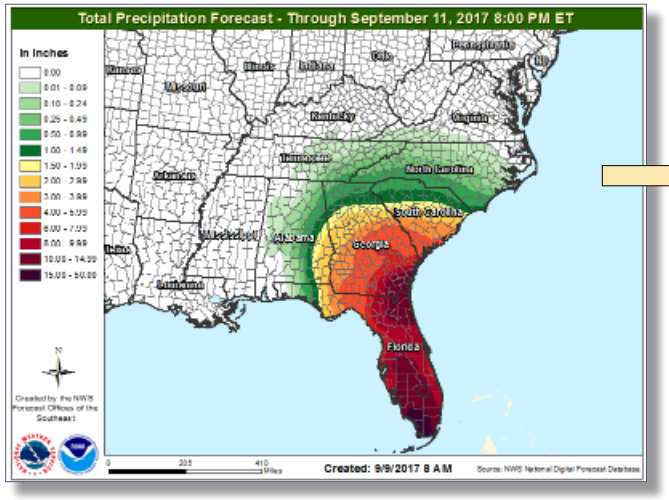
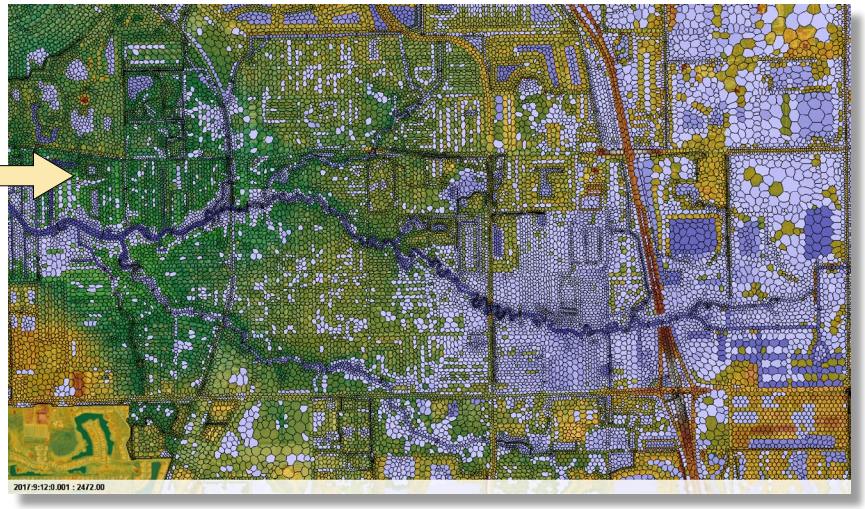




Mitigating Flood Risk with a Real-Time Flood Forecasting

Pete Singhofen/Kent Boulicault

icpr4®

STREAMLINE TECHNOLOGIES

SAI SINGHOFEN & ASSOCIATES INCORPORATED

The Team

- **Streamline Technologies**
  - Software development firm
  - Pete Singhofen, PE
  - ICPR model (integrated surface water / groundwater)
  - Innovator – Major advances in RTFF
- **Singhofen & Associates**
  - Civil engineering firm / water resources firm
  - 38-yr specialty in flood risk modeling and mitigation design
  - Kent Boulicault, PE
  - Pete is our founder and long-time partner

Hurricane Irma – September 2017

- Most of Florida
- 15” rain in many places
- ~$50B

Real-Time Flood Forecasting at the Street Level

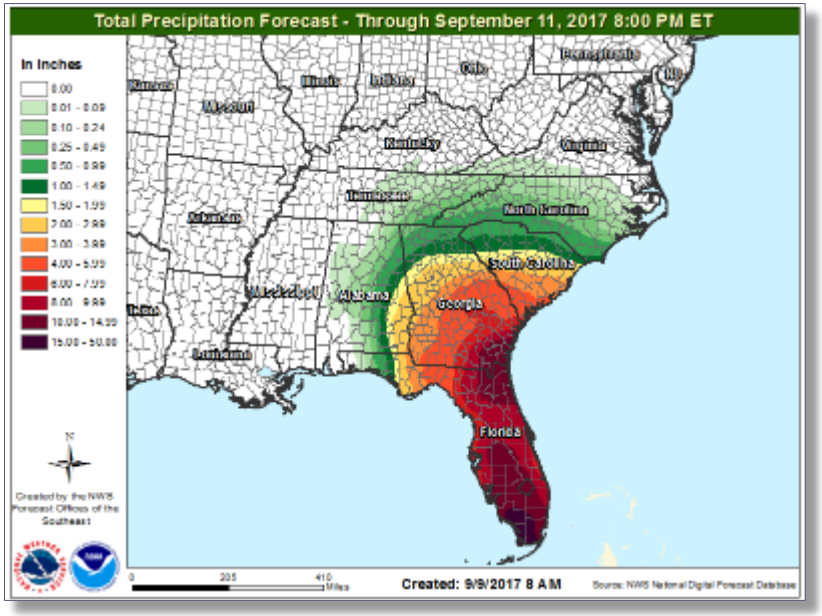
- Resilience planning tool
- Flood Risk Management - Move from reactive to proactive

- Prepare – More specific emergency management coordination
- Mitigate – Advance actions to minimize risks, consequences, damages
- Recover – Accelerate recovery by initiating specific recovery effort coordination earlier

RTFF Questions

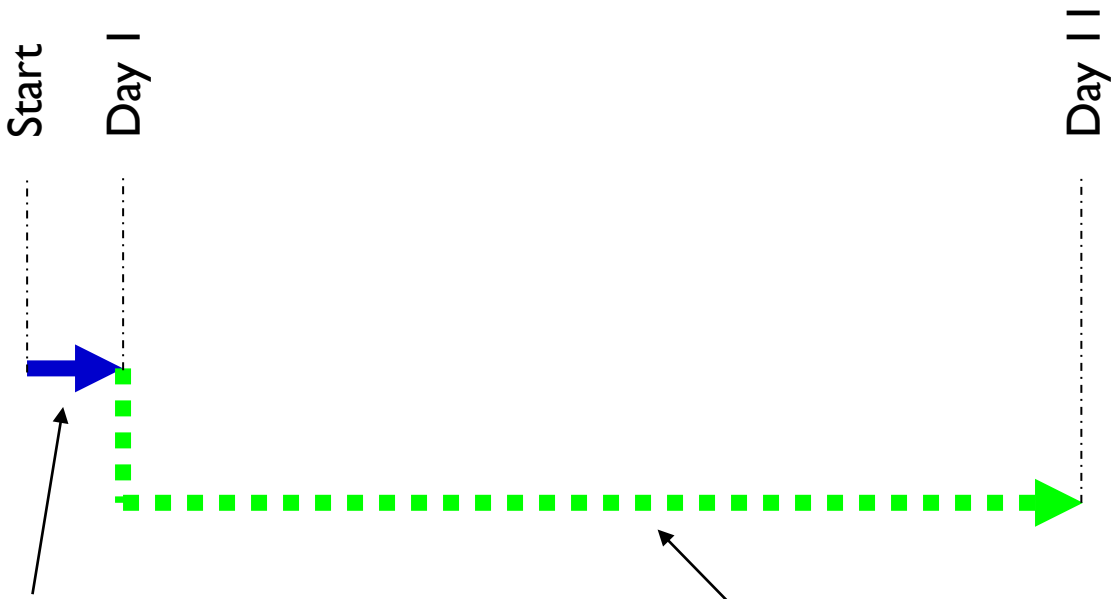
1. Can existing (hyper-resolution) watershed models be leveraged for flood forecasting purposes?
2. Are reliable and reasonably accurate forecast data readily available?
3. Can the process be automated?
4. Can a RTFF system be used for operational decision making?

NWS Gridded (1-km^2) Forcing Data Products (Rainfall/ET)



- Near Real-Time
  - ✓ updated hourly
- Short Range Forecast
  - ✓ 18-hour projection issued hourly
- Medium Range Forecast
  - ✓ 10-day projection issued every 6 hours

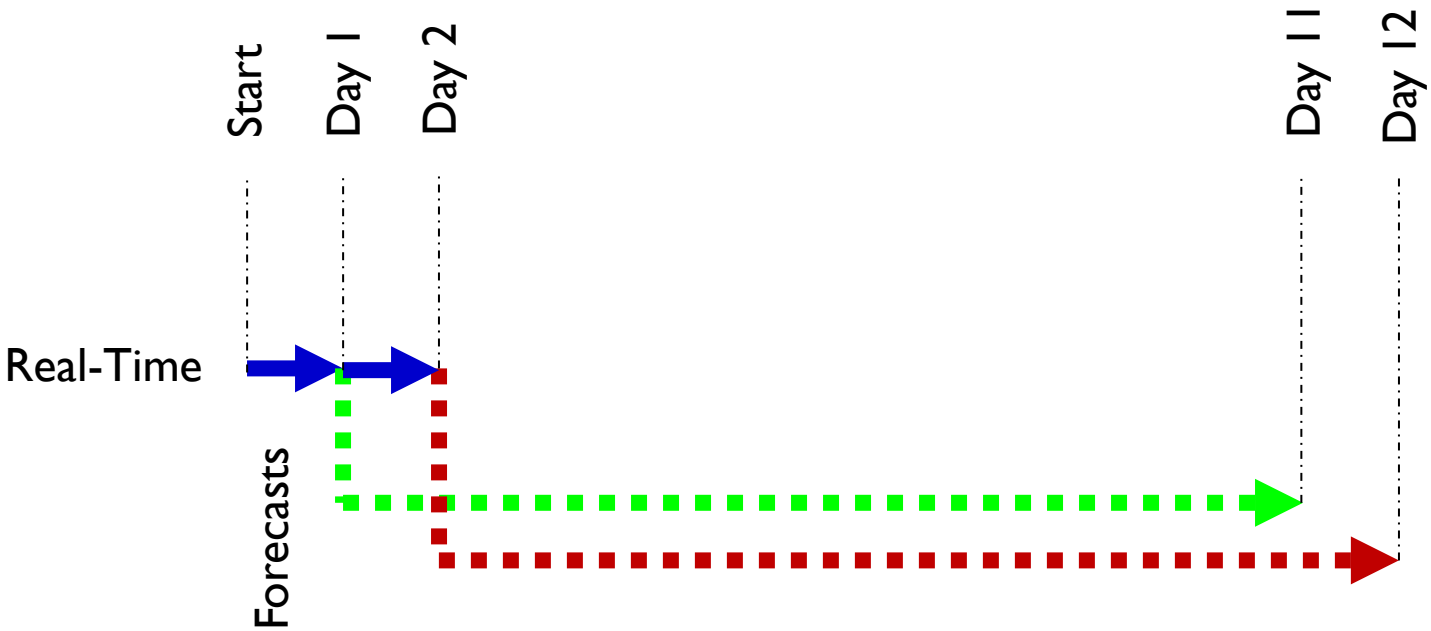
Daily Medium Range Forecast Progression



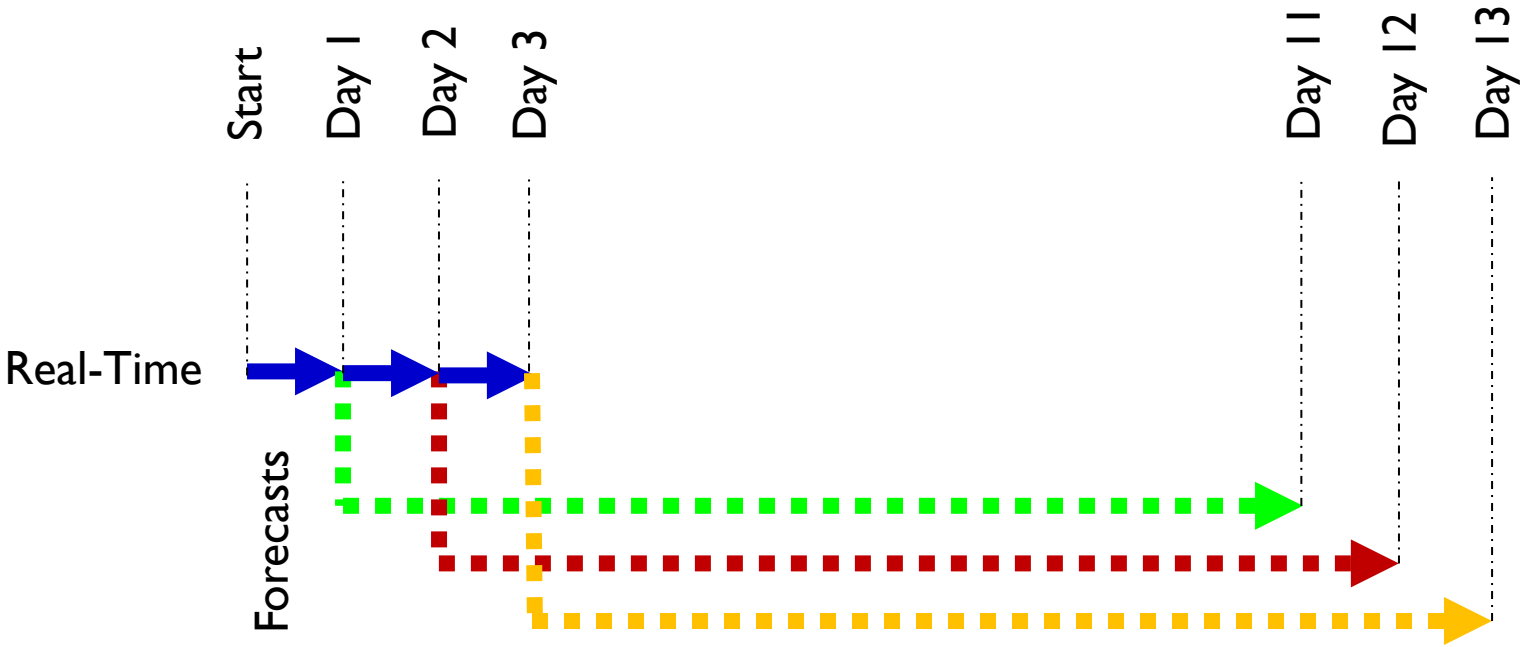
Real-Time Simulation
(tracks cumulative impacts)

10-day Medium Range Forecast
(predicts what might happen)

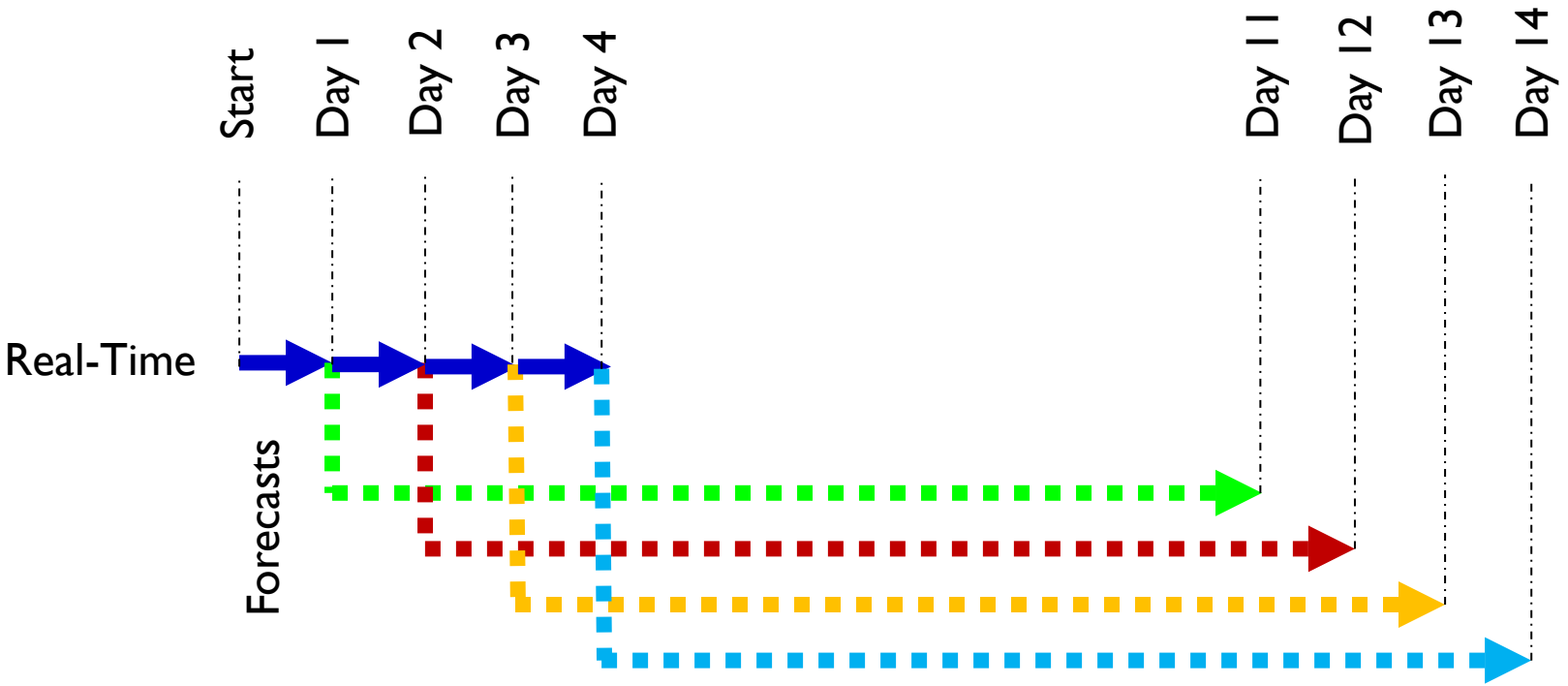
Daily Medium Range Forecast Progression



Daily Medium Range Forecast Progression



Daily Medium Range Forecast Progression



RTFF Implementation

Reduced NWM Dataset

Amazon Storage
"S3"

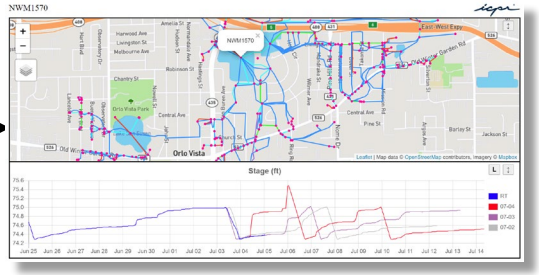
Data Retrieval App
1. Download NWS Data
2. Preprocess NWS Data

Project Specific NWS Data

icpr4 Project*
1. Run Real Time
2. Run Forecasts

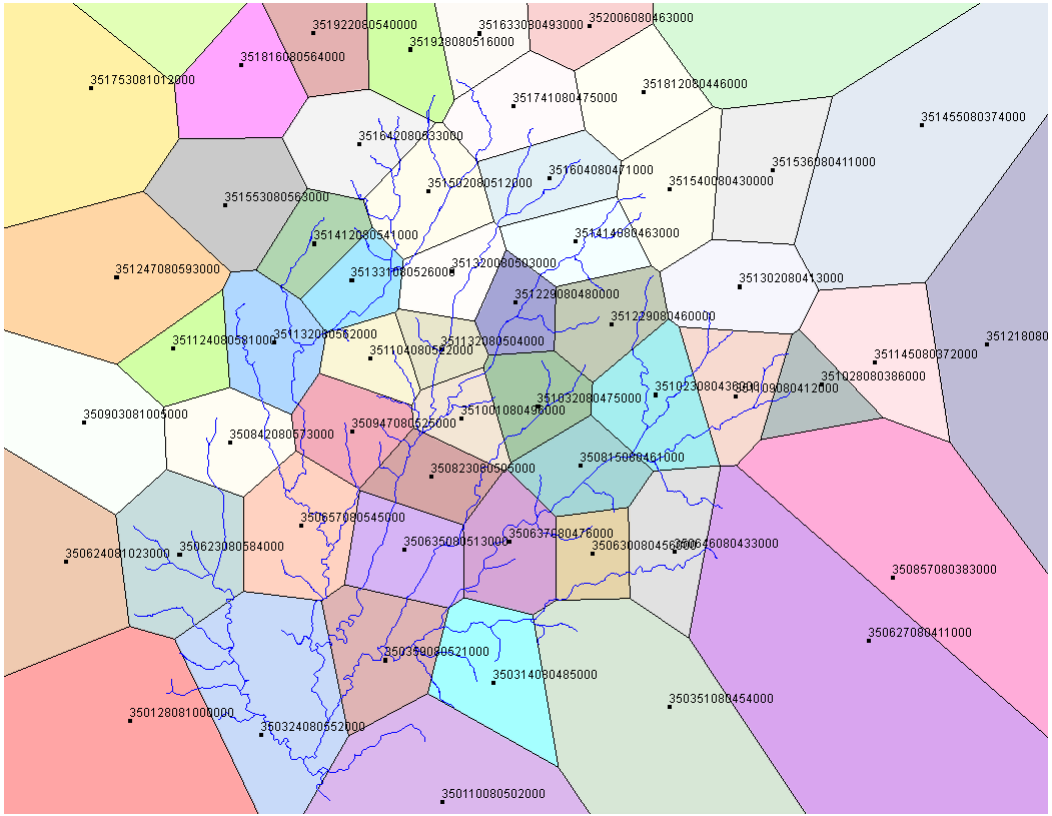
Output Bucket
(Client's Cloud)

Dashboard



* *can be run on local computer or on a virtual computer in AWS, Azure, other*

Operational Adjustments

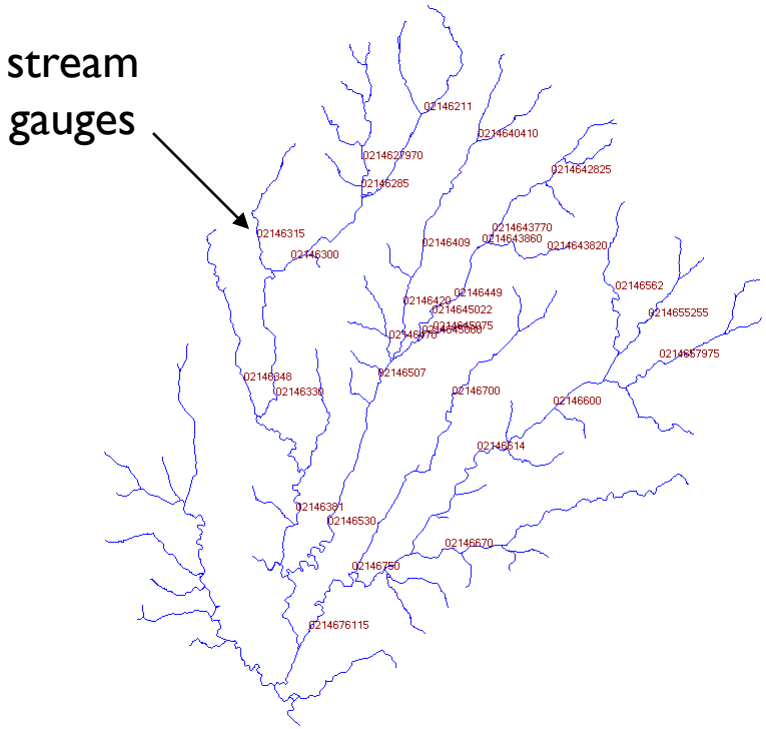


Network of 71 Rain Gauges for Mecklenburg County, NC
(updated every 5 minutes, maintained by USGS)

Live Rain Gauge Data used in Real-Time Simulations

- Alternative to NWS data
- More accurate
- Almost live
- Latency reduced from several hours to less than 10 minutes

Live Stream Gauge Data used in Real-Time Simulations

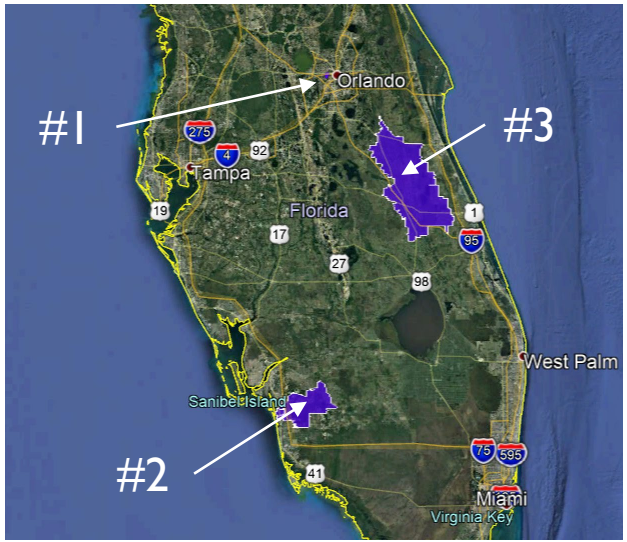


Network of 32 Stream Gauges for Mecklenburg County, NC
(updated every 5 minutes, maintained by USGS)

- Data used as internal boundary conditions in model
- WSEs are calculated in ungauged areas
- More accurate real-time representation
- Model updated a few seconds after retrieving rainfall and stream gauge data

Case Studies

1. Orlo Vista, Orange County
   - ✓ Pump System
2. Southern Lee County
   - ✓ Inland/Tidal Flooding
3. Upper St. Johns River Basin
   - ✓ Large Complex System



Case Study #1, Orlo Vista

Hurricane Irma Flooding

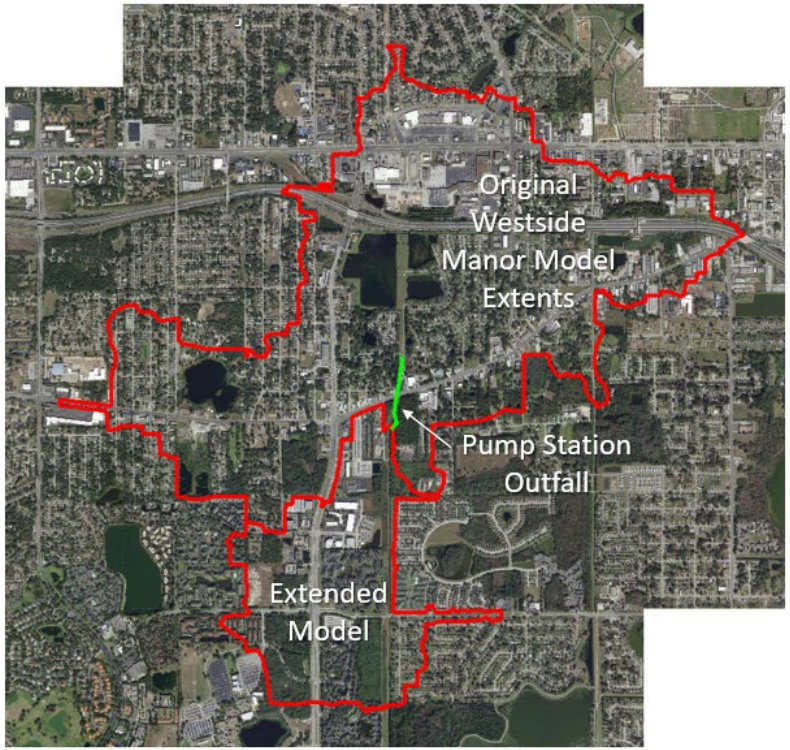
Acknowledgements

ORANGE COUNTY GOVERNMENT FLORIDA

Geosyntec consultants

icpr4 STREAMLINE TECHNOLOGIES SAI SINGHOFEN & ASSOCIATES INCORPORATED

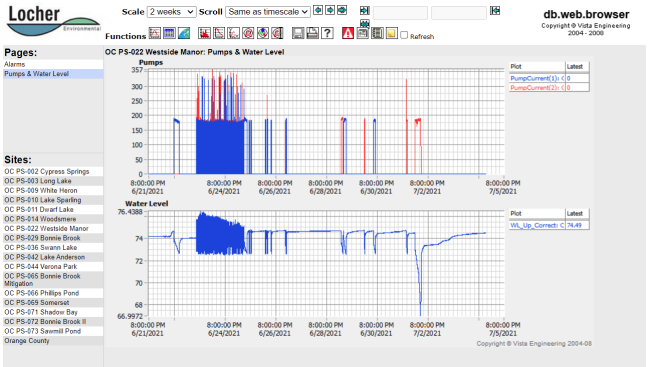
Case Study #1, Orlo Vista



The system will notify 3 assigned individuals in sequence by phone to deliver the alarm messages.

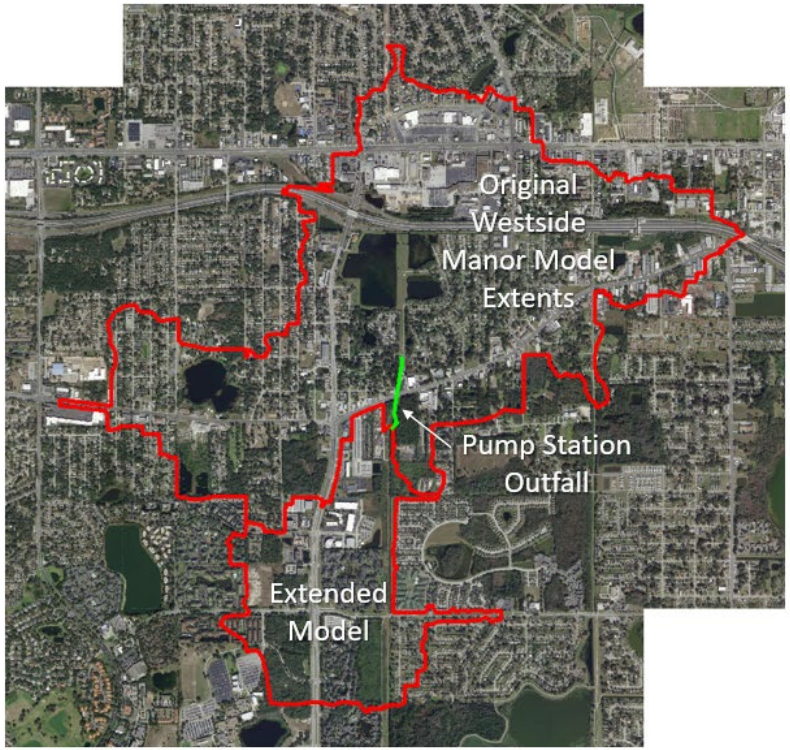
Alarm Conditions

- High Water Levels
- Lag Pump Running
- Pump Failure to Run
- Loss of Power
- Generator Running
- Generator Trouble
- Generator Failure
- Low Fuel



County monitors the pump station online in real time with the Vista Data Vision web service

Case Study #1, Orlo Vista



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Alarm Conditions

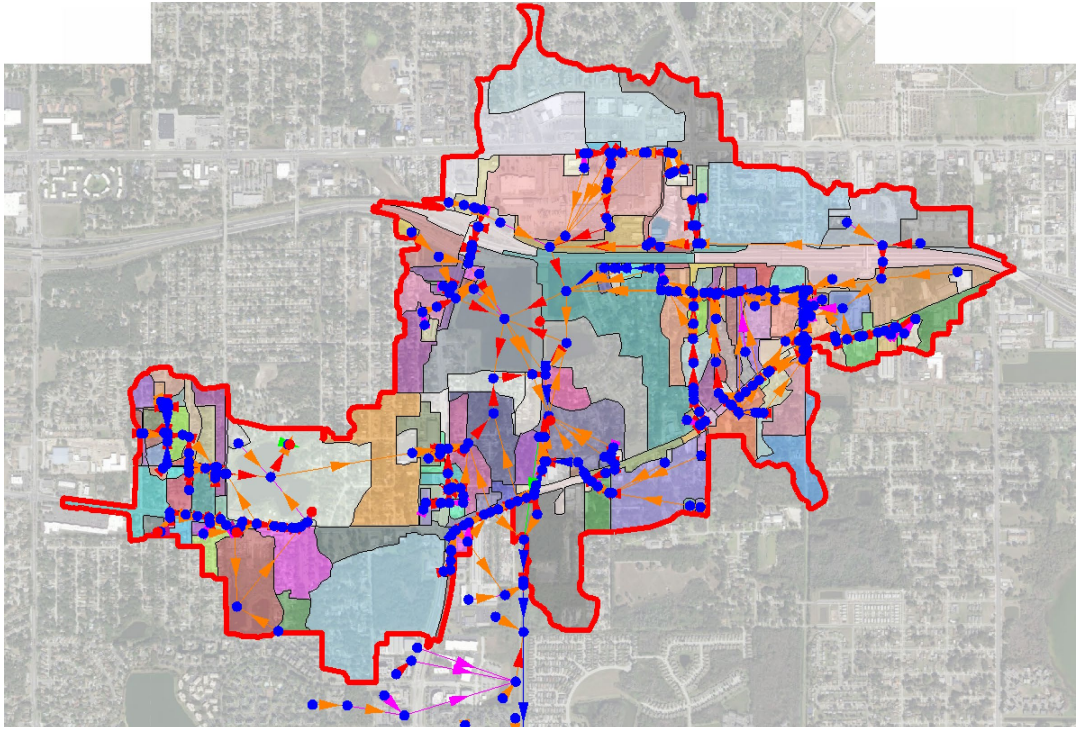
- High Water Levels
- Lag Pump Running
- Pump Failure to Run
- Loss of Power
- Generator Running
- Generator Trouble
- Generator Failure
- Low Fuel

✓ Can flood risk be reduced if high water levels are forecasted 2 to 3 days in advance?

✓ Can this knowledge be integrated into the county's alert and notification system?

Case Study #1, Orlo Vista

Model Setup

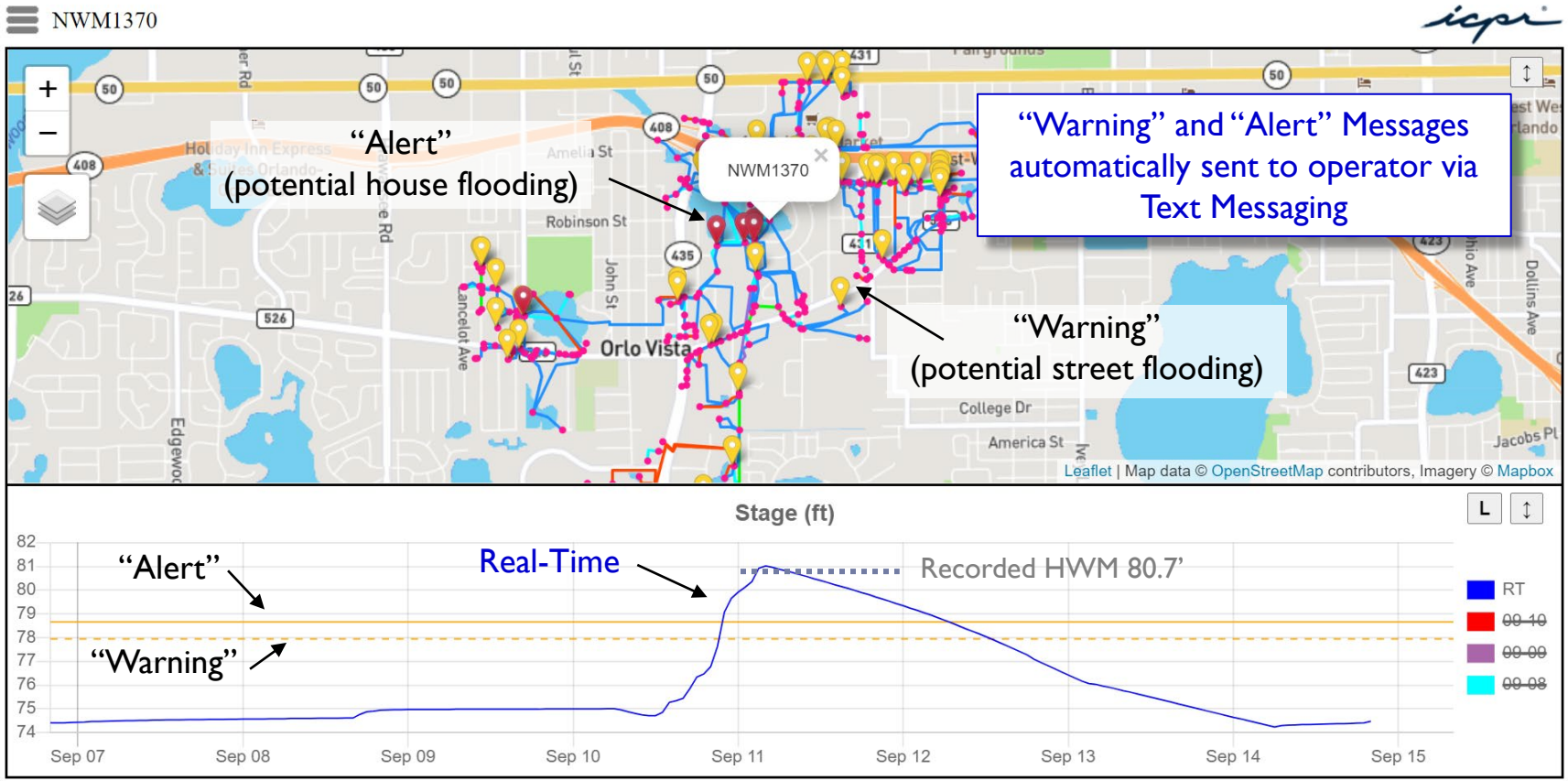


1D Nodal Network

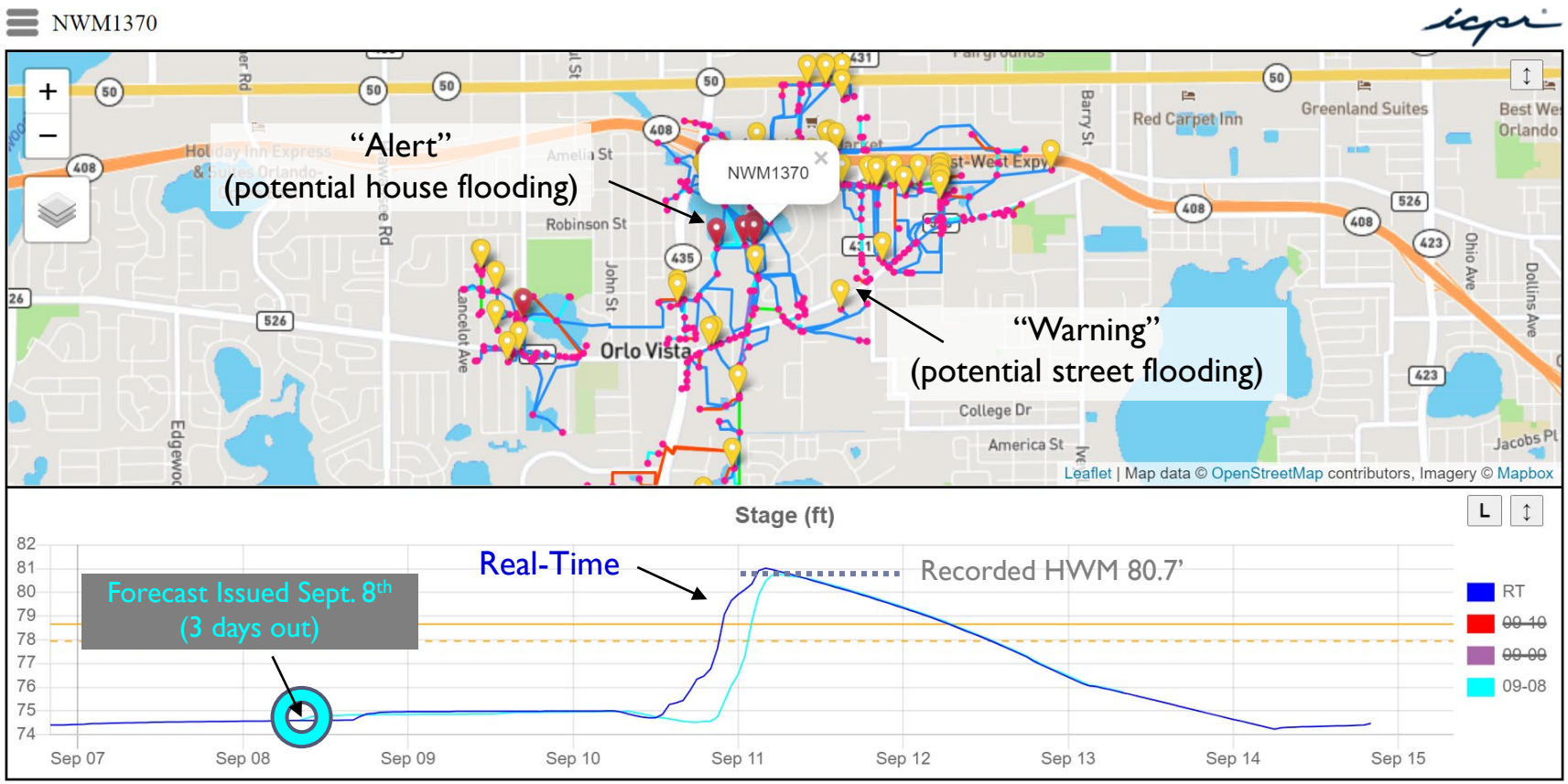
- Lakes & Ponds
- Channels
- Pipes
- Weirs
- Drop Structures
- Pump Stations
- Drain Wells

Model also includes 2d groundwater

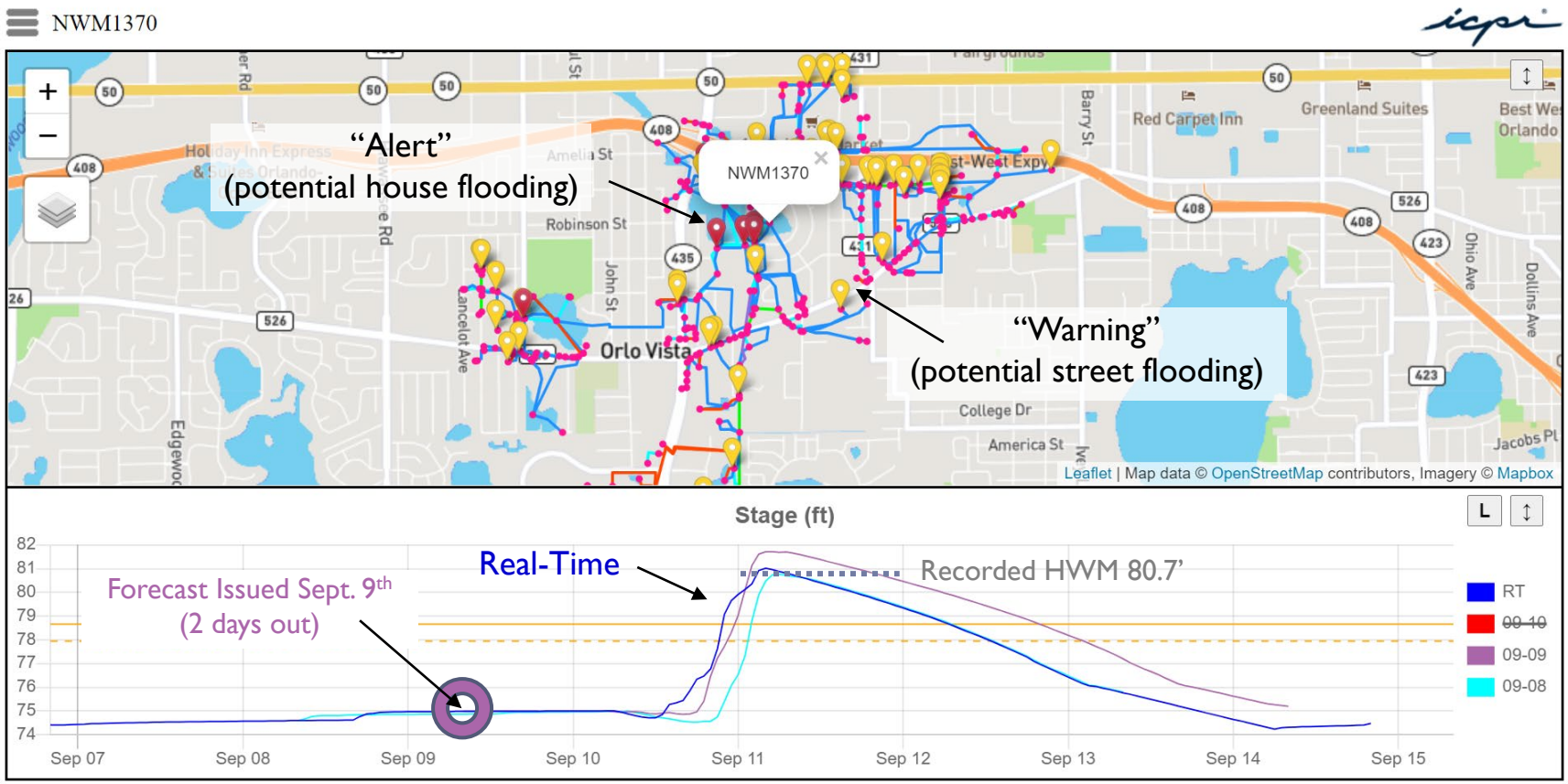
Hurricane Irma Verification Using NWS Forcing Data



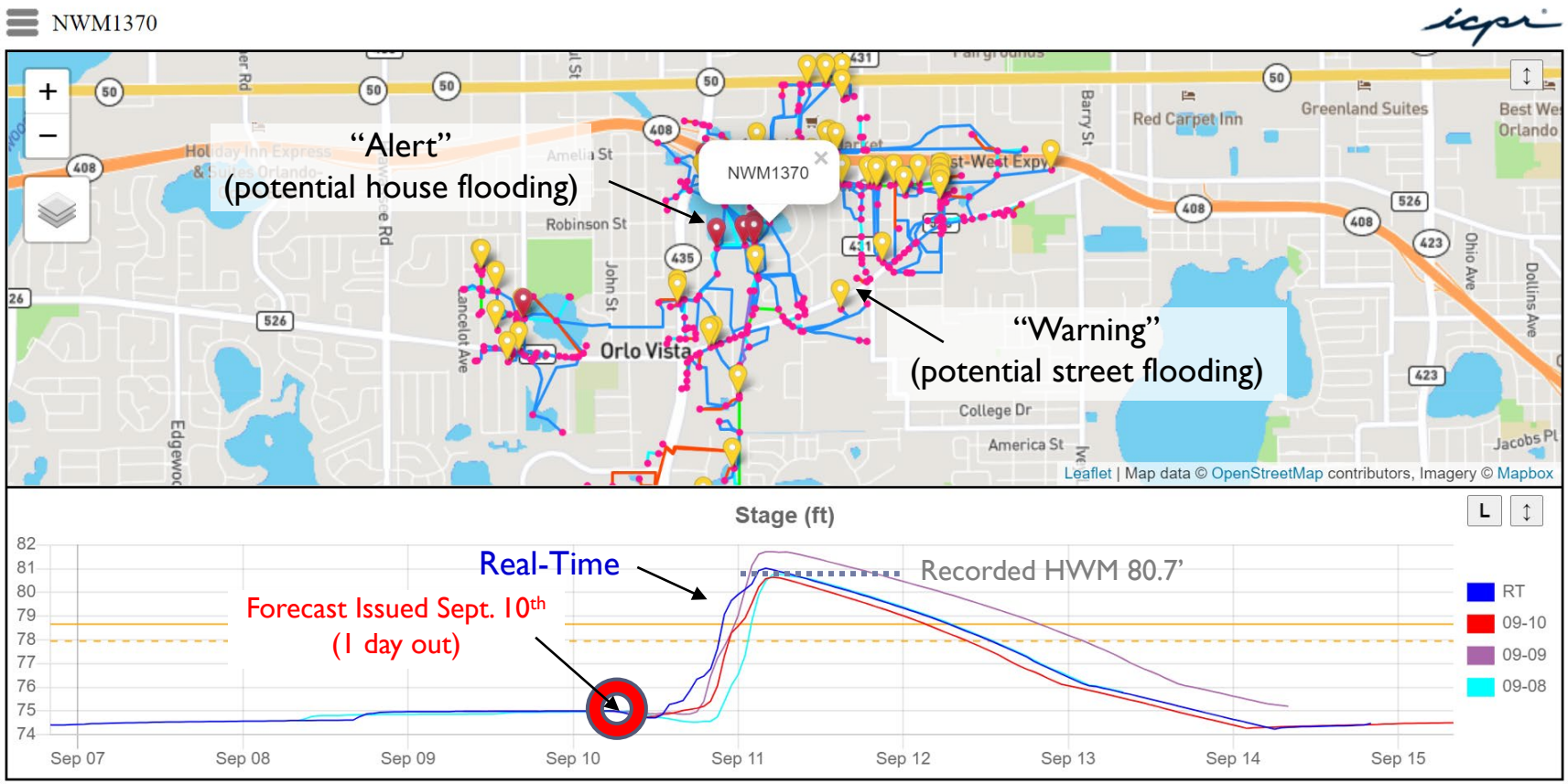
Hurricane Irma Verification Using NWS Forcing Data



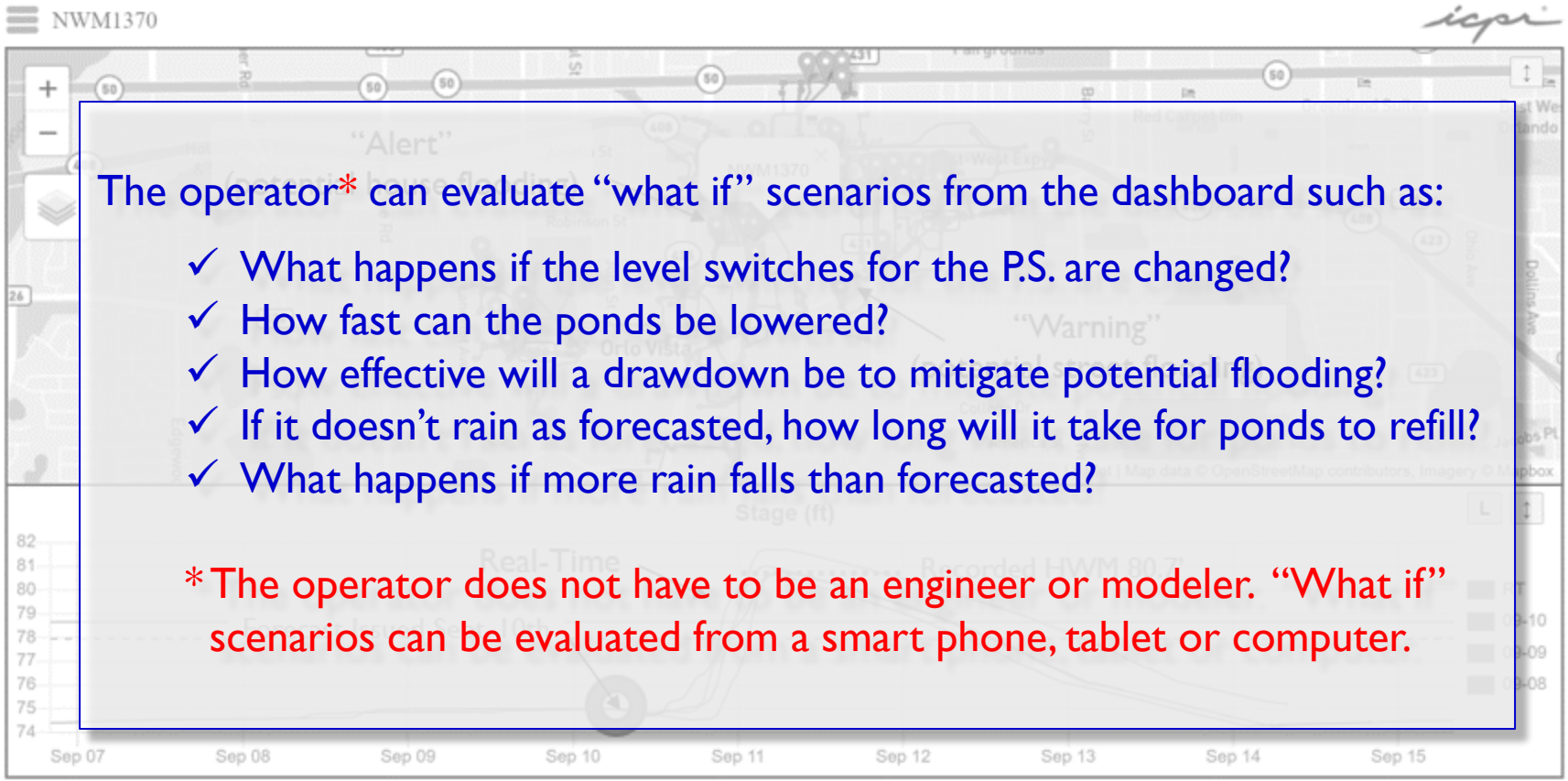
Hurricane Irma Verification Using NWS Forcing Data



Hurricane Irma Verification Using NWS Forcing Data



Hurricane Irma Verification Using NWM Forcing Data



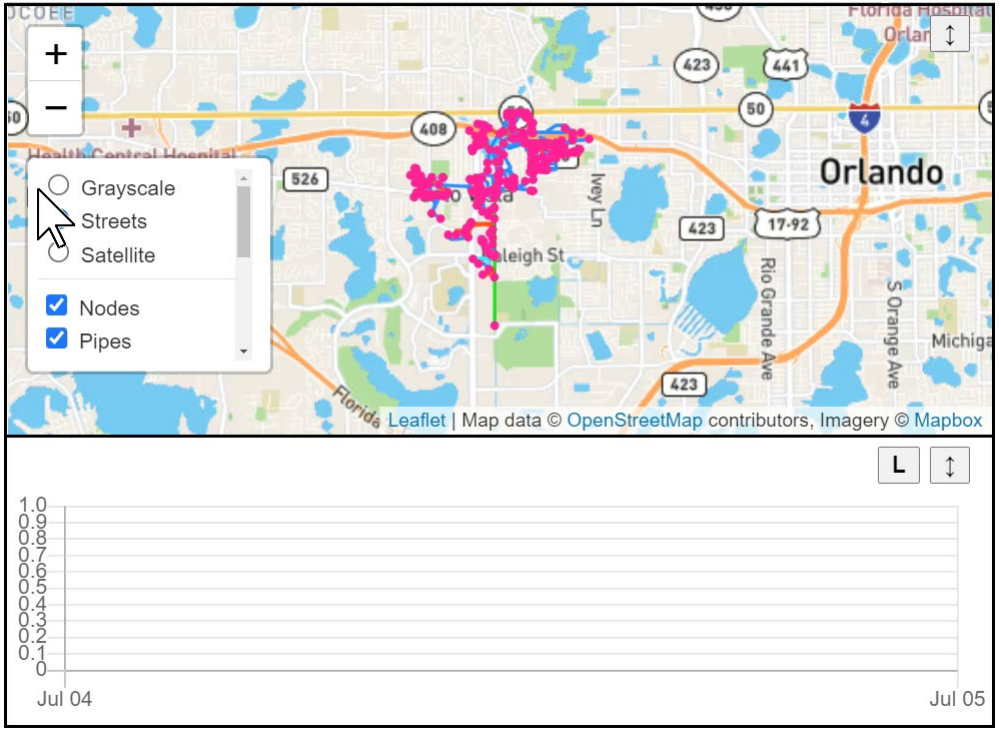
The operator* can evaluate "what if" scenarios from the dashboard such as:

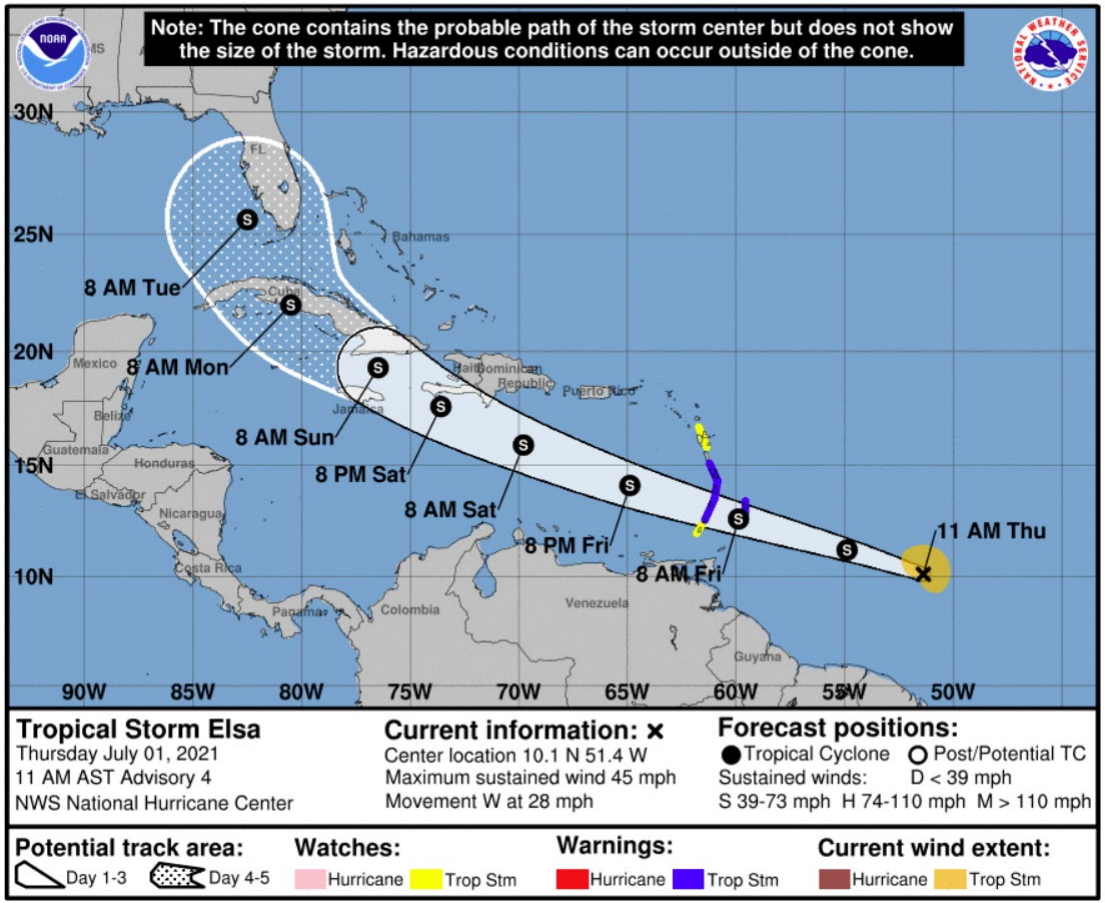
- ✓ What happens if the level switches for the P.S. are changed?
- ✓ How fast can the ponds be lowered?
- ✓ How effective will a drawdown be to mitigate potential flooding?
- ✓ If it doesn't rain as forecasted, how long will it take for ponds to refill?
- ✓ What happens if more rain falls than forecasted?

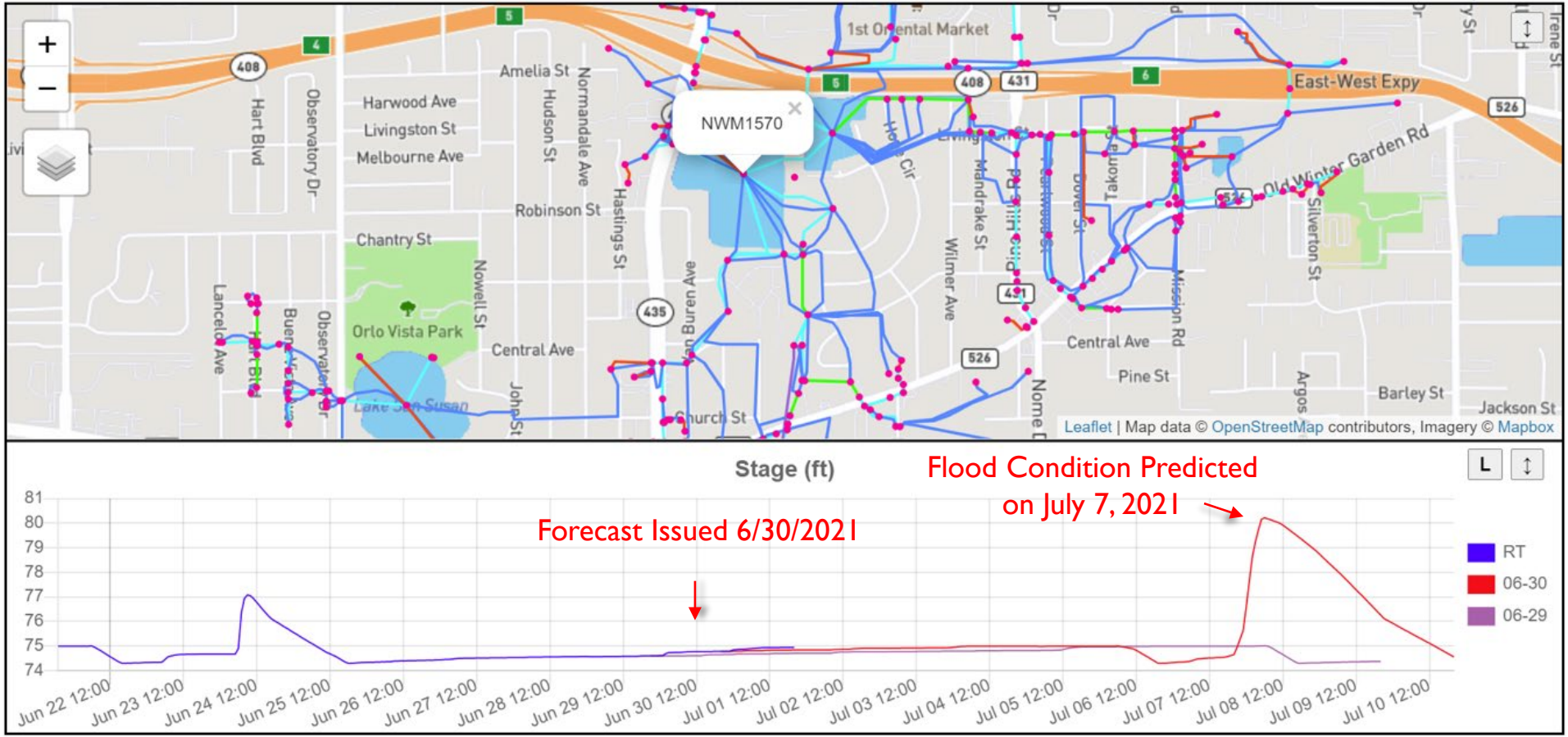
*The operator does not have to be an engineer or modeler. "What if" scenarios can be evaluated from a smart phone, tablet or computer.

Case Study #1, Orlo Vista

Dashboard Video




Note: The cone contains the probable path of the storm center but does not show the size of the storm. Hazardous conditions can occur outside of the cone.
30N
25N
20N
15N
10N
90W
85W
80W
75W
70W
65W
60W
55W
50W
8 AM Tue
8 AM Mon
8 AM Sun
8 PM Sat
8 AM Sat
8 PM Fri
8 AM Fri
11 AM Thu
Bahamas
Cuba
Mexico
Jamaica
Haiti
Dominican Republic
Puerto Rico
Belize
Guatemala
Honduras
El Salvador
Nicaragua
Costa Rica
Panama
Colombia
Venezuela
Guyana
Tropical Storm Elsa
Thursday July 01, 2021
11 AM AST Advisory 4
NWS National Hurricane Center
Current information:
Center location 10.1 N 51.4 W
Maximum sustained wind 45 mph
Movement W at 28 mph
Forecast positions:
Tropical Cyclone
Post/Potential TC
Sustained winds:
D < 39 mph
S 39-73 mph H 74-110 mph M > 110 mph
Potential track area:
Day 1-3
Day 4-5
Watches:
Hurricane
Trop Stm
Warnings:
Hurricane
Trop Stm
Current wind extent:
Hurricane
Trop Stm


NWM1570
1st Oriental Market
East-West Expy
Old Winter Garden Rd
Harwood Ave
Livingston St
Melbourne Ave
Amelia St
Robinson St
Chantry St
Central Ave
Orlo Vista Park
Lake Jessamine
Church St
Pine St
Barley St
Jackson St
Hart Blvd
Observatory Dr
Hudson St
Normandale Ave
Hastings St
Nowell St
John St
Lancelot Ave
Buena Vista Dr
Mandrake St
Wilmer Ave
Dover St
Silverton St
Mission Rd
Argos
Leaflet | Map data © OpenStreetMap contributors, Imagery © Mapbox
Stage (ft)
Flood Condition Predicted on July 7, 2021
Forecast Issued 6/30/2021
RT
06-30
06-29
81
80
79
78
77
76
75
74
Jun 22 12:00
Jun 23 12:00
Jun 24 12:00
Jun 25 12:00
Jun 26 12:00
Jun 27 12:00
Jun 28 12:00
Jun 29 12:00
Jun 30 12:00
Jul 01 12:00
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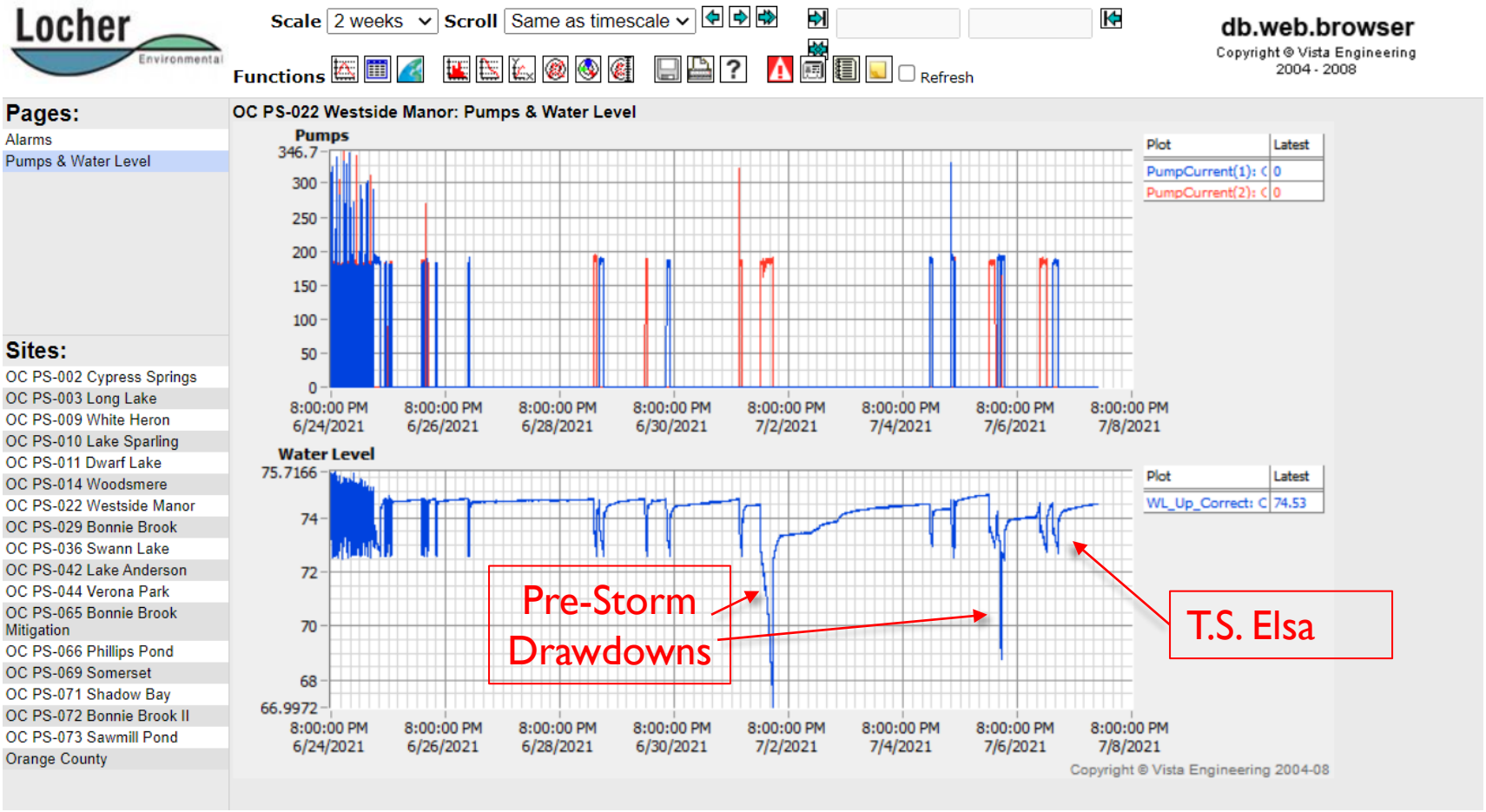
Locher Environmental
Scale 2 weeks
Scroll Same as timescale
Functions
Refresh
db.web.browser
Copyright © Vista Engineering 2004 - 2008
Pages:
Alarms
Pumps & Water Level
Sites:
OC PS-002 Cypress Springs
OC PS-003 Long Lake
OC PS-009 White Heron
OC PS-010 Lake Sparling
OC PS-011 Dwarf Lake
OC PS-014 Woodsmere
OC PS-022 Westside Manor
OC PS-029 Bonnie Brook
OC PS-036 Swann Lake
OC PS-042 Lake Anderson
OC PS-044 Verona Park
OC PS-065 Bonnie Brook Mitigation
OC PS-066 Phillips Pond
OC PS-069 Somerset
OC PS-071 Shadow Bay
OC PS-072 Bonnie Brook II
OC PS-073 Sawmill Pond
Orange County
OC PS-022 Westside Manor: Pumps & Water Level
Pumps
346.7
300
250
200
150
100
50
0
Plot
Latest
PumpCurrent(1): C
0
PumpCurrent(2): C
0
8:00:00 PM 6/24/2021
8:00:00 PM 6/26/2021
8:00:00 PM 6/28/2021
8:00:00 PM 6/30/2021
8:00:00 PM 7/2/2021
8:00:00 PM 7/4/2021
8:00:00 PM 7/6/2021
8:00:00 PM 7/8/2021
Water Level
75.7166
74
72
70
68
66.9972
Plot
Latest
WL_Up_Correct: C
74.53
Pre-Storm Drawdowns
T.S. Elsa
8:00:00 PM 6/24/2021
8:00:00 PM 6/26/2021
8:00:00 PM 6/28/2021
8:00:00 PM 6/30/2021
8:00:00 PM 7/2/2021
8:00:00 PM 7/4/2021
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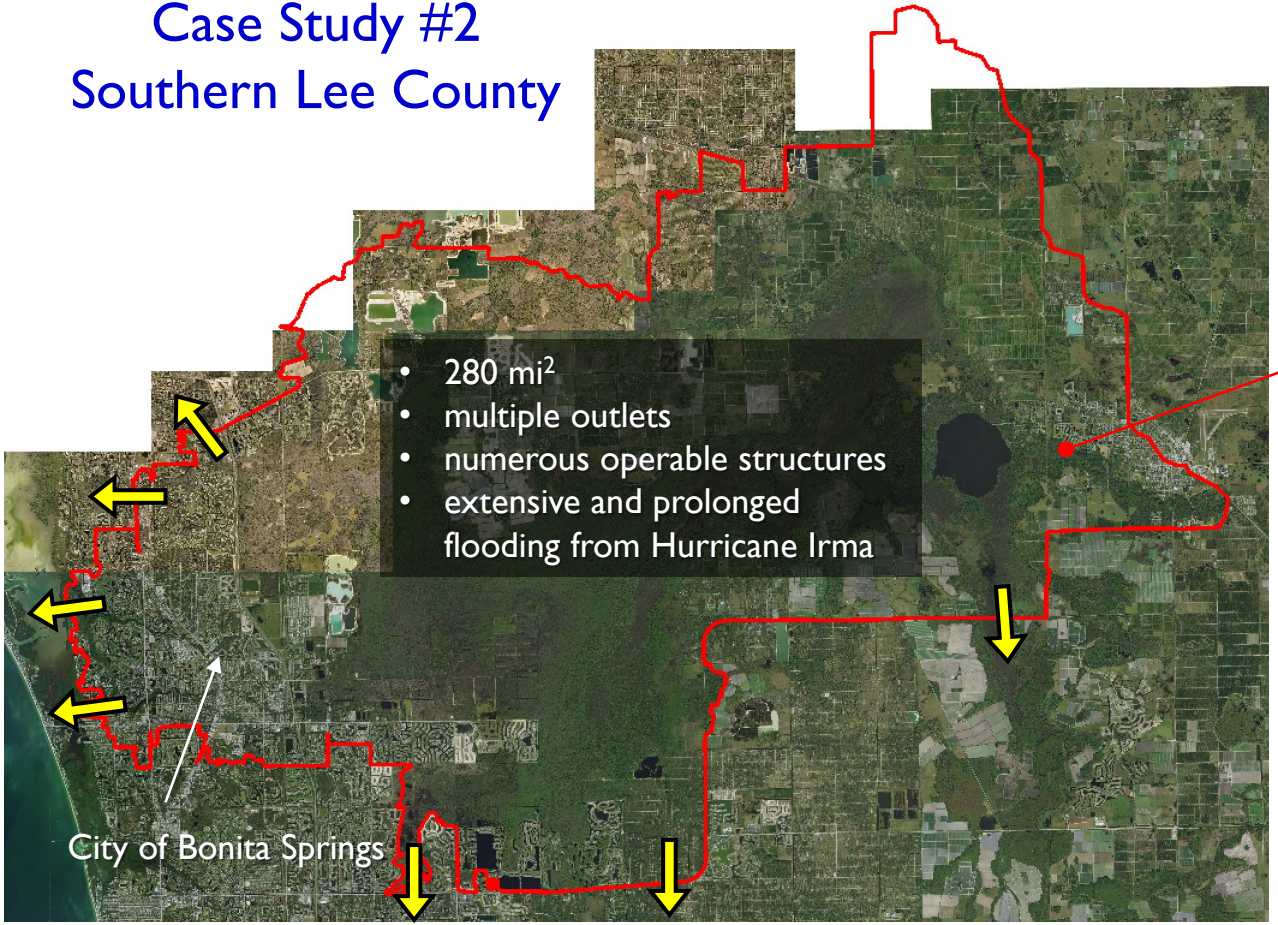
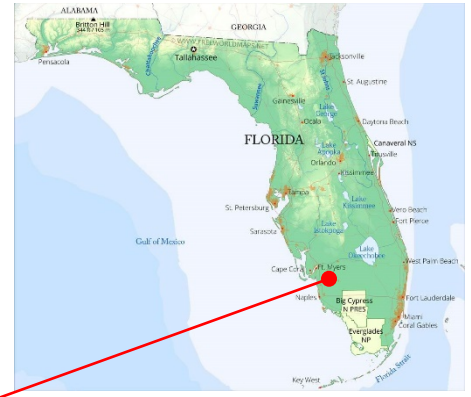
Copyright © Vista Engineering 2004-08

Case Study #2
Southern Lee County





Acknowledgements

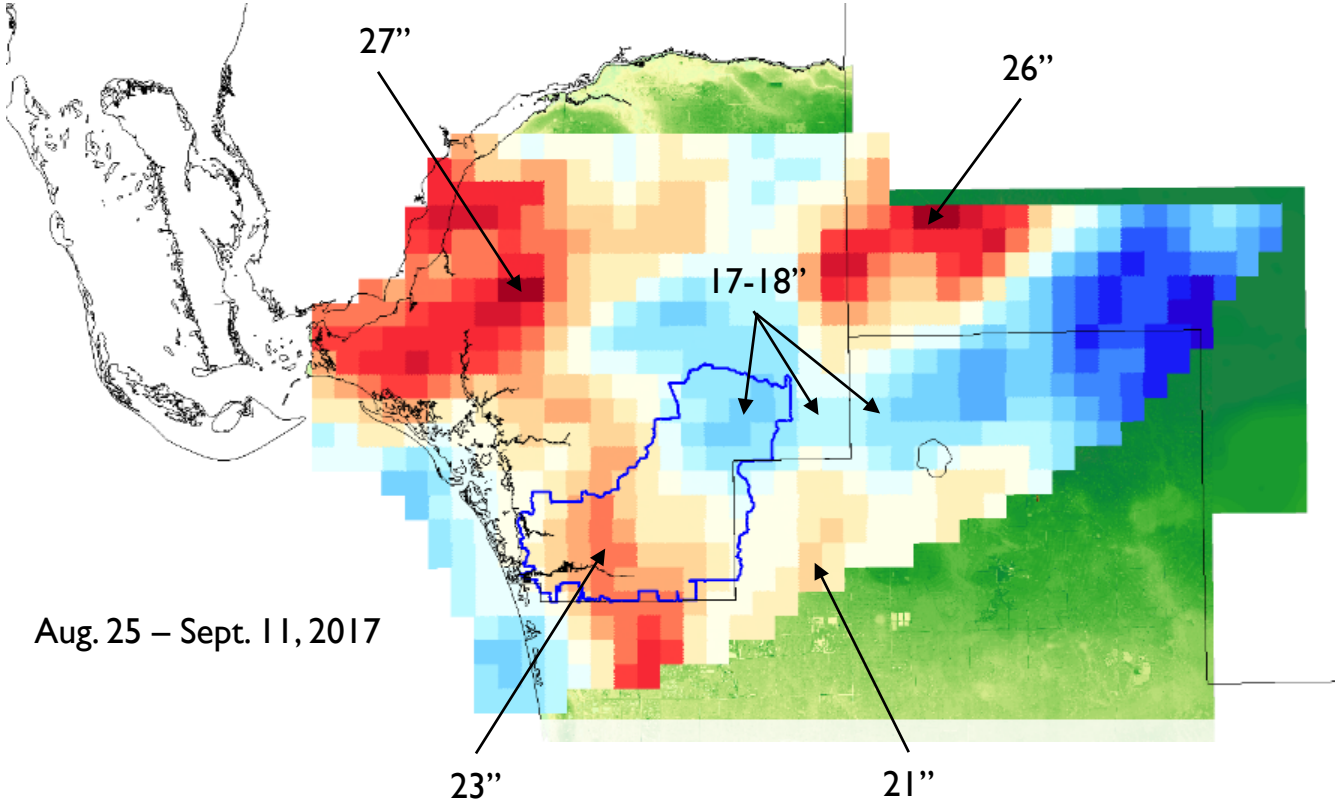
LEE COUNTY
SOUTHWEST FLORIDA

City of Bonita Springs Florida

Case Study #2, Southern Lee County

Kehl Canal Structure – 80-foot fixed crest weir and (3) low flow gated weirs

Case Study #2, Southern Lee County

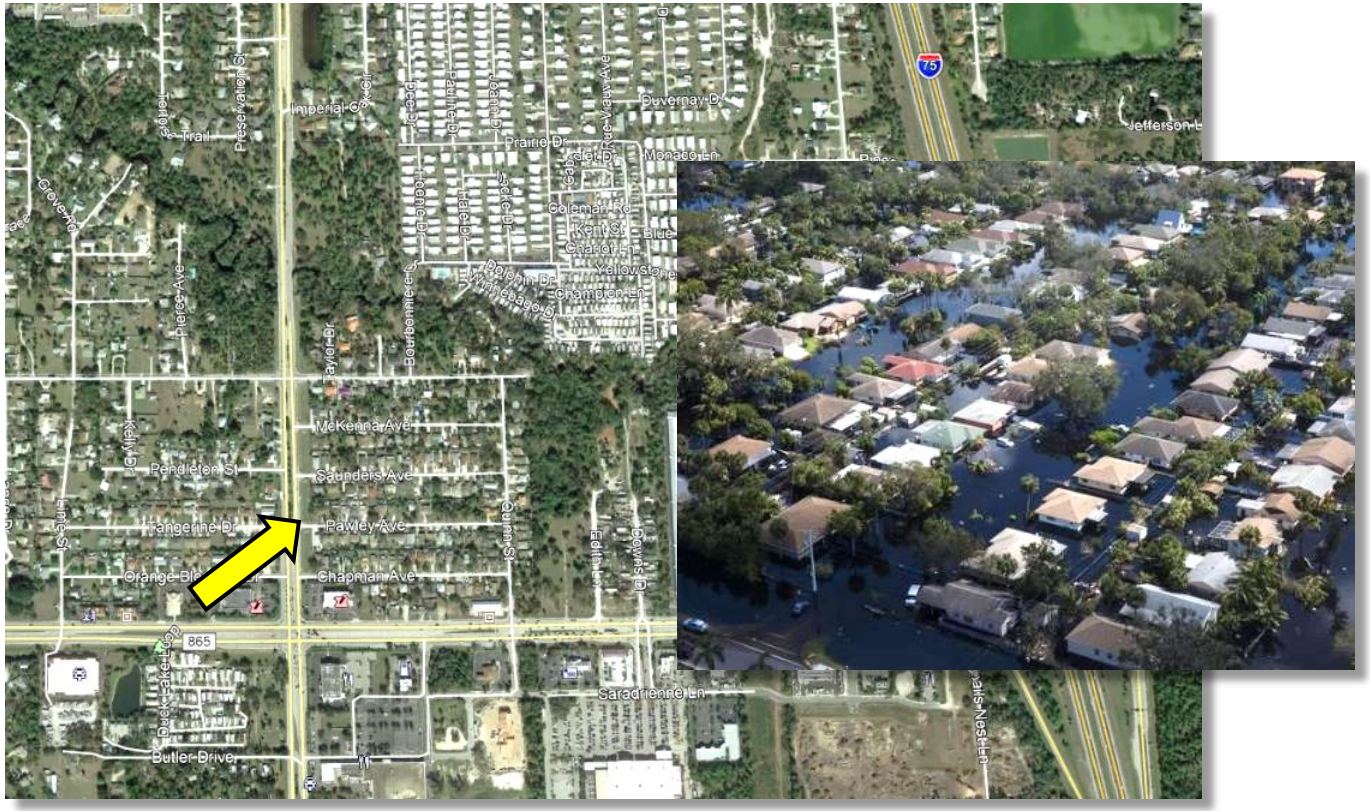


Aug. 25 – Sept. 11, 2017

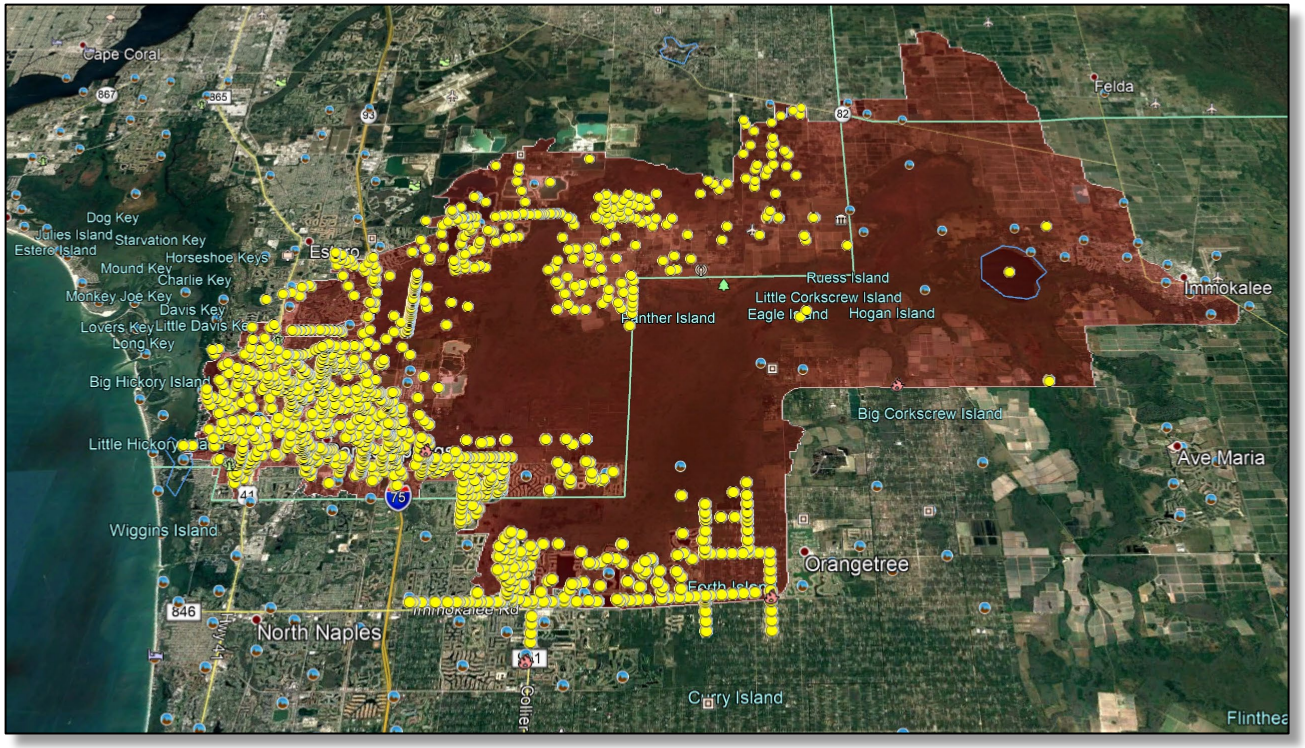
INVEST 92L
August 25-27, 2017

IRMA
September 9-11, 2017

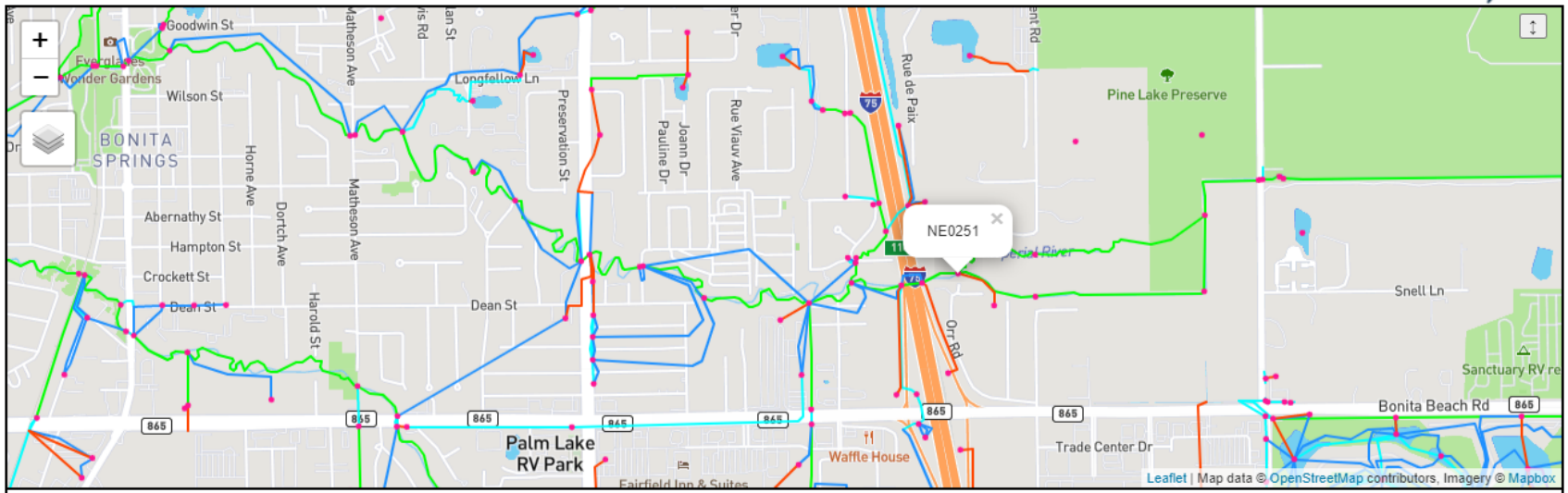
Case Study #2, Southern Lee County

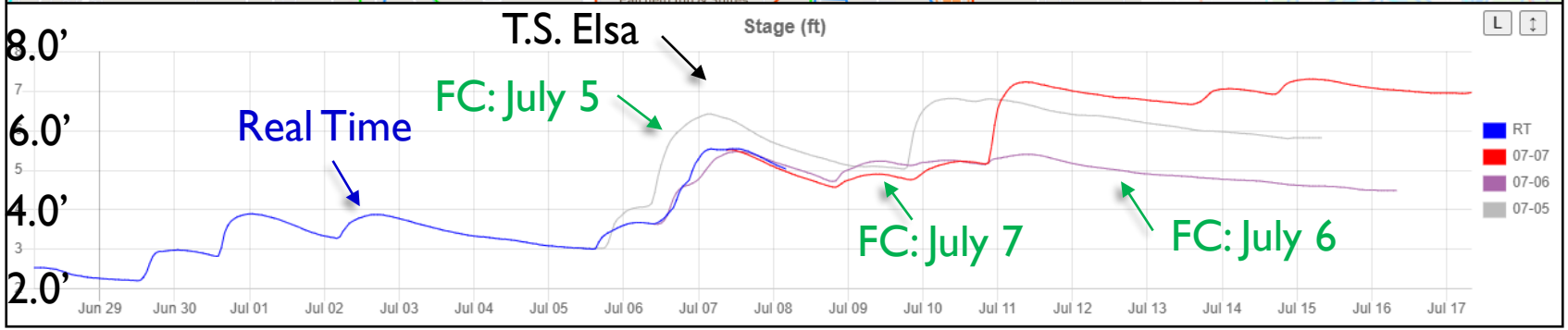


Case Study #2, Southern Lee County



Coastal/Inland Integration Possible


Goodwin St
Everglades Wonder Gardens
Wilson St
BONITA SPRINGS
Abernathy St
Hampton St
Crockett St
Dean St
Horne Ave
Dortch Ave
Matheson Ave
Harold St
Longfellow Ln
Preservation St
Joann Dr
Pauline Dr
Rue Viaux Ave
Rue de Paix
Pine Lake Preserve
NE0251
Orr Rd
Snell Ln
Sanctuary RV re
Bonita Beach Rd
Trade Center Dr
Waffle House
Palm Lake RV Park
Fairfield Inn & Suites
865
75
Leaflet | Map data © OpenStreetMap contributors, Imagery © Mapbox


(ft-NAVD)
8.0'
6.0'
4.0'
2.0'
Stage (ft)
T.S. Elsa
FC: July 5
Real Time
FC: July 7
FC: July 6
RT
07-07
07-06
07-05
Jun 29
Jun 30
Jul 01
Jul 02
Jul 03
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Jul 07
Jul 08
Jul 09
Jul 10
Jul 11
Jul 12
Jul 13
Jul 14
Jul 15
Jul 16
Jul 17

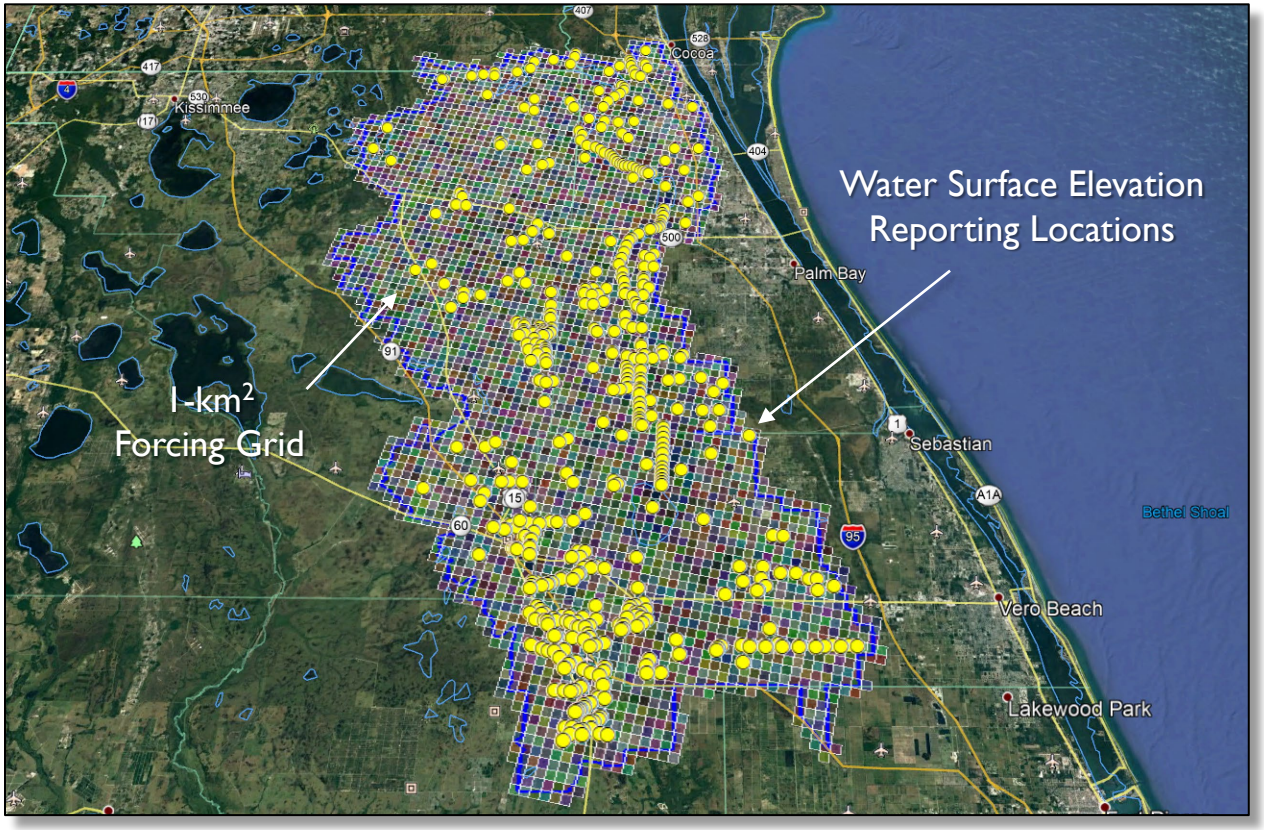
Case Study #3, Upper St. Johns River Basin

Acknowledgements

St. Johns River Water Management District

icpr4 STREAMLINE TECHNOLOGIES SAI SINGHOFEN & ASSOCIATES INCORPORATED

Case Study #3, Upper St. Johns River Basin



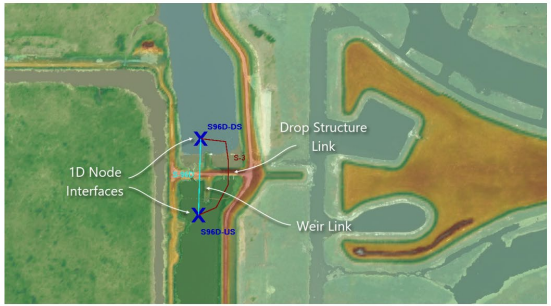
- Model Domain – 1,333 mi^2
- 3,900 1-km^2 forcing grids
- Flood control, water supply, environmental conservation
- Complex levee and canal systems
- ~50 agricultural pump stations
- ~35 major water control structures with gated spillways, gated culverts and large fixed crested weirs

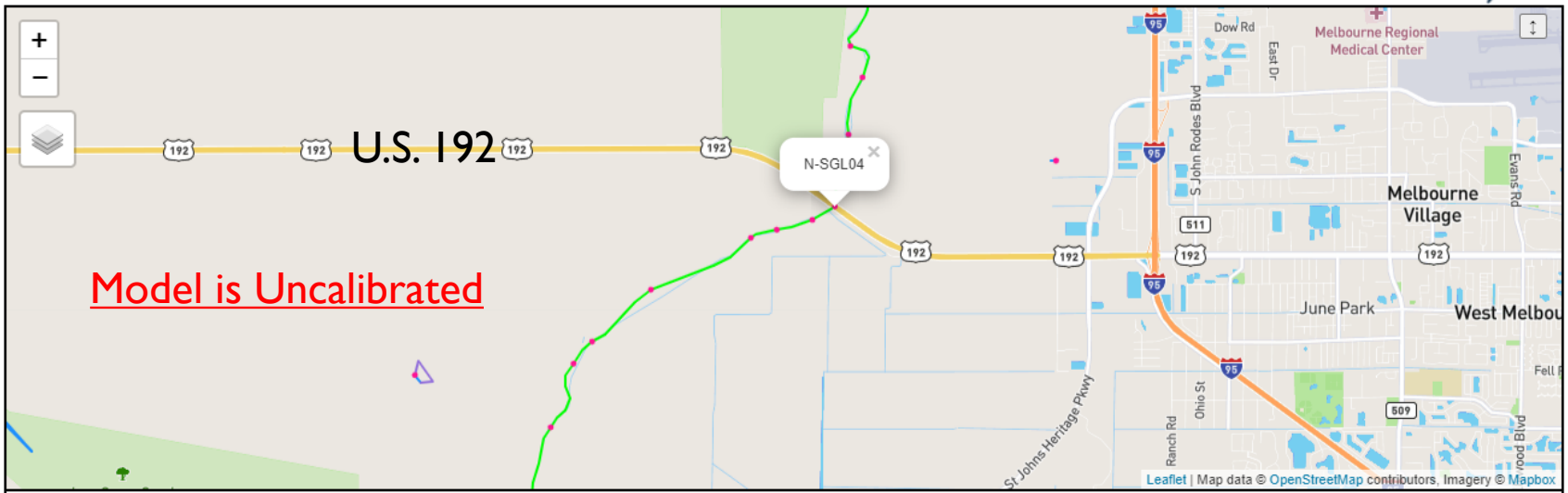
Case Study #3, Upper St. Johns River Basin

Gate Structures S-96B and S-96C
(Source: Star Controls)

Gate Structure S-96D and S-3
(Source: Star Controls)

Complex operable strucutures incorporated into model




U.S. 192
N-SGL04
Model is Uncalibrated
Melbourne Regional Medical Center
Melbourne Village
June Park
West Melbou
Dow Rd
East Dr
S John Rodes Blvd
Evans Rd
St Johns Heritage Pkwy
Ranch Rd
Ohio St
Leaflet | Map data © OpenStreetMap contributors, Imagery © Mapbox
Stage (ft)
T.S. Elsa
Real Time
FC: July 7
FC: July 5
FC: July 6
RT
07-07
07-06
07-05
14.6
14.4
14.2
14.0
13.8
13.6
13.4
13.2
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Jun 30
Jul 01
Jul 02
Jul 03
Jul 04
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Jul 12
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Jul 15
Jul 16
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Back to Our Original RTFF Questions

1. Can existing (hyper-resolution) watershed models be leveraged for flood forecasting purposes? **YES**
2. Are reliable and reasonably accurate forecast data readily available? **YES**
3. Can the process be automated? **YES**
4. Can a RTFF system be used for operational decision making? **YES**

Mitigating Flood Risk with a Real-Time Flood Forecasting System

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Questions?

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