

# **APPENDIX B**

## **ICPR4 Model Conceptual Alternatives**

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**MEMORANDUM**

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**TO:** ROBERT L. HORNER, P.E. (WESTON & SAMPSON)  
**FROM:** PETE SINGHOFEN, P.E. (STREAMLINE TECHNOLOGIES, INC.)  
**SUBJECT:** CHURCH CREEK BASIN – ICPR4 2D MODEL SETUP  
**DATE:** OCTOBER 31, 2017  
**CC:** RAJU VASAMSETTI, P.E. (WESTON & SAMPSON)

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1. **Background:** Streamline Technologies, Inc. (SLT) was responsible for the initial model port from ICPR3 to ICPR4 including implementation of 2D overland flow. That model was delivered to Weston & Sampson (W&S) on August 11, 2017 for their review and modification. Based on field inspections conducted by W&S, several modifications were made to the ICPR4 model and the revised model was sent back to SLT on October 16, 2017. W&S also expanded SLT's initial scope of services to include additional modifications to the existing condition model and evaluation of various alternatives. The purpose of this memorandum is to summarize work related to these additional tasks.

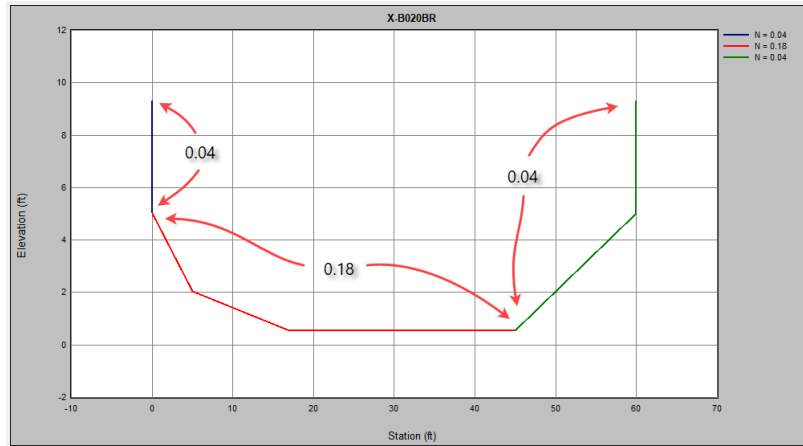
2. **Modifications to Existing Condition Model**

- a. **Changes by W&S:** Based on an email dated October 26, 2017 from Raju Vasamsetti to Robert Horner (both of W&S), the following changes to the ICPR4 model were made by W&S. These changes were included in the ICPR4 model delivered to SLT on October 16, 2017.

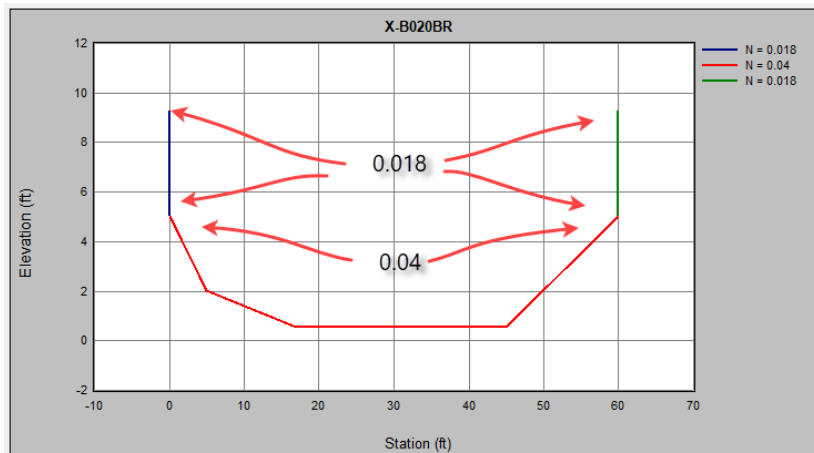
| Structure ID | Existing                    | Revised                     | Comment                                                            |
|--------------|-----------------------------|-----------------------------|--------------------------------------------------------------------|
| L-I270P1     | Manning's N = 0.01          | Manning's N = 0.024         | Field verified the pipe to be CMP                                  |
| L-B320C1     | Manning's N = 0.075         | Manning's N = 0.05          | Based on field verification                                        |
| L-A330P1     | Box culvert 8'x4'           | Box culvert 8'x3.5'         | Reduced depth based on field measurements                          |
| L-C050P1     | 1 - 36" pipe                | 2 - 36" pipes               | No. of pipes revised to 2 based on field observation               |
| L-I152P1     | Pipe dia. = 1.5'            | Pipe dia. = 1.25'           | Pipe diameter reduced from 1.5' to 1.25' based on field inspection |
| L-D160W1-W   | Secondary weir length = 17' | Secondary weir length = 12' | Revised secondary wie length based on field measurements           |
| L-I040P1     | Pipe dia. = 1.5'            | Pipe dia. = 2.0'            | Pipe dia. Increased based on field measurements                    |
| L-C320P1     | Manning's N = 0.012         | Manning's N = 0.024         | Field verified the pipe to be CMP                                  |
| L-D020P2     | 12 - 48" concrete pipes     | Box culvert 12'x4'          | Structure revised based on field observation                       |
| L-A320P2     | Twin 60" pipes              | Box culvert 10'x2'          | Structure revised based on field observation                       |
| L-0550P_SLT  | Box culvert 3'x4'           | Twin 48" pipes              | Pipes filled up more than half                                     |
| L-C291P1     | Pipe size = 1.5'            | Pipe size = 2.0'            | Pipe dia. Increased based on field measurements                    |
| L-A320P1     | Elliptical pipe 3.16' dia.  | Box culvert 10'x2'          | Structure revised based on field observation                       |
| L-I153       | Twin 18" pipes              | Twin concrete boxes 7'3"x5' | Structure revised based on field observation                       |

b. **Changes by SLT:**

- i. **Bees Ferry Bridge at Church Creek (at the Maxwell Gage):** A problem was discovered with the original hydraulic rating curves in the Woolpert ICPR3 model. The Manning's n values for the bridge opening cross section were modified by SLT and the rating curves were re-calculated in ICPR3 (using WSPRO). The revised rating curves were copied from ICPR3 and then pasted into ICPR4. The roughness coefficients for the original Woolpert ICP3 model and the modifications are shown below.



Original Bridge Opening Cross Section (Bees Ferry Road at Church Creek)  
in the Woolpert ICPR3 Model

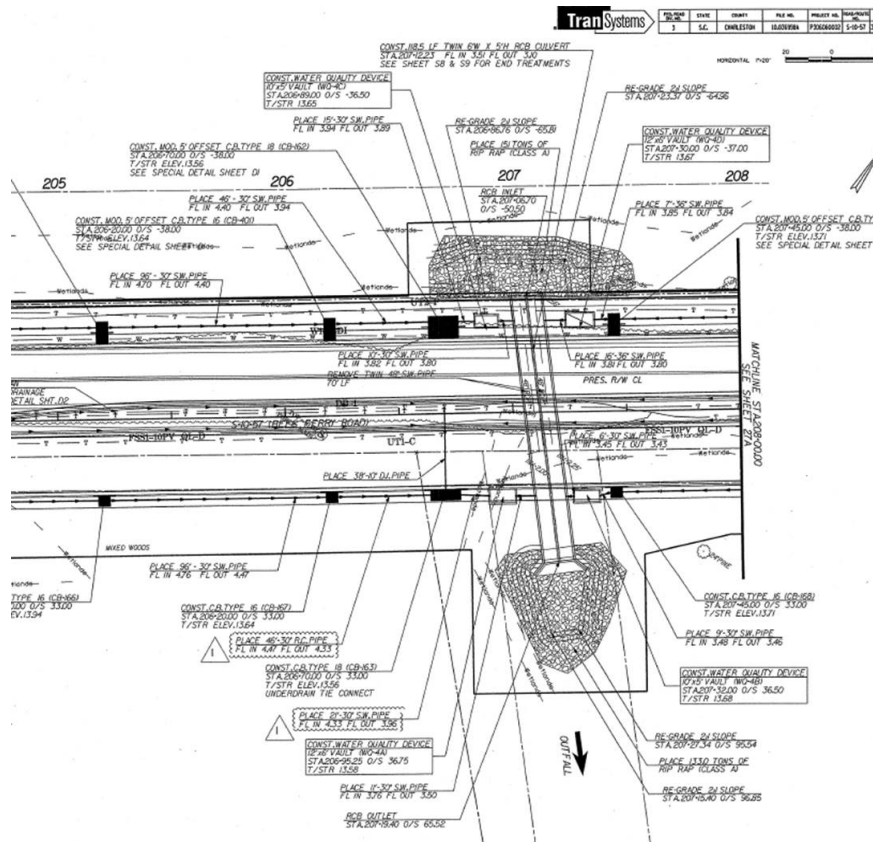


Modified Bridge Opening Cross Section (Bees Ferry Road at Church Creek)  
Used in the ICPR4 Model

- ii. **Pipes at Railroad Crossing of Church Creek Immediately Downstream of Bees Ferry Road:** One of the pipes under the railroad downstream of Bees Ferry Road is a “horseshoe” geometry (68” x 68”) which is not supported in ICPR3. Photographs are shown below. This was modeled as two separate pipes in the original ICPR3 model (a rectangular pipe and a circular pipe with a bottom clip). These were deleted and replaced with a single horseshoe geometry pipe which is supported in ICPR4.



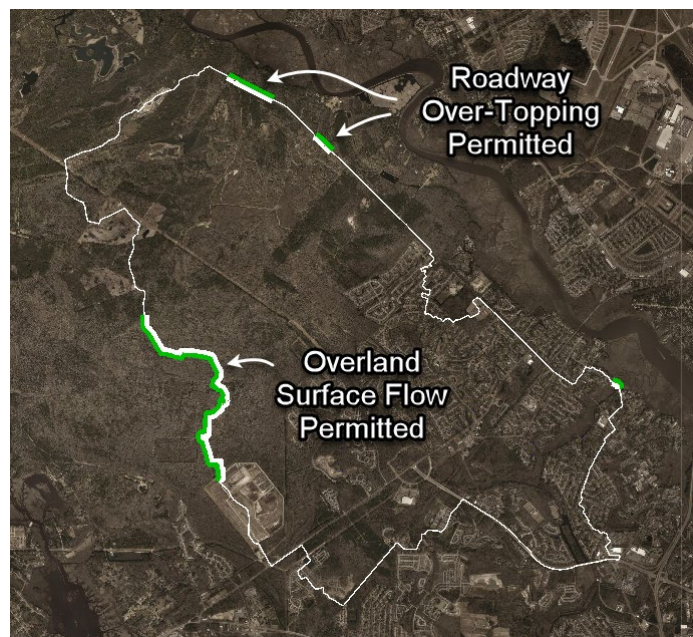
- iii. **Western Bees Ferry Crossing, Spreader and Ditch (at the Planck Gage):** A spreader with riprap exists on the south side of Bees Ferry Road at the Planck Gage. This sump area was modeled as a small level pool with a 20-foot wide broad crested weir at elevation 6 feet (NAVD88). The 1D/2D interface and computational mesh was refined downstream of this sump to better reflect berms adjacent to the ditch created from casting of spoil beside the ditch either during its construction or from maintenance of the ditch.



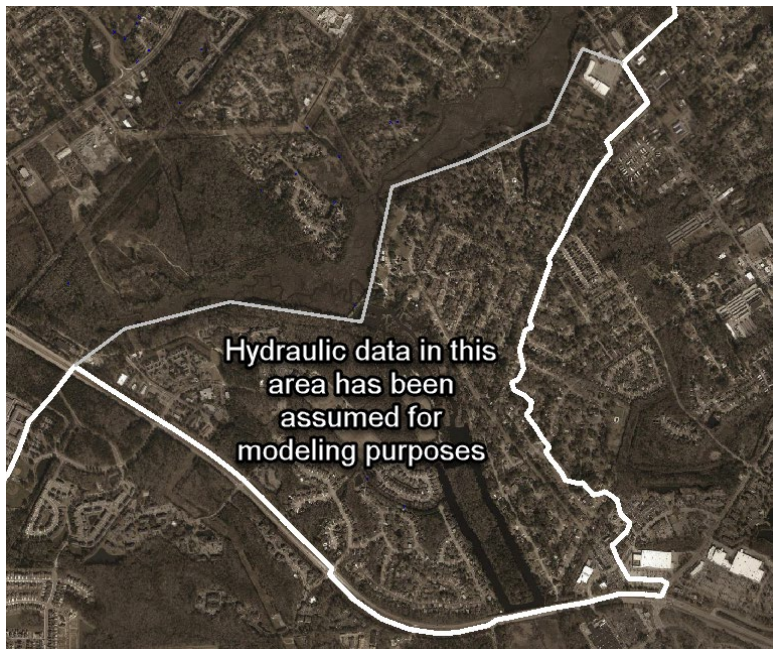
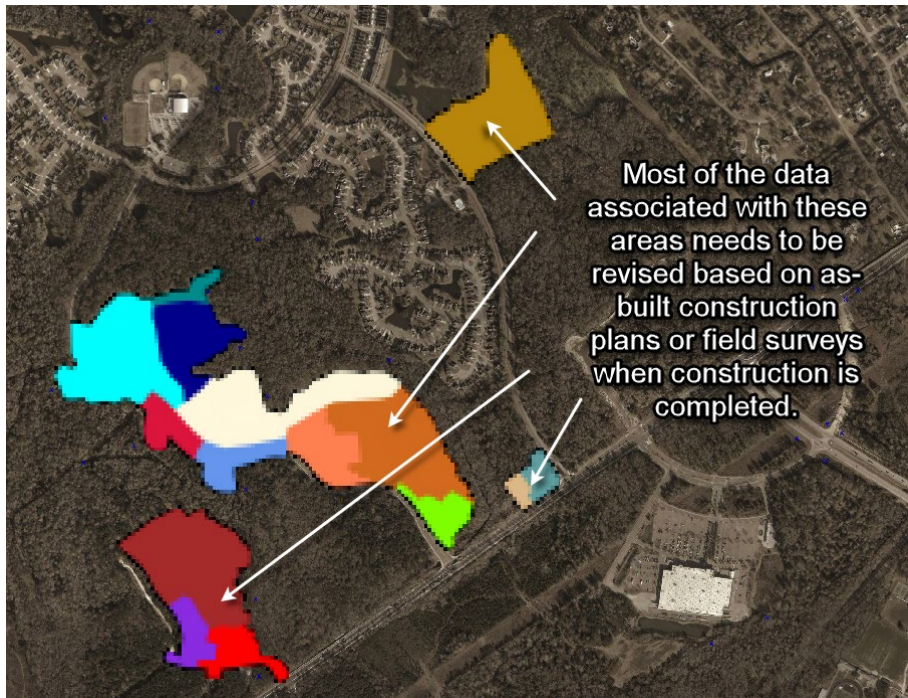
- iv. **Box Culvert Under Bees Ferry Road at Rantowles Creek (Structure L-0610P\_SLT):** Based on a phone conversation with Raju Vasamsetti, this structure was changed to an 8-ft wide by 4-ft high box culvert with

upstream and downstream invert elevations of 3.00 and 2.78 feet NAVD88, respectively.

- v. **Northern Culverts Under HW61:** Three box culverts were added along Highway 61 at the north end of the study area. The sizes were based on SCDOT construction plans. Inverts were set assuming 3 feet of cover based on roadway elevations from the DEM.
- vi. **Boundary Stage Lines:** Vertical walls are assumed around the perimeter of the overland flow region boundary unless other provisions are included in the model. A boundary stage line feature was added in the northern portion of the model to allow for roadway over-topping. A boundary stage line feature was also used along a portion of the western edge of the study area to allow discharge across the region boundary.

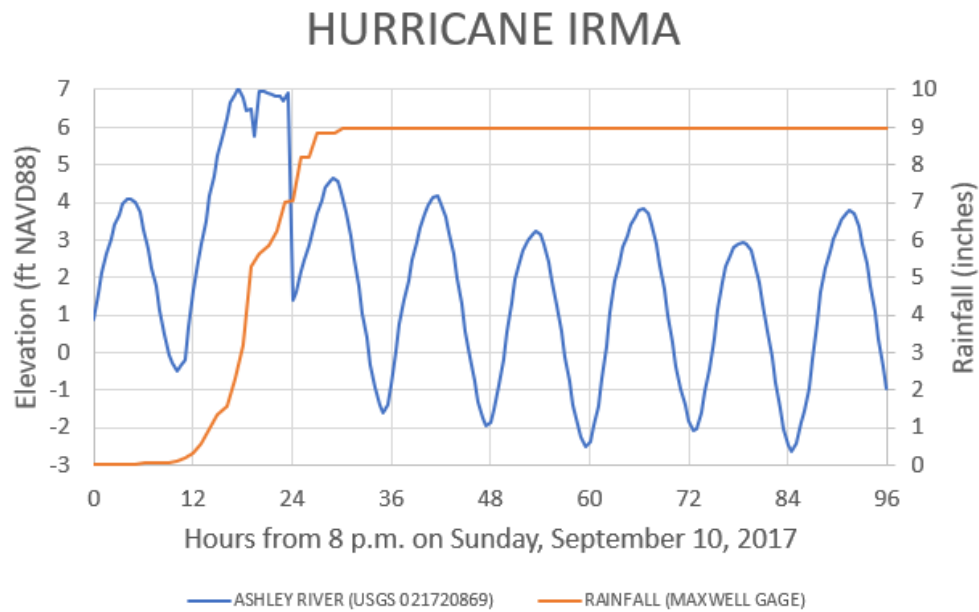


- c. **Remaining Data Gaps:** The following two images depict areas where data was unavailable. Assumptions were made regarding connectivity and hydraulic structure types.



- d. **Simulation of Hurricane Irma:** Hurricane Irma produced about 9 inches of rainfall over a 24-hour period beginning at 6 a.m. September 11, 2017 according to the Maxwell rain gage at Church Creek and Bees Ferry Road. Tidal surge in the Ashley River near the confluence with Church Creek (USGS Station 021720869) reached a maximum elevation of 7 feet (NAVD88) at about 1:30 p.m.

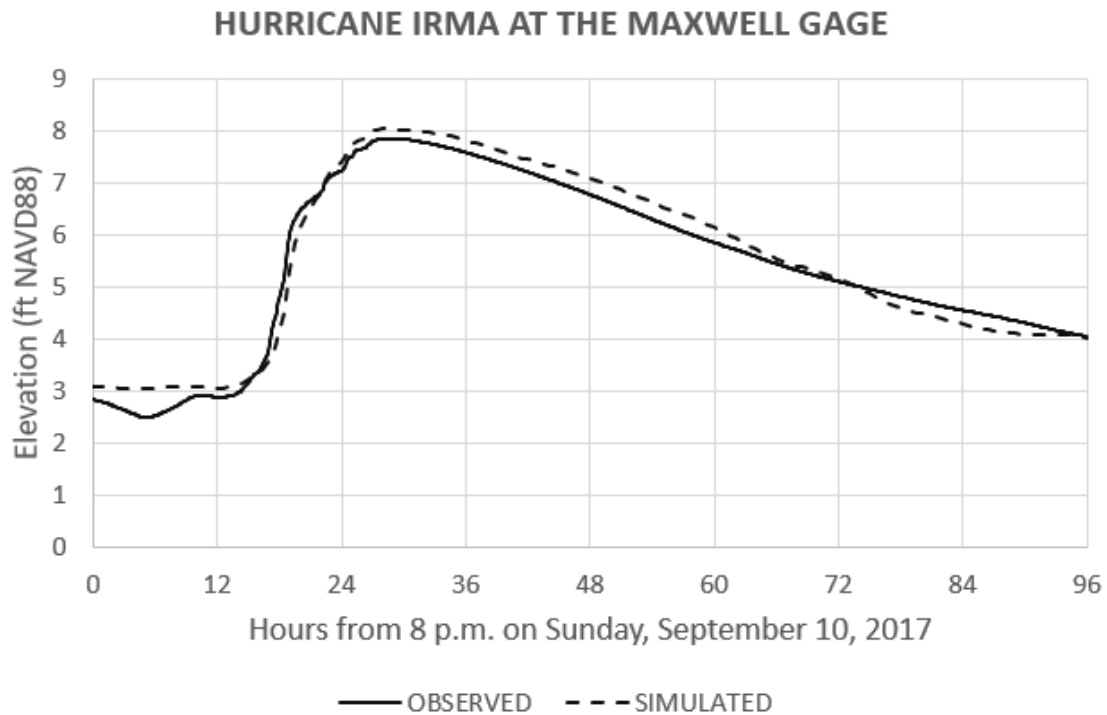
September 11. The tidal surge was above elevation 6 feet (NAVD88) for almost 8 hours. Tides were rising simultaneously with heavy rainfall as shown below.



- i. **Initial Conditions:** To establish initial conditions throughout the study area, a “base run” simulation was conducted from September 6 at 10 a.m. until 12 a.m. September 11. Approximately 2.1 inches of rain fell on September 6 and no rain after that for the “Base Run”.

Initial stages for the Hurricane Irma simulation were taken from the node stages of the “Base Run” on September 10 at 8 p.m. using the “hot start” option in ICPR. Curve numbers were reset to their original values because about 4 days had passed without any rainfall.

- ii. **Comparison of Observed and Simulated Elevations at the Maxwell Gage:** A comparison of observed and simulated stages at the Maxwell gage are shown in the chart below. The match is considered very good to excellent in timing and magnitude.

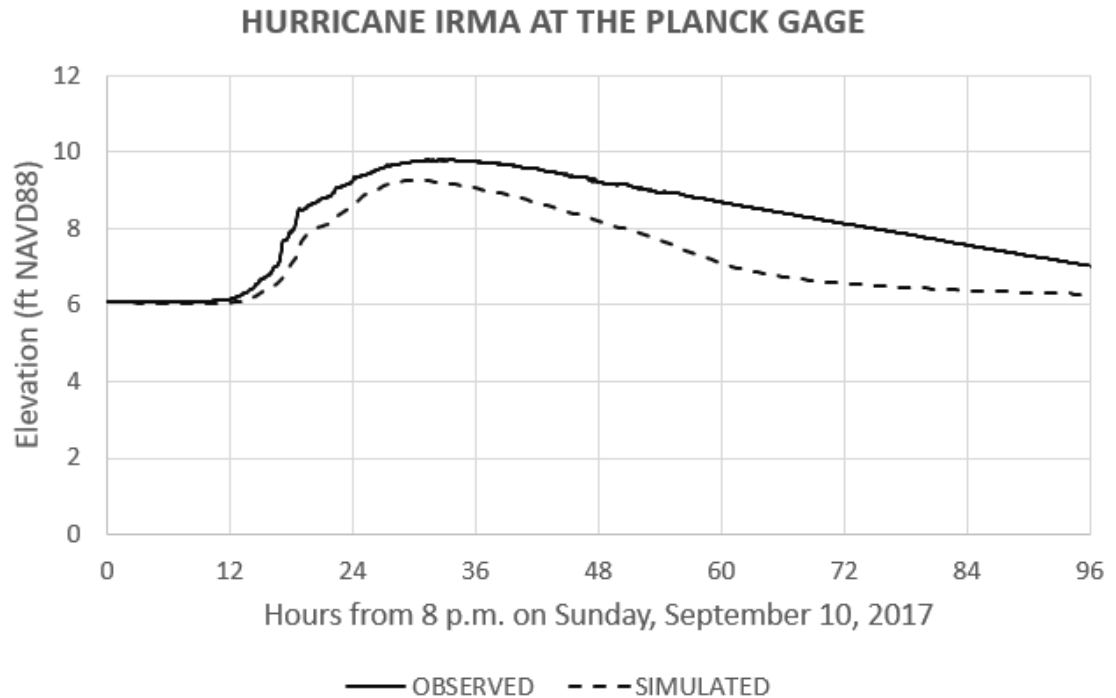


Simulated maximum flooding extents for Hurricane Irma along Church Creek north of Bees Ferry Road are depicted below.

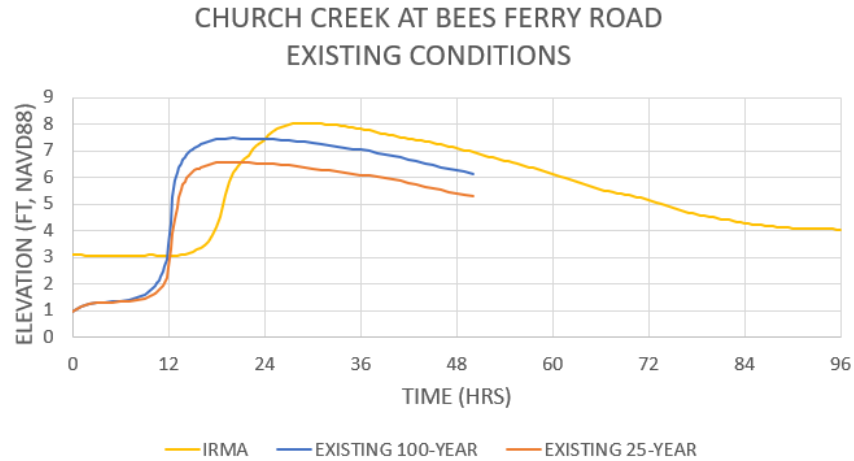


- iii. **Comparison of Observed and Simulated Elevations at the Planck Gage:** A comparison of observed and simulated stages at the Planck gage are shown in the chart below. The simulated maximum elevation is 9.3

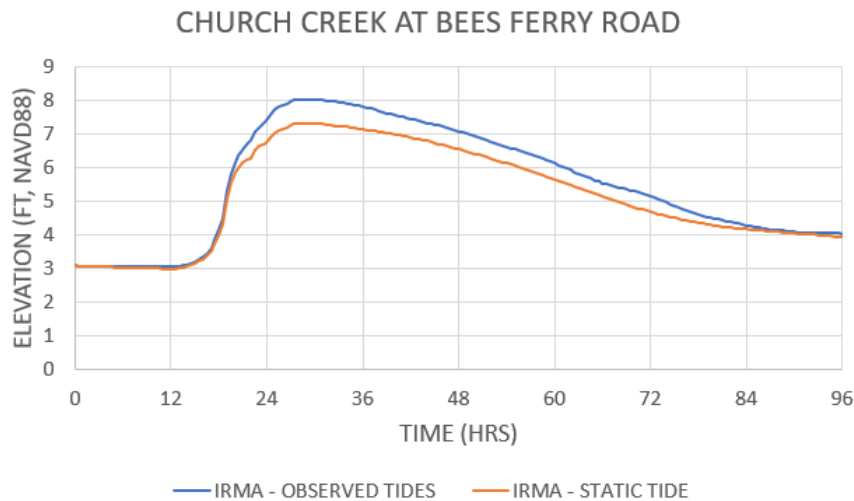
feet (NAVD88) versus the observed maximum of 9.8 feet, or about 6 inches lower than observed. Water levels recede quicker for the simulated condition. There is likely some form of blockage or obstruction along the channel south and east of Bees Ferry Road at the Planck gage. Inspections and possible surveys along this channel should be conducted.

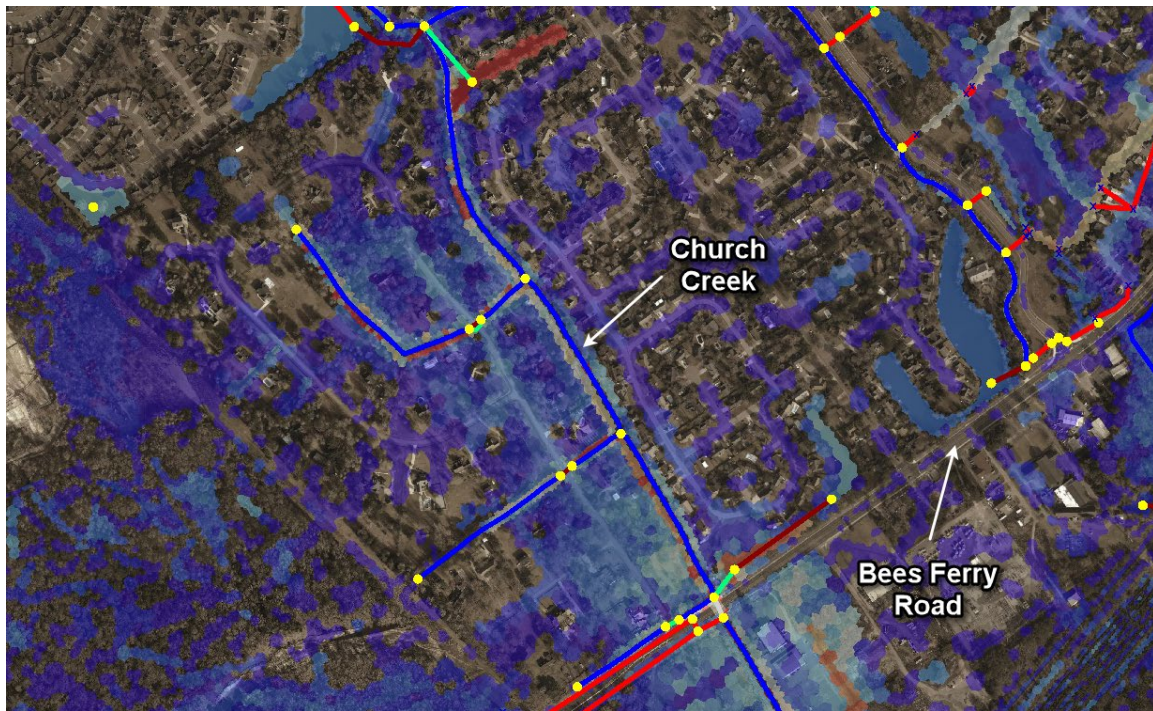


- e. **25-Year and 100-Year Results:** Stage hydrographs for Hurricane Irma, the 100-year 24-hour storm and the 25-year 24-hour storm are shown below at Church Creek and Bees Ferry Road (upstream side, at Maxwell gage, node “N-B020”). Note that although the total rainfall amount for Hurricane Irma was only 9 inches (1 inch less than the 100-year 24-hour rainfall amount of 10 inches), the maximum elevation is higher than the 100-year storm by approximately 6 inches. This is directly attributable to the high storm surge associated with Hurricane Irma. Normal tidal fluctuations were used for the 25- and 100-year simulations.

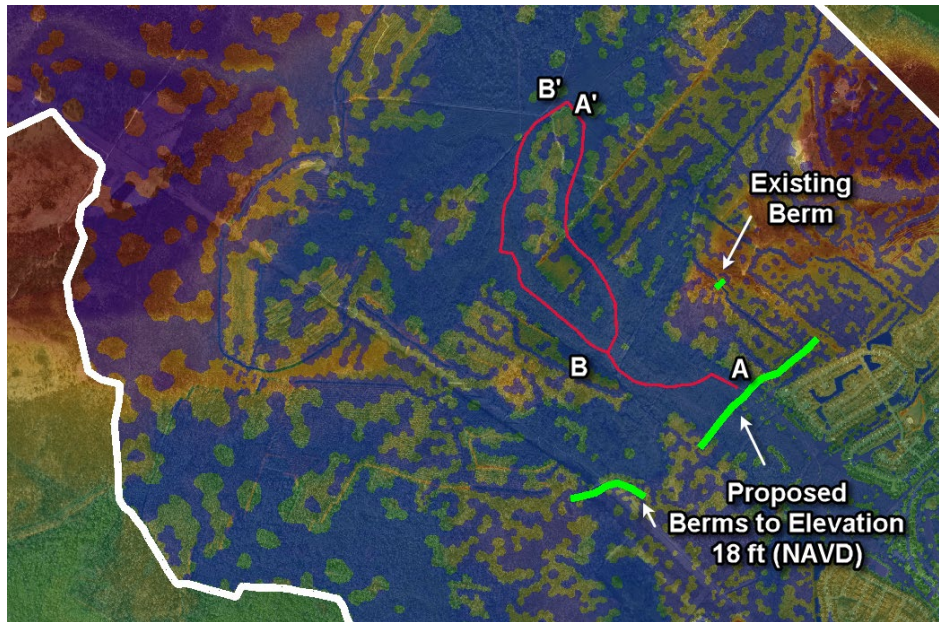


- f. **Tidal Impact:** A second Hurricane Irma simulation was conducted, but with a static tide condition of elevation -1 feet (NAVD88). The results are shown below at Bees Ferry Road (Node N-B020, Maxwell gage location). Tides do impact peak flood elevations at least up to the north side of Bees Ferry Road along Church Creek. However, structural tidal surge protection could exasperate flooding if heavy rainfall occurs concurrently with storm surge as was the case with Irma.

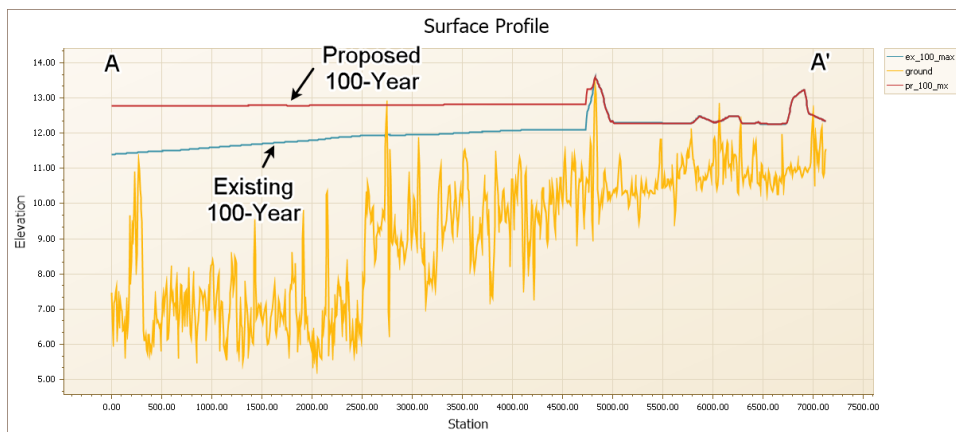




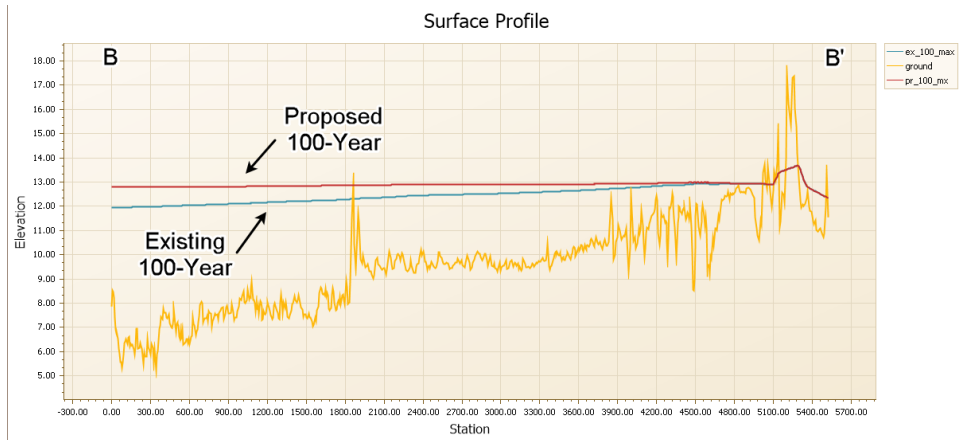
3. **Assessment of Conceptual Alternatives:** The primary conceptual alternative evaluated to alleviate flooding consisted of implementation of a large natural detention system north of Church Creek in combination with a Pump Station at Bees Ferry Road. Maintenance improvements were also included along Church Creek. Forest Lakes flow restoration south of the Church Creek marsh and under Glenn McConnell Parkway and US 17 were included in the model.
  - a. **Natural Detention System:** A natural detention system north of Church Creek was evaluated. Two berms, up to elevation 18 feet (NAVD88) are proposed as shown below. Although one or more outlets will ultimately be needed to recover the storage in the detention facility, no outlets other than natural popoffs to the north were assumed in this assessment. The maximum flood extents are shown in blue. Locations of two profiles (A – A' and B – B') are also shown.



The ground elevation is shown for Profile A – A' below along with maximum water surface elevations for the 100-year existing and proposed conditions. An increase in the maximum 100-year stage of about 1 to 1.5 feet is expected.

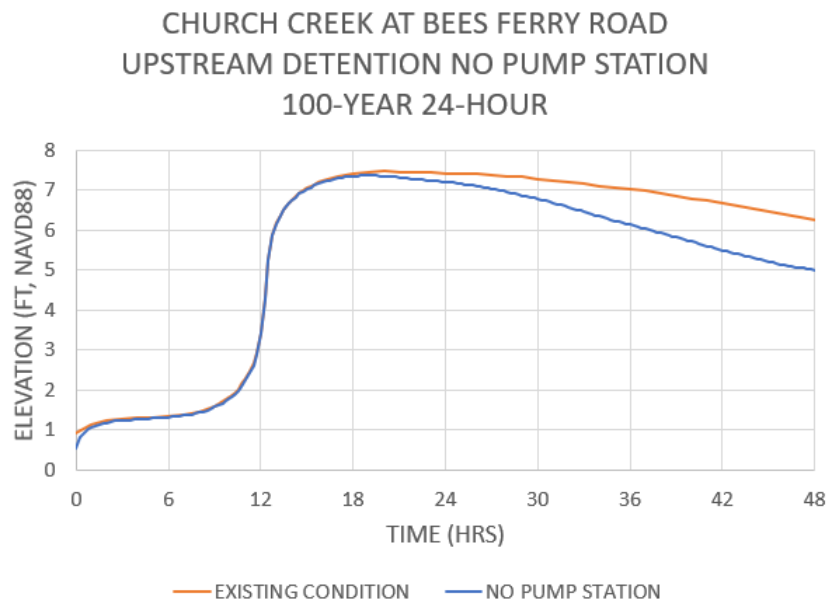


Maximum 100-year water surface elevations are shown below for Profile B – B' along with ground elevations.



As stated above, one or more outlets will ultimately be needed for this facility to recover storage. Water could be discharged slowly into Church Creek to the south after the downstream system has recovered. Water could also be taken to the north, most likely along profile A – A'. A third possibility is to create a path to Rantowles Creek through the proposed Savannah Long project. Combinations of these three possibilities could be used to distribute the flow. Regardless, impacts to downstream systems must be evaluated for each option.

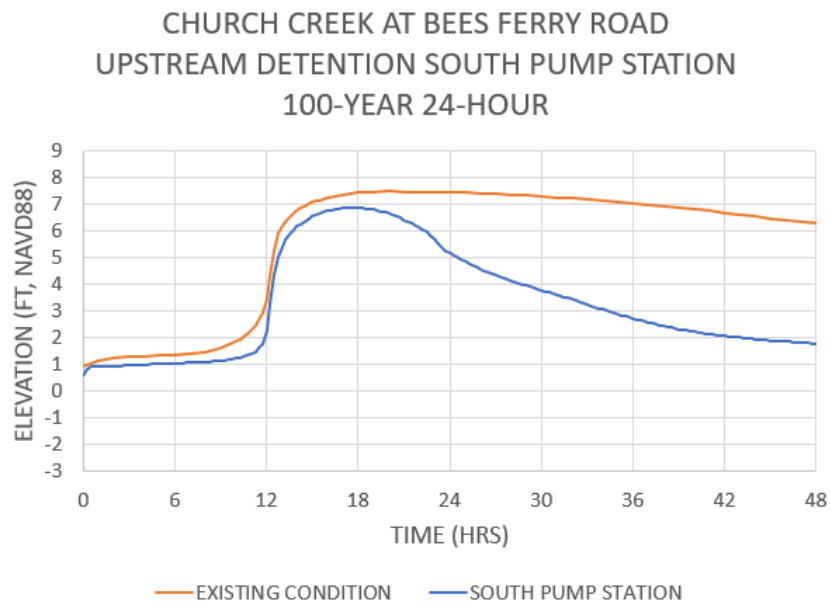
A simulation with the upstream detention, but no pump station at Bees Ferry Road was conducted. The results are shown in the chart below. Although the peak 100-year stage is only slightly lower than existing conditions, the duration of flooding is much shorter.



- b. **Pump Station at Bees Ferry Road:** A triplex pump station at Bees Ferry Road along Church Creek was evaluated. The pump station includes (3) 200-cfs pumps

with different on/off level switches. The first pump starts at elevation 0 feet (NAVD88) and shuts off at elevation -2 feet (NAVD88). The second pump starts at elevation 2 feet (NAVD88) and shuts off at elevation 0 feet (NAVD88). The third pump starts at elevation 4 feet (NAVD88) and shuts off at elevation 2 feet (NAVD88). The total pump station capacity is 600 cfs. This was modeled as a rating curve link with a stage-discharge operating table for each pump.

Two pump locations were evaluated, one on the south side of Bees Ferry and the other on the north side. The performance of both are shown in the charts below. The north pump station is more effective in terms of reducing maximum flood stages. It could possibly be improved more by deepening Church Creek upstream of Bees Ferry Road. Downstream impacts must be evaluated for the pump station alternatives.



CHURCH CREEK AT BEES FERRY ROAD  
UPSTREAM DETENTION NORTH PUMP STATION  
100-YEAR 24-HOUR

