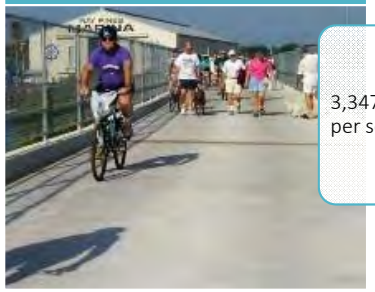
GREEN INFRASTRUCTURE AS AN EFFECTIVE POLLUTANT LOAD REDUCTION STRATEGY

Josie Benwell, M.S., ENV SP
Project Coordinator
Pinellas County Public Works

Why Green Infrastructure?

Most Densely Populated County in FL



3,347 people per square mile

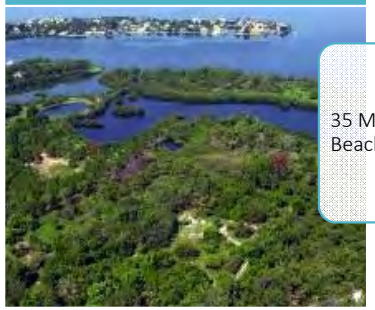
280 Square Miles - 2nd Smallest County in FL

38 miles long and 15 miles at its widest point

916,542 Residents – 6th Most Populous County in FL

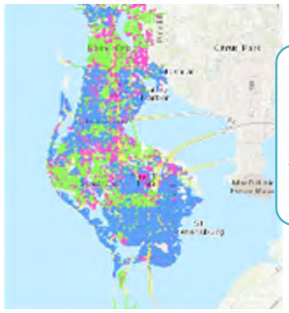
2010 Census. Estimate from 2018 is 975,280 People

588 Miles of Coastline



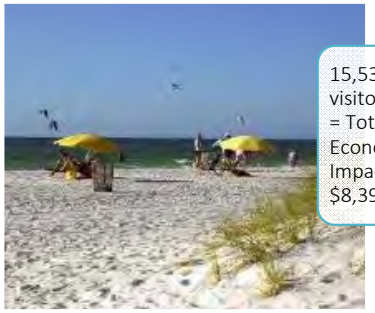
35 Miles of Beaches

4,521 Miles of Paved Roads



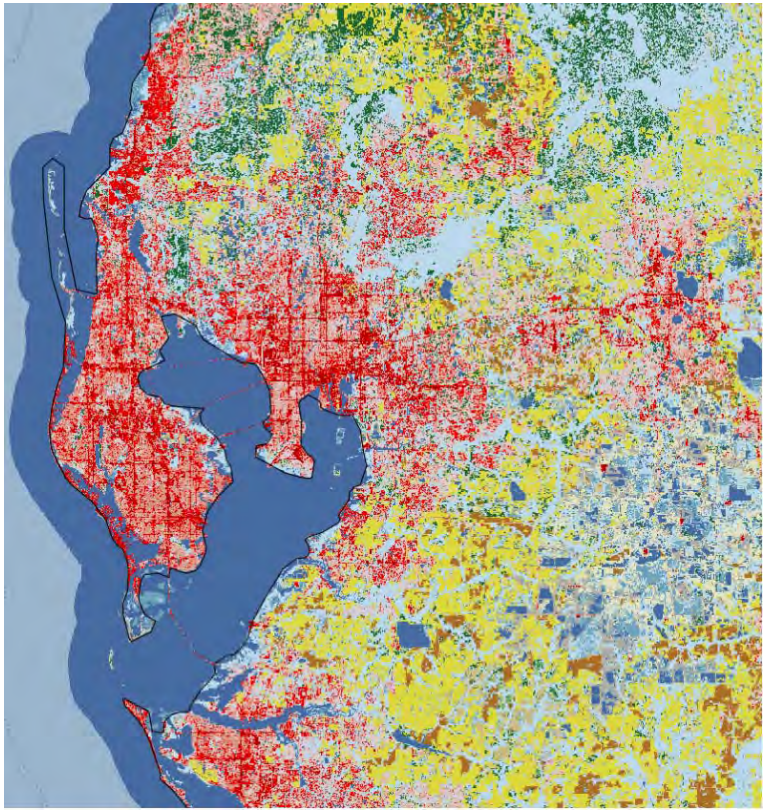
142 Bridges & 1,072 Miles of Sidewalks

Tourism is Very Important



15,539,597 visitors in 2018 = Total Economic Impact of $8,396,092,411

Why are we making Green Infrastructure a priority in Pinellas County?



National Land Cover Database (2016)

https://www.mrlc.gov/viewer/

Why are we making Green Infrastructure a priority in Pinellas County?

Environmental

- [ ] Improve Water Quality
- [ ] Mitigate Urban Heat Island Effect
- [ ] Reduce Air Pollution – Carbon Sinks
- [ ] Improve Habitat
- [ ] Increase Groundwater Recharge
- [ ] Reduce Erosion

High Land Costs

- [ ] Avoid High Land Acquisition Costs
- [ ] Avoid Eminent Domain – Use Existing ROW
- [ ] Improve Cost-Benefit of Projects
- [ ] Increase Opportunity for Grants

Operational

- [ ] Reduce Maintenance
- [ ] Lower Energy Use
- [ ] Lower Design and Construction Cost
- [ ] Decrease Mosquito Issues

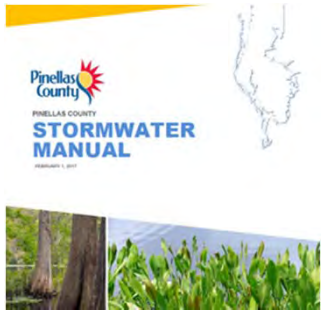
Community Benefit

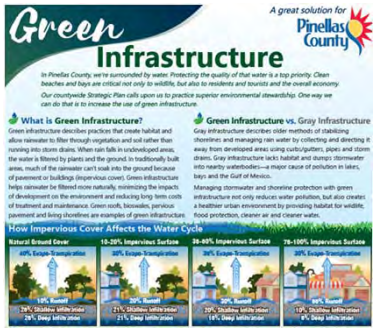
- [ ] Provide Public Education
- [ ] Enhance Aesthetics
- [ ] Recreational Opportunity – Pocket Parks
- [ ] Reduce Flooding

Gray verses Green Infrastructure

https://archdesign.utk.edu/ut-landscape-architecture-creates-guide-for-east-tennessee-water-resources/

Establishment of a Green Infrastructure Program





Stormwater Manual → Public Education Materials → Green Infrastructure Siting Project → Initial Projects in County ROW → Projects on Private Property (Adopt-A-Pond approach)

Components of new Green Infrastructure Program

Next Step: Green Infrastructure Siting Project - 3 Phases

1) Project Development

- Develop work flow and framework
- Define the data to be considered and the limits

2) Initial GIS-Based Screening

- Develop GIS-based screening tool for initial identification of potential project sites.
- Site suitability: soils, water tables, COUNTY-owned property/ROW, etc.

3) Proof of Concept

- Create water quality evaluation functionality in ICPR 4.
- Produce refined list of potential project sites based on water quality benefit provided, TMDL priorities, etc.

Contact Information:

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Green Infrastructure as an Effective Pollutant Load Reduction Strategy

Florida Stormwater Association
Winter Conference 2019

Geosyntec consultants

Mark Ellard, PE, CFM, D.WRE, ENV SP

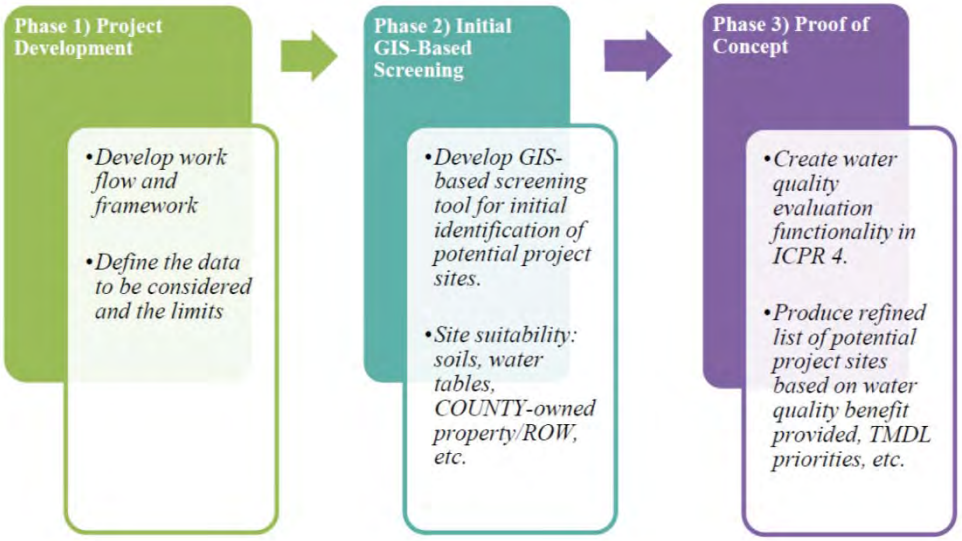
December 5, 2019

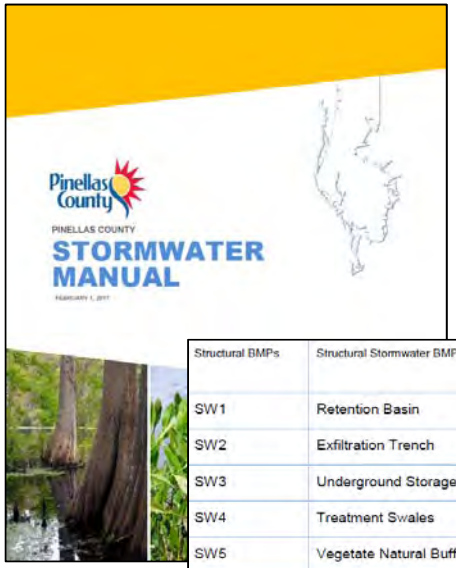
Goals

- Develop a rating and suitability framework for siting GI as part of the new GI program
  - Take into account where the COUNTY owns property or has Right-of-Way
  - TMDL /impaired water priority areas
  - Considering site suitability (landuse, soils, water table, etc.)
- End result to provide framework and toolset to evaluate water quality benefits and suitability to conceptualize and prioritize future GI projects
- Produce initial list of ranked GI projects
- Top ranked projects are conceptualized as proof of concept
- SOPs developed so COUNTY may easily replicate the results
- Establish standardized water quality benefit evaluation procedures
  - Water quality analysis functionality to evaluate GI features built into ICPR 4
  - New functionality for estimating the water quality benefit in consistent manner

Scope of Work

Task	Scope of Work Description
Task 1	Collection & Review of Existing Data
Task 2	Project Development
Task 3	Initial Screening of Sites
Task 4	Coordinate Water Quality and GI Functionality in ICPR 4
Task 5	Final (Ranked) GI Projects



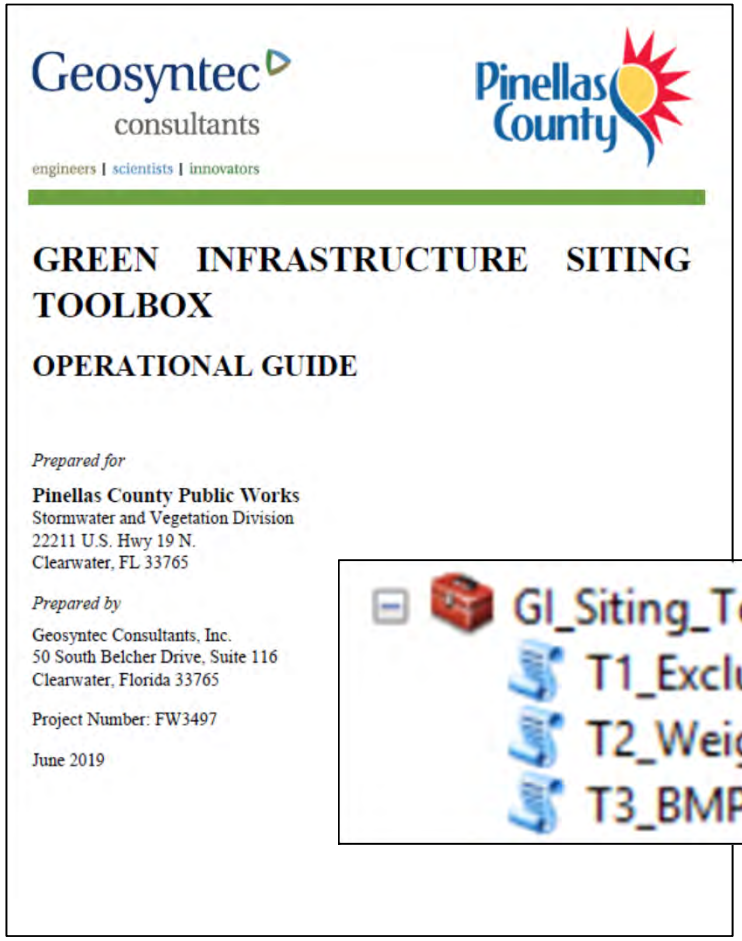


Leverage Stormwater Manual BMPs

Structural BMPs	Structural Stormwater BMPs	Manual Section	Explicit Load Reduction Credit
SW1	Retention Basin	6.1	√
SW2	Exfiltration Trench	6.2	√
SW3	Underground Storage and Retention	6.3	√
SW4	Treatment Swales	6.4	√
SW5	Vegetate Natural Buffers	6.5	√
SW6	Pervious Pavements	6.6	√
SW7	Green Roofs with Cisterns	6.7	√
SW8	Wet Detention Systems	6.8	√
SW9	Stormwater Harvesting/ Horizontal Wells	6.9	√
SW10	Up-Flow Filter Systems	6.10	√
SW11	Managed Aquatic Plant Systems	6.11	√
SW12	Biofiltration Systems/Tree Box Filters	6.12	√
SW13	Rain gardens	6.13	√
SW14	Rainwater Harvesting/Cisterns	6.14	√
SC15	Rainfall Interceptor Trees	6.15	√

SOP Manual

- Develop Flow Chart of Process
- Describe Data Requirements
  - Exclusionary Data
  - Weighting Data and Assumptions
  - BMP Suitability Guidance
- Calculations Logic
- GIS Tool Operation Procedures
- Examples


Geosyntec consultants

engineers | scientists | innovators

Pinellas County

GREEN INFRASTRUCTURE SITING TOOLBOX

OPERATIONAL GUIDE

Prepared for

Pinellas County Public Works
Stormwater and Vegetation Division
22211 U.S. Hwy 19 N.
Clearwater, FL 33765

Prepared by

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50 South Belcher Drive, Suite 116
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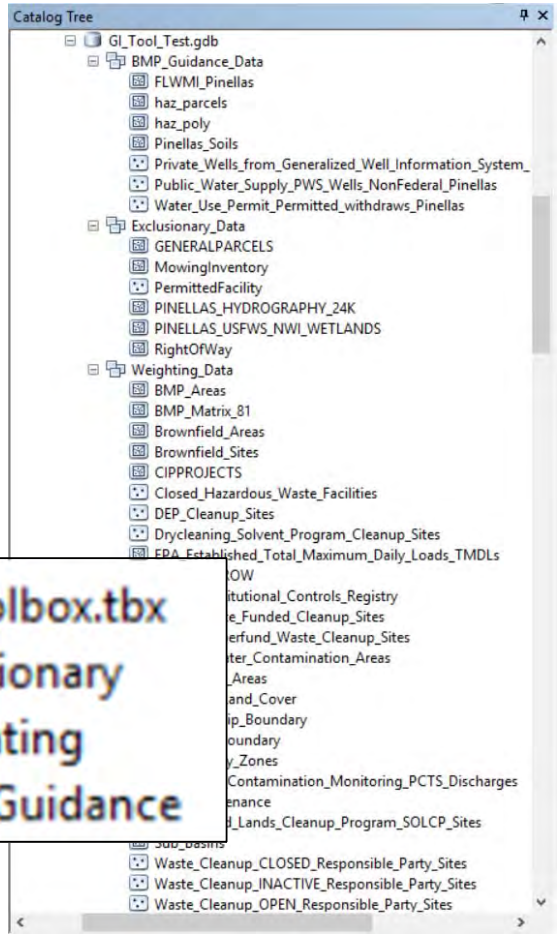
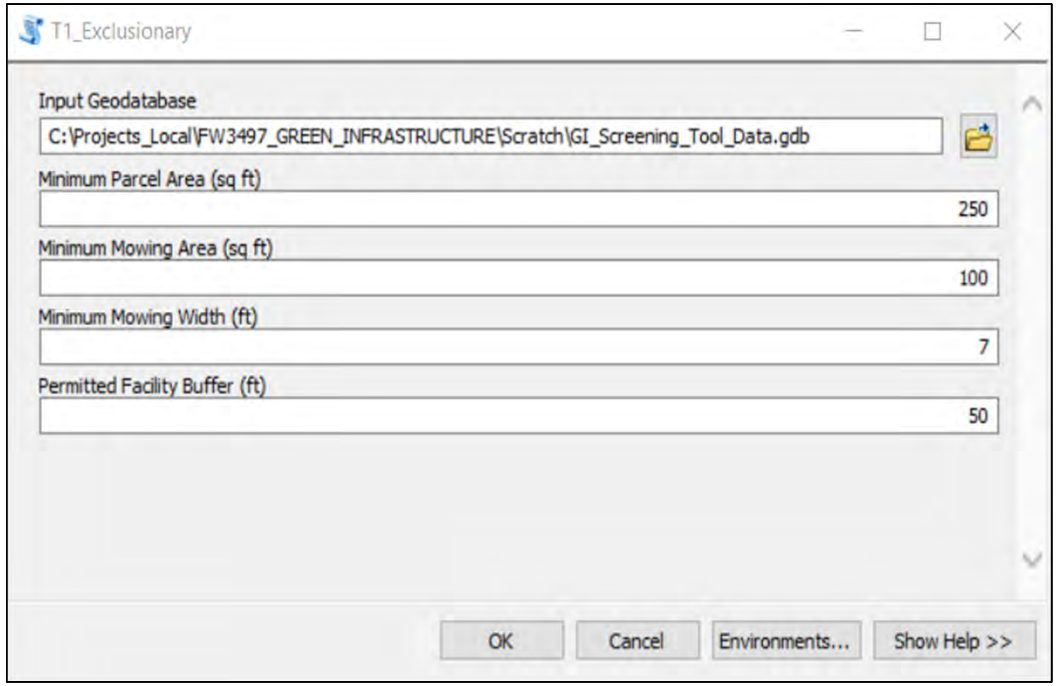
Project Number: FW3497

June 2019



Default Values of Exclusionary Tool Input Parameters

Input Parameter	Default Value	Purpose
Minimum Parcel Area (ft^2)	250	**Minimum parcel size considered for potential sites.**
Minimum Mowing Area (ft^2)	100	**Minimum mowing area size considered for potential sites.**
Minimum Mowing Width (ft)	7	**Minimum width of mowing areas considered for potential sites.**
Permitted Facility Buffer Distance (ft)	**50**	**Minimum distance between a potential site and a permitted facility point.**



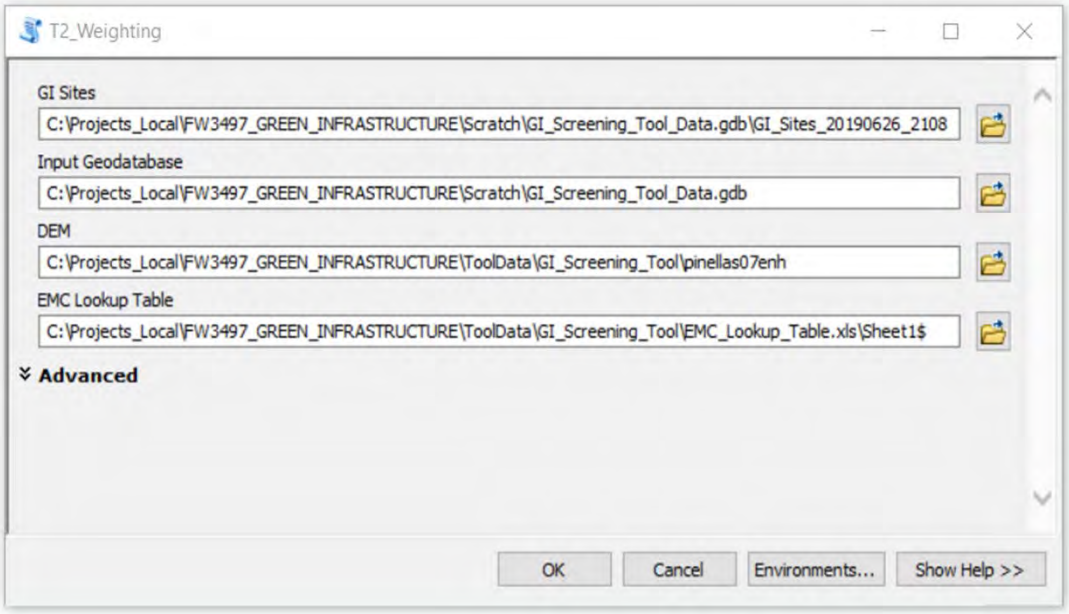
Weighting Values

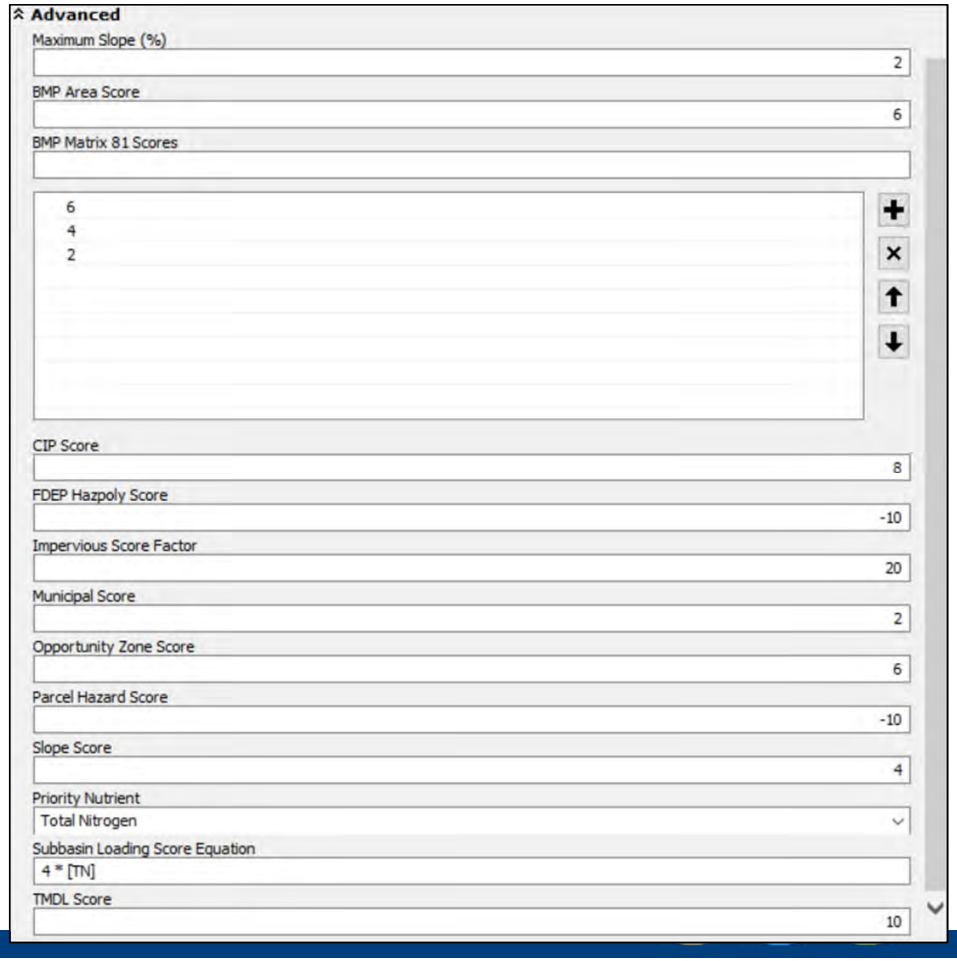
Default Values of Weighting Tool Input Parameters

Input Parameter	Default Value	Purpose
Slope Threshold (%)	2	**Upper limit of the subbasin average slope awarded the slope score.**
BMP Area Score	2	**Sub-score awarded to sites intersecting BMP areas.**
BMP Matrix 81 Scores	6 (High Rank) 4 (Medium Rank) 2 (Low Rank)	**Sub-score awarded to sites intersecting BMP Matrix 81 areas. Scores awarded based on rank.**
CIP Score	8	**Sub-score awarded to sites intersecting CIPs.**
FDEP Hazpoly Score	-10	**Sub-score awarded to sites intersecting any of the FDEP hazard sites polygon features.**
Impervious Score Factor	20	**Factor applied to the subbasin impervious percentage to calculate the impervious sub-score.**
Municipal Score	2	**Sub-score awarded to sites intersecting unincorporated areas.**
Opportunity Zone Score	6	**Sub-score awarded to sites intersecting opportunity zones.**
Parcel Hazard Score	-10	**Sub-score awarded to sites intersecting parcels containing any of the FDEP hazard sites point features.**
Slope Score	4	**Sub-score awarded to sites within subbasins with an average slope <= the slope threshold.**
Priority Nutrient	Total Nitrogen	**Used to select the default subbasin loading score equation.**
Subbasin Loading Score Equation	If priority nutrient = TN: 2*[TN] If priority nutrient = TP: 2 / (1 – [TP])	**Used to calculate sub-score based on the subbasin area-weighted average EMC.**
TMDL Score	**10**	**Sub-score awarded to sites intersecting basins with established TMDLs.**

Weighting Values

Default Values of Weighting Tool Input Parameters





BMP Guidance

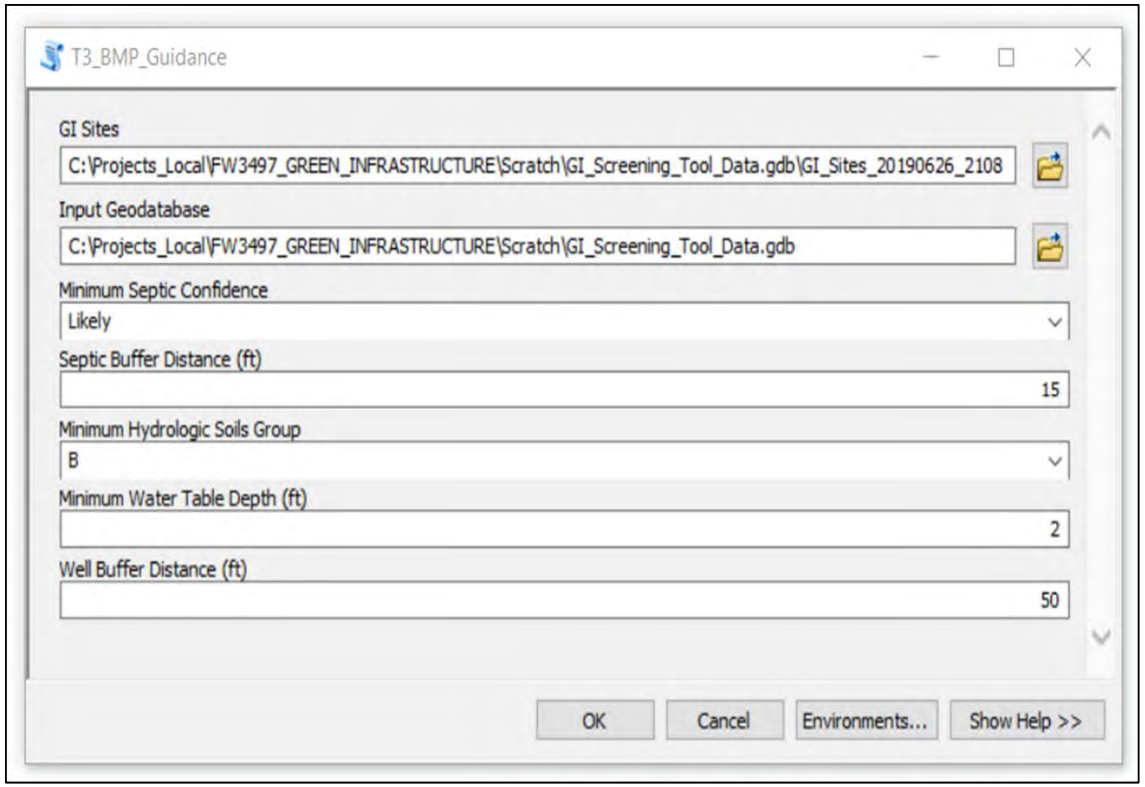
The BMP Guidance Tool performs additional spatial analyses on the ranked GI Sites to flag BMP types that may be unsuitable for a given site.

- **BMPs limited by drainage potential and proximity to septic systems and hazard sites**
  - **Retention basins**
  - **Exfiltration trench**
  - **Underground retention**
  - **Treatment swales**
  - **Vegetated natural buffer**
  - **Pervious pavements**
  - **Biofiltration / TreeBox**
  - **Rain gardens**
- **BMPs limited by proximity to septic systems and hazard sites**
  - **Wet detention**
- **BMPs limited by proximity to hazard sites**
  - **Rainwater harvesting**
  - **Stormwater harvesting**

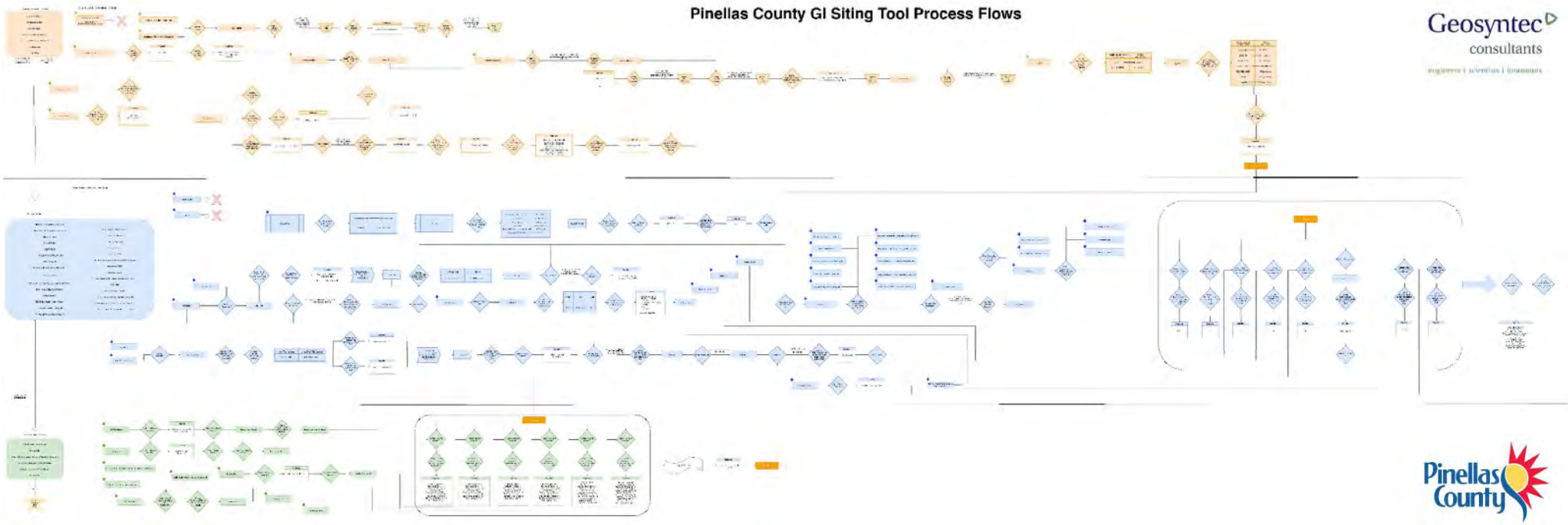
Geosyntec consultants

Default Values of BMP Guidance Tool Input Parameters

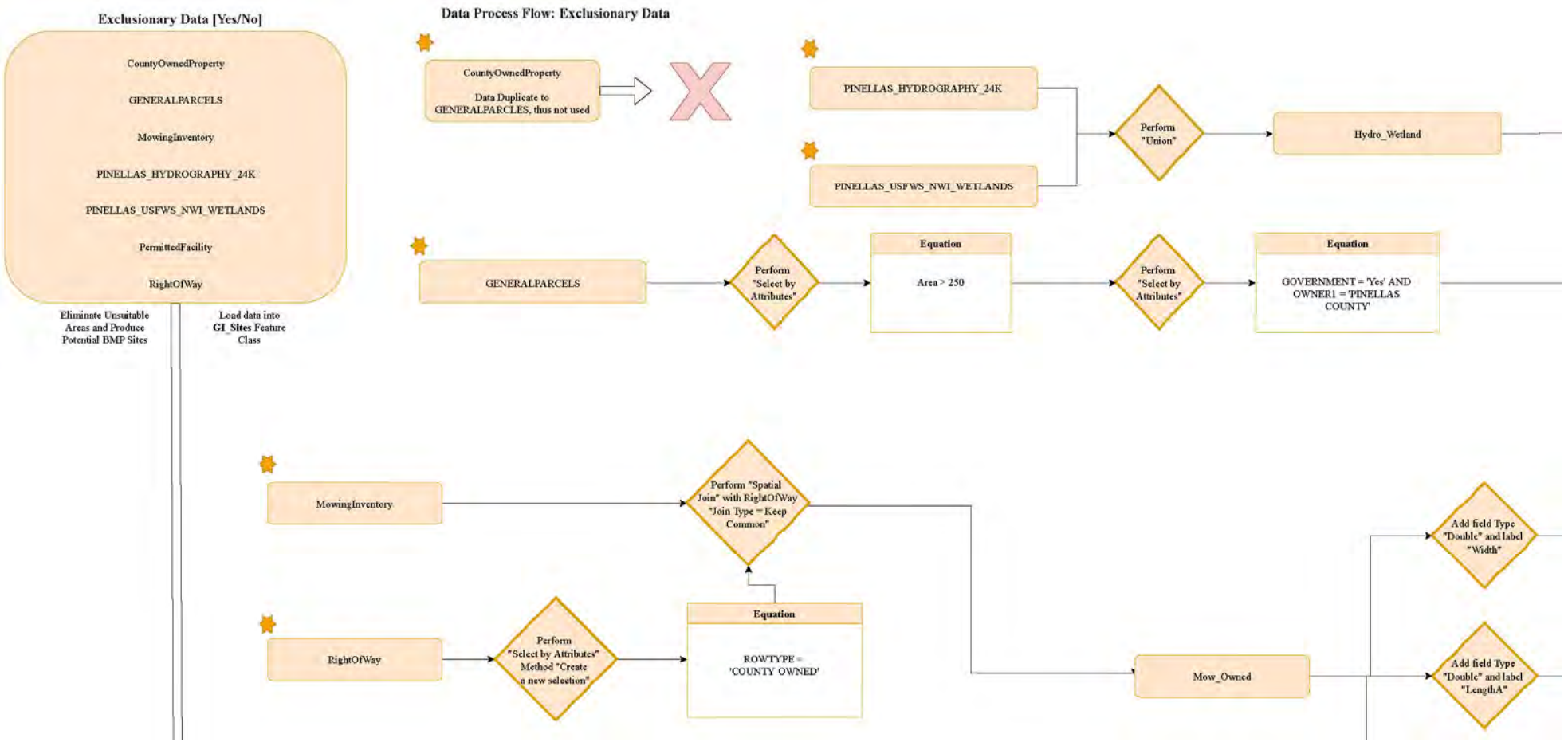
Input Parameter	Default Value	Purpose
Minimum Septic Confidence	Likely	**The minimum level of confidence (e.g., known, likely) to treat as septic systems.**
Septic Buffer Distance (ft)	15	**The minimum distance between a site and a septic system considered suitable. Selection of septic sites is based on the minimum septic confidence parameter.**
Minimum Hydrologic Soils Group	B	**The hydrologic soils group with the minimum drainage capacity (e.g., well-drained, moderately drained, poorly drained) considered suitable.**
Minimum Water Table Depth (ft)	2	**The minimum depth to the average water table elevation considered suitable.**
Well Buffer Distance (ft)	**50**	**The minimum distance between a site and a potable well considered suitable.**



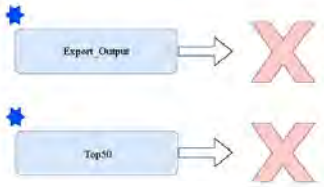
Flow Chart of Logic Process

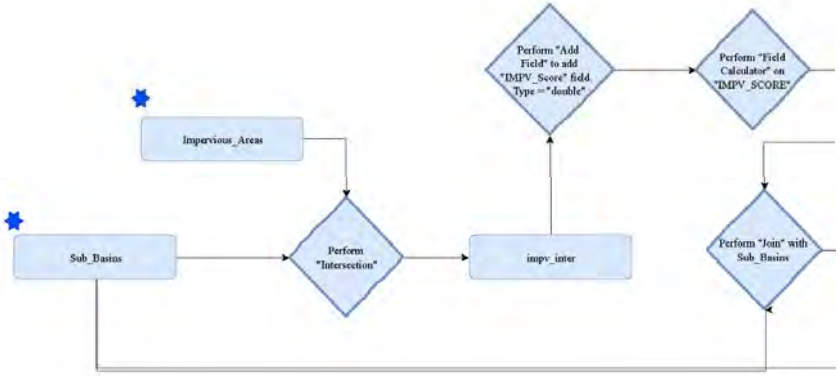


Flow Chart of Logic Process



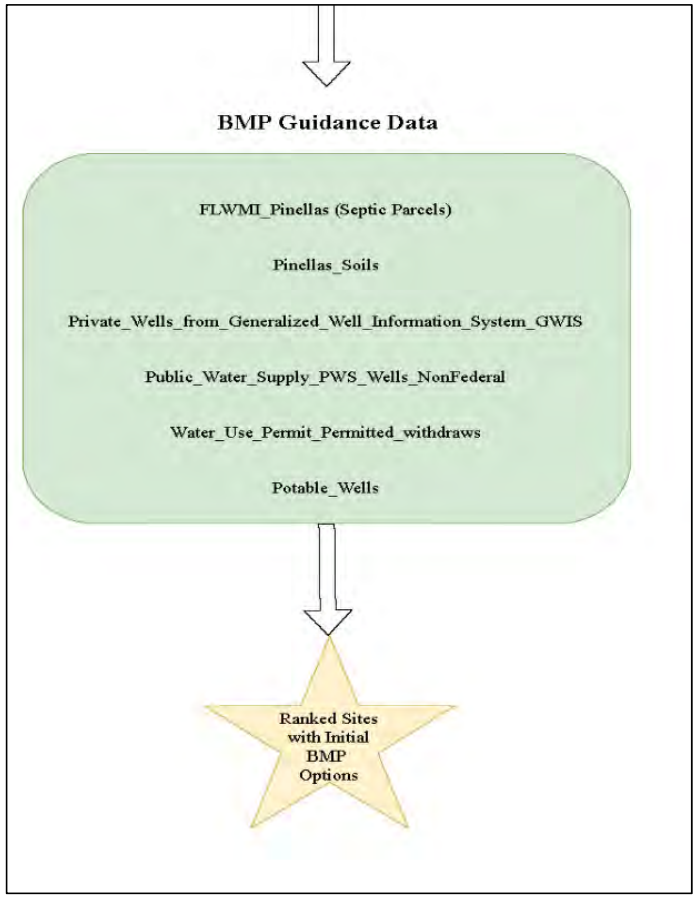
Flow Chart of Logic Process





Flow Chart of Logic Process

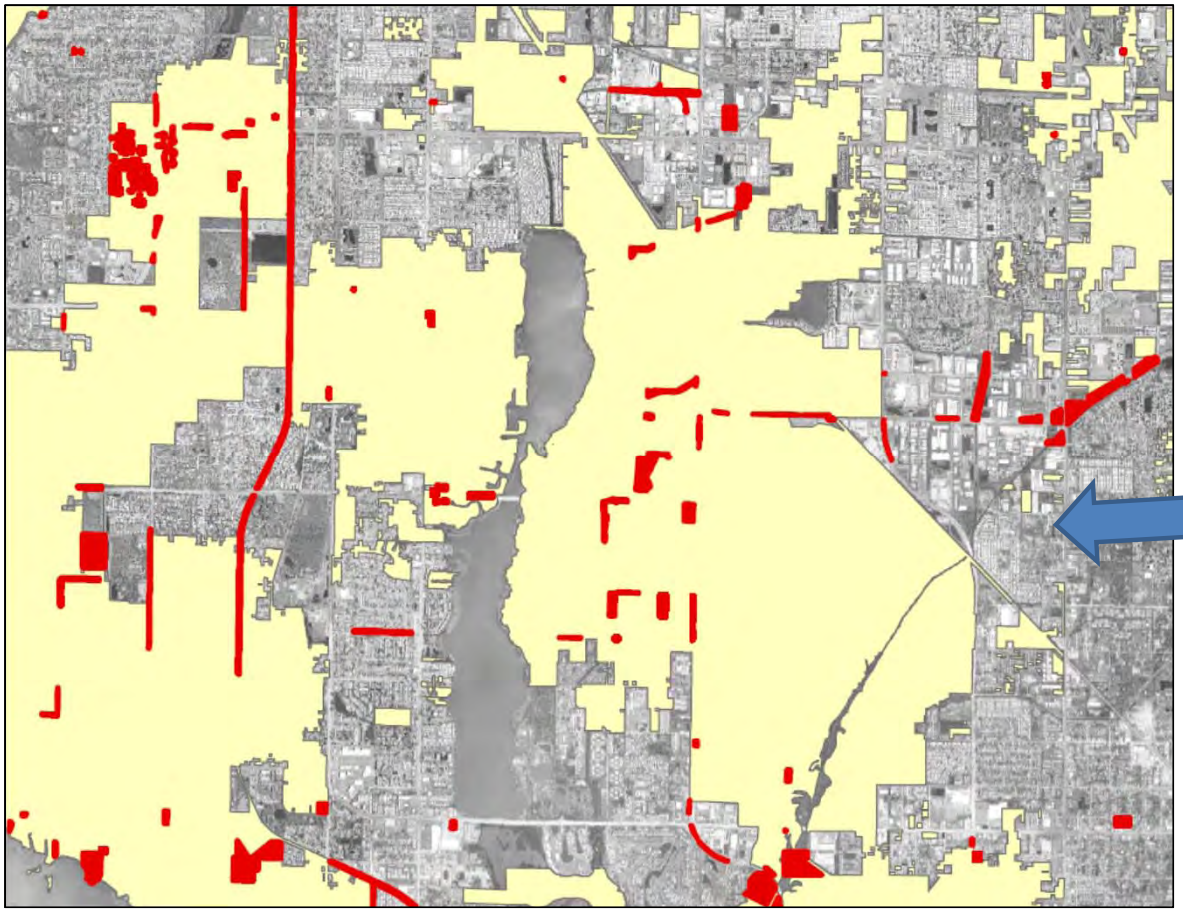
Rankings for all potential GI sites

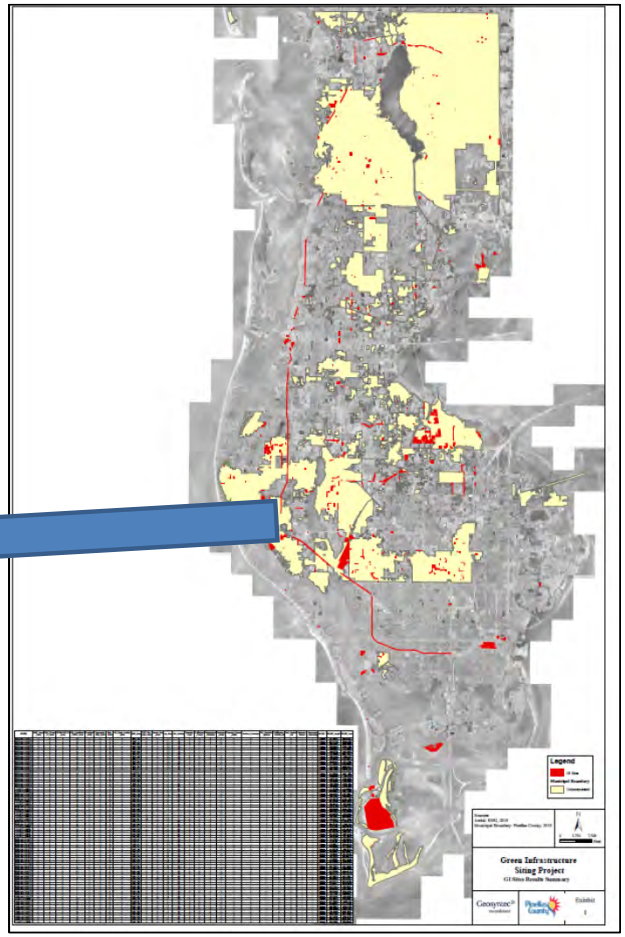


Sub - Scores ← **Site Ranking** → **BMP Suitability**

ore	Parcels_Haz_Score	Imp_Score	Site_Ranking	Retention_Basin	Exfiltration_Trench
0	0	6	44	0	0
0	0	8	40	1	1
0	0	8	39	1	1
0	0	4	35	0	0
0	0	5	32	1	1
0	0	8	31	0	0
0	0	4	27	0	0
0	0	5	27	0	0
-10	0	7	27	0	0

Initial Screening Results

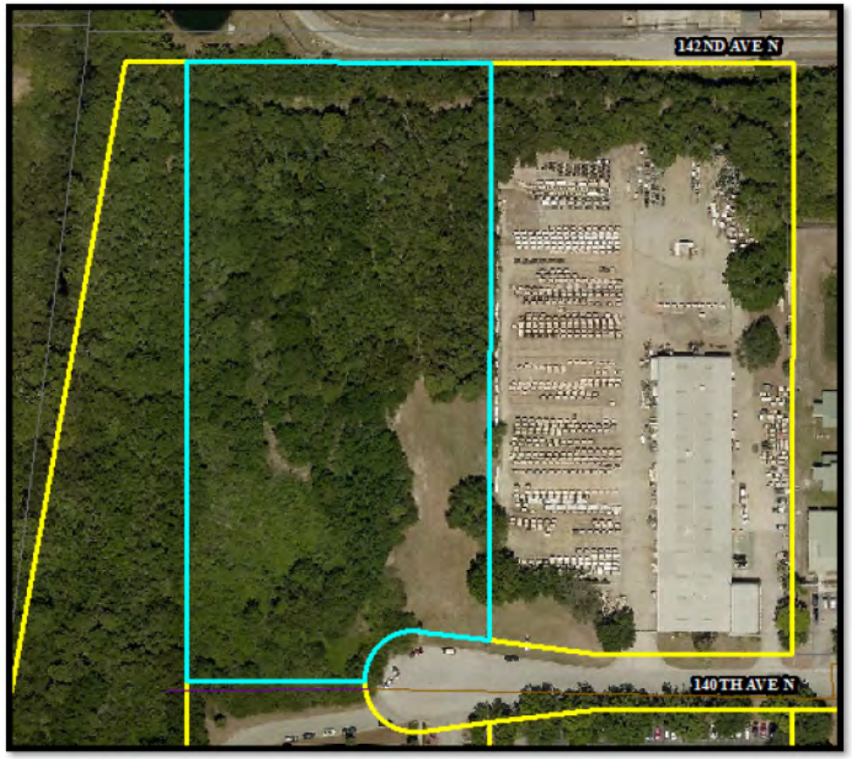




Initial Screening Results

Figure 1: Site BMP_744, Top Ranked Site

Figure 2: Site BMP_876, Second Ranked Site



Initial Screening Results

Figure 4: Site BMP_737, Second Ranked Site (tied)

Figure 6: Site BMP_517, Thirteenth Ranked Site

Initial Screening Results

Figure 7: Site BMP_708, Last Ranked Site

Figure 8: Site BMP_83, Site with Zero Score (tied)

Green Infrastructure as an Effective Pollutant Load Reduction Strategy

Florida Stormwater Association
Winter Conference 2019

WATER QUALITY MODULE

Peter J. Singhofen, P.E.
Streamline Technologies, Inc.

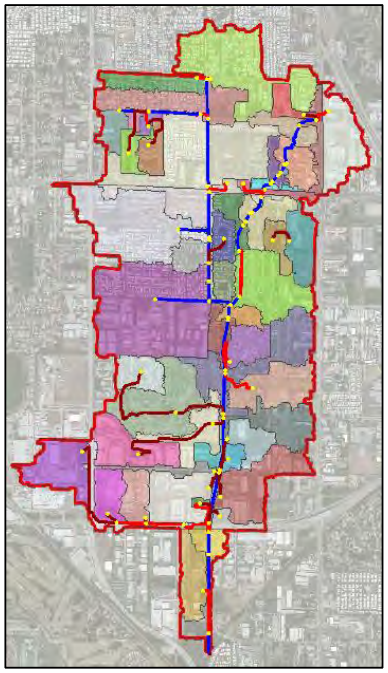
WQ MODULE DESIGN STRATEGY

- Watershed Approach
- Water Quality Fully Integrated with H&H
  - EMCs Applied to Distributed Hydrology
  - Mass Balance at Nodes
  - Pollutants Transferred via Links
  - Removal Efficiencies can be Specified at any Node or Link
  - Percolation can be used to Remove Pollutants
- Continuous Simulations Required
- Multiple Constituents Analyzed Simultaneously
- Initial, Irreducible & Boundary WQ Included

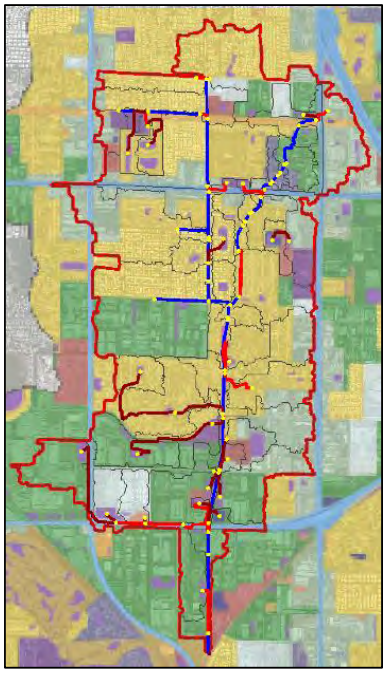
Physical processes associated with infiltration/percolation and evapotranspiration are modeled instead of relying on empirically based performance curves

ICPR Functionality	BMPs
Percolation & French Drain Links	Dry Retention, Exfiltration Trenches, Underground Storage, Treatment Swales, Pervious Pavement, Rain Gardens
Removal Efficiencies Specified at Nodes	Wet Detention Systems, Managed Aquatic Plant Systems (MAPS), User Defined BMPs
Removal Efficiencies Specified at Links	Upflow Filtration Systems, Biofiltration Systems with BAM, User Defined BMPs
Storage, Evapotranspiration & Irrigation	Vegetated Natural Buffer, Vegetated Filter Strip, Green Roof/Cistern Systems, Stormwater & Rainwater Harvesting, Interceptor Trees

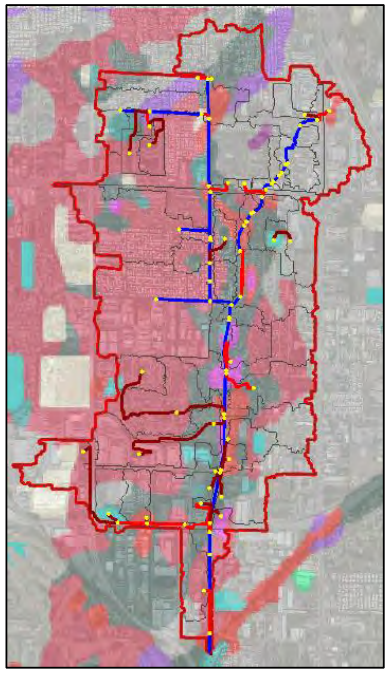
PINEBROOK CANAL
CROSS BAYOU WATERSHED, PINELLAS COUNTY



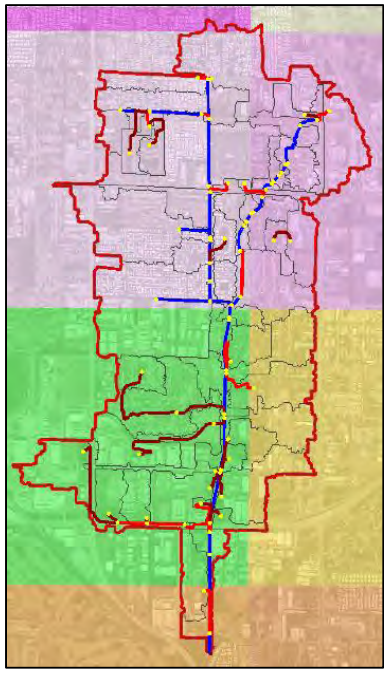
BASINS



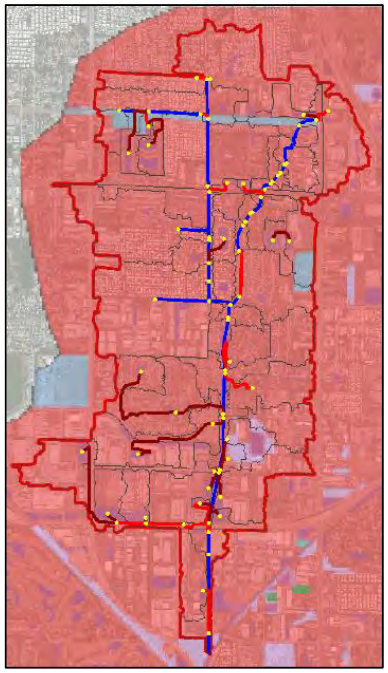
LAND USE



SOILS



NEXRAD

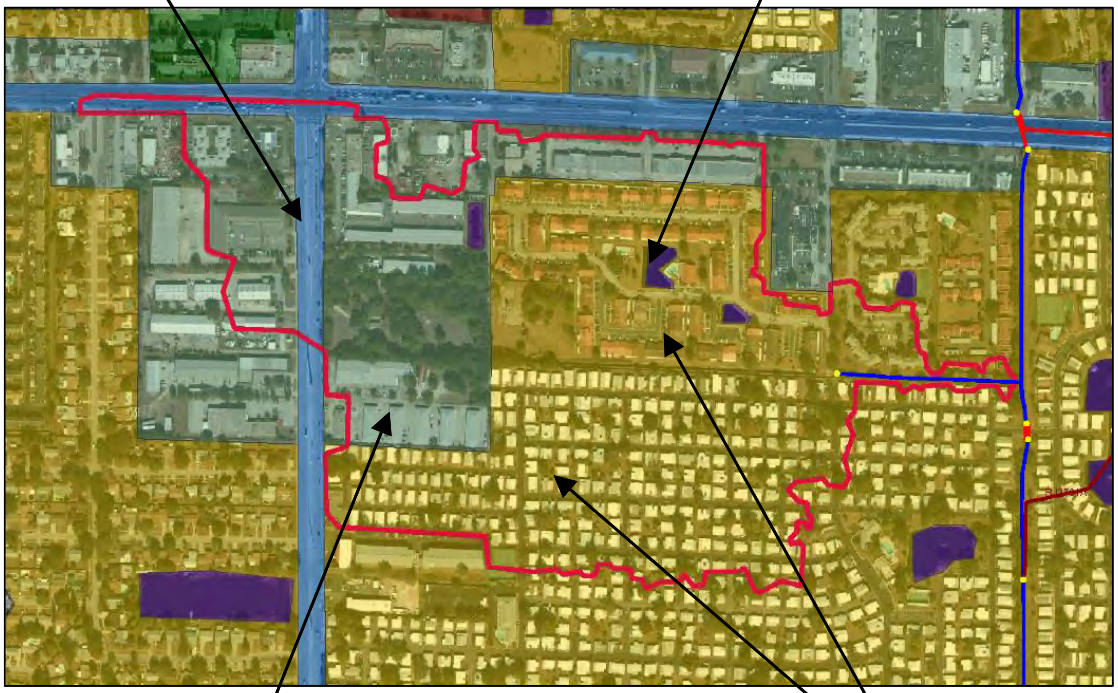


CROP ZONES (ET)

1,413 ac – 58 BASINS – 75 NODES – 176 LINKS

8100:TRANS
TN: 1.52
TP: 0.20

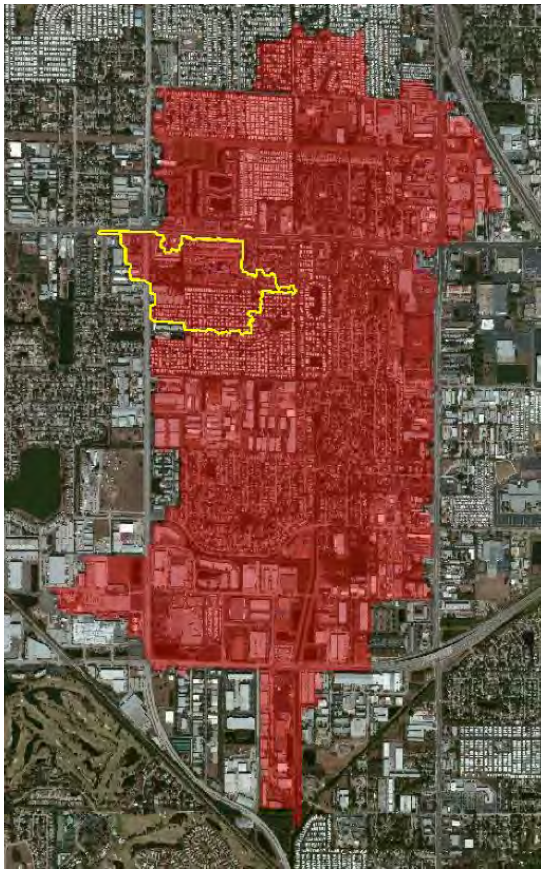
5300:WTR
TN: 0.00
TP: 0.00



1400: COM
TN: 2.40
TP: 0.35

1300: HDR
TN: 2.32
TP: 0.52

EMCs by LAND USE (mg/l)



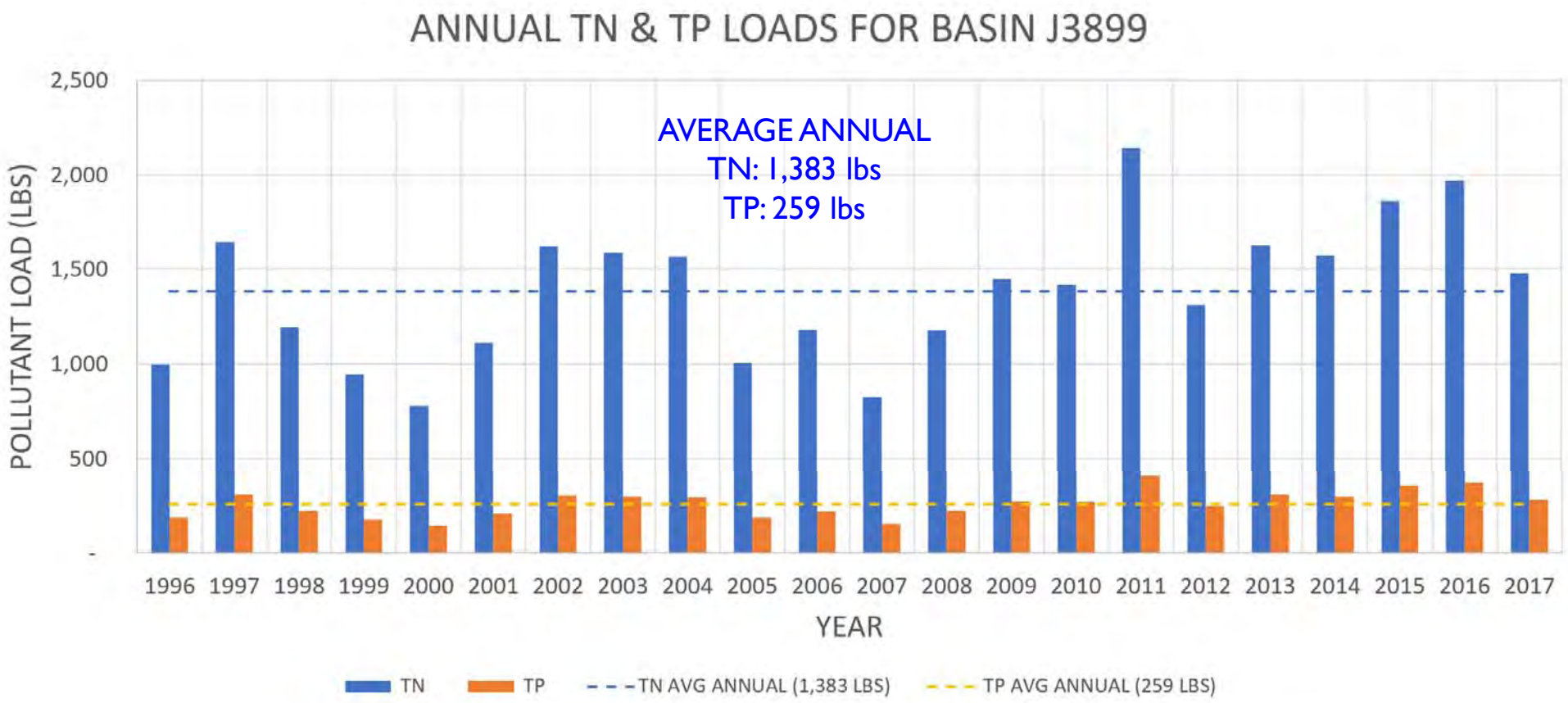
INTERSECTION of MAP LAYERS by BASIN AUTOMATED in ICPR

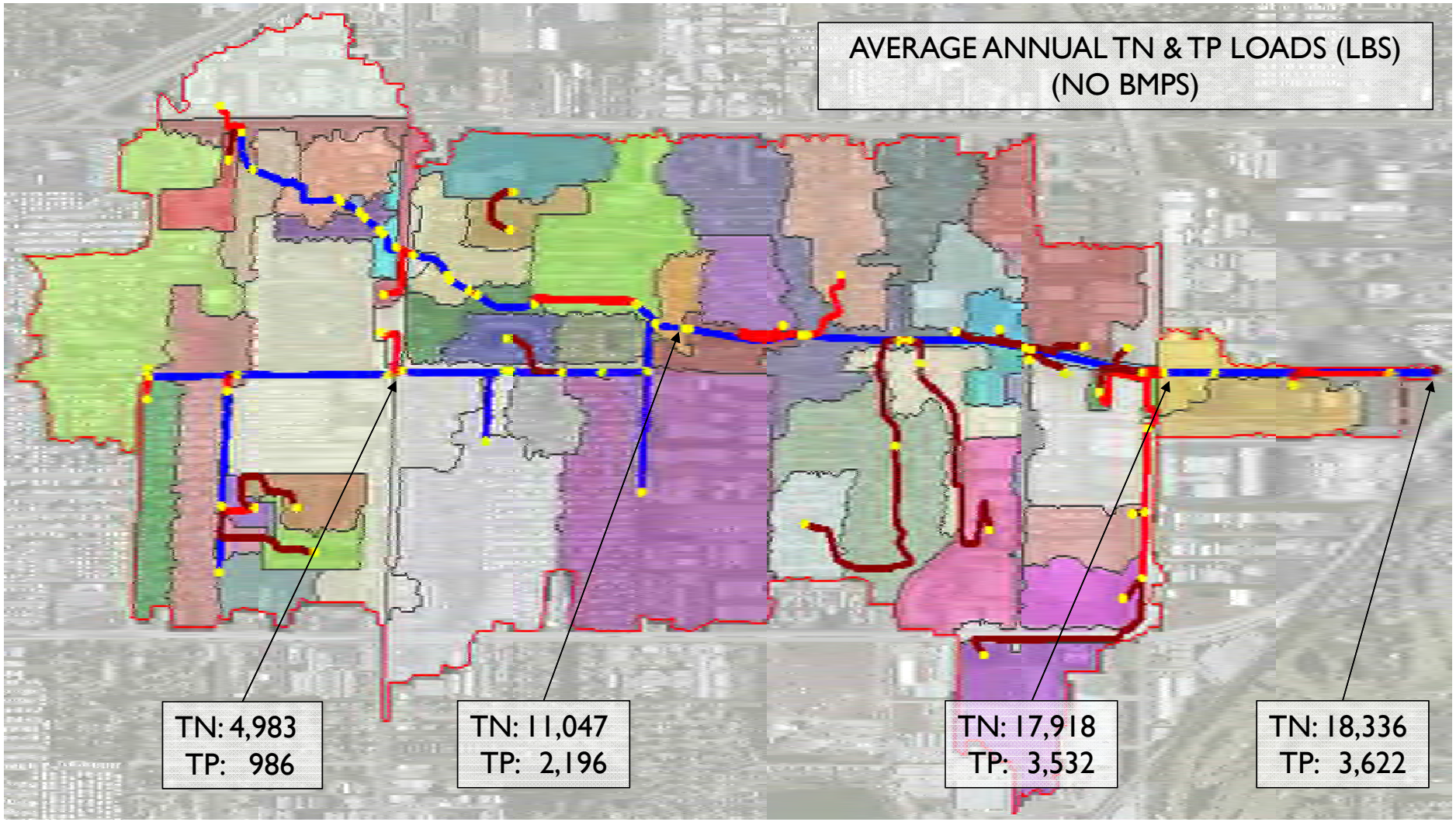
(DISTRIBUTED HYDROLOGY APPROACH)

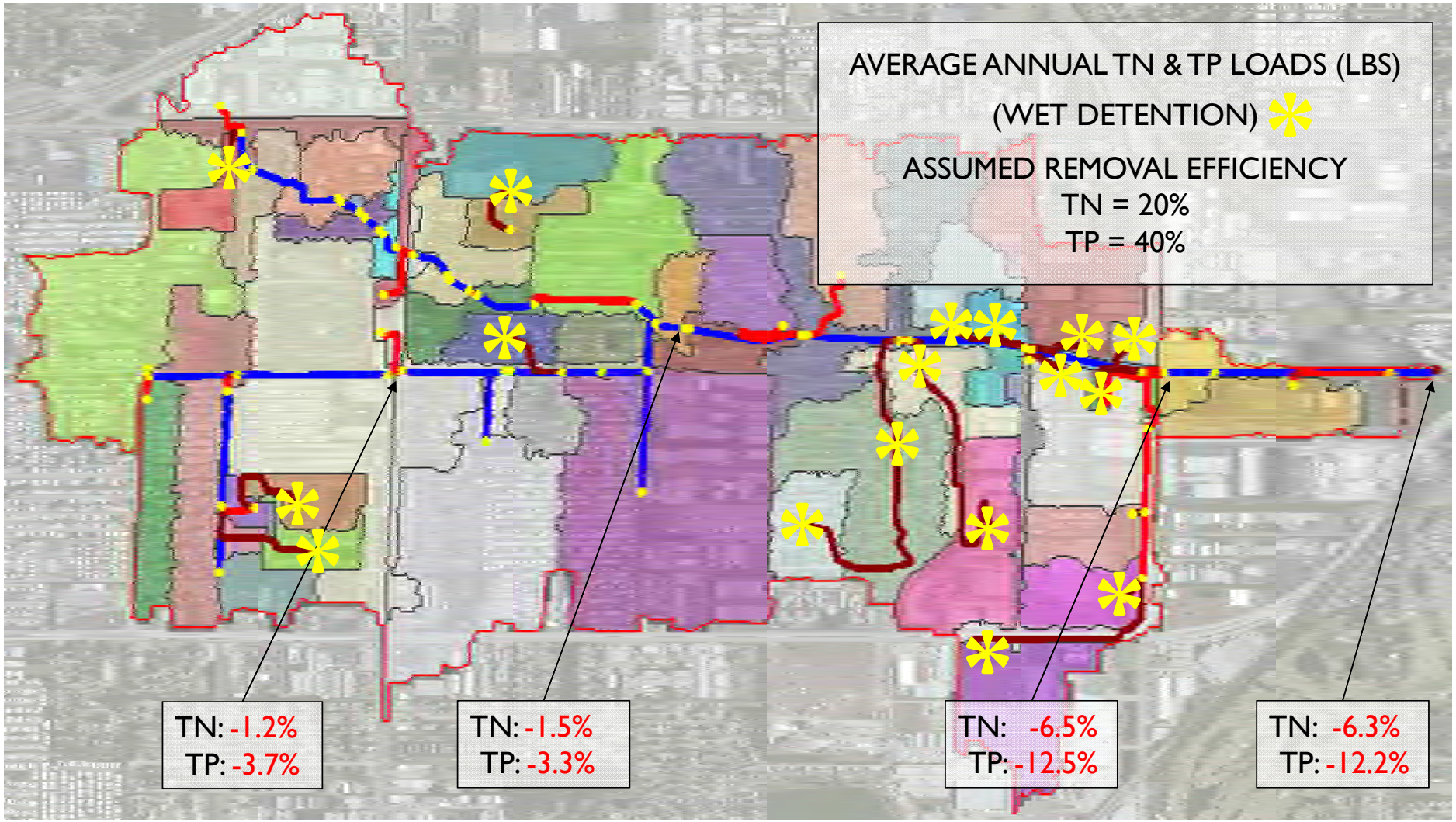
Manual Basin Sub-Basin Edit

Area	Land Cover Zone	Soil Zone	Rainfall Name	Crop Coefficient Zone	Reference ET Station
47.435698	1300	1017108	96521	Grass (Developed)	96521
15.754178	1400	1017108	96521	Grass (Developed)	96521
9.51095	1400	1017097	96521	Grass (Developed)	96521
2.218182	1300	1017097	96521	Grass (Developed)	96521
0.204545	8100	1017097	96521	Grass (Developed)	96521
3.472291	8100	1017108	96521	Grass (Developed)	96521
0.140932	1300	1017108	96521	Water	96521
0.451905	5300	1017108	96521	Water	96521
0.002732	5300	1017108	96521	Grass (Developed)	96521
1.540634	1400	1017089	96521	Grass (Developed)	96521
1.573646	1300	1017083	96521	Grass (Developed)	96521
0.013958	1300	1017083	96521	Water	96521
0.226882	5300	1017089	96521	Water	96521
0.003604	5300	1017089	96521	Grass (Developed)	96521
0.003581	1400	1017089	96521	Water	96521
0.000551	5300	1017083	96521	Water	96521
0.005969	1300	1017089	96521	Grass (Developed)	96521
0.080854	1400	1017083	96521	Grass (Developed)	96521

CONTINUOUS SIMULATION (1996 – 2017)







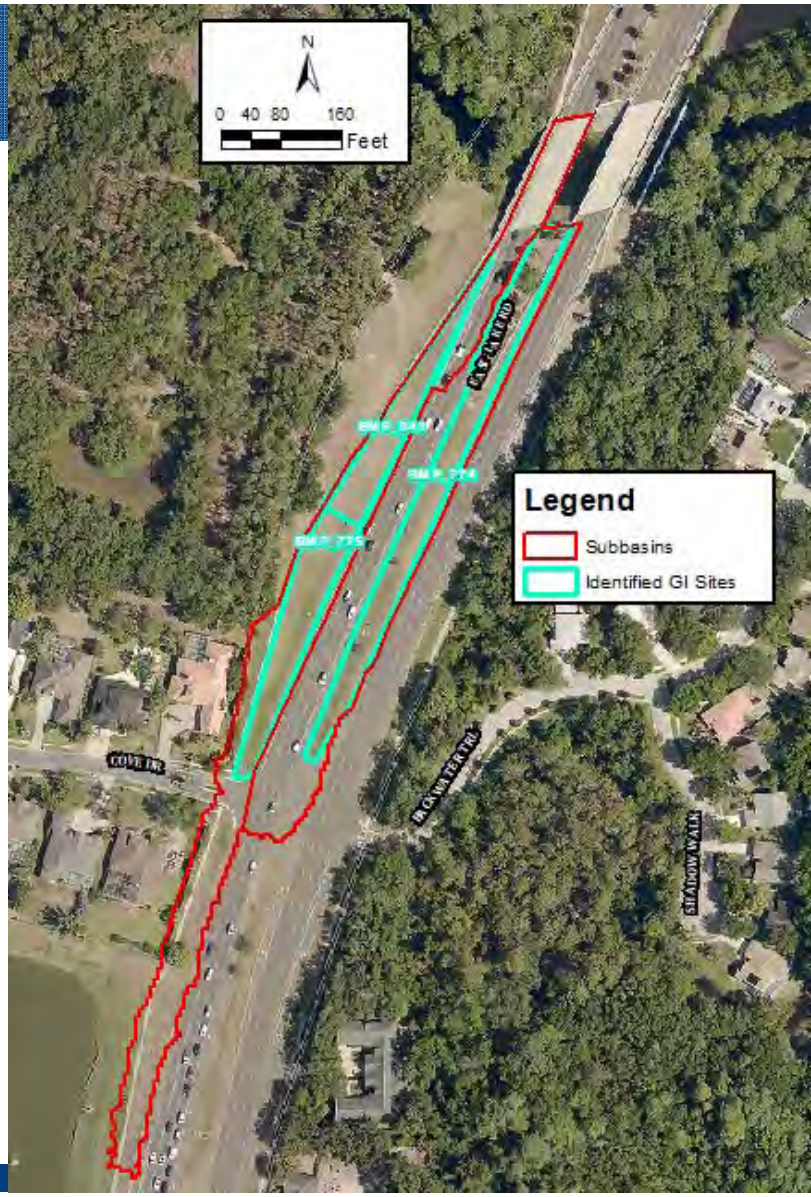
WQ MODULE STATUS

- Mathematical Algorithms Completed
  - ✓ 1D & 2D
  - ✓ BETA Testing Underway
- Working on User Interface
  - ✓ Input Forms
  - ✓ Reports
  - ✓ Charts
  - ✓ Animations
- ICPR Expert Required
- Hope to Release by 2nd Quarter 2020

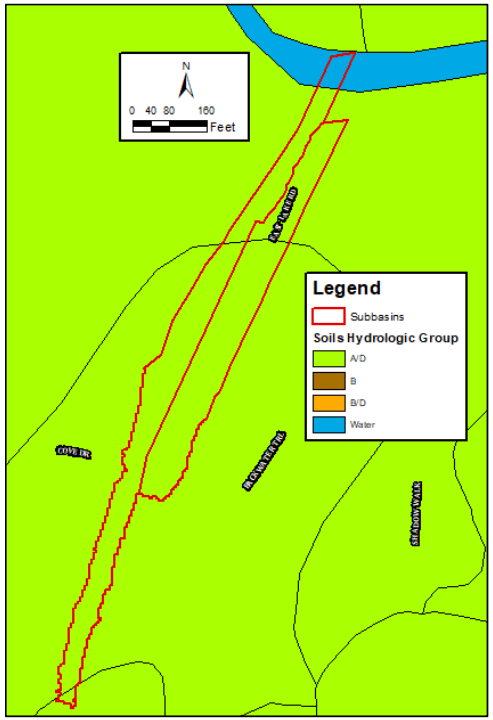
GI Project Example

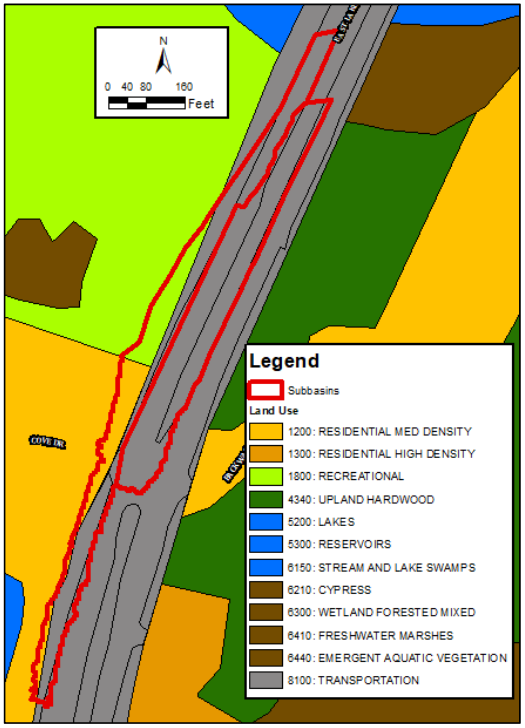
Identified Potential GI sites

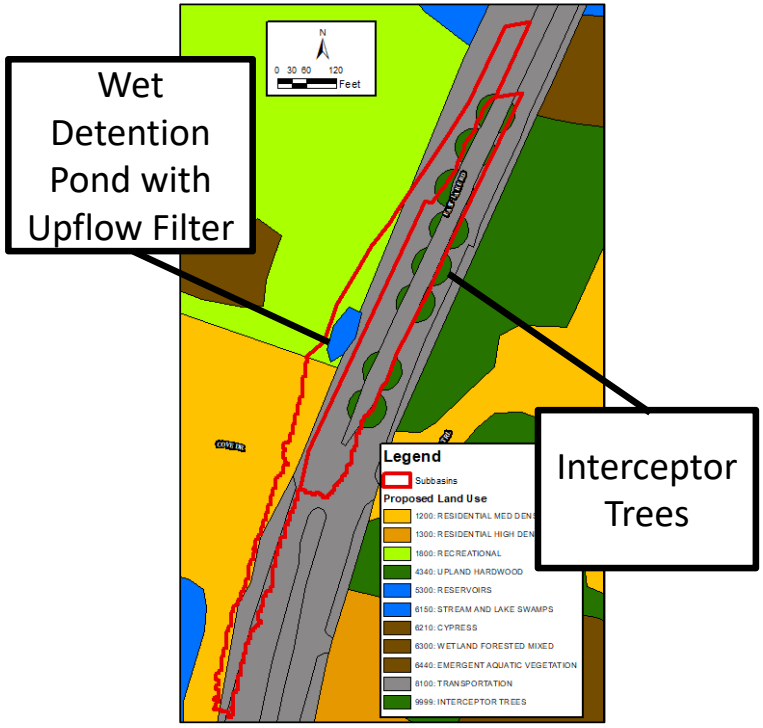
- Based on County Owned and/or maintained property
- Intended to focus on small/medium scale projects
- Ranked based on number of spatial factors
  - % impervious
  - Soils
  - Land use ~ pollution generation potential
  - Proximity to contaminated sites
  - More…
- Sites shown ranked in top 15



Identified Potential GI Sites - Characteristics







Soils:

- Impact runoff potential
- Impact BMP selection
- All A/D soils (No infiltration BMPs)

Existing Landuse:

- Transportation
- Medium Density Residential
- Recreational

Proposed Landuse adds:

- Wet Detention Pond
- Interceptor Trees
  - Result in an increase in initial abstraction for areas of canopy that cover impervious surfaces

Evaluation of Water Quality Performance Using ICPR v.4

- Water quality analysis requires continuous simulation model
  - Need hourly rainfall data for more than 10 years (preferably 15 years or more) – NOAA
    - Capture temporal variability of rainfall conditions
    - Determine average annual performance
  - Need ET data (per day) – USGS

PINELLAS_rainfall.txt - Notepad

File Edit Format View Help

```
0
60
2006    1       1       9       0.01
2006    1       2       15      0.01
2006    1       3       13      0.09
2006    1       5       7       0.01
2006    1       12      9       0.01
2006    1       13      13      0.01
2006    1       14      4       0.01
2006    1       18      3       0.1
2006    1       18      6       0.01
2006    1       18      7       0.04
2006    1       18      8       0.01
```

Rainfall CSV file

PINELLAS_ET.txt - Notepad

File Edit Format View Help

```
4
1995    6       1       12      0.28358283
1995    6       2       12      0.05759846
1995    6       3       12      0.07039374
1995    6       4       12      0.06984256
1995    6       5       12      0.22724422
1995    6       6       12      0.24818911
1995    6       7       12      0.23192926
1995    6       8       12      0.26405526
1995    6       9       12      0.25964581
1995    6       10      12      0.22598437
1995    6       11      12      0.19153554
1995    6       12      12      0.20787413
```

ET CSV file

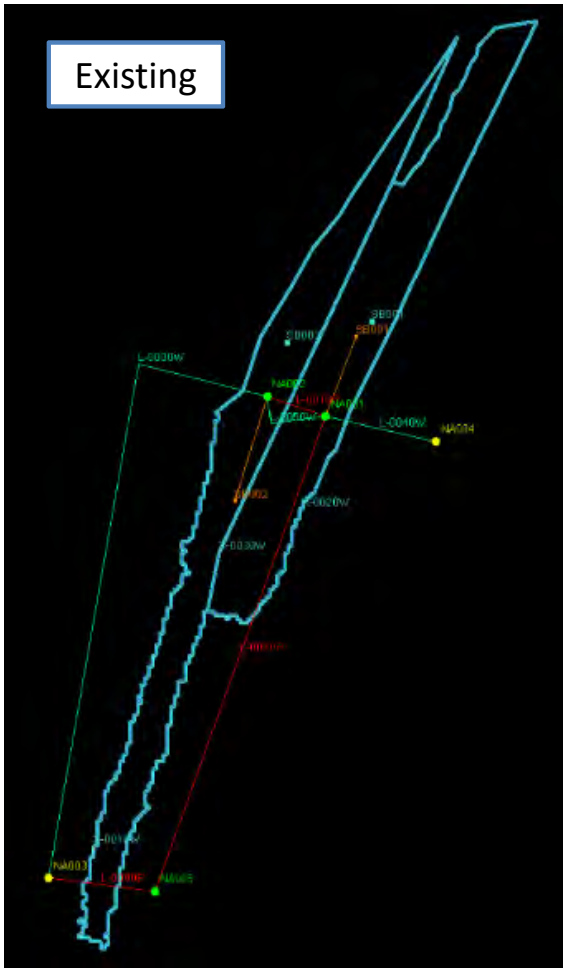
- Develop EMC table
  - Relates FLUCFCS to land use specific EMCs (based on Harper & Baker, 2011)
  - Can evaluate any water quality parameters
    - Intended for TN and TP
    - Other parameters removal must be consistent with TN and TP, i.e., follow same removal mechanisms and characteristics
  - Need to set default value
    - To provide EMC for FLUCCS codes not included in table
  - Need to set irreducible concentration for parameters
    - To account for minimum concentrations that BMPs are unable to reduce a contaminate below
    - If a removal efficiency provided by a BMP will reduce the concentration below this value, the model will default to this concentration rather than report removals that are not realistic

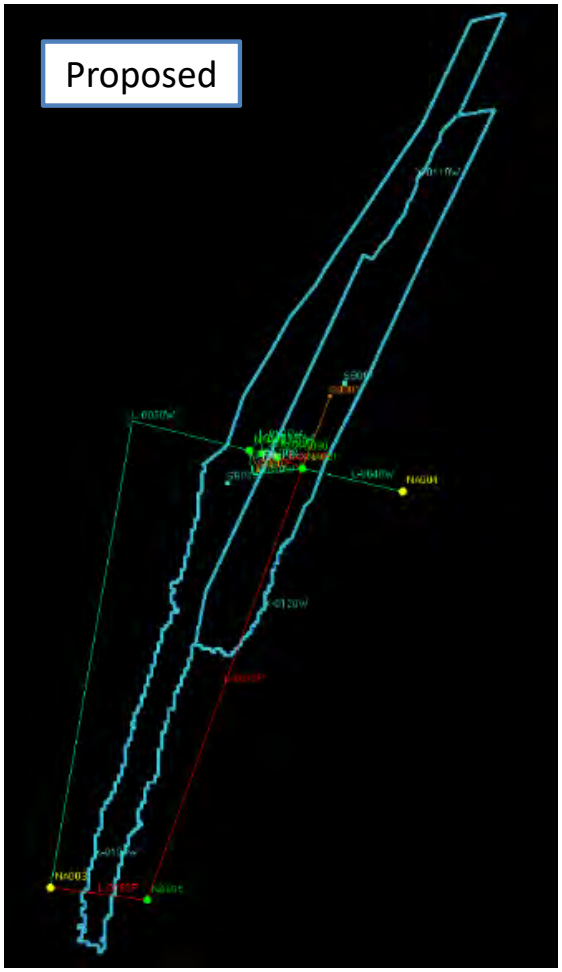
EMC table

	A	B	C
1	landuse	TN	TP
2	default	1	0.25
3	irreducible	0.2	0.01
4	1200	2.07	0.327
5	1800	2.07	0.327
6	8100	1.52	0.2
7			

Build Existing and Proposed Conditions Models

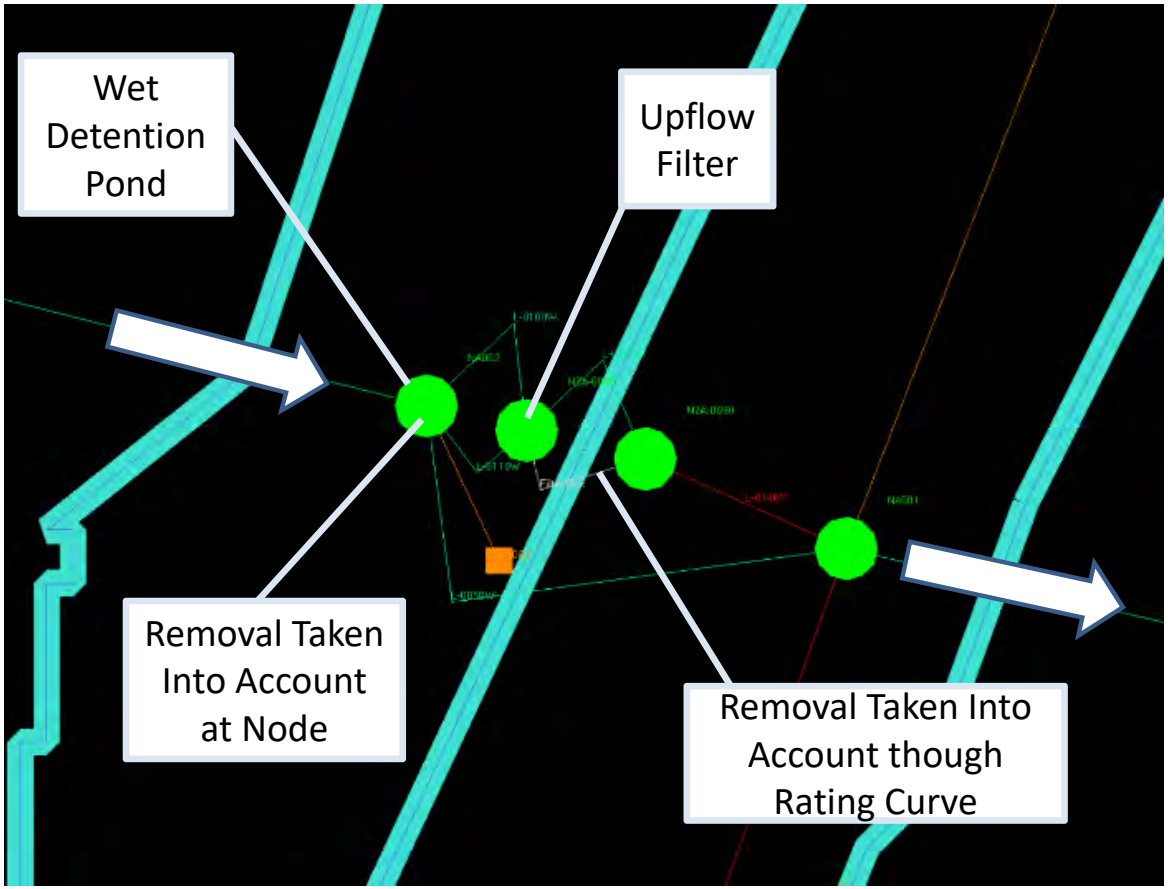
- Develop node/link networks
- Determine contributing areas
  - May be different existing to proposed
- Determine Green-Ampt parameters
  - CN method not appropriate for WQ analysis since it doesn't allow for tracking of soil storage





Build Proposed Conditions Model

- Proposed GI BMPs
  - Wet Detention Pond with Upflow Filter
    - Pond pollutant removal addressed in node
    - Upflow Filter pollutant removal addressed in rating curve
  - Interceptor Trees
    - Increase in initial abstraction applied in hydrology model for areas of canopy that cover impervious surfaces
  - Model tracks input and output loading from hydrology and through the network at each time step



Run Model and Evaluate Results

- CSV output
  - "TN_out_removed_nodes_lb" provides the cumulative TN mass that was removed due to node based BMPs
    - Note that this is the cumulative removal due to all node based BMPs
  - "TN_out_removed_links_lb" provides the cumulative TN mass that was removed due to link based BMPs
    - Note that this is the cumulative removal due to all link based BMPs

	time	TN_stored_lb	TN_out_removed_nodes_lb	TN_out_removed_links_lb	TN_in_irreducible_lb	TN_in_basin_lb	TN_in_boundary_lb	TN_out_boundary_lb	TN_in_other_lb	TN_out_other_lb
474	121472	0.83262	128.24788	156.914456	2.581526	665.469007	0	367.463322	0	14.603756
475	121473	0.83236	128.24788	156.914603	2.581526	665.469007	0	367.46343	0	14.603756
476	121474	0.8321	128.24788	156.914693	2.581526	665.469007	0	367.463537	0	14.603756
477	121475	0.83207	128.24788	156.914693	2.581526	665.469007	0	367.463636	0	14.603756
478	121476	0.83189	128.24788	156.914771	2.581526	665.469007	0	367.463737	0	14.603756
479	121477	0.83170	128.24788	156.914863	2.581527	665.469007	0	367.46383	0	14.603756
480	121478	0.83156	128.24788	156.914914	2.581527	665.469007	0	367.463918	0	14.603756
481	121479	0.83141	128.24788	156.914985	2.581527	665.469007	0	367.464005	0	14.603756
482	121480	0.83130	128.24788	156.915004	2.581527	665.469007	0	367.46409	0	14.603756
483	121481	0.83114	128.24788	156.915087	2.581528	665.469007	0	367.464171	0	14.603756
484	121482	0.83103	128.24788	156.915116	2.581528	665.469007	0	367.464248	0	14.603756
485	121483	0.83091	128.24788	156.915165	2.581528	665.469007	0	367.464322	0	14.603756
486	121484	0.83081	128.24788	156.915196	2.581528	665.469007	0	367.464393	0	14.603756
487	121485	0.8306	128.24788	156.915329	2.581529	665.469007	0	367.464463	0	14.603756
488	121486	0.83054	128.24788	156.915329	2.581529	665.469007	0	367.464532	0	14.603756
489	121487	0.83047	128.24788	156.915329	2.581529	665.469007	0	367.464596	0	14.603756
490	121488	0.83038	128.24788	156.915362	2.581529	665.469007	0	367.464659	0	14.603756
491	121489	0.83020	128.24788	156.915476	2.581529	665.469007	0	367.464719	0	14.603756
492	121490	0.83014	128.24788	156.915476	2.581529	665.469007	0	367.464779	0	14.603756
493	121491	0.83009	128.24788	156.915476	2.581529	665.469007	0	367.464837	0	14.603756
494	121492	0.82995	128.24788	156.915558	2.58153	665.469007	0	367.464892	0	14.603756
495	121493	0.82989	128.24788	156.915558	2.58153	665.469007	0	367.464946	0	14.603756
496	121494	0.82983	128.24788	156.915574	2.58153	665.469007	0	367.464997	0	14.603756
497	121495	0.82974	128.24788	156.915611	2.58153	665.469007	0	367.465047	0	14.603756
498	121496	0.82961	128.24788	156.915691	2.58153	665.469007	0	367.465094	0	14.603756
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505	121503	0.82920	128.24788	156.915805	2.581531	665.469007	0	367.465394	0	14.603756
506	121504	0.82913	128.24788	156.915835	2.581531	665.469007	0	367.465432	0	14.603756
507	121505	0.82910	128.24788	156.915835	2.581531	665.469007	0	367.465469	0	14.603756
508	121506	0.82900	128.24788	156.915898	2.581531	665.469007	0	367.465505	0	14.603756
509	121507	0.82896	128.24788	156.915898	2.581531	665.469007	0	367.46554	0	14.603756
510	121508	0.82892	128.24788	156.915902	2.581531	665.469007	0	367.465575	0	14.603756
511	121509	0.82886	128.24788	156.915931	2.581531	665.469007	0	367.465608	0	14.603756
512	121510	0.82883	128.24788	156.915931	2.581531	665.469007	0	367.46564	0	14.603756
513	121511	0.82874	128.24788	156.915985	2.581531	665.469007	0	367.465672	0	14.603756
514	121512	0.82871	128.24788	156.915985	2.581531	665.469007	0	367.465704	0	14.603756
515	121513	0.82868	128.24788	156.915985	2.581531	665.469007	0	367.465735	0	14.603756
516	121514	0.82831	128.24788	156.916326	2.581531	665.469007	0	367.465764	0	14.603756
517	121515	0.82828	128.24788	156.916326	2.581531	665.469007	0	367.465793	0	14.603756
518	121516	0.82825	128.24788	156.916326	2.581531	665.469007	0	367.465821	0	14.603756
519	121517	0.82823	128.24788	156.916326	2.581531	665.469007	0	367.465847	0	14.603756
520	121518	0.82820	128.24788	156.916326	2.581531	665.469007	0	367.465873	0	14.603756
521	121519	0.8281	128.24788	156.916326	2.581531	665.469007	0	367.465899	0	14.603756
522	121520	0.82815	128.24788	156.916326	2.581531	665.469007	0	367.465924	0	14.603756
523	121521	0.82813	128.24788	156.916326	2.581531	665.469007	0	367.465949	0	14.603756
524	121522	0.82810	128.24788	156.916326	2.581531	665.469007	0	367.465972	0	14.603756
525	121523	0.828084	128.24788	156.916326	2.581531	665.469007	0	367.465996	0	14.603756

Run Model and Evaluate Results

- CSV output
  - "TN_in_irreducible_lb" provides the minimum TN mass that can be present for the given timestep
  - "TN_in_basin_lb" provides a cumulative TN that entered the basin
  - "TN_out_boundary_lb" provides the cumulative TN removed via the BMPs
    - Note this is due to the cumulative effect of all BMPs, not for each.
  - Based on this, **total TN removal = 21.3 lb/yr** (45% removal) on an average annual basis

	time	TN_stored_lb	TN_out_removed_nodes_lb	TN_out_removed_links_lb	TN_in_irreducible_lb	TN_in_basin_lb	TN_in_boundary_lb	TN_out_boundary_lb	TN_in_other_lb	TN_out_other_lb
474	121472	0.832622	128.247885	156.914456	2.581526	665.469007		367.463322	0	14.603756
475	121473	0.832367	128.247885	156.914603	2.581526	665.469007		367.46343	0	14.603756
476	121474	0.83217	128.247885	156.914693	2.581526	665.469007		367.463537	0	14.603756
477	121475	0.832071	128.247885	156.914693	2.581526	665.469007		367.463636	0	14.603756
478	121476	0.831892	128.247885	156.914771	2.581526	665.469007		367.463737	0	14.603756
479	121477	0.831708	128.247885	156.914863	2.581527	665.469007		367.46383	0	14.603756
480	121478	0.831569	128.247885	156.914914	2.581527	665.469007		367.463918	0	14.603756
481	121479	0.831411	128.247885	156.914985	2.581527	665.469007		367.464005	0	14.603756
482	121480	0.831307	128.247885	156.915004	2.581527	665.469007		367.46409	0	14.603756
483	121481	0.831144	128.247885	156.915087	2.581528	665.469007		367.464171	0	14.603756
484	121482	0.831037	128.247885	156.915116	2.581528	665.469007		367.464248	0	14.603756
485	121483	0.830916	128.247885	156.915165	2.581528	665.469007		367.464322	0	14.603756
486	121484	0.830813	128.247885	156.915196	2.581528	665.469007		367.464393	0	14.603756
487	121485	0.83061	128.247885	156.915329	2.581529	665.469007		367.464463	0	14.603756
488	121486	0.830542	128.247885	156.915329	2.581529	665.469007		367.464532	0	14.603756
489	121487	0.830478	128.247885	156.915329	2.581529	665.469007		367.464596	0	14.603756
490	121488	0.830383	128.247885	156.915362	2.581529	665.469007		367.464659	0	14.603756
491	121489	0.830209	128.247885	156.915476	2.581529	665.469007		367.464719	0	14.603756
492	121490	0.830149	128.247885	156.915476	2.581529	665.469007		367.464779	0	14.603756
493	121491	0.830091	128.247885	156.915476	2.581529	665.469007		367.464837	0	14.603756
494	121492	0.829953	128.247885	156.915558	2.58153	665.469007		367.464892	0	14.603756
495	121493	0.829899	128.247885	156.915558	2.58153	665.469007		367.464946	0	14.603756
496	121494	0.829832	128.247885	156.915574	2.58153	665.469007		367.464997	0	14.603756
497	121495	0.829746	128.247885	156.915611	2.58153	665.469007		367.465047	0	14.603756
498	121496	0.829619	128.247885	156.915691	2.58153	665.469007		367.465094	0	14.603756
499	121497	0.829573	128.247885	156.915691	2.58153	665.469007		367.465141	0	14.603756
500	121498	0.829526	128.247885	156.915691	2.58153	665.469007		367.465188	0	14.603756
501	121499	0.829369	128.247885	156.915805	2.58153	665.469007		367.465231	0	14.603756
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514	121512	0.828716	128.247885	156.915985	2.581531	665.469007		367.465704	0	14.603756
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517	121515	0.828286	128.247885	156.916326	2.581531	665.469007		367.465793	0	14.603756
518	121516	0.828259	128.247885	156.916326	2.581531	665.469007		367.465821	0	14.603756
519	121517	0.828232	128.247885	156.916326	2.581531	665.469007		367.465847	0	14.603756
520	121518	0.828206	128.247885	156.916326	2.581531	665.469007		367.465873	0	14.603756
521	121519	0.82818	128.247885	156.916326	2.581531	665.469007		367.465899	0	14.603756
522	121520	0.828155	128.247885	156.916326	2.581531	665.469007		367.465924	0	14.603756
523	121521	0.828131	128.247885	156.916326	2.581531	665.469007		367.465949	0	14.603756
524	121522	0.828107	128.247885	156.916326	2.581531	665.469007		367.465972	0	14.603756
525	121523	0.828084	128.247885	156.916326	2.581531	665.469007		367.465997	0	14.603756

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  - Mike Hardin – Project Manager
  - Max Wallace – Project Engineer
  - Nick Hartshorn, Dan Wen, Yungie Zhang – GI Modelers


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