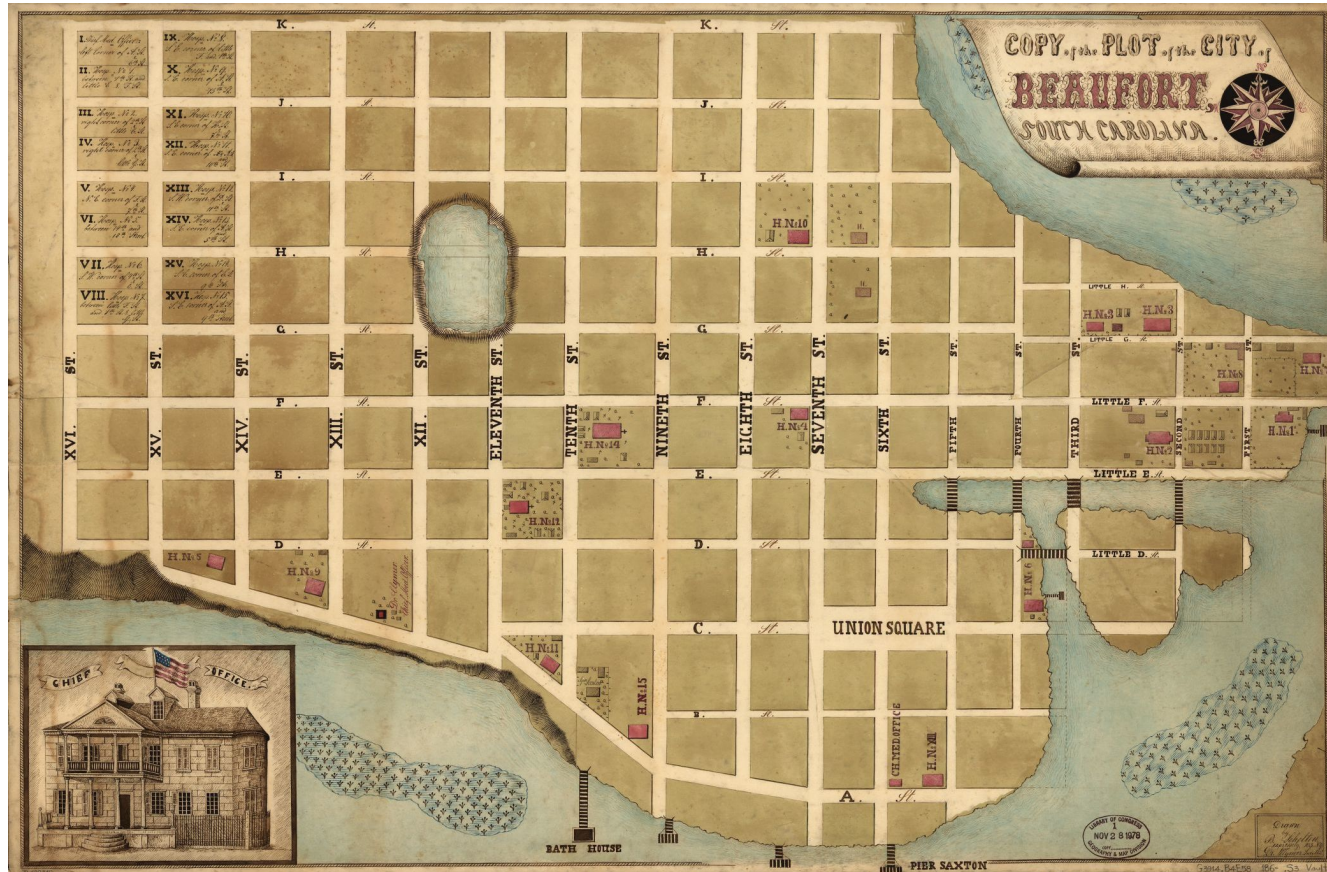




Planning for the future: Keys to successful stormwater master planning in a historic city.

SESWA 17th Annual Conference

Background



- City of Beaufort, SC
 - Chartered in 1711
 - Population of 12,361 (2010)
- Aging Infrastructure
- Extreme Events
 - Hurricane Joaquin (2015)
 - Hurricane Matthew (2016)
 - Hurricane Irma (2017)

Schelten, B. *Copy of the plot of the City of Beaufort, South Carolina.* [186, 1860] Map.

Study Area and Approach

- Point/Downtown Area
 - 155 acres
 - Limited Stormwater Data
 - Historic Structures
 - Highly Developed
- Approach
 - Data Collection
 - Public Outreach
 - Conditions Assessment
 - Recommendations

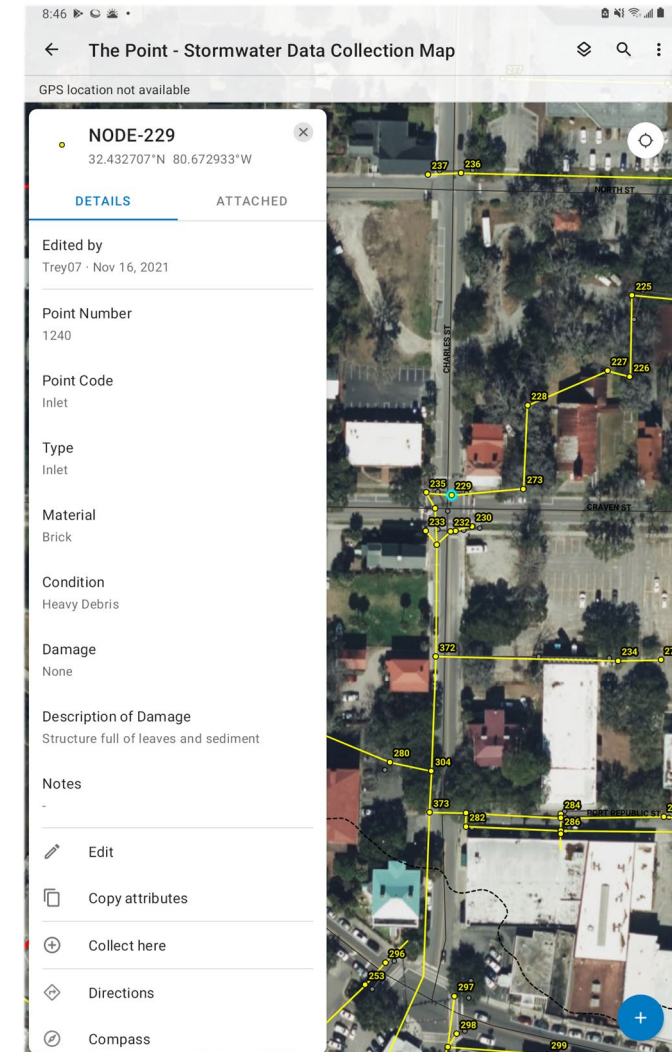


Data Collection – Field Survey

- Survey-grade GPS
 - +/- 0.1 foot accuracy
 - Inverts, rims, and location
- ESRI ArcGIS Field Maps
 - Cloud based data collection
 - Visual conditions
 - Level of clogging
 - Material and size
 - Photos

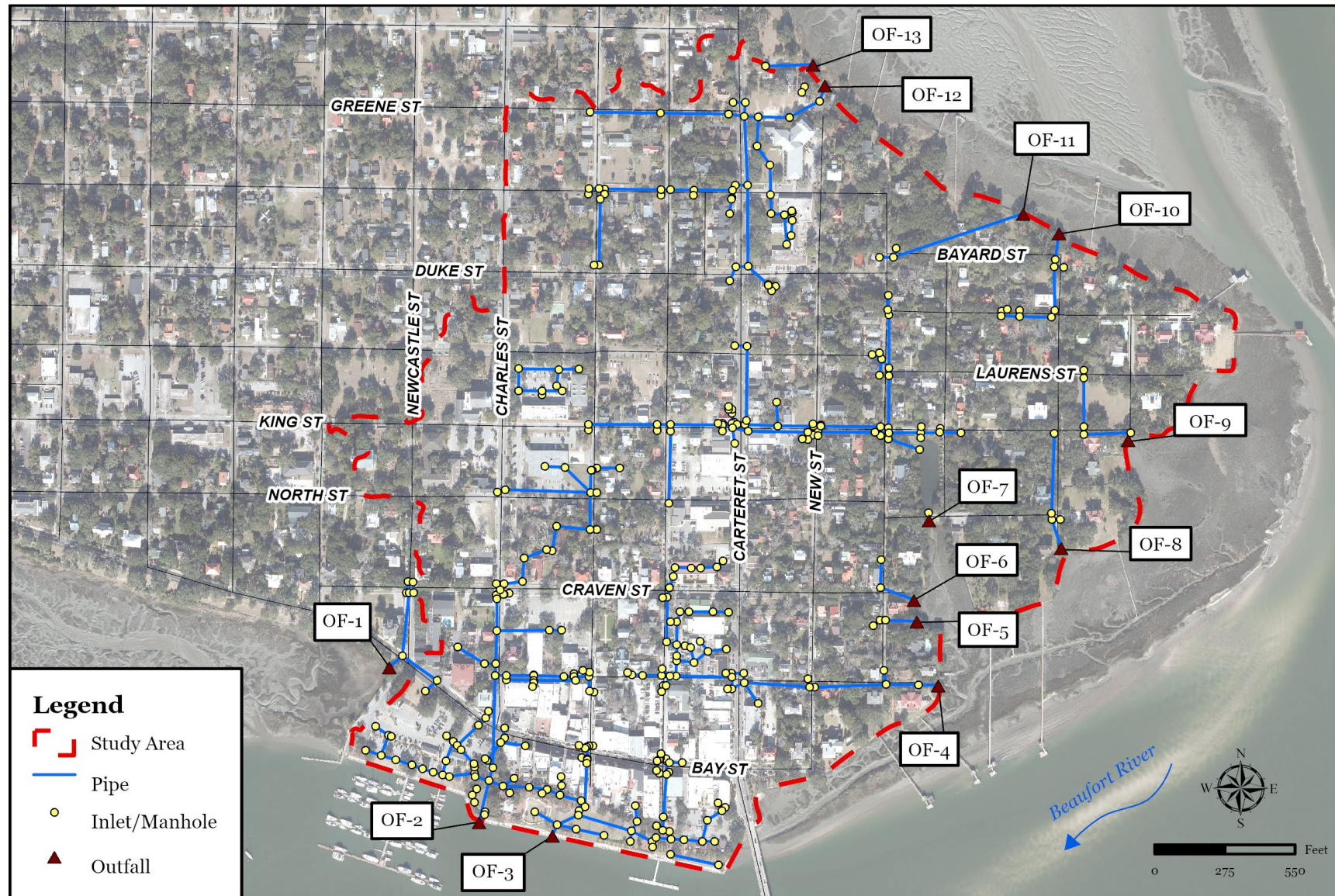


GPS survey at Pinckney Street/Bayard Street outfall.



Field Maps data collection interface.

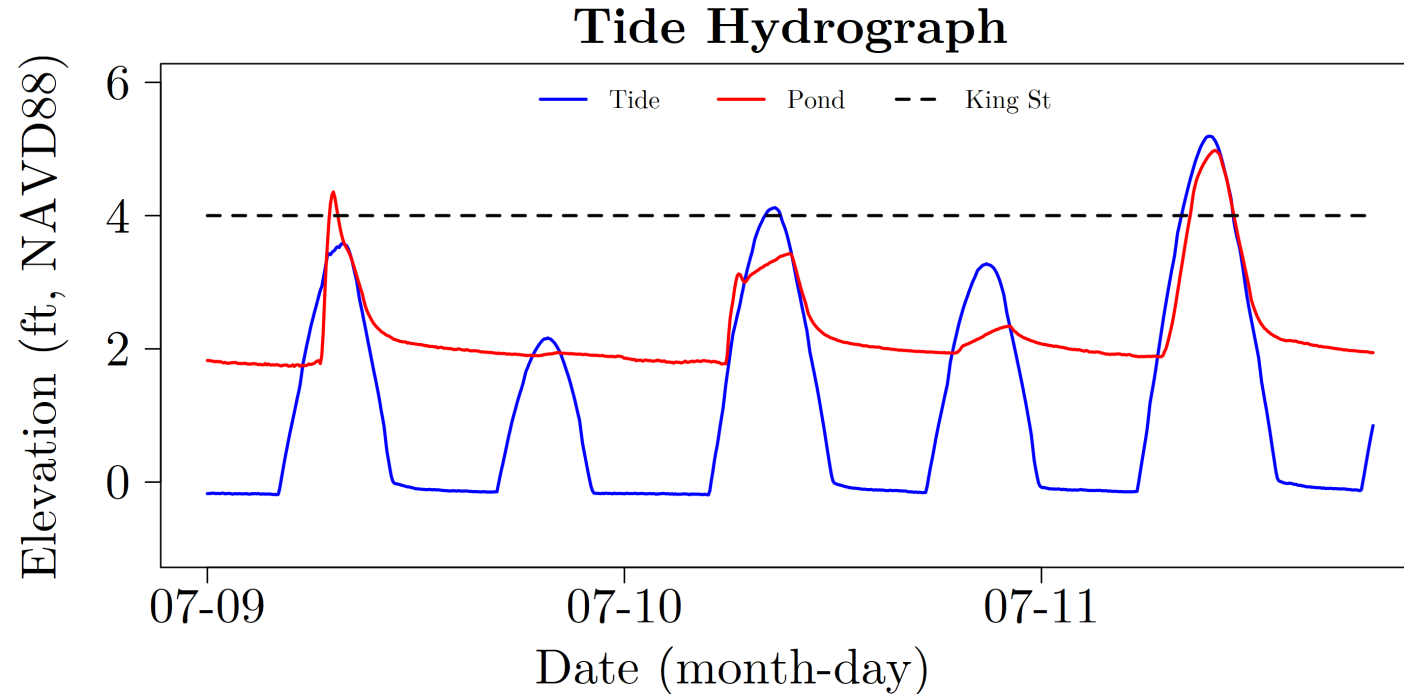
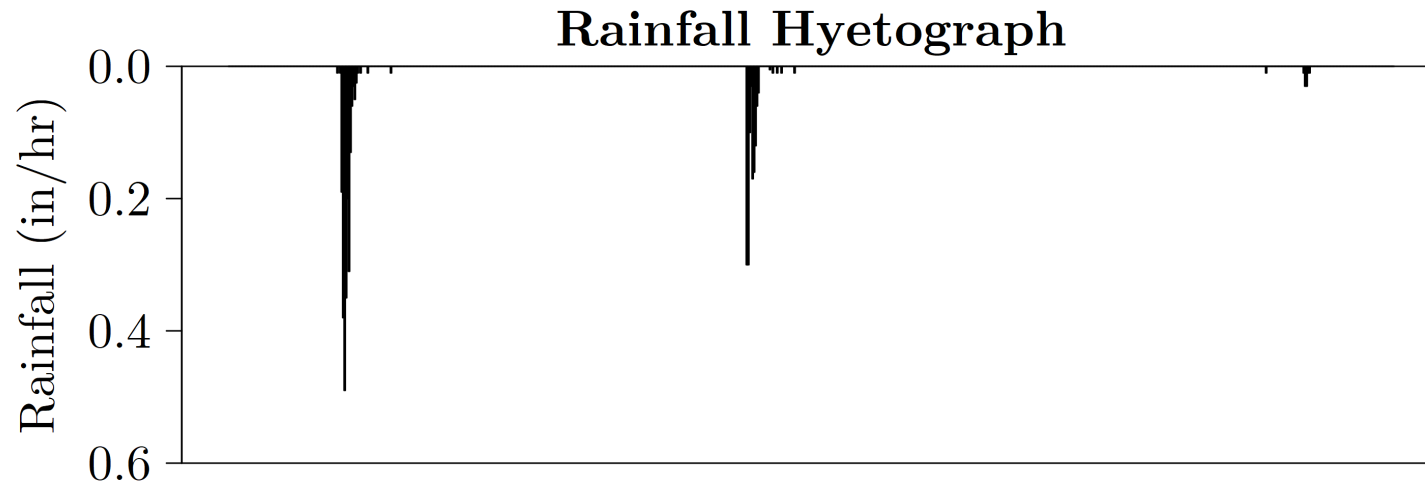
Data Collection - Field Survey



Data Collection – Hydrologic Monitoring



Data Collection – Hydrologic Monitoring



Public Outreach

The screenshot shows the 'Beaufort Downtown Drainage Study Flood Survey' web form. At the top is the City of Beaufort logo and a request for help in gathering flood impact data. Below this are instructions: 'Please help the City of Beaufort gather flood impact data in and around The Point drainage study area. This data will help support and inform flood mitigation planning efforts.' and 'Submit only one survey report per flooding occurrence. If you have more than one flooding occurrence to report, you will need to fill out multiple survey reports. After submitting each survey, a link will be available to start a new survey.' The form includes fields for 'Name*', 'Address*', and 'Approximate Date of Flooding*' (with a date picker). A 'Flooding Location*' section features a map of Beaufort with a search bar and a blue pin. Below the map, there are radio buttons for 'Private' (selected) and 'Public' to indicate the nature of the flooding. At the bottom, there is a checkbox for 'Private Property Impact (check all that apply)*' with 'Basement Flooding' listed as an option.

Interface for the online flood reporting tool used to collect information on flood occurrences around the study area.



Reported flooding at the intersection of Hamilton Street and Laurens Street on September 12, 2017. Photo submitted by Suzanne Rainey.

Reported flooding at the intersection of Craven Street and Charles Street on June 30, 2017. Photo submitted by William Butters.



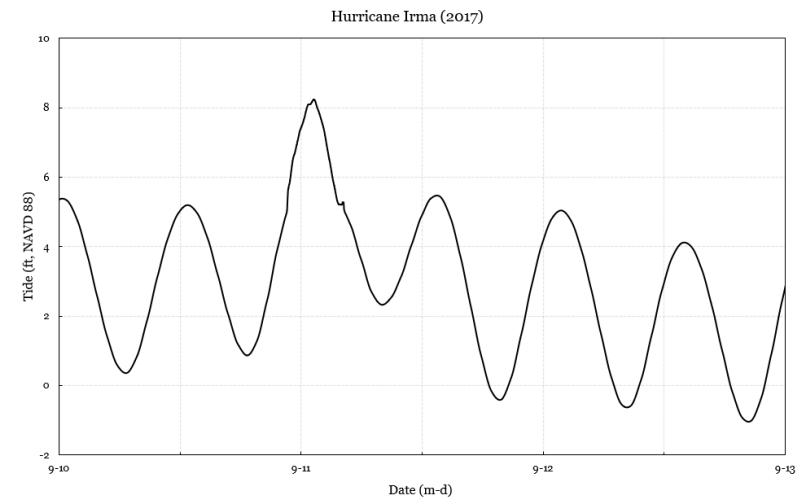
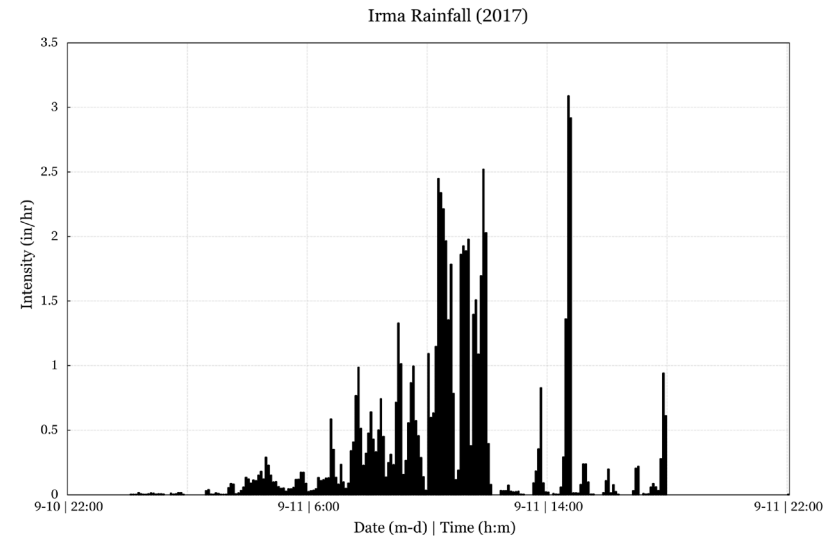
Conditions Assessment - Overview



- Historic Conditions Analysis
 - Hurricane Matthew (October 2016)
 - Hurricane Irma (September 2017)
- Current Conditions Analysis
 - Present Day Design Rainfall
 - Tide Monitoring Data
- Future Conditions Analysis
 - 50-year (2072) Climate Projection
 - Increased Rainfall Depth and Intensity
 - Sea Level Rise

Historic Conditions

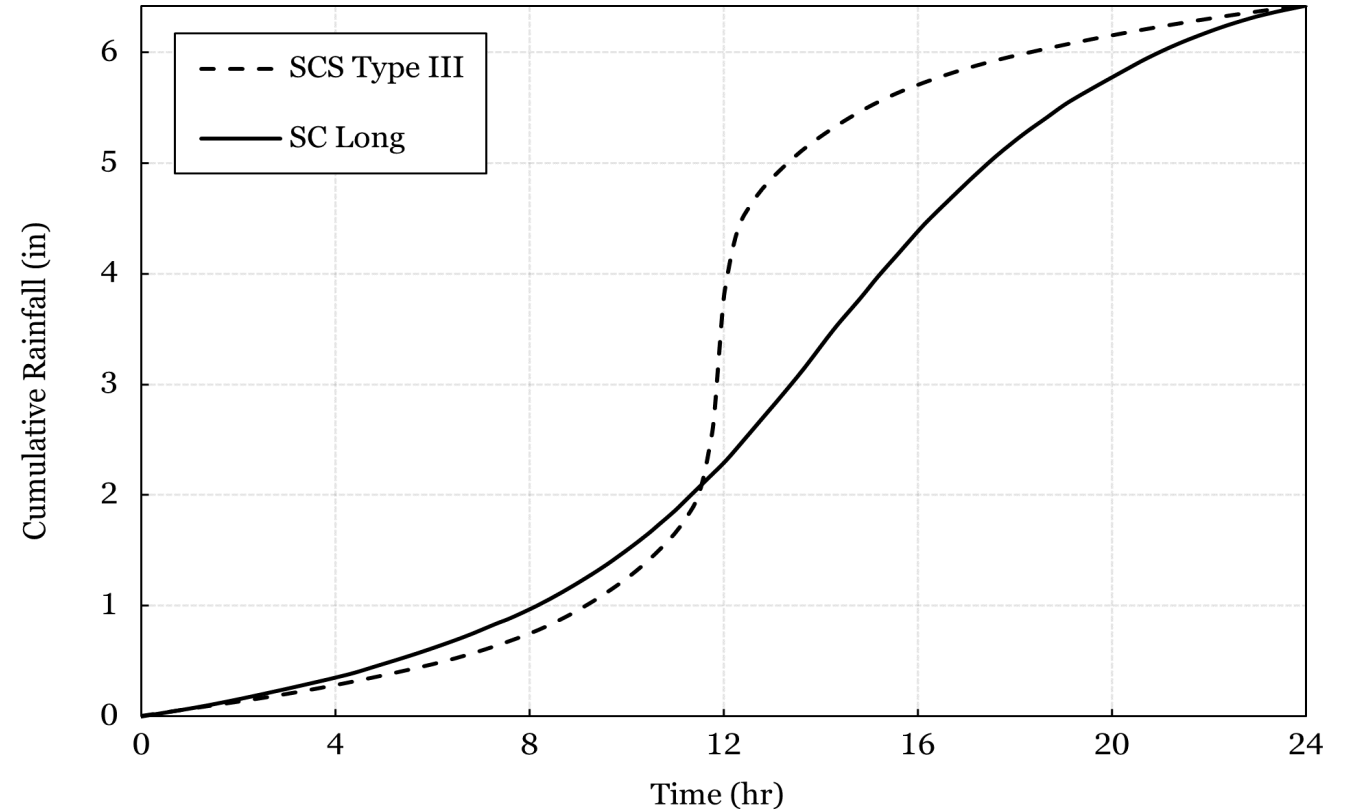
- NOAA Next Generation Radar (NEXRAD) Level 3 Data Products
- Totals Validated with Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) Network
- USGS Rapid Deployment Stage Data
 - Limited to > 5.25 feet NAVD 88
 - Coupled w/ Charleston, SC Data and NOAA Correlations



USGS rapid deployment gauge installed on US 21 bridge.

Current Conditions - Rainfall

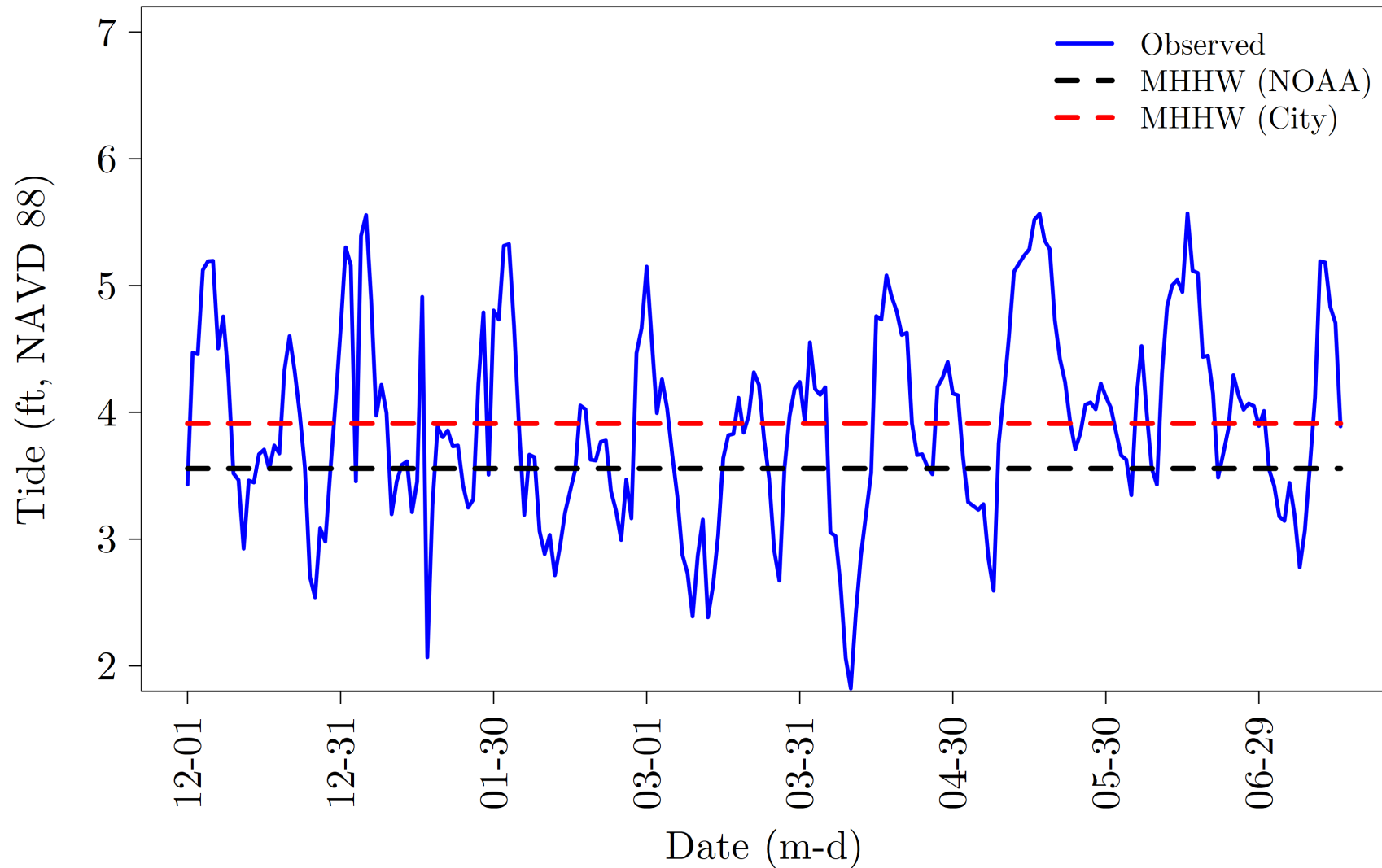
- NOAA Station 38-0559 24-hour Rainfall Totals
- Cumulative Rainfall Distributions
 - SCS Type III
 - SC Long



SCS Type III and SC Long cumulative rainfall distributions for the 10% (10-year) design event.

Current Conditions - Tide

Higher-High Tide

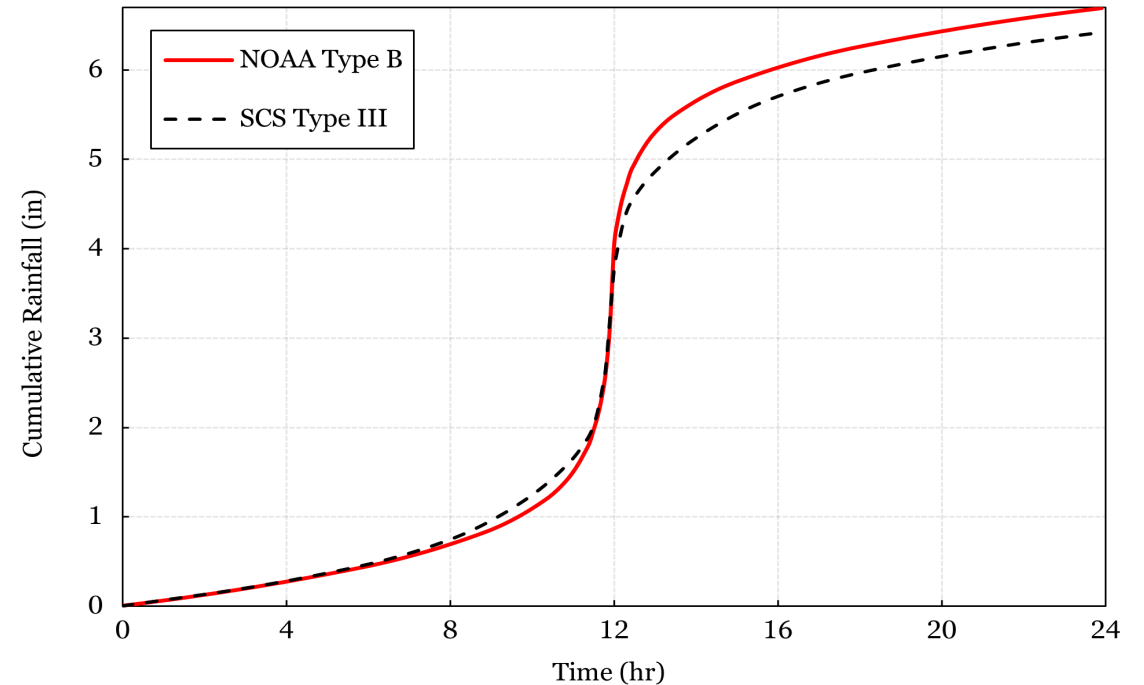


Future Conditions - Rainfall

- Fifty-Year Forecasts (Clemson)
- NOAA Type B Cumulative Rainfall Distribution
 - 4 in/hr Increase (10-year, 24-hour)

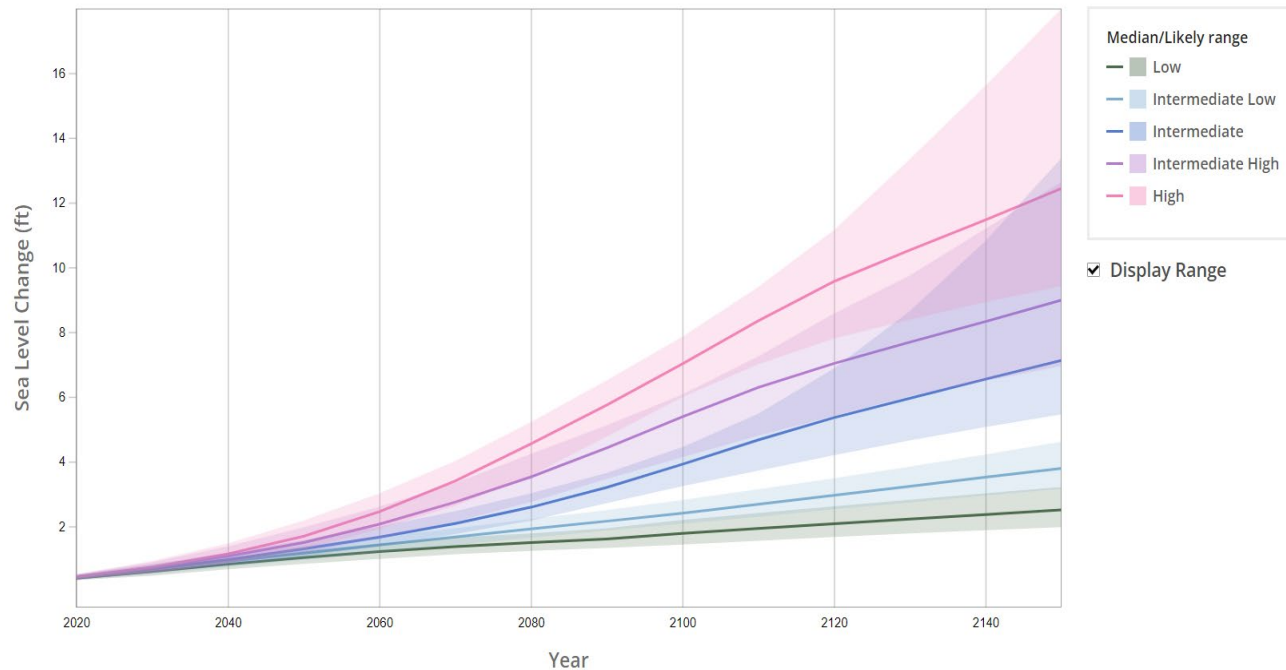
Historical and future 24-hour cumulative rainfall for NOAA station 38-0559. Rainfall totals are in inches.

Recurrence Interval (yr.)	Current	Future (50-years)
2	4.20	4.36
5	5.42	5.64
10	6.42	6.69
25	7.82	8.15
50	8.96	9.34
100	10.20	10.63



Forecasted NOAA Type B cumulative rainfall distribution for the 10% (10-year) future conditions assessment. SCS Type III current conditions distribution added for comparison.

Future Conditions - Tide



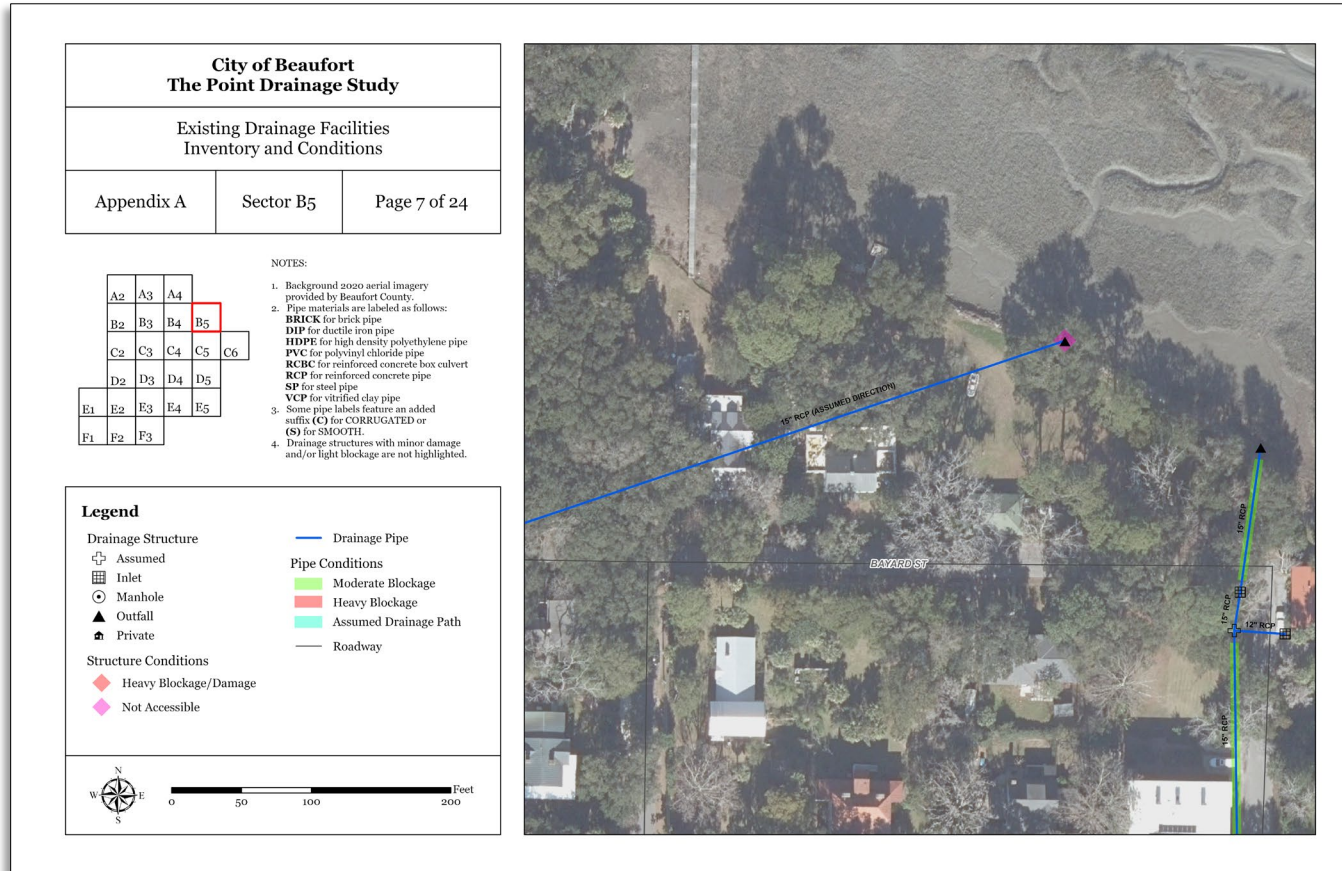
Sea level change time series depicting five varying sea level scenarios at the NOAA Fort Pulaski gauge.

- Sea Level Rise and Coastal Flood Hazard Scenarios and Tools Interagency Task Force
- Scenarios Defined by Target Values of Global Mean Sea Level (GMSL) Rise in 2100

Predicted sea level increases for the year 2072 (50-year future).

Scenario	Sea Level Increase (ft)
Low	1.39
Intermediate Low	1.72
Intermediate	2.18
Intermediate High	2.90
High	3.62

Field Survey and Visual Conditions Assessment



Conveyance Summary (Total Length = 4.5 mi)		
Material	Length (ft)	Average Geometry
<i>Circular Pipe</i>		
Concrete	14,619	18-in
Ductile Iron	1,988	15-in
Corrugated HDPE	1,393	15-in
Vitrified Clay	1,288	8-in
PVC	1,202	8-in
Corrugated Steel	687	15-in
Smooth HDPE	270	18-in
Brick	36	24-in
Smooth Steel	17	12-in
<i>Elliptical Pipe</i>		
Corrugated Steel	337	18-in x 28.5-in
Concrete	121	15-in x 22-in
Concrete Box Culvert	28	3-ft x 4-ft
Inaccessible Closed Pipe	1,576	-

Field Survey and Visual Conditions Assessment

Silted type 1 grate inlet near Greene Street and West Street intersection.



Ageing brick lined conveyance structure located in Craven Street and Charles Street intersection.

Degrading outfall pipe off East Street between Craven Street and Port Republic Street.

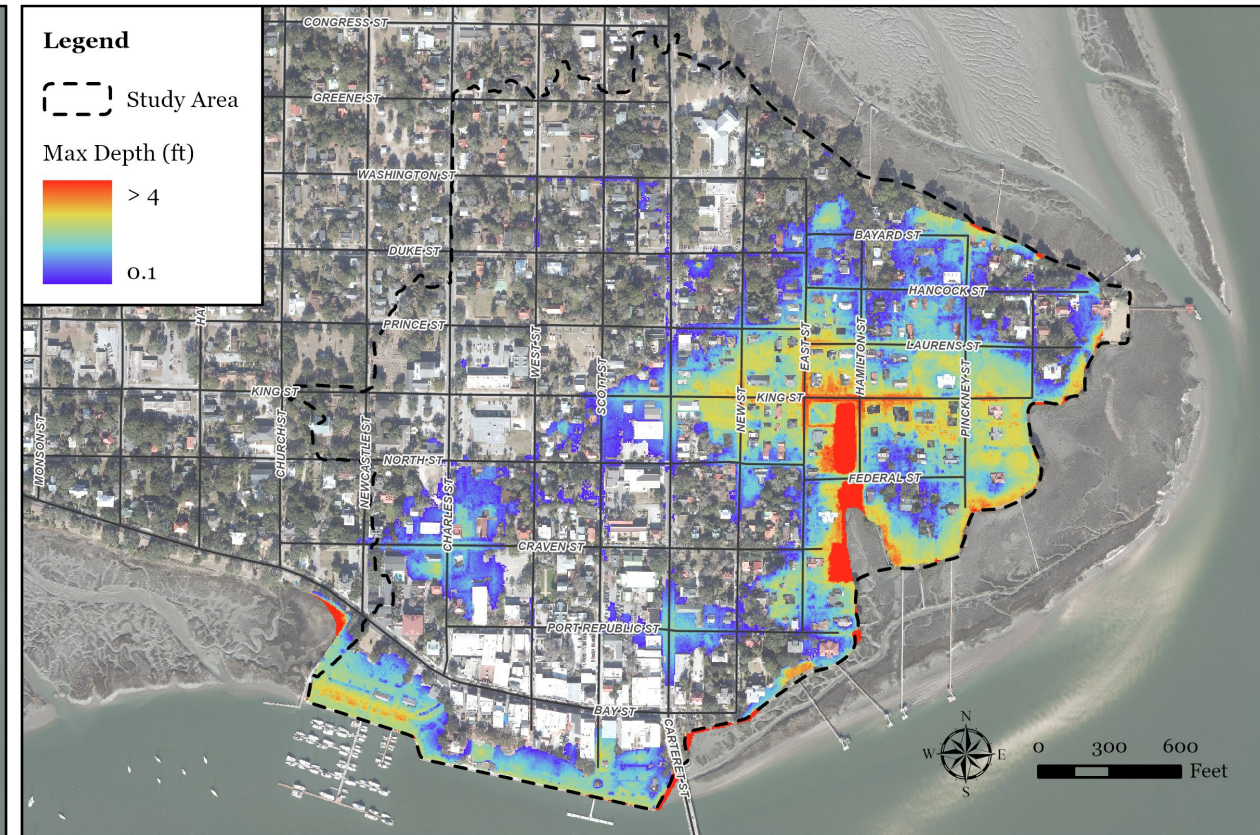
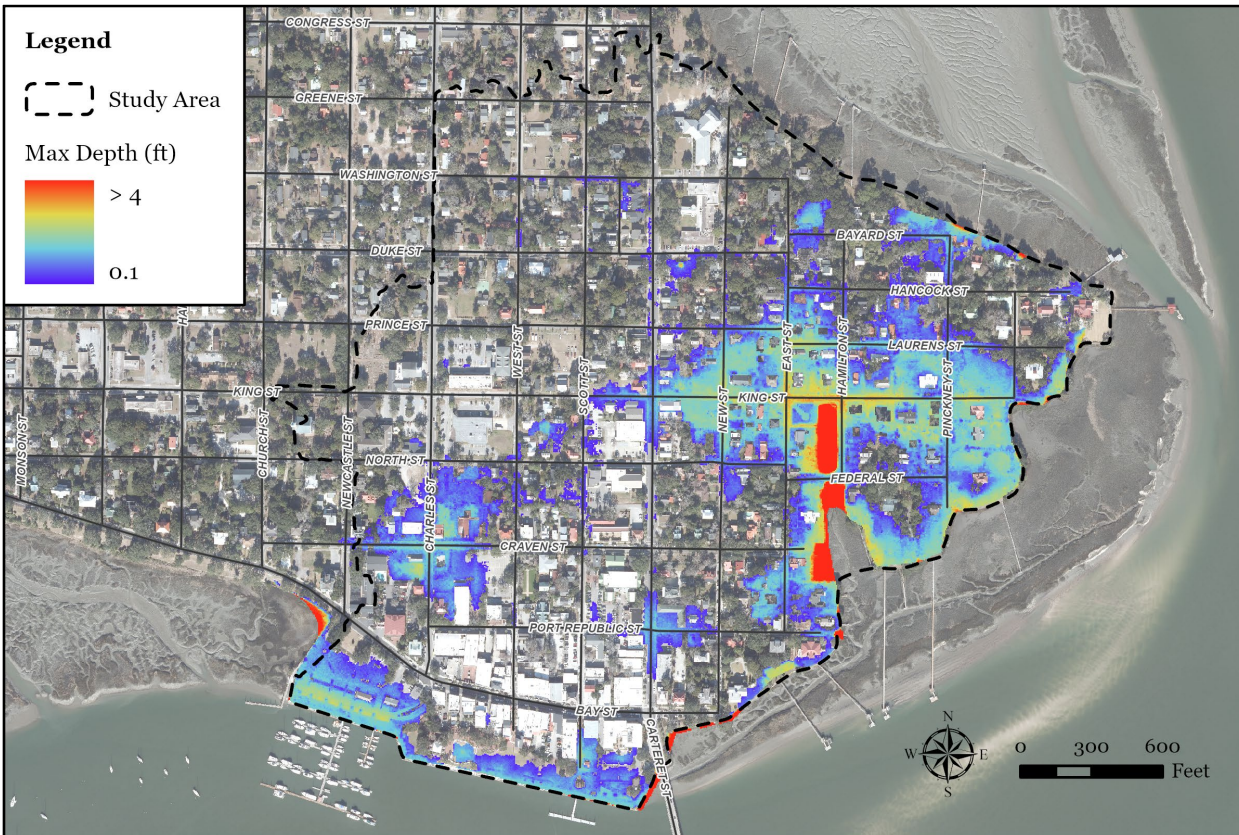


Manhole structure containing broken stormwater pipe and exposed water line near Port Republic Street and Carteret Street intersection.

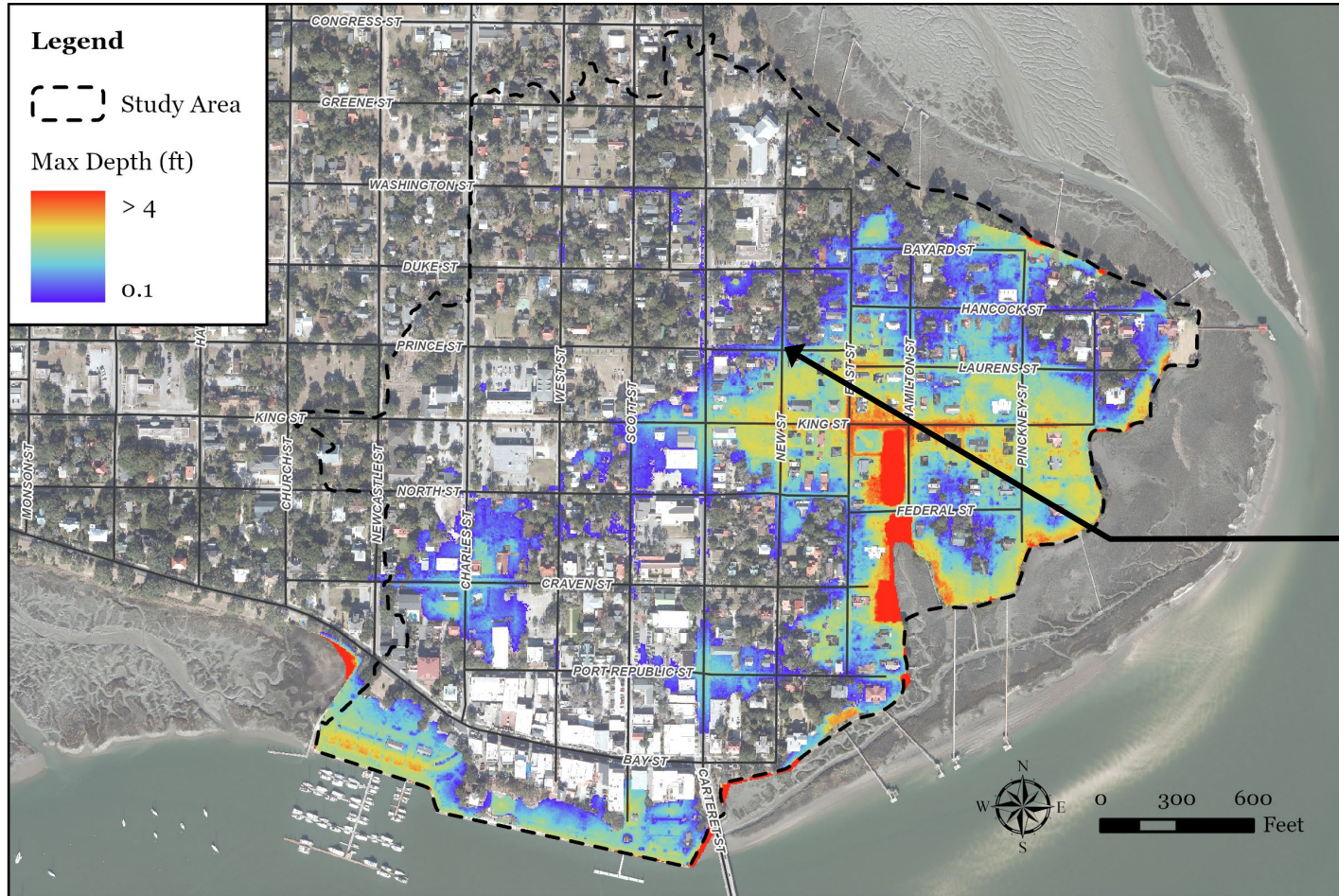
Historic Conditions Results

Hurricane Matthew (October 2016)

Hurricane Irma (September 2017)



Historic Conditions Results (Irma - 2017)

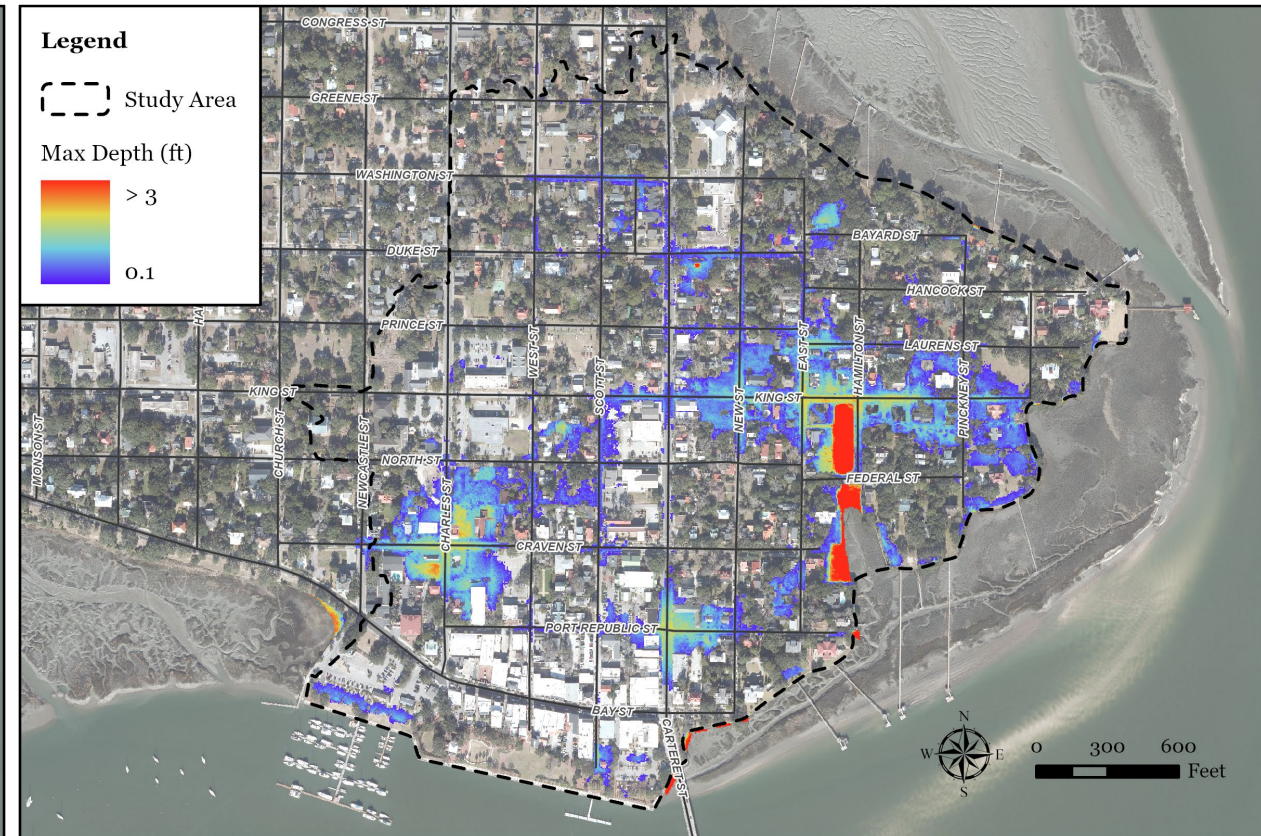
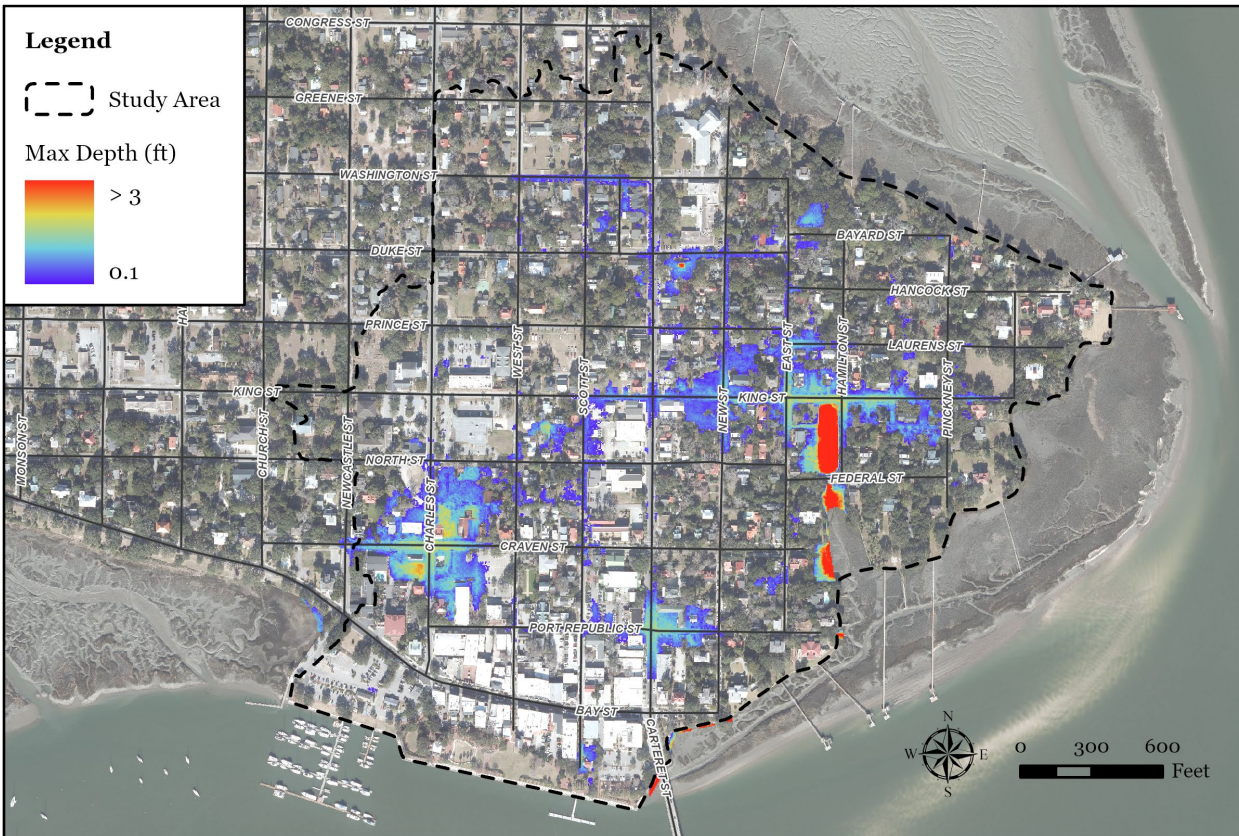


Hurricane flooding experience near the intersection of Prince Street and New Street. Photo submitted by Erich Wilms.

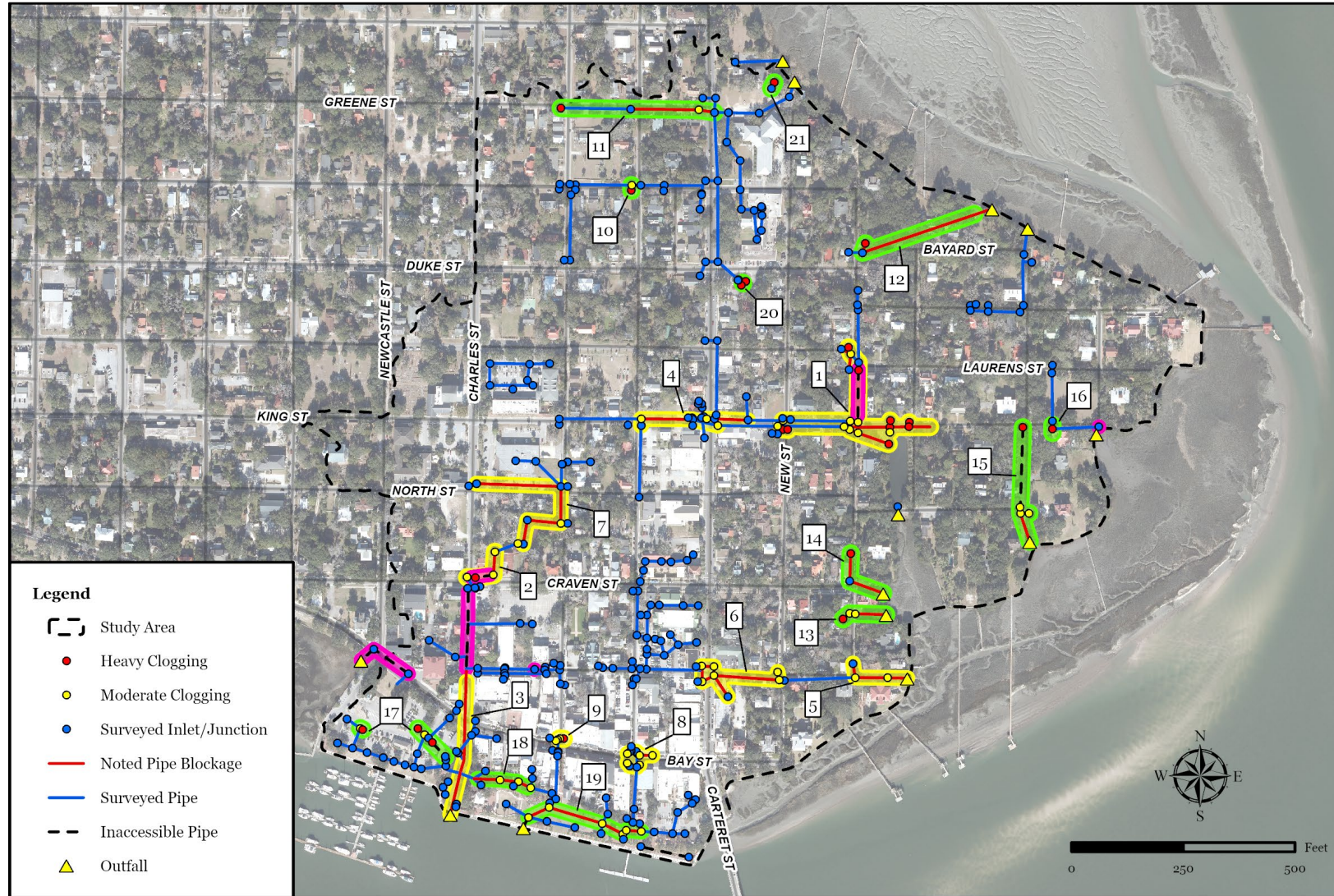
Current/Future Conditions Results (10-Year)

Current Conditions

Future Conditions



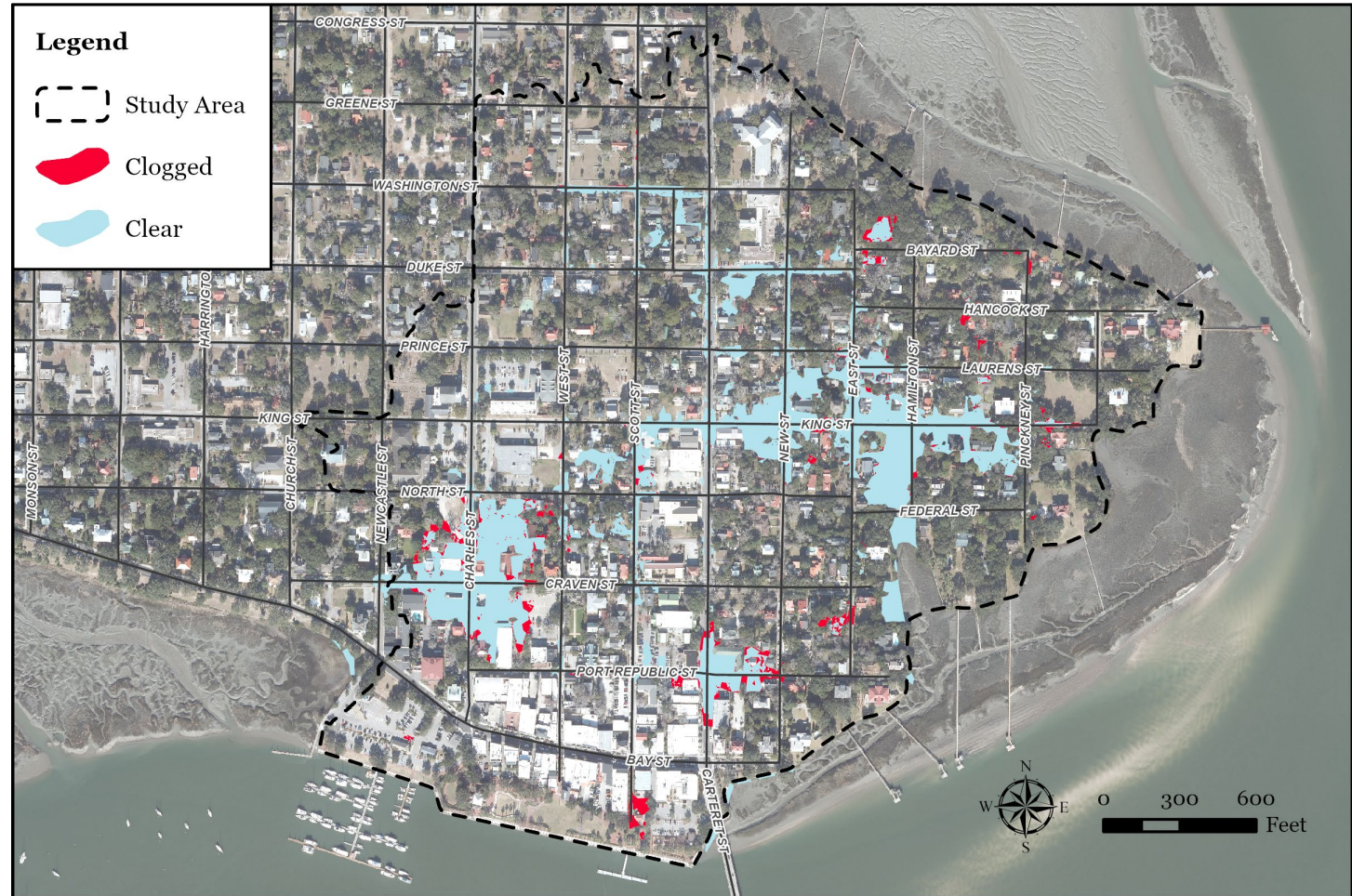
Maintenance Recommendations



Maintenance Recommendations

Adjustments to Manning's n roughness values for varying levels of reported blockage.

Base Condition	Moderate Blockage	Heavy Blockage
0.010	0.018	0.057
0.012	0.022	0.068
0.013	0.024	0.074
0.018	0.033	0.101
0.024	0.041	0.136



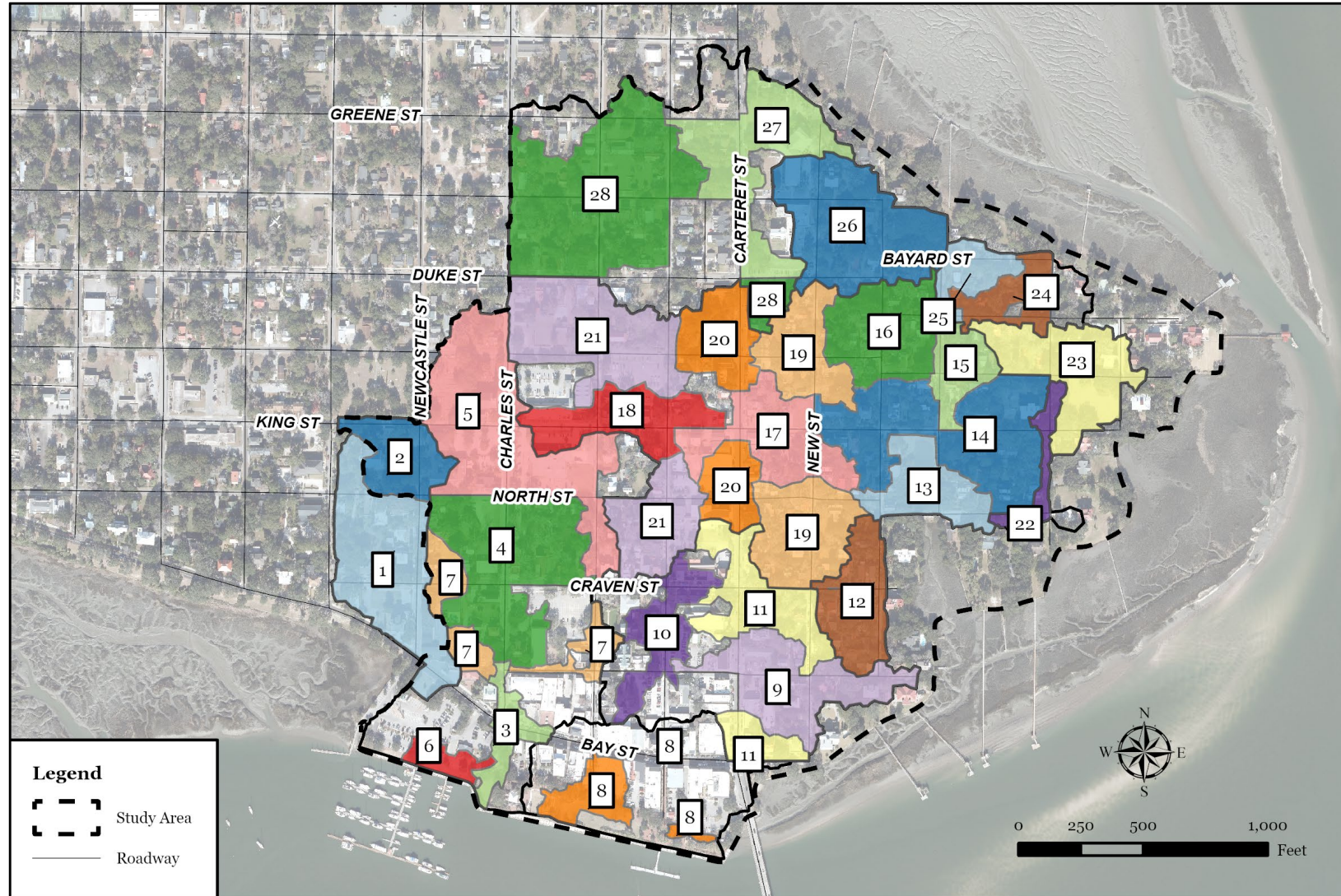
Capital Planning

- Project Recommendations
 - Develop Manageable-Sized Projects
 - Prioritization (Ranking)
 - Flood Conditions
 - Structural Condition
- Cost Estimates
 - Engineering and Permitting
 - Construction
 - Contingencies
- Funding Assessment

Example of cost estimating break down to support development of capital plan.

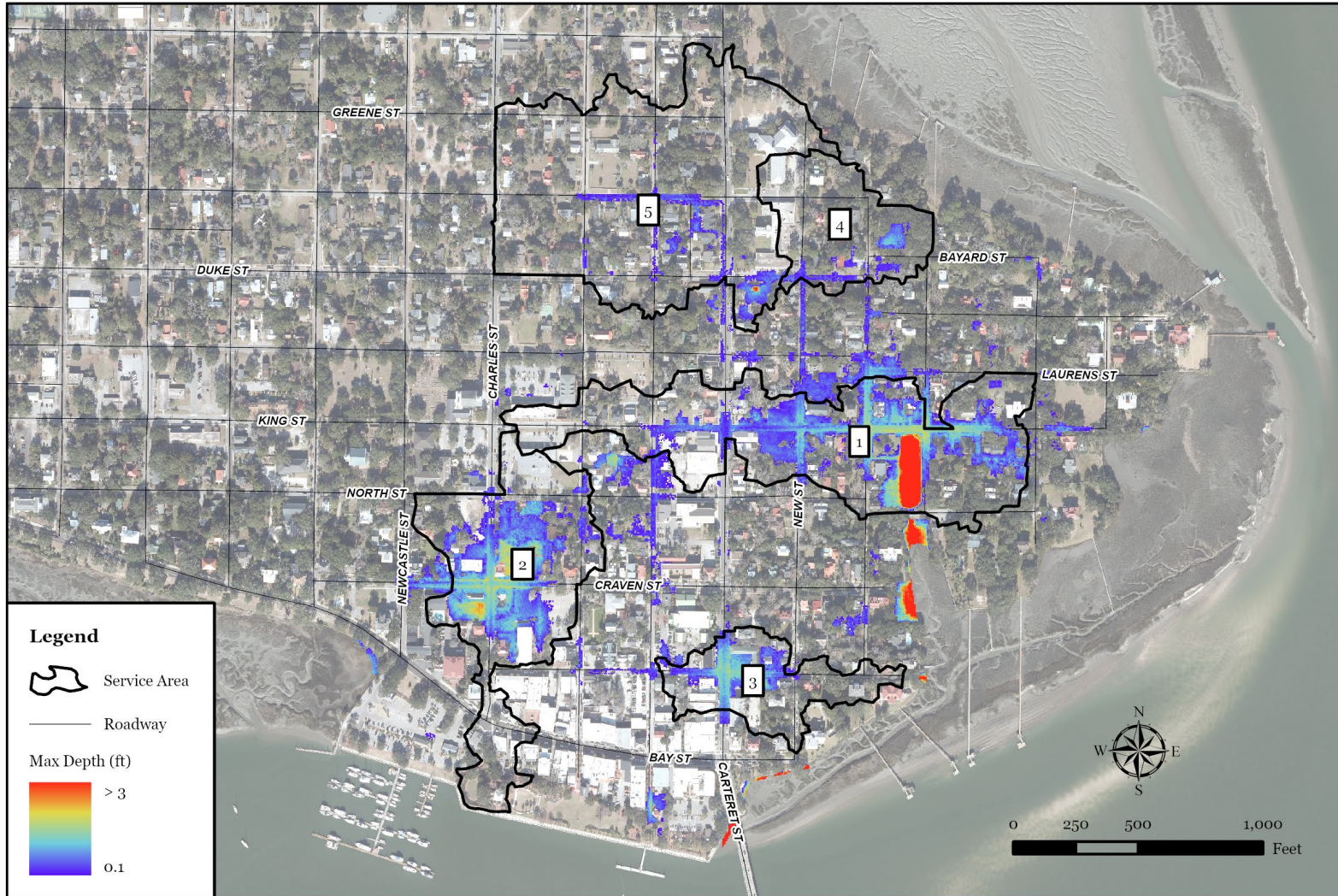
3	-	44 LF of Single 18" RCP	44	-	-	LF	180	\$	7,920	
	-	88 LF of Single 18" RCP	88	-	-	LF	180	\$	15,840	
	-	41 LF of Single 18" RCP	41	-	-	LF	180	\$	7,380	
	Replace Existing 24" RCP	121 LF of Single 48" RCP	121	-	-	LF	370	\$	44,770	
	Replace Existing 24" RCP	93 LF of Single 48" RCP	93	-	-	LF	370	\$	34,410	
	Replace Existing 24" RCP	149 LF of Single 48" RCP	149	-	-	LF	370	\$	55,130	
	Replace Existing 36" RCP	54 LF of Single 60" RCP	54	-	-	LF	515	\$	27,810	
	Replace Existing 48" RCP	167 LF of Single 72" RCP	167	-	-	LF	620	\$	103,540	
	-	Junction Box (Large)	-	-	1	EA	8500	\$	8,500	
	-	Junction Box (Medium)	-	-	4	EA	7100	\$	28,400	
	-	Junction Box (Small)	-	-	1	EA	5100	\$	5,100	
	-	Riprap Armoring	-	67	-	TON	175	\$	11,725	
	Sub-Total									\$ 350,525
	Allowance - Incidental (50%)									\$ 175,263
	Allowance - Water/Sever (50%)									\$ 175,263
	Asphalt Paving									\$ 61,748
	Curb Placement									\$ 14,200
	Contingency (20%)									\$ 149,417
	Estimated Construction									\$ 926,415
	Construction Engineering and Inspection									\$ 111,170
Estimated Engineering									\$ 136,515	
Estimated Permitting									\$ 6,826	
									\$ 1,180,926	
4	-	141 LF of Single 42" RCP	141	-	-	LF	360	\$	50,760	
	-	28 LF of Single 18" RCP	28	-	-	LF	180	\$	5,040	
	-	44 LF of Single 42" RCP	44	-	-	LF	360	\$	15,840	
	-	266 LF of Single 18" RCP	266	-	-	LF	180	\$	47,880	
	-	327 LF of Single 36" RCP	327	-	-	LF	270	\$	88,290	
	-	36 LF of Single 36" RCP	36	-	-	LF	270	\$	9,720	
	UNCONFIRMED	72 LF of Single 42" RCP	72	-	-	LF	360	\$	25,920	
	UNCONFIRMED	32 LF of Single 42" RCP	32	-	-	LF	360	\$	11,520	
	UNCONFIRMED	129 LF of Single 42" RCP	129	-	-	LF	360	\$	46,440	
	UNCONFIRMED	47 LF of Single 48" RCP	47	-	-	LF	370	\$	17,390	
	-	Junction Box (Medium)	-	-	1	EA	7100	\$	7,100	
	-	Junction Box (Small)	-	-	7	EA	5100	\$	35,700	
	Sub-Total									\$ 361,600
	Allowance - Incidental (50%)									\$ 180,800
	Allowance - Water/Sever (50%)									\$ 180,800
	Asphalt Paving									\$ 113,856
	Curb Placement									\$ 29,635
Contingency (20%)									\$ 153,111	
Estimated Construction									\$ 1,019,802	
Construction Engineering and Inspection									\$ 122,376	
Estimated Engineering									\$ 141,965	
Estimated Permitting									\$ 7,098	
									\$ 1,291,241	
Total Cost of Projects 3 and 4									\$ 2,472,167	

Overall Construction Recommendations



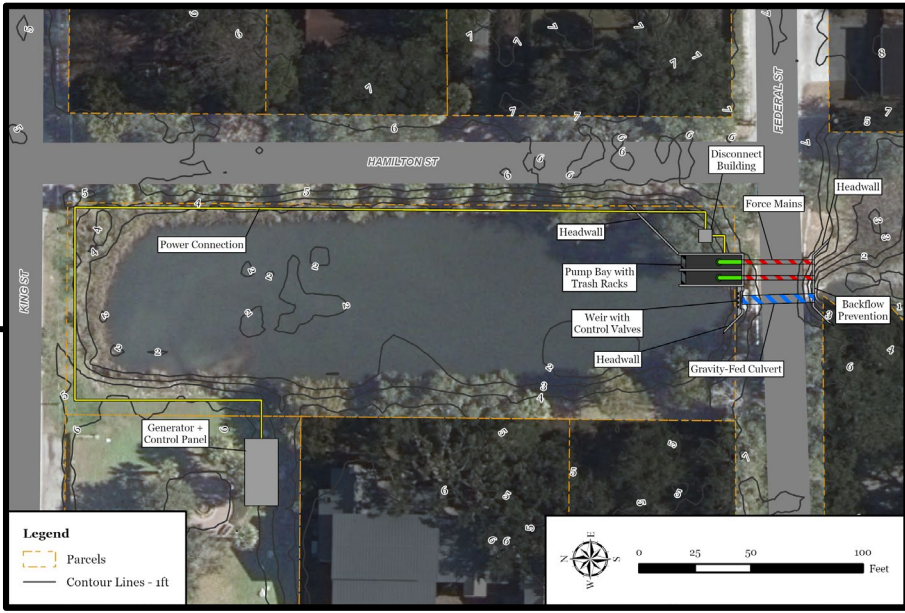
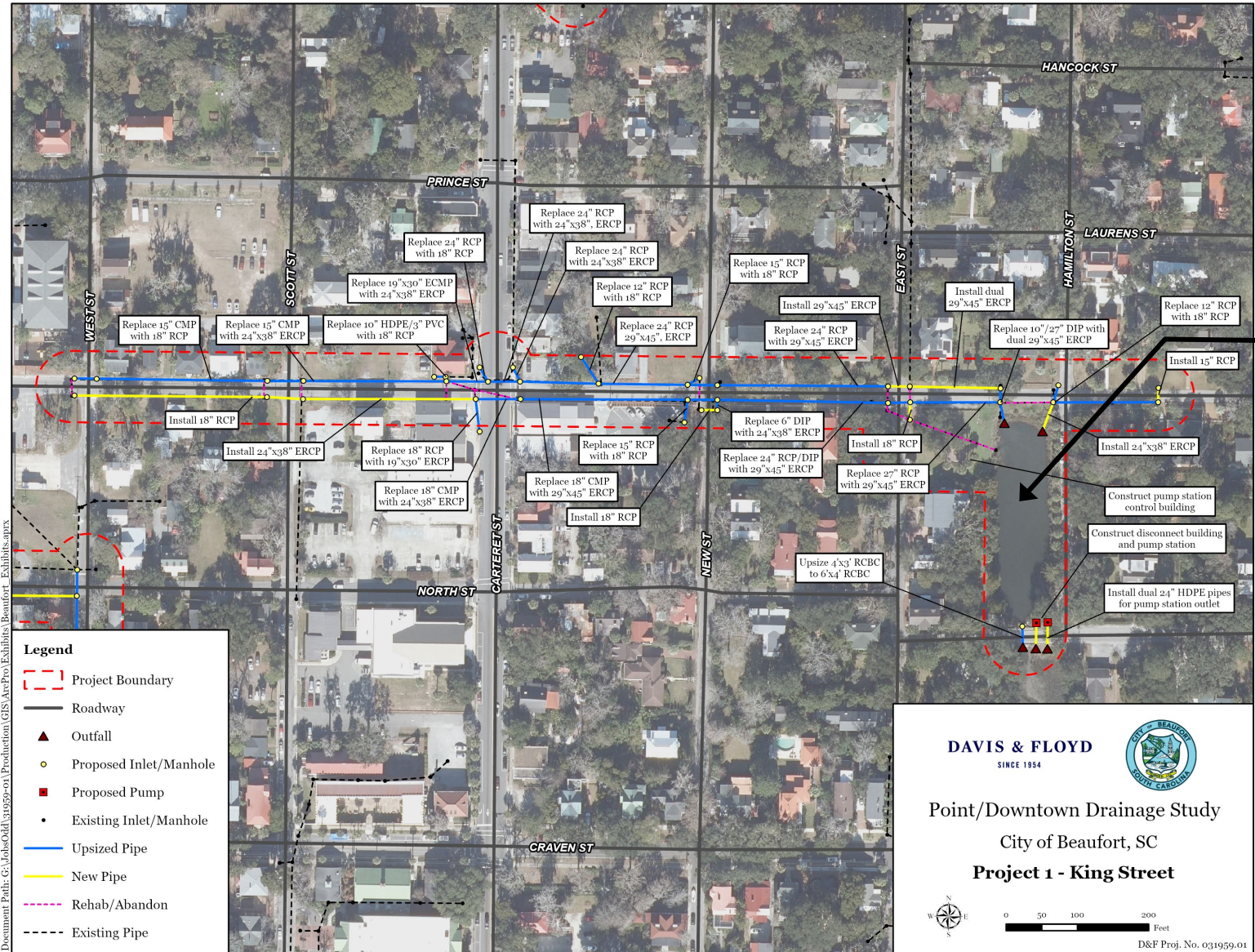
Project	Rank	Score
13	1	37.23
14	2	35.35
17	3	19.02
27	4	18.59
3	5	17.26
9	6	14.47
18	7	12.51
28	8	10.27
4	9	9.22
21	10	8.16
1	11	6.6
26	12	5.55
8	13	5.47
11	14	5.29
19	15	4.96
5	16	4.78
24	17	4.71
10	18	4.36
23	19	4.12
20	20	4.03
16	21	3.23
7	22	3.13
12	23	2.75
2	24	2.5
15	25	2.32
22	26	2.19
25	27	2.03
6	28	0.67

High Priority Construction Recommendations




Project Grouping	Estimated Cost	Potential Funding Source
1 – King Street	\$10,573,562	RIA / SCIIP
2 – Charles/Craven	\$4,184,743	SCOR / ARPA
3 – Port Republic/Carteret	\$2,474,142	SCOR/ARPA/EDA
4 – Bayard Street	\$794,029	EPA / STAG
5 – Washington/Carteret	\$3,164,626	CDBG
Total Estimated Cost	\$21,191,104	

Priority Area 1



DAVIS & FLOYD
SINCE 1954

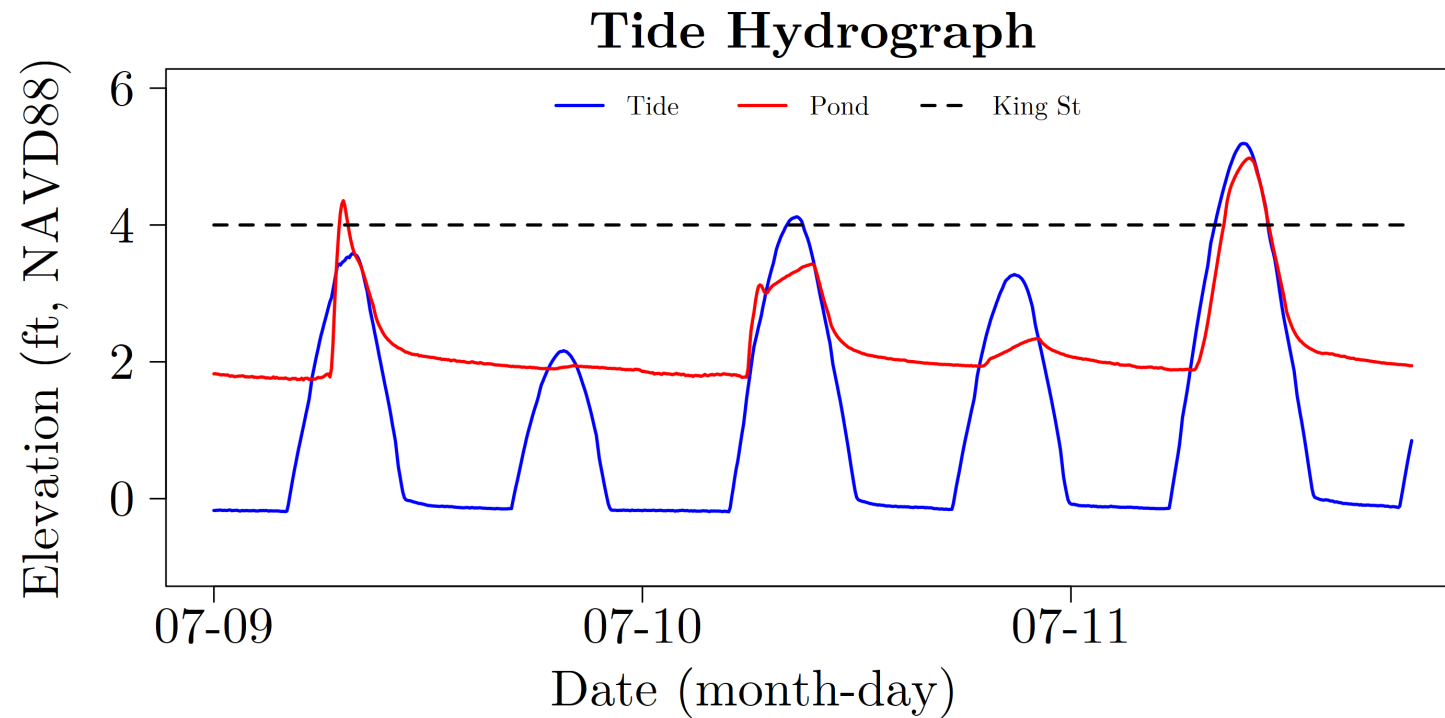
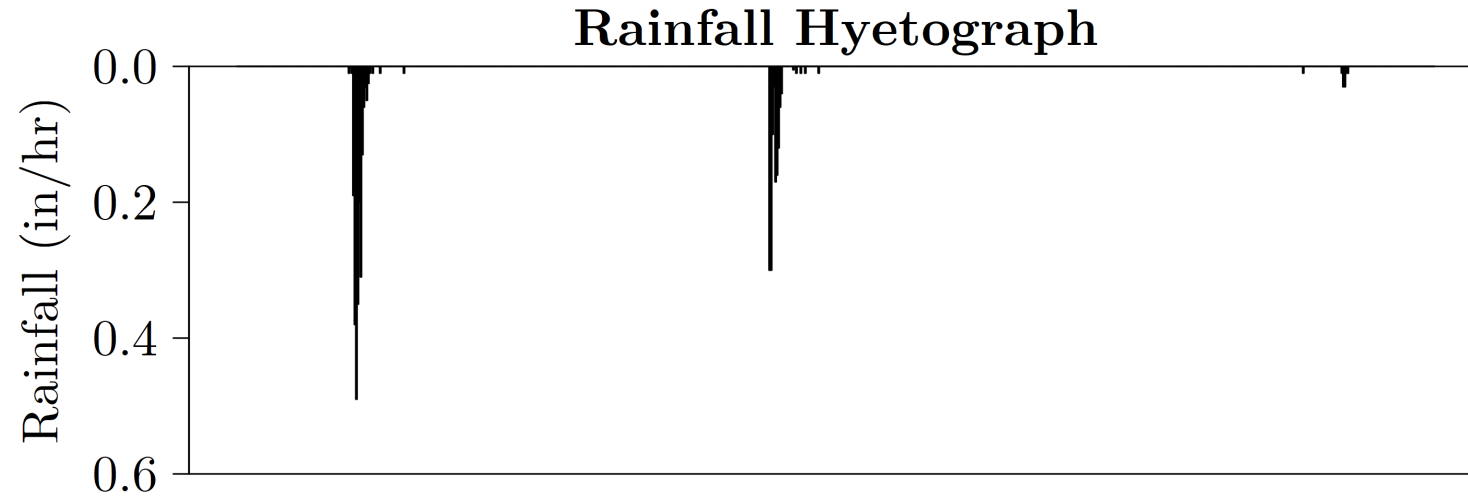


Point/Downtown Drainage Study
City of Beaufort, SC
Project 1 - King Street

0 50 100 200 Feet

D&F Proj. No. 031959.01

Priority Area 1



Priority Area 2



Conclusion and Lessons Learned

- Clearly Define Goals
 - Design Life/Scenario
 - Funding Expectations
- Data, Data, Data
 - Forms Basis of Everything!
- Problem Identification
 - Money Spent on Properly Analyzing Problem Can Save in the Long Term
 - DO NOT FORGET MAINTENANCE
- Break Up and Identify Manageable Projects
- Perception and Public Input is Critical
- Address Today's Needs w/ Future in Mind
- Prioritization
 - Service Area, Flood Duration, Flood Depths
 - Available Funding
- Be Flexible/Open Minded
- Include Key Stakeholders
 - Permitting Agencies
 - Utilities
- Consider Partnerships

Questions?

