



February 28, 2018

Hurricane Irma Post Storm Investigation:
Orange River, Olga, Hickeys Creek & Bedman Creek Watersheds, Lee County, Florida
For Lee County Department of Natural Resources (LCDNR)

Executive Summary:

As a result of September 10, 2017, Hurricane Irma flooding impacts to Lee County, AIM Engineering & Surveying has conducted a review of the general causes, documented flood level elevations, identified impediments to storm water flow and recommended short term projects to remove impediments to flow and proposed conceptual long term projects for flood hazard mitigation improvements to better conditions in the future. This qualitative study is intended to better understand “Why did flooding occur in the Orange River, Olga, Hickey Creek and Bedman Creek watersheds”. Some of the reasons found are summarized as follows:

- A massive amount of rainfall of 13.06 to 17.45 inches from Hurricane Irma (possibly a 1000-year storm event) fell on eastern Lee County. The rain gauges shown in the attached Exhibit “C” were located in the west, central and north areas of Lehigh Acres. A NEXRAD analysis was provided showing heavy storm radar measured rainfall in the area. The rain gauges provided a detailed hourly breakdown and consistently measured heavy rainfall across Lehigh. The natural and design capacity of conveyances is much less than runoff produced from 1,000-year storm event.
- A tropical storm event two weeks prior to the Hurricane Irma that was not fully discharged created adverse antecedent conditions for handling a closely occurring second storm event. Flooding impacts due to back to back storms prevented the opportunity to do meaningful maintenance work after the first storm because of shorter time frame between the two storms. Impediments (fallen trees, sedimentation, collapsed or nonfunctional culverts, etc.) to flow and lack of time available to drain flood waters from the first storm could have contributed to extreme flooding due to the following second storm.
- Fallen trees and exotic vegetation blown down by hurricane winds clogged the flow ways backing up stream flow water surface profiles causing higher flood levels and extending the flooding recovery duration.
- Storm/Flooding surges occurred in the Caloosahatchee River of approximately three (3') feet as shown on the attached Exhibit E-1 through E-3. The higher water levels further limited flow rates in the lower reaches of the flow-ways further adding to flood water levels. The S-79 structure on the Caloosahatchee River recorded a peak upstream level of EL. 6.5 NGVD '29 and a peak downstream of EL. 5.8 NGVD '29.
- Many residences have been constructed along stream banks that are now located in the FEMA designated flow-ways. These buildings block stream flow on the overflow banks.
- Flooded homes were found to be constructed below current FEMA flood protection levels.
- Drainage outfall conveyances for eastern Lee County are essentially natural flow-ways, creeks and rivers that do not serve as well as an engineer designed conveyances handling high flows from extreme storm water run-off events. Maintenance of natural areas is

difficult, expensive, and only very limited work is allowed in environmentally sensitive areas. The outfall conveyances have been studied in the past for 25-year and FEMA 100-year water surface profile.

Scope of Investigation:

This study involved a review of Lee County GIS information to identify flooding areas and develop an approach to focus efforts within the four watersheds comprising eastern Lee County. See Exhibit “A”. Photographs of the flooding event were reviewed along with permit data of existing land improvement projects for identifying study areas of high importance. Rainfall data was collected from LAMSID as shown in Exhibit “C” and field data on flood level elevations along the principle conveyances was obtained. Previous watershed studies were reviewed and comparisons between predicted flood levels and actual flood levels were mapped on the water surface profiles. Interviews were conducted with local residents, governmental officials and others for their observations of the storm event flood levels, duration and directions of flow. The major flow-ways were traversed by field personnel to photograph and note observations of impediments to flow. These impediments were mapped into the Lee County GIS system and ranked in priority of importance with approximate preliminary budgetary cost opinions.

Citizens Questionnaire Input:

Lee County citizens were provided an opportunity to submit specific information on the County’s interactive website regarding observations and complaints. For the watersheds covered under this report, seven questionnaires were submitted and are attached in Appendix “A”. The residents stated that flooding did not occur during the August 25-27, 2017 and further added that the Hurricane Irma flooding was the highest water level observed during their residency in the area. The residency duration reported in the questionnaires ranged from 2 to 34 years with an average of 19 years. The duration of flooding reported as approximately five days.

Rainfall:

Hurricane Irma proved to be a very large and catastrophic event. Formation began on August 30, 2017 while Lee County was experiencing historic rainfall from Tropical Wave Investigation 92L. Although weakening from a Category 5 to a Category 3 by landfall in Southwest Florida, the recorded rainfall intensity far surpassed the SFWMD 100-year, 3-day rainfall totals. Areas designated as floodways by FEMA Flood Insurance Rate Maps (See Exhibit “B”) experienced major flooding, and many areas throughout Lehigh Acres experienced widespread flooding. Tropical Wave Investigation 92L was a significant contributing factor in the effects of Hurricane Irma. Page Field in Fort Myers recorded 4.55 inches of rainfall during a 1-day period, which surpasses the previous record of 3.57 inches from 1995. Lehigh Acres Municipal Service Improvement District (LAMSID) Structure S-YT-2 recorded 3.63 inches for 8/27/2017 and a 4-day total of 8.36 inches from August 24-27. Flooding occurred throughout Lee County during this event. Most importantly noted is the saturation of soils and high elevation of the water table as Hurricane Irma was forming in the Atlantic. Harns Marsh was filled to capacity during this rain event, and water was continuing to be released leading up to Hurricane Irma and that limited capacity for storage of hurricane’s rainfall and runoff. Due to high water levels in the Orange River, the head differential for emptying Harns Marsh was very limited and approximately, two feet

of vertical storage in Harns Marsh reservoir was reported as not available due to undischarged remaining storm water runoff from Tropical Wave Investigation 92L.

Hurricane Irma's impact would have been better absorbed had the area not received Tropical Wave Invest 92L's record rainfall two weeks prior. Nonetheless, the massive rainfall from Hurricane Irma would have caused extensive flooding alone. The total rainfall for a SFWMD 100-year, 1-day design storm event is 10 inches. Exhibit "C" demonstrates the three greatest recordings noted as 13.06, 15.43 and 17.45 inches for 9/10/2017. The SFWMD 100-year, 3-day design storm event indicates a total rainfall of 15 inches, whereas the Hurricane Irma 5-day rainfall event produced as much as 20.31 inches. The SFWMD design storms include distributed rainfall over a period of time, whereas Hurricane Irma produced a drastic spike in rainfall intensity from 6-9 PM on 9/10/2017. This spike is consistent with the timing of the eye wall passing through Lehigh Acres. The U.S. National Ocean and Atmospheric Association (NOAA) predicts the 1000-year, one-day storm event to be 17.1" of rainfall at the location of the recorded 17.45". See Exhibit "D". Indicating a possible 1000-year storm event occurred in certain portions of eastern Lee County.

Historical Flood Information:

- The worst documented flooding in Orange River at Buckingham Road occurred in June 1936 where the USGS recorded a stage of EL. 15 MSL (*noted in Gee & Jensen report 1975) or approximately EL 14 NAVD from a five-day total rainfall of 13.53 inches. The 1936 flooding occurred when the watershed was in a much more natural state without the 1940s Buckingham Airfield and without the later developed Lehigh Acres community.
- In the Orange River at Buckingham Road, the June 1959 event having a five-day total of 14.29 inches of rainfall caused flooding to Elevation 13 MSL or EL. 12 NAVD.*
- Hurricane Donna having a five-day total rainfall of 5.5 inches caused flooding to EL. 8.5 MSL or EL. 7.5 NAVD in Buckingham Road.*
- The March 1970 flood having a five-day total rainfall of 8.69 inches, produced flooding levels to EL. 13 MSL or EL. 12 NAVD.*
- Hurricane Irma flooding level at Buckingham Road after a one-day rainfall of 17.45 inches was found to be EL. 10 NAVD.

Findings and Impediments to Flow:

- The Hurricane Irma flood levels were compared to the LCDNR-Johnson Engineering 25-year storm event water surface profiles study of the 1990s, the flood levels approximately tracked the 25-year predicted water surface profile, except where debris blocked flow channels causing sharp jumps in the water surface. See Exhibits "E" & "F". The fallen vegetative debris blocks (impediments to flow) in the channels resulted in increased flooding levels.
- Flooded homes were found to exist below the recommended FEMA flood level according to FIRM maps.
- The number of flood claims appears to be similar in Lehigh Acres and the downstream affected properties.

- Unexpected flow directions were reported in the Buckingham/Orange River area, where storm runoff was noted flowing northeasterly from FGCU property (former Sunland Training Center) across Buckingham Road towards River Road and southeasterly into Lehigh Acres at the Nine-Mile run area adding to flooding in Lehigh Acres.
- Storm water flow was reported in the Hickey Creek area coming from River Hall development to Hickey Creek area.
- Lehigh Acres reported four known locations where the LAMSID drainage network received flow from outside the District: (1) Flow was overtopping the perimeter at the northwest corner of the District, along Mackerel Canal when the District berm was washed out, (2) The SE corner at the Lee/Hendry/Collier County corner flow was received from Collier County, (3) Nine Mile Run/Angle Canal were back flowing into the LAMSID system and (4) Flow was being received from Fort Myers west of Alvin Canal as the Six Mile Cypress Slough Preserve overflowed boundaries.
- Natural streams and flow-ways were impeded by debris causing compromised flow capacity and sedimentation.

Orange River Watershed Commentary:

This natural flow way receives flow from a very large watershed of approximately 55 square miles and includes the large developed community of Lehigh Acres. The Lehigh Acres portion of the watershed has a water management system controlled by Lehigh Acres Municipal Services District (LAMSID) which contains drainage structures, weirs, gates, canals, storage basins, etc. LAMSID closely monitored the system and their facilities during the hurricane striving for the best possible operational outcome. The LAMSID system was overwhelmed by this rainfall event breaching its containment berms having stored the maximum amount of storm water runoff in order to limit downstream discharges and flooding.

Field observations and photograph reviews of the Orange River area were conducted and notations are listed as follows:

- At the headwaters numerous Java Plum exotic trees were observed to have fallen. Being a non-native plant, this species was not capable of withstanding very high winds. These trees fell in the stream path and blocked flow down the river. Other impediments to flow were observed, such as, a cattle crossing bridge with low clearance and short span, fences across the stream, as well as, fences in the floodway.
- Many homes have been constructed (pre-FEMA) in the floodway that limits flow capacity.
- Stream shoaling was observed in the lower reaches of the river.
- Tributaries and drainage ways were overgrown and blocked with exotic vegetation and sedimentation.
- Important minor arterials and collectors roads were flooded at the bridge approaches which may indicate bridge openings are inadequate. Additionally, scour conditions around the bridges was observed being probably due to excessive stream flow velocity under the bridge.
- Interviews with residents and other observers revealed high water marks and flow conditions during and after the hurricane event. An unexpected report at the south end of

Shady River Lane of very significant flow coming to the Orange River from the southwest. And a report in this same area of six and one half feet (6.5') of water depth on Peace Road. This unexpected flow may have been from basins normally outside the subject watershed but finding a path of least resistance over submerged minimal ridge lines.

- The section of the Orange River from Buckingham Road to approximately Bird Road is restrictive due to its size, vegetation and encroaching development which impacts the potential flow way capacity.

Olga Watershed Commentary:

This natural flow way receives flow from the large area of Hickey Creek Swamp and River Hall and other surrounding developments having water management systems.

Observations and photograph reviews of the Hickeys Creek were conducted and notations are listed as follows:

- At the flow-ways numerous trees and exotic vegetation blocked the stream flow.
- Stream shoaling and sedimentation was observed in the flow-ways.
- Flooding issues were not prevalent in this area, however the adjoining Hickeys Creek Watershed may benefit by improved maintenance in the Olga Watershed that would limit spill over between watersheds.

Hickeys Creek Watershed Commentary:

This natural flow way receives flow from the large developed community of Lehigh Acres. Lehigh Acres has a water management system to control offsite discharge.

Observations and photograph reviews of the Hickeys Creek were conducted and notations are listed as follows:

- At the headwaters numerous trees and exotic vegetation blocked the stream flow.
- Many homes have been constructed (pre-FEMA) in the floodway that limit flow capacity.
- Stream shoaling and sedimentation was observed in the lower reaches of the creek.
- Tributaries and drainage ways were overgrown and blocked with exotic vegetation and sedimentation.
- Homes, important minor roads and collector roads were flooded in the area.
- Interviews with residents and other observers revealed high water marks and flow conditions during and after the hurricane event. A report indicated large flows from the River Hall development down overgrown natural flow ways causing yard flooding issues due to being an undeveloped drainage conveyance.

Bedman Creek Watershed Commentary:

This natural flow way receives a flow from the large developed community of Lehigh Acres. Lehigh Acres has a water management systems to control offsite discharge.

Observations and photograph reviews of the Bedman Creek were conducted and notations are listed as follows:

- The flow-way contains numerous trees and exotic vegetation that blocked the stream flow.

- Many homes have been constructed (pre-FEMA) in the floodway that limit flow capacity.
- Stream shoaling and sedimentation was observed in the lower reaches of the creek.
- Tributaries and drainage ways were overgrown and blocked with exotic vegetation and sedimentation.
- Homes and important minor roads and collector roads were flooded in the area.
- Interviews with residents and other observers revealed high water marks and flow conditions during and after the hurricane event.

Recommendations:

- Remove debris/sediment from flow-ways and drainage ways. See attached proposed Impediments to Storm Water Flow projects list.
- Remove low bridges, fences crossing the streams and other impediments to flow.
- Improve pipe and bridge capacity at road crossings.
- Post signs in areas of flooding advising residents of past flood levels.
- Establish a program such as the Hyacinth Control District to control exotics, such as, Brazilian pepper, Java Plum trees, bamboo, etc. that are adversely impacting flow-ways and drainage ways.
- Continue improvements with Lee County and LAMSID storm water control projects, such as West Marsh Preserve in the Orange River Watershed and other storage and conveyance improvements.
- Pursue Hazard Mitigation projects to better control extreme storm event flooding through the creation of marshes for storm runoff storage and high flow conveyance improvements that provide alternate routing around natural streams that become over loaded. See attached proposed long term hazard mitigation projects list.
- Consider the feasibility of raising homes in the affected areas above the FEMA flood levels to avoid repetitive flood damage.
- Assure that building officials limit further development in the flow-way that results in loss of hydraulic stream flow capacity.

Submitted by:
AIM ENGINEERING & SURVEYING, INC.



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Hurricane Irma Damages (Impediments to storm water flow)

HURRICANE IRMA DAMAGES (Impediments to storm water flow)				AIM Engineering & Surveying, Inc.		Department:		12/12/2018	
Rank	Date	Damaged Item/Facility/Element	Detailed Description of Damages (including quantity, size, measurements, material...)	Location/Address	LAT	LONG	\$ Cost	Opinion	Comments
1	12/14/2017	Hickey Creek	Remove Debris, Exotics / sediment	From SR 80 to Hickey Canal	26.7087592	-81.67197799	\$90,000	12 miles	
2	12/14/2017	Bedman Creek	Remove Debris, Exotics / sediment	Bedman Creek	26.6995338	-81.58916849	\$200,000	2.7 miles	
3	12/14/2017	Hickey Creek	Remove Debris, Exotics / sediment	From Harris Marsh to Bird Road	26.686575	-81.725385	\$300,000	3.5 Miles	
4	12/14/2017	Hickey Creek	Remove Debris, Exotics / sediment and pipe cleaning, Add pipe	0.96 miles south of SR 80 on Bateman RD	26.6985637	-81.65133812	\$20,000	Add 1 Large Pipe	
5	12/14/2017	Hickey Creek	Remove Debris, Exotics / sediment	Hickey Canal to Bateman Road	26.7027288	-81.65594188	\$105,000	1.3 miles	
6	12/14/2017	Nine Mile Run / Orange River W/S	Remove Debris, Exotics / sediment and pipe cleaning, Add Pipe	Buckingham Road at Lehigh to FGCU DMW	26.6399155	-81.7271251	\$120,000	1.4 miles + Pipe	
7	12/14/2017	Tributary to Orange River	Remove Debris, Exotics / sediment from tributary	5870 Buckingham Rd FMY 33905	26.6572906	-81.72889545	\$65,000	Hand clear natural flow way, 0.8 miles.	
8	12/14/2017	Tributary to Caloosahatchee (Olga W/S)	Pipe Cleaning	14821 Old Olga Rd FMY 33905	26.7158361	-81.71572923	\$5,000	Pipe Cleaning	
9	12/14/2017	FGCU DMW & Conn. (Orange River W/S)	Remove Debris, Exotics / sediment DMW 0.2 miles to east, Remove Debris, Exotics / sediment FGCU DMW 2.8 miles to west	5820 Buckingham Road, FMY 33905	26.6604588	-81.7316429	\$40,000	Heavy work to east, light work to west.	
10	12/14/2017	DMW to Orange River	Sediment Removal from ditch and cross-drain pipe	S. side convergence Luckett Ext (water gap)	26.656637	-81.771778	\$8,000	1LS	
11	12/14/2017	DMW to Orange River	Debris, Exotics & Sediment Removal N-S pipe W side cul-de-sac	Luckett and Staley Rds	26.665881	-81.775938	\$8,000	1LS	
12	12/14/2017	DMW to Orange River	Remove Debris, Exotics / sediment from natural flow way	4751 Neal Rd, FMY 33905	26.6756097	-81.75226556	\$8,000	0.1 miles to south	
13	12/14/2017	DMW to Caloosahatchee (Olga W/S)	Remove Debris, Exotics / sediment from DMW	1810 Werner Dr Alva 33920	26.7188229	-81.68813594	\$10,000	0.2 miles to north	
14	12/14/2017	Pipe crossing and DMW outfall connection (Orange River W/S)	Remove Debris, Exotics / sediment at conn. To FGCU DMW. Crossdrain should be upsized.	6231 Neal Road, FMY 33905	26.6533754	-81.75354202	\$15,000	1 Pipe upsized + 1 LS	
15	12/14/2017	Tributary to Caloosahatchee (Olga W/S)	Remove Debris, Exotics / sediment, pipe cleaning	14801 Old Olga Rd FMY 33905	26.718594	-81.71605512	\$15,000	0.1 miles to north	
16	12/14/2017	DMW to Orange River	Debris, Exotics & Sediment Removal W side ditch & x-drain pipe	Staley Rd ditches Luckett Rd to Tice St	26.663451	-81.775982	\$20,000	1.0 Miles to Tice St	
17	12/14/2017	DMW to Caloosahatchee (Olga W/S)	Remove Debris, Exotics / sediment from DMW	16401 Palm Beach Blvd Alva 33920	26.7154765	-81.68806294	\$20,000	0.4 miles to north	
18	12/14/2017	DMW to Orange River	Regrading DMW & re-piping-address water flow over rd	Cul-de-sac Luckett Rd water back up Staley	26.666712	-81.775786	\$35,000	0.3 Miles + Pipe	
19	12/14/2017	DMW to Orange River	Debris, Exotics and Sediment Removal DMW pipe (upsized pipe)	Staley Farms Rd	26.654865	-81.773771	\$40,000	0.4 Miles + Pipe	
20	12/14/2017	DMW to Orange River	Remove Debris, Exotics / sediment and reset pipe	12200 Homestead Rd, FMY 33905	26.6711875	-81.77200842	\$50,000	0.5 to the north, remove fence	
21	12/14/2017	Tributary to Caloosahatchee (Olga W/S)	Remove Debris, Exotics / sediment from natural flow way	14651 Palm Beach Blvd FMY 33905	26.7103884	-81.77732212	\$50,000	0.6 miles to north	
22	12/14/2017	Tributary to Caloosahatchee (Olga W/S)	Remove Debris, Exotics / sediment from natural flow way	2395 S Olga Dr, FMY 33905	26.7120572	-81.71076074	\$70,000	0.3 miles to south, 0.6 miles to north	
23	12/14/2017	DMW to Orange River	Restore outfall ditch	N. side of Luckett Rd Ext. at end Co. Maint	26.666718	-81.77717121	\$90,000	1.0 Miles to Homestead Road	
24	12/14/2017	DMW to Orange River	Remove Debris, Exotics / sediment to North	Tice power line ditch at Orange River Blvd	26.6805019	-81.78255577	\$100,000	0.9 Miles + 1LS	
25	12/14/2017	DMW to Orange River	Remove Debris, Exotics / sediment from DMW	12240 Orange River Blvd, FMY 33905	26.6788715	-81.77220188	\$200,000	1.4 Miles DMW + 2 Pipe Upsize	
26	12/14/2017	Orange River	Sediment Removal	From Harris Marsh to Bird Road	26.6780102	-81.73674513	\$200,000	0.8 Miles	
27	12/14/2017	Orange River	Scour at Bridge	Buckingham Rd Bridge	26.67023	-81.731951	\$20,000	1LS	
28	12/14/2017	Orange River	Shoaling Removal	DMW discharge near Ellis Road	26.691658	-81.778831	\$100,000	1LS	
29	12/14/2017	DMW to Orange River	Remove Debris, Exotics / sediment	14711 Orange River Rd, FMY 33905	26.657248	-81.717254	\$25,000	0.3 miles to north	
30	12/14/2017	Natural Flow Way to Hickey Creek	Improve Flow/Way, Remove Debris, Exotics / sediment, add Pipes	17300 Frank Rd Alva 33920	26.708048	-81.675329	\$90,000	0.5 miles S Hickey Ck-River Hall + Pipes	
31	12/14/2017	Flowway to Orange River	Improve Flow/Way, Remove Debris, Exotics / sediment, add Pipes	5440 Jackson Rd, FMY 33905	26.694822	-81.703405	\$95,000	0.7 miles to south + Pipes	
32	12/14/2017	DMW to Hickey Creek	Remove Debris, Exotics / sediment from DMW	0.68 miles south of SR 80 on Bateman RD	26.702629	-81.6514873	\$60,000	0.3 miles to west	
33	12/14/2017	Tributary to Hickey Creek	Remove Debris, Exotics / sediment, Pipe Cleaning, Add pipe	0.45 miles south of SR 80 on Bateman RD	26.7058852	-81.65152279	\$90,000	0.5 miles to west + 1 Pipe	
34	12/14/2017	PL DMW to Orange River	Remove Debris, Exotics / sediment to northeast	5121 Country Lakes Drive FMY 33905	26.6693079	-81.79217488	\$15,000	0.2 Miles	
35	12/14/2017	Tributary to Caloosahatchee Bedman W/S	Remove Debris, Exotics / sediment from natural flow way	12111 Palm Beach Blvd Alva 33920	26.7067207	-81.60544895	\$30,000	0.15 miles to north, 0.2 miles to south	
36	12/14/2017	Natural flow way to Orange River	Remove Debris, Exotics, fence / sediment from natural flow way	4790 Higginbotham Rd, FMY 33905	26.6750429	-81.74387408	\$35,000	0.3 miles to south + 1 Pipe	
37	12/14/2017	Tributary to Orange River	Remove Debris, Exotics / sediment from natural flow way	Northwest corner of Orange Loop Rd	26.668743	-81.75105577	\$55,000	0.2 Miles to north, 0.5 Miles to south	
38	12/14/2017	PL DMW to Orange River	Remove Debris, Exotics / sediment to north	5342 Tice St, FMY 33905	26.6710082	-81.79008885	\$65,000	0.8 Miles	
39	12/14/2017	Tributary to Orange River	Remove Debris, Exotics / sediment and pipe cleaning	12241 Coyle Rd FMY 33905	26.6694811	-81.75942007	\$90,000	0.06 miles to north, 1 mile to south	
40	12/14/2017	Tributary to Orange River	Remove Debris, Exotics / sediment from natural flow way	13731 Bird Rd FMY 33905	26.6873905	-81.73204366	\$75,000	0.7 Miles to west + 3 Pipe work	

Conceptual Long Term Projects for Hazard Mitigation

Orange River

- Buckingham Trail 20-20 Marsh on Nine Mile Run –storage improvement
- Buckingham Bypass Flow-way with stepped marshes –conveyance/storage improvement
- Orange River parallel lakes –conveyance improvement
- Extend Orange River Blvd. to east ½ miles for access during flooding –transportation improvement
- Mirror Lakes Golf Course SW ¼ of Sec 15-45-27 conversion to marsh –storage improvement

Hickey Creek

- Flood-way diversion to Caloosahatchee River (Ext. of Hickey Canal) –conveyance improvement
- Lehigh Section 10 Marsh-flood water reservoir (Previous 20-20 applicant) –storage improvement
- Hickey Creek Mitigation Park marsh/reservoir –storage improvement
- River Hall Drainage way Connections –conveyance improvement

Bedman Creek

- Dog to Carlos Canal Flood Diversion Channel (Previous 20-20 applicant) –conveyance improvement
- Dog to Hendry Canal Sec 19-44-28 Hendry Co Marsh/water diversion –storage/conveyance imps.

Olga Watershed

- Hickey Swamp Outfall for River Hall flood water diversion –conveyance improvement

HURRICANE IRMA POST STORM INVESTIGATION:

EXHIBITS

A – Location Map / Lidar Map

B – FEMA Flood Map

C – Rainfall

D – NOAA Precipitation Frequency Prediction

E – Caloosahatchee River Stages (NGVD)

F – Water Surface Profiles

(Using the Johnson Engineering 1992 Watershed Study for Lee County, the approximate Hurricane Irma Flood Levels and FEMA Base Flood Elevation Line were added. All data was adjusted to NAVD '88)

- 1- Orange River
- 2- Hickey Creek
- 3- Bedman Creek

Note: Approximate Hurricane Irma Flood Levels were determined from high water marks in the field using RTK GPS methods with an expected accuracy of +/- 0.3 feet.

APPENDIXES

A – Citizen's Questionnaires

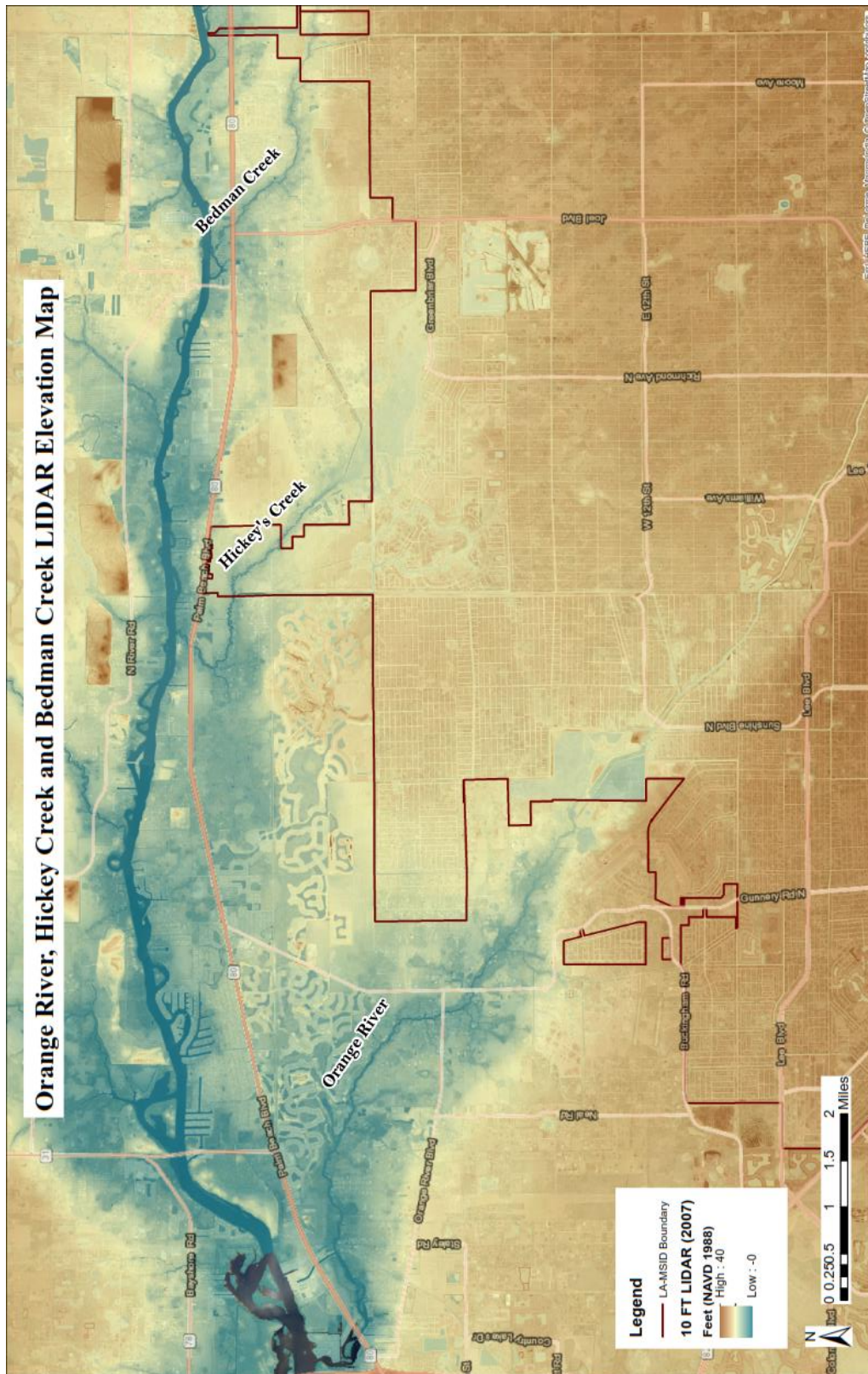


Exhibit "B"

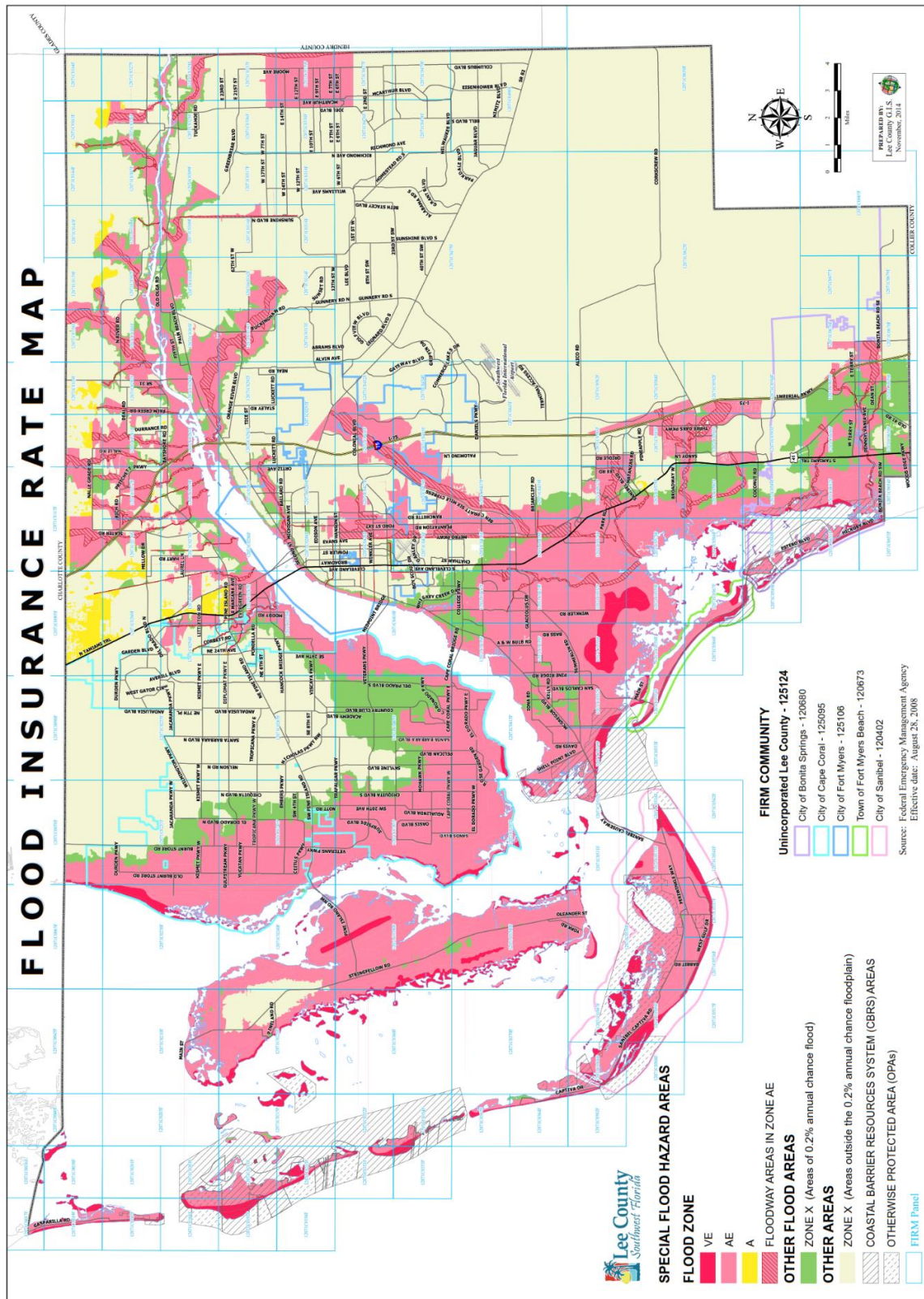


Exhibit "C"

Rainfall:

Rainfall Amount - Inches per Hour			
Date: Sunday, September 10, 2017			
Hour	Location		
	G-RG-1	G-RG-2	S-H-3
12:00 AM	0.06	0.02	0.99
1:00 AM	0.02	0.03	0.01
2:00 AM	0.1	0.18	0.09
3:00 AM	0.04	0.05	0.1
4:00 AM	0.03	0.04	0.06
5:00 AM	0.1	0.16	0.05
6:00 AM	0.62	1.09	0.24
7:00 AM	0.19	0.14	0.37
8:00 AM	0.16	0.17	0.13
9:00 AM	0.71	0.5	0.25
10:00 AM	0.19	0.22	0.58
11:00 AM	0.54	0.37	0.24
12:00 PM	0.31	0.22	0.34
1:00 PM	0.47	0.36	0.23
2:00 PM	1.35	1.17	0.44
3:00 PM	1.6	1.12	1.01
4:00 PM	0.98	0.79	1.02
5:00 PM	1.36	0.55	1.02
6:00 PM	7.66	3.56	0.59
7:00 PM	0.94	2.25	0.79
8:00 PM	0.02	0.07	3.55
9:00 PM	0	0	3.17
10:00 PM	0	0	0.12
11:00 PM	0	0	0.04
TOTAL	17.45"	13.06"	15.43"

Source: LAMSID Rainfall Gauges

Exhibit "D"

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches) ¹											
Duration	Average recurrence interval (years)										
	1	2	5	10	25	50	100	200	500	1000	
5-min	0.550(0.457-0.670)	0.618(0.513-0.754)	0.729(0.603-0.893)	0.821(0.675-1.01)	0.947(0.748-1.21)	1.04(0.804-1.36)	1.14(0.845-1.53)	1.23(0.875-1.72)	1.36(0.924-1.97)	1.46(0.982-2.15)	
10-min	0.805(0.650-0.981)	0.905(0.751-1.10)	1.07(0.853-1.31)	1.20(0.988-1.48)	1.38(1.10-1.77)	1.53(1.18-1.99)	1.67(1.24-2.24)	1.81(1.28-2.52)	1.99(1.35-2.88)	2.13(1.41-3.15)	
15-min	0.982(0.815-1.20)	1.10(0.916-1.35)	1.30(1.08-1.60)	1.47(1.21-1.81)	1.69(1.34-2.16)	1.86(1.42-2.42)	2.03(1.51-2.73)	2.20(1.56-3.07)	2.43(1.65-3.51)	2.60(1.72-3.84)	
30-min	1.56(1.30-1.91)	1.78(1.46-2.14)	2.07(1.71-2.53)	2.33(1.91-2.87)	2.68(2.12-3.43)	2.96(2.35-3.85)	3.23(2.40-4.34)	3.50(2.48-4.88)	3.86(2.63-5.58)	4.13(2.73-6.11)	
60-min	2.08(1.73-2.54)	2.32(1.93-2.83)	2.72(2.25-3.33)	3.05(2.51-3.76)	3.52(2.79-4.50)	3.88(2.95-5.06)	4.24(3.15-5.71)	4.61(3.28-6.44)	5.11(3.48-7.40)	5.49(3.63-8.12)	
2-hr	2.60(2.17-3.15)	2.89(2.41-3.50)	3.37(2.80-4.10)	3.78(3.12-4.62)	4.35(3.47-5.54)	4.80(3.73-6.23)	5.28(3.95-7.04)	5.73(4.09-7.95)	6.36(4.36-9.15)	6.85(4.55-10.1)	
3-hr	2.83(2.37-3.41)	3.15(2.63-3.80)	3.69(3.07-4.47)	4.15(3.44-5.06)	4.81(3.84-6.10)	5.33(4.15-6.89)	5.86(4.40-7.83)	6.42(4.60-8.88)	7.17(4.93-10.3)	7.76(5.18-11.4)	
6-hr	3.15(2.65-3.77)	3.58(3.01-4.30)	4.32(3.62-5.21)	4.96(4.13-6.01)	5.88(4.73-7.44)	6.61(5.19-8.52)	7.37(5.57-9.81)	8.17(5.90-11.3)	9.26(6.41-13.2)	10.1(6.80-14.7)	
12-hr	3.43(2.90-4.08)	4.05(3.43-4.83)	5.12(4.31-6.13)	6.05(5.06-7.28)	7.38(5.98-9.31)	8.46(6.67-10.9)	9.57(7.27-12.7)	10.7(7.81-14.7)	12.4(8.61-17.6)	13.6(9.22-19.7)	
24-hr	3.91(3.33-4.63)	4.62(3.92-5.47)	5.87(4.96-6.97)	6.99(5.88-8.35)	8.68(7.08-10.9)	10.07(8.29-12.9)	11.5(8.82-15.2)	13.1(9.60-17.9)	15.3(10.8-21.7)	17.1(11.7-24.6)	
2-day	4.73(4.04-5.56)	5.38(4.59-6.33)	6.60(5.61-7.79)	7.75(6.55-9.20)	9.56(7.90-12.1)	11.1(8.93-14.2)	12.8(9.92-16.9)	14.7(10.9-20.1)	17.4(12.4-24.6)	19.7(13.5-28.1)	
3-day	5.23(4.46-6.12)	6.02(5.15-7.05)	7.44(6.34-8.74)	8.74(7.41-10.3)	10.7(8.85-13.4)	12.4(9.95-15.7)	14.2(11.0-18.6)	16.1(11.9-21.9)	18.9(13.4-26.5)	21.1(14.5-30.0)	
4-day	5.66(4.86-6.60)	6.56(5.63-7.67)	8.15(6.96-9.55)	9.56(8.12-11.3)	11.8(9.61-14.5)	13.4(10.7-16.9)	15.2(11.8-19.8)	17.2(12.7-23.1)	19.9(14.2-27.8)	22.1(15.2-31.3)	
7-day	6.93(5.98-8.05)	7.92(6.82-9.20)	9.81(8.25-11.2)	11.1(9.46-13.0)	13.2(11.0-16.3)	15.0(12.1-18.7)	16.8(13.1-21.7)	18.7(13.9-25.0)	21.4(15.3-29.6)	23.5(16.3-33.1)	
10-day	8.12(7.02-9.39)	9.13(7.88-10.6)	10.8(9.35-12.6)	12.3(10.5-14.4)	14.5(12.0-17.6)	16.2(13.1-20.1)	17.9(14.0-23.0)	19.8(14.6-26.3)	22.4(16.0-30.8)	24.4(17.0-34.2)	
20-day	11.5(9.99-13.2)	12.7(11.0-14.6)	14.6(12.1-16.9)	16.2(13.9-18.8)	18.4(16.3-22.1)	20.1(16.3-24.6)	21.8(17.0-27.6)	23.4(17.6-30.8)	25.6(18.5-34.9)	27.3(19.1-38.1)	
30-day	14.3(12.5-16.4)	15.7(13.7-18.0)	18.0(15.6-20.7)	19.8(17.1-22.9)	22.2(18.4-26.6)	23.9(19.4-29.2)	25.6(20.1-32.2)	27.2(20.4-36.5)	29.3(21.1-39.5)	30.7(21.6-42.6)	
45-day	17.9(15.6-20.4)	19.7(17.2-22.5)	22.5(19.6-25.8)	24.7(21.4-28.4)	27.4(22.8-32.5)	29.4(23.8-35.5)	31.2(24.5-38.9)	32.8(24.7-42.5)	34.7(25.1-46.6)	36.0(25.4-49.8)	
60-day	20.9(18.3-23.8)	23.1(20.2-26.3)	26.5(23.1-30.2)	29.0(25.2-33.3)	32.2(26.8-37.9)	34.4(28.0-41.4)	36.3(28.6-45.2)	38.1(28.7-48.1)	40.1(29.0-53.6)	41.3(29.3-57.0)	

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parentheses are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in CSV format

Main Link Categories:
[Home](#) | [OWP](#)

Precipitation frequency estimates

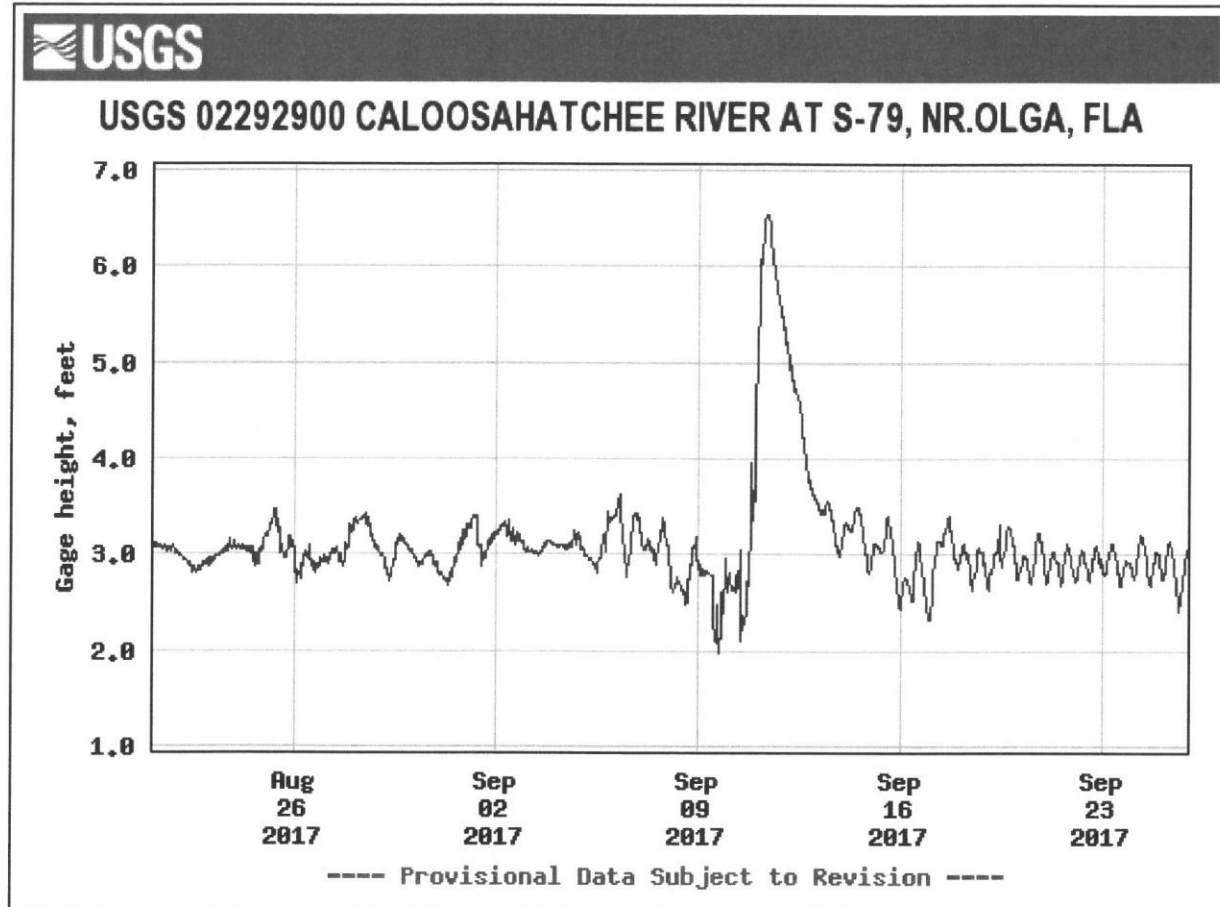
Submit

US Department of Commerce,
National Oceanic and Atmospheric Administration,
National Weather Service,
Office of Water Prediction (OWP),
1325 East West Highway
Silver Spring, MD 20910
Page Author: [HOSC webmaster](#)
Page last modified: April 21, 2017

Map Disclaimer,
Disclaimer,
Credits,
Glossary

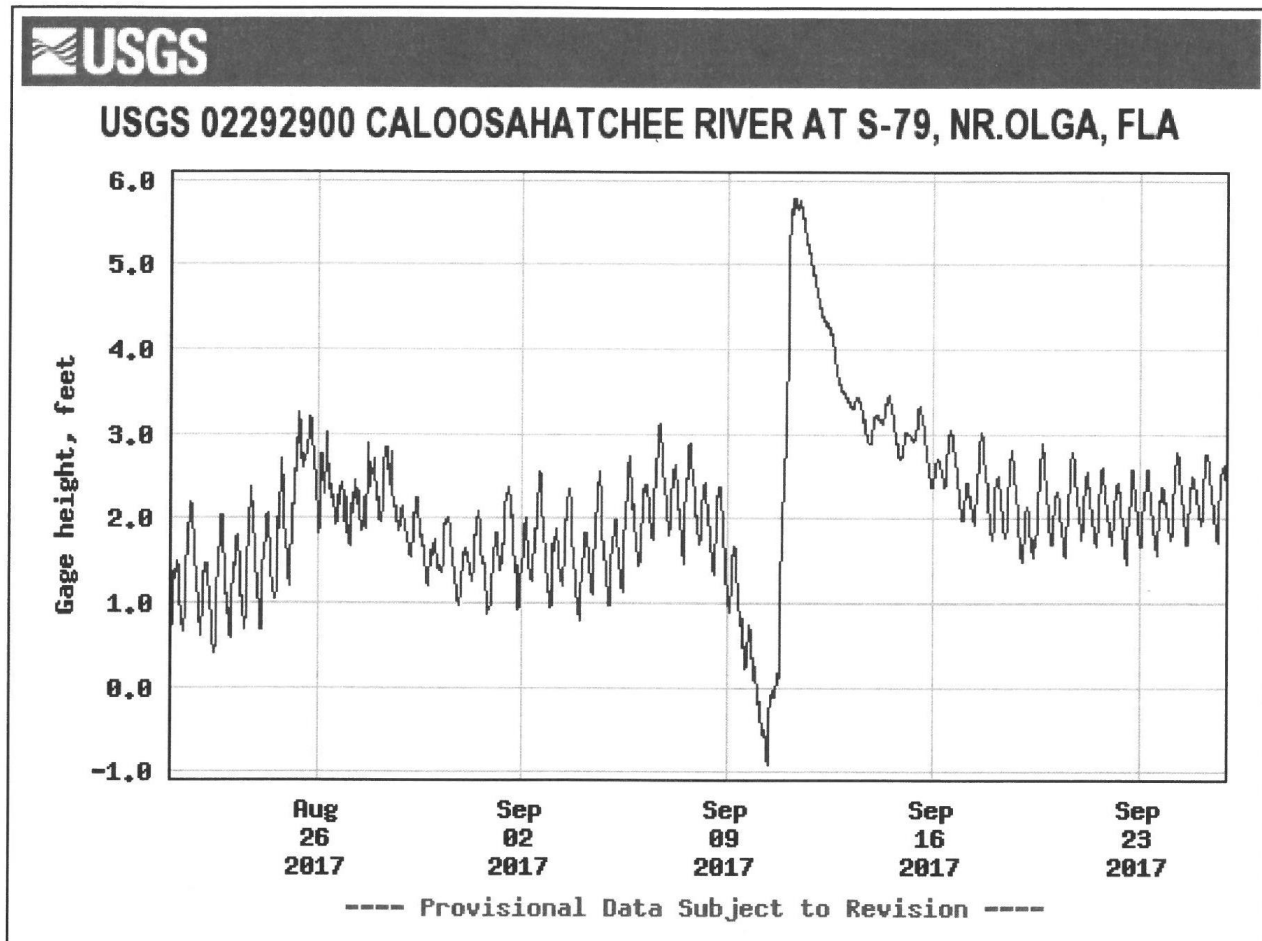
Privacy Policy,
About Us,
Career Opportunities

Exhibit "E-1"



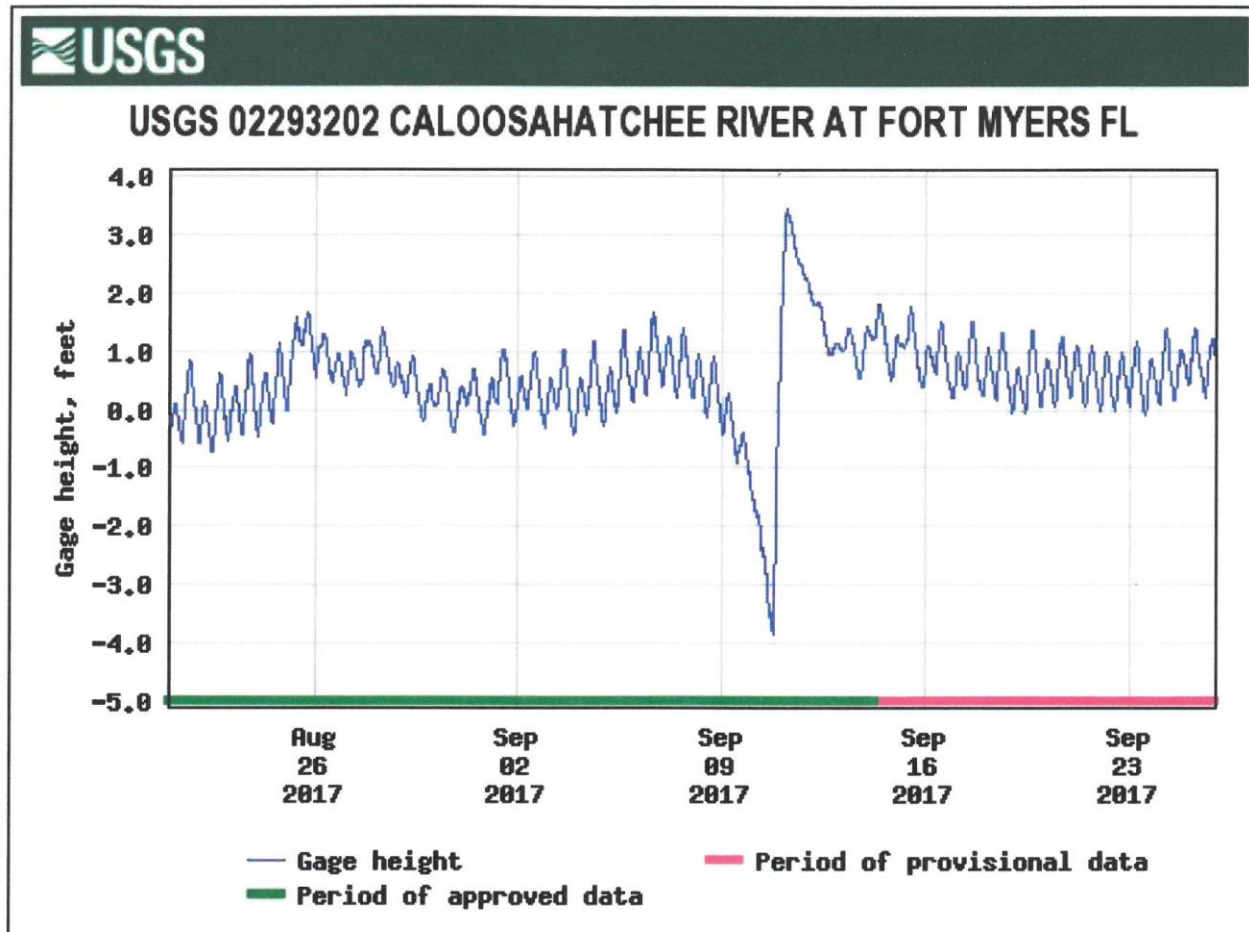
Olga Locks – Upstream Stage (NGVD)

Exhibit "E-2"

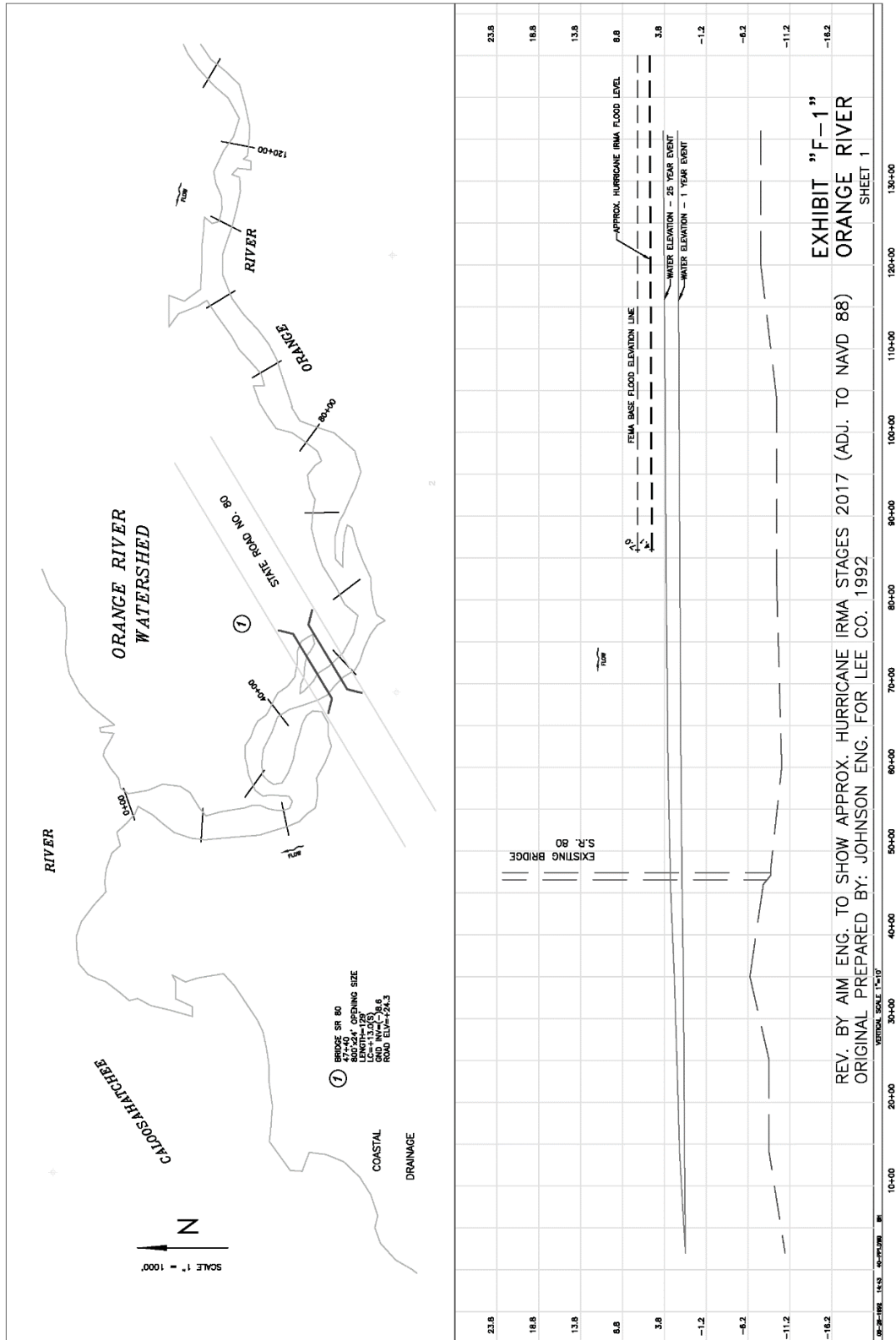


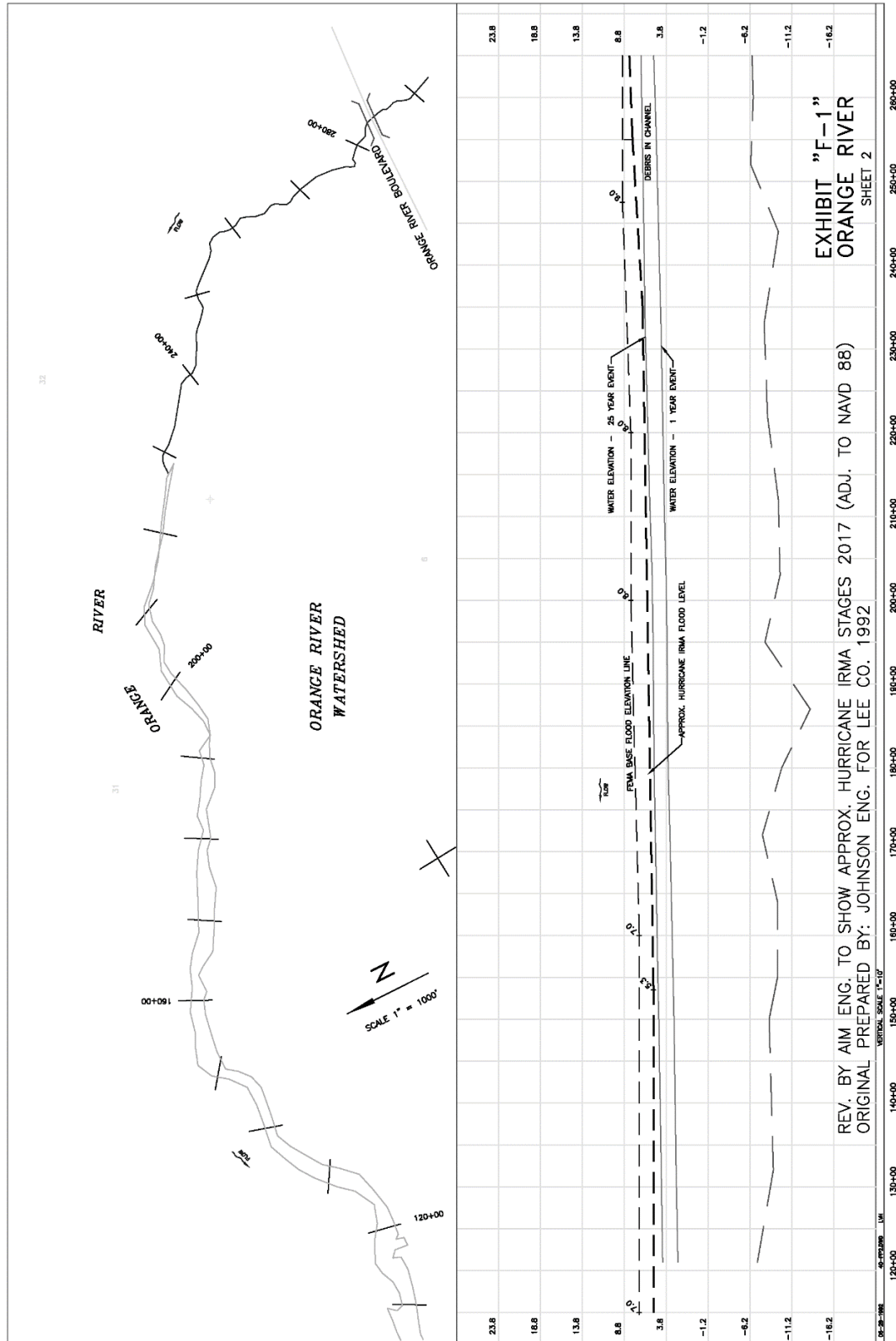
Olga Locks – Downstream Stage (NGVD)

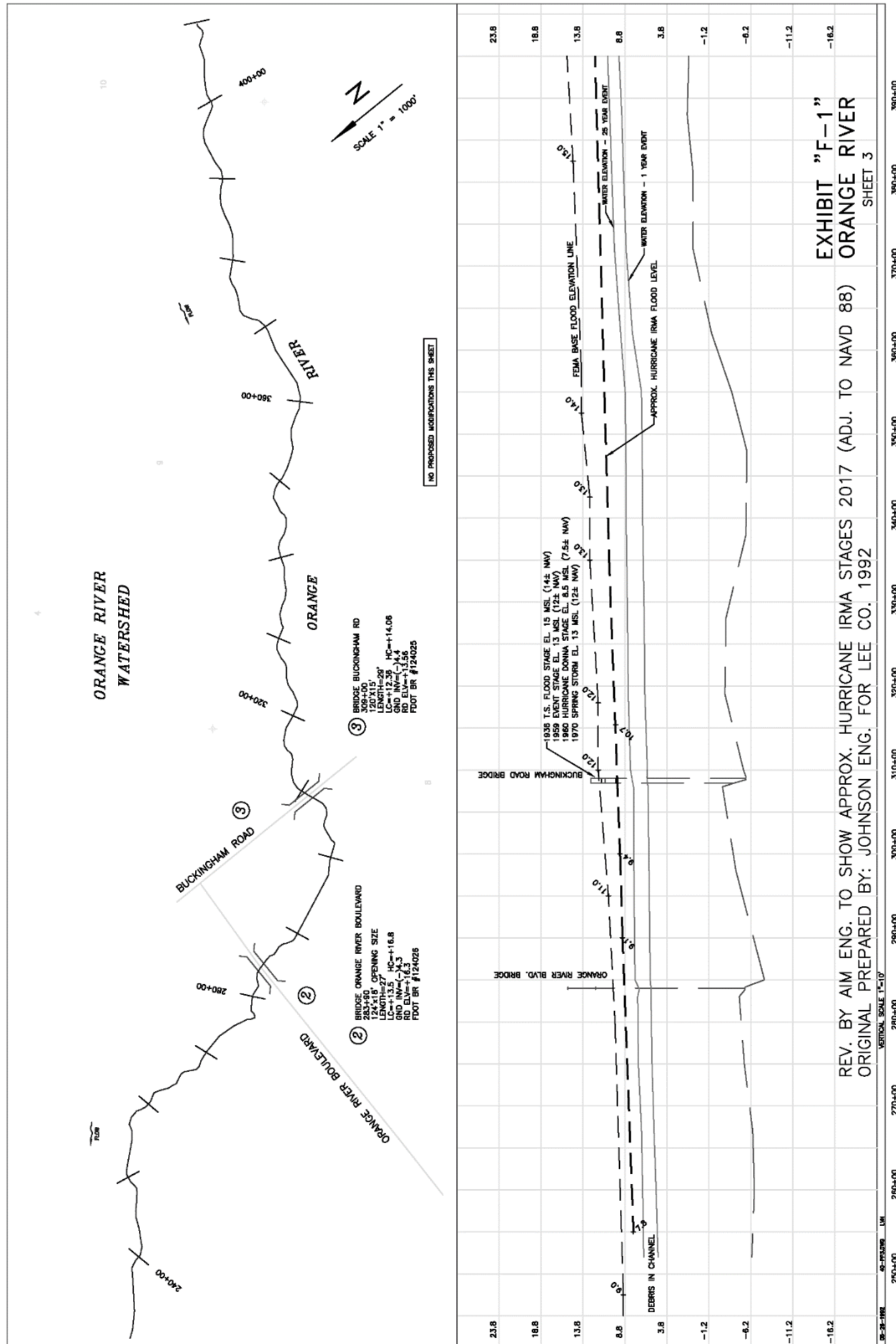
Exhibit "E-3"

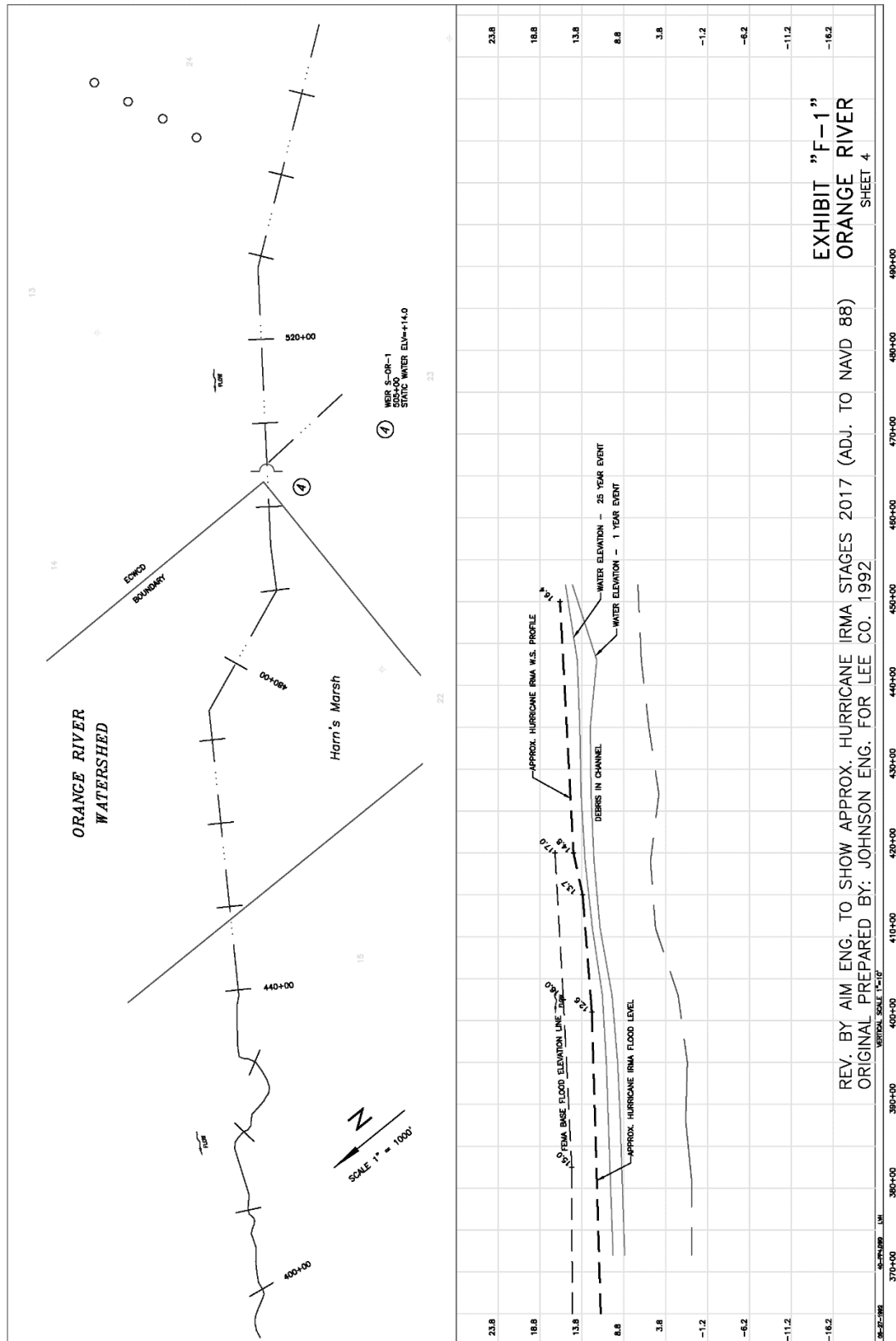


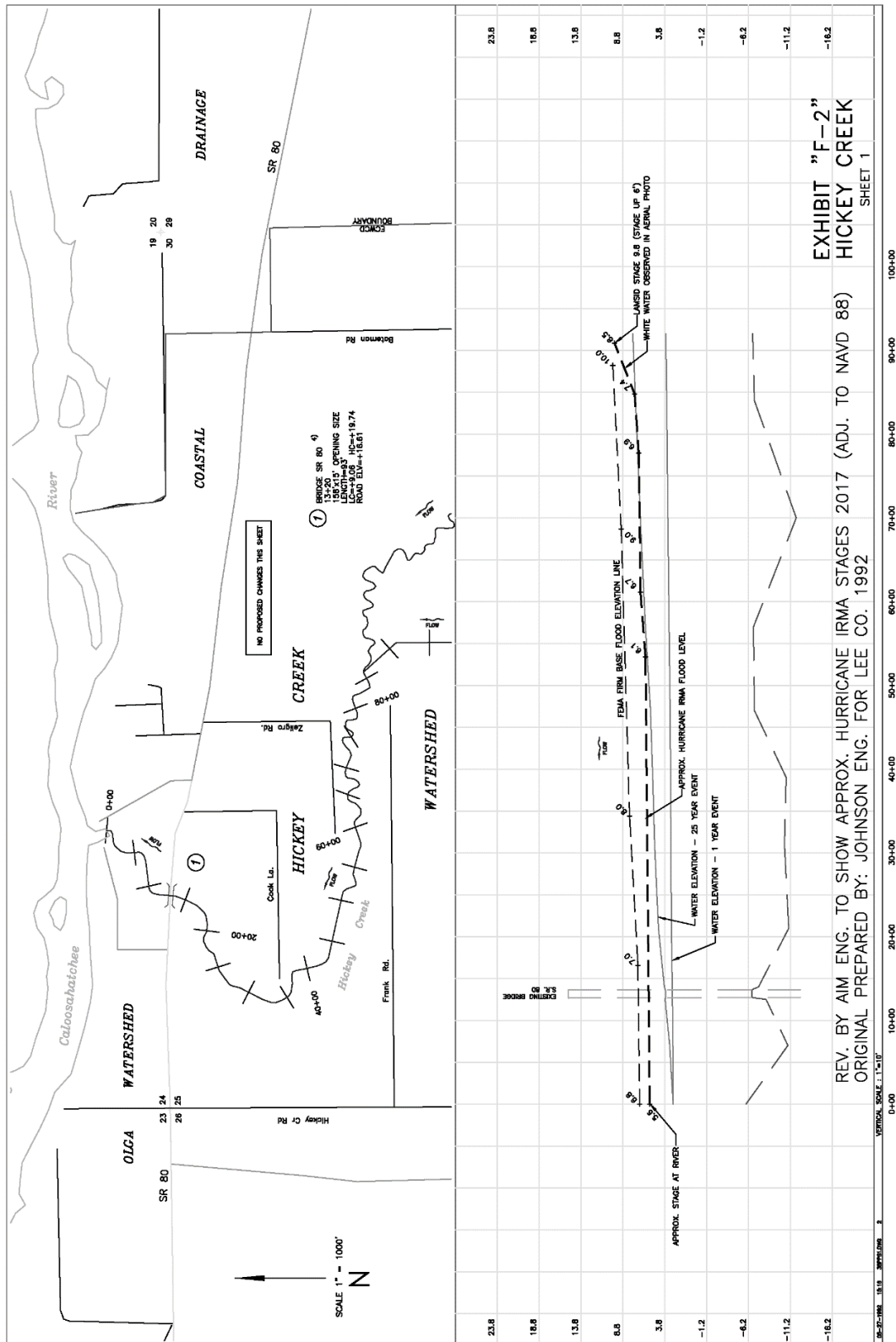
Downstream Fort Myers – Stage (NGVD)

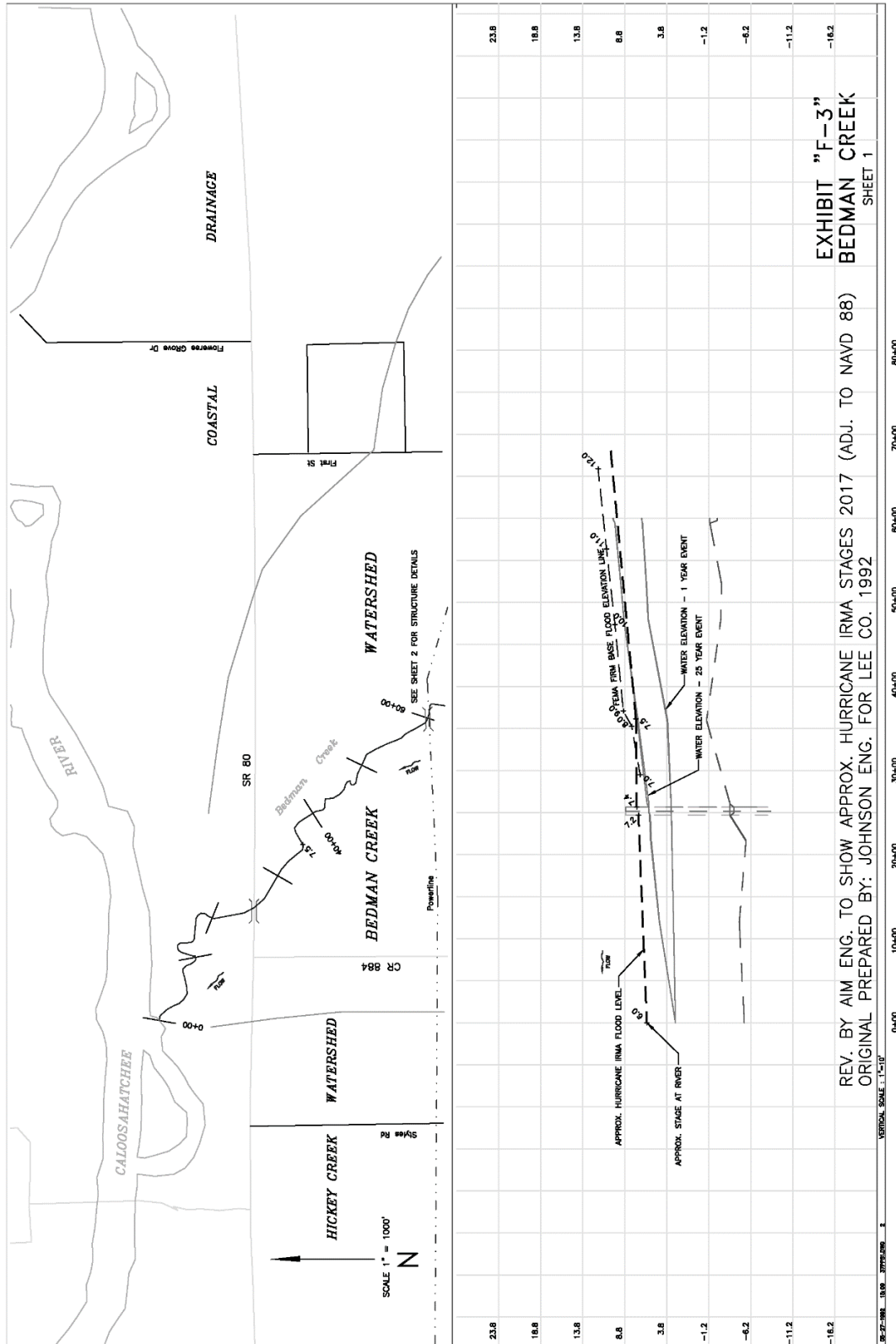


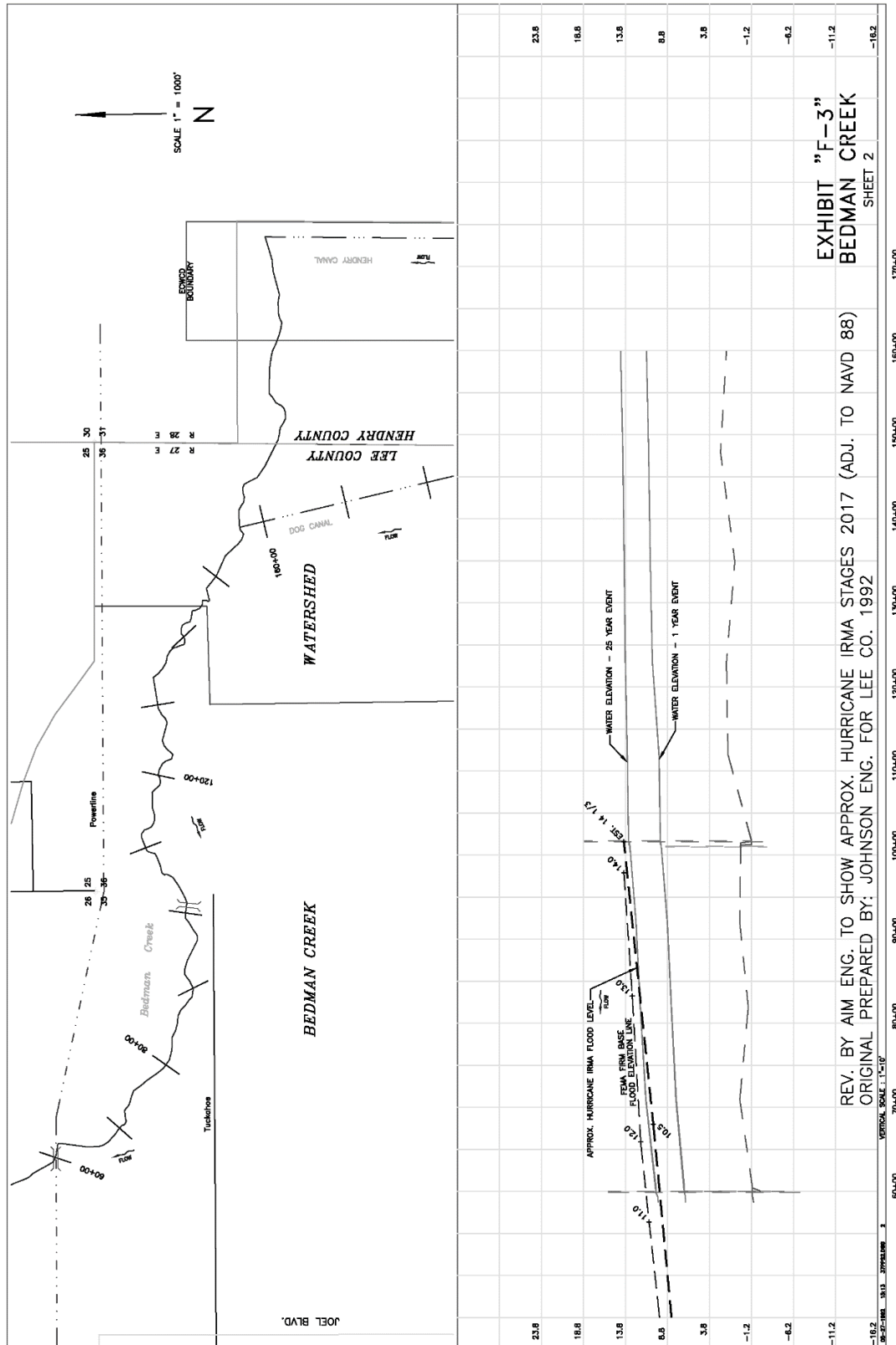












Appendix A Citizen's Questionnaires

Hurricane Irma Post Storm Investigation

February 28, 2018

Public Flooding Questionnaire: 22861 Tuckahoe Rd.

I want to: Sign up for email and fill out the flooding questionnaire because I experienced flooding during the August 25-27 Rain Event or Hurricane Irma (September 10)

Email christopherjsex@leeschools.net

Property owner or renter? Property Owner

Name Chris Sexton

Phone number

City Alva

How many years at this address 26

Were you flooded during the August 25-27 Rain Event? No

Did you stay at the property during the August 25-27 Rain Event?

Aug High Water Date

Time of high water

Aug High Water Date observed

Time of high water observation

Is this the highest you have seen the water level?

Historic water level comments

Did your house flood during the August 25-27 Rain Event?

How deep was the water in your house?

How many days did water remain in your house?

Did your property flood during the August 25-27 Rain Event?

On average how deep was the water on your property?

How many days did water remain on your property?

Owner/Renter summary of August 25-27 flooding experience

Do you have any photos of the August 25-27 flooding?

Were you flooded during Hurricane Irma (September 10)? Yes

Did you stay at the property during Hurricane Irma? Yes

Irma high water date

Time of high water

Irma high water date observed

Time of high water observation

Yes

Hurricane Irma Post Storm Investigation

February 28, 2018

Is this the highest you have seen the water level?

Historic water level comments

Did your house flood during Hurricane Irma? Yes

How deep was the water in your house? >12 inches

How many days did water remain in your house? 4

Did your property flood during Hurricane Irma? Yes

On average how deep was the water on your property? >4 feet

How many days did water remain on your property? 6

How many feet away was the water to your home? 0-10 feet

Owner/Renter summary of Hurricane Irma flooding experience

Do you have any photos of Hurricane Irma flooding? Yes

Attachments:

- No attachments found



Hurricane Irma Post Storm Investigation

February 28, 2018

Public Flooding Questionnaire: 17521 oak creek road

I want to: Sign up for email and fill out the flooding questionnaire because I experienced flooding during the August 25-27 Rain Event or Hurricane Irma (September 10)

Email

Property owner or
renter?

Name

Phone number

City alva

How many years at this
address 19

Were you flooded during
the August 25-27 Rain
Event? No

Did you stay at the
property during the
August 25-27 Rain
Event?

Aug High Water Date

Time of high water

Aug High Water Date
observed

Time of high water
observation

Is this the highest you
have seen the water
level?

Historic water level
comments

Did your house flood
during the August 25-27
Rain Event?

How deep was the water
in your house?

How many days did
water remain in your
house?

Did your property flood
during the August 25-27
Rain Event?

On average how deep
was the water on your
property?

How many days did
water remain on your
property?

Owner/Renter summary
of August 25-27
flooding experience

Hurricane Irma Post Storm Investigation

February 28, 2018

Do you have any photos
of the August 25-27
flooding?

Were you flooded during Yes
Hurricane Irma
(September 10)?

Did you stay at the Yes
property during
Hurricane Irma?

Irma high water date sep 11

Time of high water 12:00

Irma high water date
observed

Time of high water
observation

Is this the highest you Yes
have seen the water
level?

Historic water level
comments

Did your house flood No
during Hurricane Irma?

How deep was the water
in your house?

How many days did
water remain in your
house?

Did your property flood Yes
during Hurricane Irma?

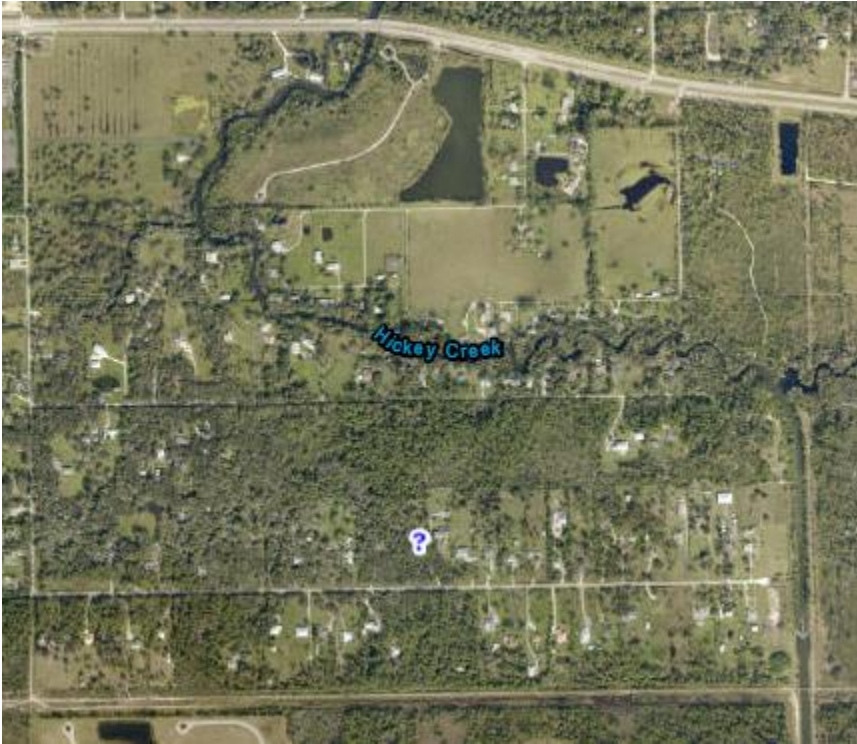
On average how deep 2 feet
was the water on your
property?

How many days did >7
water remain on your
property?

How many feet away >20 feet
was the water to your
home?

Owner/Renter summary Source of flooding was pinpointed to culvert installed through FPL ROW and swale cut through the
of Hurricane Irma ROW--North of River Hall Property. Culvert was not permitted by Lee Co. or SFWMD. Swale cut was
flooding experience not permitted by Lee Co. or SFWMD. Water remained for greater than 21 days(this was double the flood
of 1943 and 1944--worst flood Lee Co. has ever experienced) The Aug rain event is normal for this time
of year--it is NOT out of the ordinary

Do you have any photos Yes
of Hurricane Irma
flooding?



Hurricane Irma Post Storm Investigation

February 28, 2018

Public Flooding Questionnaire: 14041 Cemetery Road

I want to: Sign up for email and fill out the flooding questionnaire because I experienced flooding during the August 25-27 Rain Event or Hurricane Irma (September 10)

Email: Julierz@centurylink.net

Property owner or renter? Property Owner

Name: Julie Zatkovich

Phone number: 239-851-3795

City: Ft Myers

How many years at this address: 27

Were you flooded during the August 25-27 Rain Event? No

Did you stay at the property during the August 25-27 Rain Event?

Aug High Water Date

Time of high water

Aug High Water Date observed

Time of high water observation

Is this the highest you have seen the water level?

Historic water level comments

Did your house flood during the August 25-27 Rain Event?

How deep was the water in your house?

How many days did water remain in your house?

Did your property flood during the August 25-27 Rain Event?

On average how deep was the water on your property?

How many days did water remain on your property?

Owner/Renter summary of August 25-27 flooding experience

Do you have any photos of the August 25-27 flooding?

Were you flooded during Hurricane Irma (September 10)? Yes

Did you stay at the property during Hurricane Irma? Yes

Irma high water date: 9/11/17

Time of high water: Started rising 0600

Irma high water date observed

Time of high water observation

Is this the highest you have seen the water level? Yes

Hurricane Irma Post Storm Investigation February 28, 2018

Historic water level comments

Did your house flood during Hurricane Irma? **Yes**

How deep was the water in your house? **>12 inches**

How many days did water remain in your house? **4**

Did your property flood during Hurricane Irma? **Yes**

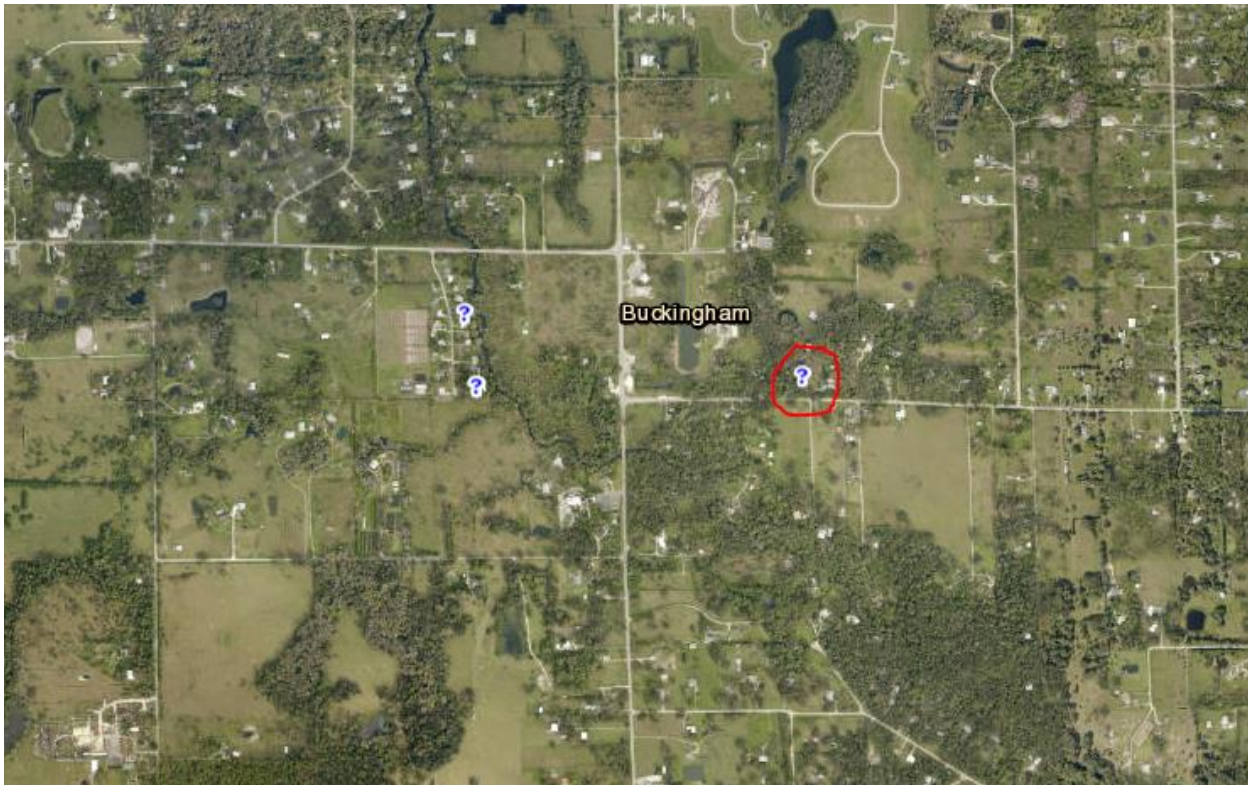
On average how deep was the water on your property? **>4 feet**

How many days did water remain on your property? **>7**

How many feet away was the water to your home? **0-10 feet**

Owner/Renter summary of Hurricane Irma flooding experience **Man made disaster rather than act of God**

Do you have any photos of Hurricane Irma flooding? **Yes**



Hurricane Irma Post Storm Investigation

February 28, 2018

Public Flooding Questionnaire: 4851 Shady River Lane

I want to: Sign up for email and fill out the flooding questionnaire because I experienced flooding during the August 25-27 Rain Event or Hurricane Irma (September 10)

Email fecrowley@comcast.net

Property owner or renter? Property Owner

Name Domnick and Frances Minella

Phone number 239-851-0287

City Fort Myers

How many years at this address 13

Were you flooded during the August 25-27 Rain Event? No

Did you stay at the property during the August 25-27 Rain Event?

Aug High Water Date

Time of high water

Aug High Water Date observed

Time of high water observation

Is this the highest you have seen the water level?

Historic water level comments

Did your house flood during the August 25-27 Rain Event?

How deep was the water in your house?

How many days did water remain in your house?

Did your property flood during the August 25-27 Rain Event?

On average how deep was the water on your property?

How many days did water remain on your property?

Owner/Renter summary of August 25-27 flooding experience

Hurricane Irma Post Storm Investigation

February 28, 2018

Do you have any photos
of the August 25-27
flooding?

Were you flooded
during Hurricane Irma
(September 10)?

Yes

Did you stay at the
property during
Hurricane Irma?

No

Irma high water date

Time of high water

Irma high water date
observed

9/15/17

Time of high water
observation

9:00 AM

Is this the highest you
have seen the water
level?

Yes

Historic water level
comments

Did your house flood
during Hurricane Irma?

Yes

How deep was the
water in your house?

>12 inches

How many days did
water remain in your
house?

5

Did your property flood
during Hurricane Irma?

Yes

On average how deep
was the water on your
property?

>4 feet

How many days did
water remain on your
property?

>7

How many feet away
was the water to your
home?

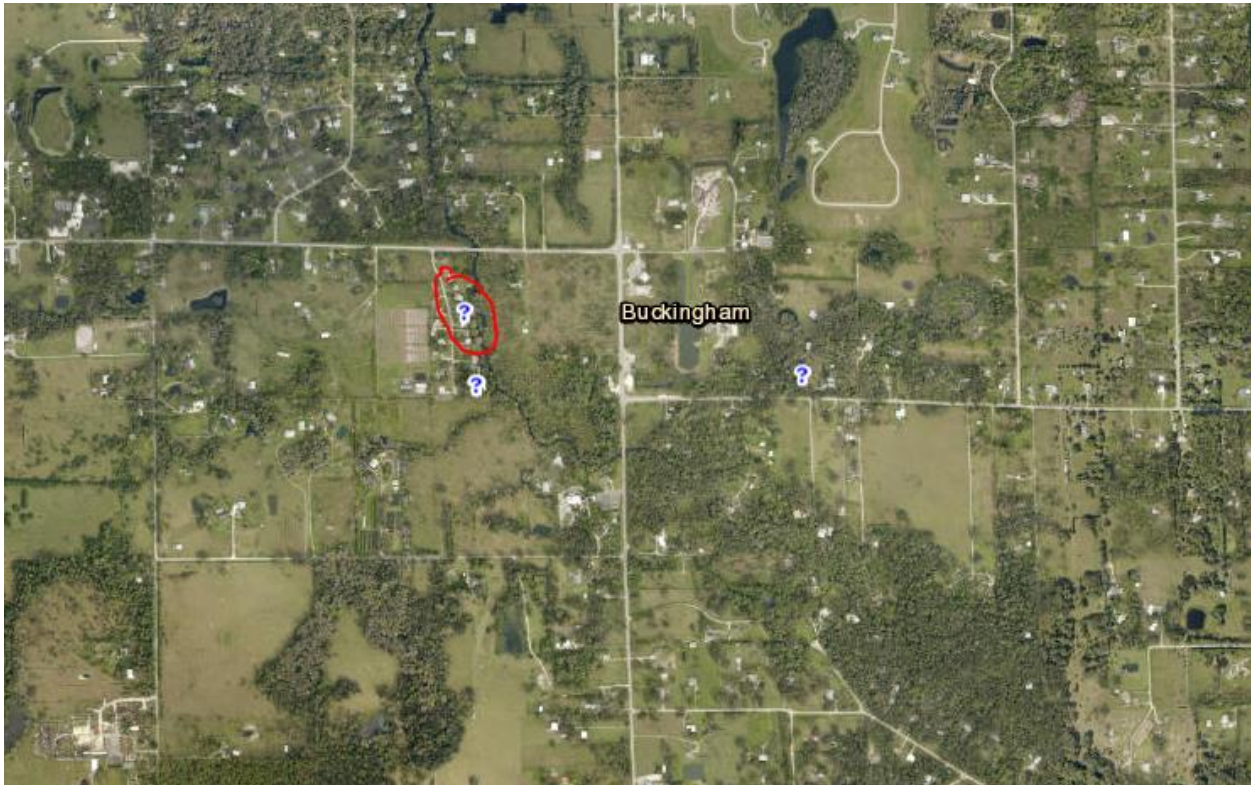
0-10 feet

Owner/Renter summary
of Hurricane Irma
flooding experience

WE left the area on 9/7/17 and returned on 9/15/17. WE could not return down our street till 9/15/17. Our neighbors stayed in their home during Hurricane Irma and took pictures for us after the Hurricane. We had 24 inches of water in the home and over 42 inches outside the home. Our home has never flooded since it was built in the 1960s. Not only the experience of losing most of everything we own (a home that was featured in the Grandeur magazine); but the experience dealing with Insurance providers, FEMA, and now Wells Fargo holding our reimbursement check has been the worst experience.

Do you have any photos
of Hurricane Irma
flooding?

Yes



Hurricane Irma Post Storm Investigation

February 28, 2018

Public Flooding Questionnaire: 4931 Shady River Lane

I want to: Sign up for email and fill out the flooding questionnaire because I experienced flooding during the August 25-27 Rain Event or Hurricane Irma (September 10)

Email: bill@burdetteinc.com

Property owner or renter? Property Owner

Name: Bill Burdette

Phone number: 239-936-1404

City: Buckingham

How many years at this address: 34

Were you flooded during the August 25-27 Rain Event? No

Did you stay at the property during the August 25-27 Rain Event?

Aug High Water Date

Time of high water

Aug High Water Date observed

Time of high water observation

Is this the highest you have seen the water level?

Historic water level comments

Did your house flood during the August 25-27 Rain Event?

How deep was the water in your house?

How many days did water remain in your house?

Did your property flood during the August 25-27 Rain Event?

On average how deep was the water on your property?

How many days did water remain on your property?

Owner/Renter summary of August 25-27 flooding experience

Do you have any photos of the August 25-27 flooding?

Were you flooded during Hurricane Irma (September 10)? Yes

Did you stay at the property during Hurricane Irma? Yes

Irma high water date: started 9/11, crested 9/13, receded 9/15

Time of high water

Irma high water date observed

Time of high water observation

Is this the highest you have seen the water level? Yes

Hurricane Irma Post Storm Investigation

February 28, 2018

Historic water level comments

Did your house flood during Hurricane Irma? Yes

How deep was the water in your house? 10-12 inches

How many days did water remain in your house? 5

Did your property flood during Hurricane Irma? Yes

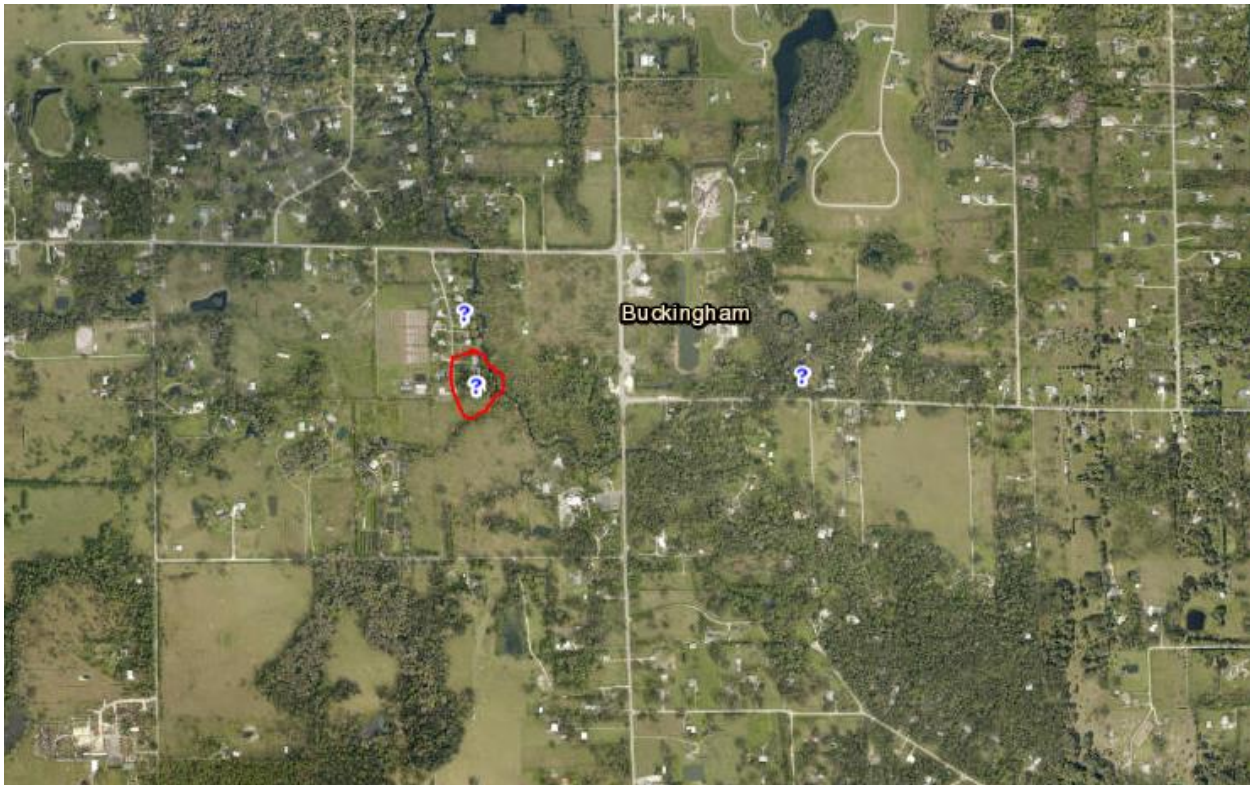
On average how deep was the water on your property? >4 feet

How many days did water remain on your property? 5

How many feet away was the water to your home? 0-10 feet

Owner/Renter summary of Hurricane Irma flooding experience Flood waters came from the south with rapid current that was sustained through 9/13

Do you have any photos of Hurricane Irma flooding? Yes



Hurricane Irma Post Storm Investigation

February 28, 2018

Public Flooding Questionnaire: 3306 32nd ST W

I want to: Sign up for email and fill out the flooding questionnaire because I experienced flooding during the August 25-27 Rain Event or Hurricane Irma (September 10)

Email BabyJaisMom@gmail.com

Property owner or renter? Property Owner

Name Talisa Freeman

Phone number 239-281-1330

City Lehigh Acres

How many years at this address 2

Were you flooded during the August 25-27 Rain Event? No

Did you stay at the property during the August 25-27 Rain Event?

Aug High Water Date

Time of high water

Aug High Water Date observed

Time of high water observation

Is this the highest you have seen the water level?

Historic water level comments

Did your house flood during the August 25-27 Rain Event?

How deep was the water in your house?

How many days did water remain in your house?

Did your property flood during the August 25-27 Rain Event?

On average how deep was the water on your property?

How many days did water remain on your property?

Owner/Renter summary of August 25-27 flooding experience

Hurricane Irma Post Storm Investigation

February 28, 2018

Do you have any
photos of the August
25-27 flooding?

Were you flooded
during Hurricane Irma
(September 10)?

Yes

Did you stay at the
property during
Hurricane Irma?

Yes

Irma high water date

Time of high water

18:00

Irma high water date
observed

Time of high water
observation

Is this the highest you
have seen the water
level?

Yes

Historic water level
comments

Did your house flood
during Hurricane Irma?

No

How deep was the
water in your house?

How many days did
water remain in your
house?

Did your property flood
during Hurricane Irma?

Yes

On average how deep
was the water on your
property?

4 feet

How many days did
water remain on your
property?

>7

How many feet away
was the water to your
home?

0-10 feet

Owner/Renter summary
of Hurricane Irma
flooding experience

I remember walking out of the front door during the eye of the storm, to check to see how my property was holding up. The water had surpassed the hill that my house was on and my neighbor's house clearly had already taken in water. There was approximately 3 feet of dry land surrounding my house, my mailbox was under and so was my 4ft fence. The day after, I waded to the middle of my street to seek assistance - the water was up to my waist (I'm 5'6). In the days after Irma, we (3 adults and 12 children) were stranded until that Wednesday.

Do you have any
photos of Hurricane
Irma flooding?

Yes



Hurricane Irma Post Storm Investigation
February 28, 2018

Public Flooding Questionnaire: 2169 BERKLEY WAY

I want to: Sign up for email and fill out the flooding questionnaire because I experienced flooding during the August 25-27 Rain Event or Hurricane Irma (September 10)

Email bahamtil@embarqmail.com

Property owner or renter? Property Owner

Name BARBARA HAMTIL

Phone number 239-368-2778

City LEHIGH ACRES

How many years at this address 13

Were you flooded during the August 25-27 Rain Event? No

Did you stay at the property during the August 25-27 Rain Event?

Aug High Water Date

Time of high water

Aug High Water Date observed

Time of high water observation

Is this the highest you have seen the water level?

Historic water level comments

Did your house flood during the August 25-27 Rain Event?

How deep was the water in your house?

How many days did water remain in your house?

Did your property flood during the August 25-27 Rain Event?

On average how deep was the water on your property?

How many days did water remain on your property?

Owner/Renter summary of August 25-27 flooding experience

Do you have any photos of the August 25-27 flooding?

Were you flooded during Hurricane Irma (September 10)? Yes

Did you stay at the property during Hurricane Irma? No

Irma high water date

Time of high water

Irma high water date observed 9/11/2017

Time of high water observation 3PM

Hurricane Irma Post Storm Investigation

February 28, 2018

Is this the highest you have seen the water level? **Yes**

Historic water level comments

Did your house flood during Hurricane Irma? **No**

How deep was the water in your house?

How many days did water remain in your house?

Did your property flood during Hurricane Irma? **Yes**

On average how deep was the water on your property? **2 feet**

How many days did water remain on your property? **5**

How many feet away was the water to your home? **0-10 feet**

Owner/Renter summary of Hurricane Irma flooding experience

Do you have any photos of Hurricane Irma flooding? **Yes**

