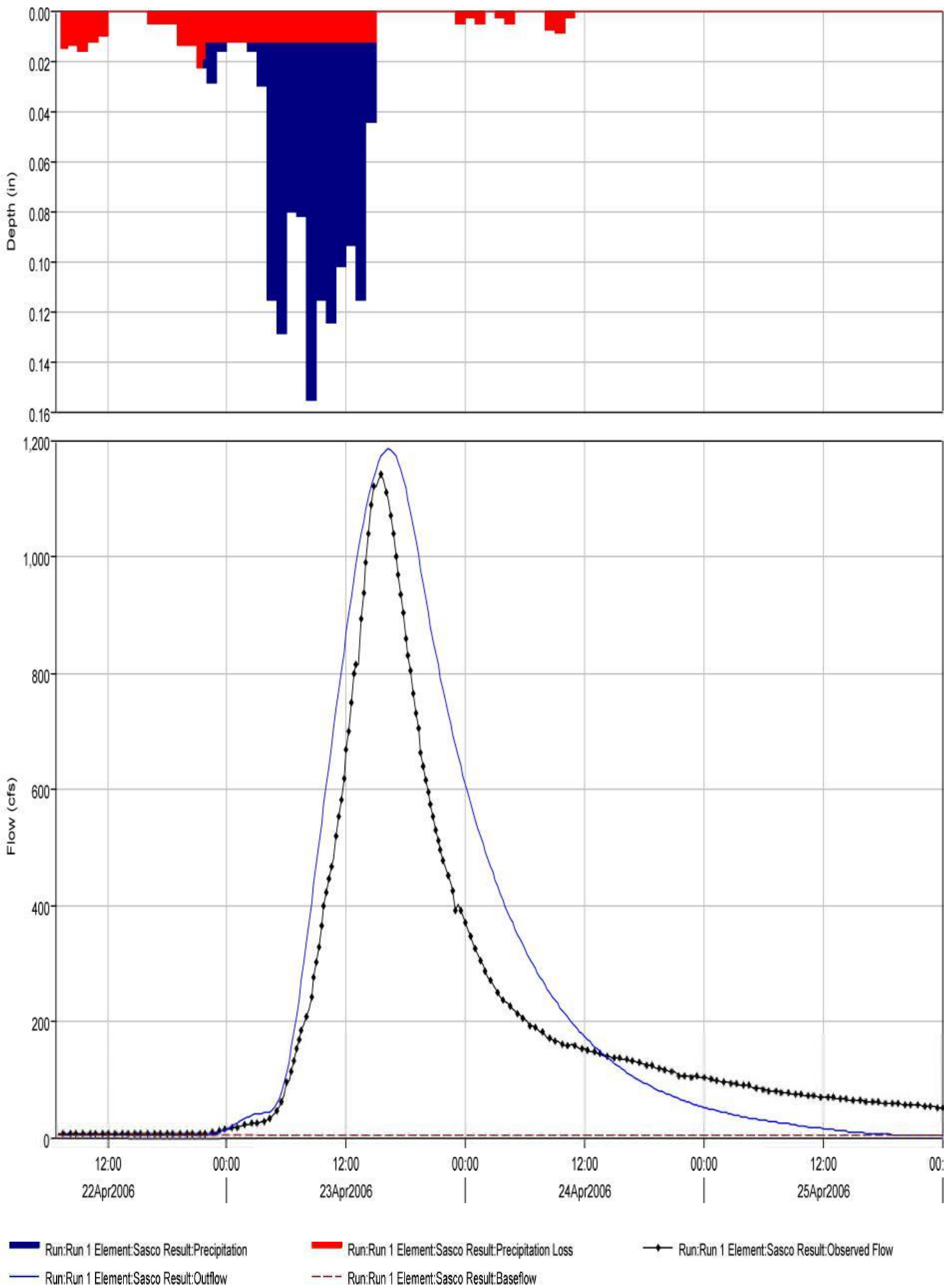
Sasco Brook Calibration Run, April 2007



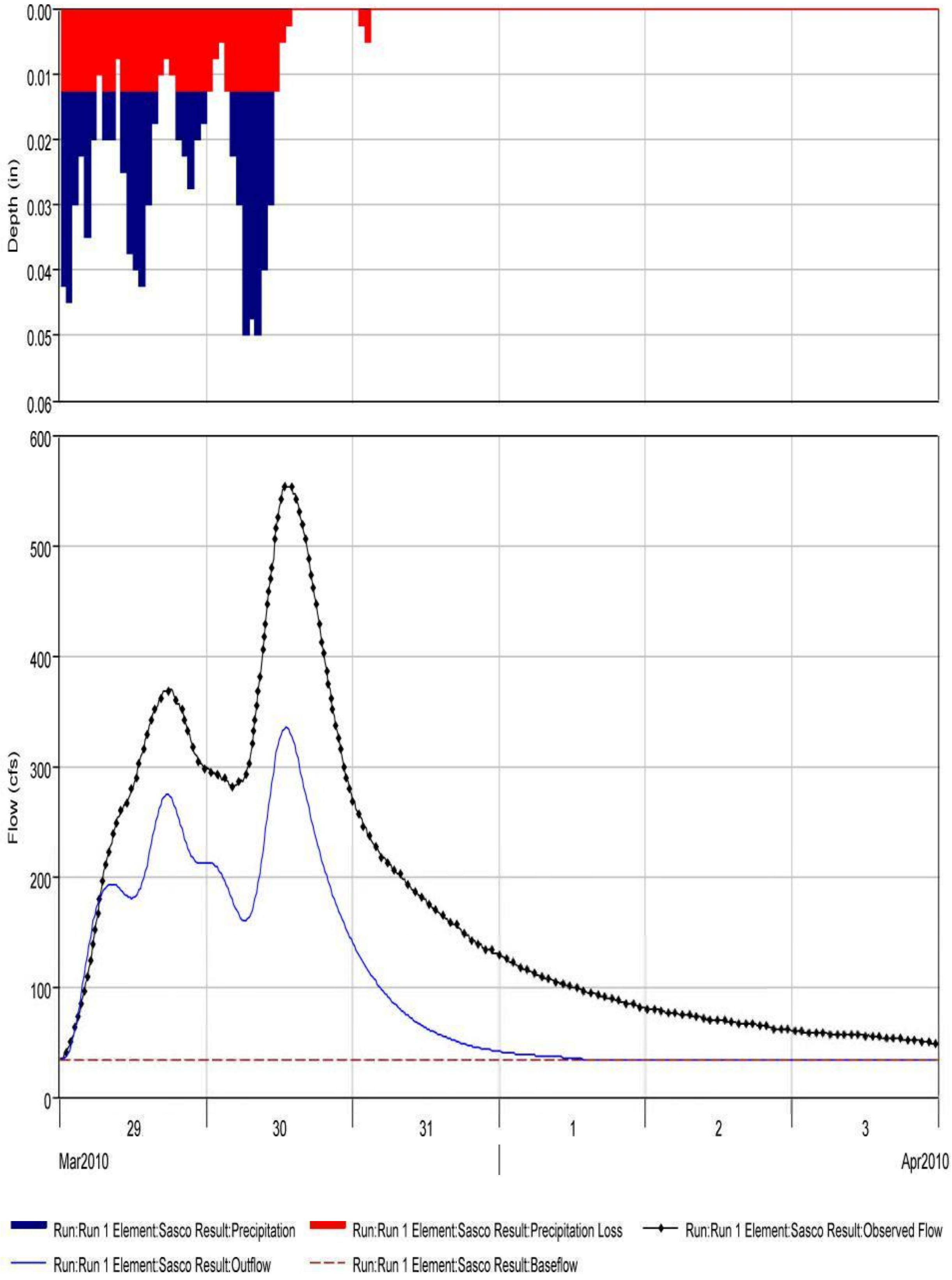
Sasco Brook Calibration Run, March 2010



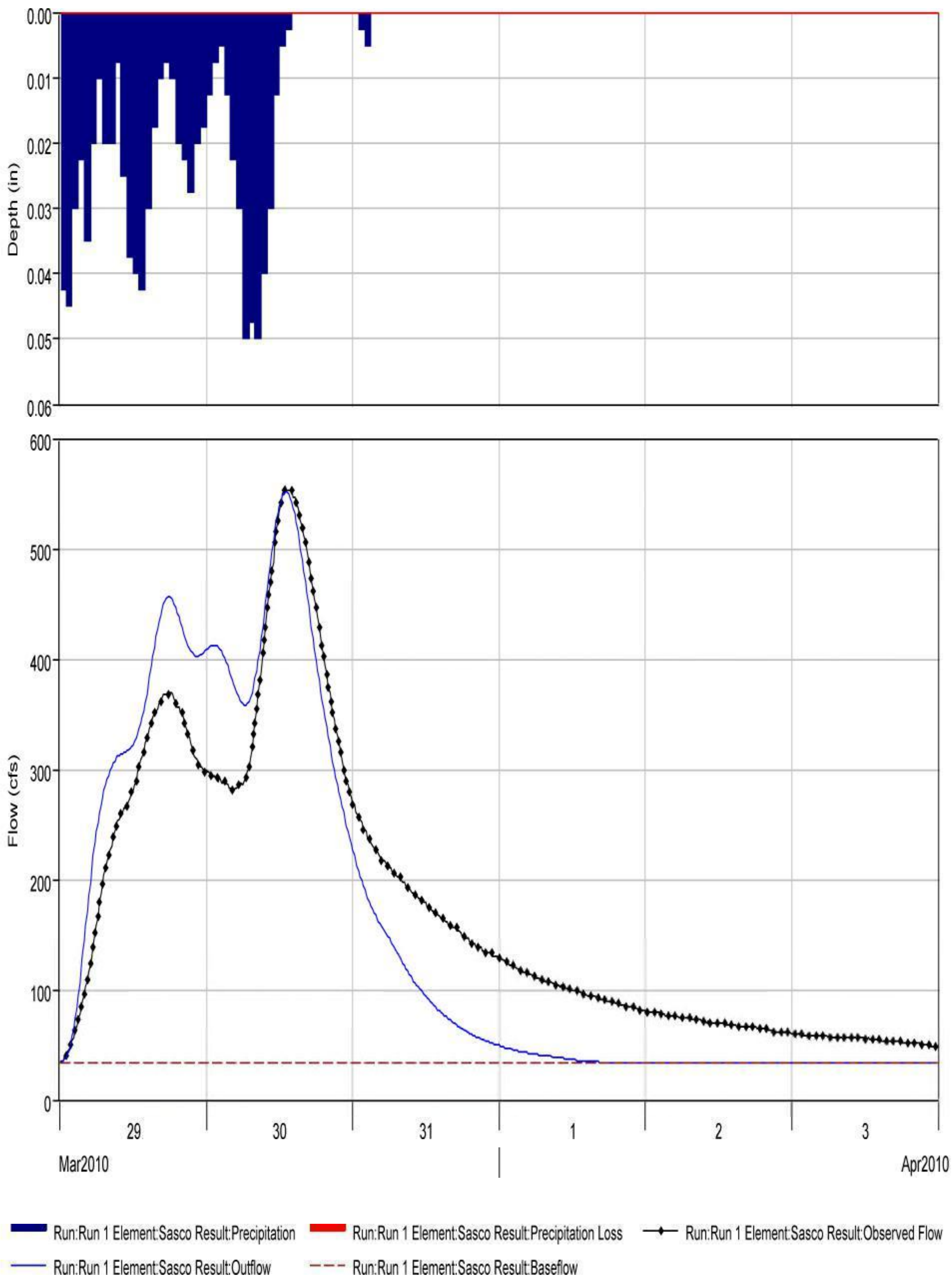
Sasco Brook Verification Run, April 2006



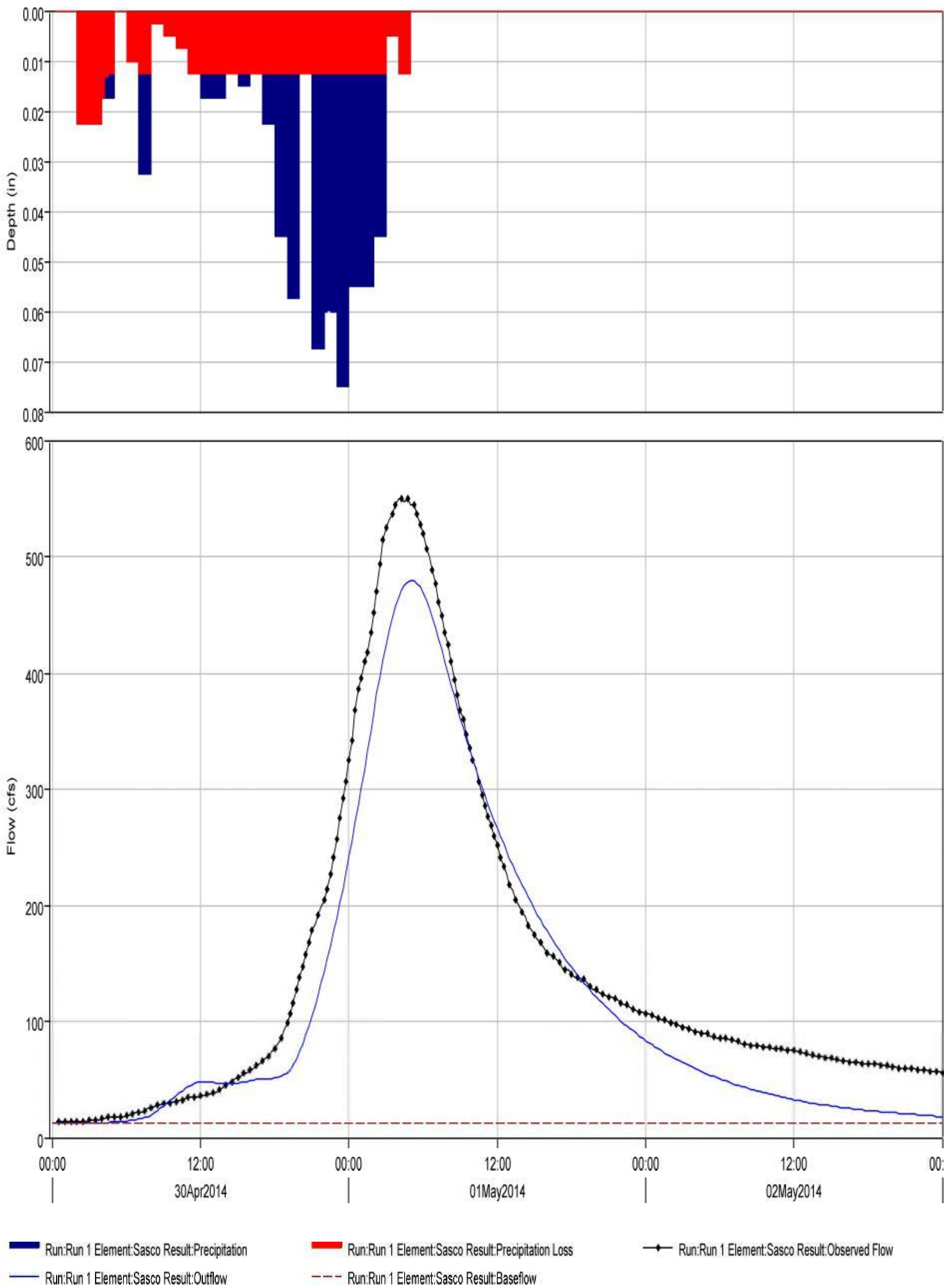
Sasco Brook Verification Run, March 2010 with Infiltration



Sasco Brook Verification Run, March 2010 without Infiltration



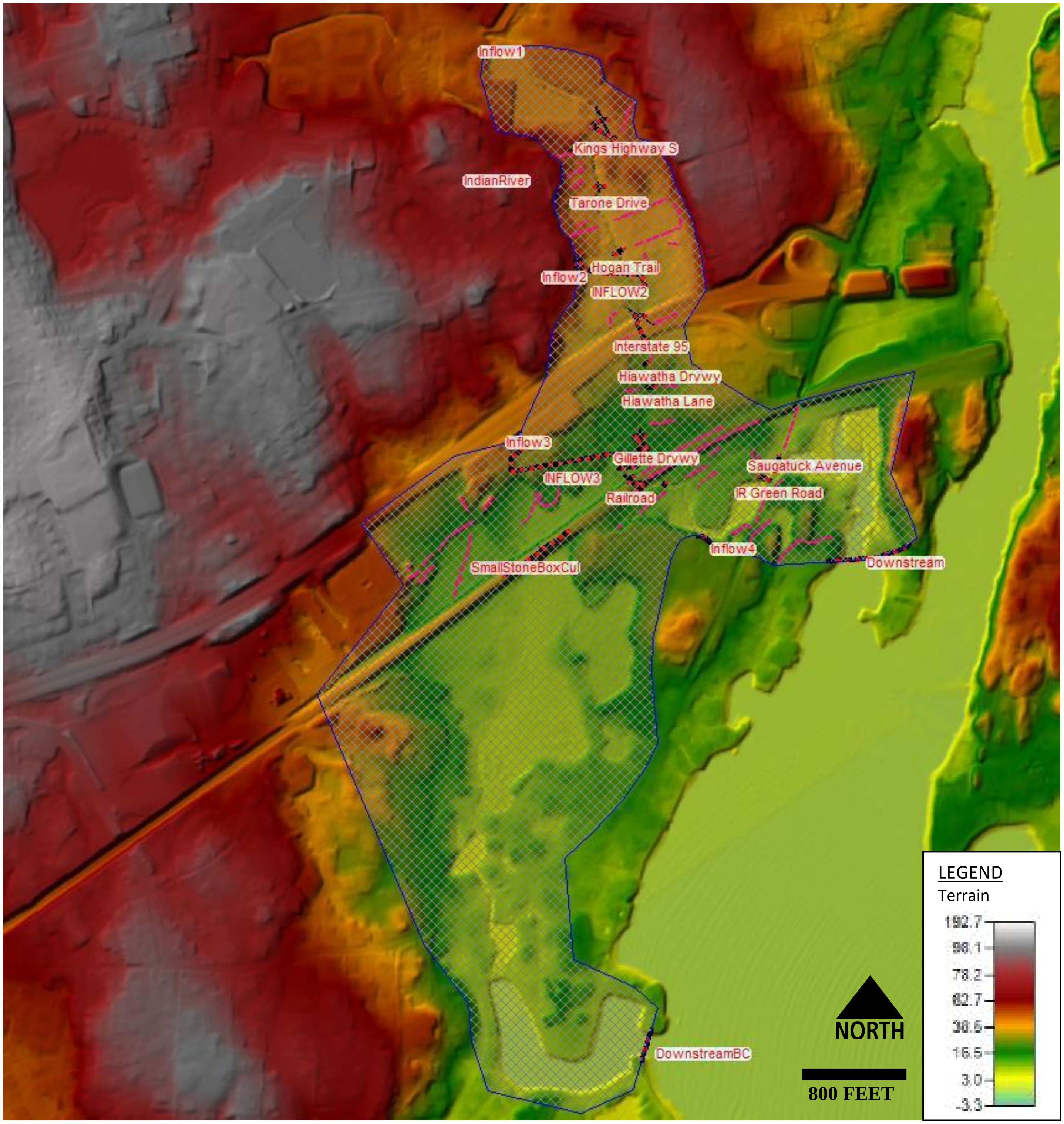
Sasco Brook Verification Run, May 2014



	HEC-HMS Simulated Peak Flows [cfs]				
Sub-Basin ID	10-year	25-year	50-year	100-year	500-year
INDIAN RIVER 1	251	312	359	406	559
INDIAN RIVER 2	45	56	64	73	100
INDIAN RIVER 3	44	55	63	72	99
INDIAN RIVER 4	81	100	115	130	177
MUDDY BROOK 1	30	37	43	48	66
MUDDY BROOK 2	69	85	98	111	152
MUDDY BROOK 3	150	187	215	244	336
MUDDY BROOK 4	193	242	280	318	441
MUDDY BROOK 5	218	270	311	352	484
MUDDY BROOK 6	199	250	290	329	460
MUDDY BROOK 7	134	168	194	221	307
NEW CREEK 1	55	69	79	89	122
NEW CREEK 2	56	70	81	92	128
NEW CREEK 3	159	199	231	262	364
NEW CREEK 4	28	35	40	46	64
NEW CREEK 5	79	100	116	132	185
POPLAR PLAINS 1	108	134	155	175	242
POPLAR PLAINS 2	61	75	86	97	133
POPLAR PLAINS 3	52	65	74	84	115
POPLAR PLAINS 4	97	120	138	155	212
POPLAR PLAINS 5	54	67	77	86	118
POPLAR PLAINS 6	49	61	71	80	111
POPLAR PLAINS 7	99	124	145	165	230
PUSSY WILLOW 1	77	95	110	124	171
PUSSY WILLOW 2	54	66	75	84	115
PUSSY WILLOW 3	80	98	113	128	175
PUSSY WILLOW 4	161	200	231	261	360
PUSSY WILLOW 5	195	244	282	320	444
SILVER BROOK 1A	18	22	26	29	39
SILVER BROOK 1B	42	53	61	69	96
SILVER BROOK 2A	268	333	384	435	599
SILVER BROOK 2B	58	73	84	95	132
SILVER BROOK 3	160	202	235	268	375
SILVER BROOK 4	90	113	131	149	207
STONY BROOK 1	516	646	747	848	1177
STONY BROOK 2	136	169	195	221	305
STONY BROOK 3	46	56	65	73	100
STONY BROOK 4	53	66	76	86	118
STONY BROOK 5	186	230	265	299	410
STONY BROOK 6	133	165	190	214	295
WILLOW BROOK 1	30	37	42	47	64
WILLOW BROOK 2	14	18	21	23	32
WILLOW BROOK 3	55	70	81	92	129
WILLOW BROOK 4	53	67	78	88	124
WILLOW BROOK 5	106	135	158	180	253
WILLOW BROOK 6	87	109	127	144	201
WILLOW BROOK 7	43	53	62	70	98

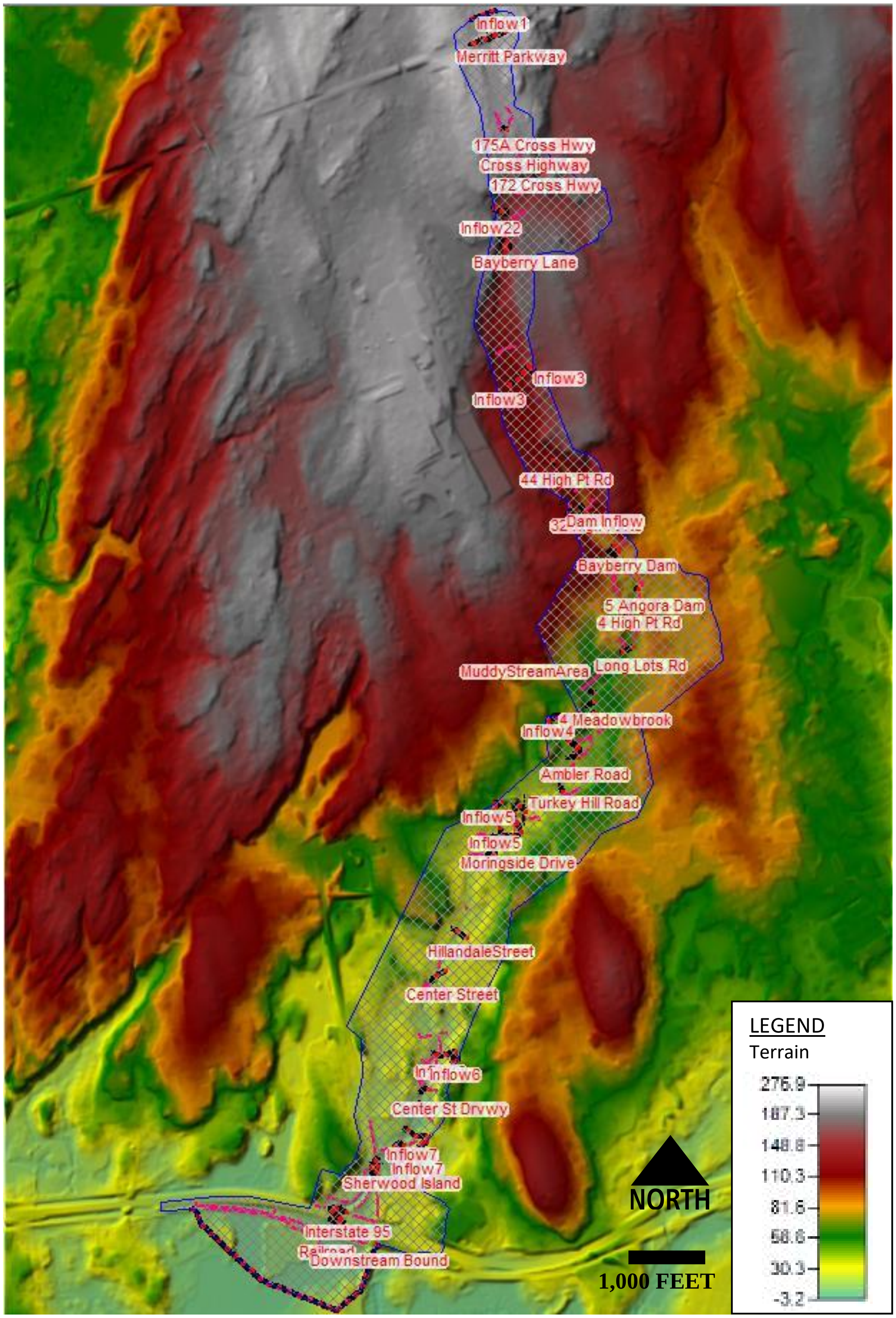
Appendix D – 2D Flow Areas for Eight Streams

Indian River



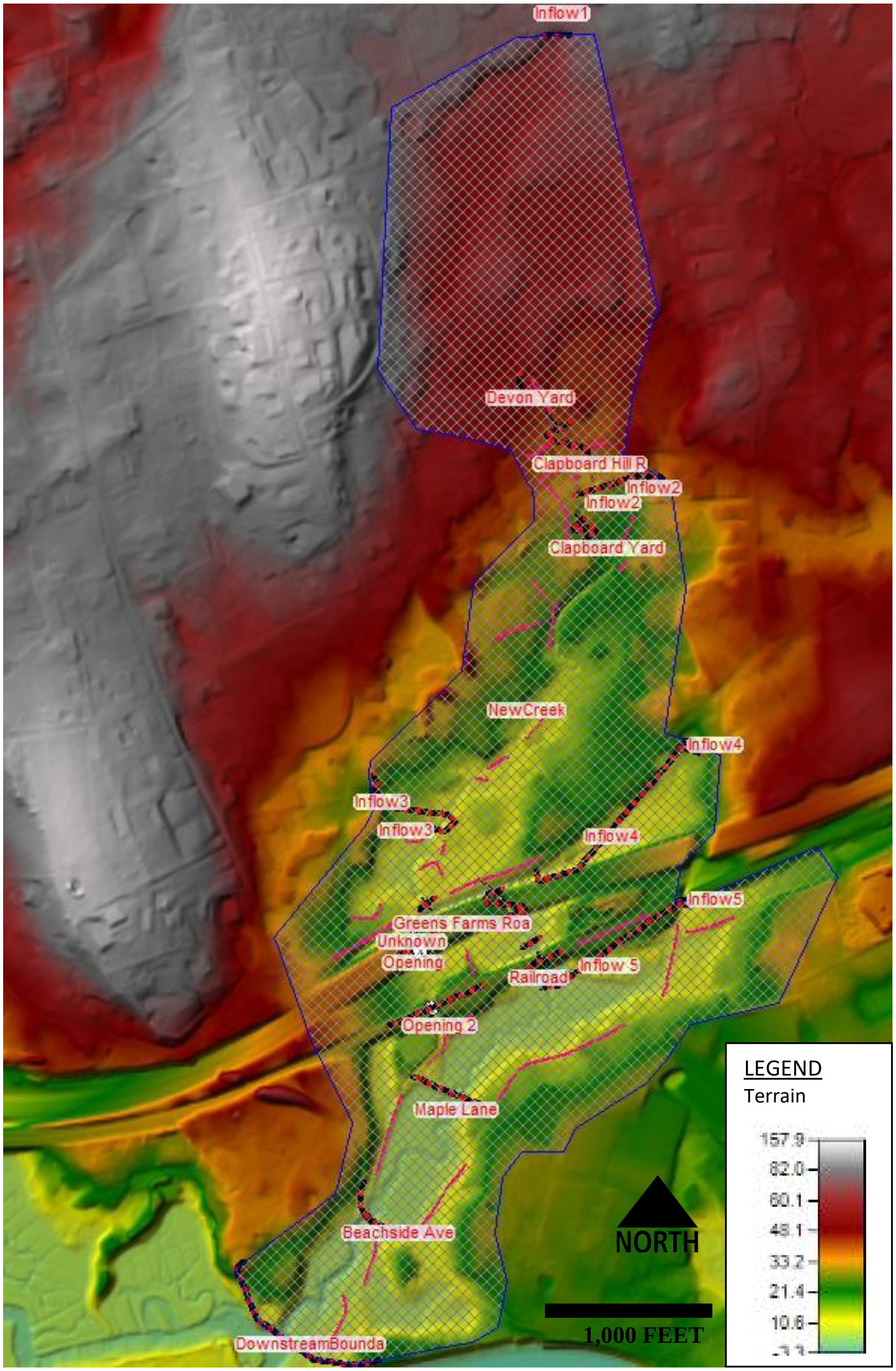
Note: Basemap depicts terrain in feet, NAVD88.

Muddy Brook



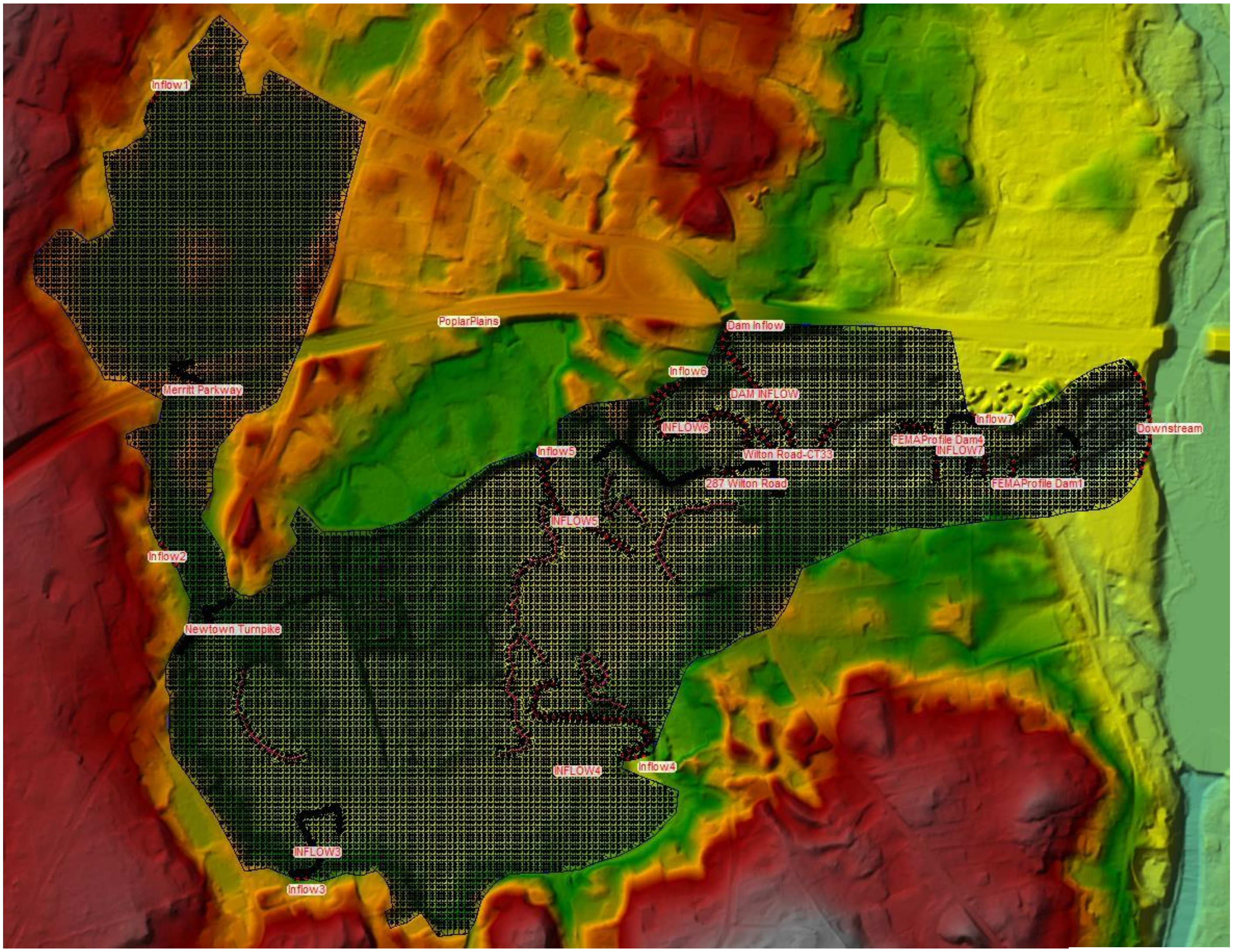
Note: Basemap depicts terrain in feet, NAVD88.

New Creek

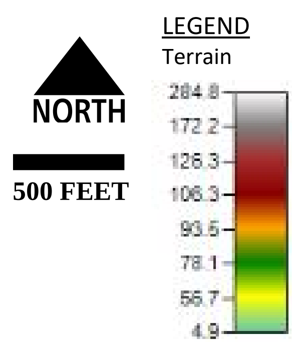


Note: Basemap depicts terrain in feet, NAVD88.

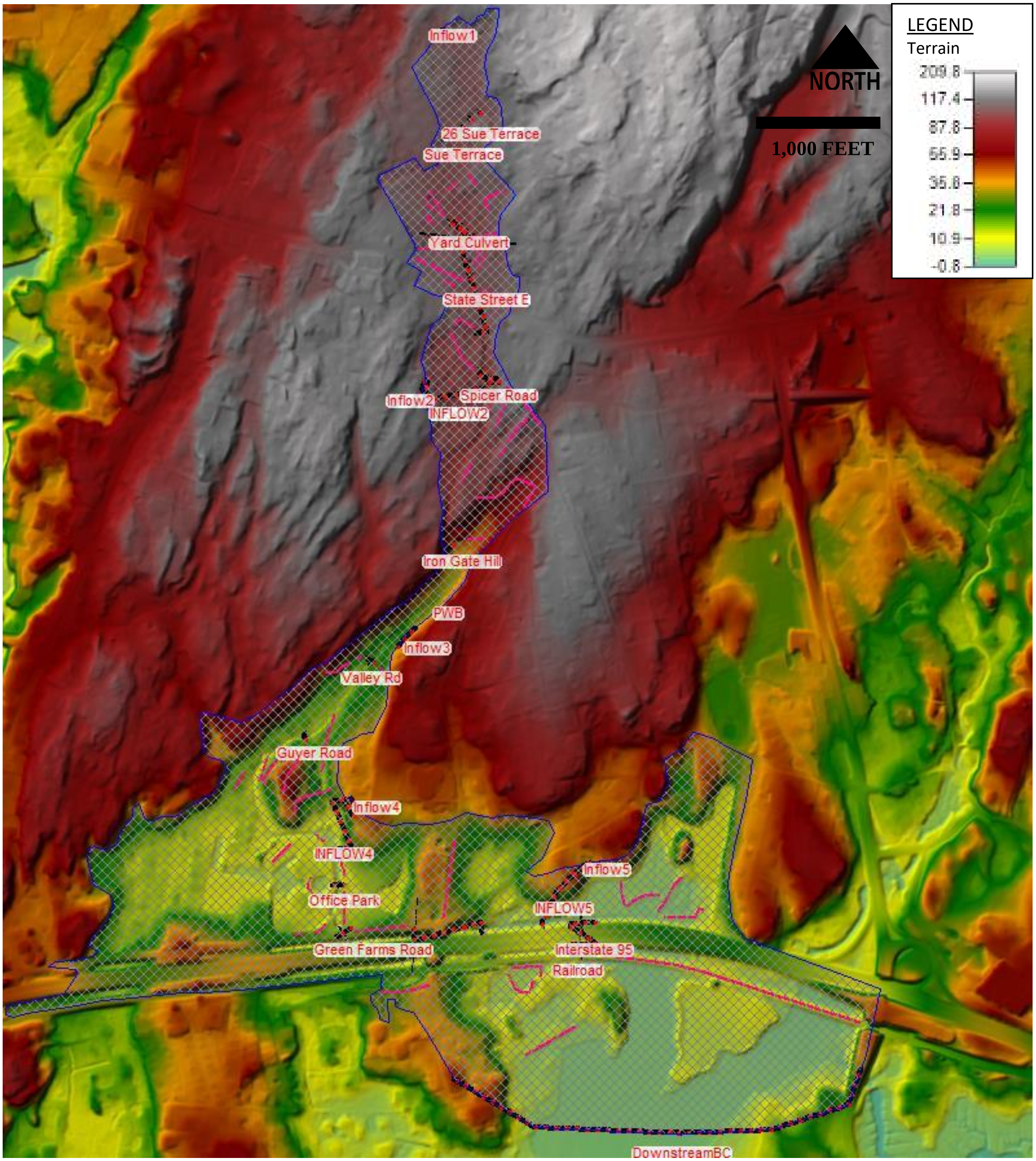
Poplar Plains Brook



Note: Basemap depicts terrain in feet, NAVD88.

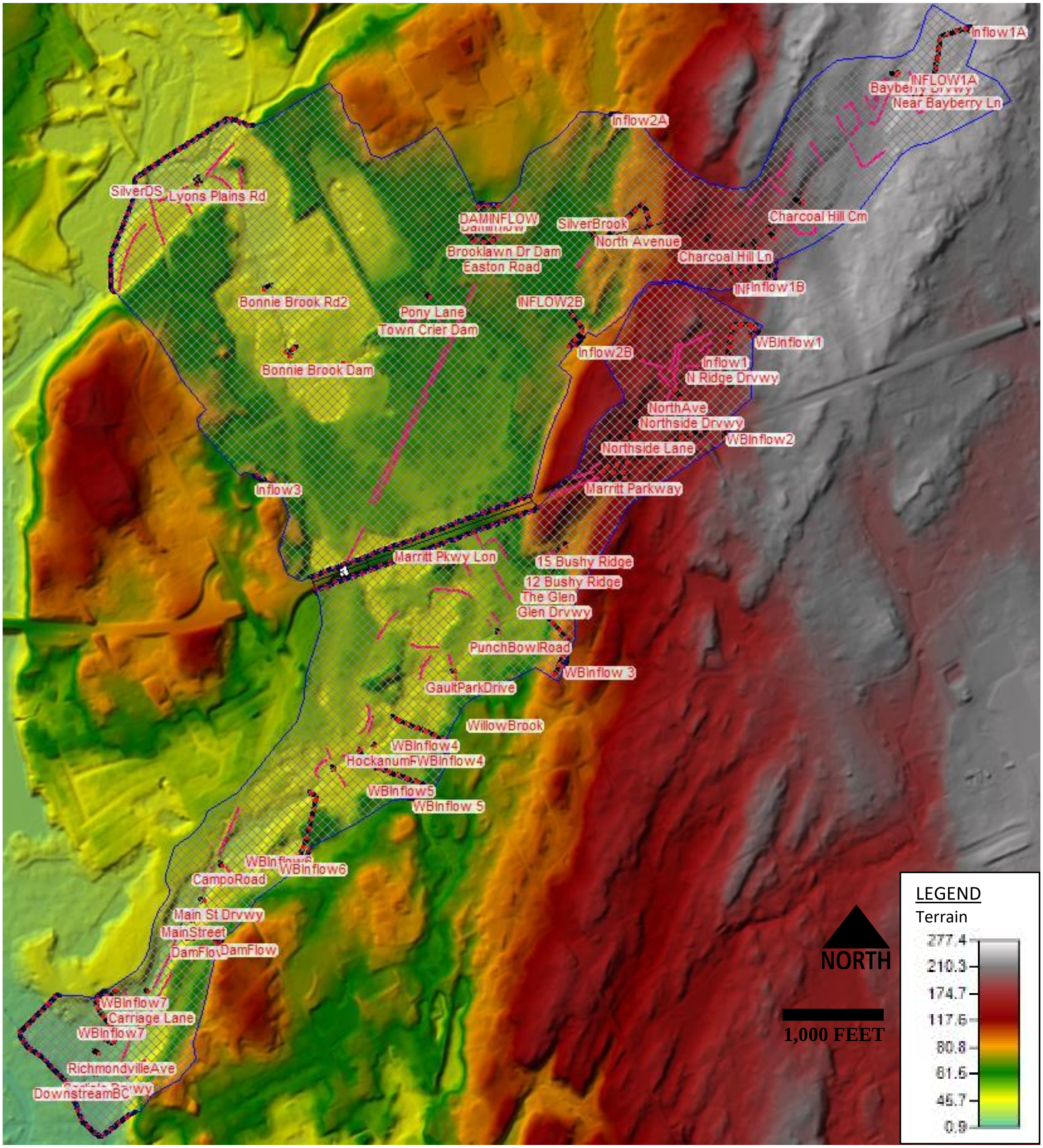


Pussy Willow Brook



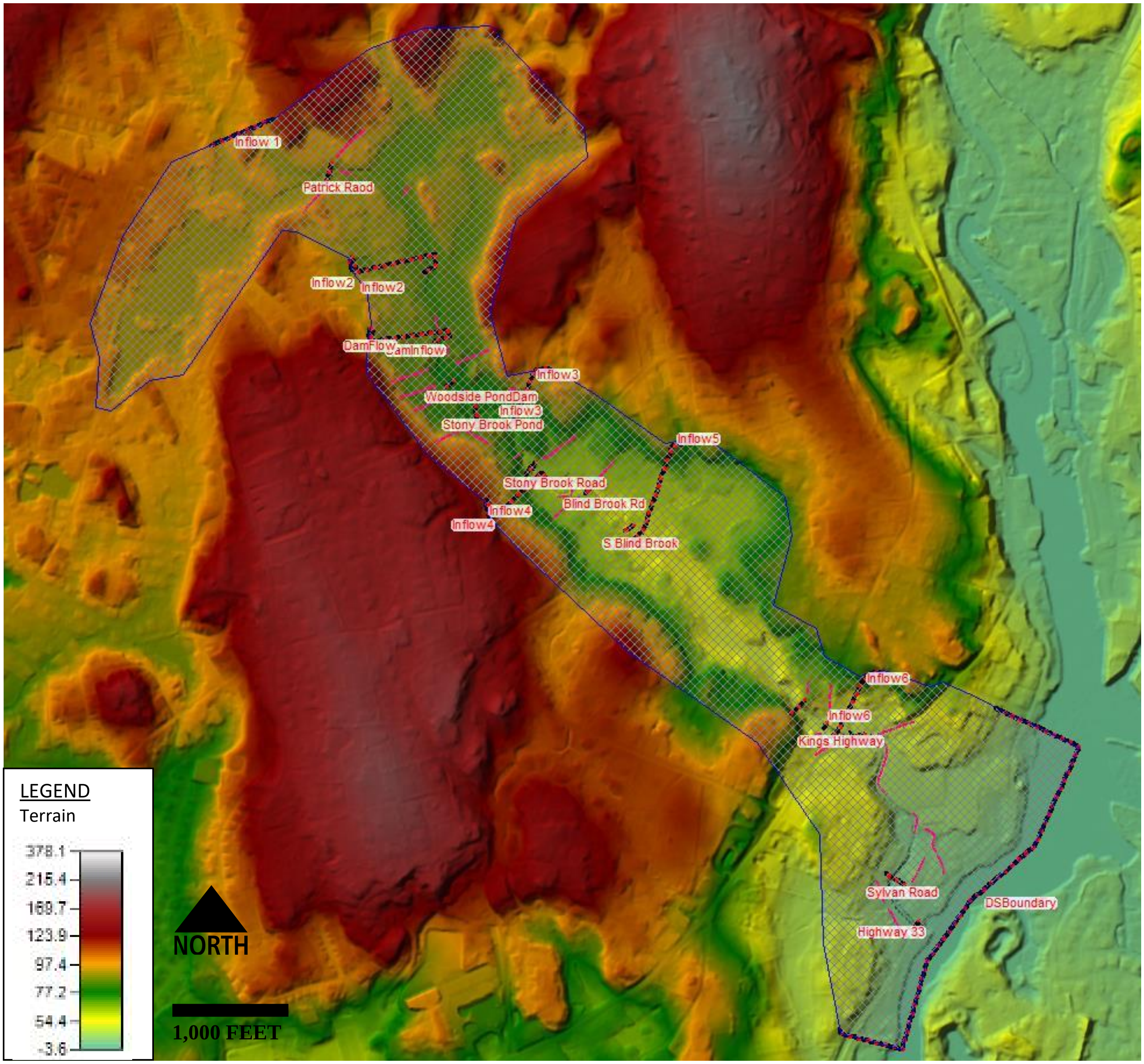
Note: Basemap depicts terrain in feet, NAVD88.

Silver Brook & Willow Brook



Note: Basemap depicts terrain in feet, NAVD88.

Stony Brook



Note: Basemap depicts terrain in feet, NAVD88.

Appendix E – Summary of Bridges/Culverts/Dams

Note:
RCP: Reinforced Concrete Pipe
CMP: Corrugated Metal Pipe
Drvwy: Driveway

Indian River

GZA identified twelve major culvert crossings along Indian River within the Town, which are listed in order from most upstream to most downstream in the following table:

Crossing Name	Conveyance Structure Type	Approximate Opening Dimensions (feet)	Data Sources Other Than Field Data
Kings Highway S [*Photo #1*]	RCP Culvert	Two openings; 4.5’ diameters	Upstream invert elevation from contours. Length from aerial/contours.
Tarone Drive [*Photo #2*]	RCP Culvert	Two openings; 4.5’ diameters	Length from aerials/contours.
Hogan Trail [*Photo #3*]	RCP Culvert	Two openings; 3.4’ diameters	Length from aerials/contours.
Interstate 95 (1) [*Photo #4*]	RCP Culvert	Single opening; 3.4’ diameter	Length, diameter, and construction material from Town Engineer. Upstream invert elevation from contours. Construction material from photo.
Hiawatha Drvwy [*Photo #5*]	RCP Culvert	Two openings; 2.3’ diameters	Length from aerials/contours.
Hiawatha Lane [*Photo #6*]	RCP Culvert	Two openings; 2.2’ diameters	Length from aerials/contours.
Gillette Drvwy [*Photo #7*]	Elliptical CMP Culvert	Single opening; 2.9’ height with 5.1’ span	Length from aerials/contours.
Hiawatha Ln Ext [*Photo #8*]	Elliptical CMP Culvert	Single opening; 2.9’ height with 5.4’ span	Length from aerials/contours.
Railroad (2) [*Photo #9*]	RCP Culvert	Two openings; 7’ diameters	Length, dimensions, and construction material from CTDOT inspection report. Invert elevations from contours/inspection report.
RR Access Road (3) [*Photo #10*]	Circular Culverts	Culvert #1: 3' diameter RCP; Culvert #2: 3' diameter RCP; Culvert #3: 4.5' diameter RCP; Culvert #4: 3' diameter CMP	Dimensions and construction material from photos. Length from aerials/contours. Invert elevations from contours/terrain.
IR Green Road [*Photo #11*]	Concrete Box Culvert	Two openings; 2.1’ height with 10.2’ and 10.4’ spans	Length from aerials/contours. Invert elevations from terrain.
Saugatuck Avenue (4) [*Photo #12*]	RCP Culvert	Single opening; 6.3’ diameter	Length from aerials/contours.

FOOTNOTES FOR INDIAN RIVER’S SPECIAL CIRCUMSTANCES

1. **Interstate 95:** Structure was not measured in field due to access issues, however, photographs were taken.
2. **Railroad:** Structure was not measured in field due to access issues, however, photographs were taken. Inspection report notes and field photos confirmed significant sediment buildup at the left-hand culvert at the

downstream end (approximately 1.5’ of the culvert remains unobstructed). Approximately 2' sediment buildup in right-hand culvert was noted in the CTDOT inspection report (Bridge No. 08290R).

3. **RR Access Road:** Structure was not measured in field due to access issues, however, photographs were taken. Estimations were made from photos, because three culverts were completely submerged and GZA assumed culverts were at least half filled with sediment.
4. **Saugatuck Avenue:** Approximately 1' of sediment was along bottom of culvert based on field measurements.

Muddy Brook

GZA identified 15 bridges, 14 culvert crossings, and two dams along Muddy Brook within the Town, which are listed in order from most upstream to most downstream in the following table:

Crossing Name	Conveyance Structure Type	Approximate Opening Dimensions (feet)	Data Sources Other Than Field Data
Merritt Parkway (1) *[No Photo Available]*	RCP Culvert	Single opening; 3' diameter	Length and dimensions from Town Engineer. Invert elevations from terrain/contours.
175A Cross Hwy (Driveway) *[Photo #13]*	RCP Culvert	Single opening; 2.5' diameter	Length from aerials.
Cross Highway *[Photo #14]*	Plastic Culvert	Single opening; 2' diameter	Length from aerials.
172 Cross Hwy (Driveway) *[Photo #15]*	Elliptical CMP Culvert	Two openings; 2.7' height with 4' span	Length from aerials.
Bayberry Lane *[Photo #16]*	RCP Culvert	Two openings; 1.6' diameters	Length from aerials.
44 High Pt Rd (Driveway) *[Photo #17]*	Concrete Arch Culvert	Two openings; 2.2' height with 2.6' span	Length from aerials.
32 High Pt Rd (Driveway) *[Photo #18]*	RCP Culvert	Two openings; 1.5' diameters	Length from aerials.
Bayberry Dam *[Photo #19]*	Dam	10' spillway; 1' spillway depth	Dimensions from aerials/field photos. Length from aerial/contours. Invert elevations from terrain/contours.
Bayberry Drvwy 2 *[Photo #20]*	RCP Culvert	Two openings; 3.3' diameters	Length from aerials.
Bayberry Drvwy 1 *[Photo #21]*	Mason Bridge	Single opening; 3.5' height with 6.5' span	Length from aerials.
5 Angora Dam (2) *[Photo #22]*	Dam	8' total span; 1' depth	Dimensions from aerials/field photos. Length from field photos.
4 High Pt Rd (Driveway) *[Photo #23]*	Concrete Bridge	Single opening; 4.2' height with 6.2' span	Length from aerials.
High Point Road *[Photo #24]*	Concrete Bridge	Single opening; 3.7' height with 8' span	Length from aerials.
Long Lots Rd *[Photo #25]*	Mason Bridge	Single opening; 3' height with 10' span	Length from aerials.
Meadowbrook Lane *[Photo # 26]*	RCP Culverts	Two openings; 4' diameters	Length from aerials.
4 Meadowbrook (Driveway) (3) *[Photo #27]*	RCP Arch Culvert	Two openings; 2.7' height with 2.8' span	Length from aerials.
8 Meadowbrook (Driveway) *[Photo #28]*	RCP Culvert	Two openings; 3.7' diameters	Length from aerials.
Ambler Road *[Photo #29]*	Elliptical CMP Culvert	Two openings; 2.9' height with 4.5' span	Length from aerials.

Turkey Hill Road *[Photo #30]*	Concrete Box Culvert	Single opening; 4.7' height with 8.2' span	Dimensions and length from CTDOT inspection report.
US Rt 1 (Post Road East) [4] *[Photo #31]*	Concrete Box Culvert	Single opening; 4.6' height with 7.3' span	Dimensions from CTDOT inspection report. Length from aerials.
Morningside Drive[5] *[Photo #32]*	Concrete Box Culvert	Single opening; 3.2' height with 8.5' span	Length from aerials.
Hillandale Street *[Photo #33]*	Mason Bridge	Single opening; 4.2' height with 11.3' span	Length from aerials.
Center Street *[Photo #34]*	Concrete Bridge	Two openings; 6.6' height with 7.8' span and 1.3' spacing	Length from aerials.
Center St Drvwy *[Photo #35]*	Concrete Bridge	Single opening; 8' height with 10' span	Length from aerials.
Greens Farms Road *[Photo #36]*	Concrete Bridge	Single opening; 4' height with 11.7' span	Dimensions from CTDOT inspection report/photos. Length from aerials.
Nyala Farm Road *[Photo #37]*	Elliptical CMP Culvert	Two openings; 7.5' height with 11.75' span	Dimensions from CTDOT inspection report. Length from aerials.
Sherwood Island *[Photo #38]*	Concrete Bridge	Single opening; 8.6' height with 11.7' span	Length from aerials.
Interstate 95 [6] *[No Photo Available]*	Concrete Box Culvert	Single opening; 9' height with 10' span	Dimensions and length from CTDOT inspection report. Invert elevations from terrain/contours.
Railroad [7] *[No Photo Available]*	Concrete Arch Culvert	Single opening; 7'11" height with 8' span	Dimensions and length from CTDOT inspection report. Invert elevations from terrain/contours.

FOOTNOTES FOR MUDDY BROOK'S SPECIAL CIRCUMSTANCES

1. **Merritt Parkway:** Structure was not measured in field due to access issues.
2. **5 Angora Dam:** Structure was not measured in field; however, photographs were taken.
3. **4 Meadowbrook (Driveway):** A small dam feature was present just upstream of the culvert, however, it appears the feature is a platform for a wire fence (Photo #27). The feature was not considered significant nor modeled.
4. **US Rt 1 (Post Road East):** The downstream culvert dimensions were conservatively used for this study (upstream culvert was two CMP culverts and downstream was a box culvert).
5. **Morningside Drive:** The downstream culvert dimensions were conservatively used for this study (upstream culvert was two box culverts and downstream was a box culvert).
6. **Interstate 95:** Structure was not measured in field due to access issues.
7. **Railroad:** Structure was not measured in field due to access issues.

New Creek

GZA identified two bridges and seven culvert crossings along New Creek within the Town, which are listed in order from most upstream to most downstream in the following table:

Crossing Name	Conveyance Structure Type	Approximate Opening Dimensions (feet)	Data Sources Other Than Field Data
Devon Yard [(1)] *[Photo #39]*	CMP Culvert	Single opening; 2' diameter	Dimensions and construction material from photo. Invert elevations from terrain/contours. Length from aerials.
Clapboard Hill Rd *[Photo #40]*	RCP Culvert	Two openings; 4' diameters	Length from aerials.
Clapboard Yard [(2)] *[No Photo Available]*	RCP Culvert	Single opening; 2' diameter	Dimensions and construction material were assumed to be the same as nearby culvert, because structure was not measured in field. Invert elevations from terrain/contours. Length from aerials.
Greens Farms Road *[Photo #41]*	RCP Culvert	Single opening; 3.3' diameter	Length from aerials.
Interstate 95 [(3)] *[No Photo Available]*	RCP Culvert	Single opening; 5' diameter	Length, dimensions, and construction material provided by Town Engineer. Invert elevations from terrain/contours.
Private Road *[Photo #42]*	CMP Culvert	Single opening; 4' diameter	Length from aerials.
Railroad [(4)] *[No Photo Available]*	CMP Culvert	Single opening; 5.1' diameter	Dimensions and construction material from CTDOT inspection report. Length from aerials. Invert elevations from terrain/contours.
Maple Lane *[Photo #43]*	Concrete Bridge	Single opening; 4.7' height with 7' span	Length from aerials.
Beachside Ave *[Photo #44]*	Concrete Bridge	Two openings; 5.5' height with 6' span	Length from aerials.

FOOTNOTES FOR NEW CREEK'S SPECIAL CIRCUMSTANCES

1. **Devon Yard:** Structure was not measured in field; however, photographs were taken. Dimensions and construction material were estimated from field photo.
2. **Clapboard Yard:** Structure was not measured in field. Dimensions and construction material were assumed to be the same as Devon Yard culvert.
3. **Interstate 95:** Structure was not measured in field due to access issues.
4. **Railroad:** Structure was not measured in field due to access issues.

Poplar Plains Brook

GZA identified two bridges, three culvert crossings, and five dams along Poplar Plains Brook within the Town, which are listed in order from most upstream to most downstream in the following table:

Crossing Name	**Conveyance Structure Type**	**Approximate Opening Dimensions (feet)**	**Data Sources Other Than Field Data**
Merritt Parkway (1) [*No Photo Available*]	RCP Culvert	Single opening; 4’ diameter	Length, dimensions, and construction material from Town Engineer. Invert elevations from terrain.
Newtown Turnpike [*Photo #45*]	RCP Culvert	Two openings; 2’ diameters	Length from aerials/contours.
287 Wilton Road (Driveway) [*Photo #46*]	Concrete Bridge	Single opening; 1.9’ height with 5.3’ span	Length from aerials/contours.
Wilton Road-CT33 [*Photo #47*]	RCP Culvert	Single opening; 4’ diameter	Dimensions and length from Town Engineer.
FEMAProfile Dam5 [*Photo #48*]	Dam	47’ total span; 4’ spillway span with 0.6’ depth	Top of dam and top of spillway/water surface elevations from terrain. Total span of dam from photos.
FEMAProfile Dam4 [*Photo #49*]	Dam	53’ total span; 4.8’ spillway span with 0.3’ depth	Top of dam and top of spillway/water surface elevations from terrain. Total span of dam from photos.
FEMAProfile Dam3 [*Photo #50*]	Dam	67’ total span; 6.3’ spillway span with 0.5’ depth	Top of dam and top of spillway/water surface elevations from terrain. Total span of dam from photos.
FEMAProfile Dam2 (2) [*Photo #51*]	Dam	40’ total span; 7’ spillway span with 0.3’ depth. 2.5' width and 0.5' depth of eroded portion.	Top of dam elevation from terrain. Total span of dam from photos.
FEMAProfile Dam1 (3) [*Photo #52*]	Dam	31’ total span; 3’ spillway span with 0.25’ depth. 2.5' width and 1.25’ depth of eroded portion.	Spillway and erosion dimensions from photos. Top of dam elevation from terrain. Total span of dam from aerials/contours.
Rices Ln Bridge [*Photo #53*]	Concrete Bridge	Single opening; 2.7’ height with 7.3’ span	Height of bridge measurement included approximate 2.7' thick support beam beneath bridge deck. Length from aerials/contours.

FOOTNOTES FOR POPLAR PLAINS BROOK’S SPECIAL CIRCUMSTANCES

1. **Merritt Parkway:** Structure was not measured in field due to access issues.
2. **FEMAProfile Dam2:** Field notes indicated the presence of a gate in the middle of the dam, however, the gate appears to be closed. Significant erosion around the north side of the dam was present and modeled in HEC-RAS.

3. **FEMAProfile Dam1:** Top of dam was inaccessible in the field. Significant erosion near left bank was present and modeled in HEC-RAS.

Pussy Willow Brook

GZA identified 15 major culvert crossings along Pussy Willow Brook within the Town, which are listed in order from most upstream to most downstream in the following table:

Crossing Name	Conveyance Structure Type	Approximate Opening Dimensions (feet)	Data Sources Other Than Field Data
Unknown Drvwy (1) *[No Photo Available]*	RCP Culvert	Single opening; 0.5' diameter	Dimensions and construction material were assumed to be the same as nearby culverts, because structure was not measured in field. Invert elevations from contours. Length from aerials/contours.
26 Sue Terrace (2) [*Photo #54*]	RCP Culvert	Single opening; 0.5' diameter	Dimensions and construction material were assumed to be the same as nearby culverts, because structure was not measured in field. Invert elevations from contours. Length from aerials/contours.
Sue Terrace Yard (3) [*Photo #55*]	RCP Culvert	Single opening; 0.5' diameter	Dimensions and construction material were assumed to be the same as nearby culverts, because structure was not measured in field. Invert elevations from contours. Length from aerials/contours.
Sue Terrace (4) [*Photo #56*]	RCP Culvert	Single opening; 0.5' diameter	Dimensions and construction material were assumed to be the same as nearby culverts, because structure was not measured in field. Invert elevations from contours. Length from aerials/contours.
Yard Culvert (5) [*No Photo Available*]	CMP Culvert	Single opening; 0.5' diameter	Dimensions and construction material were assumed to be the same as nearby culverts, because structure was not measured in field. Invert elevations from contours. Length from aerials/contours.
State Street E [*Photo #57*]	CMP Arch Culvert	Single opening; 4' height with 7.8' span	Invert elevations from contours. Length from aerials/contours.
Spicer Road [*Photo #58*]	CMP Arch Culvert	Single opening; 2.5' height with 3' span	Length from aerials/contours. Assumed a 90-degree elbow in culvert due to opposite orientation of inlet and outlet.
Iron Gate Hill [*Photo #59*]	RCP Culvert	Two openings; 2' diameters	Length from aerials/contours.
Valley Road [*Photo #60*]	RCP Culvert	Two openings; 3' diameters	Length from aerials/contours.
Guyer Road [*Photo #61*]	Elliptical RCP Culvert	Single opening; 2.8' height with 6.8' span	Length from aerials/contours.
Office Park [*Photo #62*]	CMP Arch Culvert	Single opening; 4.3' height with 7' span	Length from aerials/contours.

Green Farms Road [(6)] [*Photo #63*]	Concrete Culvert (Box and RCP)	Box Culvert: 4’ height with 10’ span; RCP Culvert: 4’ diameter	Dimensions, length, and construction material from plan drawings in CTDOT inspection report. Invert elevations from contours.
Hillspoint Road [(7)] [*No Photo Available*]	RCP Culvert	Single opening; 6’ diameter	Dimensions, length, and construction material from CTDOT inspection report. Invert elevations from contours.
Interstate 95 [(8)] [*In background of Photo #64*]	RCP Culvert	Single opening; 6’ diameter	Dimensions, length, and construction material from Town Engineer. Invert elevations from contours.
Railroad [(9)] [*Photo #64*]	RCP Culvert	Single opening; 6’ diameter	Dimensions and construction material from field photos. Invert elevations from contours. Length from aerials/contours.

FOOTNOTES FOR PUSSY WILLOW BROOK’S SPECIAL CIRCUMSTANCES

1. **Unknown Drvwy:** Structure was not measured in the field; however, GZA assumed it is same as nearby culverts.
2. **26 Sue Terrace:** Conveyance structure was not visible at the time of the field visit; however, a stream crossing was present. Culvert may have been clogged with debris, estimated 0.5’ culvert diameter. Measurements were not taken in field.
3. **Sue Terrace Yard:** Conveyance structure was not easily visible at the time of the field visit; however, a culvert was present. Measurements were not taken in field.
4. **Sue Terrace:** Conveyance structure was not visible at the time of the field visit; however, a stream crossing was present. Culvert may have been clogged with debris. Measurements were not taken in field.
5. **Yard Culvert:** Structure was not measured in the field; however, GZA assumed it is similar to nearby culverts.
6. **Green Farms Road:** Road to streambed distance was 11’ in CTDOT inspection report (Bridge # 158-007), however, 6" of sediment was noted to be present in culvert.
7. **Hillspoint Road:** Structure was not measured in field. CTDOT inspection report (Bridge# 158-011) noted approximately 1’ of sediment along bottom of culvert.
8. **Interstate 95:** Structure was not measured in field due to access issues.
9. **Railroad:** Structure was not measured in field due to access issues, however, photographs were taken (Bridge# 08033R).

Silver Brook

GZA identified seven bridge culverts, nine culvert crossings, and three small dams along Silver Brook within the Town, which are listed in order from most upstream to most downstream in the following table:

Crossing Name	**Conveyance Structure Type**	**Approximate Opening Dimensions (feet)**	**Data Sources Other Than Field Data**
Near Bayberry Ln [*Photo #65*]	CMP Culvert	Single opening; 1' diameter	Length from aerials/contours. Driveway to streambed distance from photos.
Bayberry Drvwy [*Photo #66 and 67*]	RCP Culvert	Single opening; 1' diameter	Length from aerials/contours.
Bayberry Lane [*Photo #67*]	RCP Culvert	Single opening; 2' diameter	Length from aerials/contours.
Charcoal Hill Cm [*Photo #68*]	RCP Culvert	Single opening; 1.2' diameter	Length from aerials/contours.
Charcoal Pool (1) [*No Photo Available*]	Circular Plastic Culvert	Single opening; 1.1' diameter	Dimensions and construction material were assumed to be the same as nearby culverts, because structure was not measured in field. Invert elevations from contours. Length from aerials/contours.
Charcoal Hill Rd [*Photo #69*]	Circular Plastic Culvert	Two openings; 1.1' diameters	Length from aerials/contours.
Charcoal Hill Ln [*Photo #70*]	RCP Culvert	Single opening; 2.7' diameter	Length from aerials/contours.
North Avenue (2) [*Photo #71*]	RCP Culvert	Single opening; 2' diameter	Length from aerials/contours. The culvert was assumed not to be straight due to opposite orientation of inlet and outlet. The upstream invert elevation from terrain.
Easton Road (3) [*Photo #72*]	CMP Culvert	Two openings; 2' diameters	Length from aerials/contours.
Brooklawn Dr Dam [*Photo #73 and 74*]	Dam	14' total span; 1' height with 0.3' thickness	Dam thickness from photos. Top of dam elevation from terrain.
Brooklawn Drive [*Photo #74*]	Concrete Box Bridge Culvert	Single opening; 2.4' height with 9.8' span	Length from aerials/contours.
Pony Lane (4) [*No Photo Available*]	Concrete Box Bridge Culvert	Single opening; 4' height with 10' span	Dimensions were assumed to be the same as Town Crier Lane structure, because structure was not measured in field. Invert elevations from contours. Length from aerials/contours.
Town Crier Dam (5) [*Photo #75 and 76*]	Dam	7' total span; 1' height with 0.3' thickness	Dimensions were assumed to be the same as Brooklawn Dr Dam, because structure was not measured in field. Top of dam elevation from contours/terrain.
Town Crier Lane [*Photo #76*]	Concrete Box Bridge Culvert	Single opening; 4' height with 10' span	Length from aerials and the Town of Westport.
Bonnie Brook Rd1 [*Photo #77*]	Concrete Box Bridge Culvert	Single opening; 2.2' height with 12' span	Length from aerials/contours.

Bonnie Brook Dam [*Photo #78*]	Dam	13.4’ total span; 0.25’ spillway depth and 1.5 spillway span	Length from terrain/contours.
Bonnie Brook Ln [*Photo #79*]	Concrete Box Bridge Culvert	Single opening; 3.9’ height with 10.1’ span	Length from aerials/contours.
Bonnie Brook Rd2 [*Photo #80*]	Concrete Box Bridge Culvert	Two openings; 2.8’ height with 7’ span	Length from aerials/contours.
Lyons Plains Rd [*Photo #81*]	Concrete Box Bridge Culvert	Single opening; 3.0’ height with 12’ span	Length from aerials/contours.

FOOTNOTES FOR SILVER BROOK’S SPECIAL CIRCUMSTANCES

1. **Charcoal Pool:** Structure was not measured in field due to access issues.
2. **North Avenue:** The culvert length and direction were unknown and estimated from aerials/contours. The culvert was assumed not to be straight due to opposite orientation of inlet and outlet. The upstream culvert dimensions were conservatively used for this study (upstream culvert was one opening and downstream was two openings with a 2' diameter). The upstream culvert was not accessible at the time of the field visit; the upstream invert elevation was estimated from terrain.
3. **Easton Road:** A drop structure was present at the upstream culvert entrance as the stream entered a stormwater vault feature, however, this was not included in the HEC-RAS model.
4. **Pony Lane:** Structure was not measured in field due to access issues.
5. **Town Crier Dam:** Structure was not measured in field, however, GZA assumed dam similar to upstream dam.

Stony Brook

GZA identified nine bridge crossings and three dams along Stony Brook within the Town, which are listed in order from most upstream to most downstream in the following table:

Crossing Name	Conveyance Structure Type	Approximate Opening Dimensions (feet)	Data Sources Other Than Field Data
Partrick Road [*Photo #82*]	Concrete Bridge	Three openings; 4.2’ height with 12’ span, and 2’ spacing	Dimensions from CTDOT inspection report/contours. Length from aerials.
Woodside Pond Dam [*Photo #83*]	Dam	30’ total span; 6.25’ spillway span; 1’ height; 2’ depth	Dimensions from aerials/field photos. Length from field photos.
Woodside Drvwy [*Photo #84*]	Wooden Deck Bridge	Single opening; 3.66’ height with 8’ span	Length from aerials/photos.
Stony Brook Pond [*Photo #85*]	Dam	12’ span; 2’ depth	Dimensions and length from aerials/field photos.
Stony Brook Road [*Photo #86*]	Concrete Bridge	Three openings; 4’ height with 10’ span, and 2’ spacing	Dimensions from CTDOT inspection report/photos. Length from aerials.
Blind Brook Rd [*Photo #87*]	Concrete Bridge	Three openings; 4.4’ height with 10.5’ span, and 1.3’ spacing	Length from aerials.
S Blind Brook [*Photo #88*]	Mason Bridge	Single opening; 5’ height with 8.8’ span	Length from aerials.
Nash Pond Dam [*Photo #89*]	Dam	115’ total span; 15’ spillway span; 3.4’ spillway height; 4’ depth	Dimensions and length from aerials/field photos.
Kings Highway [*Photo #90*]	Concrete Bridge	Single opening; 4.4’ height with 12.5’ span	Length from aerials.
Post Road (US Route 1) [*Photo #91*]	Concrete Bridge	Single opening; 6.8’ height with 23’ span	Dimensions from CTDOT inspection report. Length from aerials.
Sylvan Road [*Photo #92*]	Concrete Bridge	Single opening; 5’ height with 26.1’ span	Dimensions from CTDOT inspection report. Length from aerials.
Highway 33 [*Photo #93*]	Concrete Bridge	Single opening; 8.5’ height with 16’ span	Dimensions from CTDOT inspection report. Length from aerials.

Willow Brook

GZA identified four bridges, 18 culvert crossings and one dam along Willow Brook within the Town, which are listed in order from most upstream to most downstream in the following table:

Crossing Name	Conveyance Structure Type	Approximate Opening Dimensions (feet)	Data Sources Other Than Field Data
N Ridge Drvwy [*Photo #94*]	RCP Culvert	Single opening; 2' diameter	Length from aerials.
North Ave [*Photo #95*]	RCP Culvert	Single opening; 1' diameter	Length from aerials.
Northside Drvwy [*Photo #96*]	CMP Culvert	Single opening; 4' diameter	Length from aerials.
Northside Yard [*Photo #97*]	Plastic Culvert	Single opening; 2' diameter	Length from aerials.
Northside Lane [*Photo #98*]	RCP Culvert	Single opening; 2' diameter	Length from aerials.
Merritt Parkway (1) *[No Photo Available]*	RCP Culvert	Single opening; 2.5' diameter	Length, diameter, and construction material from Town Engineer. Invert elevations from terrain.
15 Bushy Ridge (Driveway) [*Photo #99*]	RCP Culvert	Single opening; 2' diameter	Length from aerials.
Bushy Ridge Road [*Photo #100*]	RCP Culvert	Single opening; 2' diameter	Length from aerials.
12 Bushy Ridge (Driveway) (2) [*Photo #101*]	RCP Culvert	Two openings; 1' diameters	Length from aerials.
The Glen [*Photo #102*]	Elliptical RCP Culvert	Single opening; 1.8' height with 3.1' span	Length from aerials.
Glen Drvwy [*Photo #103*]	Concrete Bridge	Single opening; 1.8' height with 5' span	Length from aerials.
Punch Bowl Drive [*Photo #104*]	RCP Culvert	Single opening; 2' diameter	Length from aerials.
Gault Park Drive [*Photo #105*]	RCP Culvert	Single opening; 2' diameter	Length from aerials.
Hockanum Road [*Photo #106*]	RCP Culvert	Single opening; 2' diameter	Length from aerials.
Weston Road [*Photo #107*]	RCP Culvert	Two openings; 1.5' diameters	Length from aerials.
Campo Road [*Photo #108*]	Box Culvert	Single opening; 3.5' height with 5.7' span	Length from aerials.
Main St Drvwy [*Photo #109*]	RCP Culvert	Single opening; 2.9' diameter	Length from aerials.
Main Street [*Photo #110*]	Concrete Arch Culvert	Single opening; 2.7' height with 5.2' span	Length from aerials.
Cemetery Drvwy [*Photo #111*]	Mason Bridge	Single opening; 2.9' height with 5.9' span	Length from aerials.

Carriage Lane [*Photo #112*]	RCP Culvert	Two openings; 6’ diameters	Length from aerials.
Main St Dam [*Photo #113*]	Dam	21’ total span; 10’ spillway span; 1.25’ spillway height; 1’ depth	Total span of dam from aerials/photo.
Richmondville Ave [*Photo #114*]	Concrete Bridge	Single opening; 2.6’ height with 11.8’ span	Length from aerials.
Carlisle Drvwy [*Photo #115*]	Wooden Deck Bridge	Single opening; 4.4’ height with 12.2’ span	Length from aerials.

FOOTNOTES FOR WILLOW BROOK’S SPECIAL CIRCUMSTANCES

1. **Merritt Parkway:** Structure was not measured in field due to access issues.
2. **12 Bushy Ridge (Driveway):** A drop structure was present at the upstream culvert entrance; however, this was not included in the HEC-RAS model.

Photo No. 1

Photo No. 2

Photo No. 3

Photo No. 4

Photo No. 5

Photo No. 6

Photo No. 7

Photo No. 8

Photo No. 9

Photo No. 10
(Upstream above, downstream right)

Photo No. 11

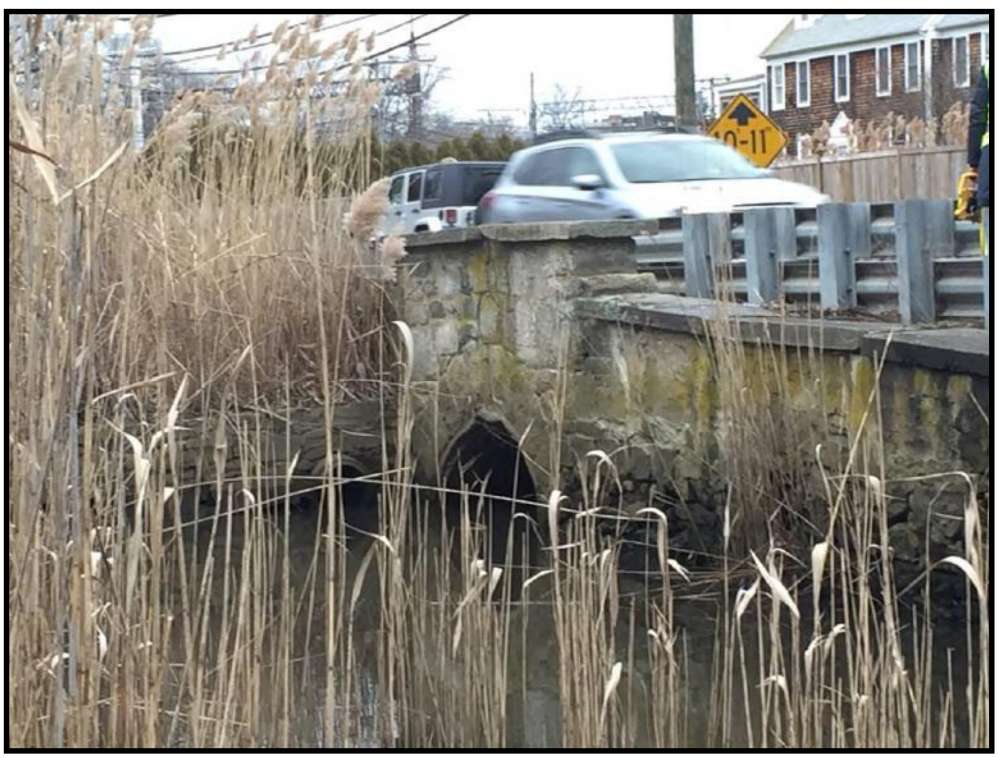


Photo No. 12

Photo No. 13

Photo No. 14

Photo No. 15

Photo No. 16
(Upstream above, downstream left)

Photo No. 17

Photo No. 18

Photo No. 19

Photo No. 20

Photo No. 21

Photo No. 22

Photo No. 23

Photo No. 24

Photo No. 25
(Upstream above, downstream right)

Photo No. 26

Photo No. 27
(Upstream above, downstream right)

Photo No. 28

Photo No. 29

Photo No. 30

Photo No. 31
(Upstream above, downstream right)

Photo No. 32
(Upstream above, downstream right)

Photo No. 33

Photo No. 34

Photo No. 35

Photo No. 36

Photo No. 37

Photo No. 38

Photo No. 39

Photo No. 40
(Upstream above, downstream right)

Photo No. 41

Photo No. 42

Photo No. 43

Photo No. 44

Photo No. 45
(Upstream above, downstream right)

Photo No. 46

Photo No. 47

Photo No. 48

Photo No. 49

Photo No. 50

Photo No. 51
(Full dam span above, eroded portion right)

Photo No. 52

Photo No. 53

Photo No. 54

Photo No. 55

Photo No. 56

Photo No. 57

Photo No. 58
(Upstream above, downstream right)

Photo No. 59
(Upstream above, downstream right)

Photo No. 60

Photo No. 61

Photo No. 62

Photo No. 63

Photo No. 64

Photo No. 65

Photo No. 66

Photo No. 67

Photo No. 68

Photo No. 69

Photo No. 70

Photo No. 71
(Upstream above, downstream right)

Photo No. 72
(Upstream above, downstream right)

Photo No. 73

Photo No. 74

Photo No. 75

Photo No. 76

Photo No. 77

Photo No. 78

Photo No. 79

Photo No. 80

Photo No. 81

Photo No. 82

Photo No. 83

Photo No. 84

Photo No. 85

Photo No. 86

Photo No. 87

Photo No. 88

Photo No. 89

Photo No. 90

Photo No. 91

Photo No. 92

Photo No. 93

Photo No. 94

Photo No. 95

Photo No. 96

Photo No. 97
(Upstream above, downstream right)

Photo No. 98

Photo No. 99

Photo No. 100

Photo No. 101

Photo No. 102

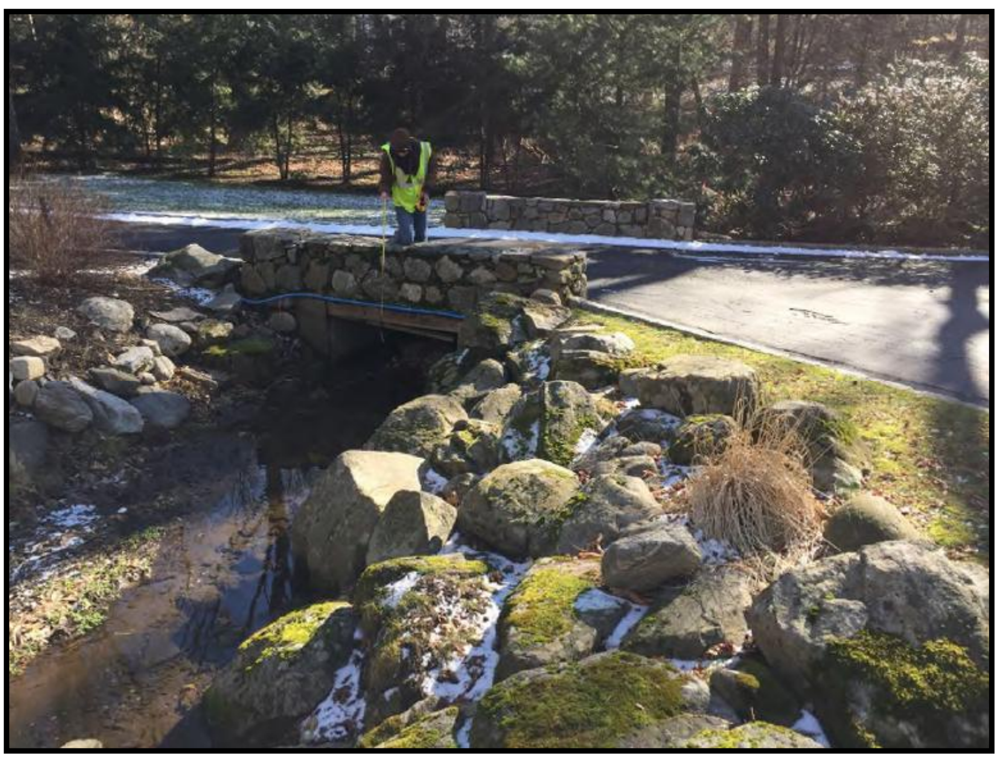


Photo No. 103

Photo No. 104

Photo No. 105

Photo No. 106

Photo No. 107

Photo No. 108

Photo No. 109

Photo No. 110

Photo No. 111

Photo No. 112

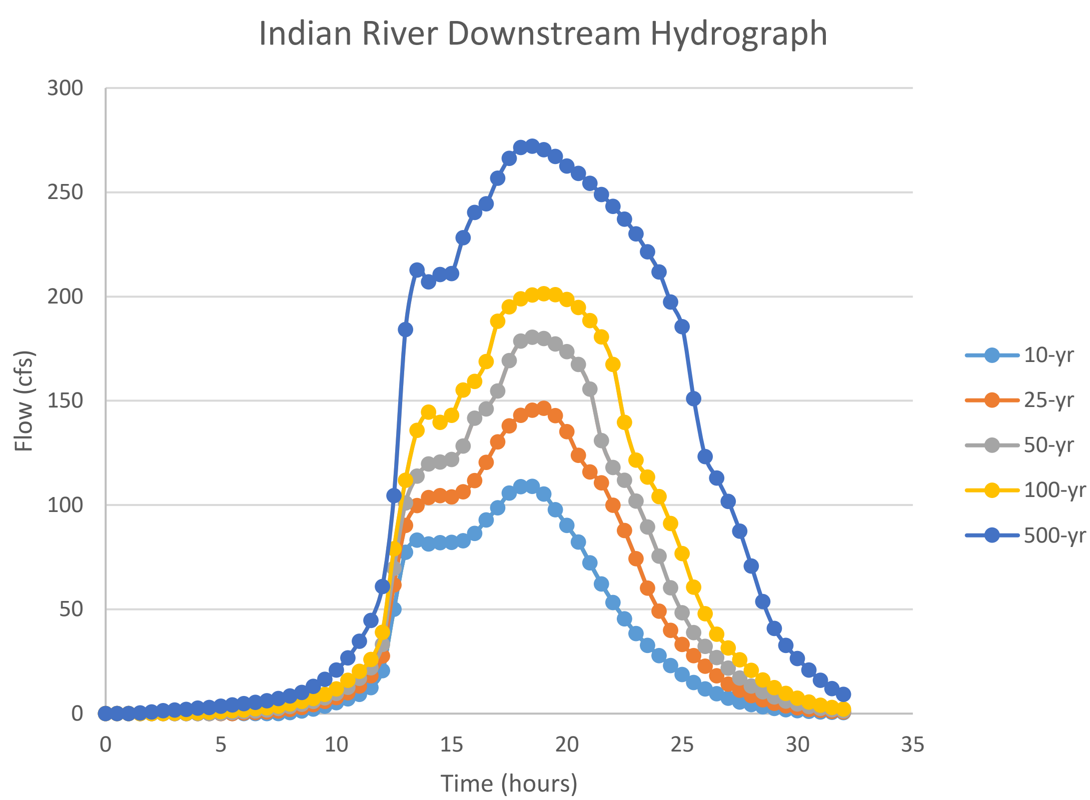
Photo No. 113

Photo No. 114

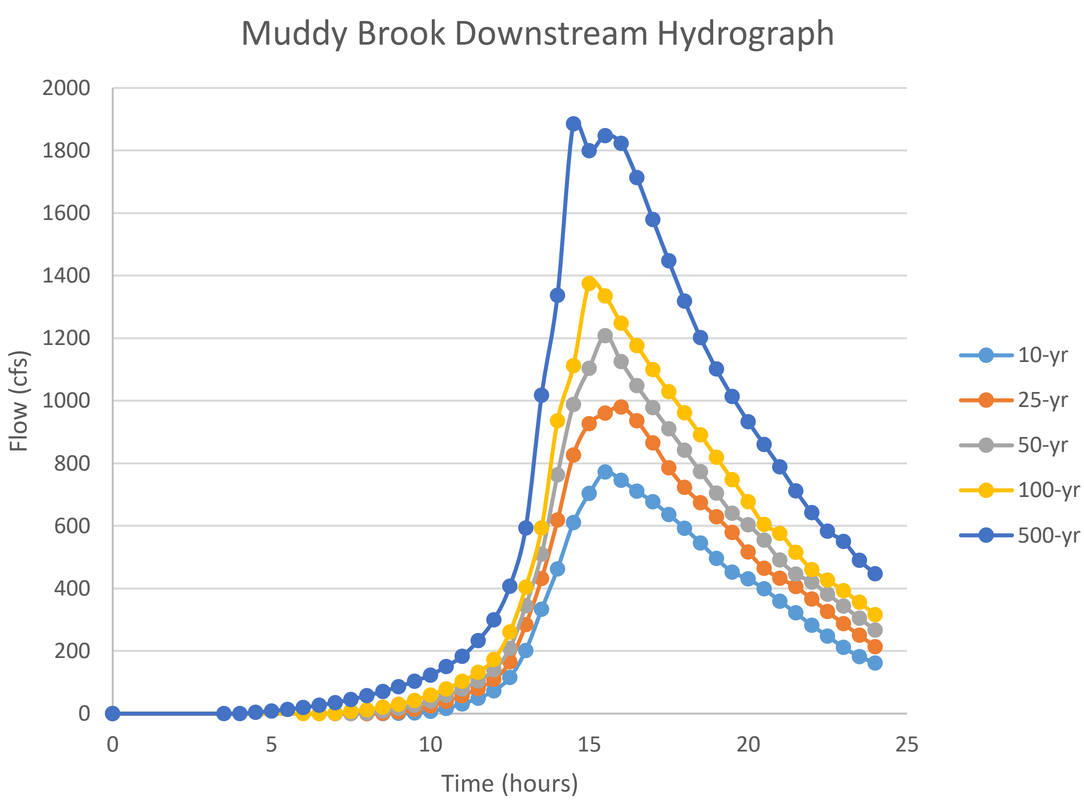
Photo No. 115

Appendix F – HEC-RAS Outputs – Downstream Hydrographs

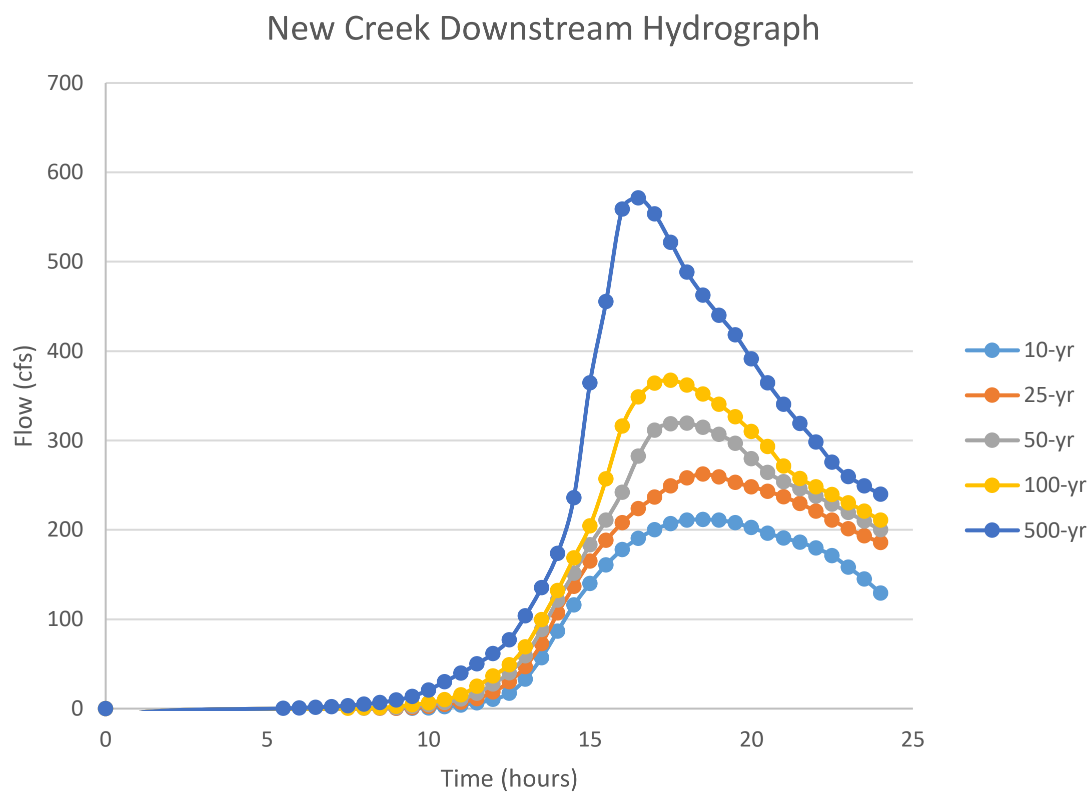
Indian River



Muddy Brook

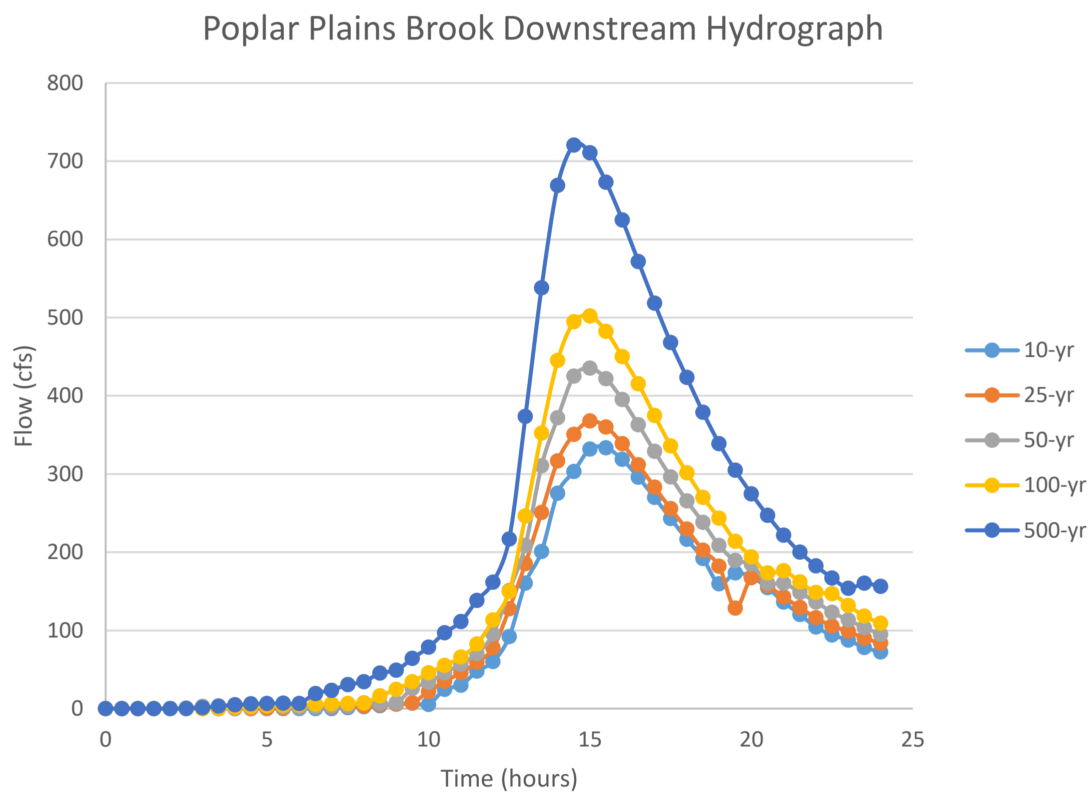

Muddy Brook Downstream Hydrograph
Flow (cfs)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
5
10
15
20
25
Time (hours)
10-yr
25-yr
50-yr
100-yr
500-yr

New Creek

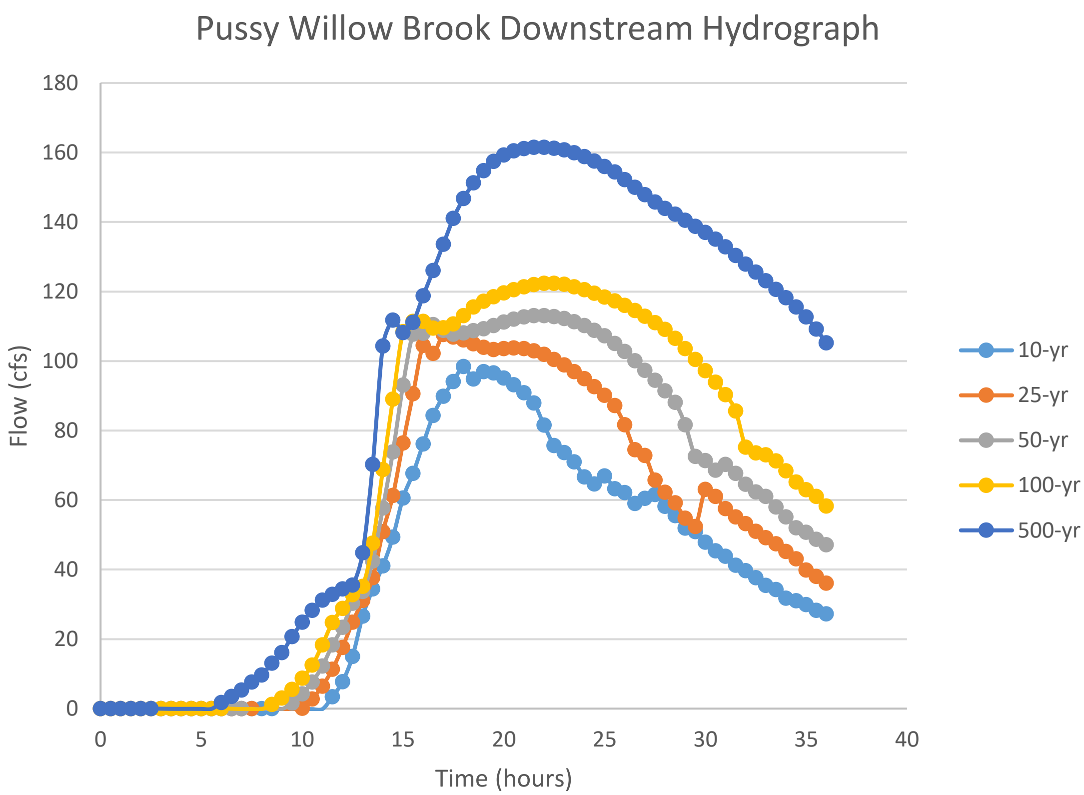


New Creek Downstream Hydrograph
Flow (cfs)
700
600
500
400
300
200
100
0
0
5
10
15
20
25
Time (hours)
10-yr
25-yr
50-yr
100-yr
500-yr

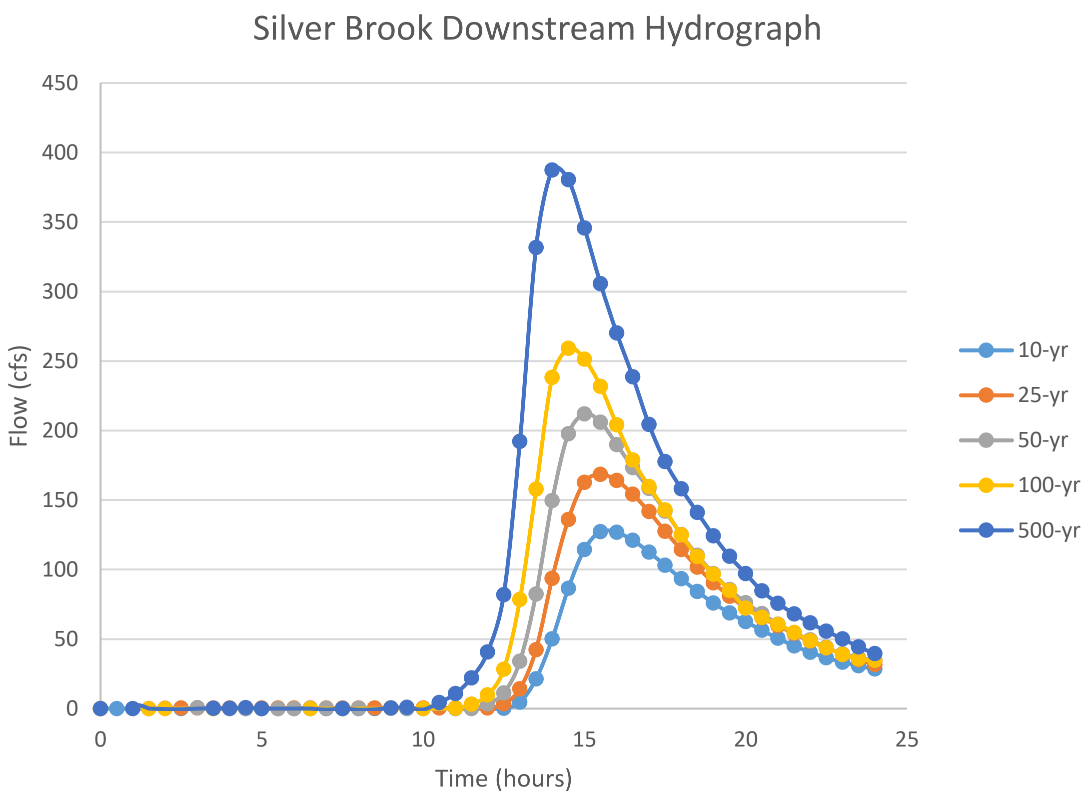
Poplar Plains Brook



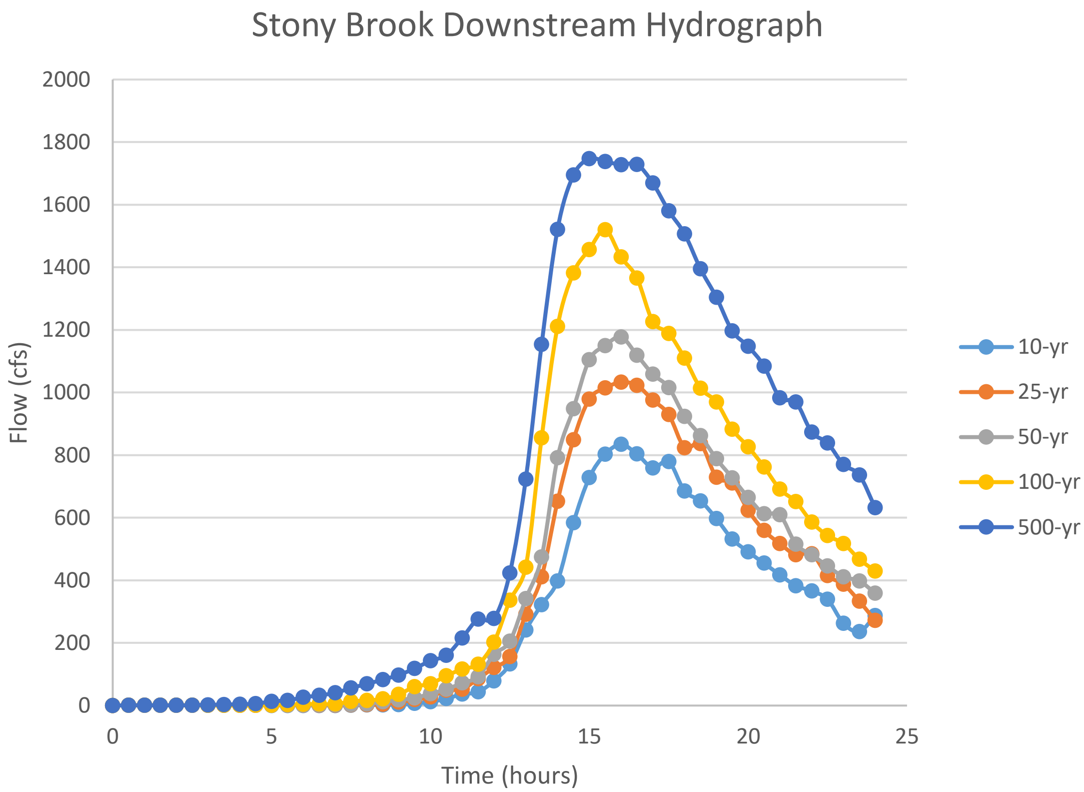
Pussy Willow Brook



Silver Brook

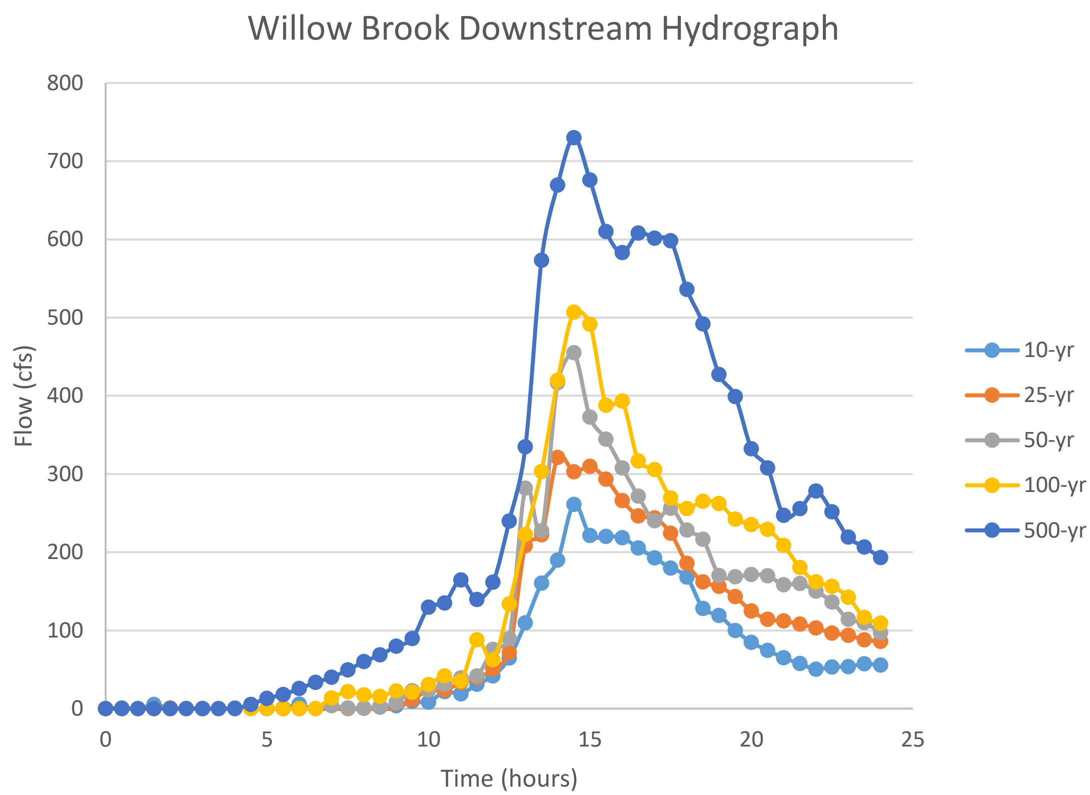


Stony Brook

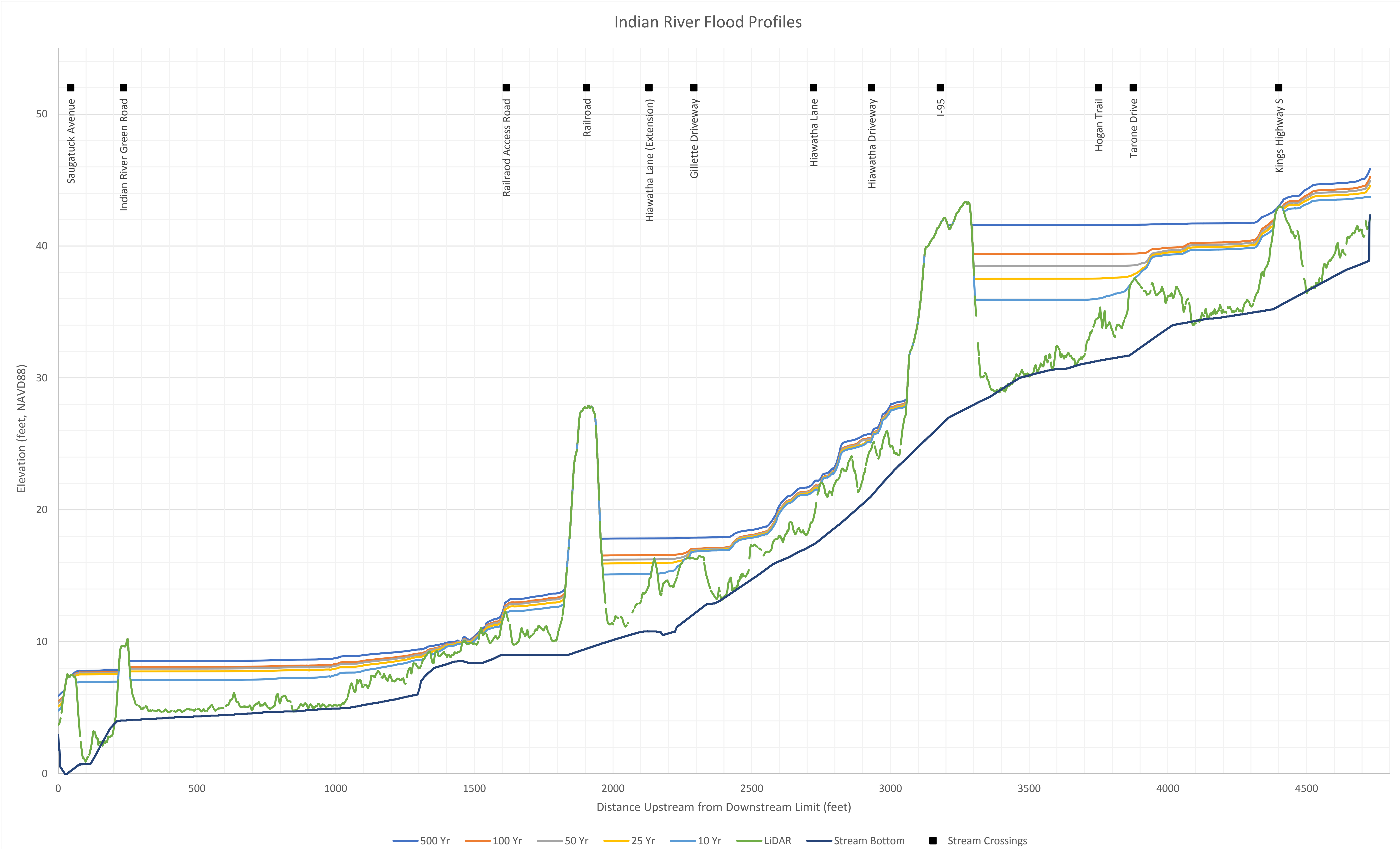


Stony Brook Downstream Hydrograph
Flow (cfs)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
5
10
15
20
25
Time (hours)
10-yr
25-yr
50-yr
100-yr
500-yr

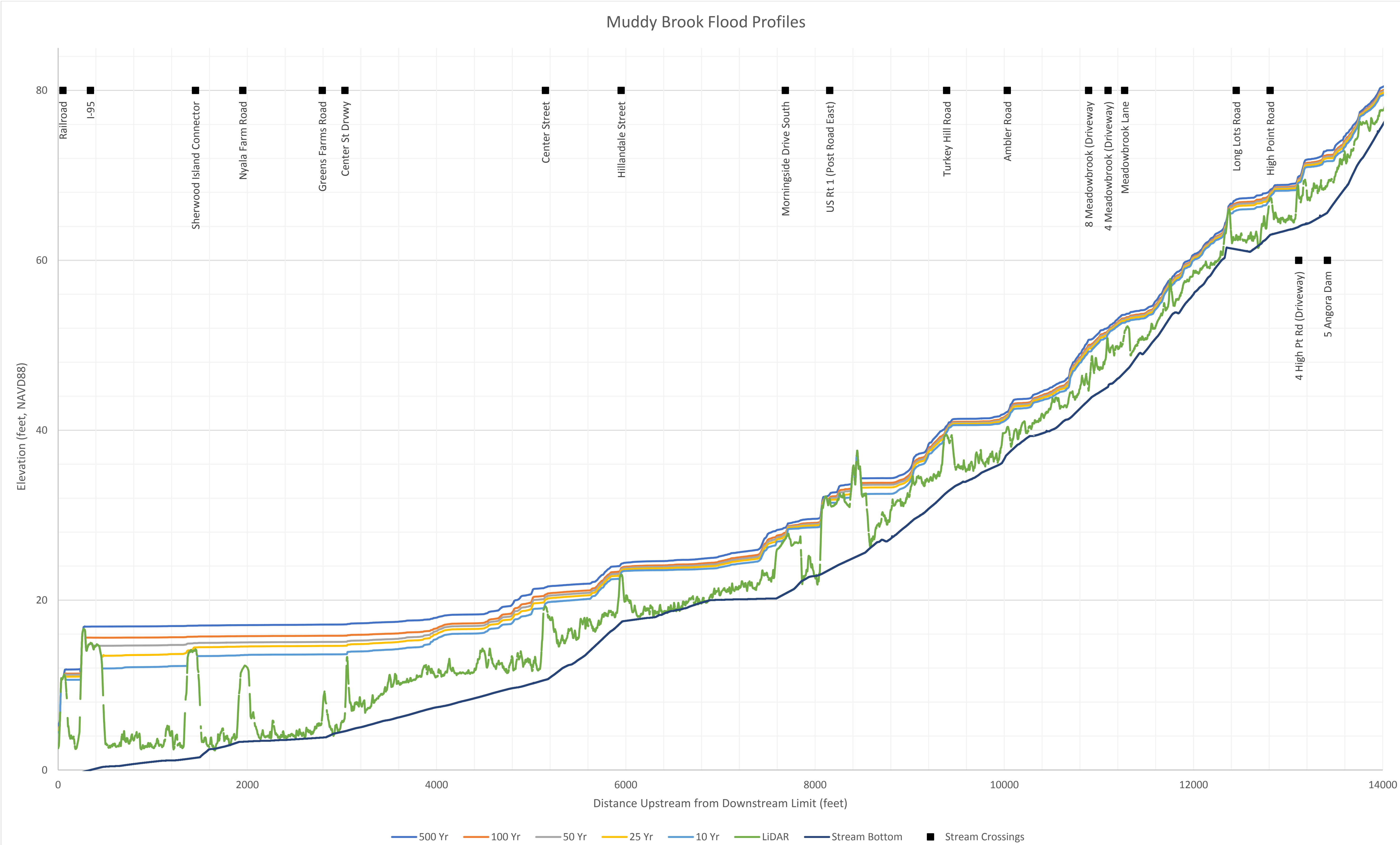
Willow Brook



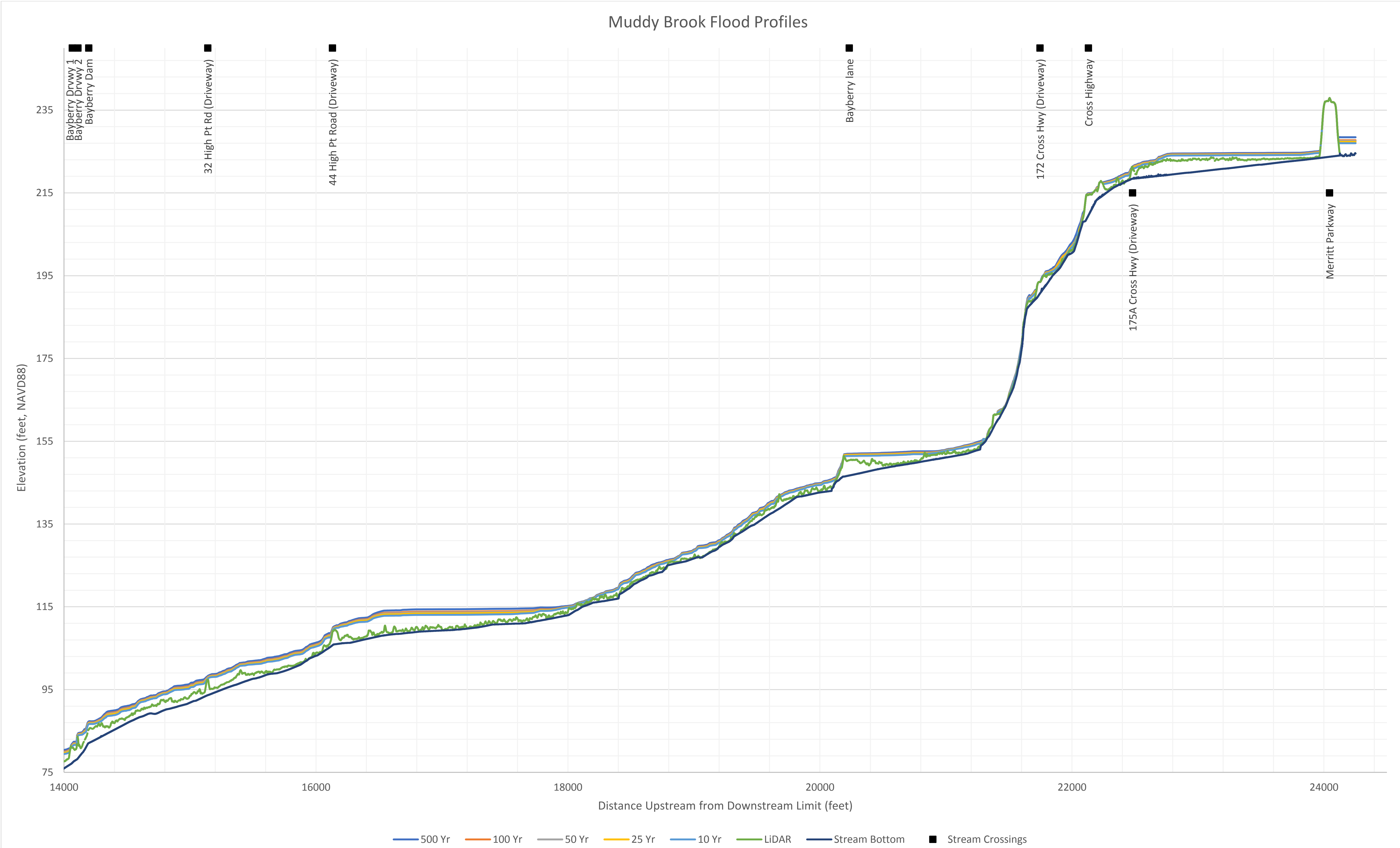
Appendix G – Stream Profiles



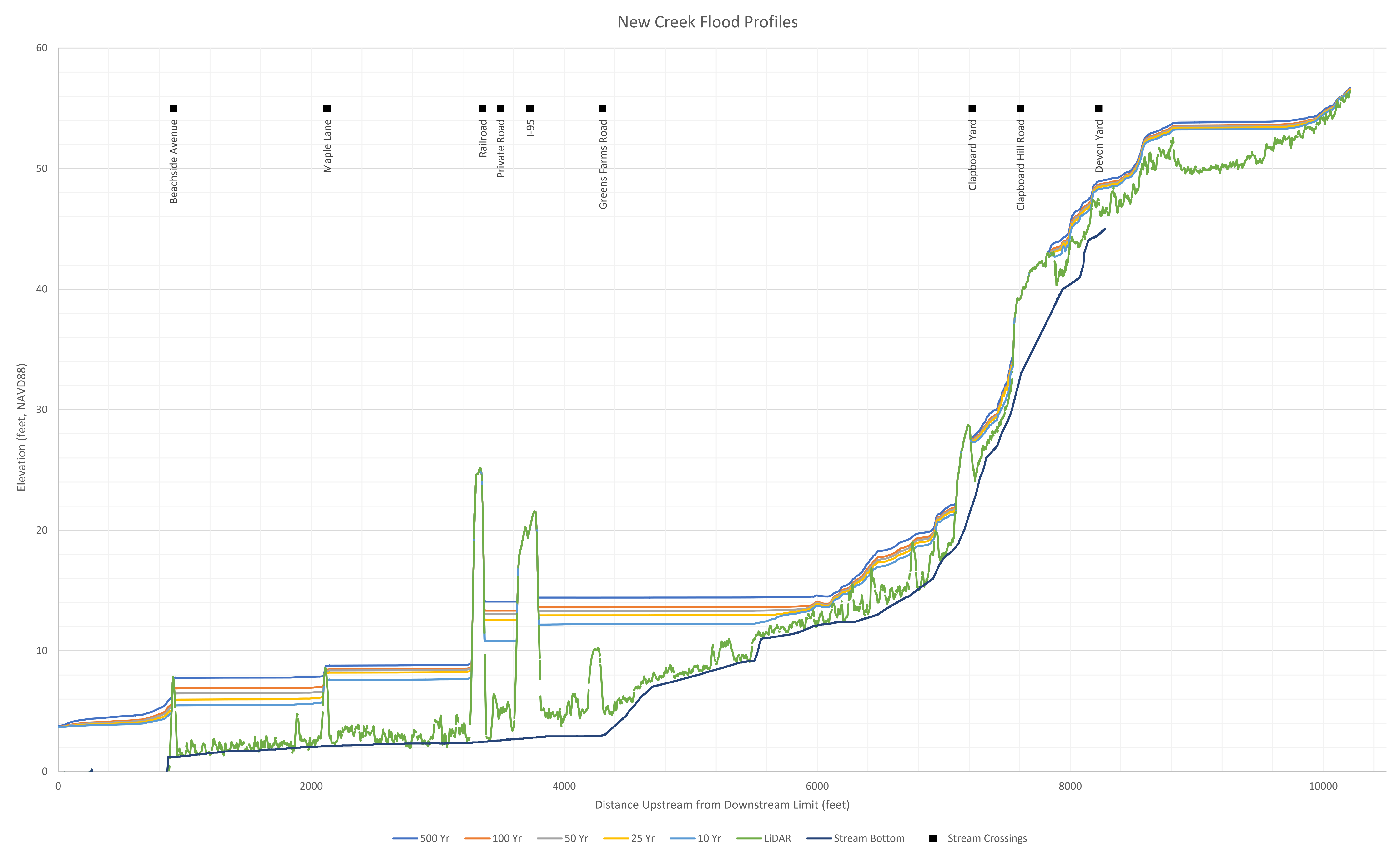
Indian River Flood Profiles
Saugatuck Avenue
Indian River Green Road
Railraod Access Road
Railroad
Hiawatha Lane (Extension)
Gillette Driveway
Hiawatha Lane
Hiawatha Driveway
I-95
Hogan Trail
Tarone Drive
Kings Highway S
Elevation (feet, NAVD88)
0
10
20
30
40
50
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Distance Upstream from Downstream Limit (feet)
500 Yr
100 Yr
50 Yr
25 Yr
10 Yr
LiDAR
Stream Bottom
Stream Crossings



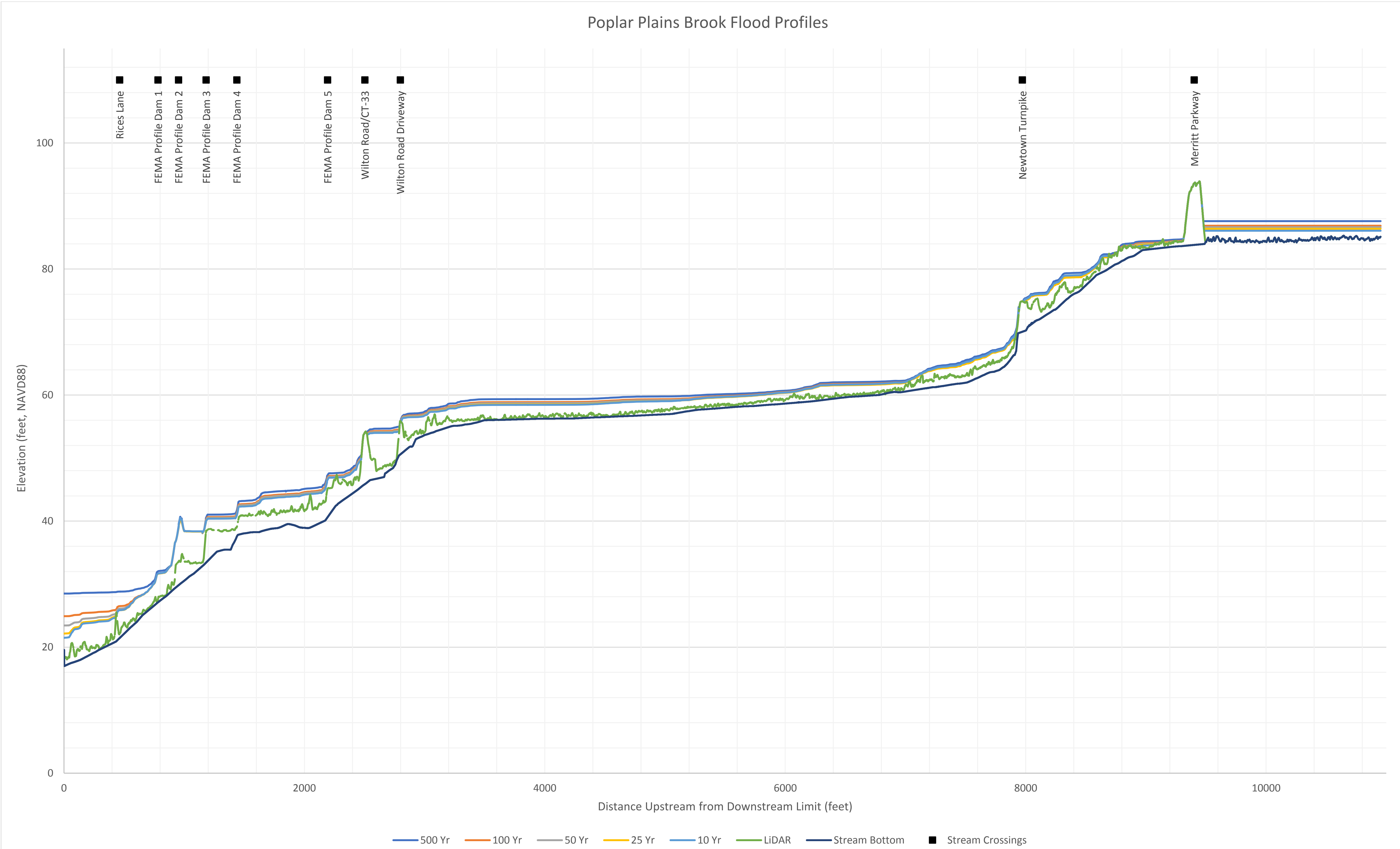
LiDAR data is from along stream centerline.



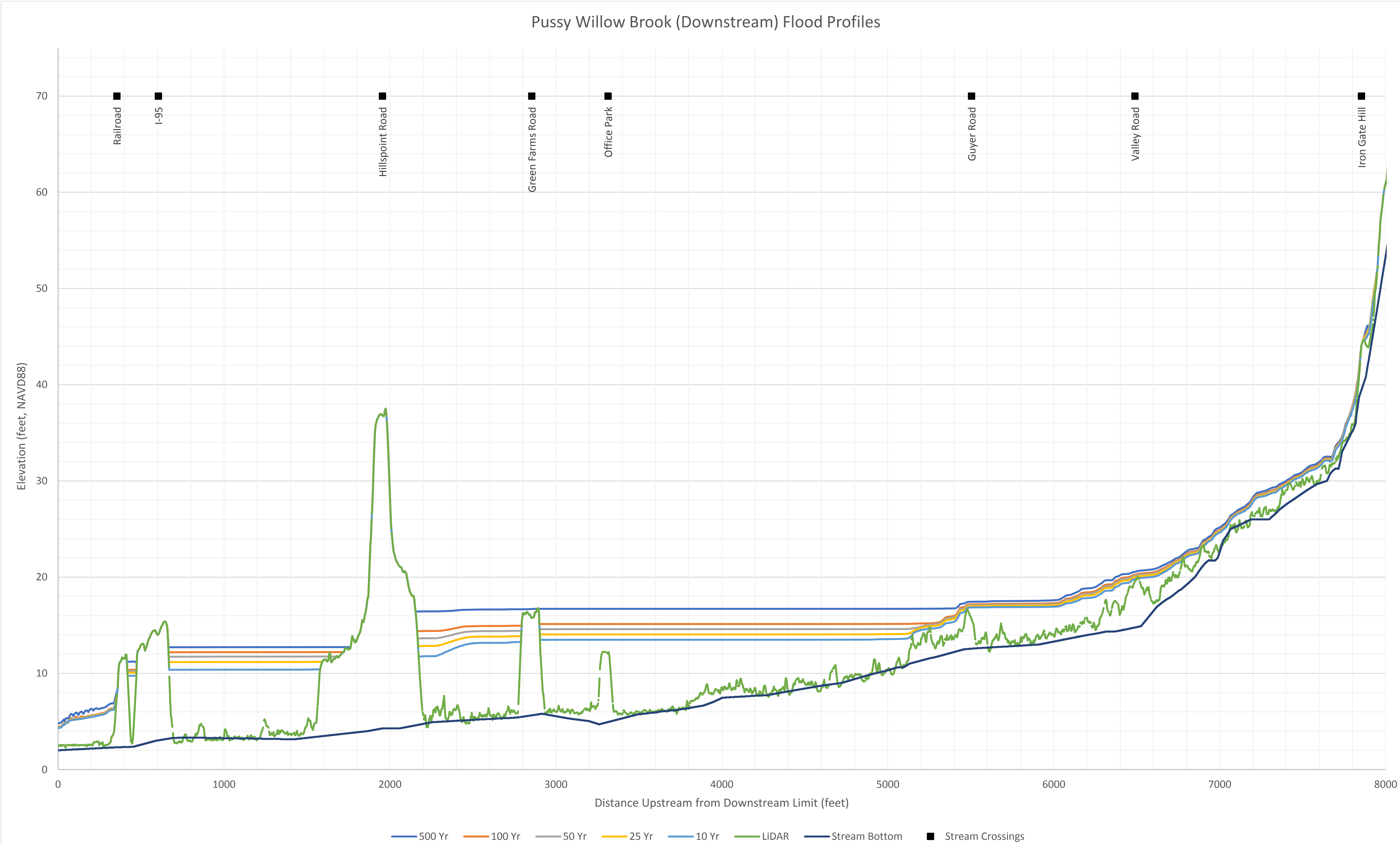
LiDAR data is from along stream centerline.



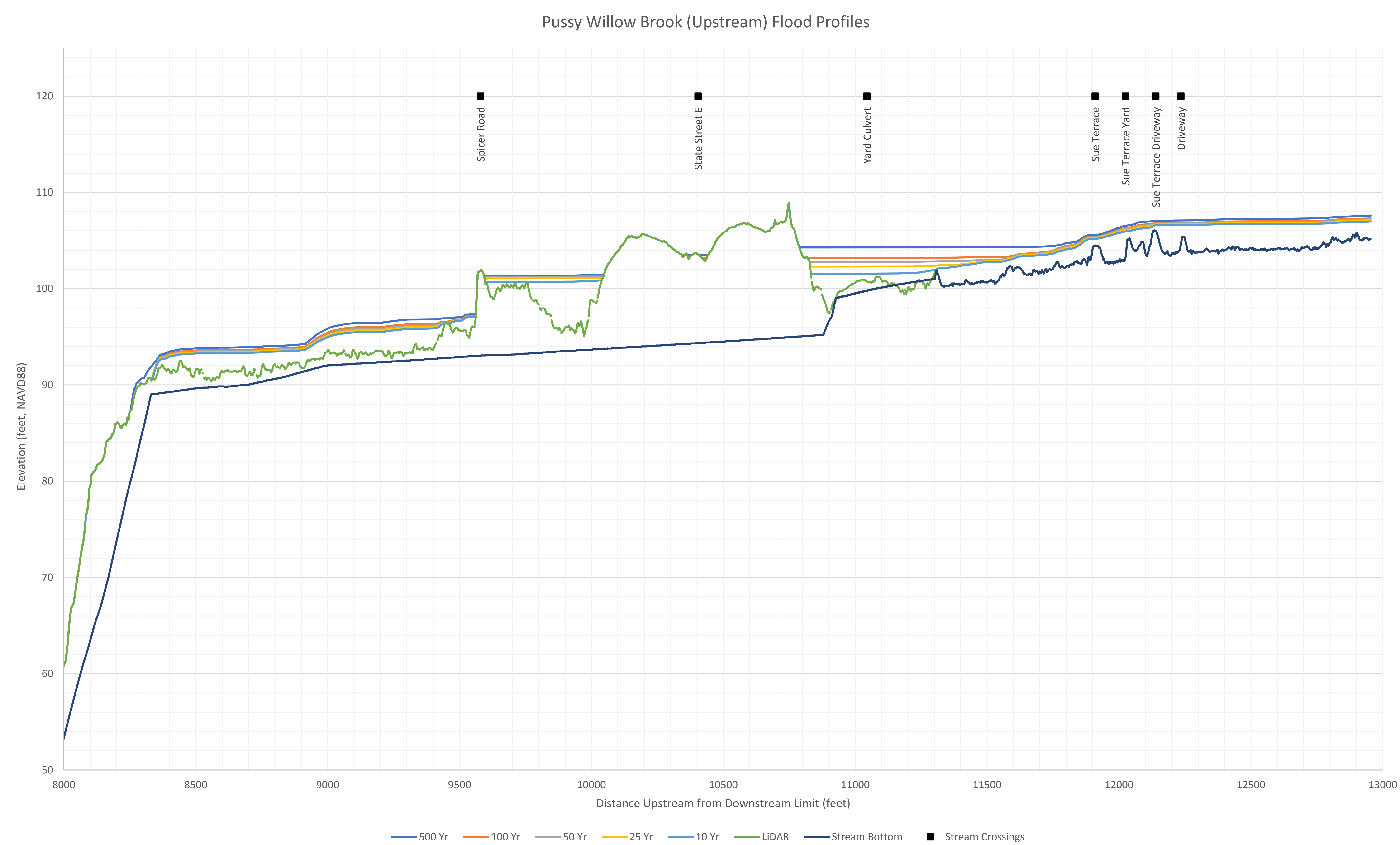
LiDAR data is from along stream centerline.



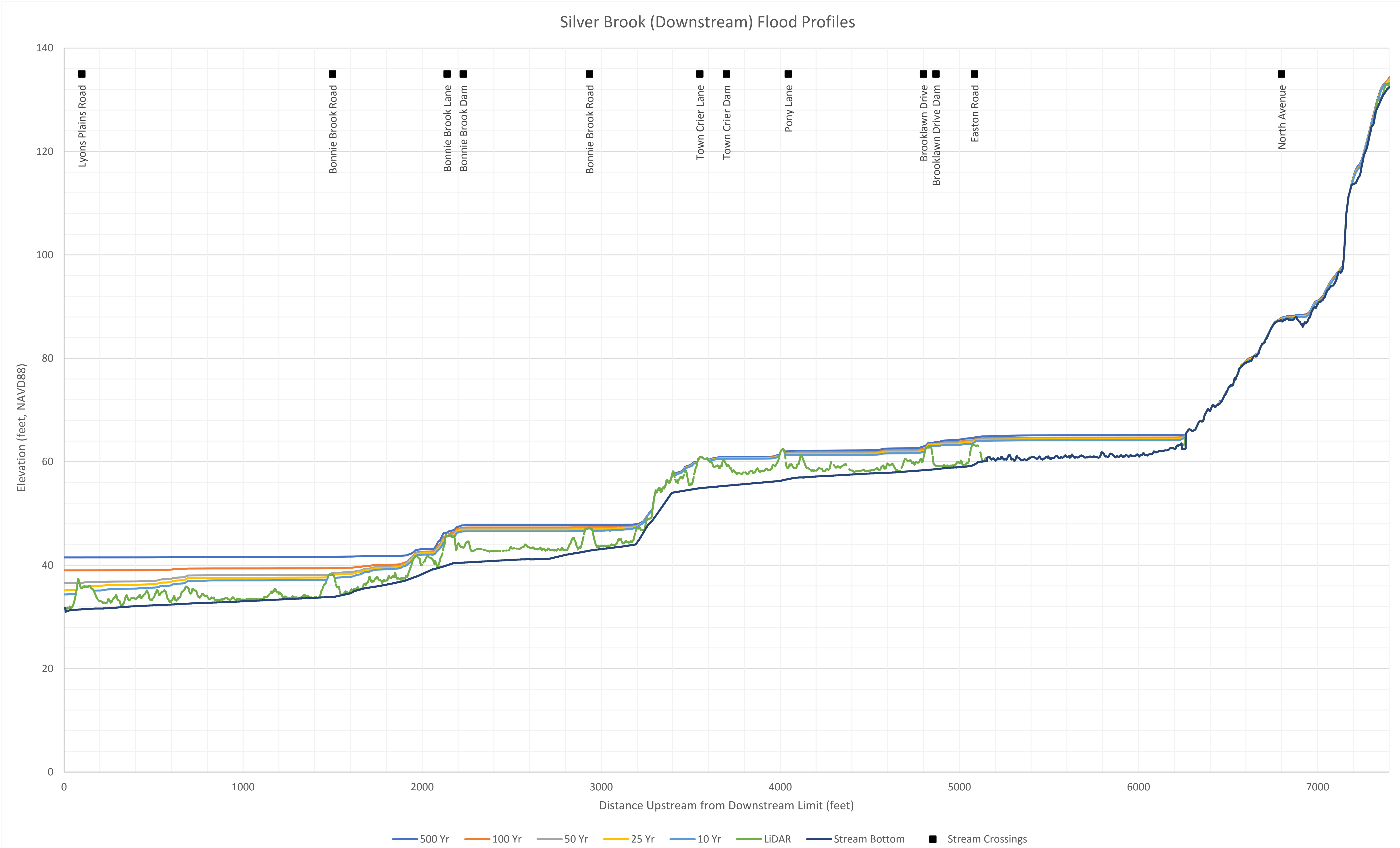
LiDAR data is from along stream centerline.



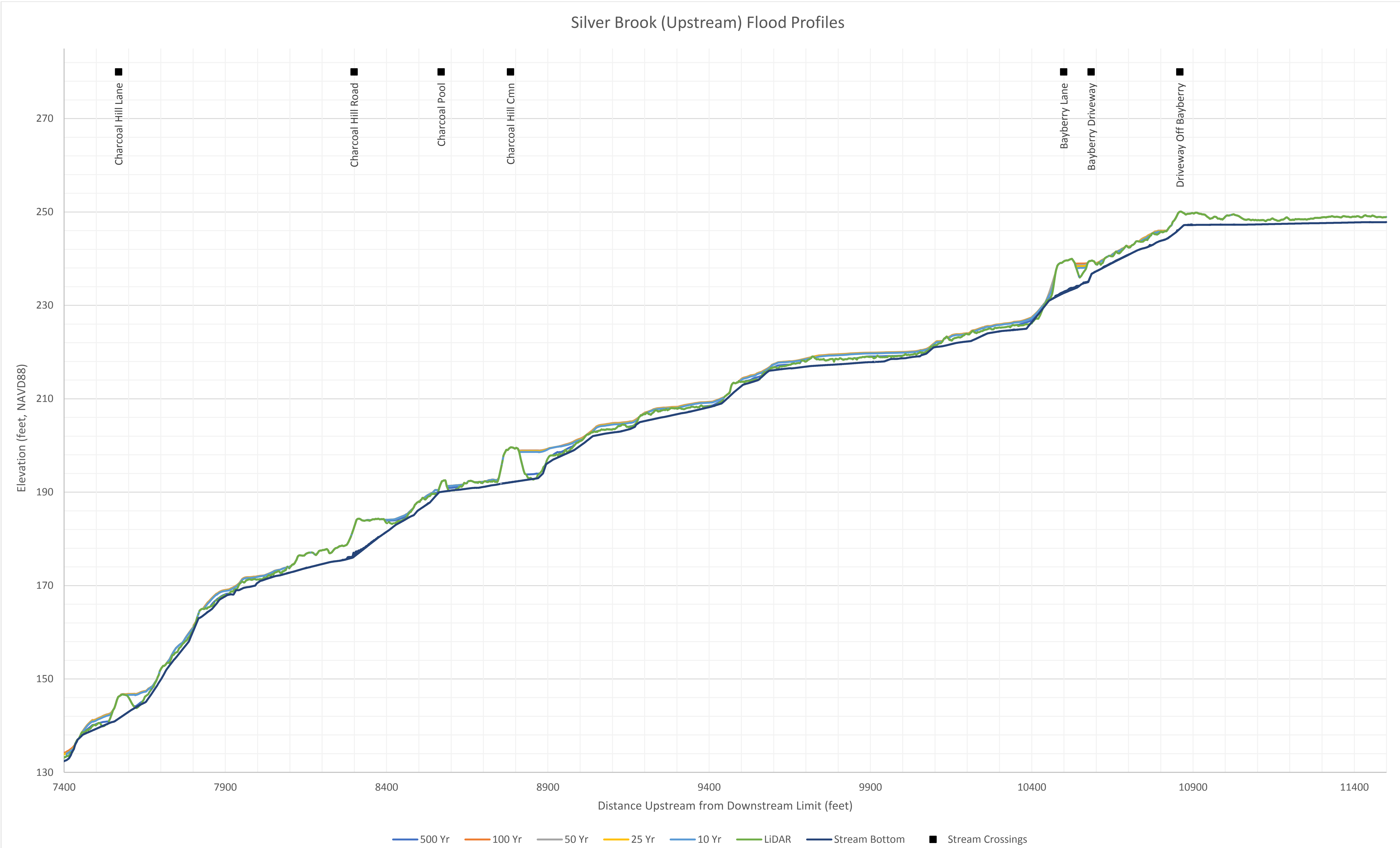
LiDAR data is from along stream centerline.



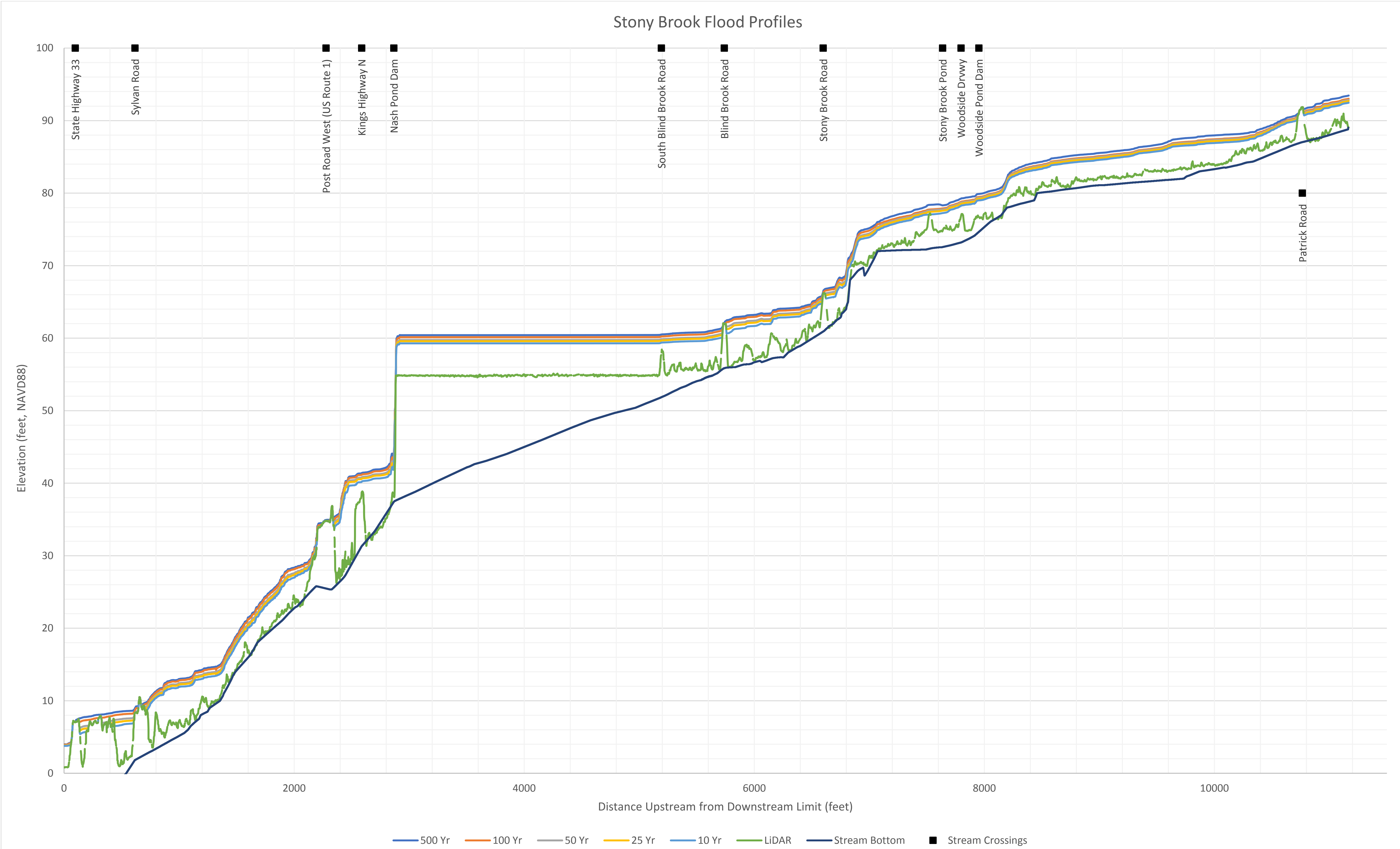
LiDAR data is from along stream centerline.



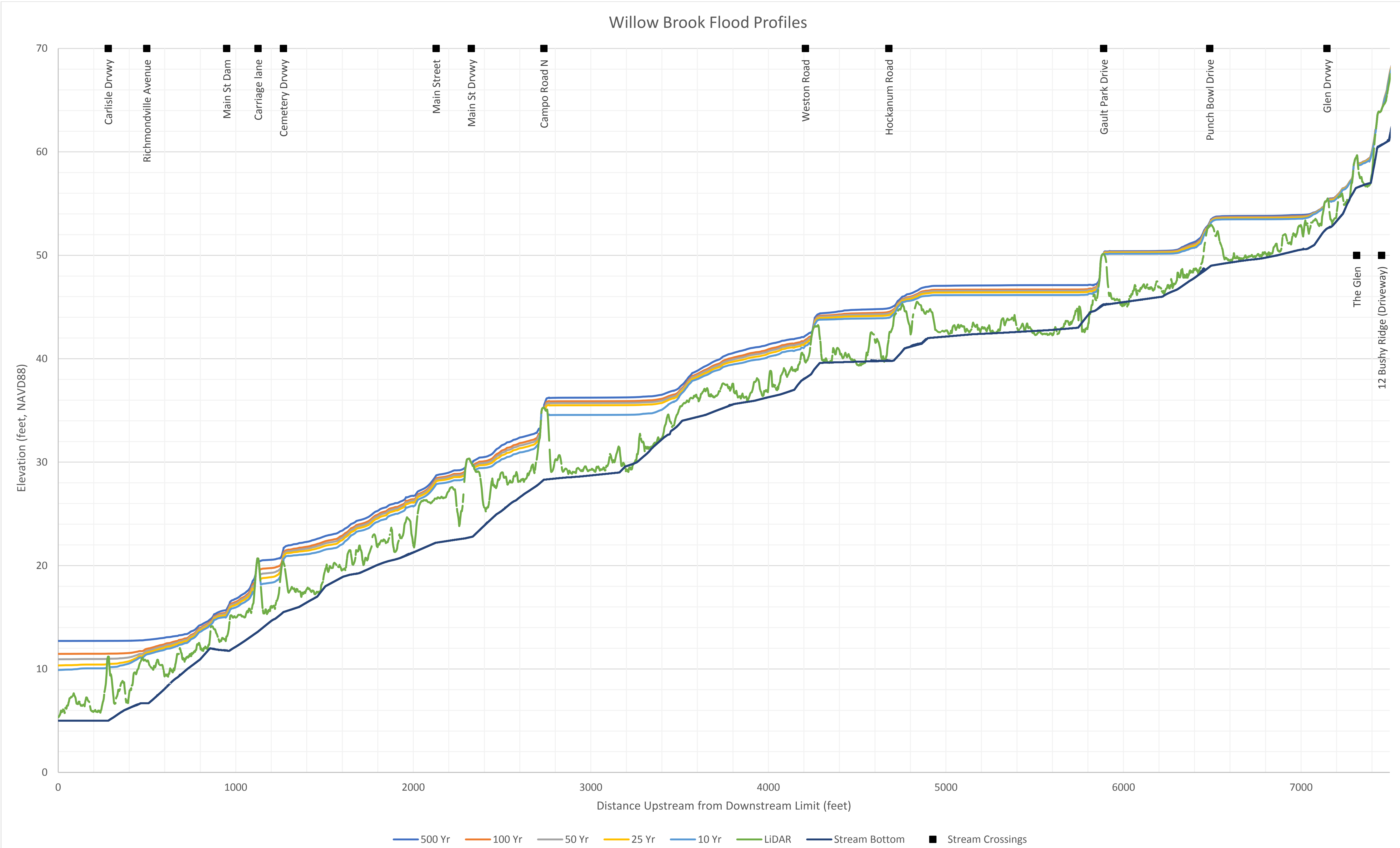
Silver Brook (Downstream) Flood Profiles
Lyons Plains Road
Bonnie Brook Road
Bonnie Brook Lane
Bonnie Brook Dam
Bonnie Brook Road
Town Crier Lane
Town Crier Dam
Pony Lane
Brooklawn Drive
Brooklawn Drive Dam
Easton Road
North Avenue
Elevation (feet, NAVD88)
140
120
100
80
60
40
20
0
0
1000
2000
3000
4000
5000
6000
7000
Distance Upstream from Downstream Limit (feet)
500 Yr
100 Yr
50 Yr
25 Yr
10 Yr
LiDAR
Stream Bottom
Stream Crossings



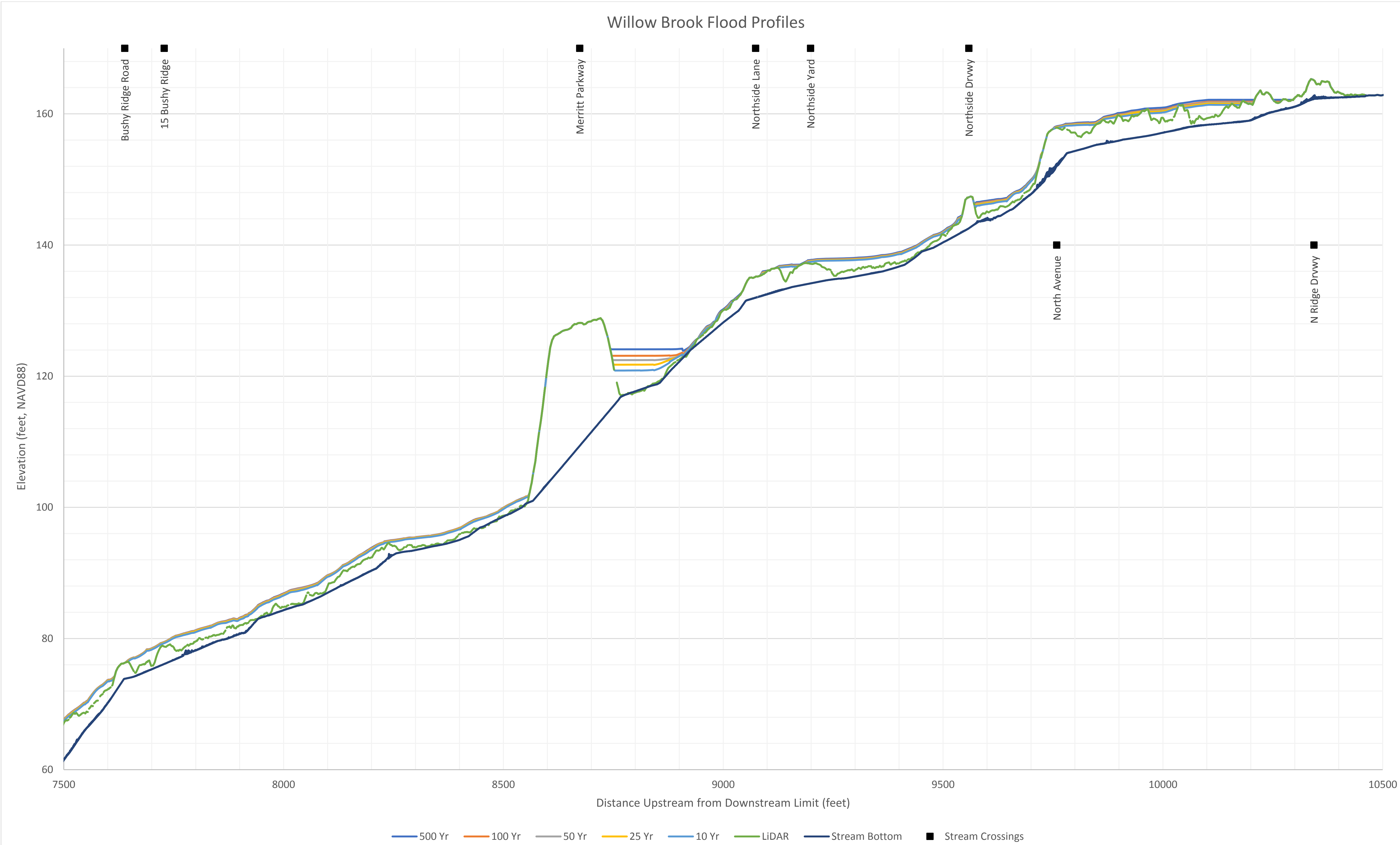
LiDAR data is from along stream centerline.



LiDAR data is from along stream centerline.

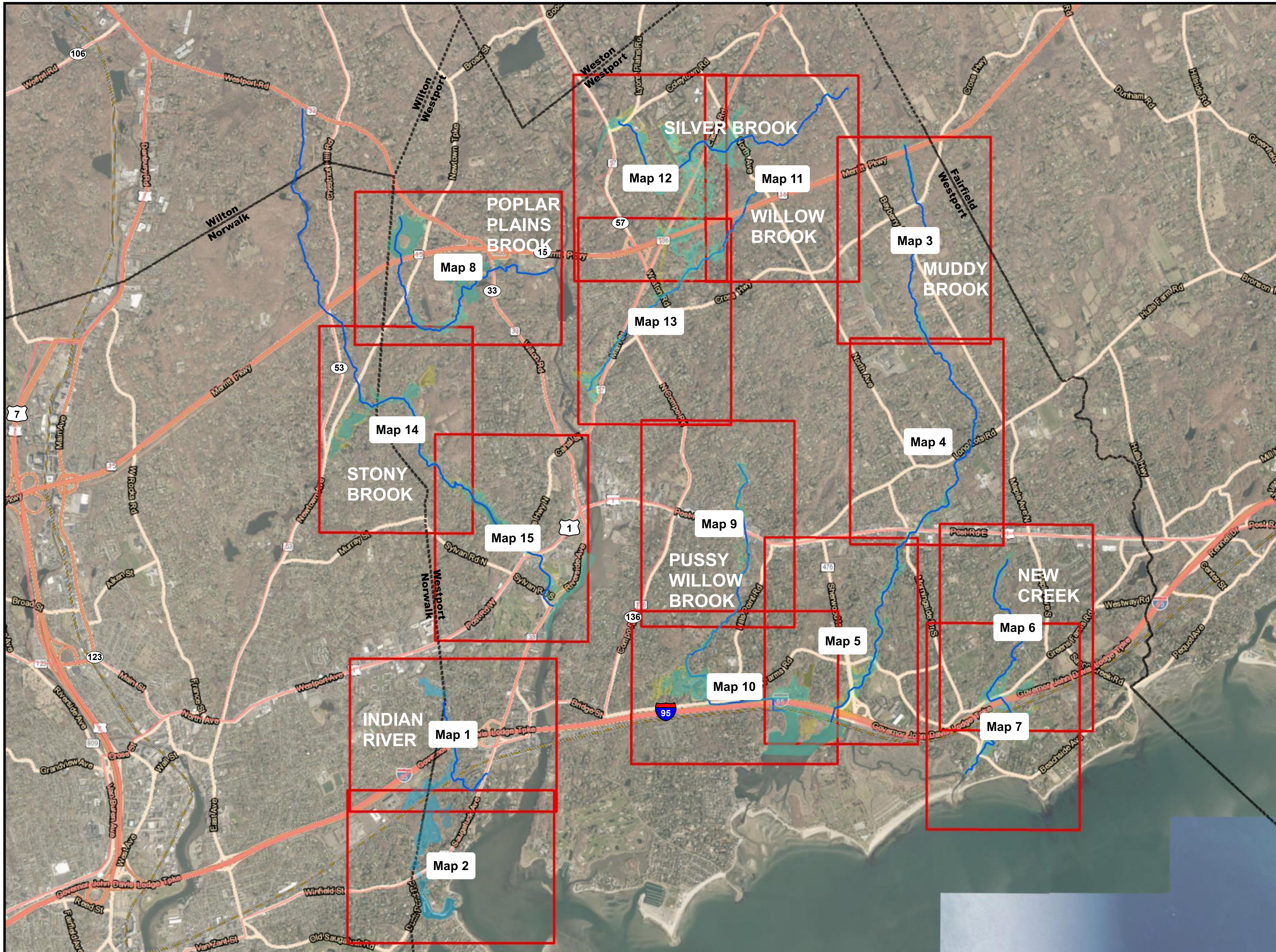


LiDAR data is from along stream centerline.



LiDAR data is from along stream centerline.

Appendix H – Stream Flood Maps



NORTH

0 1,500 3,000 6,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

NOTES:
1. AERIAL PHOTO FROM THE TOWN OF WESTPORT (DATE OF IMAGERY IS 8/14/2010) AND ESRI WORLD IMAGERY.
2. BUILDINGS SHAPEFILE FROM THE TOWN OF WESTPORT, DATED 2013.
2. FLOODING IS APPROXIMATE AND A RESULT OF THE METHODS, PROCEDURES, AND ASSUMPTIONS EMPLOYED BY GZA FOR THIS PROJECT.

FLOODING FROM THE EIGHT STUDIED STREAMS

INDEX MAP

Prepared For:
TOWN OF WESTPORT
WESTPORT, CT

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Reviewed By: CES
Operator: KLK

Dwg. Date: 10/10/2017
Job No.: 01.0173028.00

Document Path: J:\170,000-179,999\173028\173028-00.SJB\Work Files\GIS\Data\Edited Data\Study_1_Results\Inundation Maps.mxd

NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
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STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

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FLOODING FROM INDIAN RIVER

MAP 1 OF 15

Prepared For:

TOWN OF WESTPORT
WESTPORT, CT

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Job No.: 01.0173028.00

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NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

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FLOODING FROM INDIAN RIVER

MAP 2 OF 15

Prepared For:

TOWN OF WESTPORT
WESTPORT, CT

Prepared By:

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Proj. Mgr.:	SJB	Dwg. Date:	10/9/2017
Designed By:	KLK		
Reviewed By:	CES	Job No.:	01.0173028.00
Operator:	KLK		

NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

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FLOODING FROM MUDDY BROOK

MAP 3 OF 15

Prepared For:

TOWN OF WESTPORT
WESTPORT, CT

Prepared By:

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Proj. Mgr.:	SJB	Dwg. Date: 10/9/2017	
Designed By:	KLK		
Reviewed By:	CES	Job No.: 01.0173028.00	
Operator:	KLK		

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NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

NOTES:
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FLOODING FROM MUDDY BROOK

MAP 4 OF 15

Prepared For:
TOWN OF WESTPORT
WESTPORT, CT

Prepared By:
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Proj. Mgr.: SJB
Designed By: KLK
Reviewed By: CES
Operator: KLK

Dwg. Date: 10/9/2017
Job No.: 01.0173028.00

Document Path: J:\170,000-179,999\173028\173028-00.SJB\Work Files\GIS\Data\Edited Data\Study_1_Results\Inundation Maps.mxd

NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

NOTES:
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2. BUILDINGS SHAPEFILE FROM THE TOWN OF WESTPORT, DATED 2013.
2. FLOODING IS APPROXIMATE AND A RESULT OF THE METHODS, PROCEDURES, AND ASSUMPTIONS EMPLOYED BY GZA FOR THIS PROJECT.

FLOODING FROM MUDDY BROOK

MAP 5 OF 15

Prepared For:
TOWN OF WESTPORT
WESTPORT, CT

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Designed By:	KLK		
Reviewed By:	CES	Job No.:	01.0173028.00
Operator:	KLK		

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NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
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- U UNKOWN
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FLOODING FROM NEW CREEK

MAP 6 OF 15

Prepared For:

TOWN OF WESTPORT
WESTPORT, CT

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Operator:	KLK		

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NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

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FLOODING FROM NEW CREEK

MAP 7 OF 15

Prepared For:
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WESTPORT, CT

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Reviewed By: CES	Operator: KLK	Job No.: 01.0173028.00

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NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

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FLOODING FROM POPLAR PLAINS BROOK

MAP 8 OF 15

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TOWN OF WESTPORT
WESTPORT, CT

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Reviewed By:	CES	Job No.:	01.0173028.00
Operator:	KLK		

NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

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FLOODING FROM PUSSY WILLOW BROOK

MAP 9 OF 15

Prepared For:

TOWN OF WESTPORT
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Job No.: 01.0173028.00

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NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

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FLOODING FROM PUSSY WILLOW BROOK

MAP 10 OF 15

Prepared For:
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Job No.: 01.0173028.00

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NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

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FLOODING FROM SILVER BROOK & WILLOW BROOK

MAP 11 OF 15

Prepared For:
TOWN OF WESTPORT
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Job No.: 01.0173028.00

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NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

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FLOODING FROM SILVER BROOK & WILLOW BROOK

MAP 12 OF 15

Prepared For:
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Reviewed By: CES	Operator: KLK	Job No.: 01.0173028.00

NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

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FLOODING FROM SILVER BROOK & WILLOW BROOK

MAP 13 OF 15

Prepared For:

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Designed By:	KLK		
Reviewed By:	CES	Job No.:	01.0173028.00
Operator:	KLK		

NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
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FLOODING FROM STONY BROOK

MAP 14 OF 15

Prepared For:

TOWN OF WESTPORT
WESTPORT, CT

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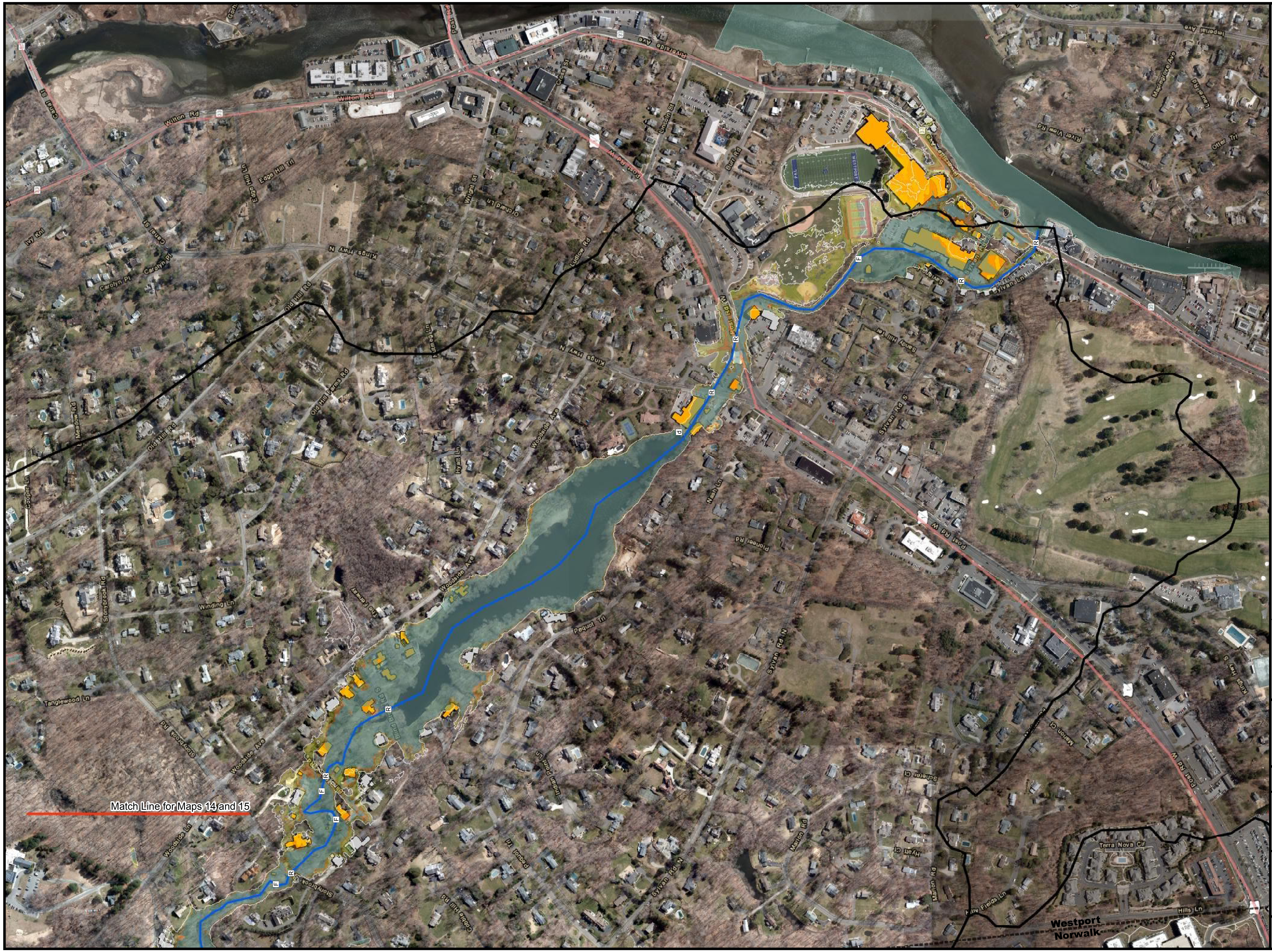

NORTH

0 250 500 1,000 Feet

LEGEND

- 500-YEAR 24-HOUR STORM EVENT FLOOD ZONE
- 100-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 50-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- 10-YEAR, 24-HOUR STORM EVENT FLOOD ZONE
- RIVER
- TOWN BOUNDARY
- RAILROAD
- MAP SHEET BOUNDARY / MATCH LINE
- WATERSHED BOUNDARY
- BUILDINGS WITH 25% IN 100-YEAR FLOOD ZONE
- OTHER BUILDINGS IN 100-YEAR FLOOD ZONE (< 25%)

STREAM CROSSINGS

- d DAM
- D DRIVEWAY
- F FOOTBRIDGE
- r RAILROAD
- R INTERSTATE/HIGHWAY/ROAD
- U UNKOWN
- Y YARD CULVERT

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FLOODING FROM STONY BROOK

MAP 15 OF 15

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