Virginia Beach Stormwater Master Plan Model

Model Content and Application Technical Guidance

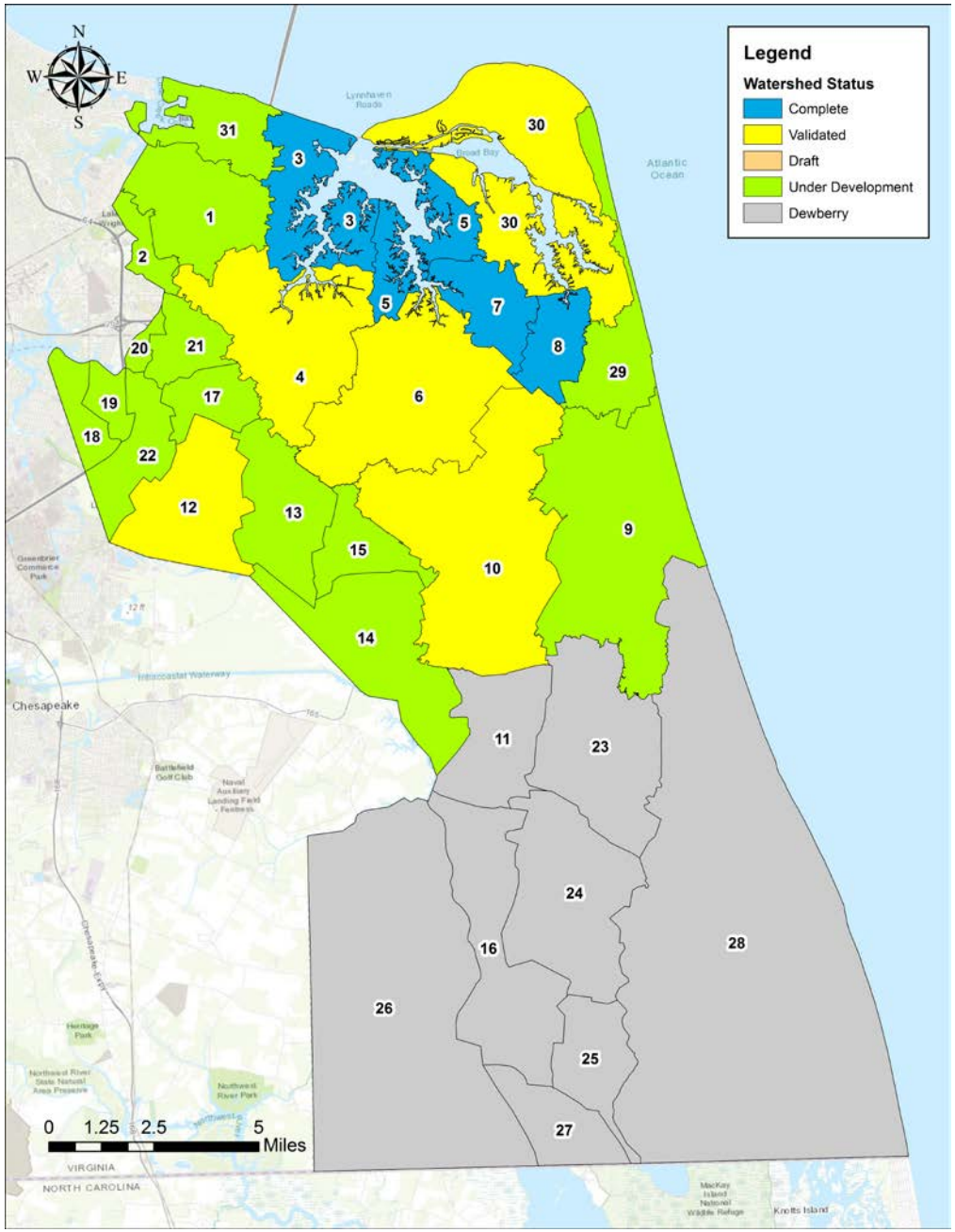
7/8/2018

CDM Smith

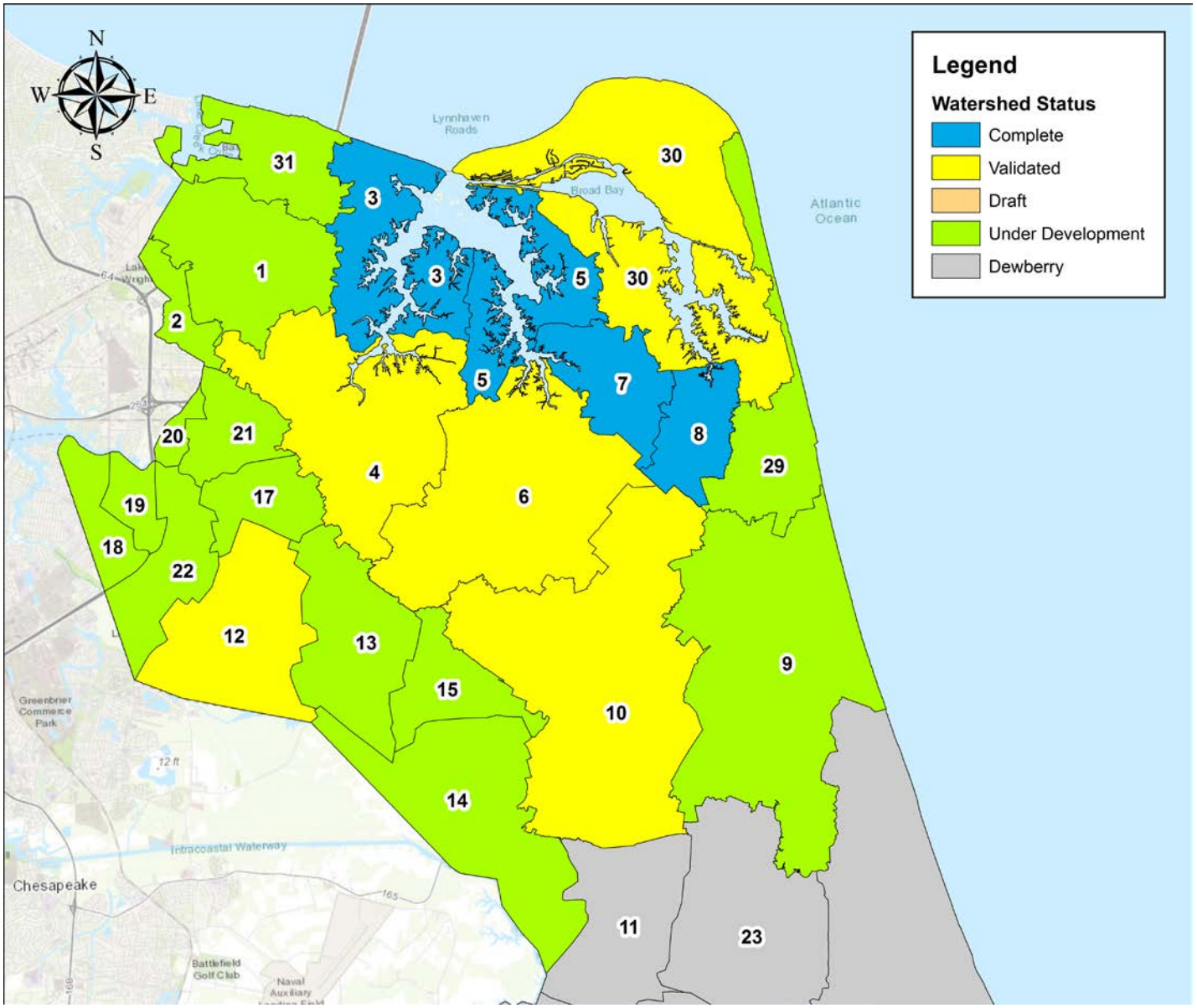
Meeting Outline

- Introduction
  - Overview
  - Source data and datum
- Methodology
  - Hydrology
  - Hydraulics
  - Boundary conditions
  - Model validation
- Master plan model application
  - Master plan model application
  - Master plan model limitations
  - Examples

City Watersheds and Model Status



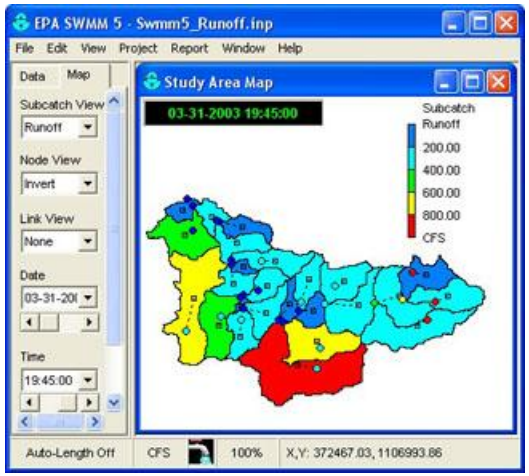
City Watersheds and Model Status

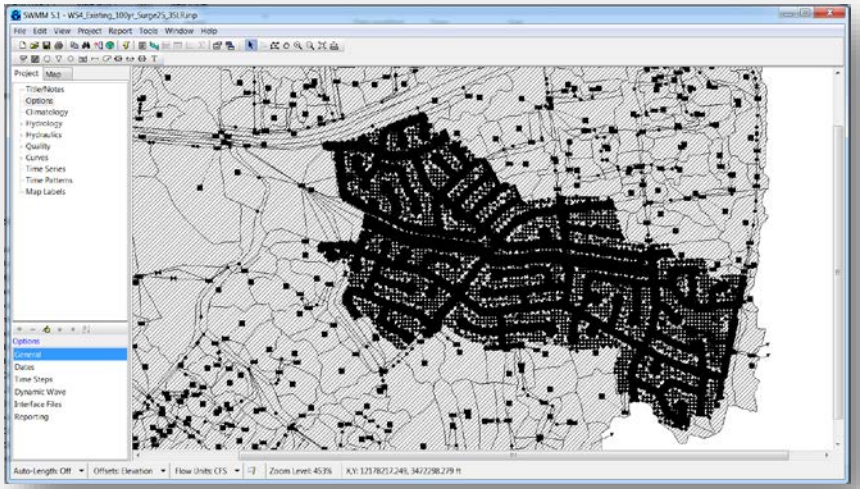


Model Software

EPA United States Environmental Protection Agency

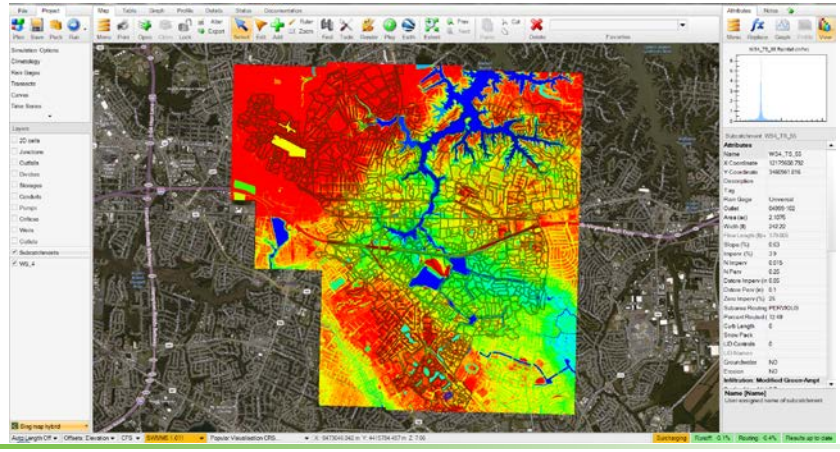
Storm Water Management Model (SWMM)

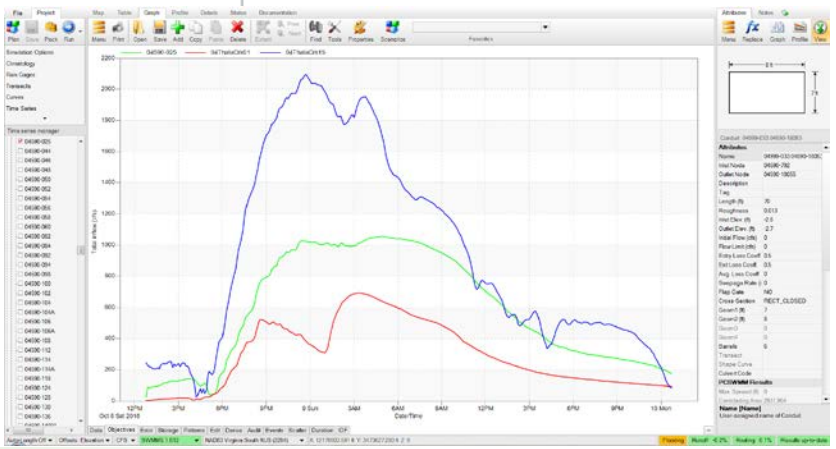




Computational Hydraulics International

CHI | PCSWMM





Model Resolution

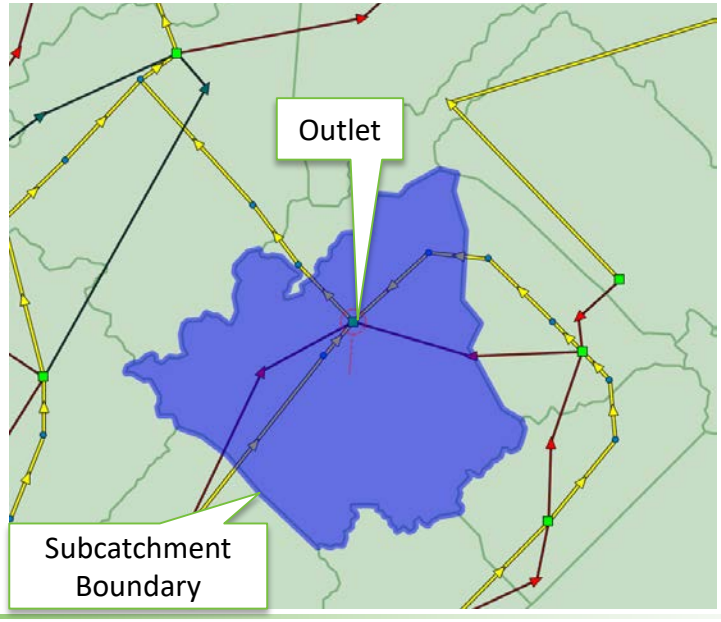
Primary stormwater management system (PSMS):

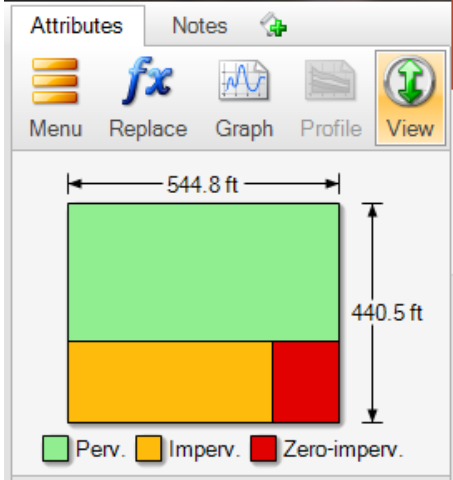
- Open channels and pipes 24-inch diameter and larger
- Stormwater Management Facilities (SWMF)
- Overland flow paths
- 2-D modeling where applicable
- Based on Public Works Stormwater Infrastructure GIS
- Models continue downstream to MS4 outfall and/or tidal boundary condition
- North American Vertical Datum of 1988 (NAVD 88)
  - Included conversions from NGVD 1929 and NGVD 1929 with 1972 adjustment

Methodology

Hydrology

Outlet	10260-270
Area (ac)	5.51
Width (ft)	544.82
Flow Length (ft)	440.541
Slope (%)	0.5



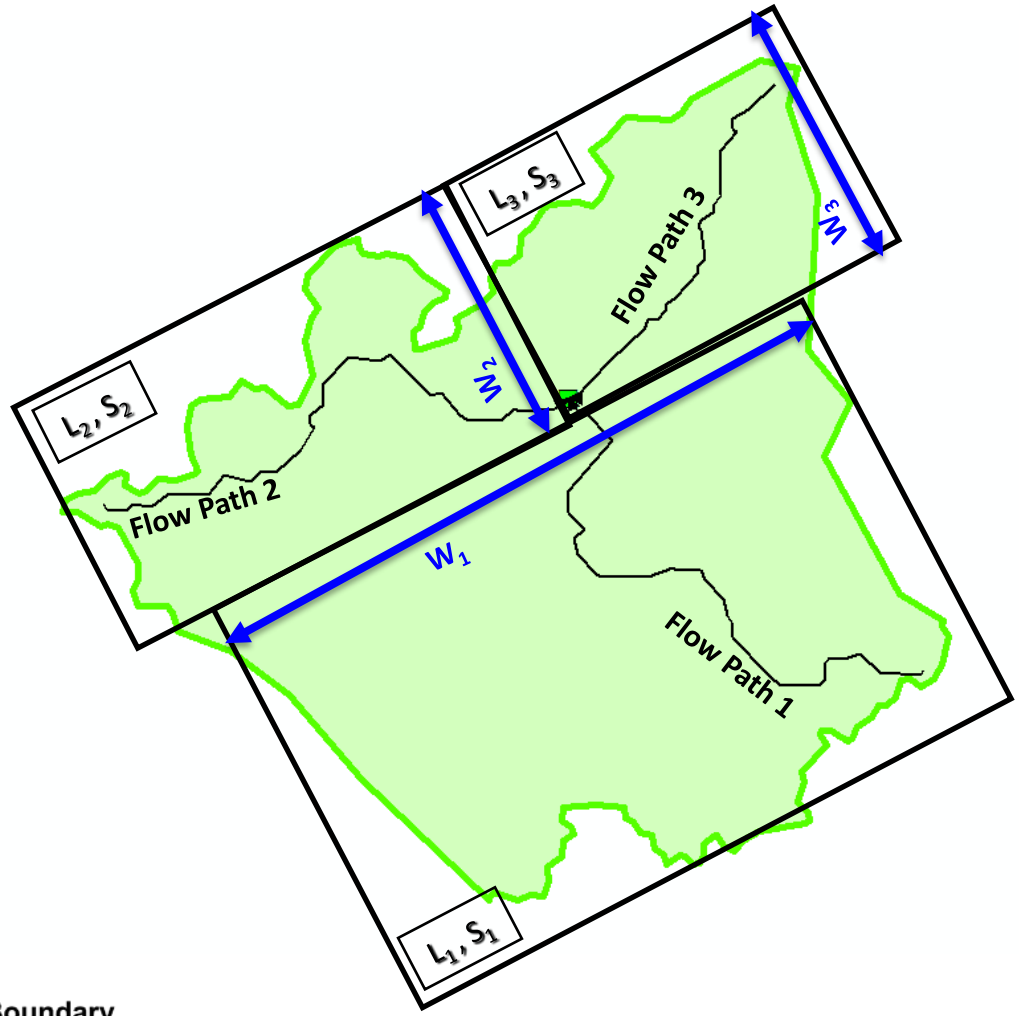


Subcatchment: WS10-PC-016

Attributes	
Name	WS10-PC-016
X-Coordinate	3717749.843
Y-Coordinate	1050348.094
Description	
Tag	
Rain Gage	Universal
Outlet	10260-270
Area (ac)	5.51
Width (ft)	544.82
Flow Length (ft)	440.541
Slope (%)	0.5
Imperv. (%)	37.4
N Imperv	0.015
N Perv	0.253
Dstore Imperv (in	0.1
Dstore Perv (in)	0.25
Zero Imperv (%)	25
Subarea Routing	PERVIOUS
Percent Routed (	30.864
Curb Length	0
Snow Pack	
LID Controls	0
LID Names	
Groundwater	NO
Erosion	NO

Hydrology

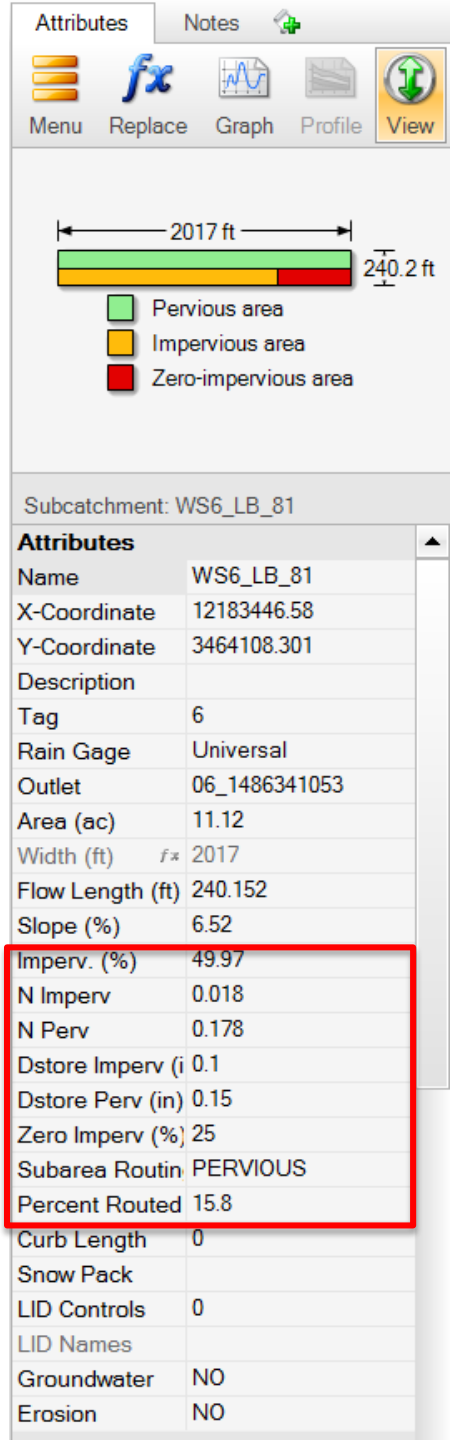
Flow Width (three-path approach)



Lx: Flow path length
Sx: Flow path slope
Wx: Flow path width

Hydrology

Imperv. (%)	49.97
N Imperv	0.018
N Perv	0.178
Dstore Imperv (i	0.1
Dstore Perv (in)	0.15
Zero Imperv (%)	25
Subarea Routin	PERVIOUS
Percent Routed	15.8

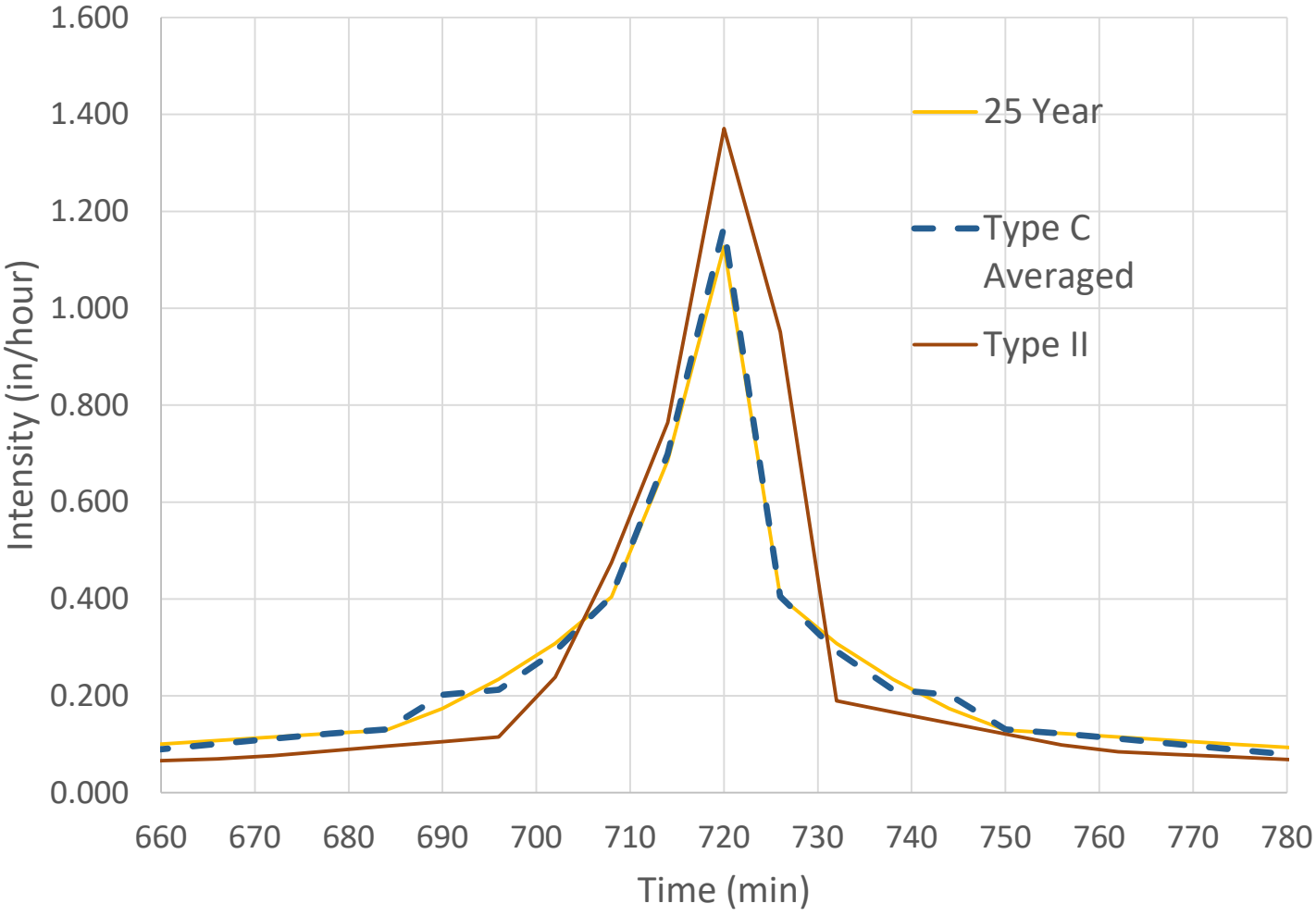


Hydrology (Rainfall Patterns and Inputs)

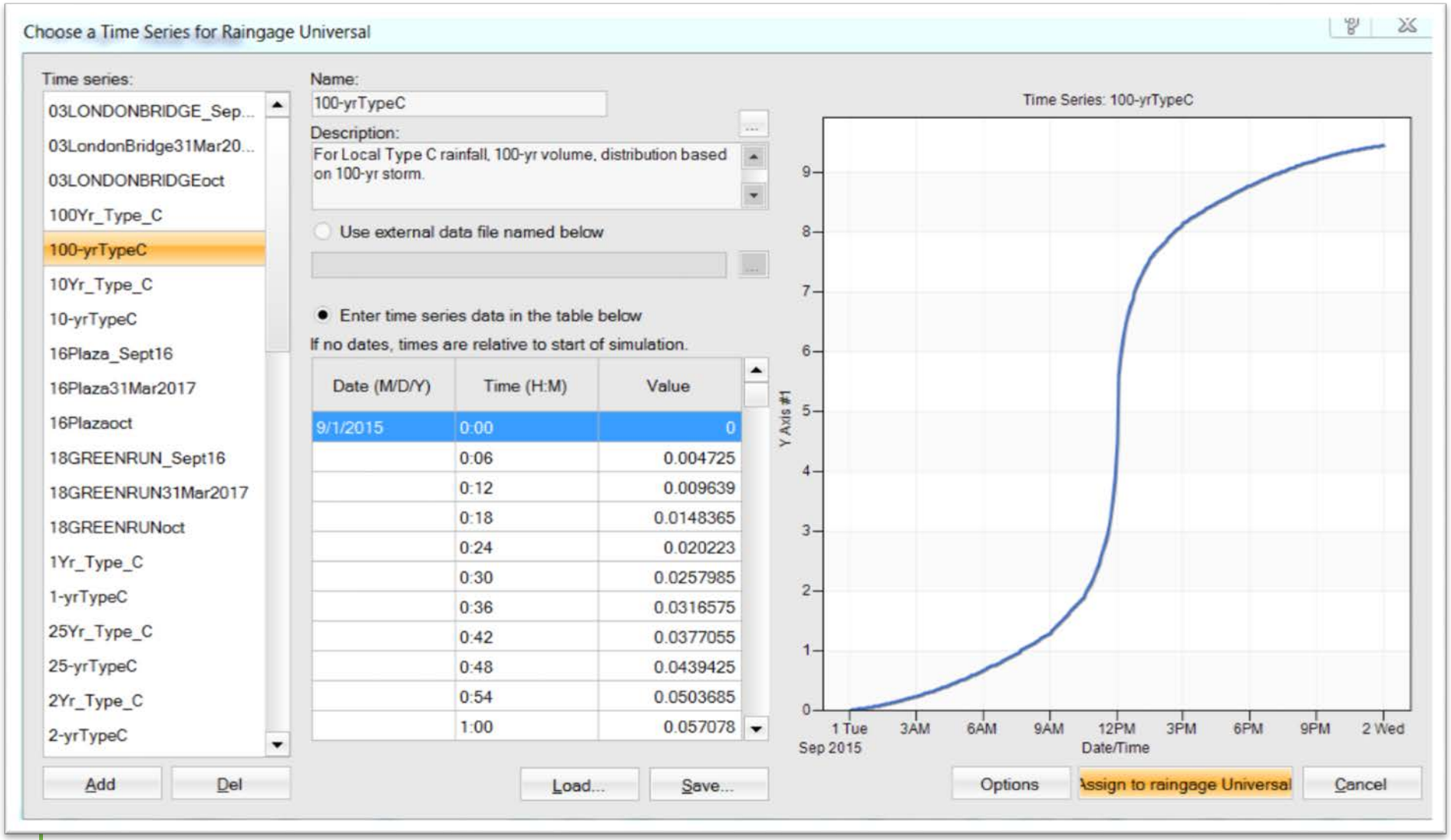
- Historical rainfall (Rain gauge data) for model calibration
- Design storm rainfall for master plan simulations
  - NOAA Atlas 14 Type C
  - One set of rainfall hyetographs for the entire City
- Rainfall depth
  - Based on values at the Centroid of the City (Watershed 6)
- Temporal pattern
  - Based on shape of 25-year rainfall hyetograph

Hydrology (Rainfall Patterns and Inputs)

NOAA Atlas 14 Type C Hyetograph

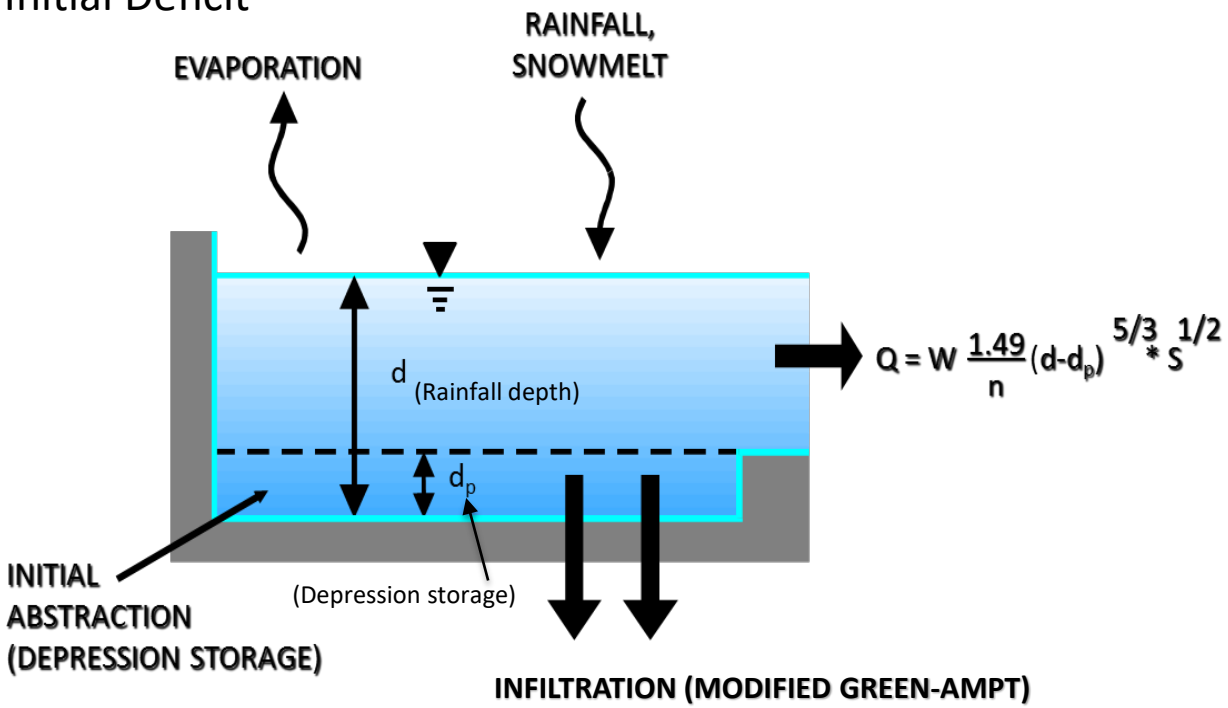


Hydrology (Rainfall Patterns and Inputs)

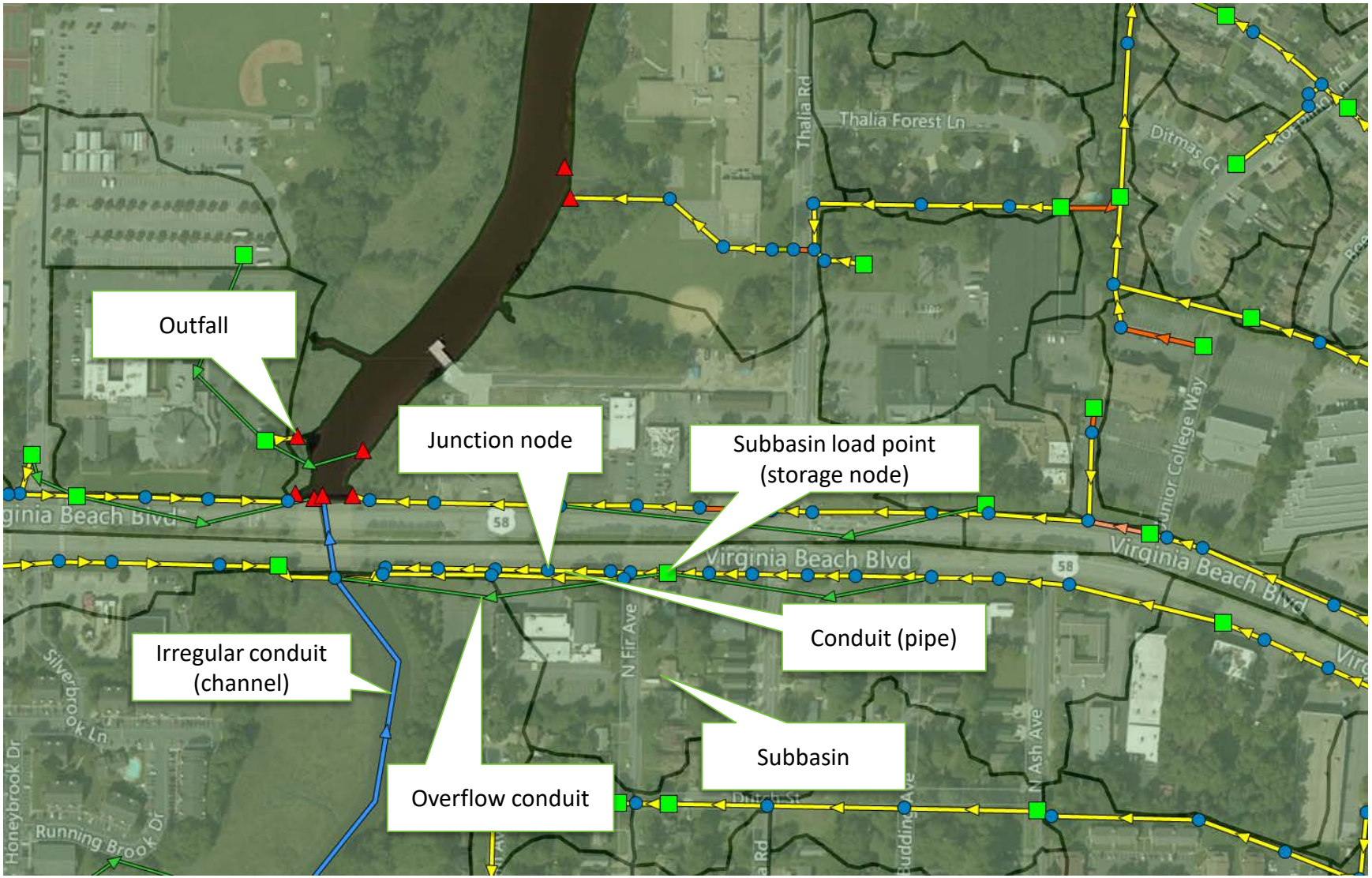


Hydrology

- Infiltration (Soil)
  - Modified Green-Ampt infiltration
    - Suction Head
    - Conductivity
    - Initial Deficit

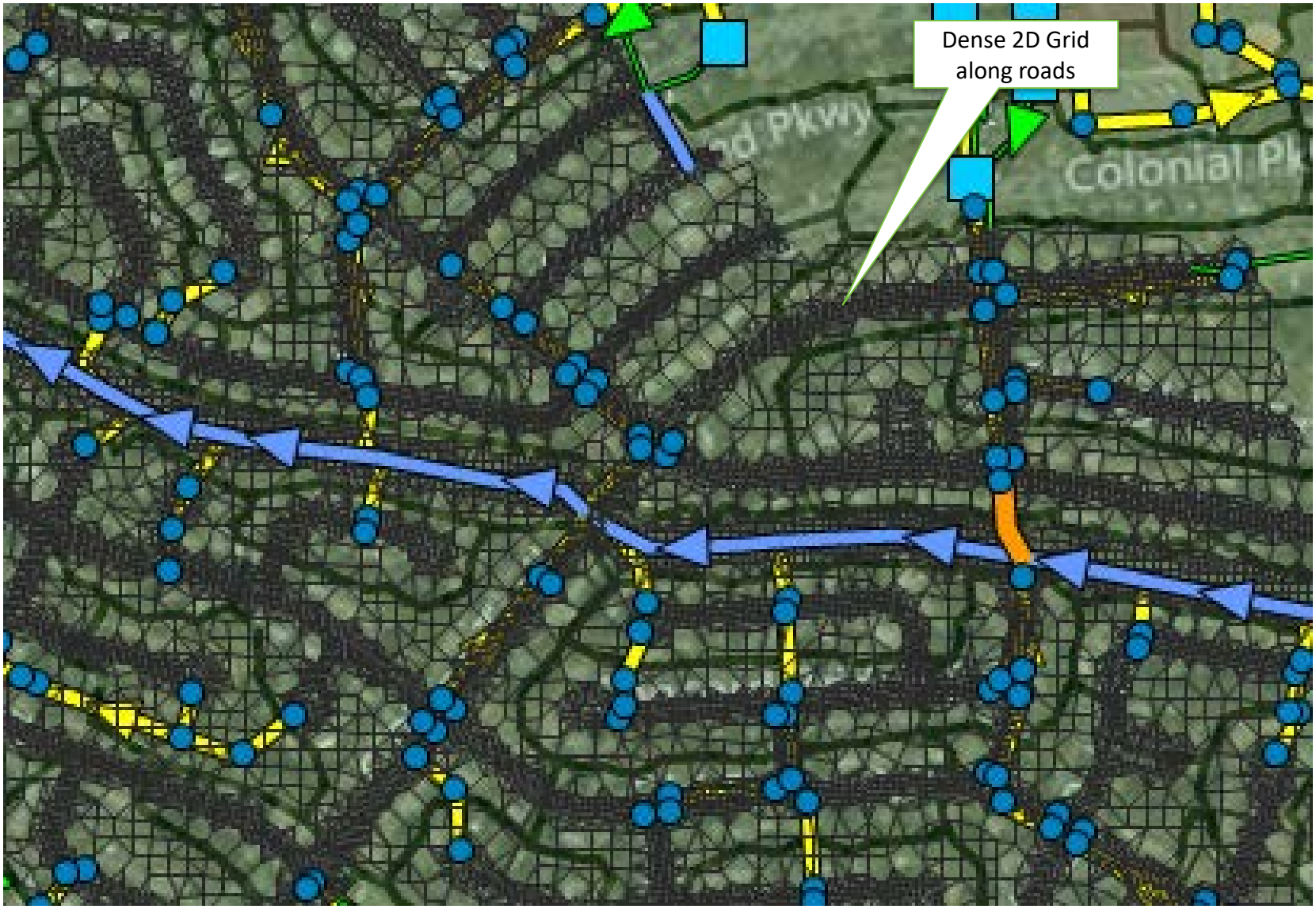


Hydraulics (View in PCSWMM)

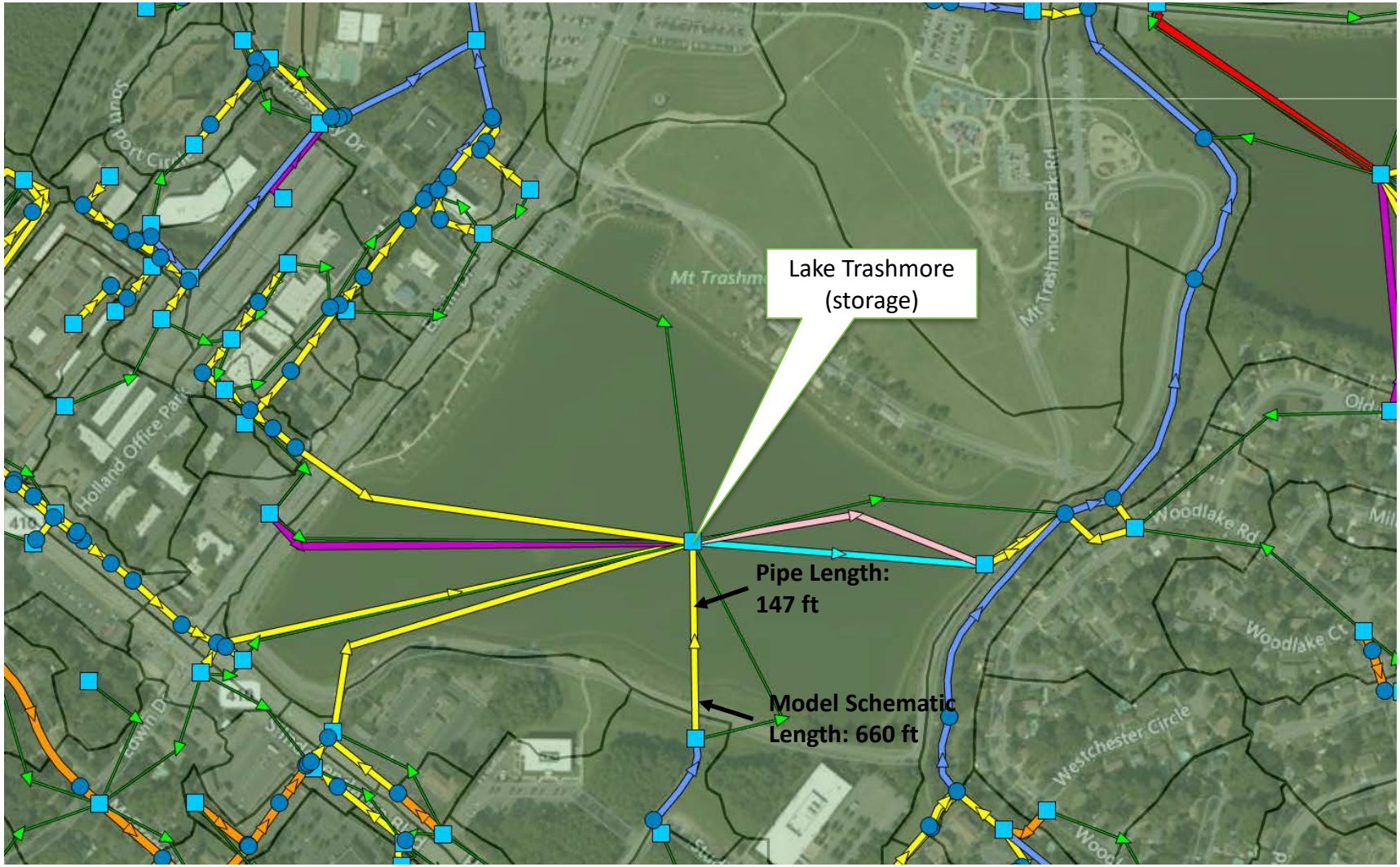


Hydraulics (2-D Area)

Hydraulics (2-D Area)

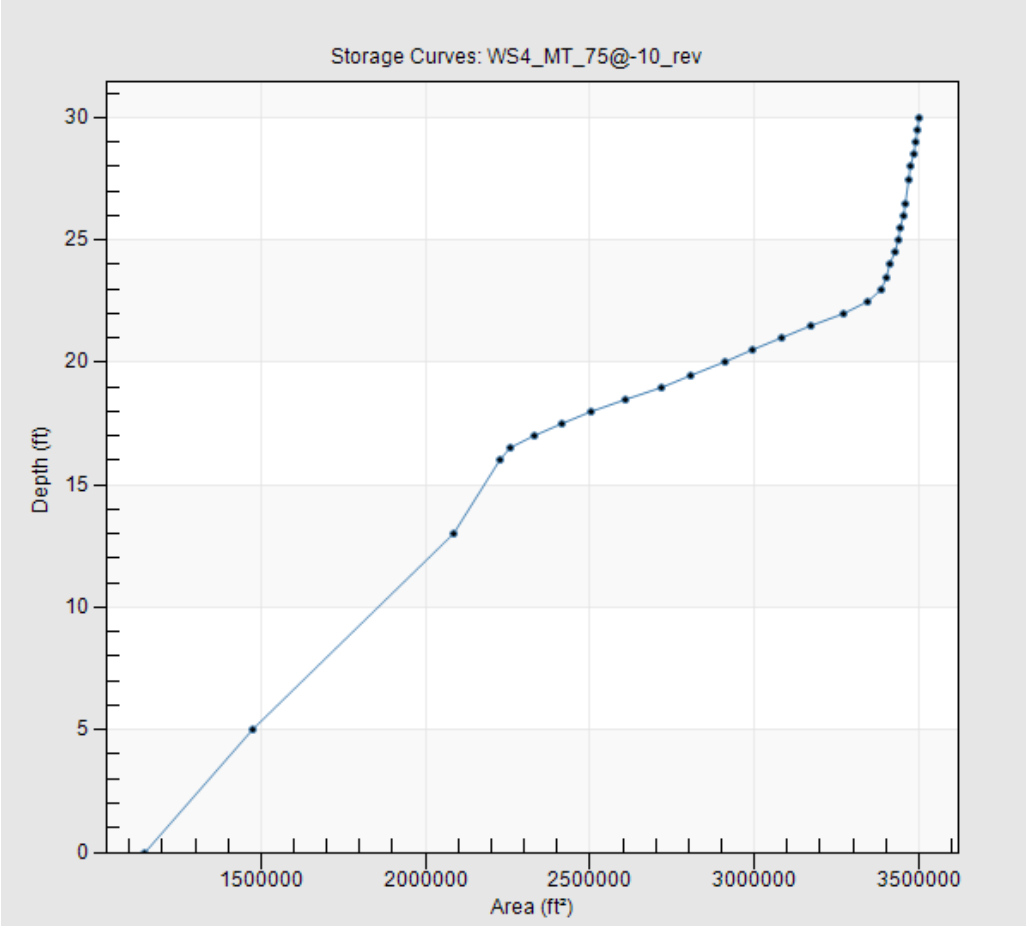


Hydraulics (Lake and SMF Example)

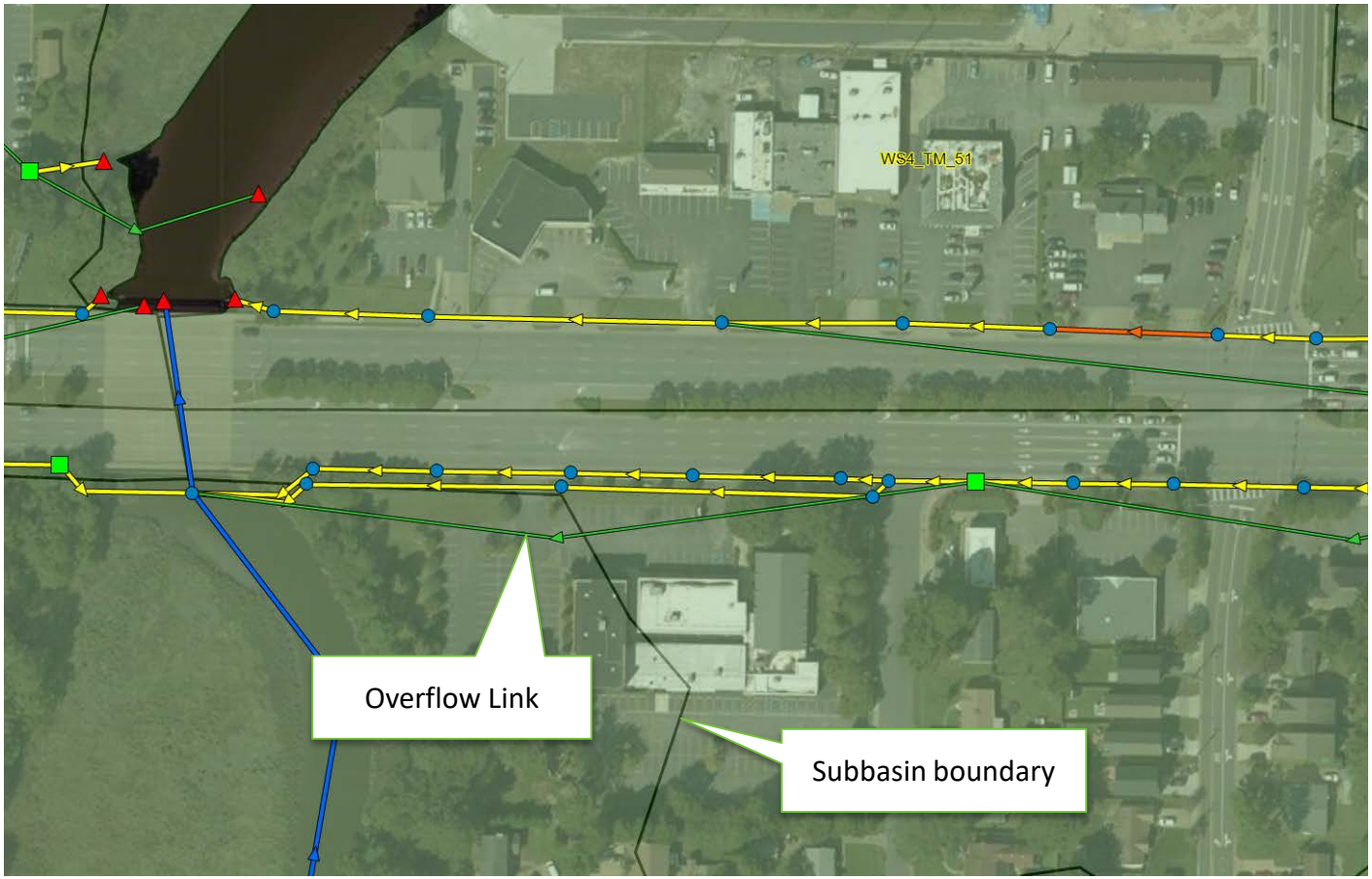


Hydraulics – Stage Area Relationships

- Conveyance system storage: Stage-area-storage in open (irregular) conduits
- Surface storage at storage nodes: stage-storage area relationships computed from topography (LiDAR and GIS)
- Approach foundation: No double-counting surface area and conveyance system storage

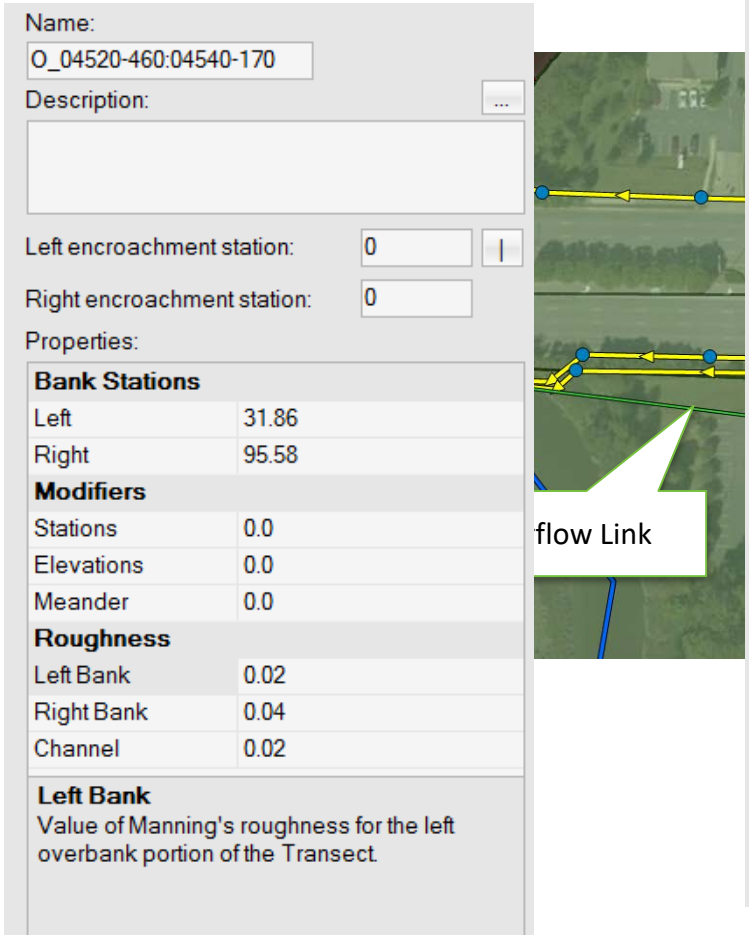


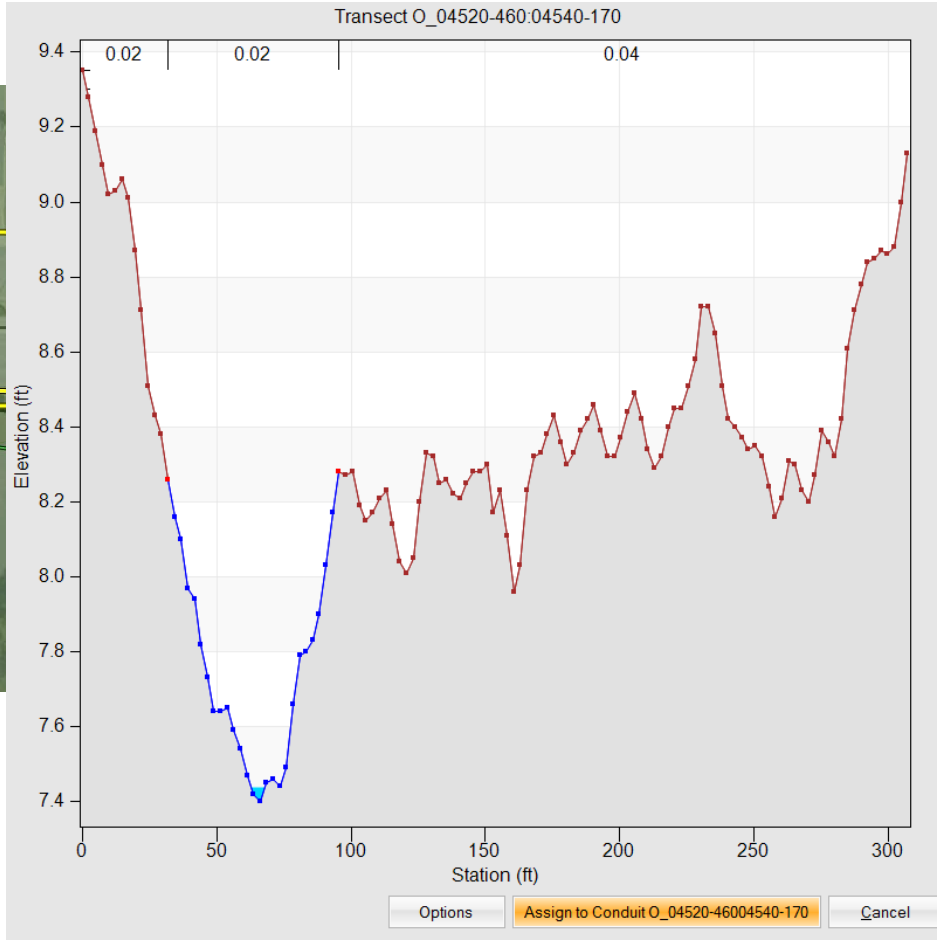
Hydraulics – Overland Flow



- Irregular links used to equalize flood depths between neighboring subbasins

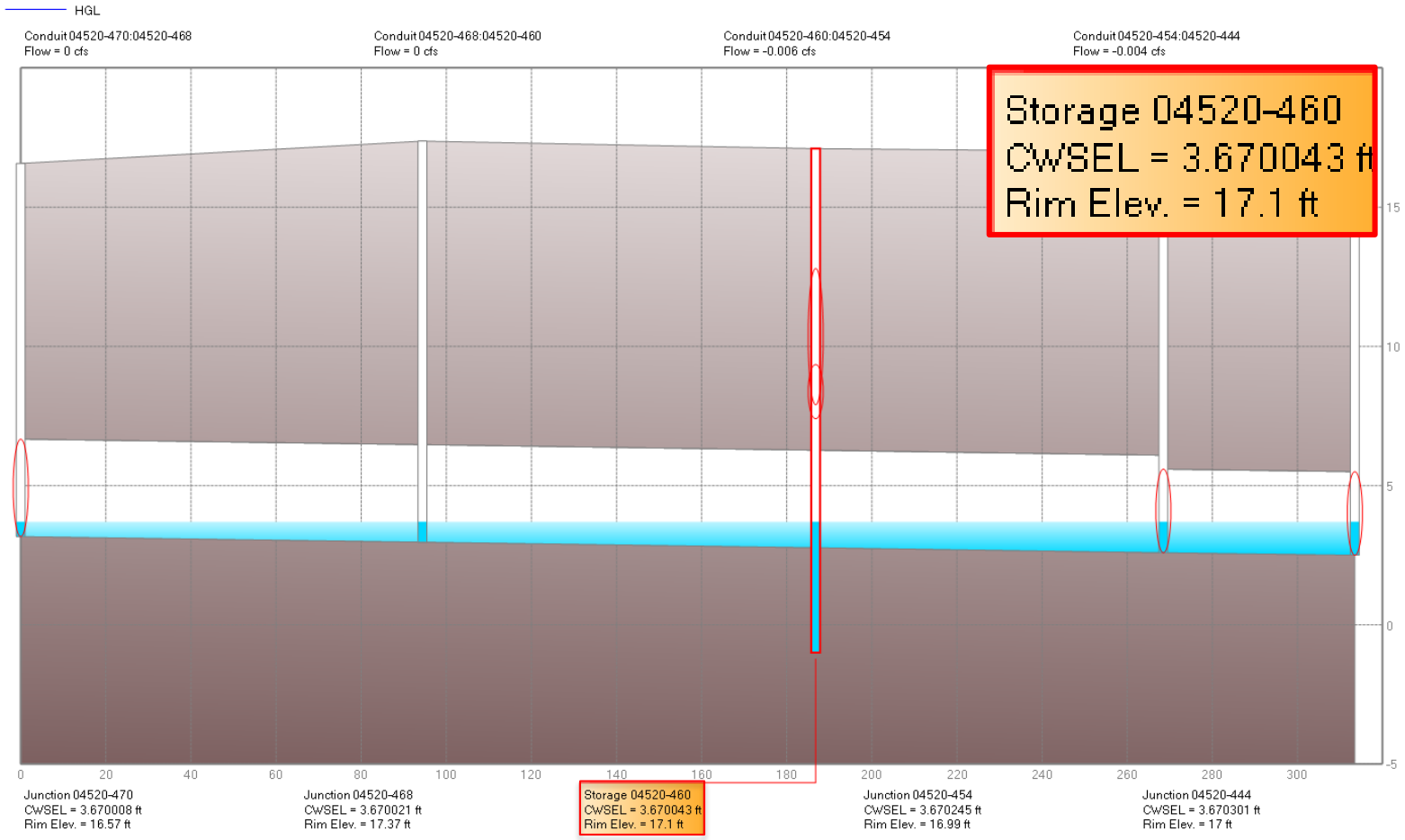
Hydraulics – Overflow links





- Link transect computed from topography (LiDAR and GIS)

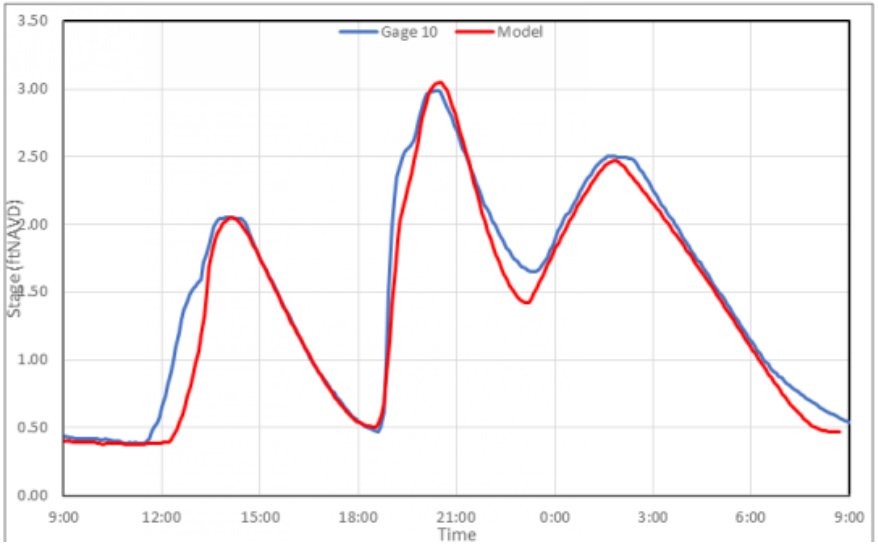
Model Representation of Rim



- Ground Elevation at 04520-460 : 7.1 ft NAVD 88
- Model rim: 17.1 ft

Model Validation

- Historical rainfall events based on flood call history
- Observed and field surveyed high water elevations from 2016
- 10-year event profile compared with VDOT hydraulic grade line calculation



Coordination and References

Section 2 Model Approach

NEEDED: Pictures to Update the City's Master Drainage Plans

- https://www.vbgov.com/government/departments/public-works/storm-water/Pages/storm-pics-master-drain-plan-6-8-17.aspx

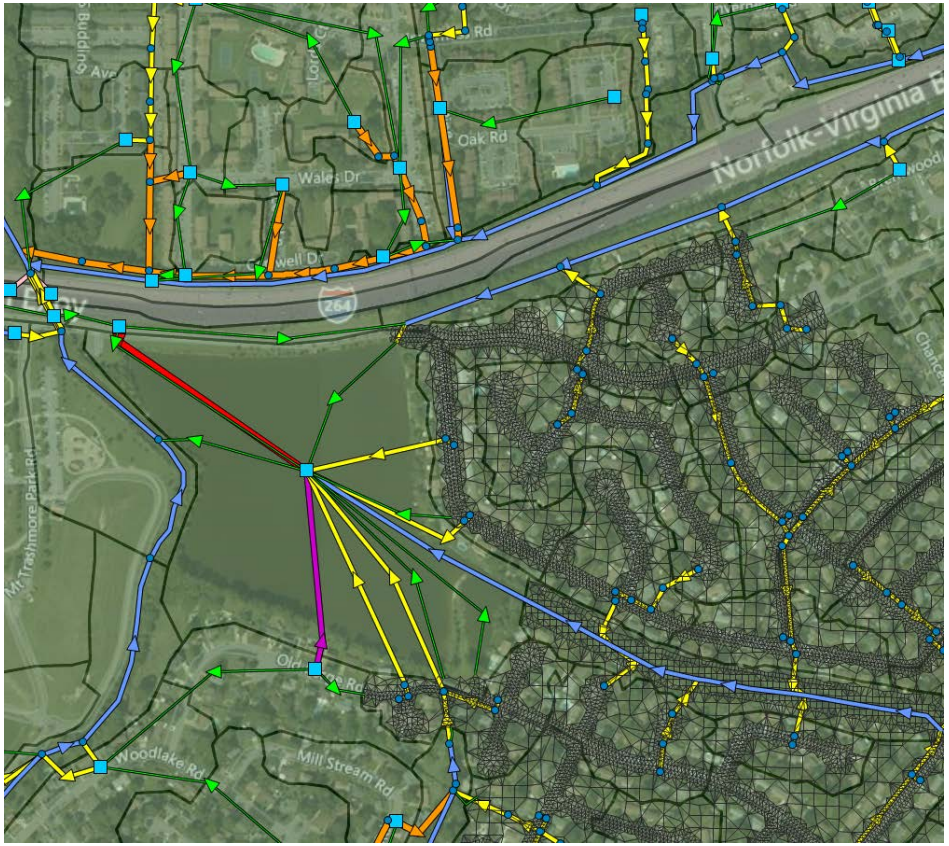
Comprehensive Sea Level Rise

- https://www.vbgov.com/government/departments/public-works/storm-water/Pages/pw-slr-8-2015.aspx

Master Plan Model Application

Master Plan Model Application

- Flows and water surface elevations in the PSMS
- Locations with surcharging in the PSMS
- Performance of storage facilities
- Overland flow between subbasins
- Surface flooding (storage node water surface elevations)
- Influence of downstream tidal conditions

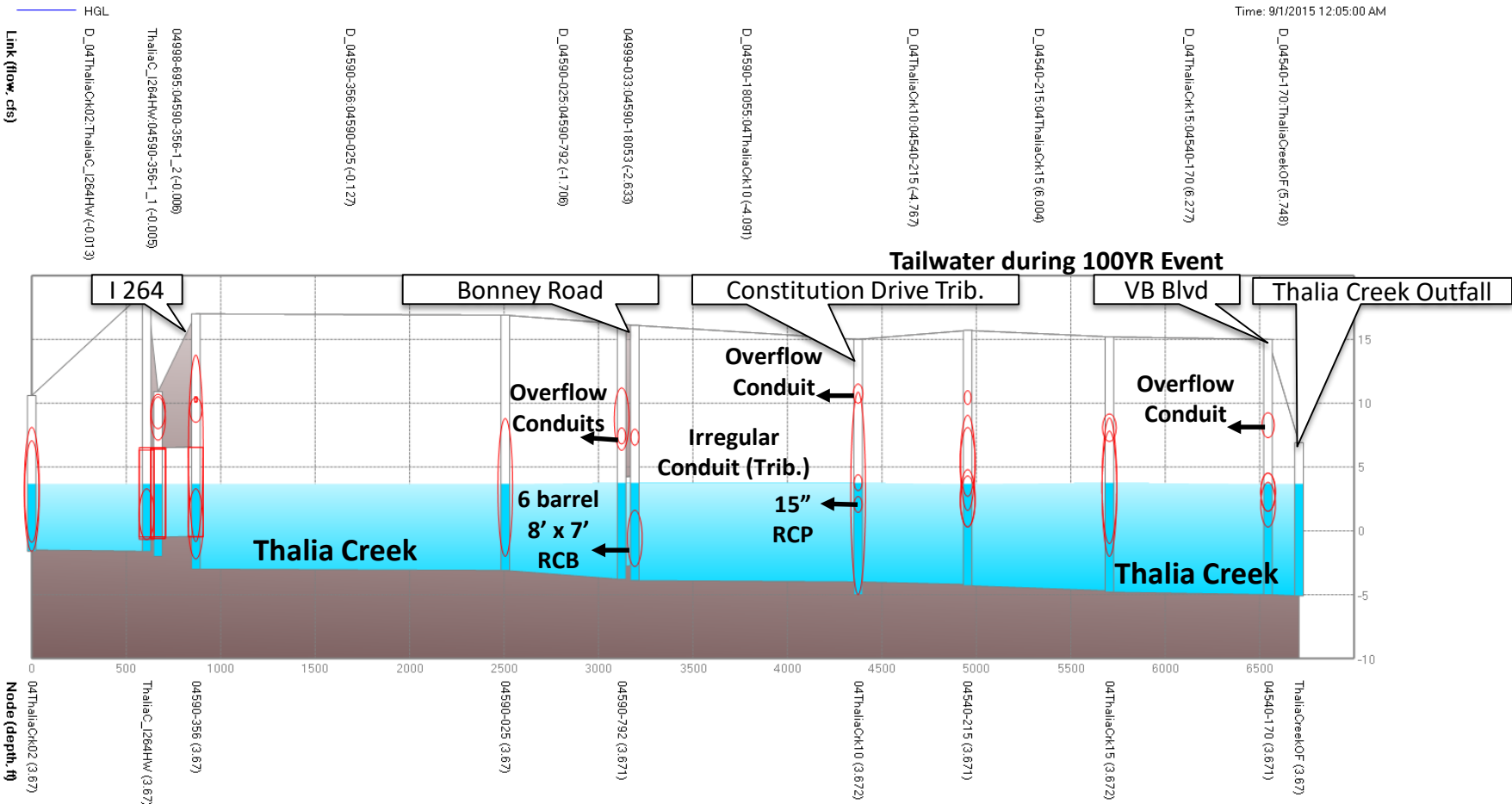


Additional Master Plan Model Applications

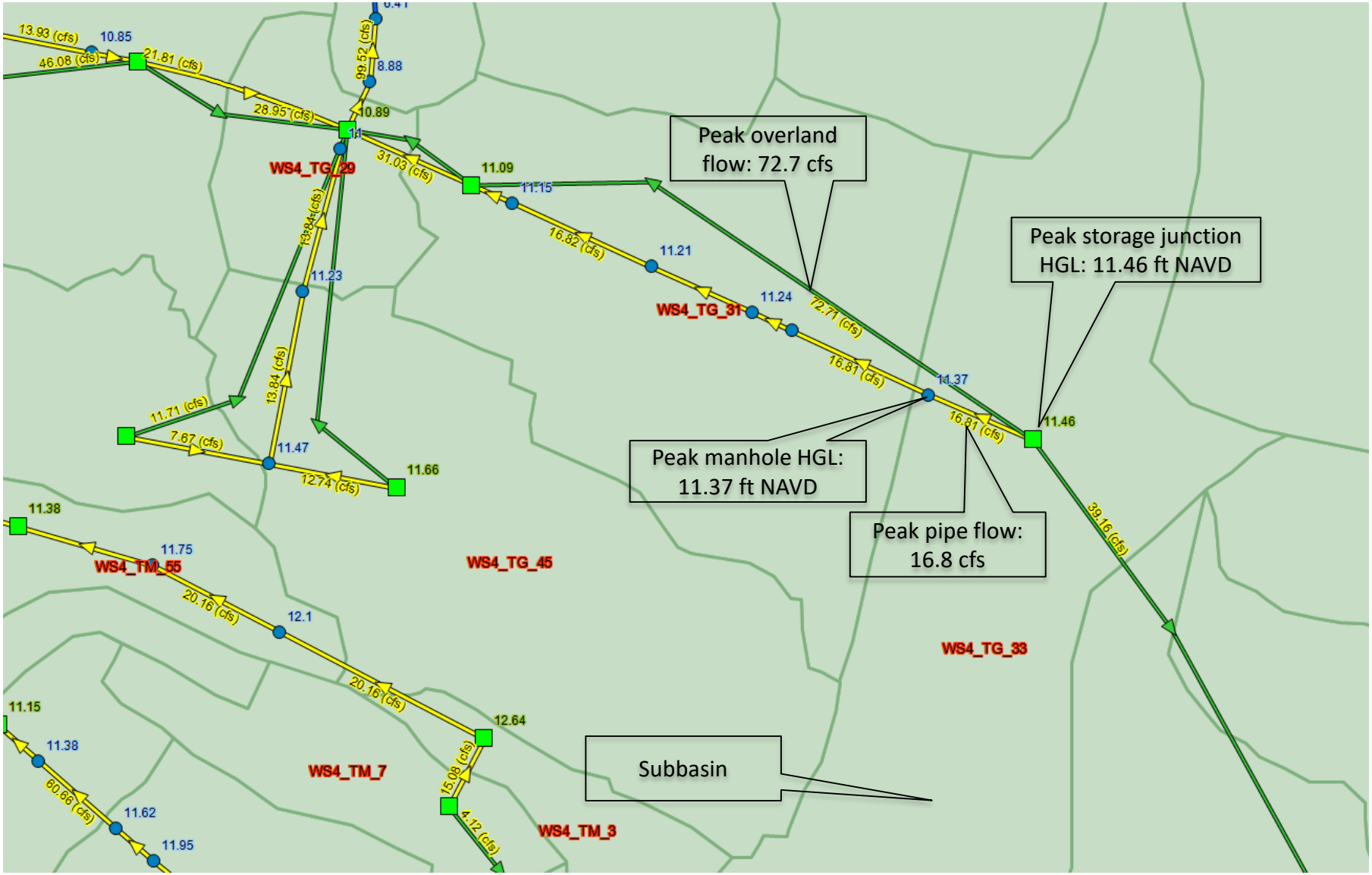
1. Site specific evaluations
   a. Tailwater to support site design
   b. System flow-routing understanding, “what-if” scenarios for downstream impacts and improvements
2. Starting Point for refined site-specific evaluations
   a. Site specific topography and critical elevations
   b. Site specific drainage features
   c. System flow-routing refinements
3. Intent: Provide information and tools to assist with engineering evaluations and compliance with DPW Standards

Model Application – Tailwater Conditions

- Profile view through Thalia Creek

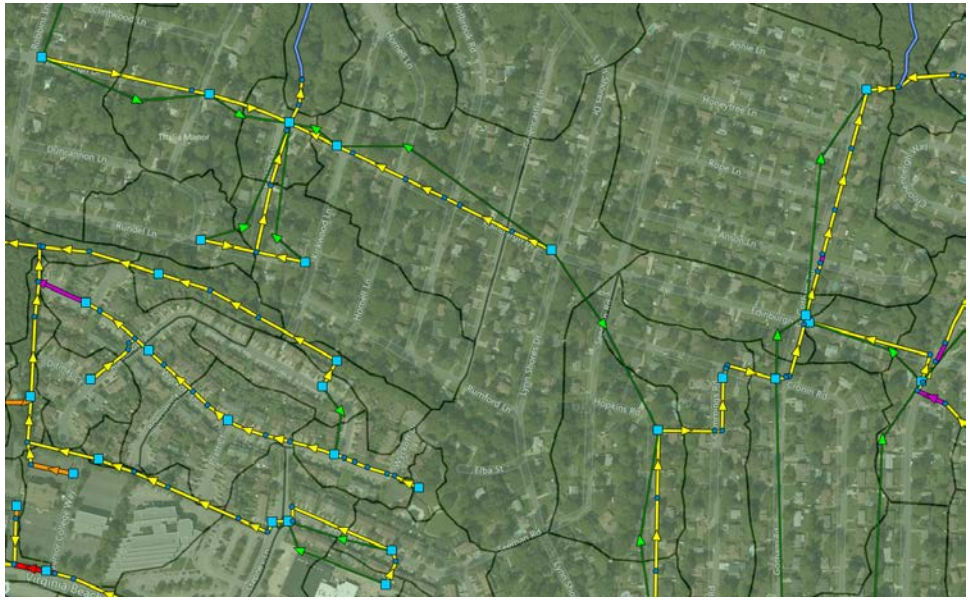


Model Application – Subbasin Conditions

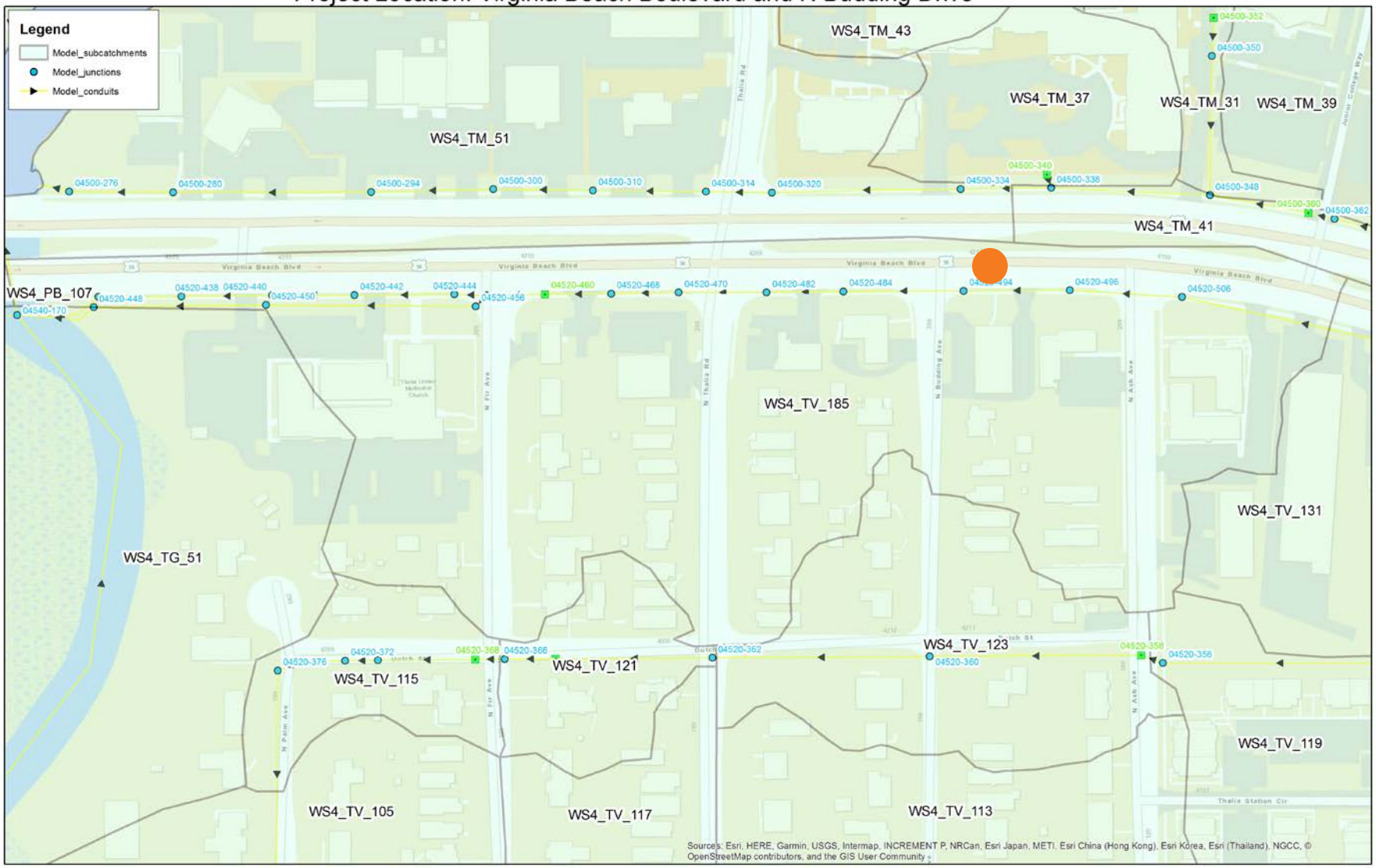


Master Plan Model Limitations

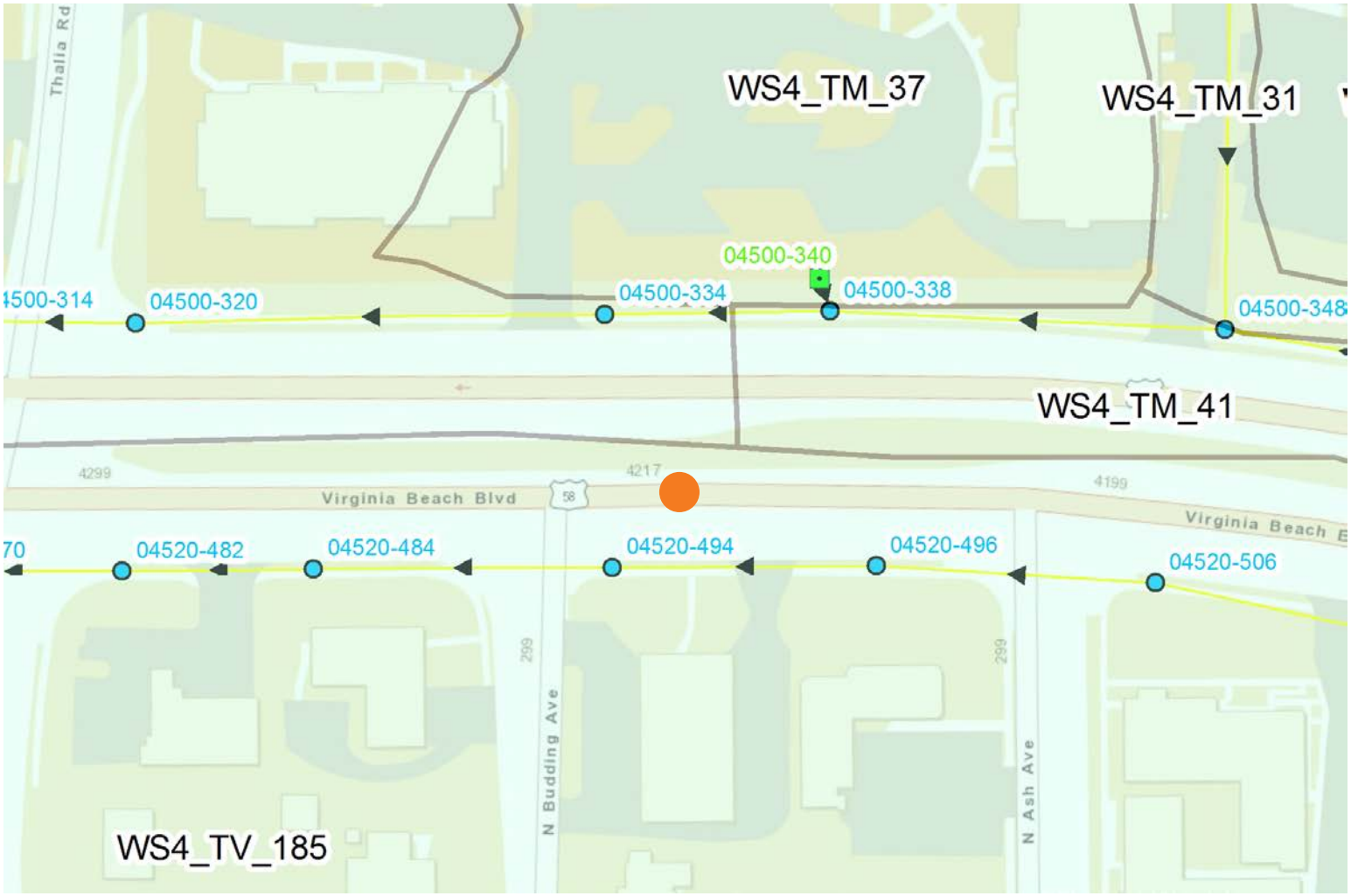
- Results based on available data:
  - GIS stormwater infrastructure
  - GIS invert elevations
  - LiDAR topography data
  - City impervious area
  - City land use
  - City soils data (from NRCS)
- Areas upstream of the modeled PSMS
- Overland flow within a single subbasin located upstream of the subbasin storage node



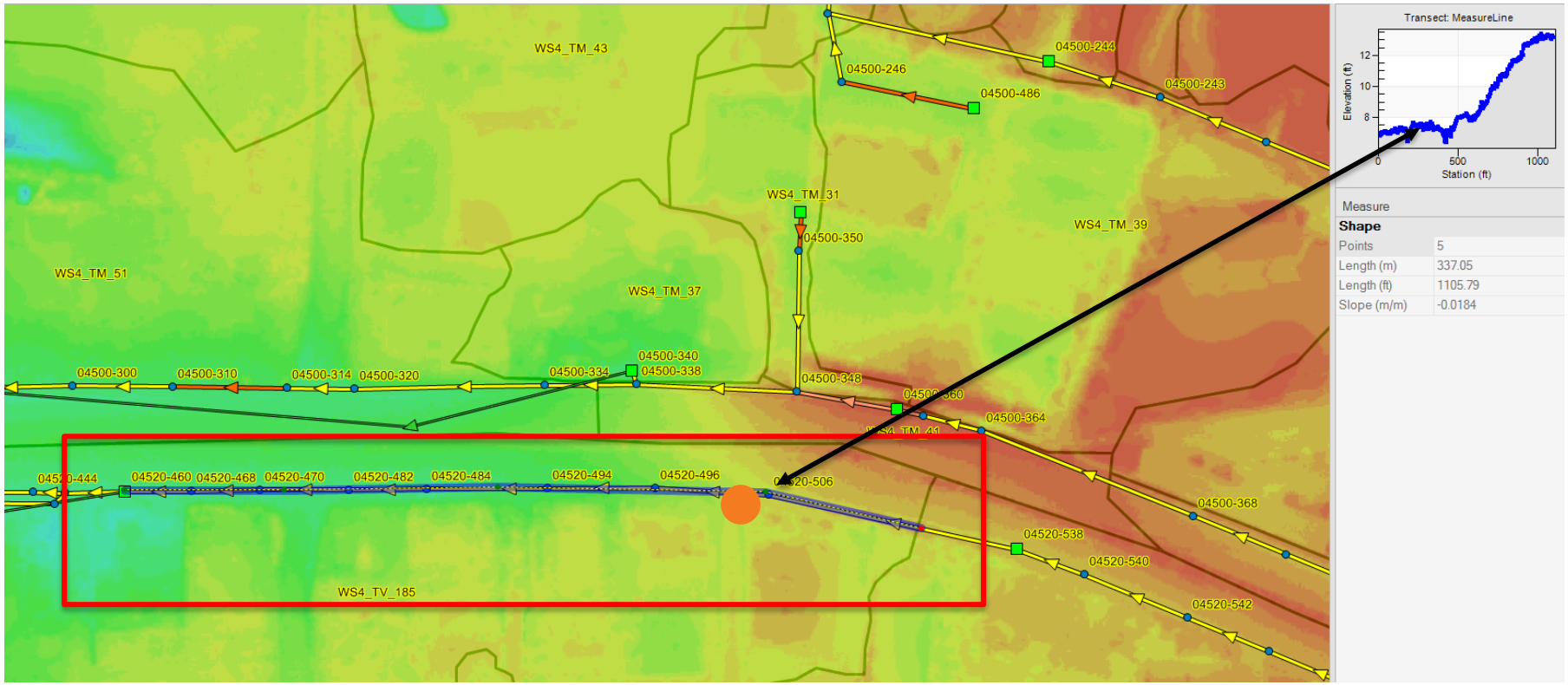
Example Application for Site of Interest



Example Application for Site of Interest



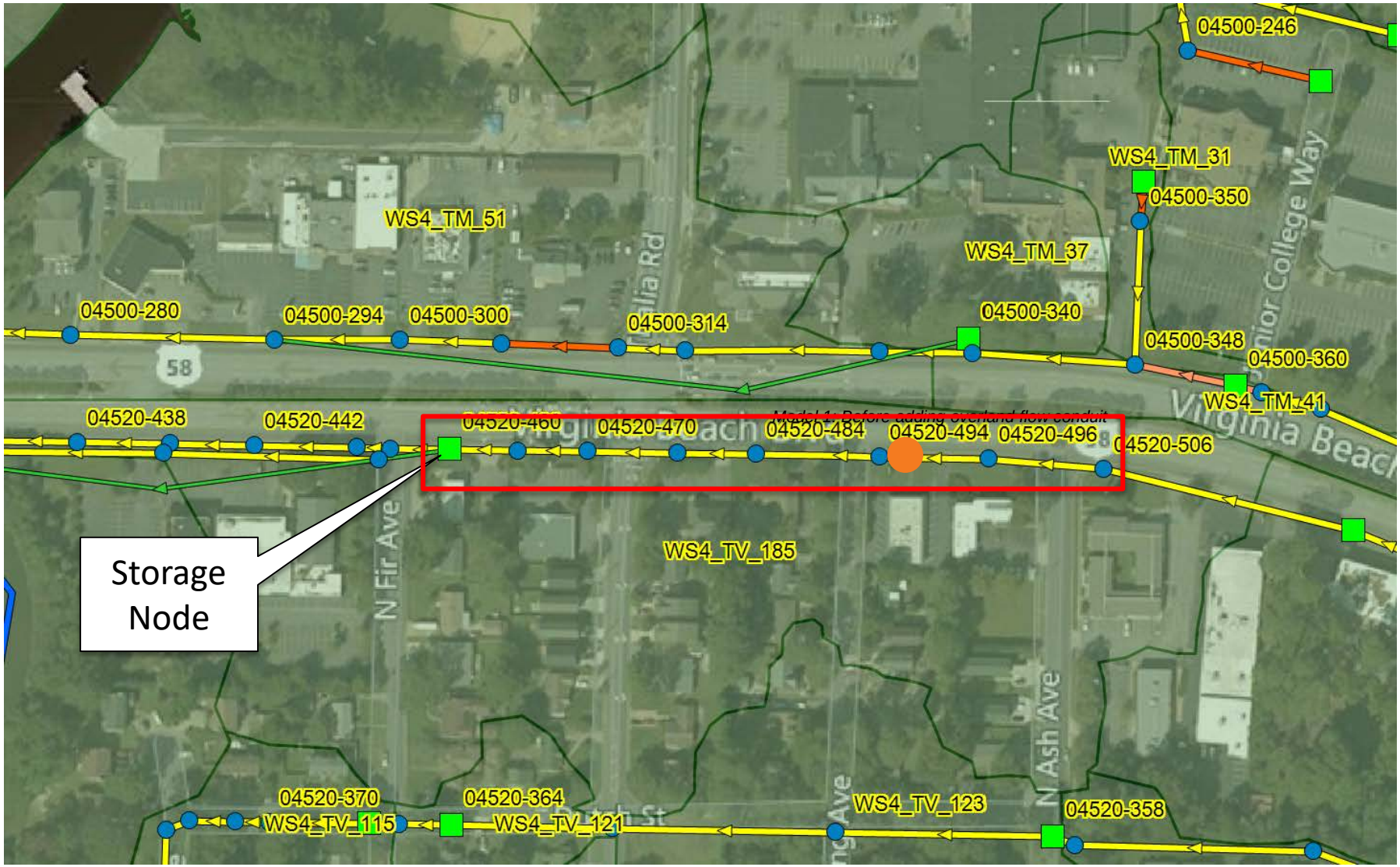
Master Plan Model Content



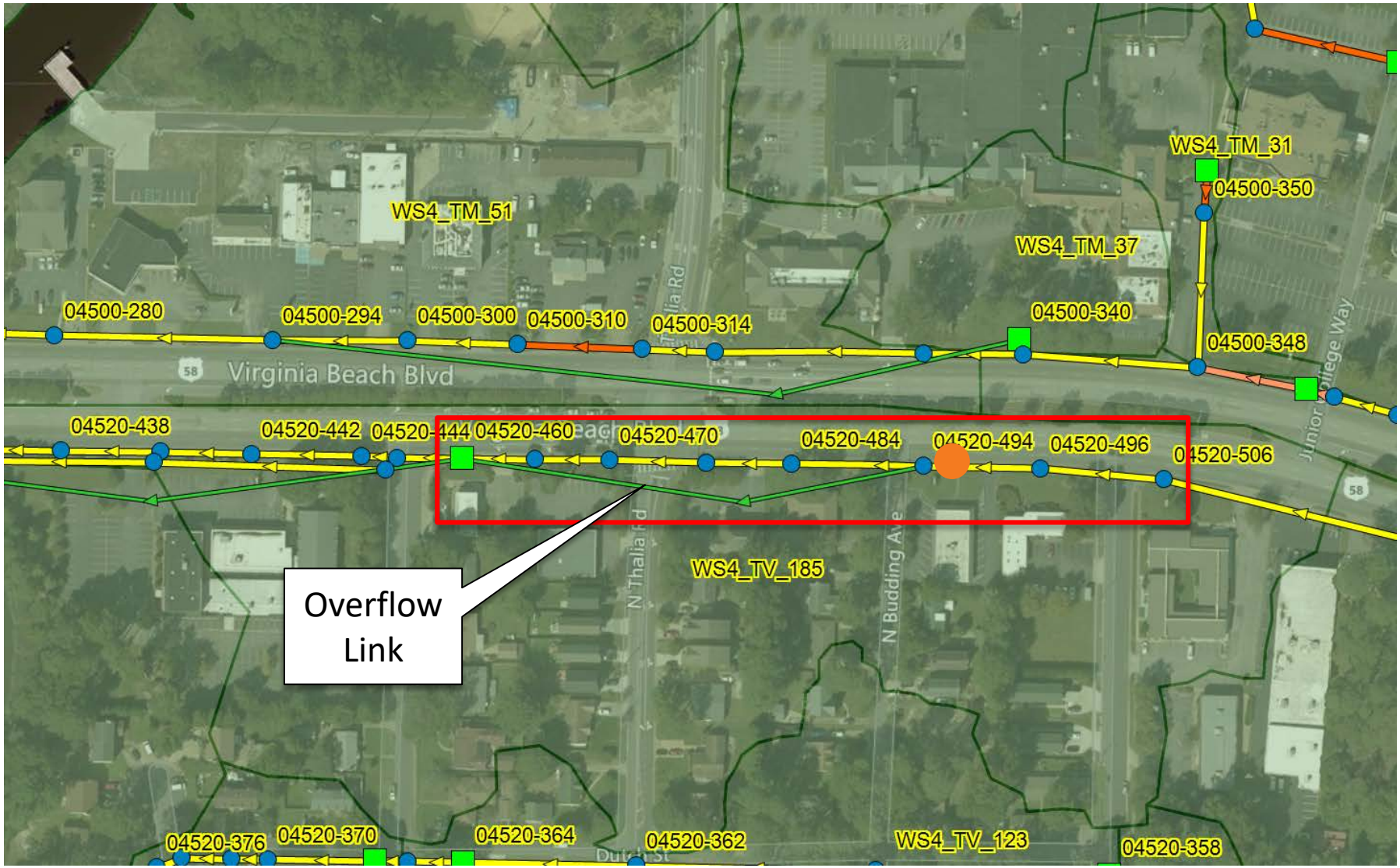
Steep gradient from edge of catchment to storage node

- Desired boundary conditions: 10-year and 100-year HGL
  - Ground elevation 8 feet
  - 10-year HGL = 9.3 feet and 100-year HGL = 10.1 feet

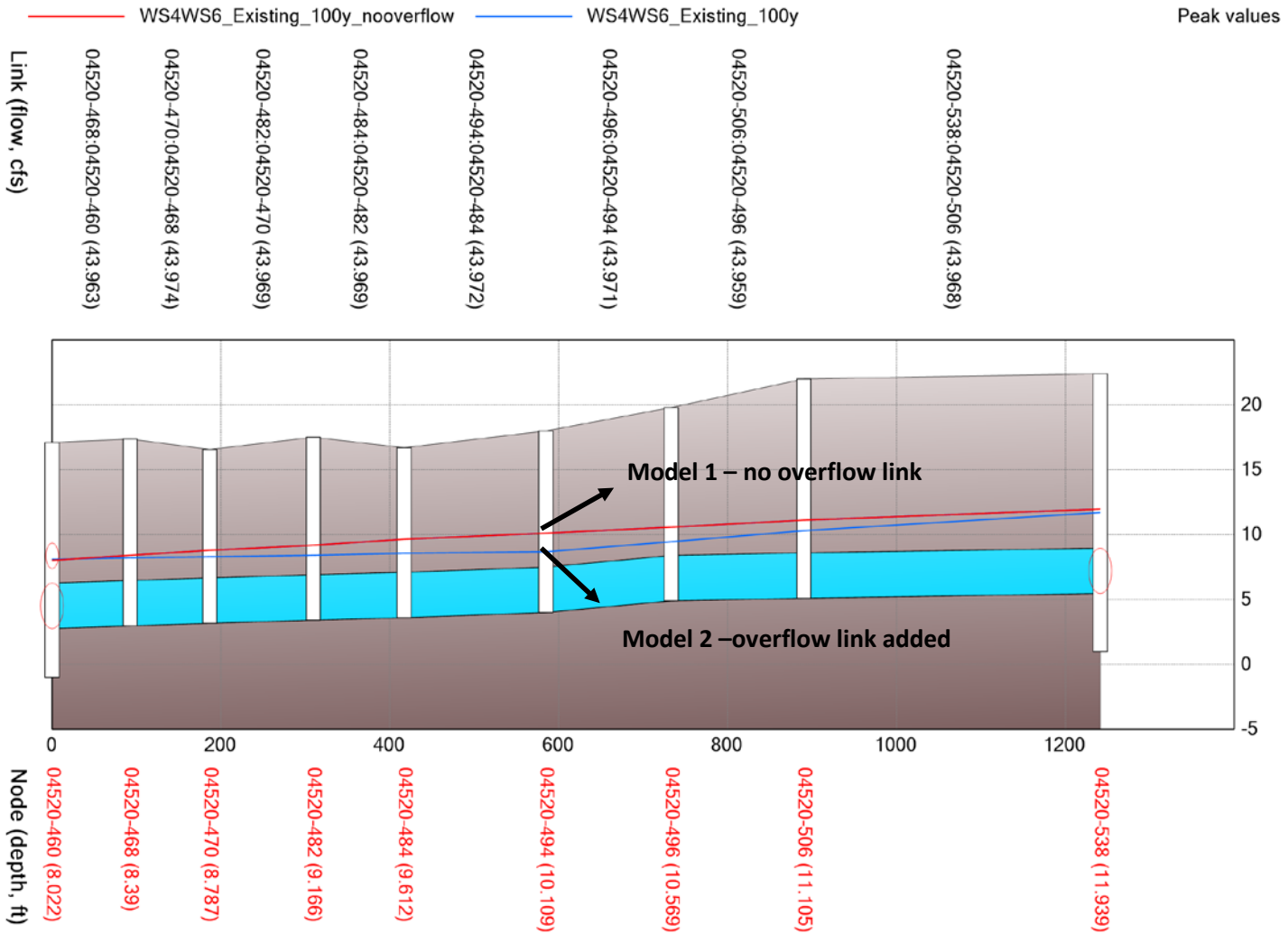
Application for Site of Interest



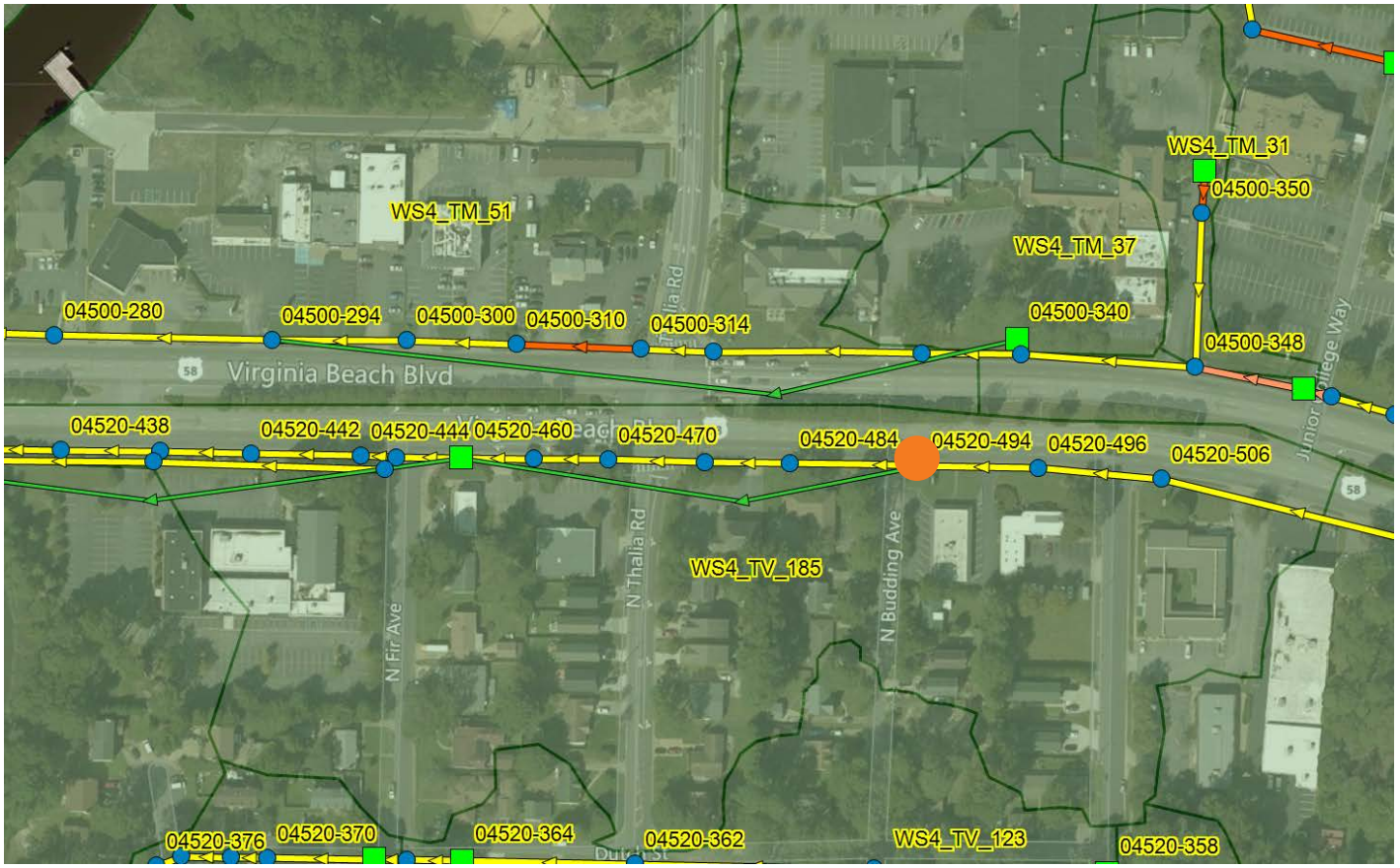
Additional Overland Flow Path



Refined Model Results

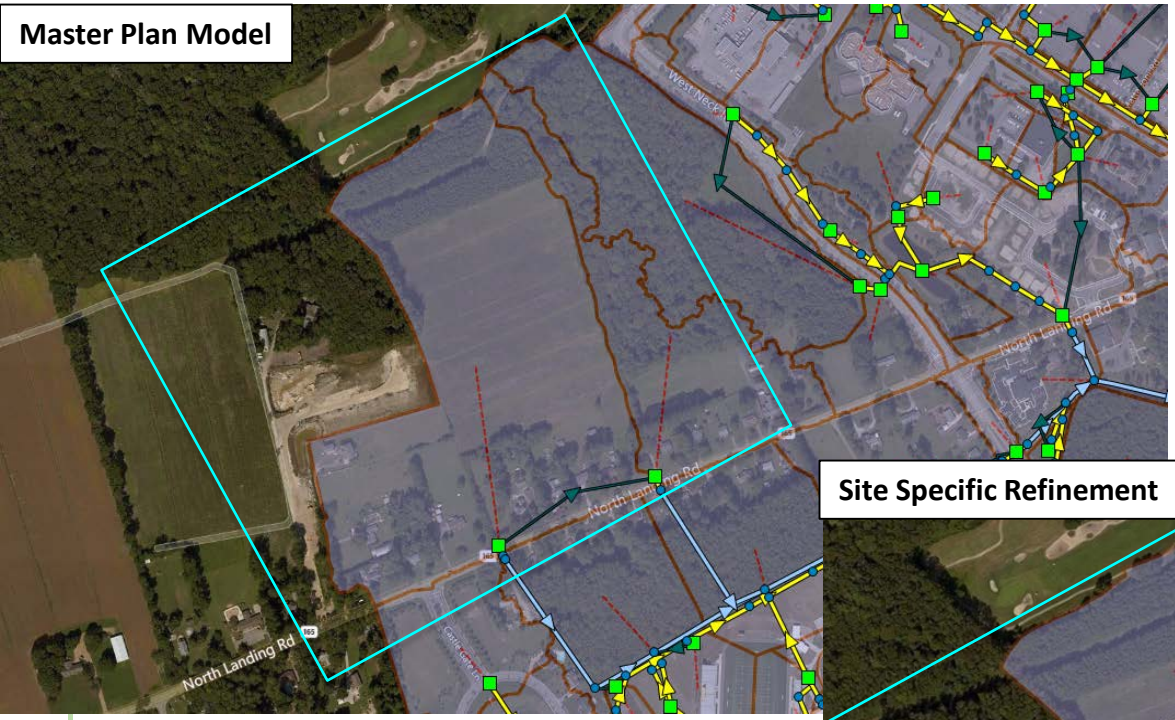


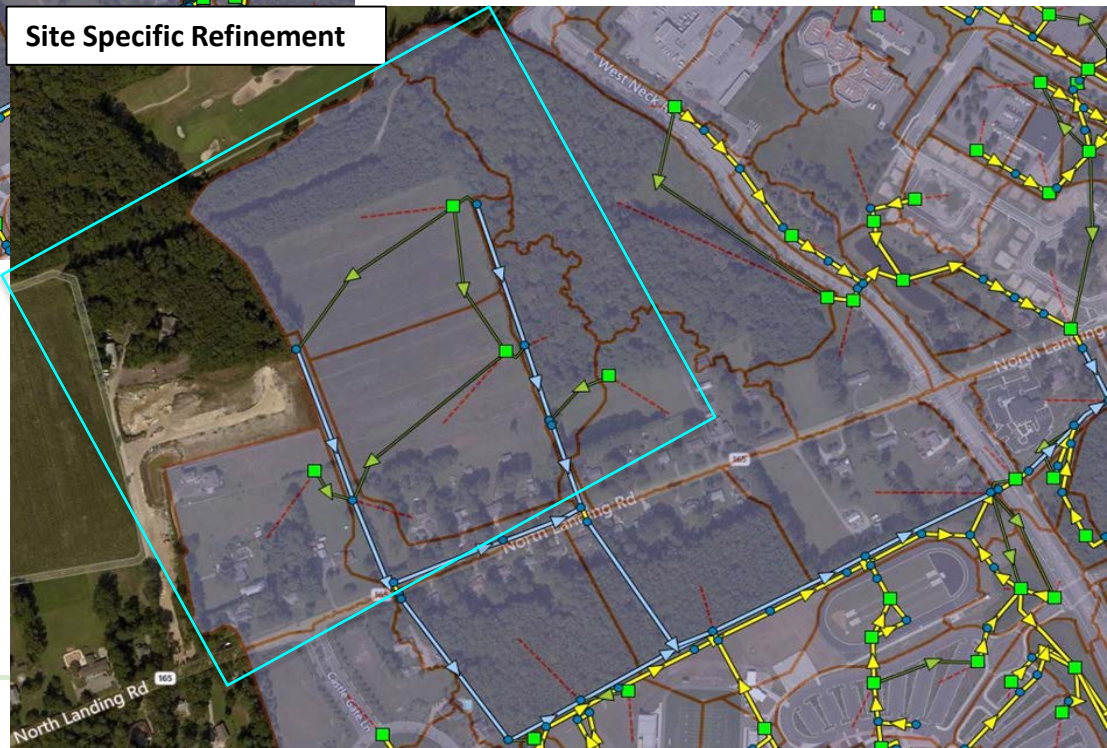
Refined Model Results



- Desired boundary conditions: 10-year and 100-year HGL
  - Ground elevation 8 feet
  - 10-year HGL = 8.5 feet and 100-year HGL = 8.7 feet

Example Model Refinement





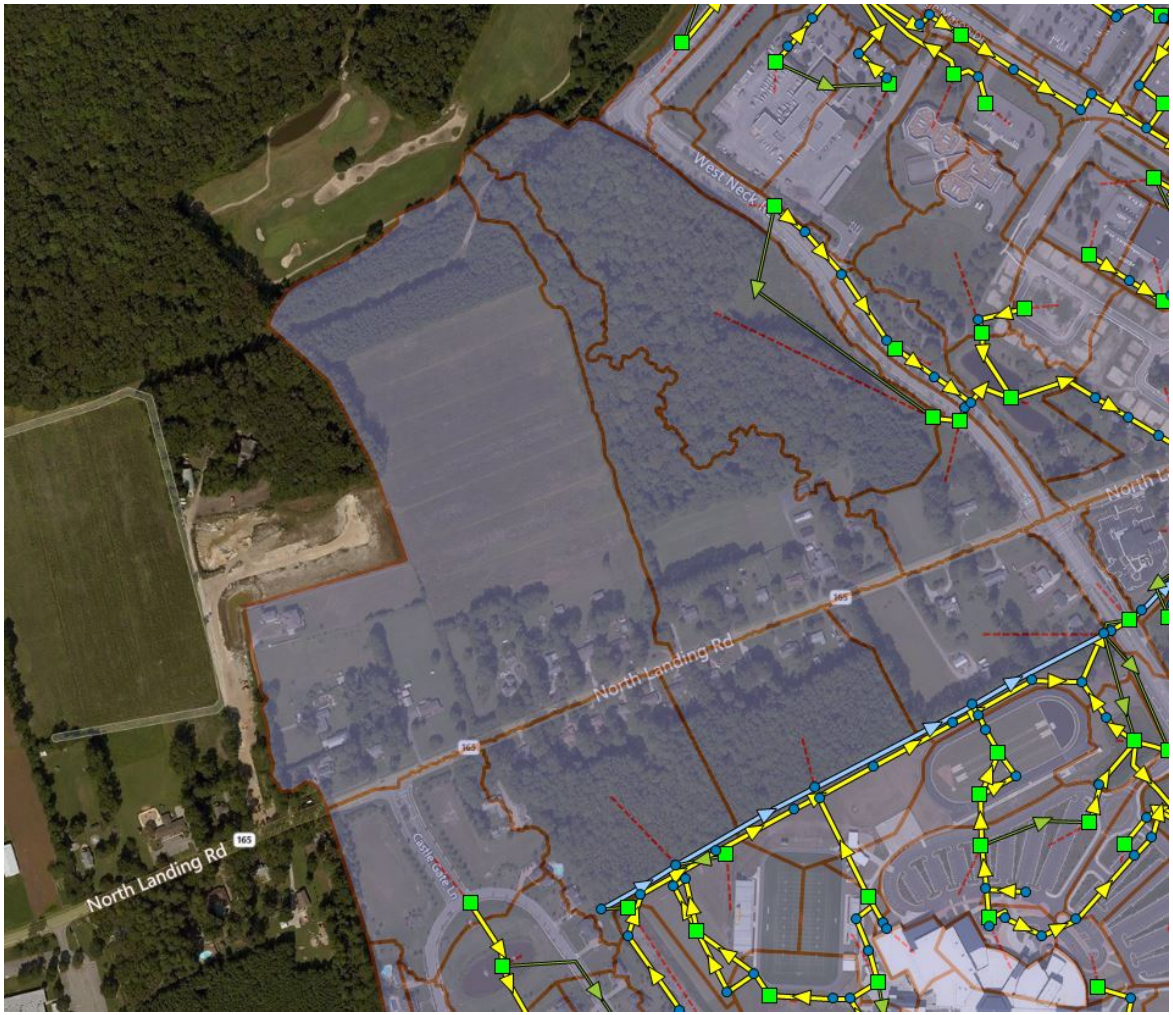
Watershed 10
Veteran Care Center

Master Plan Model Refinement to Reflect Existing Conditions

Example Model Refinement

Step 1:

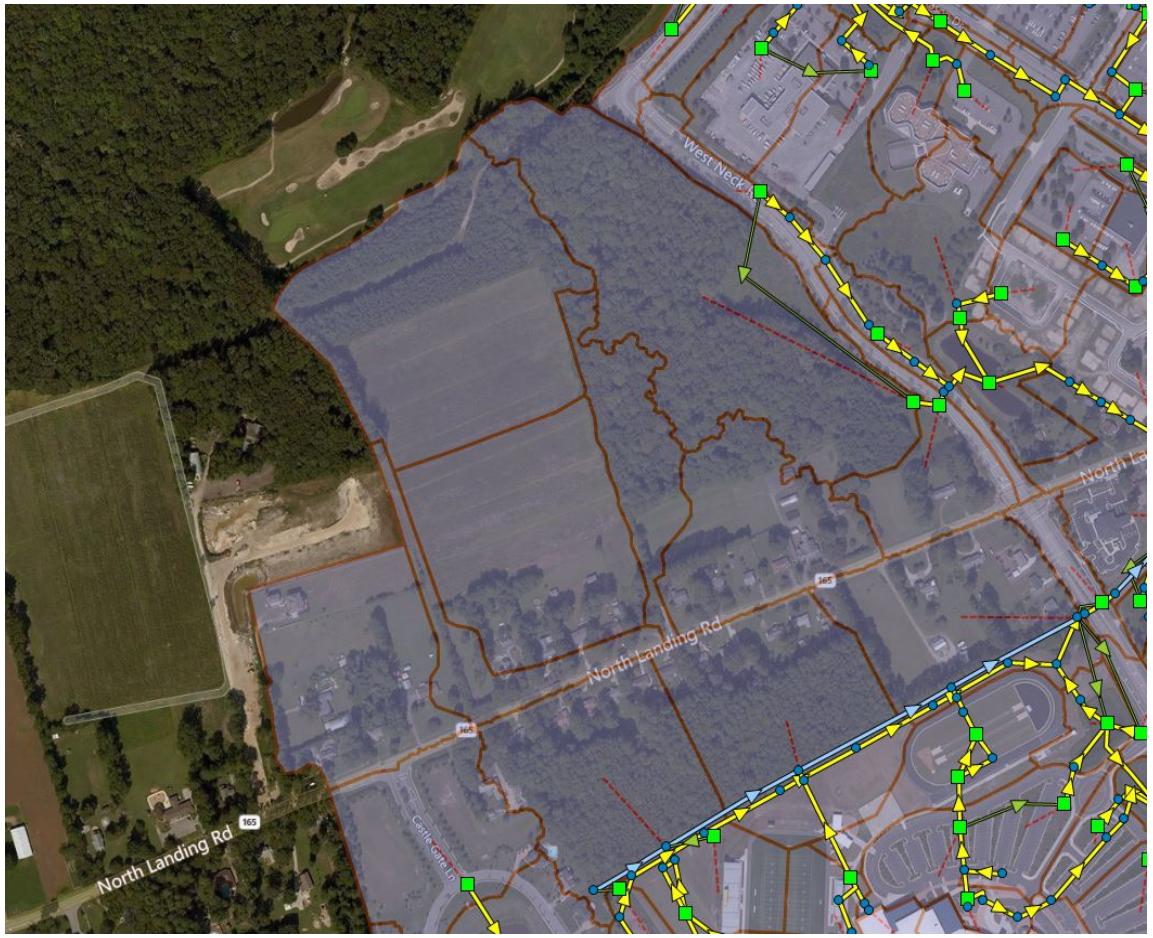
- Delete all the nodes and links that will be updated/replaced with refined data



Example Model Refinement

Step 2:

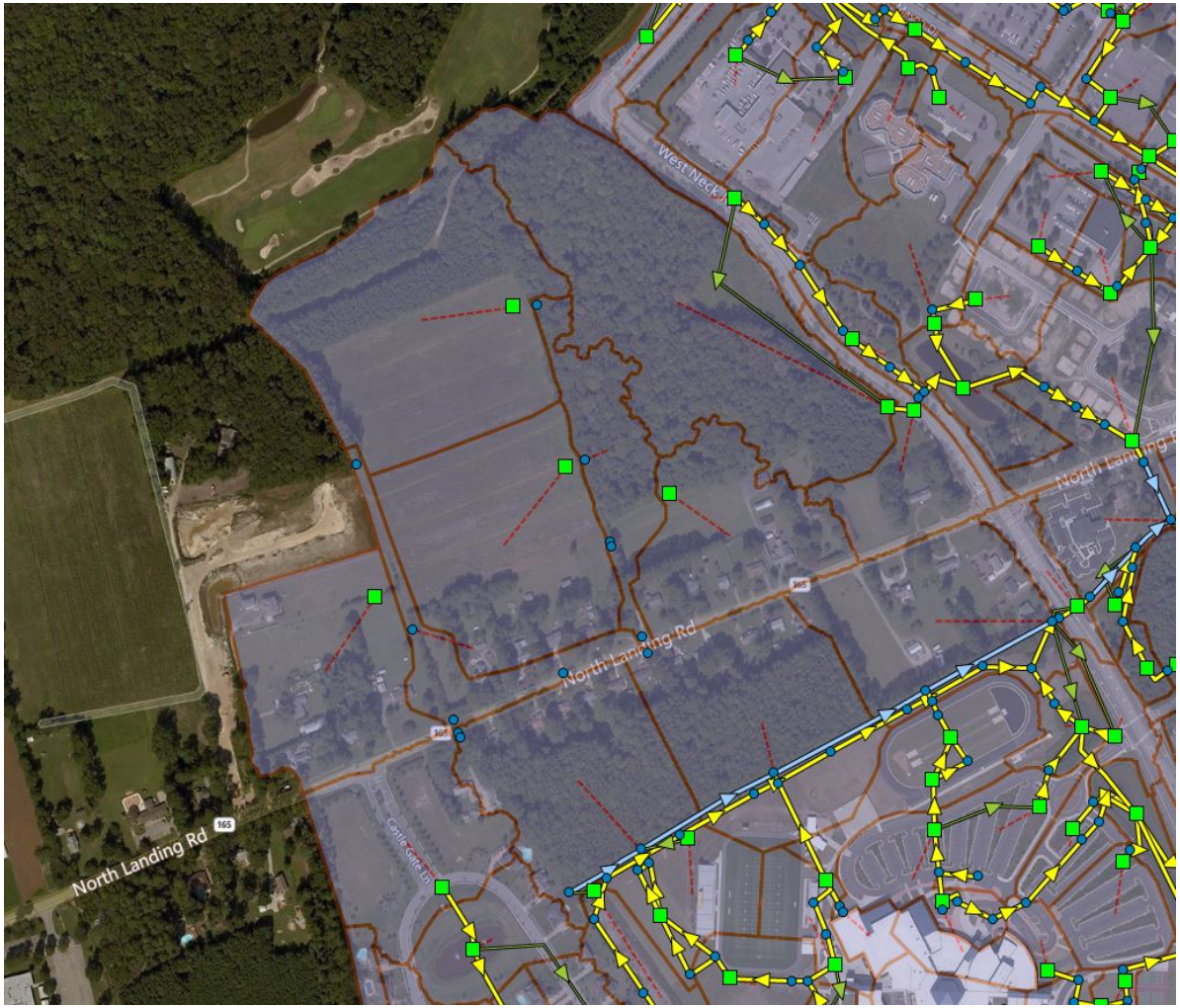
- Update the delineation and runoff parameters of the subbasins to represent the new development.
- In this example, it involves splitting two subbasins into six subbasins



Example Model Refinement

Step 3:

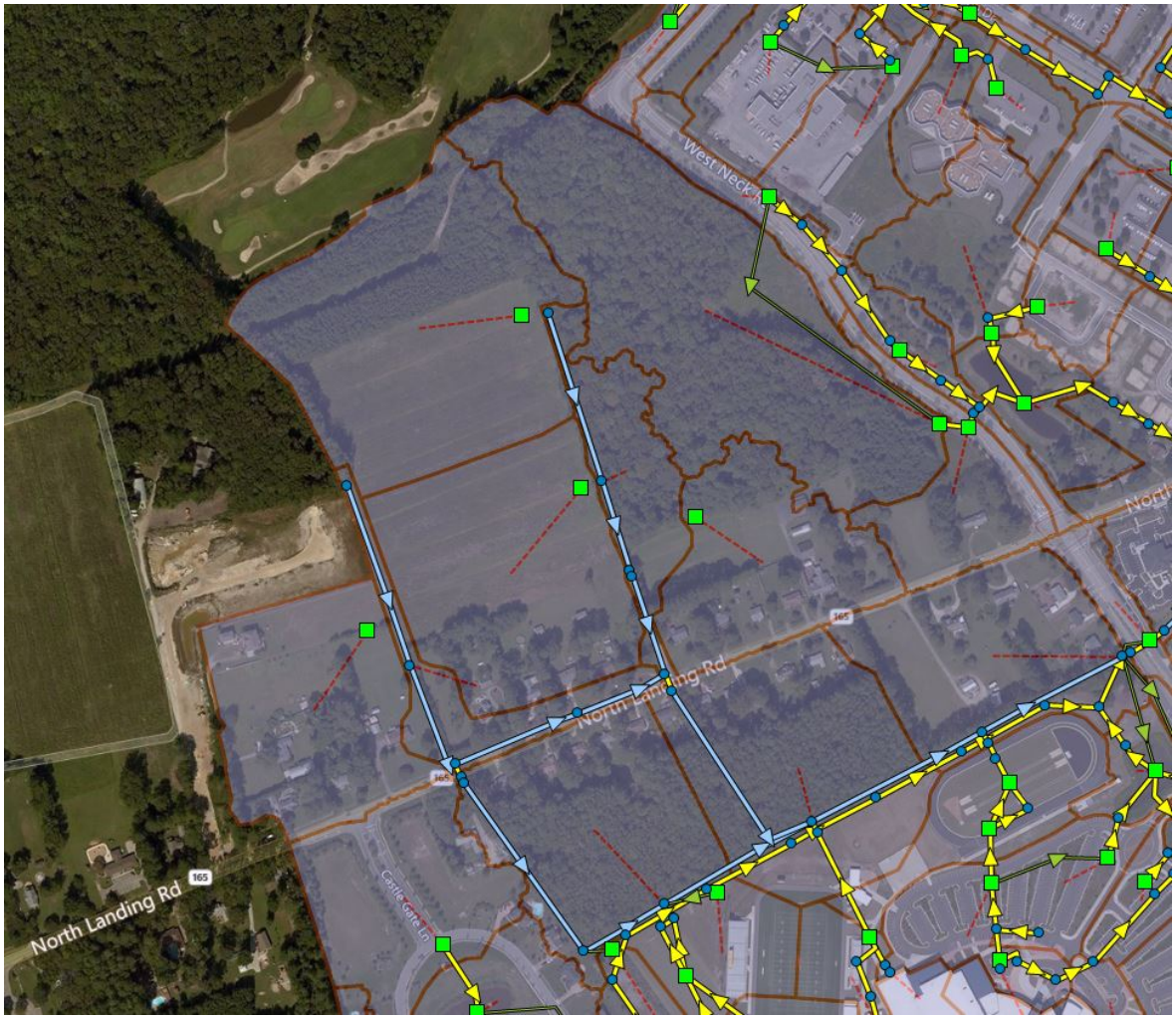
- Add storage nodes to represent surface storage and detention facilities.
- Storage nodes for surface storage are assigned to the subbasin “Outlet”
- Add junctions along the hydraulic system



Example Model Refinement

Step 4:

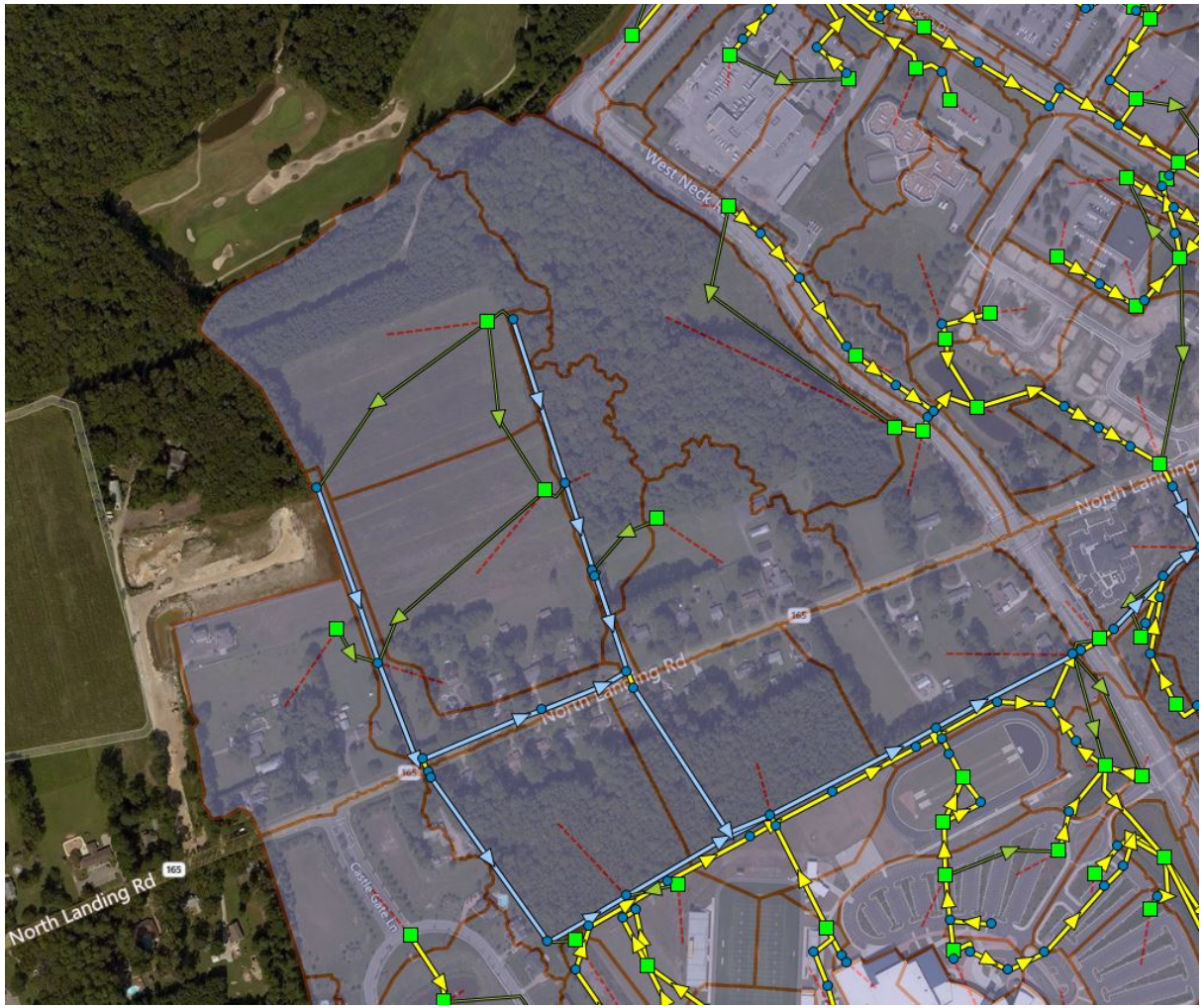
- Add links to represent the hydraulic system:
  - Open channels
  - Stormwater pipes



Example Model Refinement

Step 5:

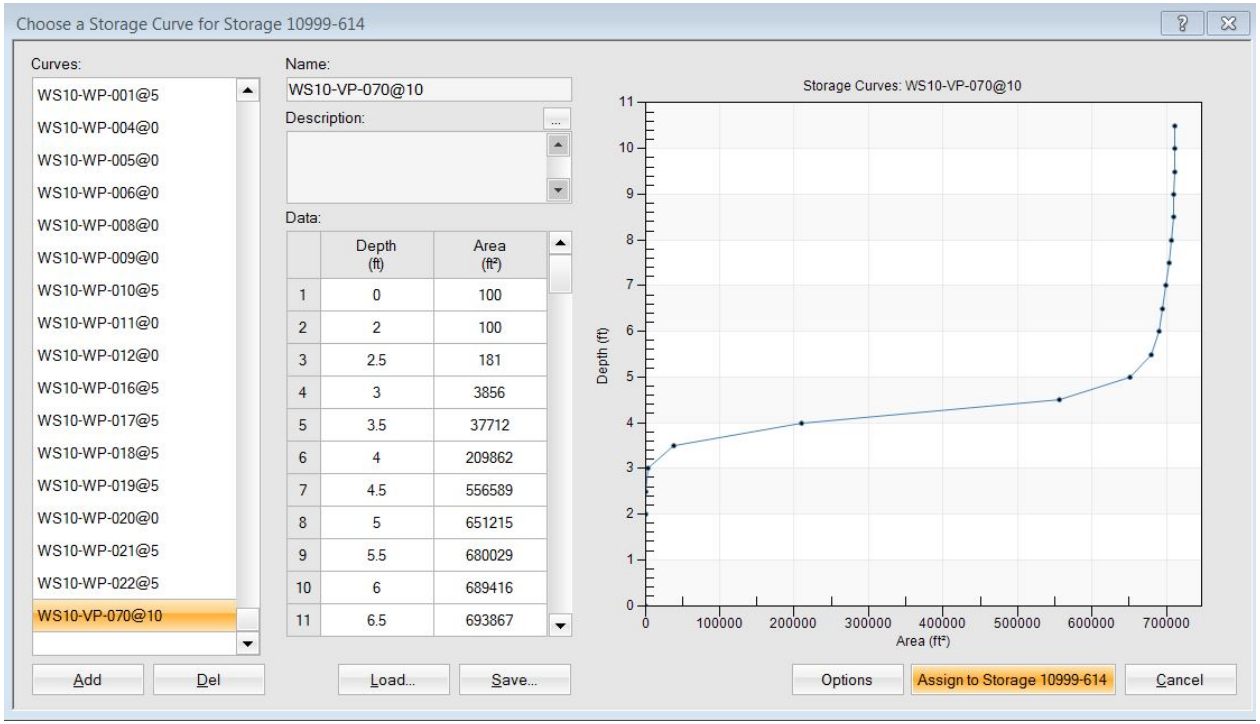
- Add overland flow paths connecting adjacent subbasins and the hydraulic system



Example Model Refinement

Step 6a:

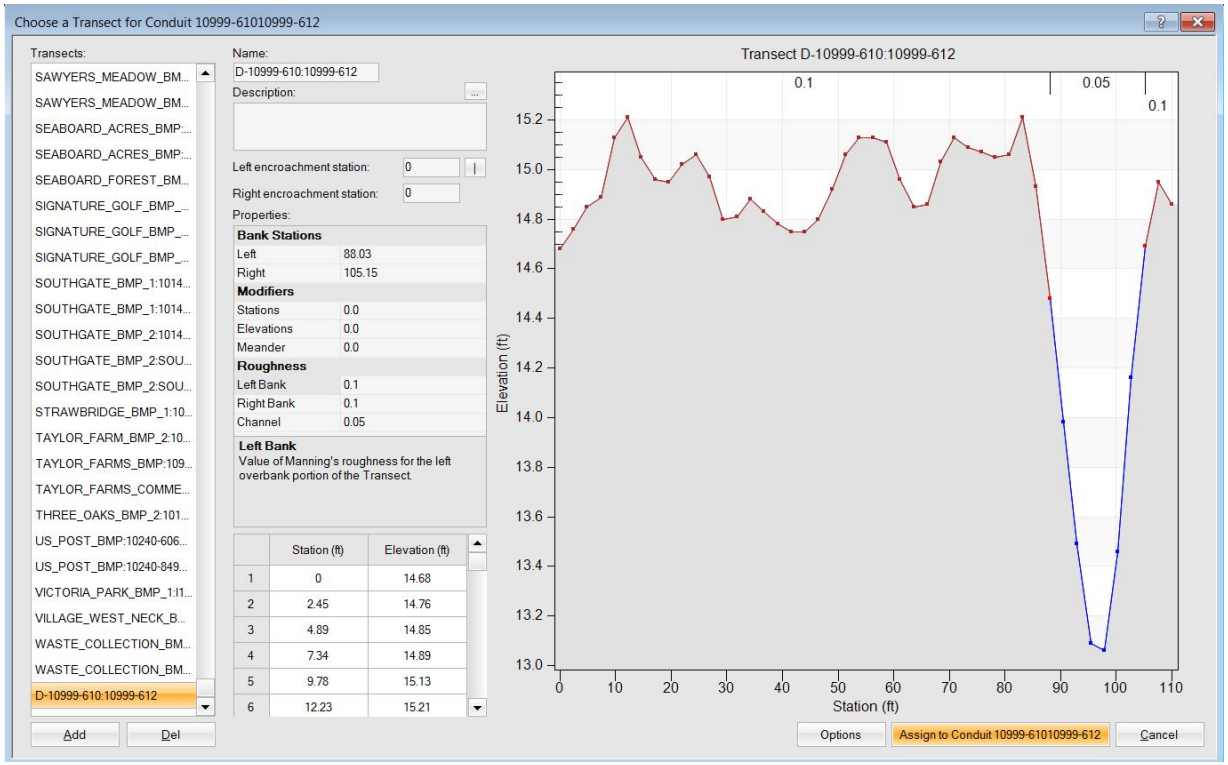
- Build and assign a stage-storage curve for each storage node



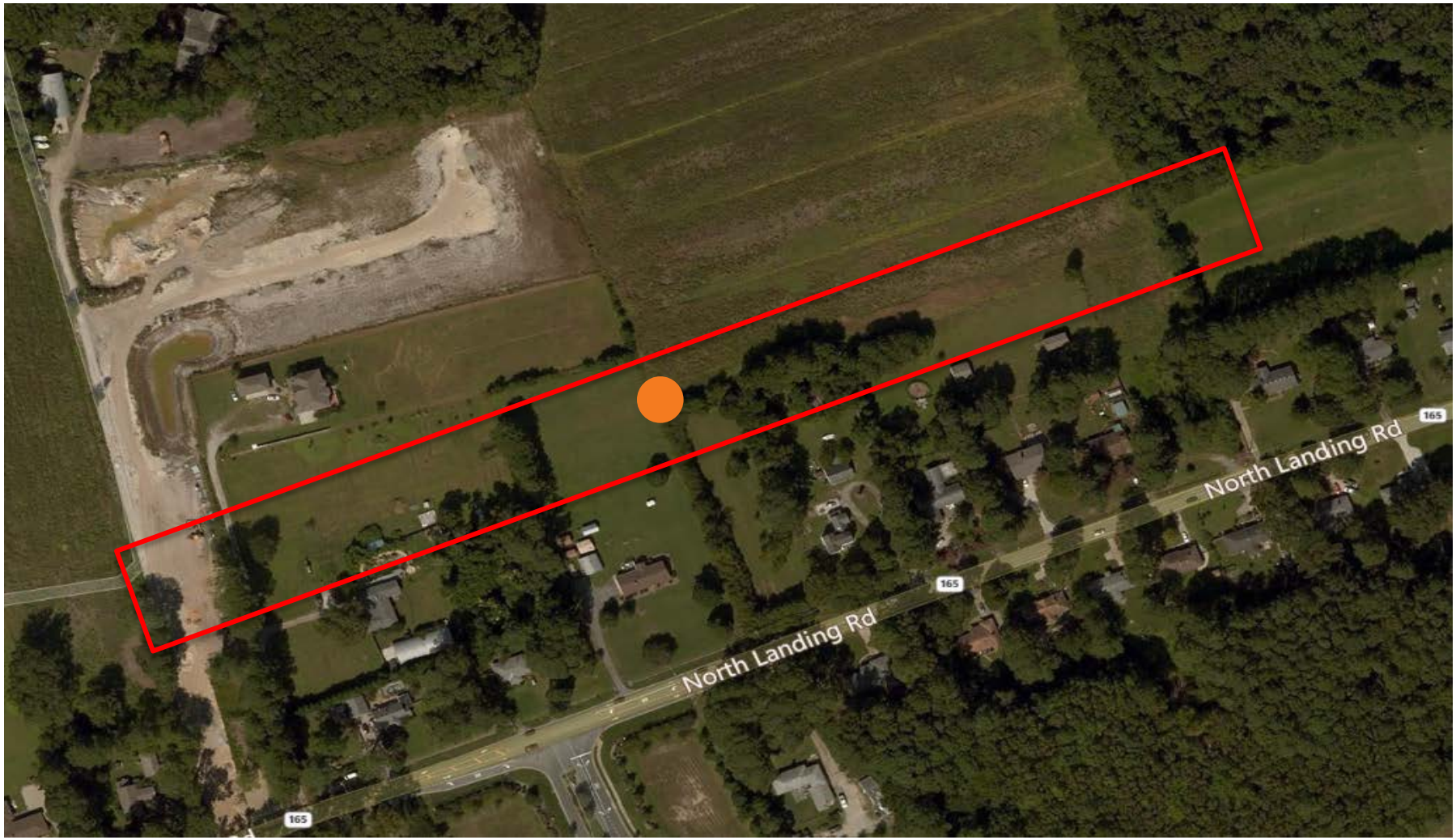
Example Model Refinement

Step 6b:

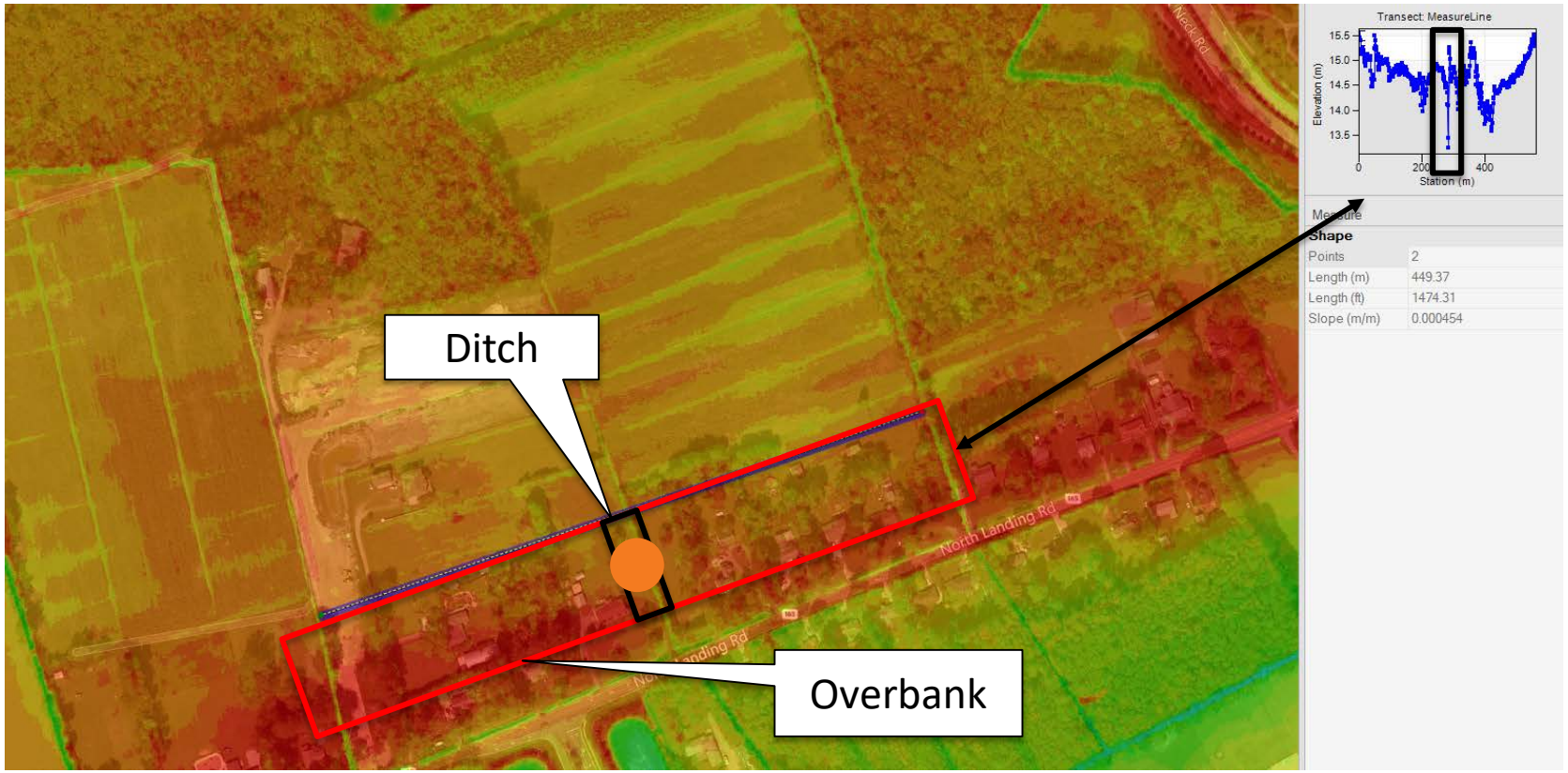
- Assign a transect for each open channel, ditch and overland flow path



Example Model Refinement: Storage Assignment

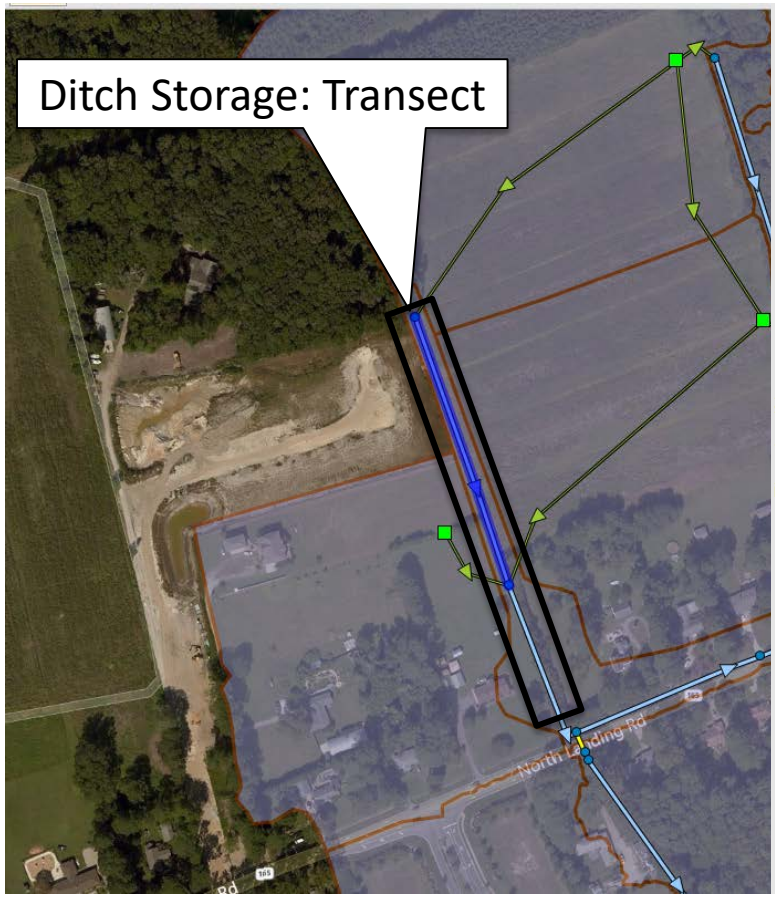


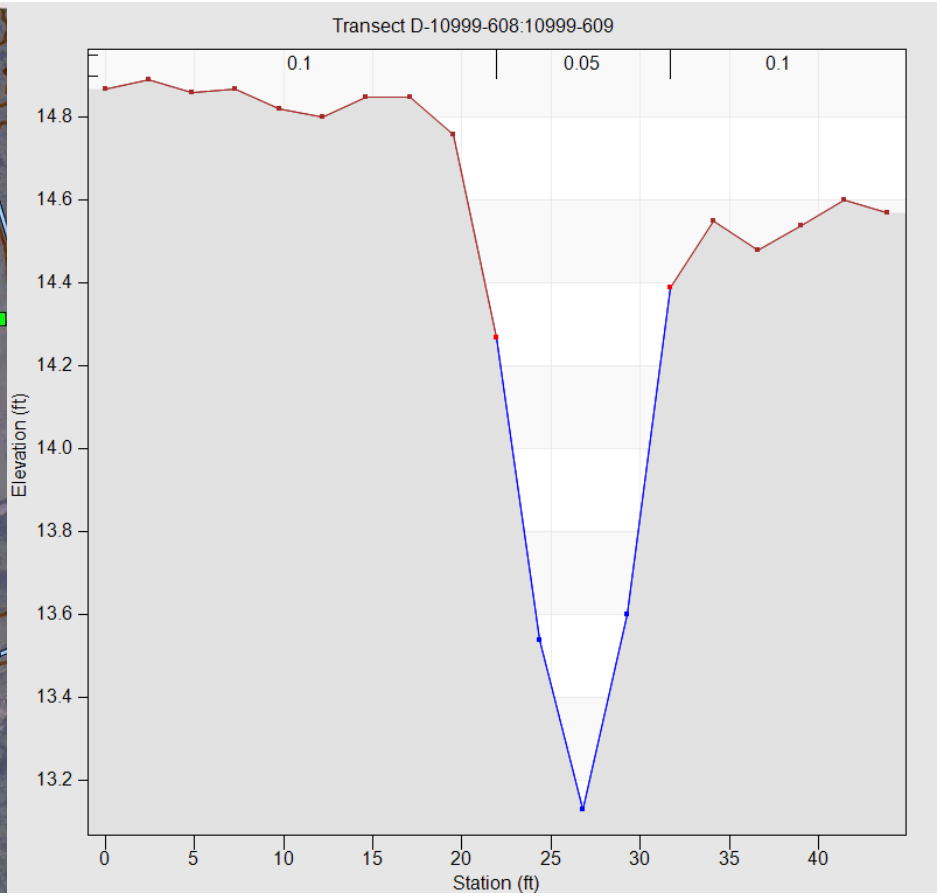
Example Model Refinement: Storage Assignment



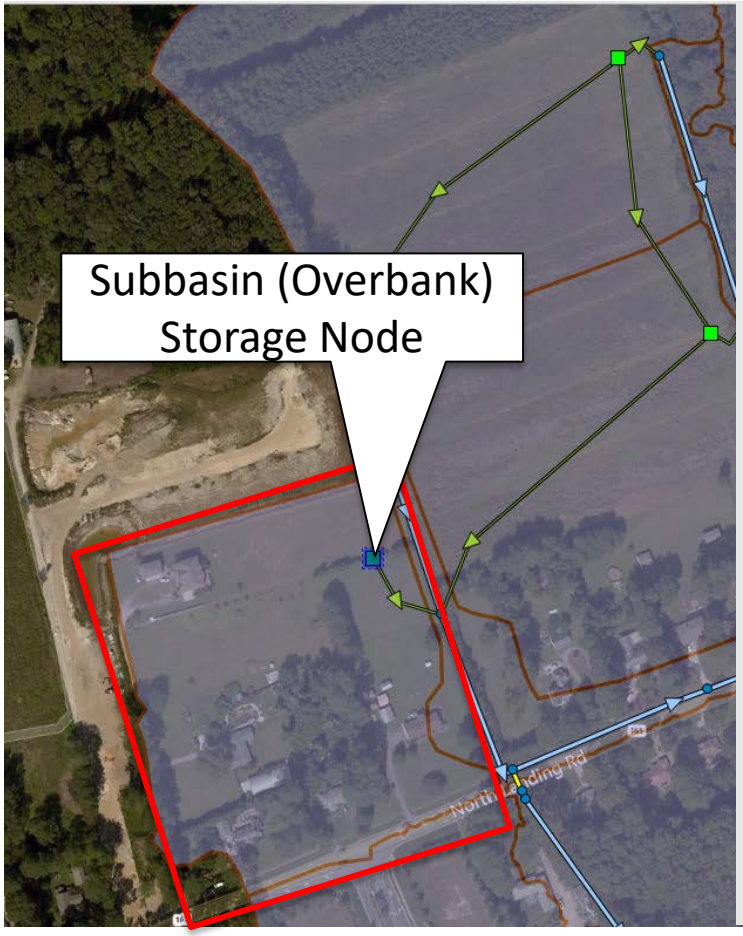
- Critical to not double count storage
- Define ditch storage and overbank storage separately

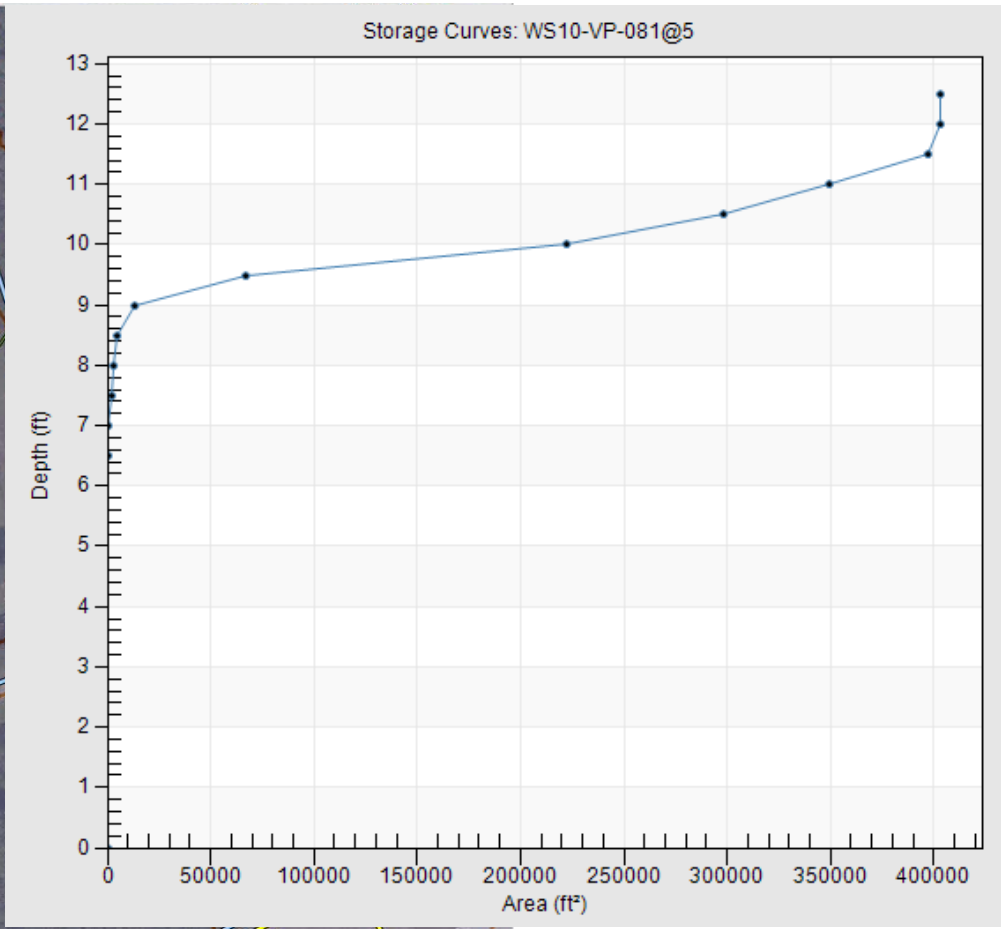
Example Model Refinement: Storage Assignment





Example Model Refinement: Storage Assignment

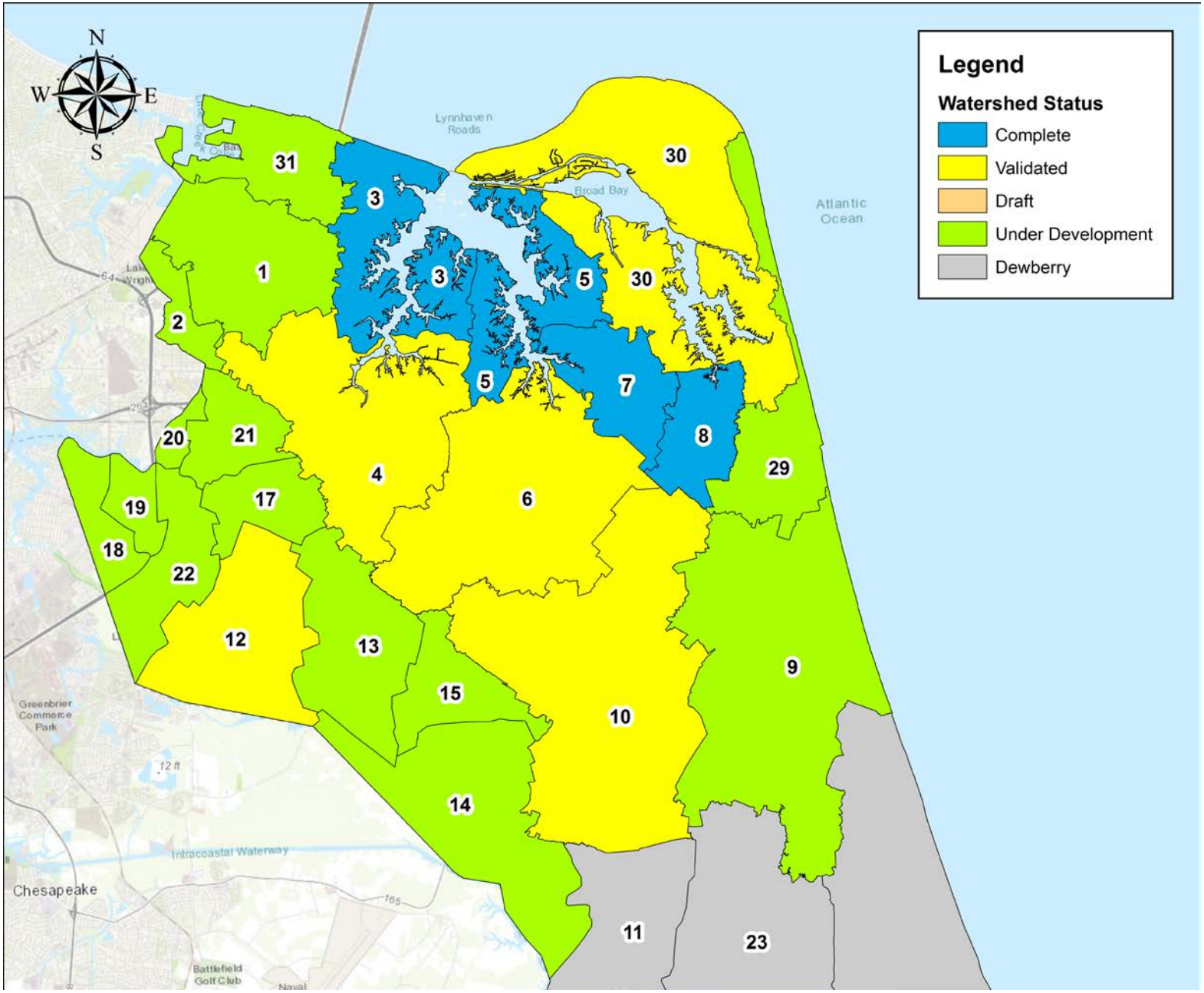




Example Model Refinement

Overview of model refinement elements

- Design drawings or “As-Built” drawings
- GIS refinements (additional pipes and nodes)
- Additional control structures (not in GIS)
- Import new GIS
- Refine subbasins and process parameters
- Storage curves
- New open channels
- New overland flow links
- Initial depths


N
W
E
S
Legend
Watershed Status
Complete
Validated
Draft
Under Development
Dewberry
Lynnhaven Roads
Broad Bay
Atlantic Ocean
Lake Wright
Greenbrier Commerce Park
12 ft
Intracoastal Waterway
Chesapeake
Battlefield Golf Club
31
3
30
1
3
5
30
2
5
7
8
20
21
4
6
29
19
17
18
22
12
13
15
10
9
14
11
23