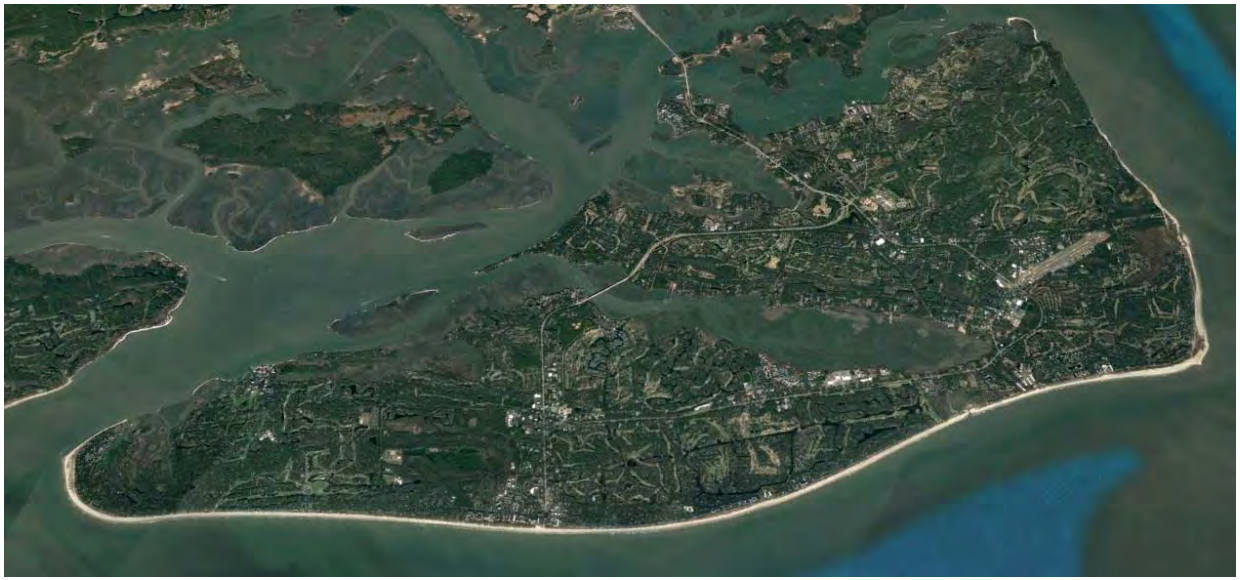
Keeping Up with the Times - 2D's Role in Modernizing Drainage Study Program

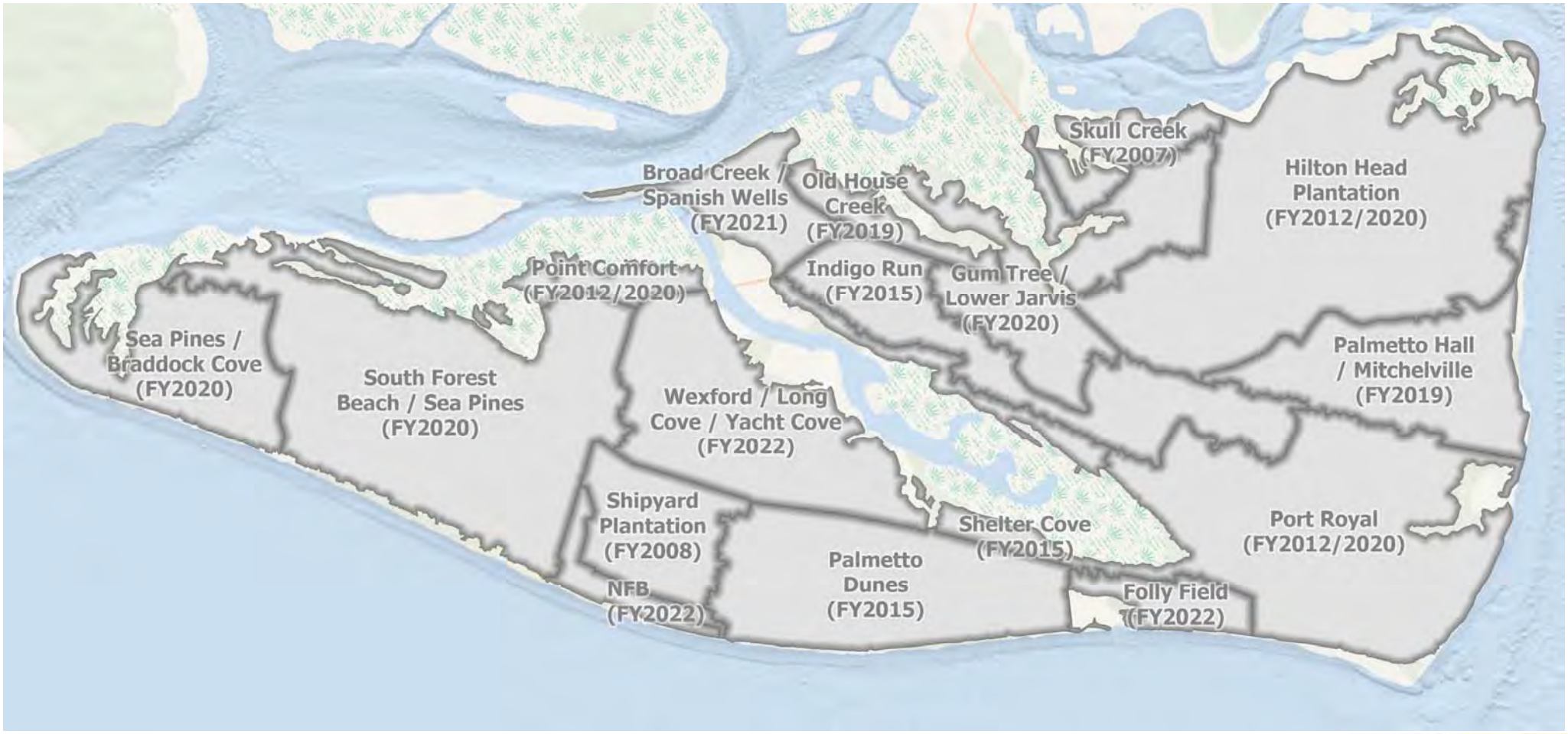
Hilton Head Island, SC

Program Overview

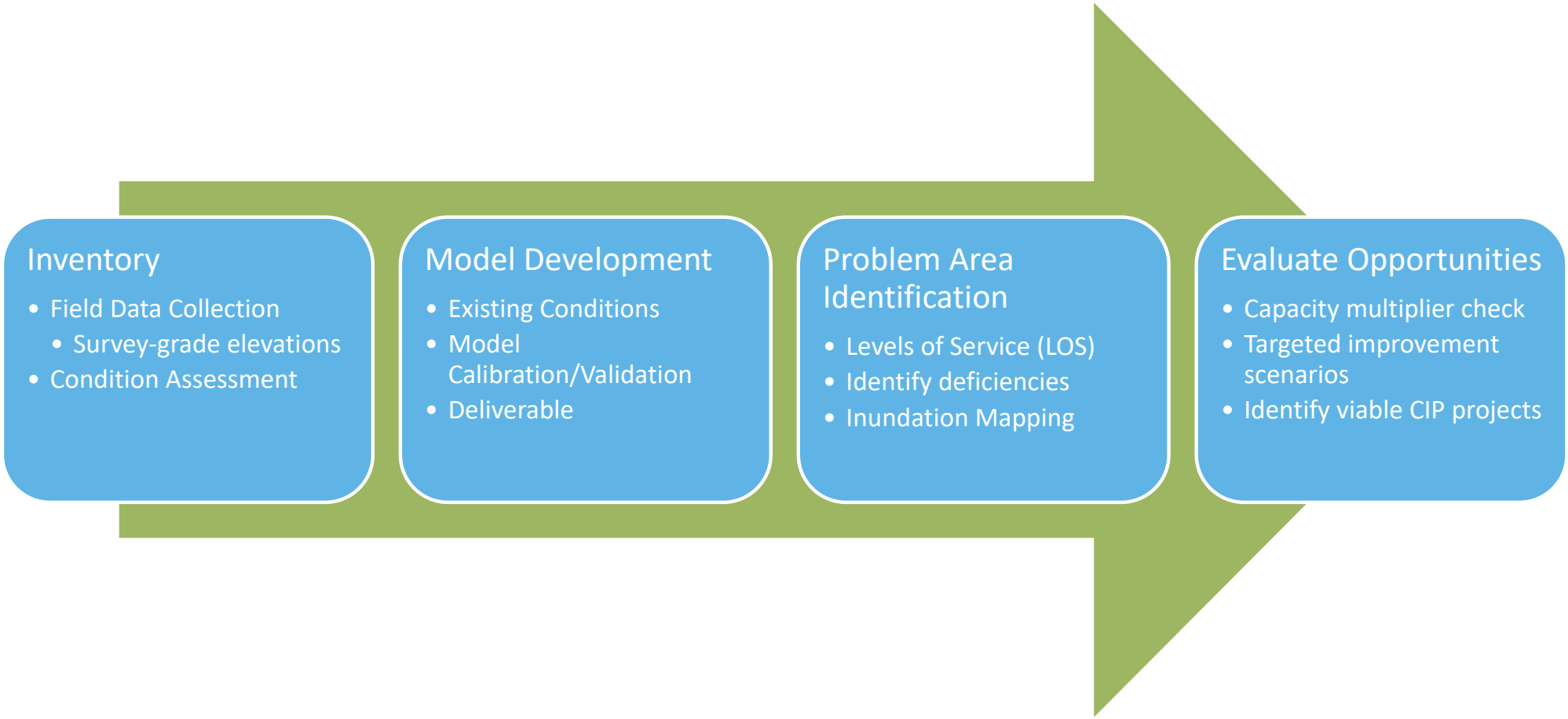
- Goal: Develop dynamic H&H models for all watersheds on the island, on a watershed-by-watershed basis
- Program schedule was laid out in 2012
  - Anticipated completion in 2024
- Work was done prior to 2012
  - Models to target specific capital improvement needs
  - Models developed and inventory collected with varied levels of scope and criteria
- Current status: program is about 40% complete (7 out of 15 major watersheds)
- Funding set at $350,000/year
- Models can be manipulated and modified by Town staff as needed



The Original Plan: 2012



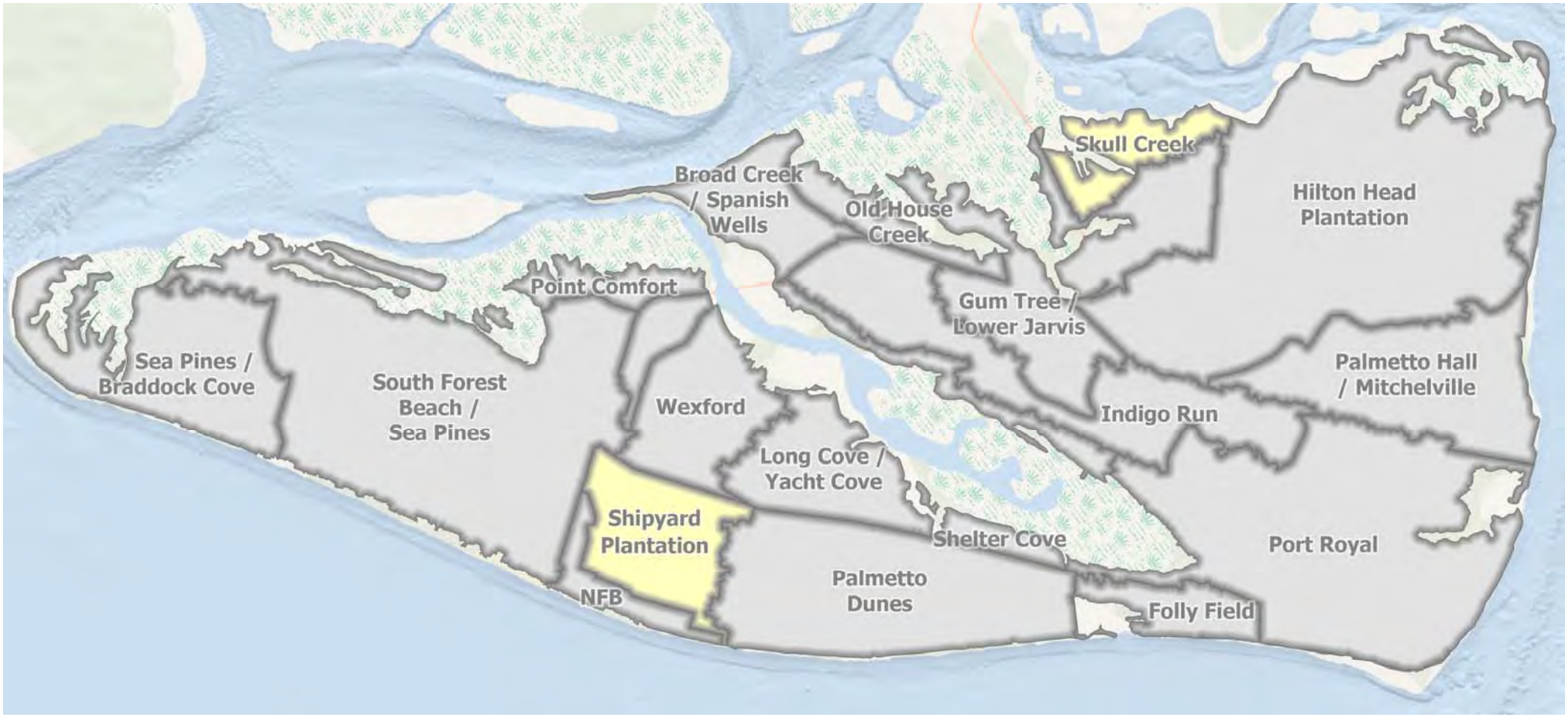
Typical Project Scope



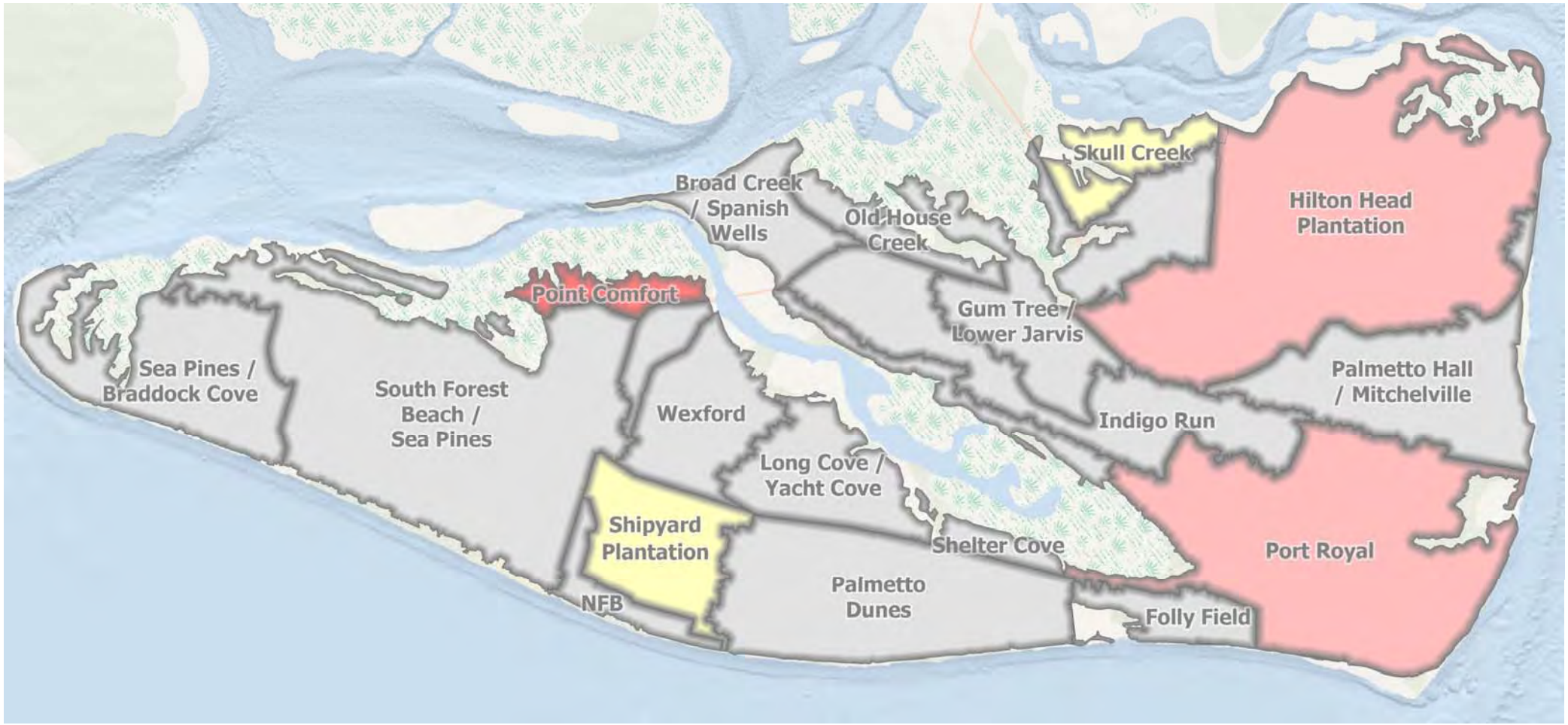
Intended Uses – Program Purpose

- Develop a pre-storm protocol
  - Lagoon drawdown times
  - Calculate protection volumes
  - Investigate benefits of pond level control using telemetry and automation
- Capital improvement project development
  - Model determines benefit of potential projects
  - Large-scale development projects can be plugged in
- Sea Level Rise
  - Determine potential extents
  - Decision tool for policy development and planning
  - Policy implementation tool

The First Studies: 1D Models

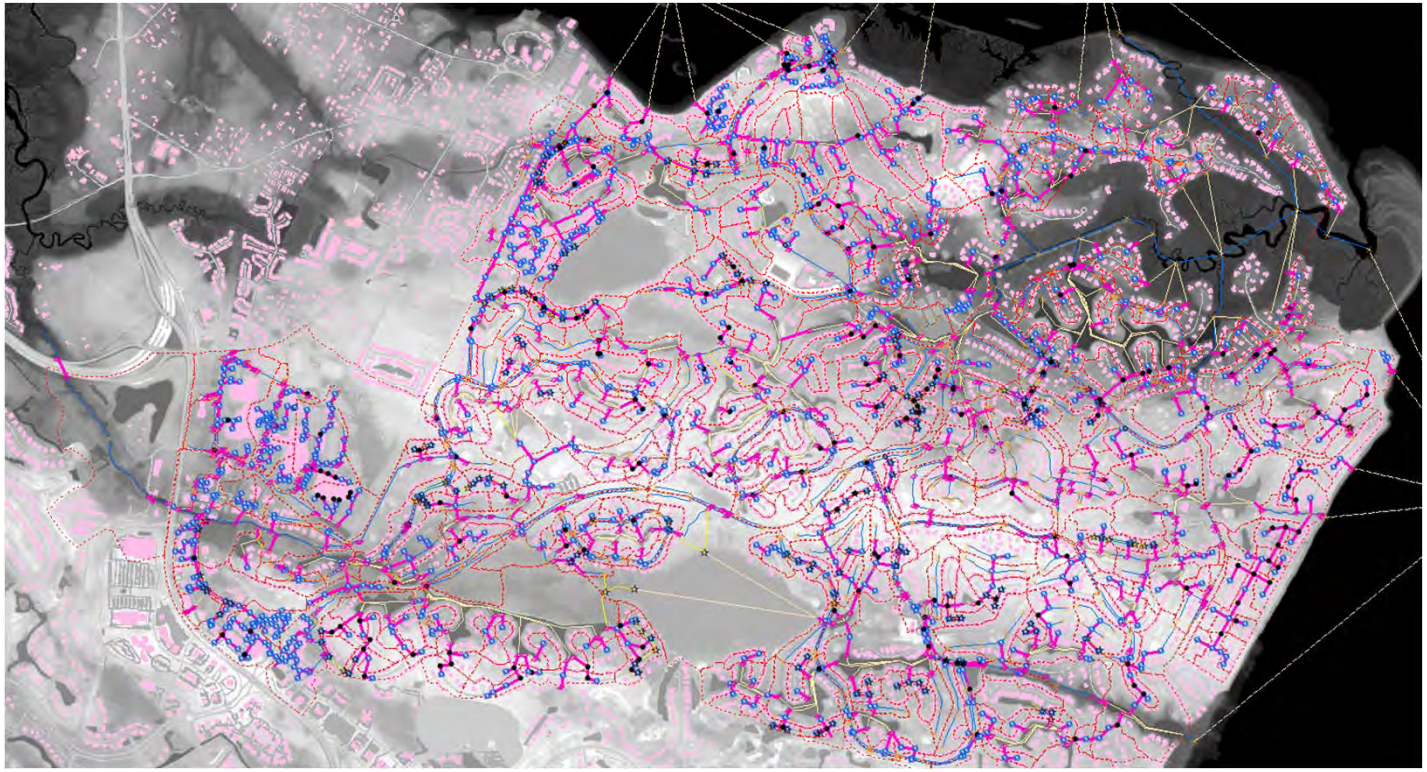


2012: 1D Models and 2D Pilot Model



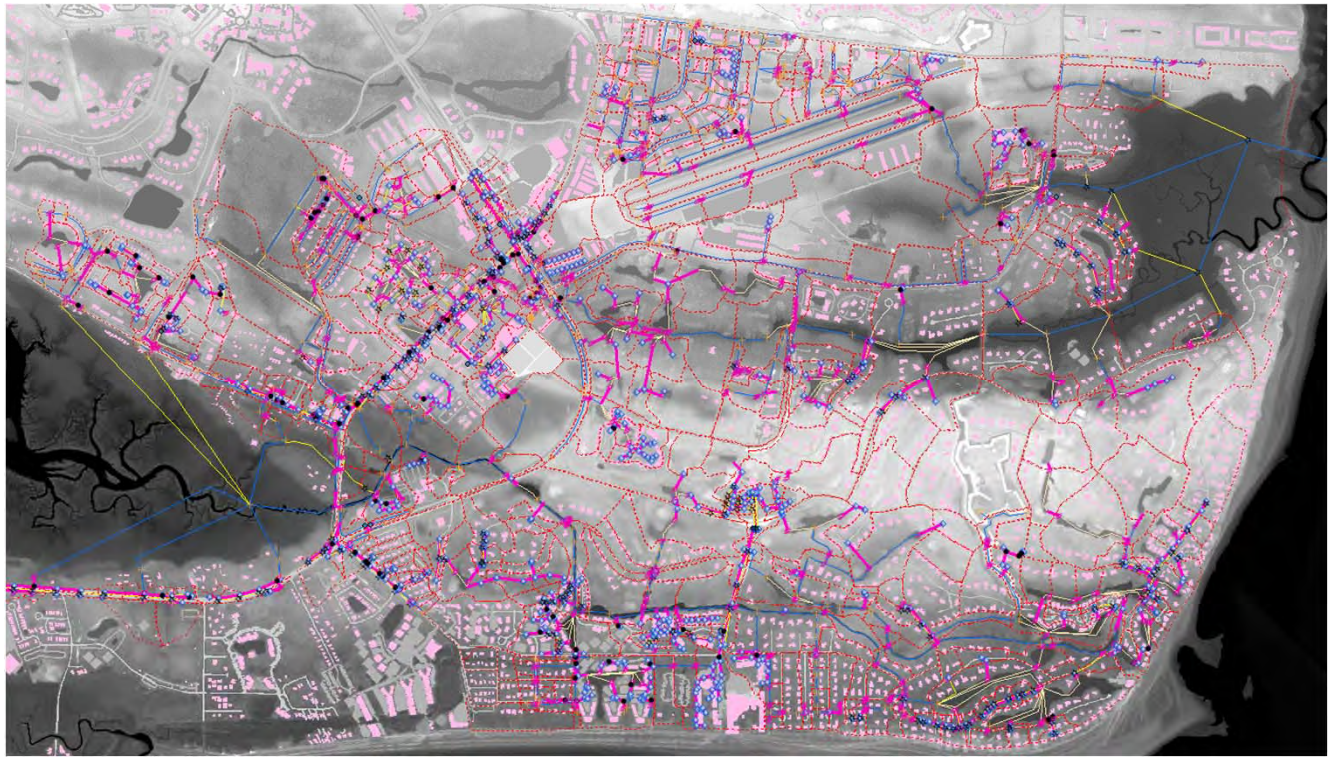
2012: 1D Hilton Head Plantation

- Study Area ≈ 3,812 acres
- Developed a 1D Model
  - 643 Sub-basins
  - 3,400 nodes
  - 3,800 links
  - > 400 surface flow links
  - 115 ponds
- Pressure transducers installed to validate model
- Level of Service (LOS)
- Identify Problem Areas



2012: 1D Port Royal Plantation

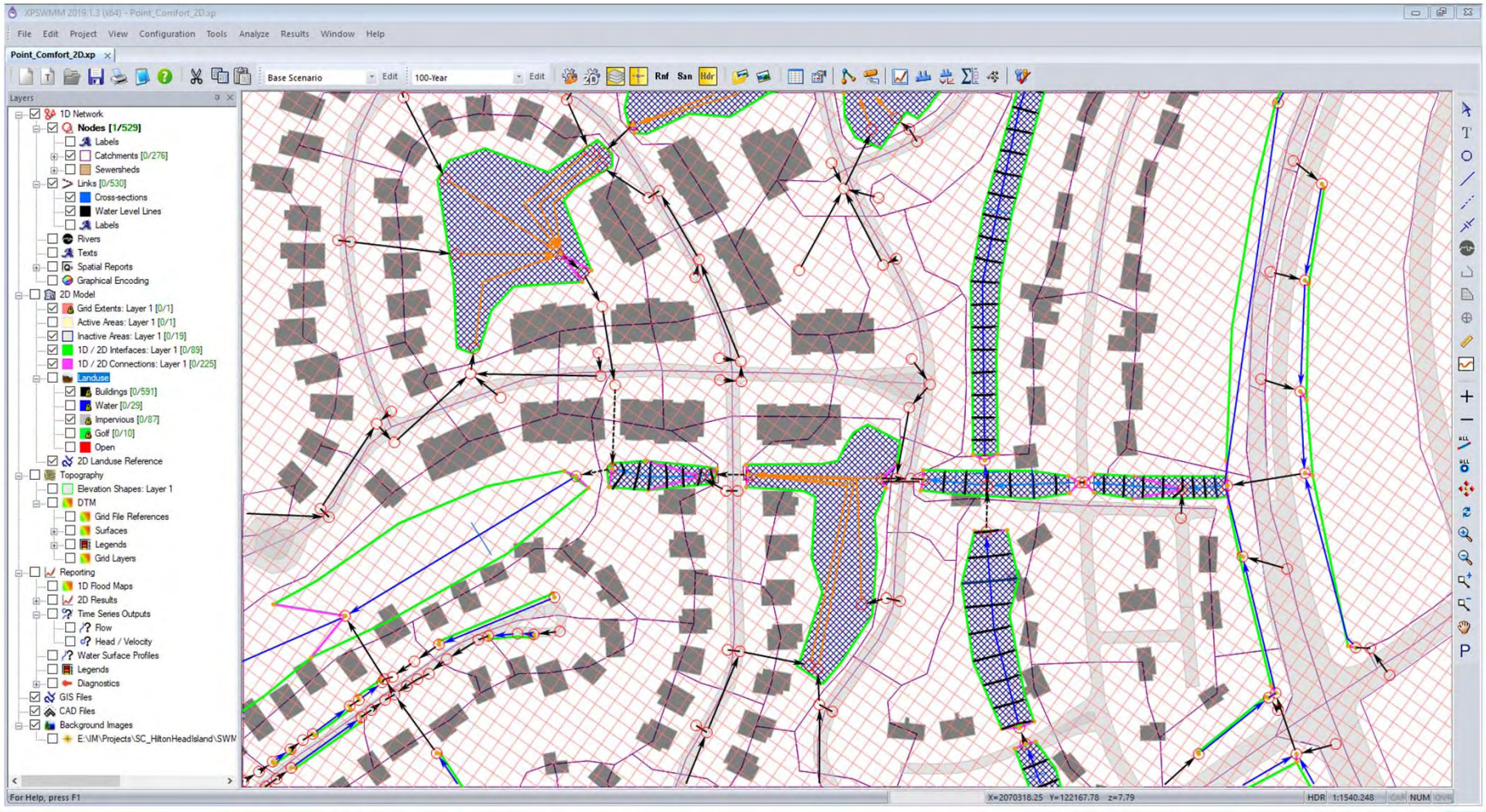
- Study Area ≈ 2,725 ac
- Developed 1D Models
  - 812 Sub-basins
  - 2,400 nodes
  - 2,800 links
  - >600 surface flow links
  - 93 ponds
- Split into 2 Models
  - 2/3 area drains to major marsh area
  - 1/3 drains towards Broad Creek
- Pressure transducers installed to validate model
- Level of Service (LOS)
- Identify Problem Areas



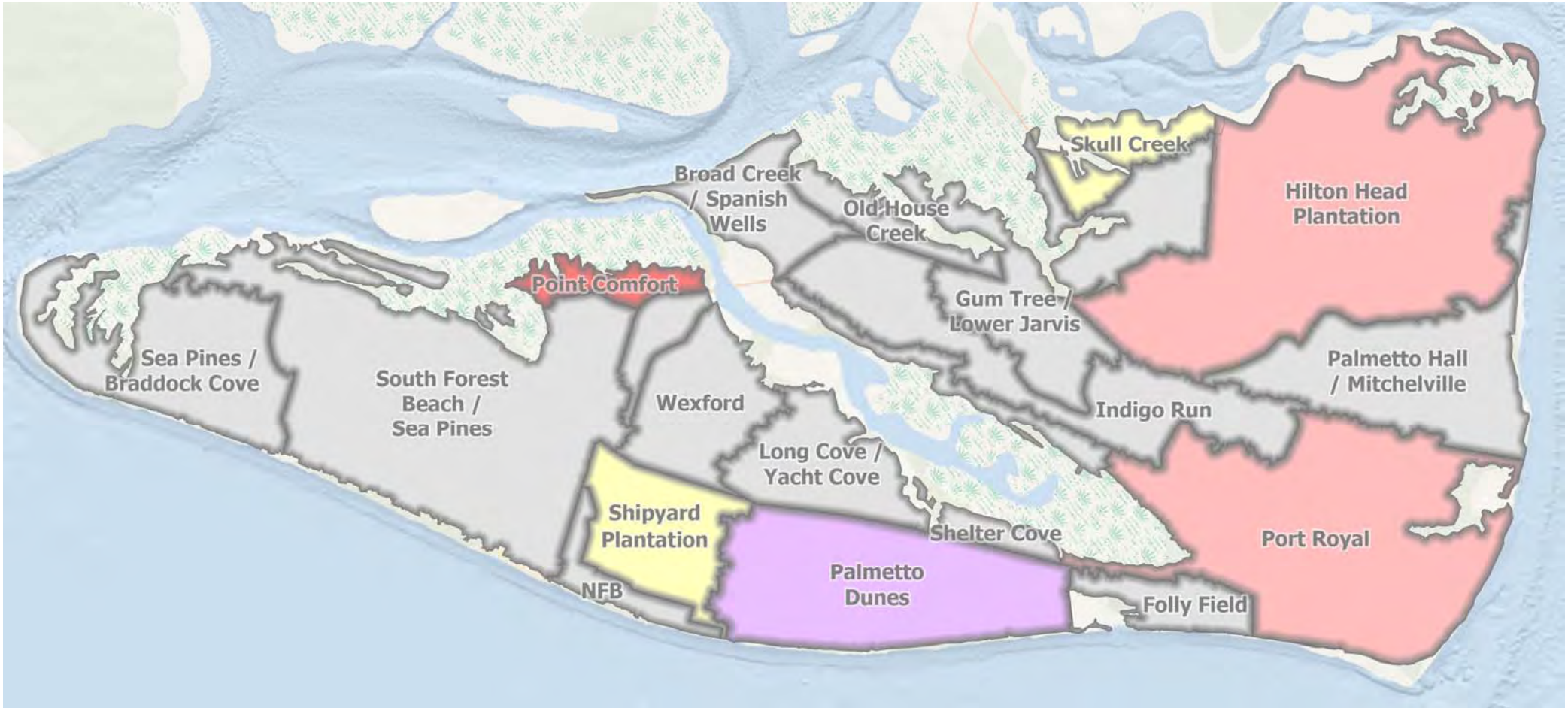
2012: Point Comfort 1D Model

- Point Comfort ≈ 242 acres
  - 271 Sub-basins
  - 600 nodes
  - >700 links
  - 14 ponds
- Tide Control by Downstream Weir or Control Structure
- Pressure transducers installed to validate model
- Level of Service (LOS)
- Identify Problem Areas

2012: Point Comfort 2D Model

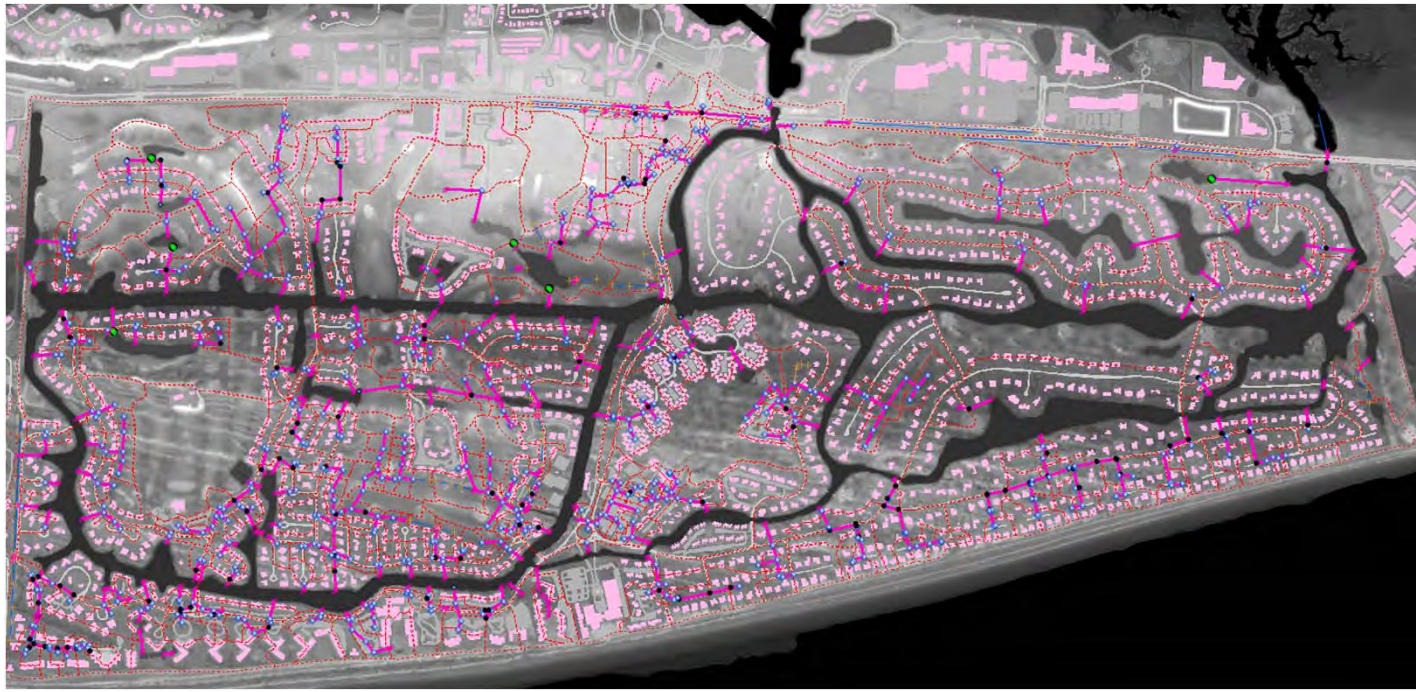


2014: Palmetto Dunes 1D/2D Model



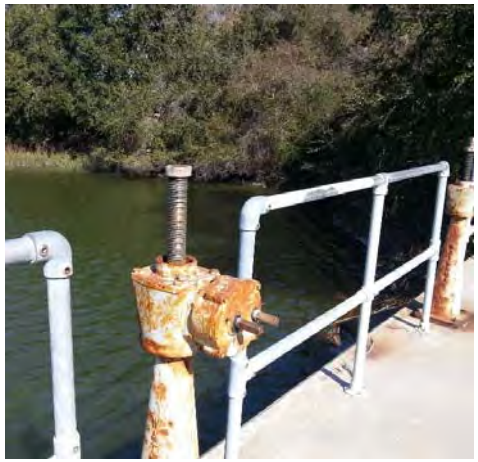
2014 Palmetto Dunes 1D/2D Modeling

- Palmetto Dunes ≈ 1,610 acres
- 581 Sub-basins
- 840 Links
- 1,064 Nodes
- 1 long interconnected channel/lagoon system
- Palmetto Dunes model burned in small channels or extended pipe outfall until discharge to a lagoon.
- Initial Water Level Polygons were used to set Pond Normal Pool Elevations

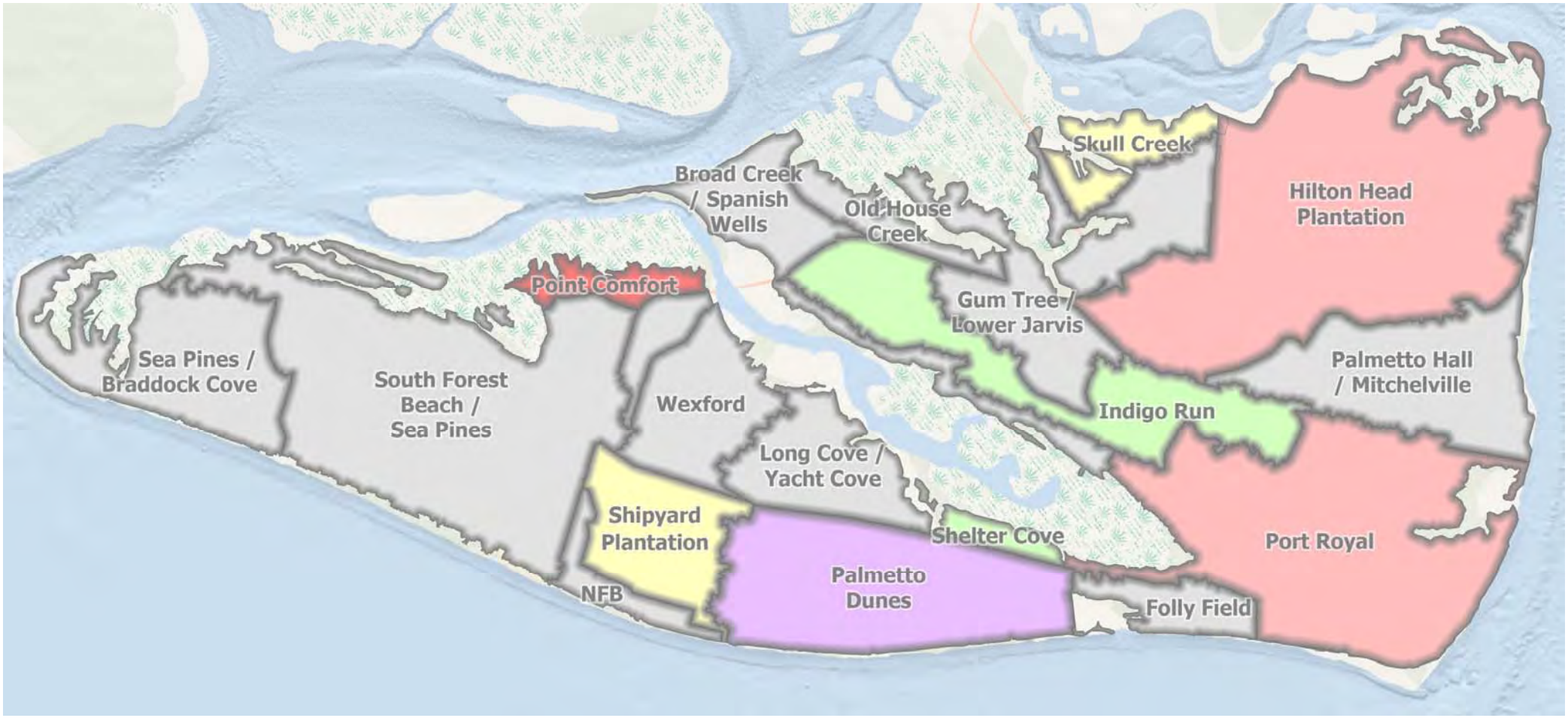


2014 Palmetto Dunes 1D 2D Modeling

- Controlled by two sets of manually operated tide gates (no records of operation)
  - One at the northern most end
  - One in the middle at William Hilton Pkwy
- Drainage system very tidally influenced
- Pressure transducers installed to validate model

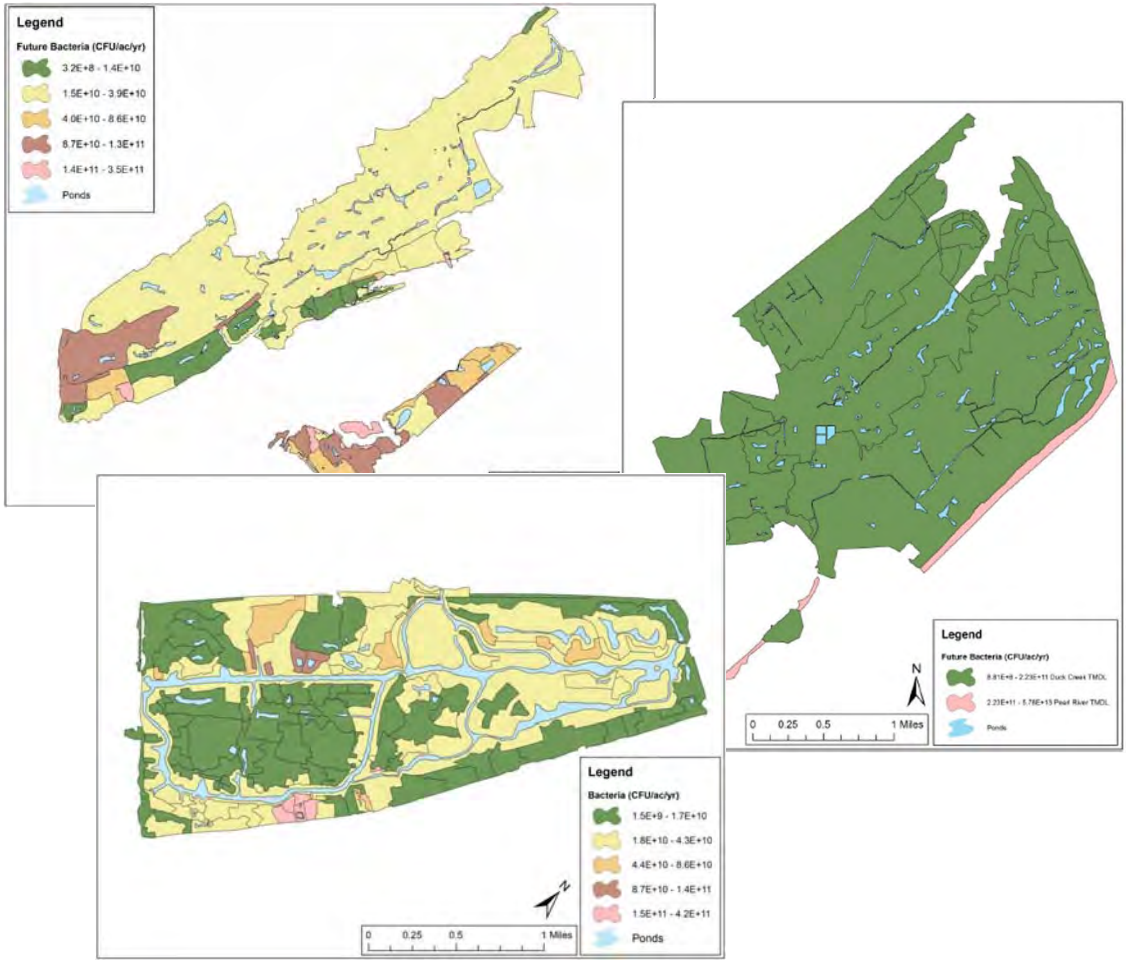


2015: Broad Creek Water Quality

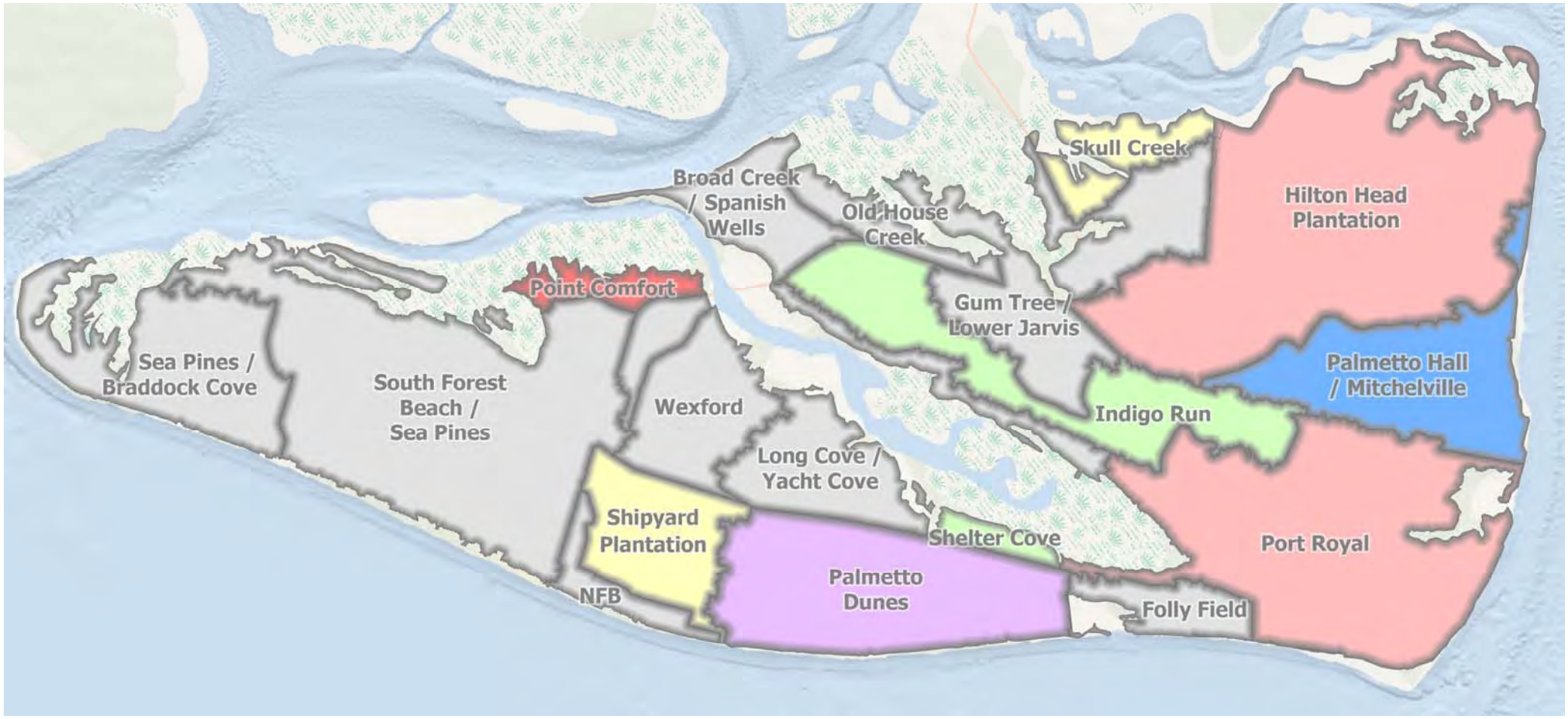


2015: Broad Creek Water Quality

- Water Quality Modeling performed for portions of Watersheds that discharged to Broad Creek
  - Indigo Run
  - Shelter Cove
  - Palmetto Dunes
  - Port Royal Plantation
- Partly funded by 319 Nonpoint Source Pollution grant received for development of the watershed plan for the Upper Broad Creek watershed
- IDEAL model was used
- Model existing loading of pollutants and impact of ponds/lagoons and other BMPs on the discharges from all land areas.
- Created list of potential water quality projects and cost estimates.

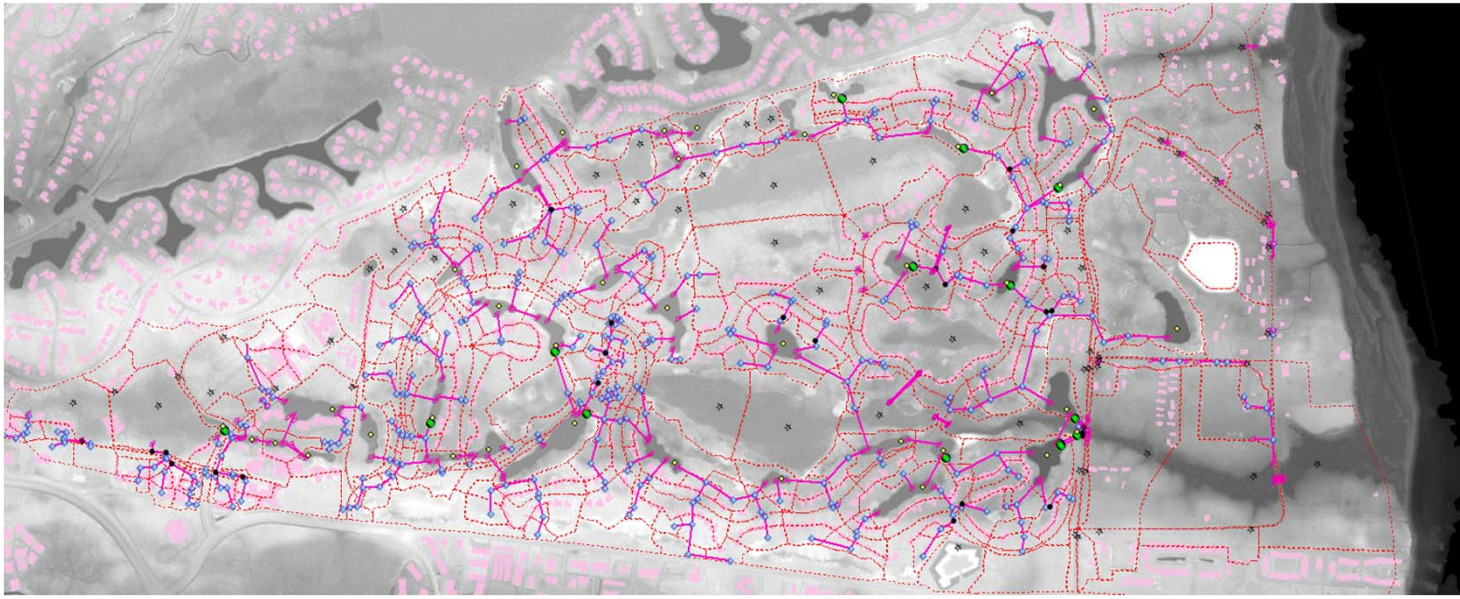


2018: Palmetto Hall/Mitchellville 1D/2D



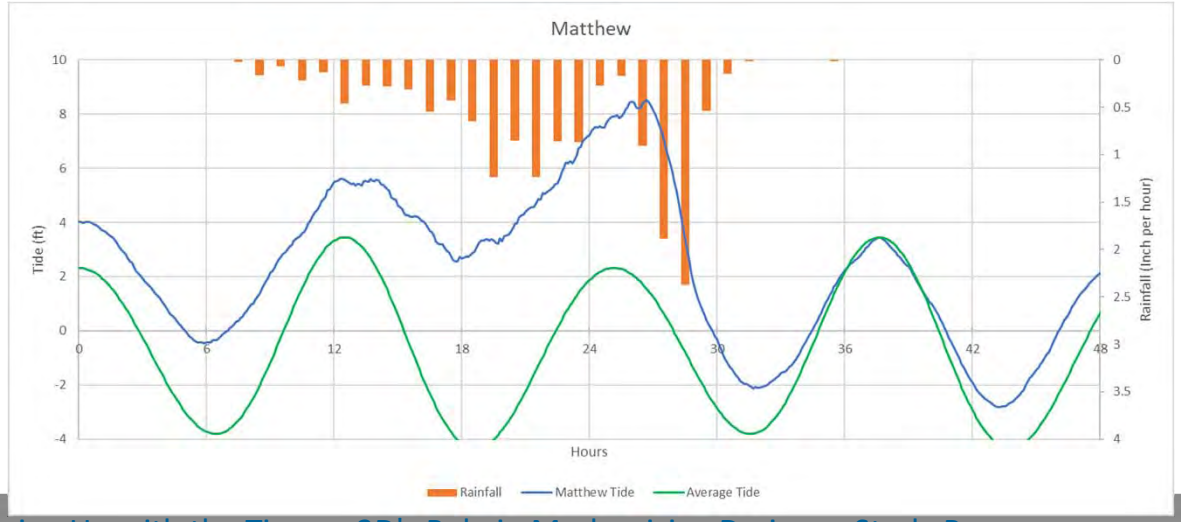
Palmetto Hall/Mitchellville 1D/2D Model

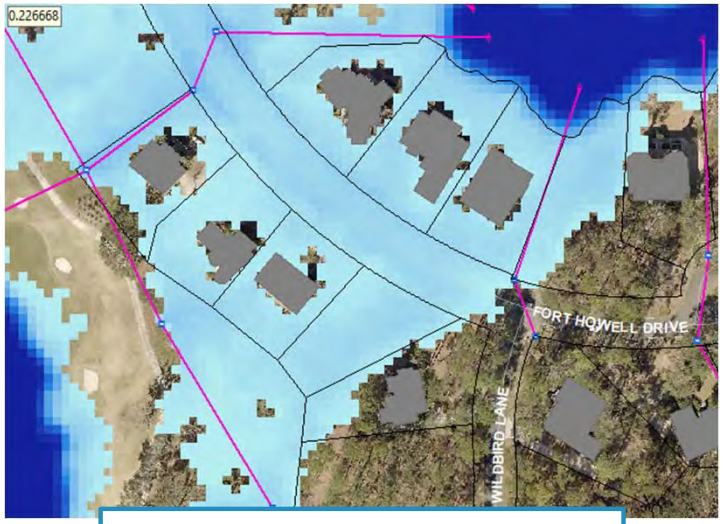
- Study Area ≈ 1,113 acres
  - 670 nodes
  - 460 links
  - 38 ponds
  - 424 Sub-basins
- 2 ponds control water levels discharging under Fish Haul Road
- Level of Service (LOS)
- Identify Problem Areas



Hurricane Mathew (Oct 2016)

- 14.9 inches in 24 hours
- Matthew Max Tide = 8.5 ft
- Mean Higher High Water = 3.45 ft
- Mean Annual Max Tide = 5.65 ft
- Verification Storm for
  - Inundation Extents
  - Impacted Houses

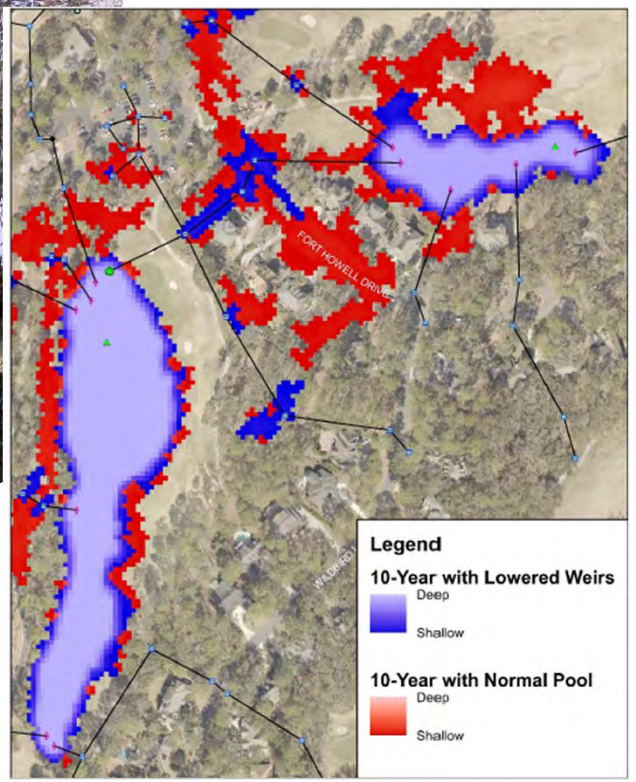




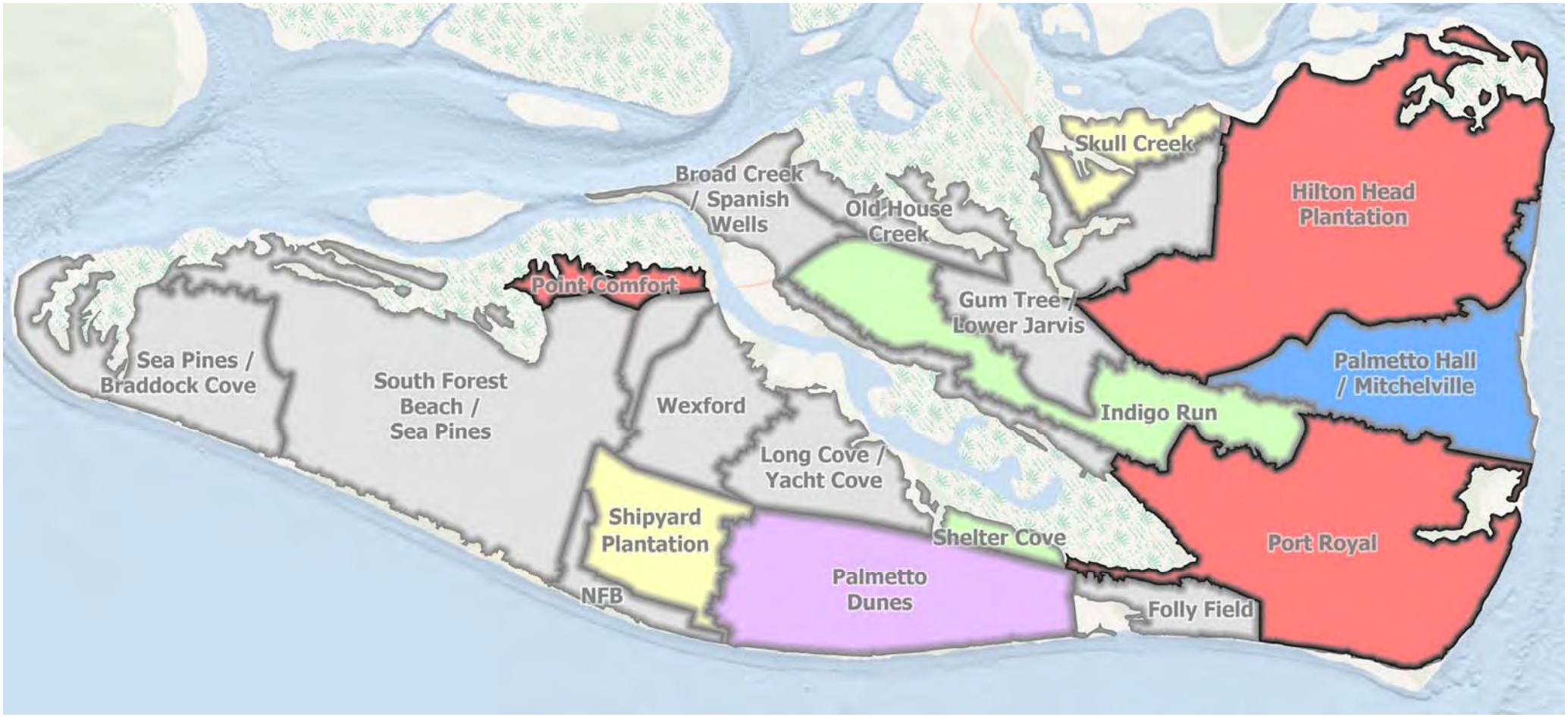
Fort Howell Drive during Hurricane Matthew

Palmetto Hall/Mitchellville
Pre-Storm Maintenance Measures Analysis

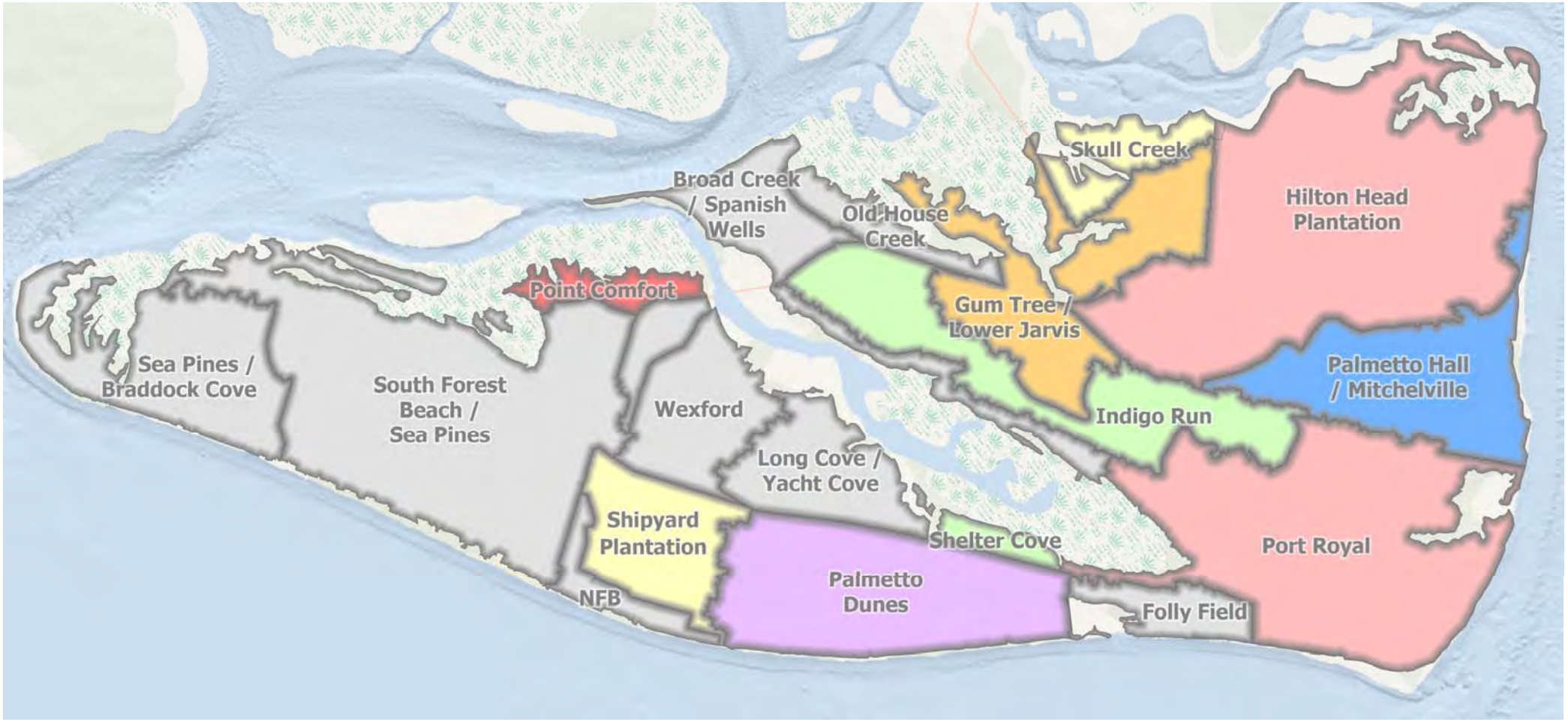
- Interconnected pond system controlled by a series of half-pipe CMP risers with flashboards
- Many owned and operated by Palmetto Hall Plantation Golf and Country Club
- Flashboards could be removed ahead of large storm events for added storage
  - Modeled by modifying the outlet structures
  - Helped during smaller events, no noticeable benefit during larger events



2020: 1D →1D/2D Model Conversion



2020: Gum Tree/ Lower Jarvis 2D

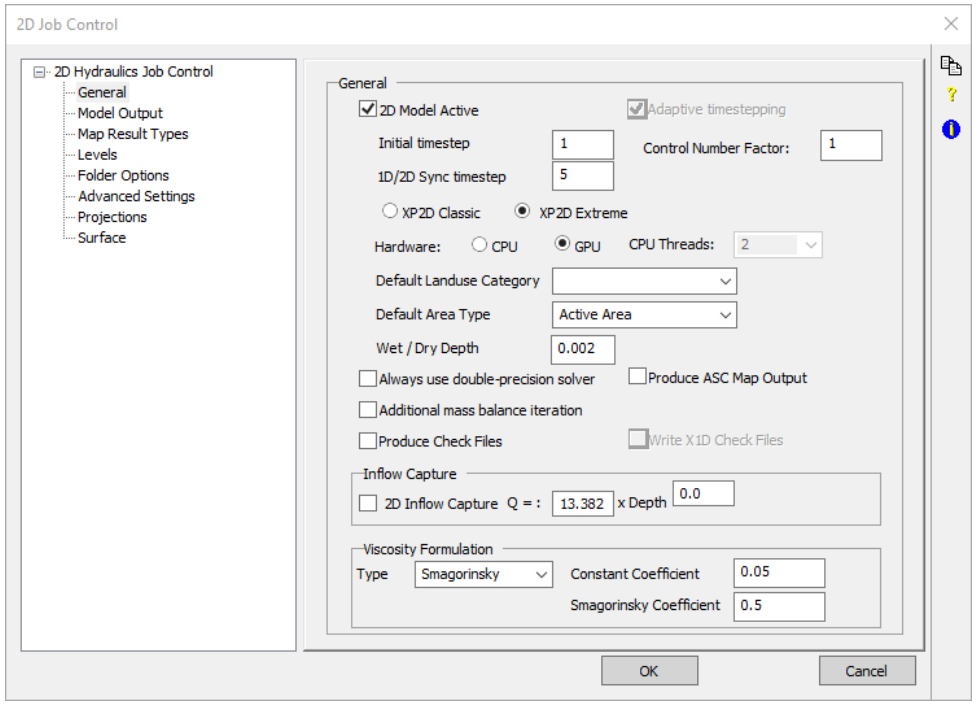


2020: Gum Tree/ Lower Jarvis (Skull Creek) 2D

- Study Area = 5,231 acres (8.17 sq. miles)
- Gum Tree/ Lower Jarvis /Skull Creek = 1,770 acres
  - 4,553 nodes
  - 3,833 links
  - 1,295 Sub-basins
- Combined 1D/2D model
  - HHP model
  - Skull Creek model by others
  - New system inventory for Gum Tree & Lower Jarvis Creeks
  - Jarvis Creek Pump Station

Advances in XP-SWMM 2D Engine (Major Enhancements)

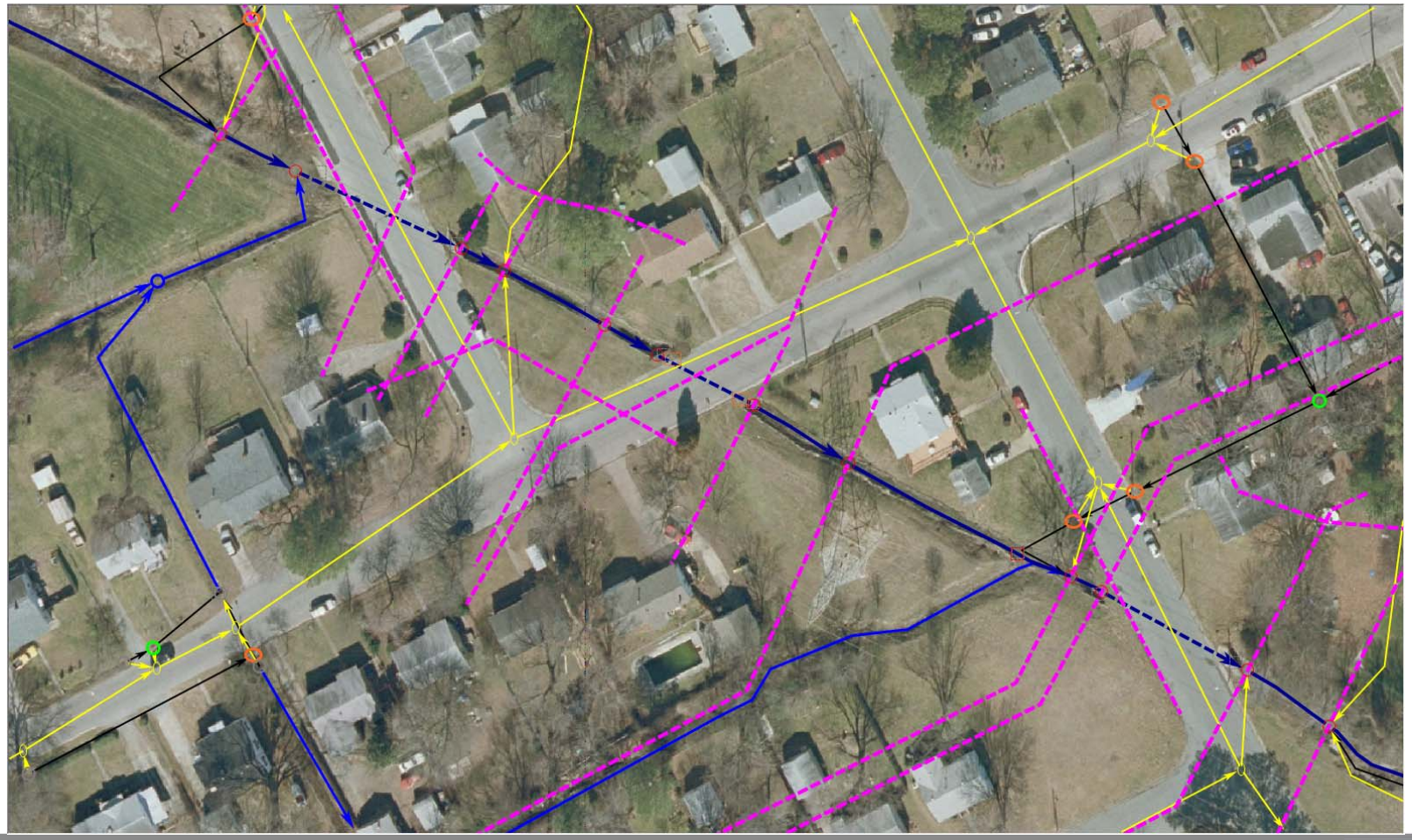
- 2012.x
  - 1D (single core / simulations in series)
  - 2D (Classic – fixed 2D time step)
- 2017.x
  - GPU (2D only w/ adaptive time stepping)
- 2018.x
  - 2D Extreme (1D/2D) CPU/GPU
    - Multi-threaded CPU simulations
    - 1D/2D GPU simulations
  - 2D Classic w/ adaptive time stepping
- 2019.x
  - 64-bit Graphical User Interface
  - TUFLOW 2018-03-AE engine build
  - Multi-threaded GPU simulations



XP-SWMM Run Times

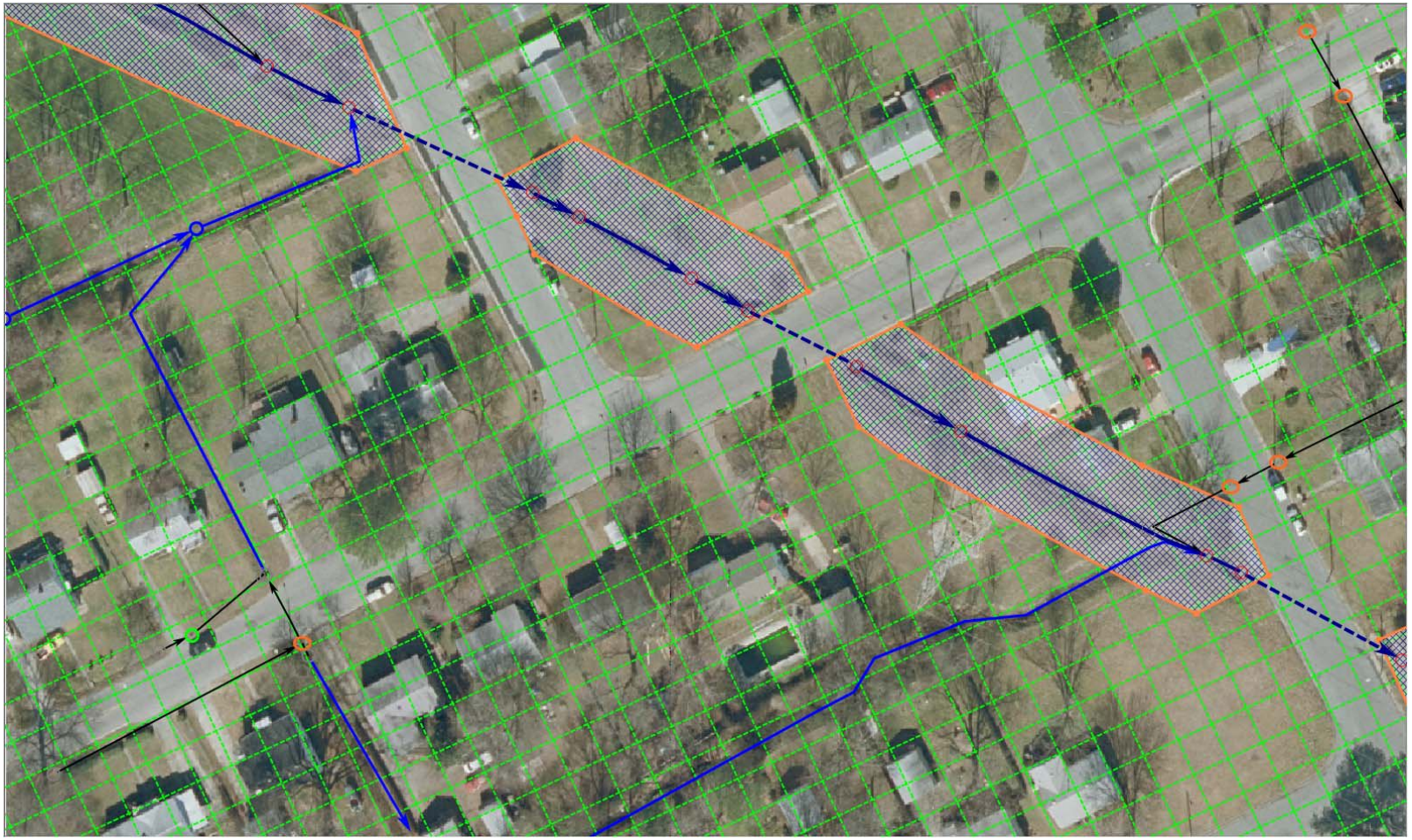
	2012 1D Simulations in Series	2012 / 2014 2D Classic Fixed Time Step	2019 2D Extreme GPU Multi-thread, adaptive time step
Hilton Head Plantation *2012/2020* 3,813 acres	2.5 Day Duration 75 minutes per event 7.5 hrs for 6 events	-----	2 Day Duration 7.5 hrs for 6 events
Port Royal Plantation *2012/2020* 2,725 acres	West Model: 5 Day Duration, 85 minutes per event, 8.5 hrs for 6 events East Model: 5 Day Duration, 30 minutes per event, 3 hrs for 6 events 11.5 hrs for both models	-----	*East/West Combined 5 Day Duration 6 hrs for 6 events
Point Comfort *2012/2020* 242 acres	2 Day Duration 20 minutes per event 2 hrs for 6 events	2 Day Duration 185 minutes per event 18 hrs for 6 events	2 Day Duration 2 hrs for 6 events
Palmetto Dunes *2014* 1,610 acres	------	2 Day Duration 150 minutes per event 15 hrs for 6 events	2 Day Duration 1.75 hrs for 6 events
Palmetto Hall **2018** 1,113 acres	------	-----	2 Day Duration 5 hrs for 6 events
Jarvis / HHP **2020** 5,231 acres	------	-----	2 Day Duration 10 hrs for 6 events

1D Channels

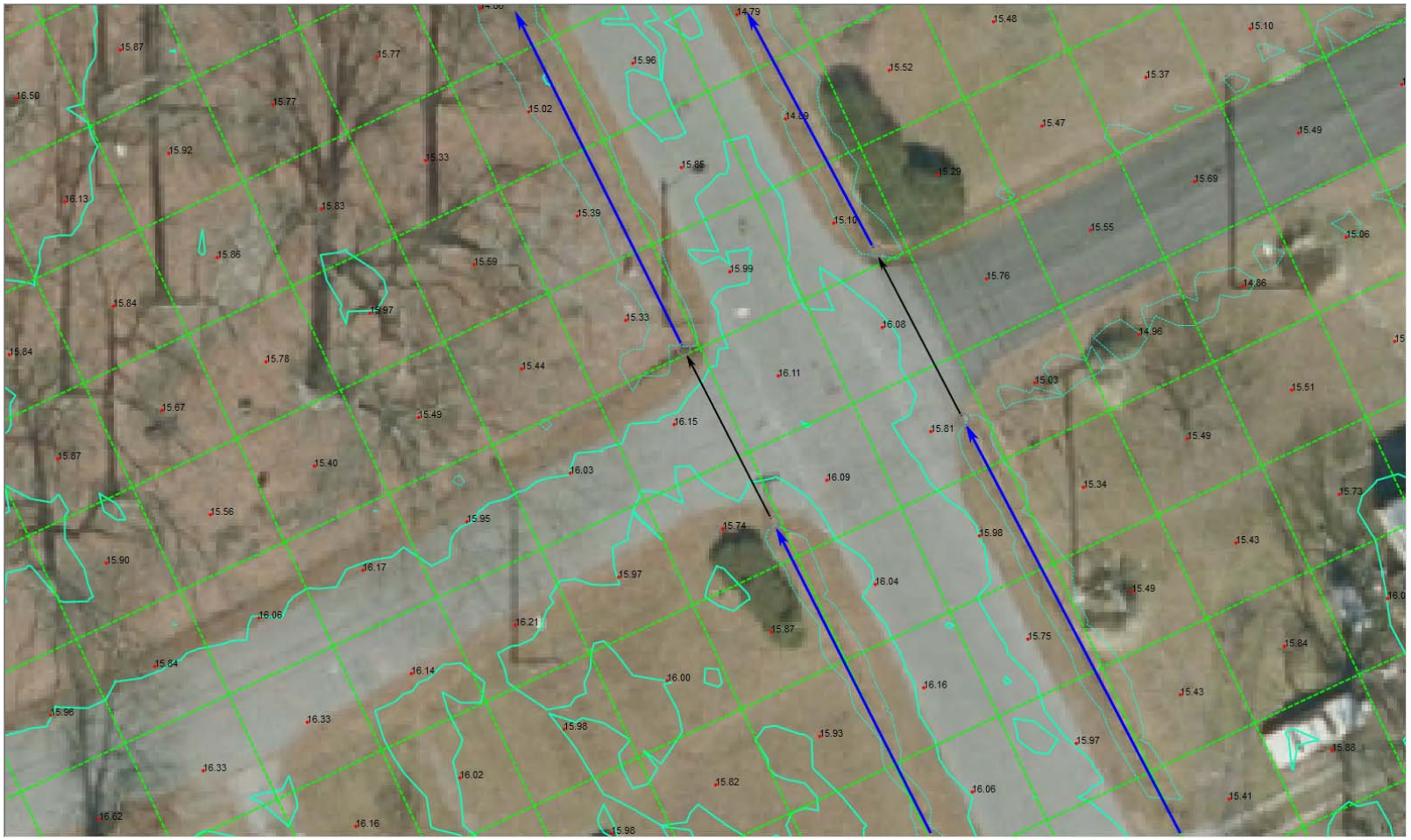


2D Channels

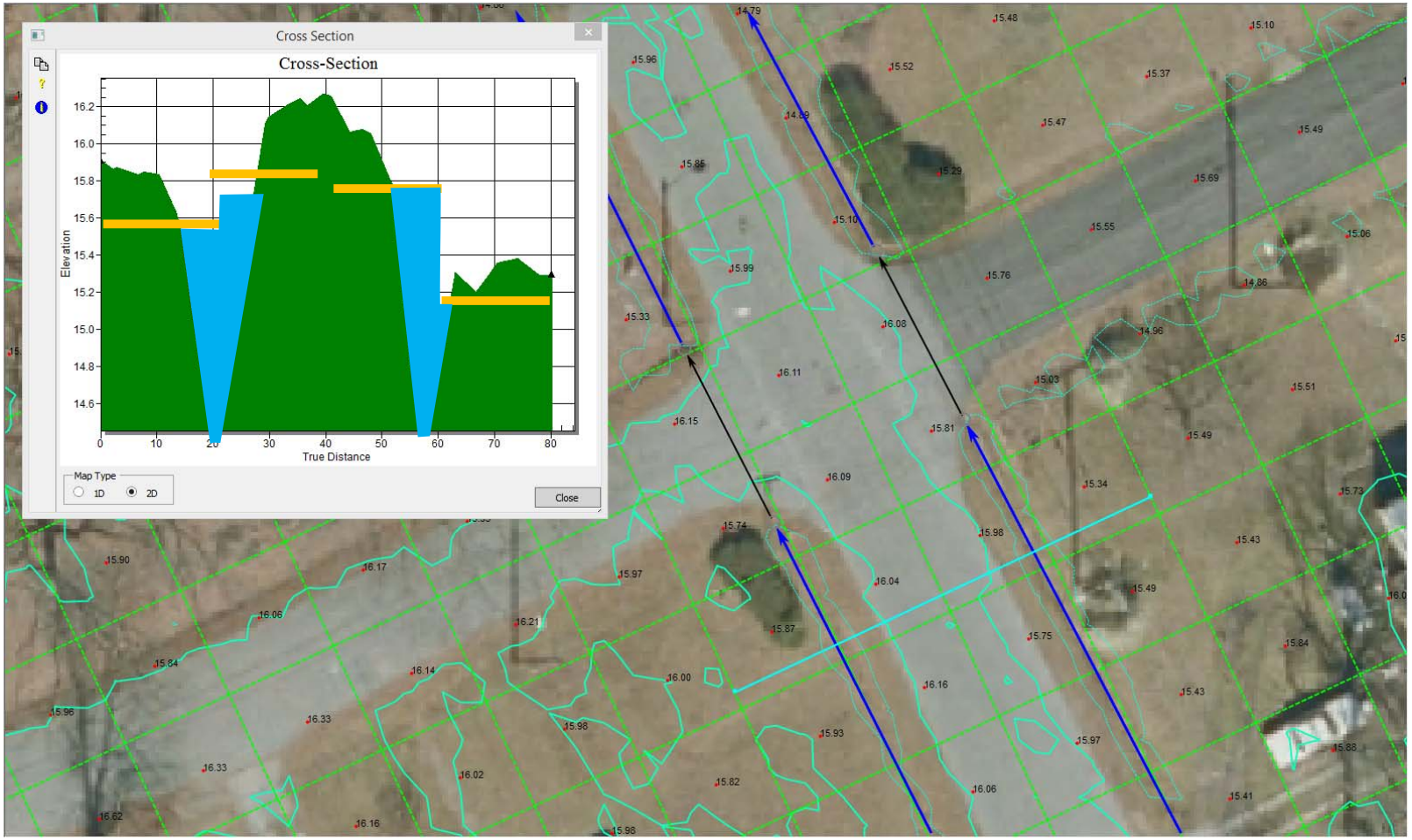
1D Channels / 2D Overbanks



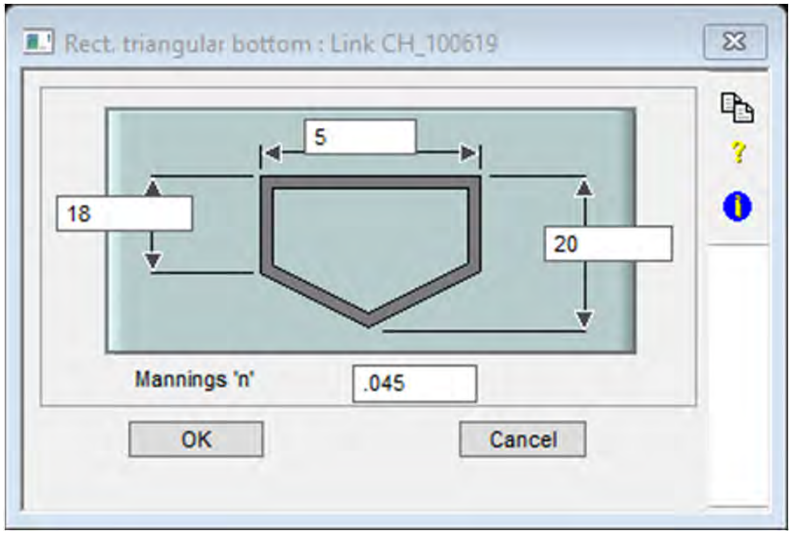
Small Channels



Small Channels



Channel's Low Flow Section

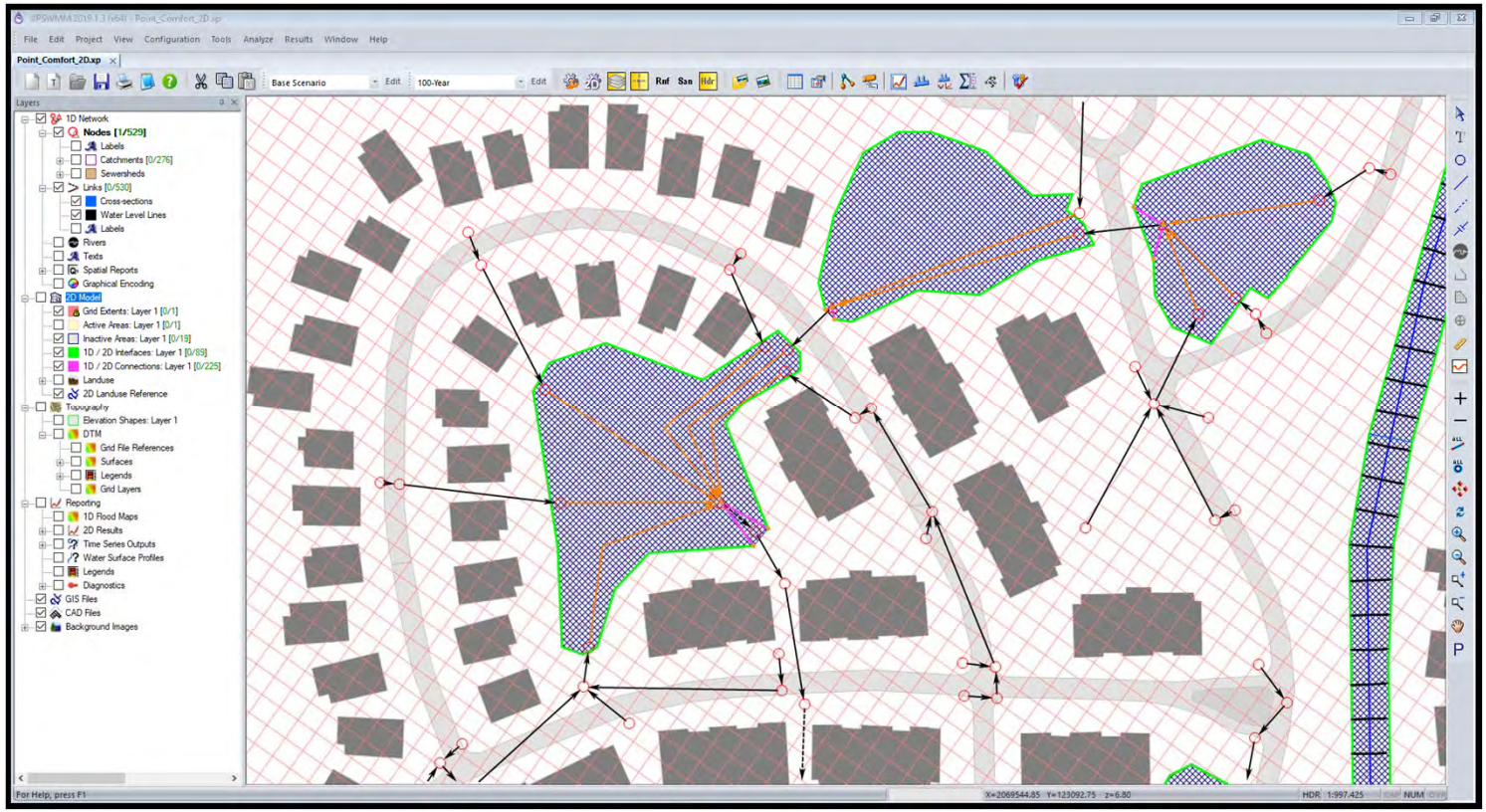


- 2D Grid covers entire channel section
- 1D closed conduit link conveys flow low section
- Node inverts are linked with 2D Grid

Ponds – 1D vs 2D

Ponds as 1D

- Storage Nodes
- 2D Inactive Areas
- 1D/2D Interfaces
- 1D/2D Connections

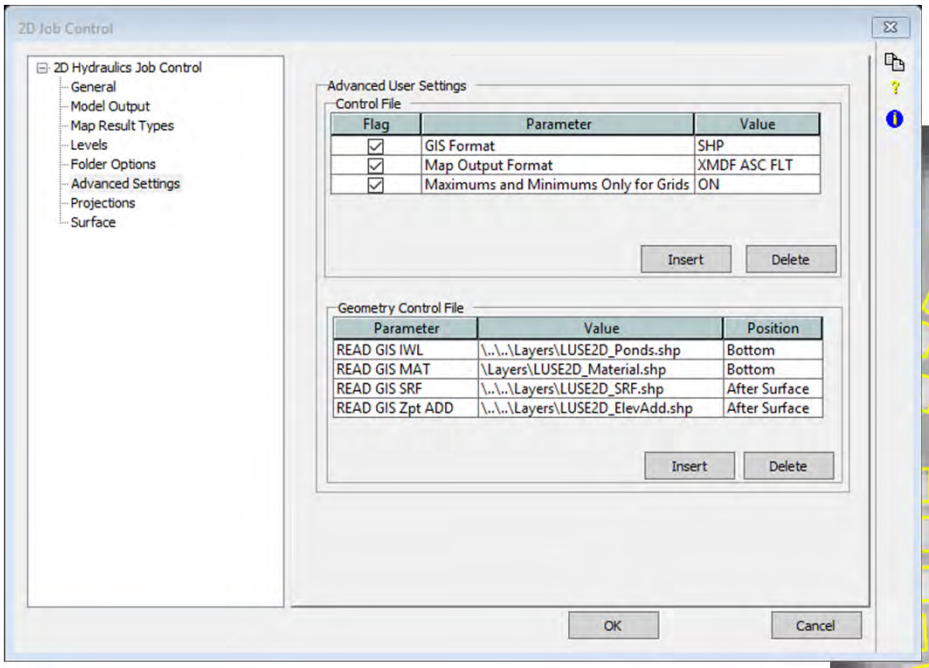


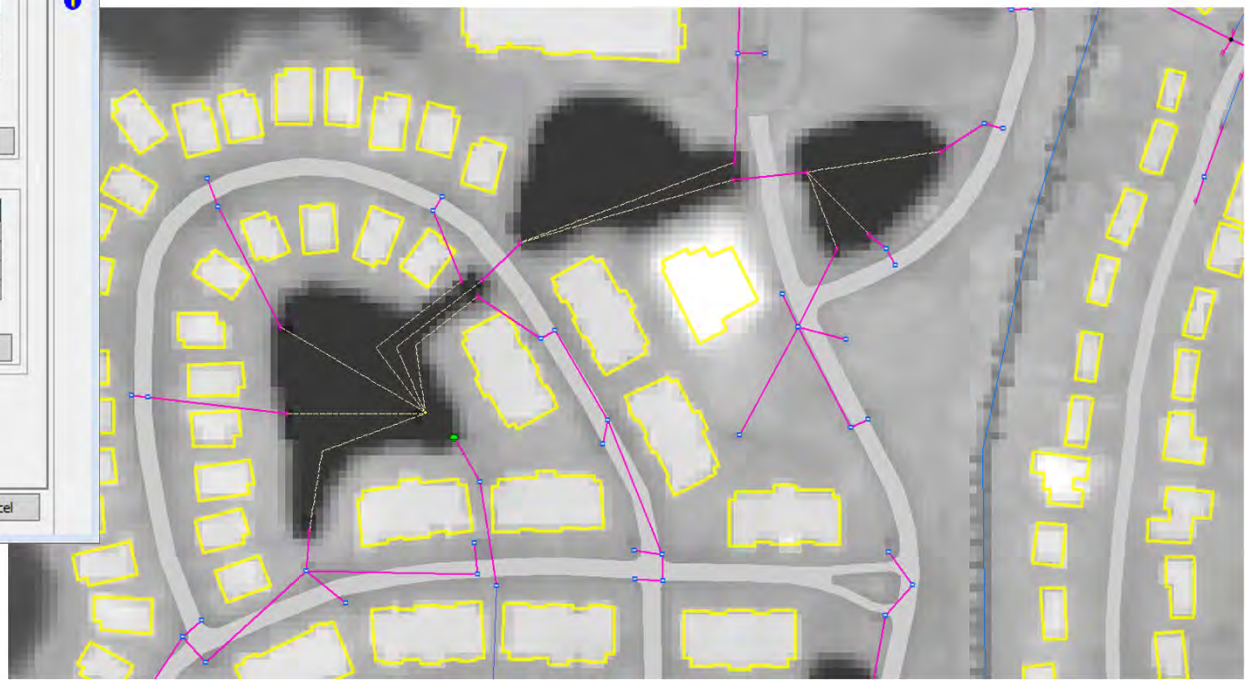
Ponds – 1D vs 2D

Ponds as 2D

- Ponds are Burned into the DEM
- Initial Water Surface is set using Polygons and the 2D Advanced Settings
- Pipe End and Control Structure Nodes linked to 2D via invert
- Continuous 2D Grid

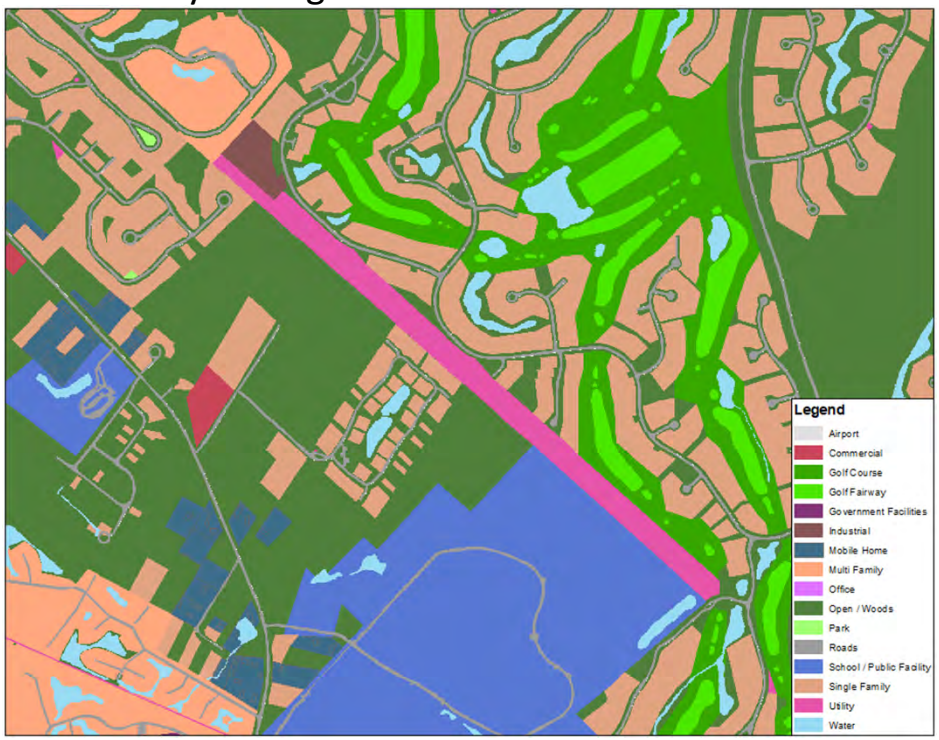
Advanced Features For Buildings



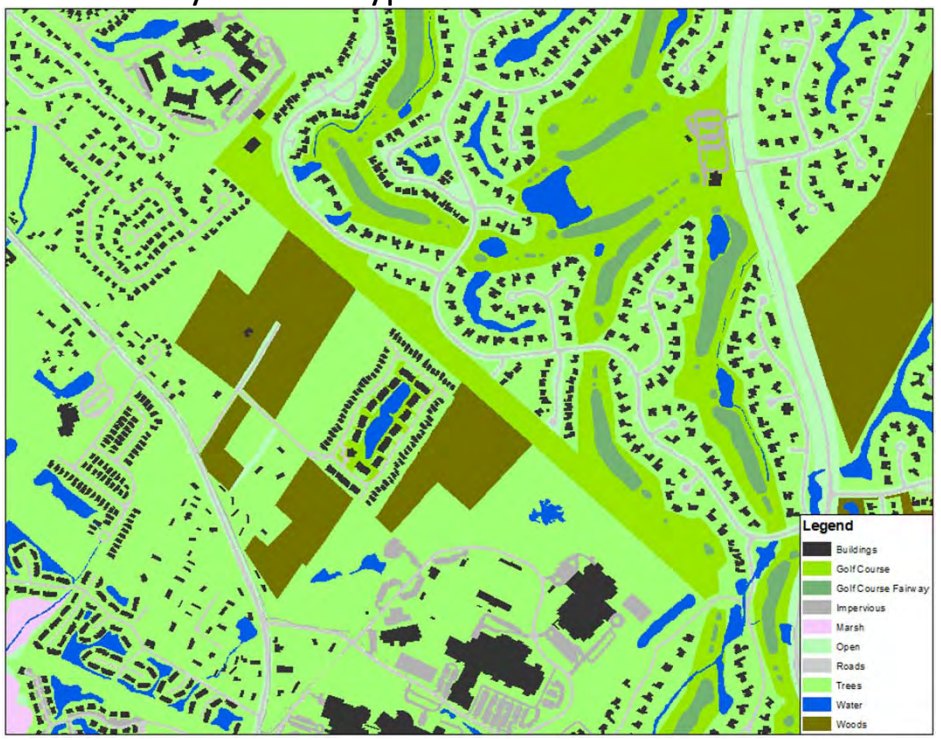


Landuse

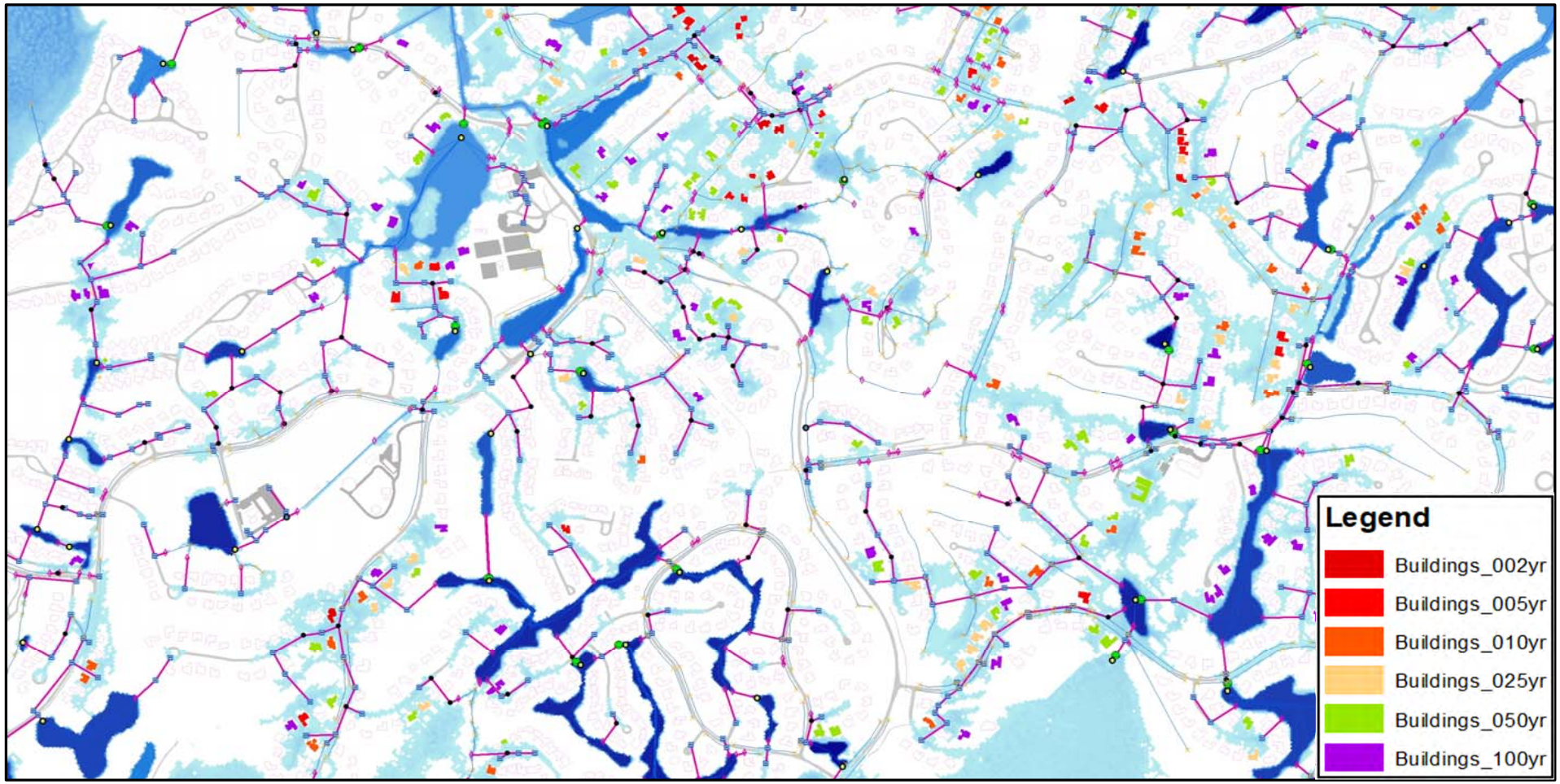
Landuse by Zoning



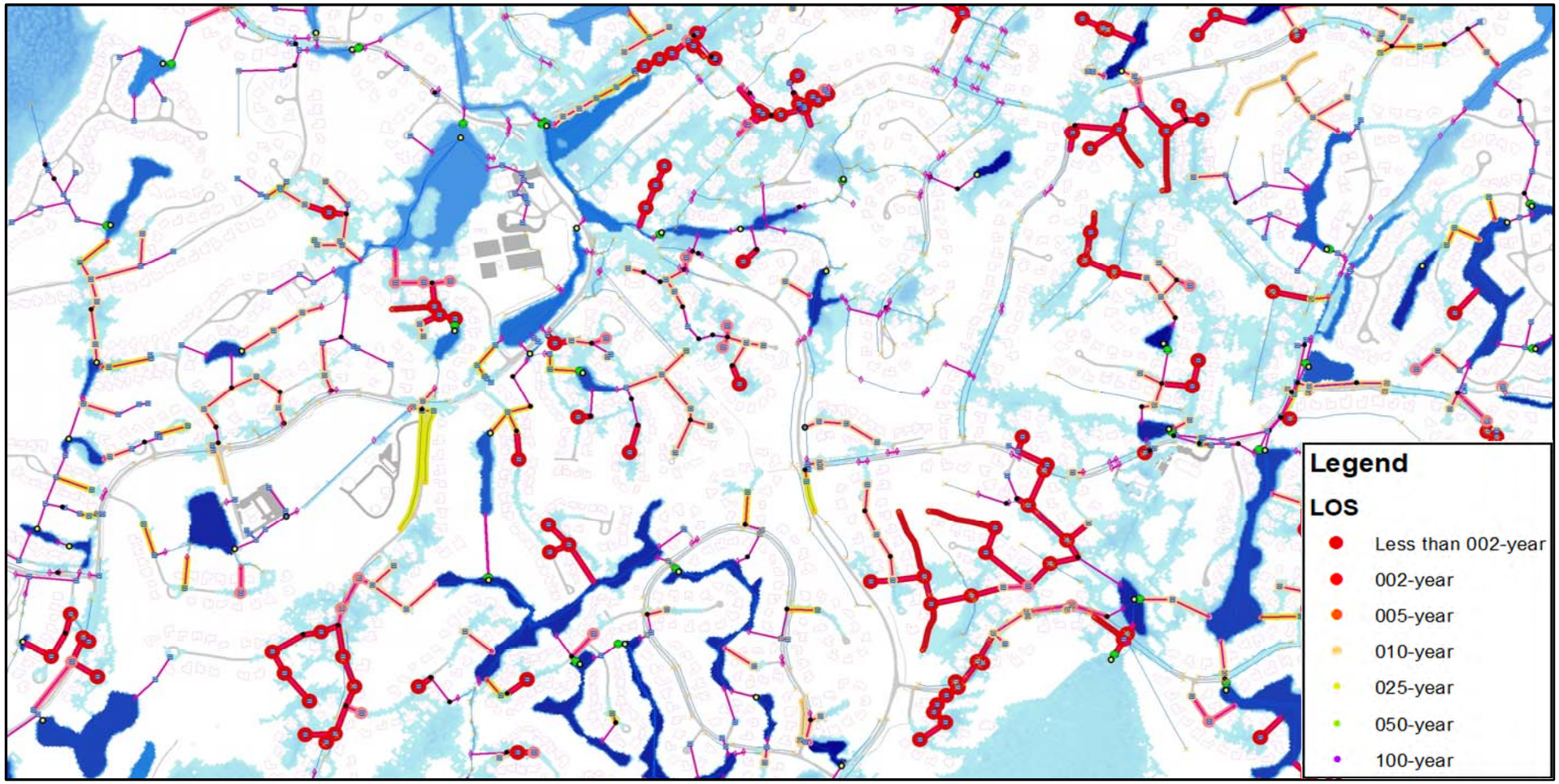
Landuse by Surface Type



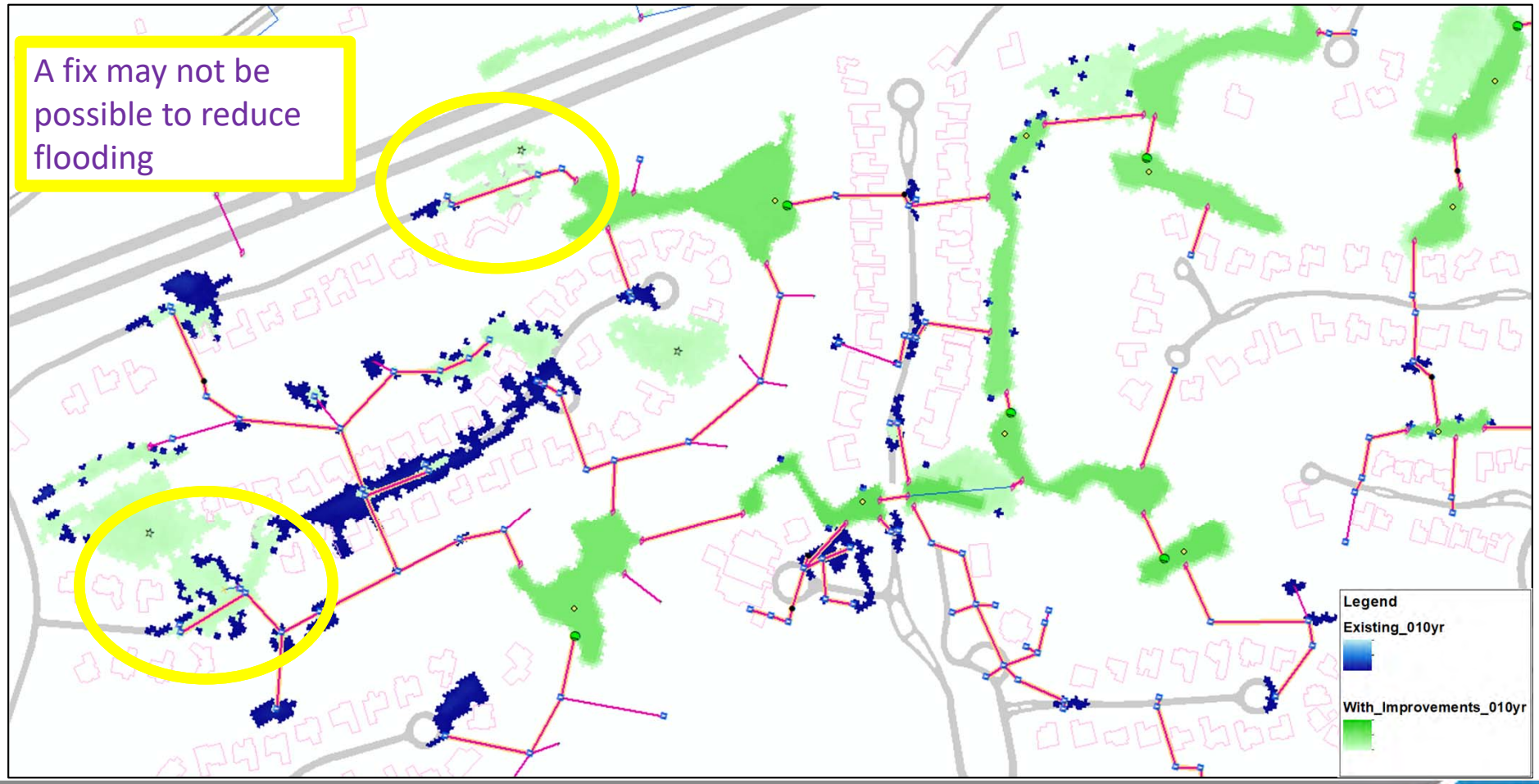
Inundation Maps with Impacted Structures



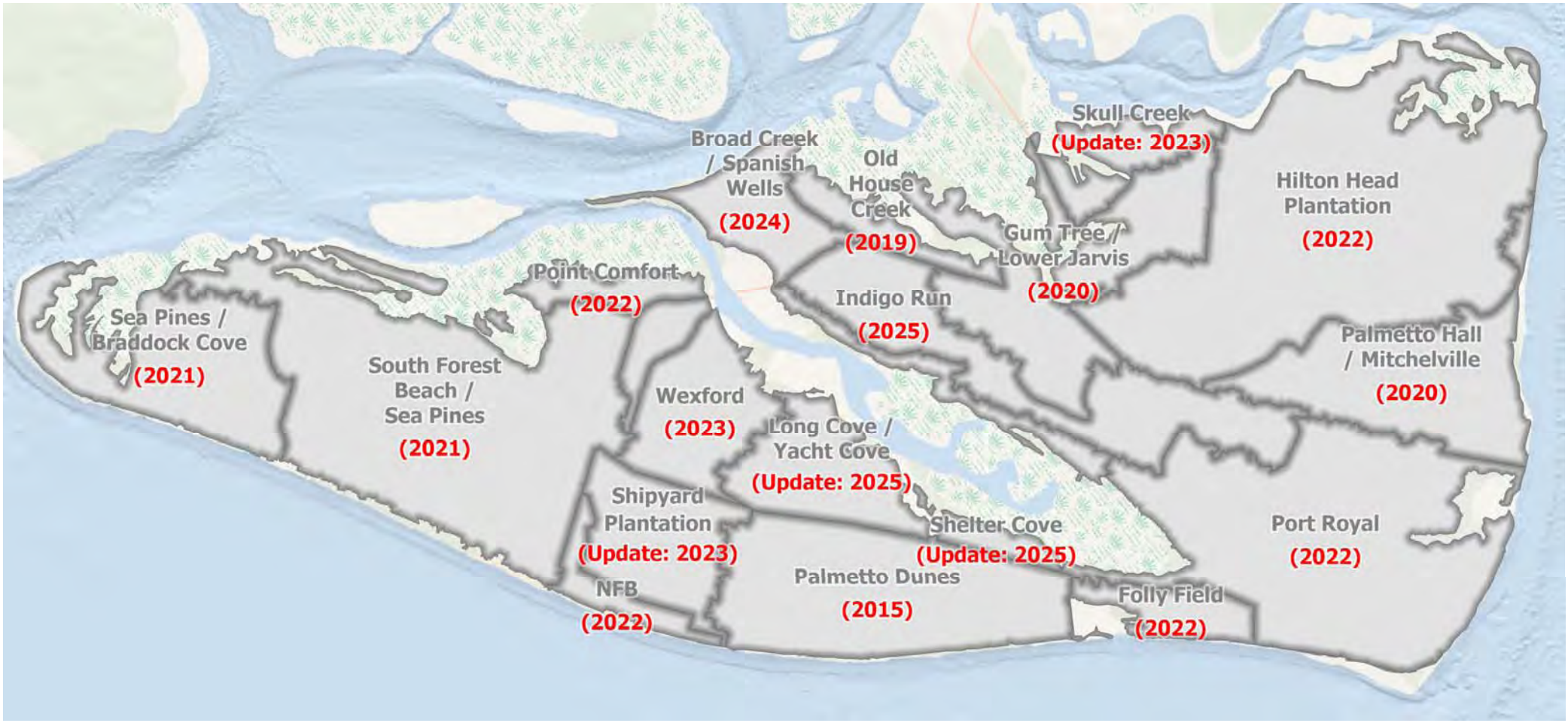
Level of Service Determination



Alternatives Evaluation and Analysis



The Updated Plan




QUESTIONS?