SPATIAL WATERSHED ITERATIVE LOADING MODEL (SWIL)

APPLIED ECOLOGY, INC.

November 18, 2020 – Complete Version

PRESENTATION KEY TOPICS

- Introduction
- The evolution the Spatial Watershed Iterative Loading Model (SWIL)
- Model Inputs (Selected)
- Model Outputs
  - SWIL 3.0 – Official for TMDL development
  - Latest SWIL
- Model Calibration
- What's next?

INTRODUCTION

- A TMDL was issued by FDEP for the Indian River Lagoon (IRL) and Banana River Lagoon (BRL) on March 18, 2009
  - NIRL, CIRL, and BRL listed as impaired for nutrients and DO
  - Nutrients said to stimulate algae which clouded seagrass and reduced the extent of coverage
  - TMDL was established based on relationship between TN and TP loads and seagrass depth limits
  - TMDL includes loads in lbs/year **and** % reduction required in each WBID for TN/TP
- Watershed loadings were estimated by SJRWMD using:
  - Pollutant Loading Screening Model (PLSM) developed by SJRWMD for year 1999
  - Hydrologic Simulation Program Fortran (HSPF) for year 2000
  - PLSM provided better agreement and was selected
- Seagrass depth limits were developed using 1943-2001 series of photo-interpreted seagrass coverages

REFINING THE IRL TMDL: ORIGINAL GOALS

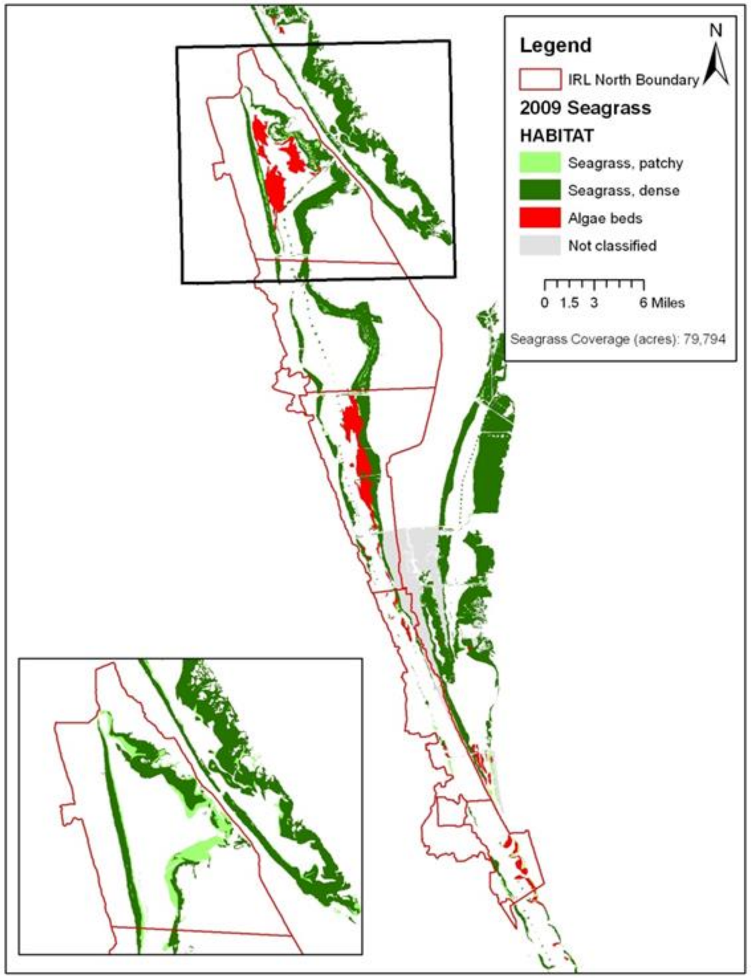
In 2011, to address stakeholder concerns, Brevard County with partners spearheaded a project to revise the TMDL to address the perceived deficiencies

Refinement of the TMDL included multiple steps:

- *Update input coverages and refine or develop the watershed loading model*
- Understand load-biological response relationships
- Provide new targets, based on the relationships established, if appropriate
- Pinpoint the total loads necessary to meet the desired target
- *Reallocate the loads, if necessary, using the developed watershed model*

WHAT IS THE SPATIAL WATERSHED ITERATIVE LOADING (SWIL) MODEL?

- Spatial Model (GIS platform)
- Iterative (many months at a time)
- Two Initial Goals:
  - Provide more accurate loads both temporally and spatially, critical to building relationships to biological responses
  - Allow flexibility for future allocation in an automated fashion



WATERSHED LOADING MODELS IN THE IRL

PLSM	SWIL
• One snapshot in time (1999/2000)	• Monthly 1995-2010 (since then expanded to 2017)
• Annual Volumes and Loads	• Monthly and annual #s
• Baseflow and Direct Runoff values are not segregated	• Segregates direct runoff and baseflow values
• 1999 land use and soils, ERP boundaries	• Updated land use, 2010 soils & treatments
• Mean annual rainfall	• Spatial mean per segment
• Impoundments = reduce rainfall	• Impoundments by location and management scheme
• Original EMCs and C values	• Updated EMCs and C values
• Treatments as one size fits all	• Wet versus dry treatments

SWIL 1

- July 2012
- Initial Effort

SWIL 2

- Completed April 2014
- Response to FDEP comments, EMC table, BMP efficiencies, Spoil Islands
- Improve Speed & Use

SWIL 3

- April 2015
- Improve Calibration (12 vs. 192 C)
- Updated ET Rasters
- Baseflow normalization process

SWIL 4A

- August 2015
- Ability to handle 3 model years
- Mosquito Lagoon & all Central IRL

SWIL 4B (5)

- March 2018
- Includes up to end of 2017
- Most of IRL

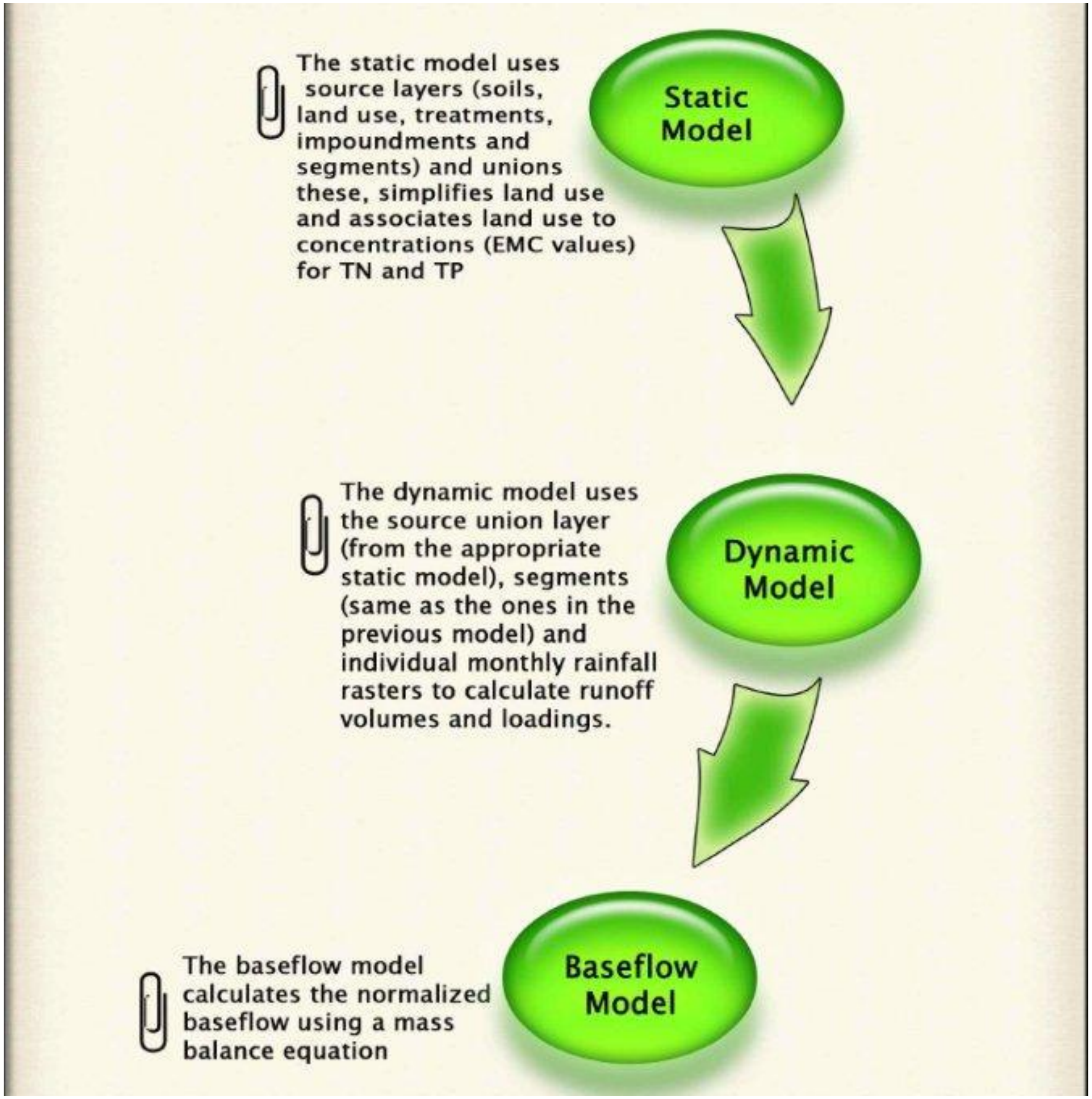
❖ SWIL 4A version in terms of spatial boundaries

❖ SWIL 4B in terms of temporal coverage

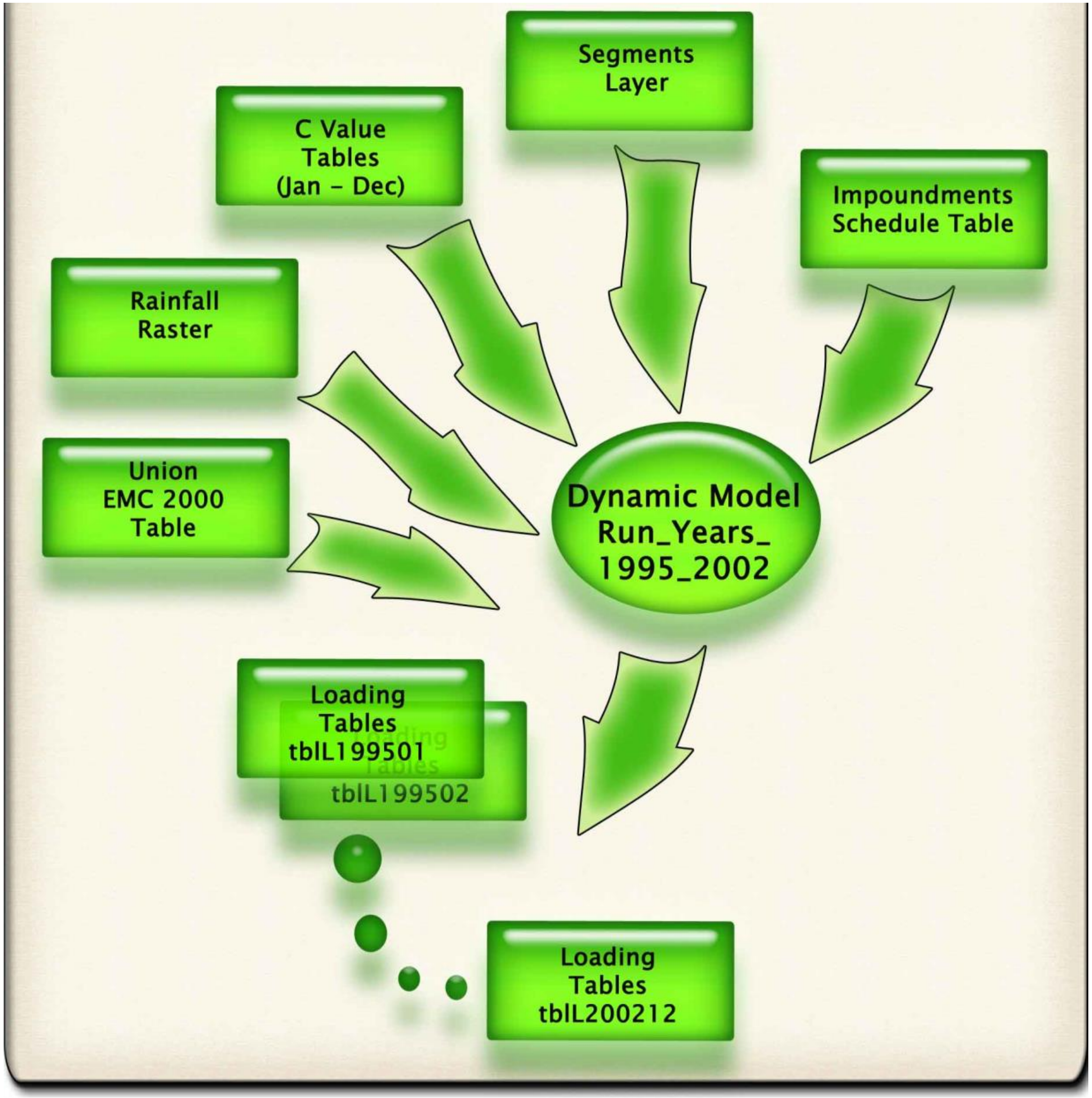
SWIL MODEL DEVELOPMENT

CONCEPTUAL IDEA AND MODEL INPUTS **FOR SWIL 3.0**

SWIL IN A NUTSHELL



STATIC PORTION



DYNAMIC: DIRECT RUNOFF

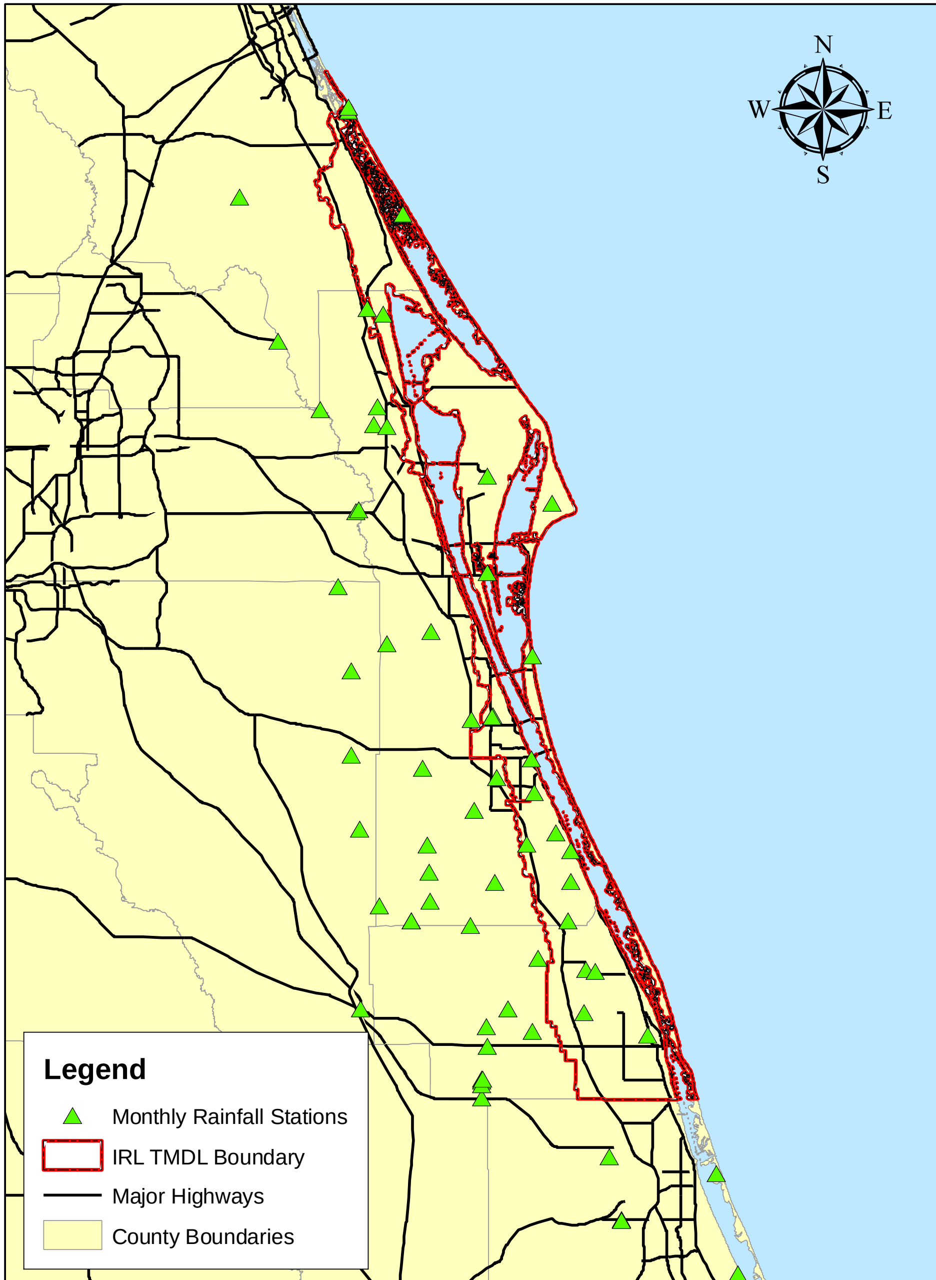
DYNAMIC: BASEFLOW

MODEL INPUTS

- Rainfall
- Evapotranspiration (ET)
- Soil Hydrologic Characteristics
- Land Use/Land Cover and hydrologic characteristics
- Runoff coefficients (C Values)
- Runoff EMC values
- Baseflow contribution (volumes and baseflow EMC)
- BMPs (treatment and efficiencies)
- Impoundments and management scheme
- Spoil islands

RAINFALL AND EVAPOTRANSPIRATION

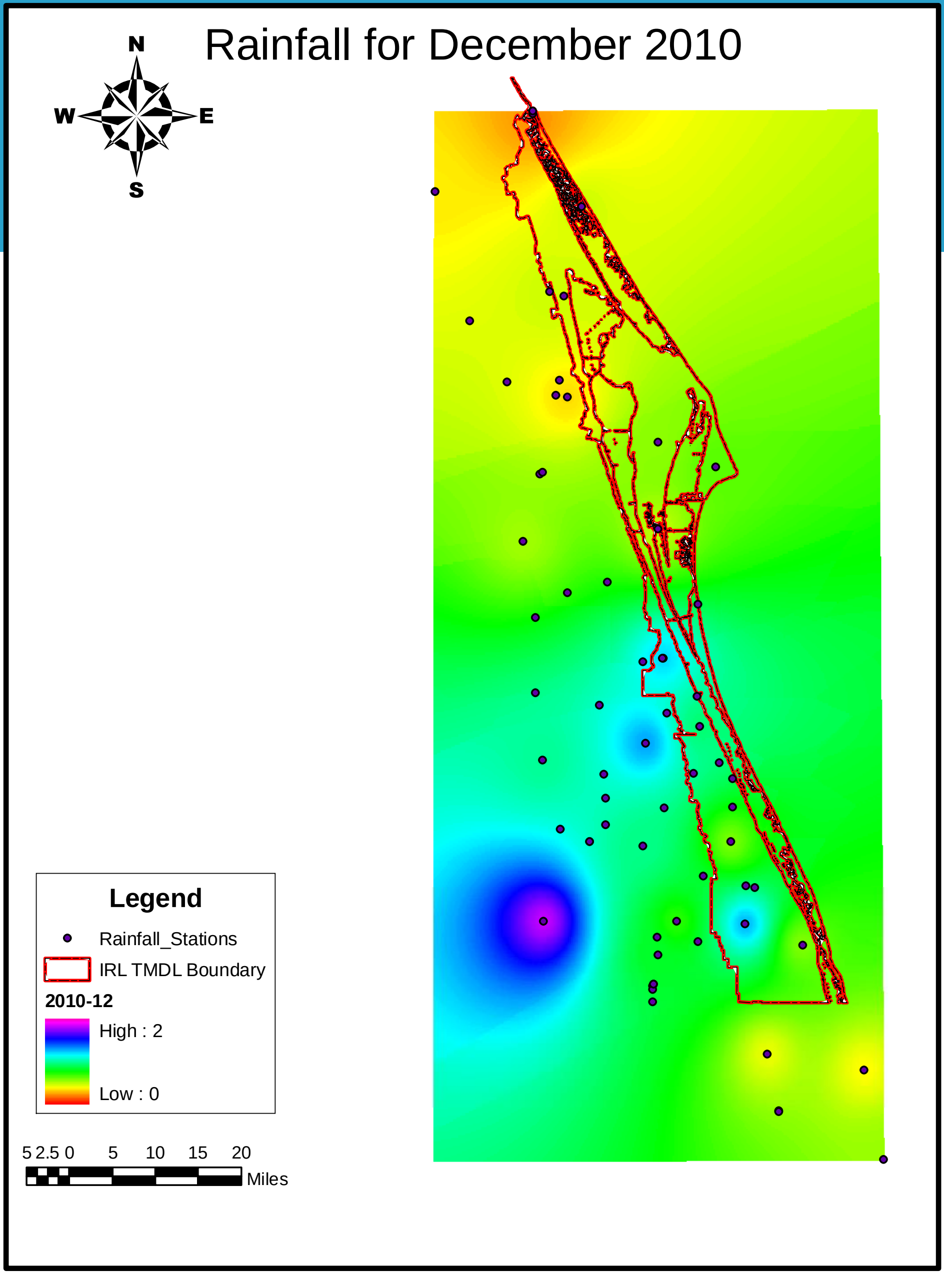
MODEL INPUTS FOR SWIL 3.0

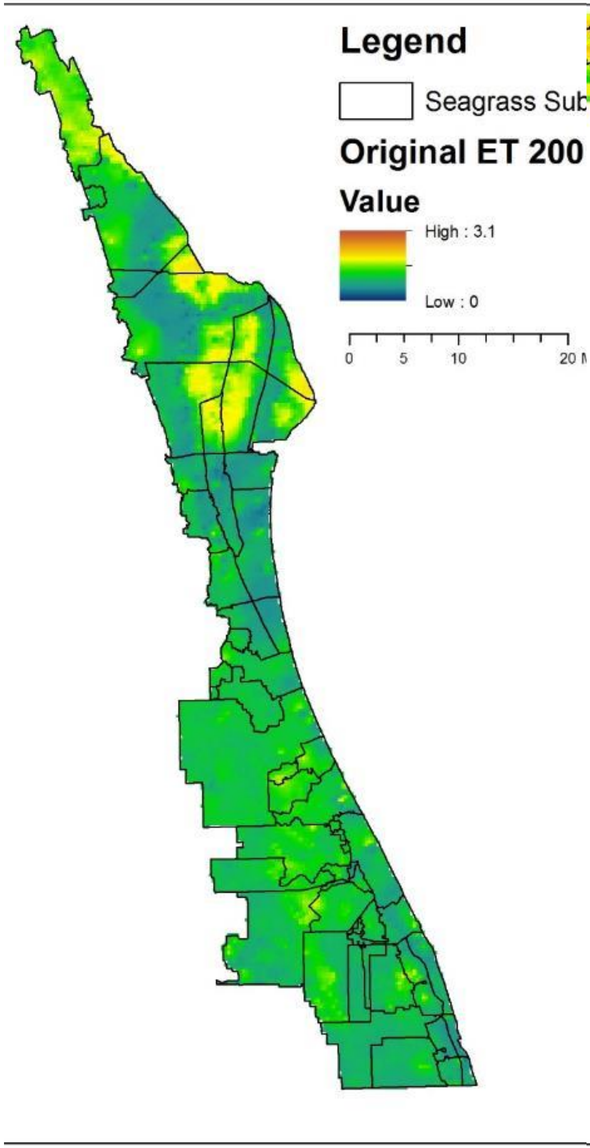


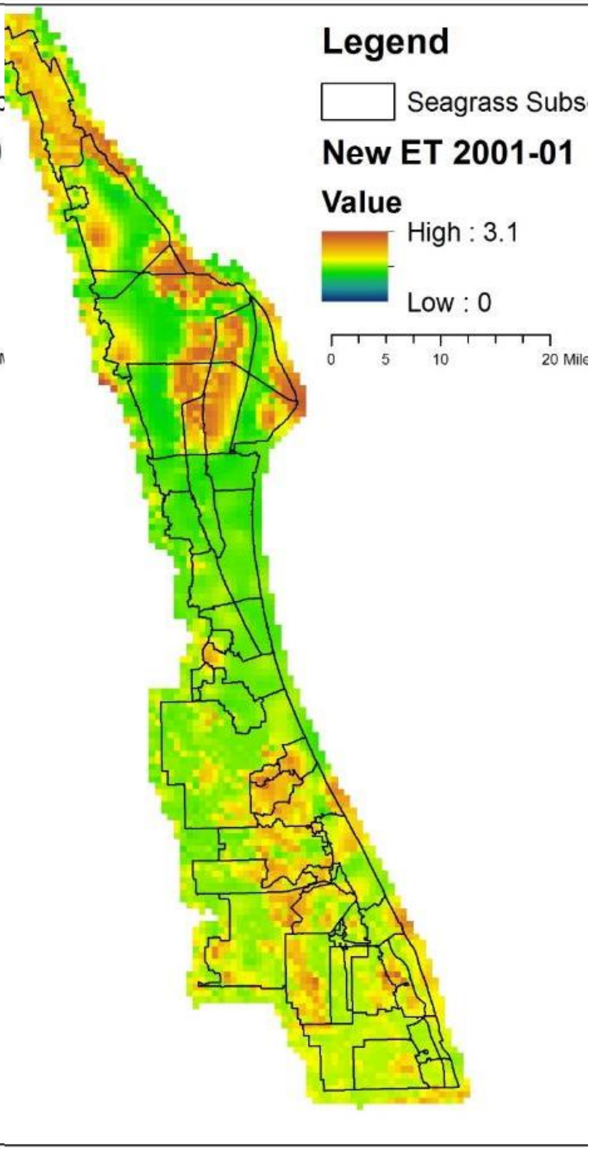
- 59 sites
- Period of record: 10 - >60 years
- Monthly rainfall data extracted from each site for period from 1995 – 2010 (16-year period)

EXAMPLE: RAINFALL

- PLSM model used an annual time step
- Revised model uses a monthly time step
- Developed rainfall isopleths and raster files for each month in the period from 1995 – 2010 (192 separate files)







Used Modis Satellite Data (MOD 16) product algorithm

Changed algorithm in 2014 to U. Montana

Model recalibrated due to higher ET

Monthly data available 2000-2014

Used average of POR ET by month for any others

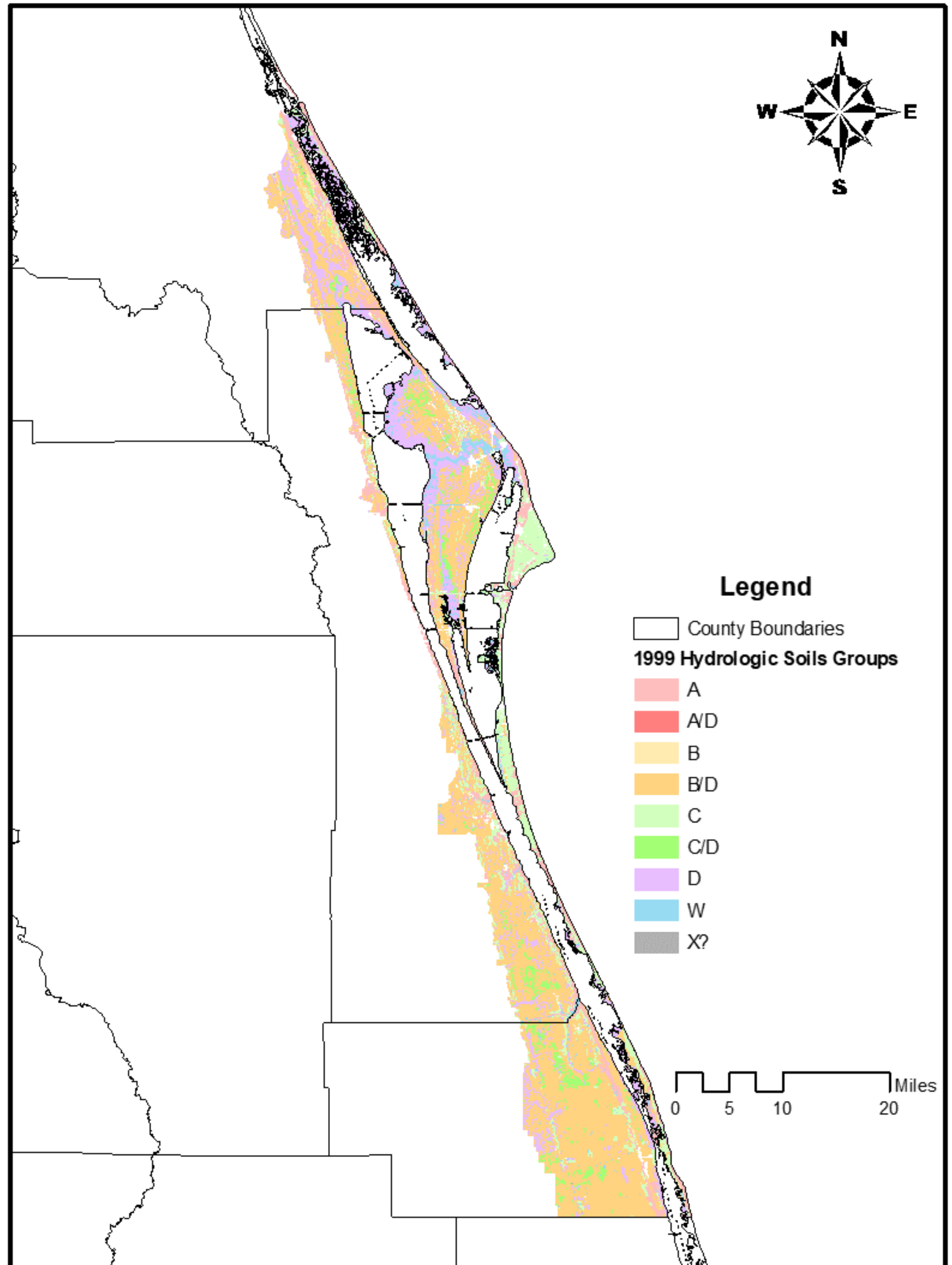
SOIL HYDROLOGIC GROUP

MODEL INPUTS FOR SWIL 3.0

1999 SOILS GROUPS

Problems:

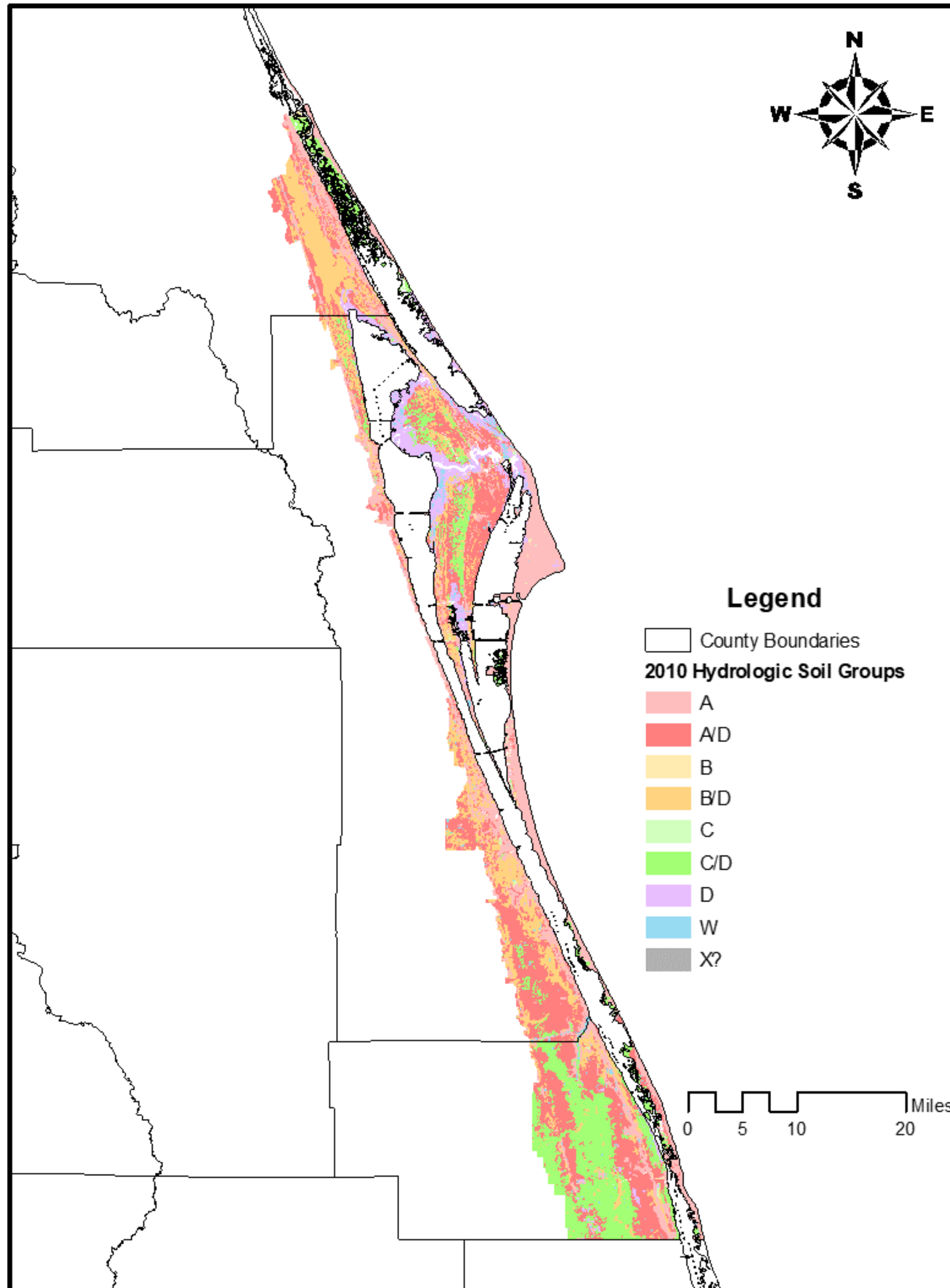
- Many areas appear to be incorrectly classified
- Barrier island areas classified as HSG C or D
- Large areas listed as "Urban" or "X" with no soil grouping



2010 SOILS GROUPS

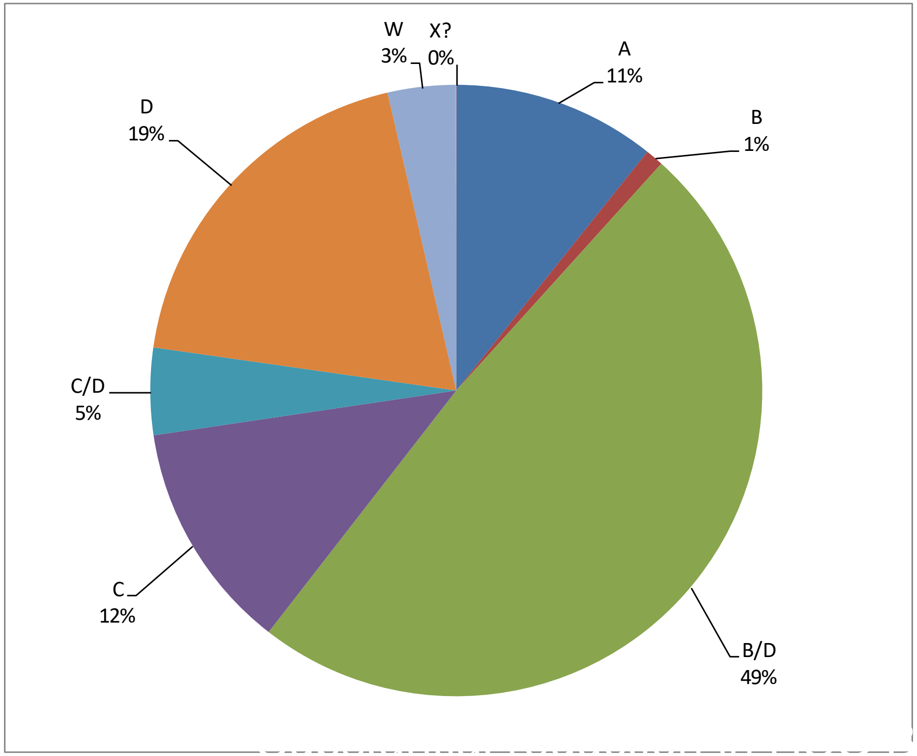
Improvements:

- Most incorrect classifications were corrected
- Still have urban areas with no soil grouping (blank)

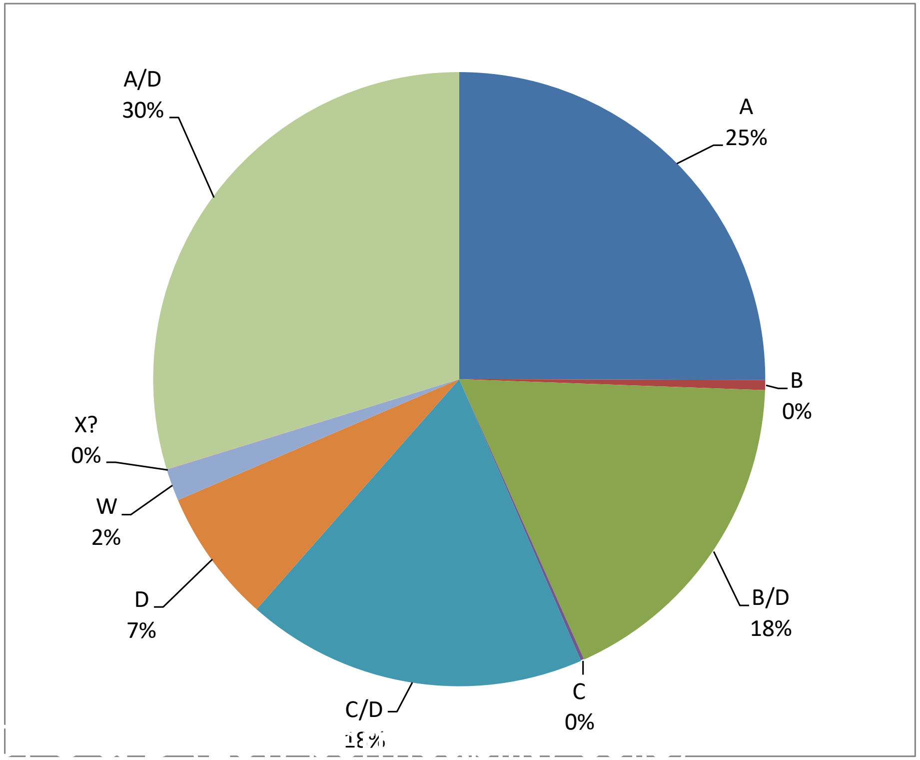


COMPARISON OF 1999 AND 2010 HYDROLOGIC SOIL GROUPINGS

1999

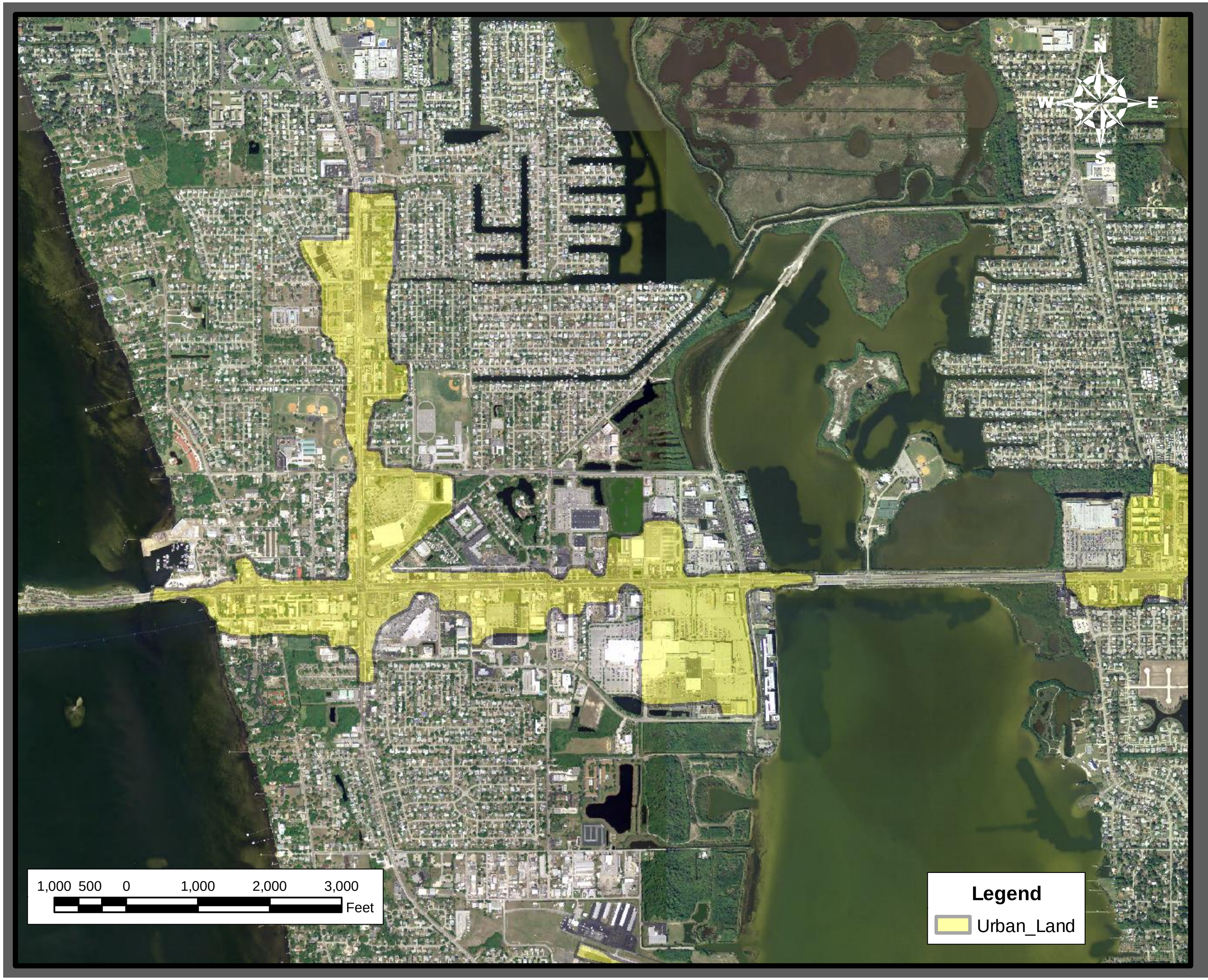


2010

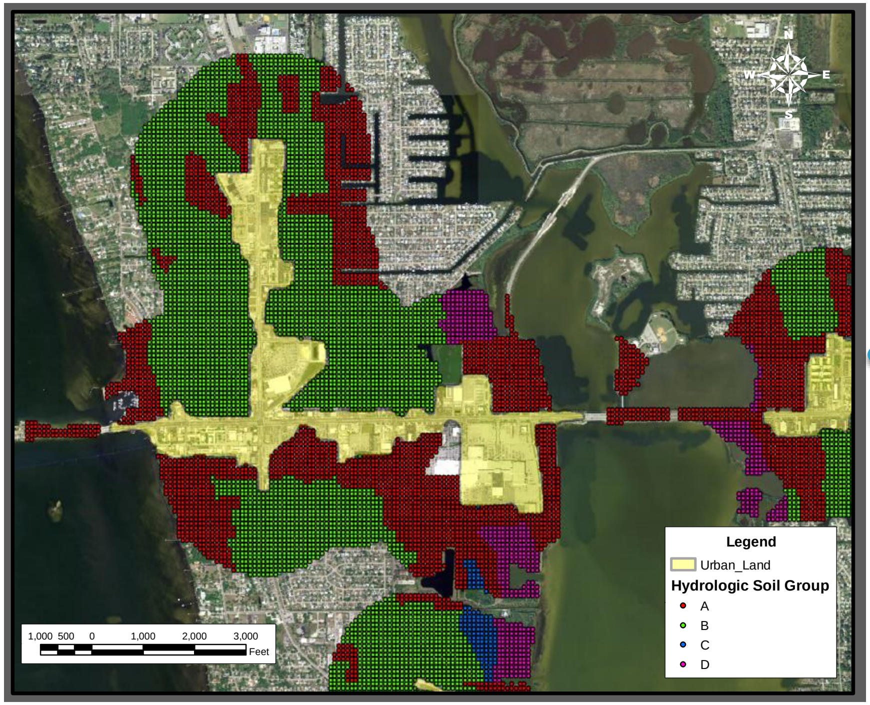


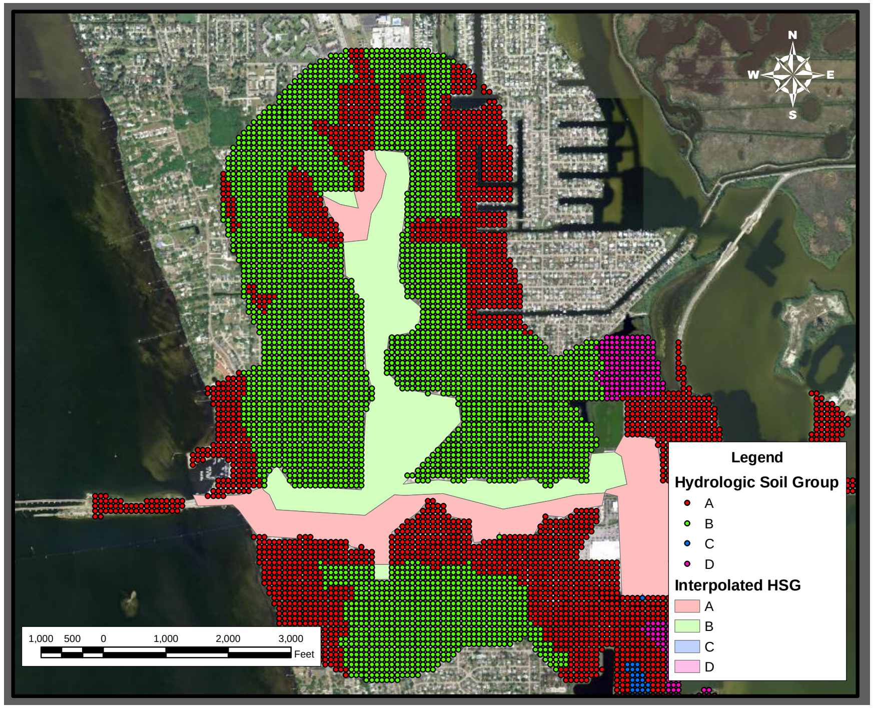
EXAMPLES OF URBAN SOILS

(~ 6% OF TOTAL)



SOIL HSG ESTIMATION METHODOLOGY





CONSOLIDATED IRL LAND USE SUMMARY

34% reduction in runoff volume from reclassification of the basin soil types

Land Use	Area (acres)	Curve Number 1999	Curve Number 2010
Agriculture	1,361	77.4	74.2
Citrus	30,305	77.0	76.3
Commercial	11,560	80.6	71.9
Dry Prairie	18,038	65.3	60.4
High Density Residential	14,543	70.3	60.8
Hydric Hammock	6,121	74.5	70.9
Industrial	4,728	70.8	59.9
Institutional	15,668	66.6	52.0
Low Density Residential	22,673	66.4	56.4
Medium Density Residential	47,106	69.9	58.4
Mesic Flatwoods	1,275	76.8	76.6
Mining	594	65.3	69.4
Open	11,603	73.5	66.3
Pasture	25,711	78.9	76.9
Recreational 1	5,566	71.4	61.5
Recreational 2	2,268	73.7	64.1
Row Crops	501	88.2	88.1
Ruderal	1,321	79.2	77.0
Scrub	36,697	65.2	58.9
Transportation	5,552	73.1	62.0
Upland Flatwoods	22,838	67.8	62.1
Upland Mixed	131	60.2	43.5
Water	16,921	98.0	98.0
Wet Flatwoods	23,243	74.0	70.4
Wet Prairies	6,407	72.6	75.8
Wetland	89,572	76.5	75.1
Xeric Hammock	7,795	63.5	37.8
Grand Total	**430,096**	**73.7**	**67.8**

LAND USE AND HYDROLOGIC CHARACTERISTICS

MODEL INPUTS FOR SWIL 3.0

LAND USE/LAND COVER DEVELOPMENT

- SWIL 3.0 was able to handle two model years (model swapped input static layers for the 1995-2010 run)
- Land use years selected were 2000 and 2004 originally
  - Year 2000: applied from January1995 - December 2002
  - Year 2004: applied from January 2003 – December 2010
- Land Use/Land Cover data sources:
  - Property Appraiser (PA) records converted to FLUCCS land cover values
  - In urban areas (residential, commercial, industrial, and institutional) PA data was used as priority
  - In natural areas within Brevard County, the Natural Communities Inventory was used
  - SJRWMD 1999 or 2004 used everywhere else

CONSOLIDATED LAND USE SUMMARY FOR THE IRL

- Started with FLUCFS classification
- Grouped by similar runoff characteristics
- 27 consolidated land use types

Land Use	Area (acres)	Percent Impervious (%)	DCIA (% of total area)
Agriculture	1,361	5	0
Citrus	30,305	0	0
Commercial	11,560	80	60
Dry Prairie	18,038	0	0
High Density Residential	14,543	50	30
Hydric Hammock	6,121	0	0
Industrial	4,728	30	10
Institutional	15,668	20	10
Low Density Residential	22,673	15	0
Medium Density Residential	47,106	40	20
Mesic Flatwoods	1,275	0	0
Mining	594	0	0
Open	11,603	0	0
Pasture	25,711	0	0
Recreational 1	5,566	5	0
Recreational 2	2,268	20	10
Row Crops	501	0	0
Ruderal	1,321	0	0
Scrub	36,697	0	0
Transportation	5,552	50	30
Upland Flatwoods	22,838	0	0
Upland Mixed	131	0	0
Water	16,921	0	0
Wet Flatwoods	23,243	0	0
Wet Prairies	6,407	0	0
Wetland	89,572	0	0
Xeric Hammock	7,795	0	0
Grand Total	**430,096**	**10.9**	**5.7**

Test Plots

- Used to define typical hydrologic characteristics for defined land use categories

- Minimum of 10 test plots per major land use

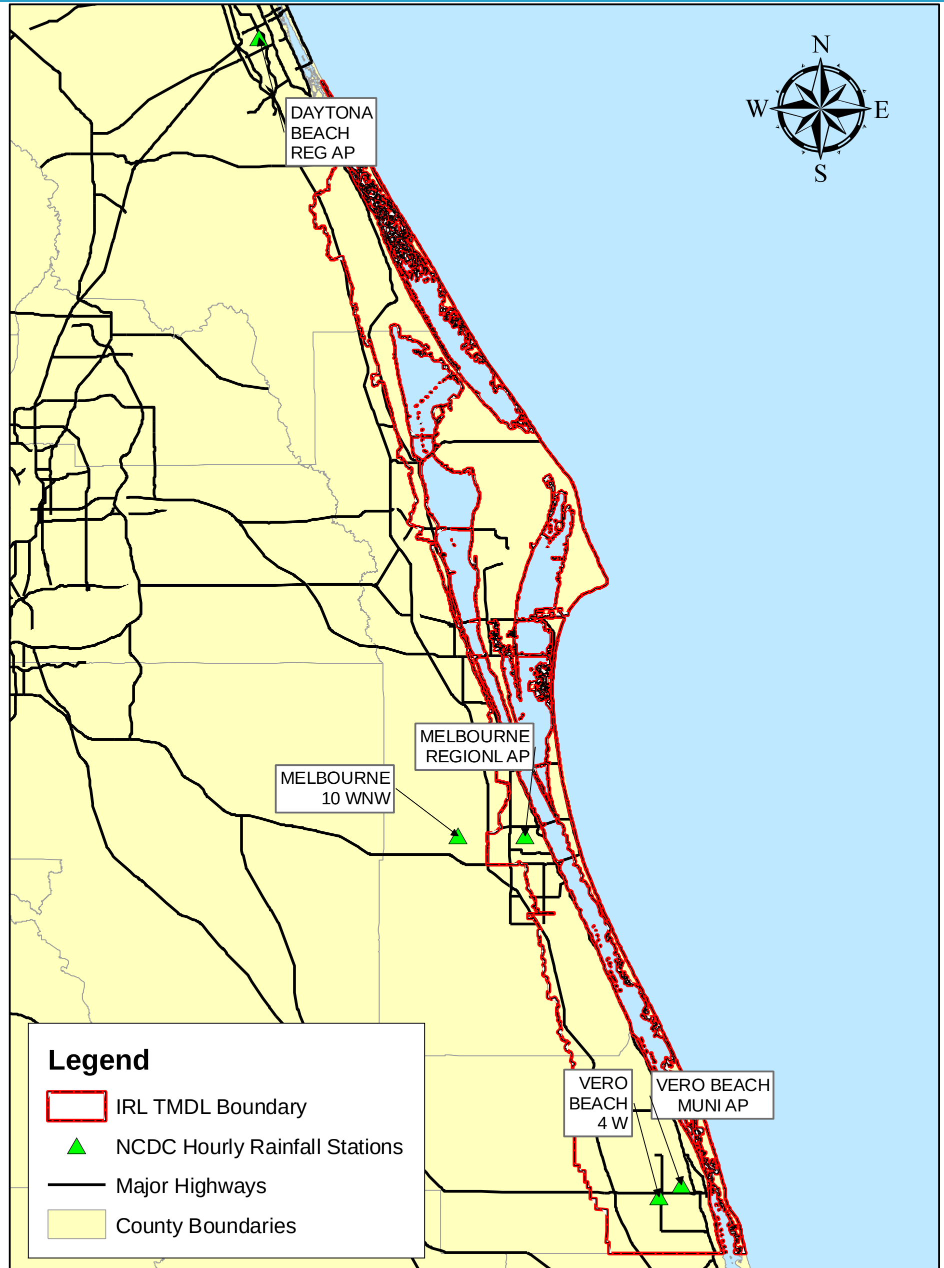
- Used to develop impervious and % DCIA

RUNOFF COEFFICIENTS

MODEL INPUTS FOR SWIL 3.0

HISTORICAL HOURLY RAINFALL RECORDING SITES IN THE IRL

- 3 hourly sites
- Used to develop continuous rainfall event data file over available period of record
- RO modeling developed by H. Harper using SCS Method
- Modeled 395 combinations using individual rain events covering entire POR for precipitation data



RUNOFF MODELING (H. HARPER)

- Runoff model uses the SCS method
  - Directly connected impervious area (DCIA)
    - Percentage of impervious area which has a direct hydraulic connection to the drainage system (0 – 100%)
  - Curve Number (CN)
    - Measure of the runoff generating potential of the pervious areas (grass, landscaping, etc.) and impervious areas which are not DCIA (0 – 100)
  - Non-Directly Connected Impervious Areas (non-DCIA):
    - Includes pervious areas + impervious areas which are not considered to be DCIA
  - Non-DCIA Curve Number (non-DCIA CN Value):

$$\text{Non-DCIA CN Value} = \frac{(\text{Area}_{\text{perv.}}) \times (\text{CN}_{\text{perv.}}) + (\text{Area}_{\text{non-DCIA}}) \times 98}{(\text{Area}_{\text{perv.}}) + (\text{Area}_{\text{non-DCIA}})}$$

  - Modeling conducted for 395 combinations using individual rain events covering entire period of record for precipitation data

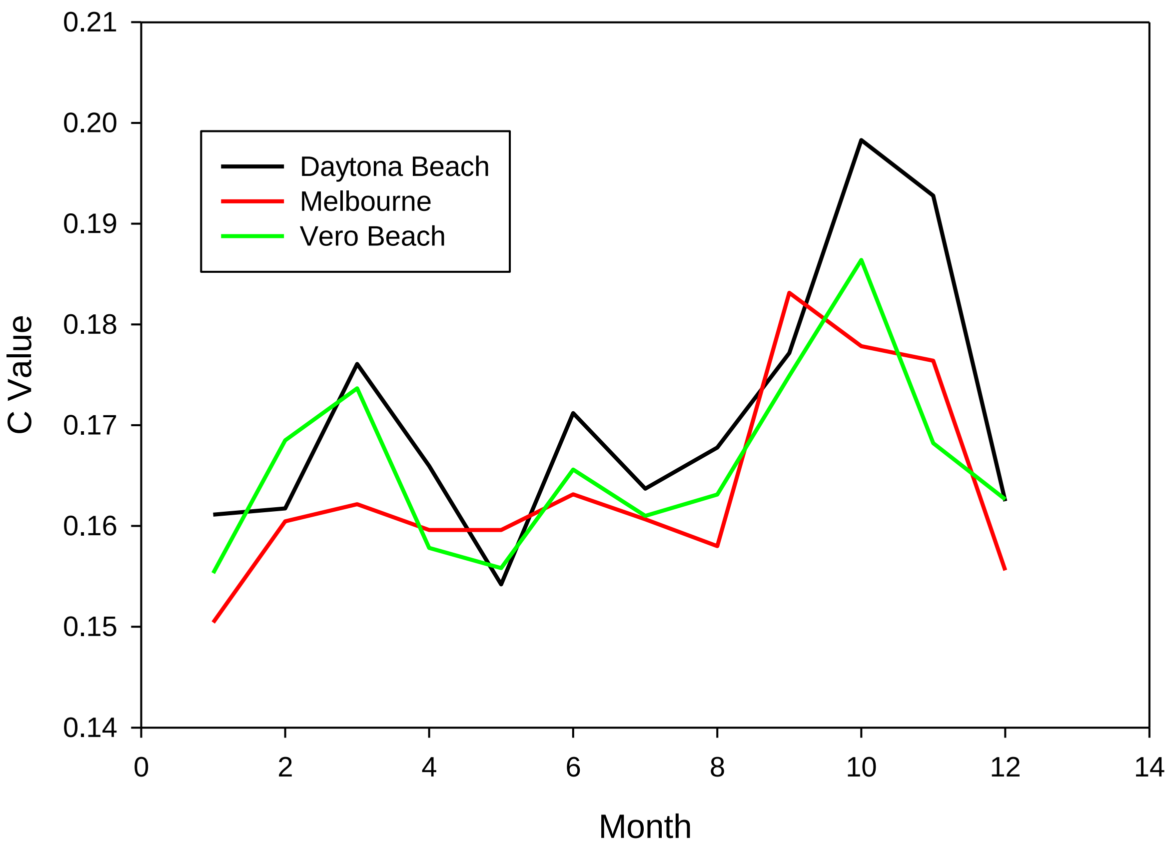
CALCULATED ANNUAL C-VALUES FOR LAND USE CATEGORIES

Land Use	Hydrologic Soil Group	Monthly C Value											
		1	2	3	4	5	6	7	8	9	10	11	12
Agriculture	A	0.002	0.005	0.009	0.001	0.000	0.007	0.004	0.005	0.019	0.035	0.029	0.012
	A/D	0.104	0.096	0.095	0.063	0.065	0.135	0.097	0.108	0.174	0.246	0.178	0.109
	B	0.026	0.024	0.030	0.011	0.011	0.041	0.026	0.031	0.067	0.108	0.080	0.041
	B/D	0.104	0.096	0.095	0.063	0.065	0.135	0.097	0.108	0.174	0.246	0.178	0.109
	C	0.068	0.060	0.062	0.035	0.036	0.092	0.062	0.072	0.126	0.188	0.136	0.078
	C/D	0.104	0.096	0.095	0.063	0.065	0.135	0.097	0.108	0.174	0.246	0.178	0.109
	D	0.104	0.096	0.095	0.063	0.065	0.135	0.097	0.108	0.174	0.246	0.178	0.109
	W	0.555	0.586	0.587	0.547	0.531	0.603	0.569	0.577	0.636	0.668	0.602	0.541
	X?	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Citrus	A	0.000	0.001	0.004	0.000	0.000	0.002	0.001	0.001	0.008	0.016	0.015	0.004
	A/D	0.090	0.082	0.082	0.052	0.054	0.118	0.083	0.094	0.156	0.225	0.162	0.097
	B	0.017	0.017	0.023	0.007	0.006	0.029	0.018	0.022	0.052	0.086	0.065	0.032
	B/D	0.090	0.082	0.082	0.052	0.054	0.118	0.083	0.094	0.156	0.225	0.162	0.097
	C	0.054	0.048	0.052	0.027	0.027	0.075	0.050	0.058	0.107	0.164	0.119	0.066
	C/D	0.090	0.082	0.082	0.052	0.054	0.118	0.083	0.094	0.156	0.225	0.162	0.097
	D	0.090	0.082	0.082	0.052	0.054	0.118	0.083	0.094	0.156	0.225	0.162	0.097
	W	0.555	0.586	0.587	0.547	0.531	0.603	0.569	0.577	0.636	0.668	0.602	0.541
	X?	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commercial	A	0.480	0.497	0.510	0.489	0.477	0.510	0.495	0.498	0.532	0.546	0.516	0.479
	A/D	0.480	0.497	0.510	0.489	0.477	0.510	0.495	0.498	0.532	0.546	0.516	0.479
	B	0.501	0.516	0.527	0.503	0.491	0.535	0.514	0.519	0.561	0.582	0.542	0.497
	B/D	0.501	0.516	0.527	0.503	0.491	0.535	0.514	0.519	0.561	0.582	0.542	0.497
	C	0.526	0.543	0.552	0.525	0.514	0.564	0.539	0.545	0.592	0.617	0.569	0.520
	C/D	0.526	0.543	0.552	0.525	0.514	0.564	0.539	0.545	0.592	0.617	0.569	0.520
	D	0.544	0.563	0.571	0.543	0.531	0.584	0.557	0.564	0.613	0.638	0.587	0.536
	W	0.610	0.636	0.643	0.613	0.599	0.655	0.628	0.634	0.682	0.705	0.649	0.599
	X?	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dry Prairie	A	0.000	0.001	0.003	0.000	0.000	0.002	0.000	0.001	0.006	0.013	0.013	0.002
	A/D	0.058	0.052	0.055	0.029	0.030	0.080	0.054	0.062	0.113	0.171	0.124	0.070
	B	0.005	0.008	0.013	0.003	0.001	0.013	0.007	0.009	0.029	0.050	0.040	0.018
	B/D	0.058	0.052	0.055	0.029	0.030	0.080	0.054	0.062	0.113	0.171	0.124	0.070
	C	0.031	0.028	0.034	0.013	0.013	0.047	0.030	0.036	0.074	0.119	0.087	0.045
	C/D	0.058	0.052	0.055	0.029	0.030	0.080	0.054	0.062	0.113	0.171	0.124	0.070
	D	0.058	0.052	0.055	0.029	0.030	0.080	0.054	0.062	0.113	0.171	0.124	0.070
	W	0.555	0.586	0.587	0.547	0.531	0.603	0.569	0.577	0.636	0.668	0.602	0.541
	X?	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

VARIABILITY IN MONTHLY C-VALUES WITHIN THE IRL AREA – TYPICAL RESIDENTIAL SITE

- Improvement with custom 192 C value tables was marginal
- SWIL uses 12 C values:
  - model expediency
  - allows model expansion beyond 1995-2010

C Value for (CN=40, DCIA=20)



EMC VALUES

MODEL INPUTS FOR SWIL 3.0

SELECTION OF EMC VALUES

- H. Harper conducted review of current EMC database which was developed by Harper & Baker (2007)
- Data evaluated for appropriateness for IRL conditions
  - Reviewed characteristics of watershed areas included in database studies
  - Many studies contained in the database were conducted on watersheds in the IRL basin, especially the agriculture studies

Recommended EMC Values for Use in the Indian River Lagoon TMDL Evaluation

Land Use	Area (acres)	Percent of Total (%)	Percent Impervious (%)	Percent DCIA (%)	Runoff emc (mg/l)		Reference
					Total N	Total P	
Wetland	89,572	20.8	0	0	1.50	0.100	Available Wetland STORET Data for IRL Area
Medium Density Residential (MDR)	47,106	11.0	40	20	1.87	0.301	Florida emc Database
Scrub	36,697	8.5	0	0	1.16	0.096	ERD (2009) - Xeric Scrub
Citrus	30,305	7.0	0	0	2.07	0.152	Florida emc Database
Pasture	25,711	6.0	0	0	3.30	0.621	Florida emc Database
Wet Flatwoods	23,243	5.4	0	0	1.18	0.015	ERD (2009)
Upland Flatwoods	22,838	5.3	0	0	1.00	0.034	ERD (2009) - Mesic Flatwoods
Low Density Residential (LDR)	22,673	5.3	15	0	1.51	0.178	Average of MDR & open space
Dry Prairie	18,038	4.2	0	0	1.95	0.107	ERD (2009)
Water	16,921	3.9	100	100	Deposition Values		Use Atmospheric Deposition Conc.
Institutional	15,668	3.6	20	10	1.51	0.178	Assumed equivalent to LDR
High Density Residential (HDR)	14,543	3.4	50	30	2.10	0.497	Florida emc Database
Open	11,603	2.7	0	0	1.15	0.055	Harper and Baker (2007)
Commercial	11,560	2.7	80	60	1.64	0.214	Average of low and high intensity commercial
Xeric Hammock	7,795	1.8	0	0	1.32	2.82	ERD (2009)
Wet Prairies	6,407	1.5	0	0	0.78	0.009	ERD (2009)
Hydric Hammock	6,121	1.4	0	0	1.07	0.026	ERD (2009)
Recreational 1 - Golf Courses	5,566	1.3	5	0	1.87	0.301	Assumed equivalent to MDR
Transportation	5,552	1.3	50	30	1.37	0.167	Florida emc Database
Industrial	4,728	1.1	30	10	1.19	0.213	Florida emc Database
Recreational 2 - Parks, etc.	2,268	0.5	20	10	1.51	0.178	Assumed equivalent to LDR
Agriculture	1,361	0.3	5	0	2.61	0.485	Florida emc Database
Ruderal	1,321	0.3	0	0	1.32	0.347	ERD (2009)
Mesic Flatwoods	1,275	0.3	0	0	1.00	0.034	ERD (2009)
Mining	594	0.1	0	0	1.18	0.150	Florida emc Database
Row Crops	501	0.1	0	0	2.46	0.489	Florida emc Database
Upland Mixed Forest	131	0.0	0	0	0.68	2.29	ERD (2009)
Grand Total/Mean Value	**430,098**	**100**	**10.9**	**5.7**	**1.64**	**0.231**	

Updated version of runoff characterization data outlined in "Performance Efficiency Evaluation of Stormwater Management Systems in Florida", Harper and Baker, 2007

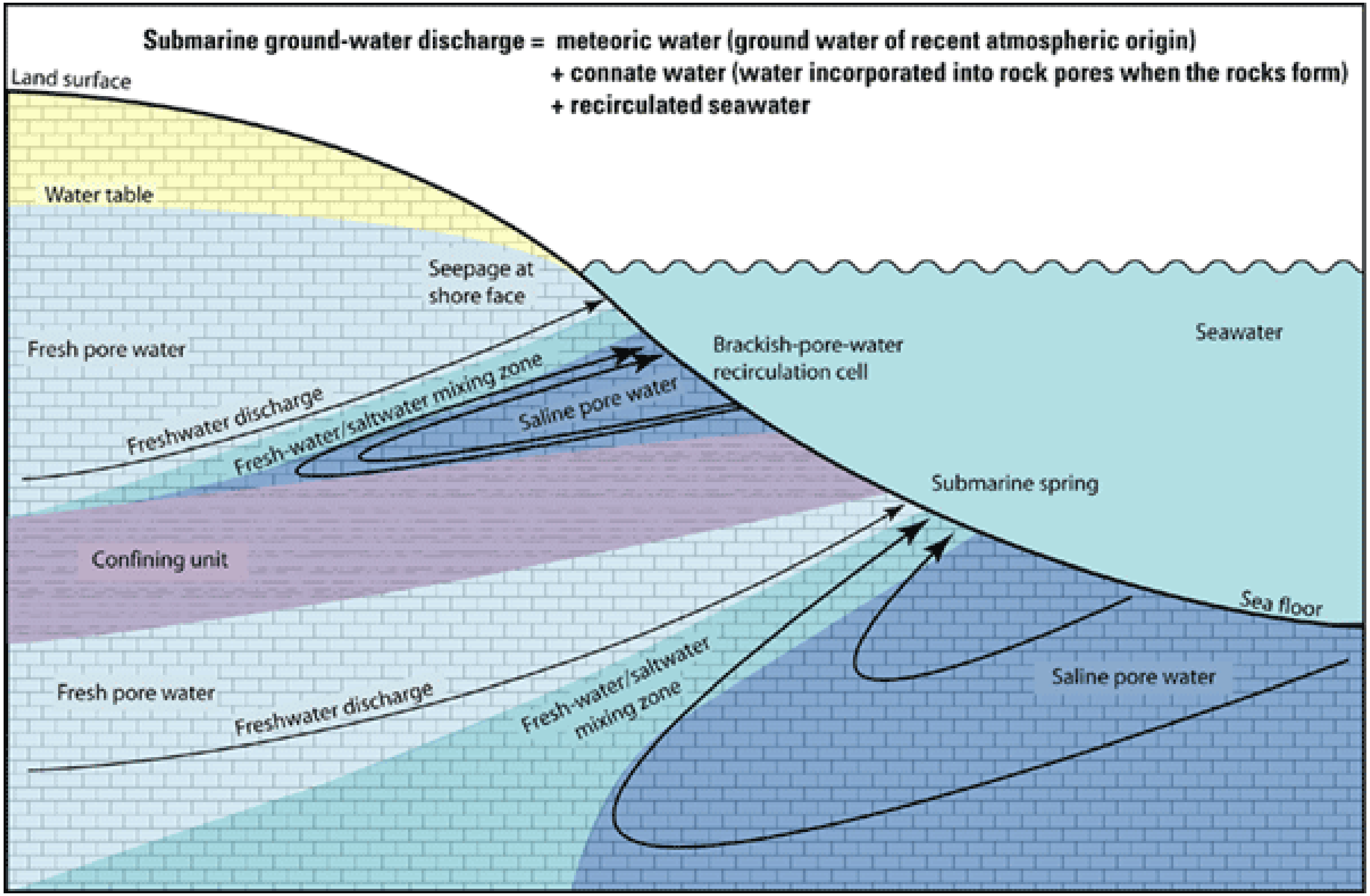
"Runoff Characteristics of Natural Vegetation Communities in Florida", Environmental Research & Design, Inc. (ERD), 2009

"Performance Efficiency Evaluation of Stormwater Management Systems in Florida", Harper and Baker, 2007

BASEFLOW

MODEL INPUTS FOR SWIL 3.0

Typical IRL Coastal Geology

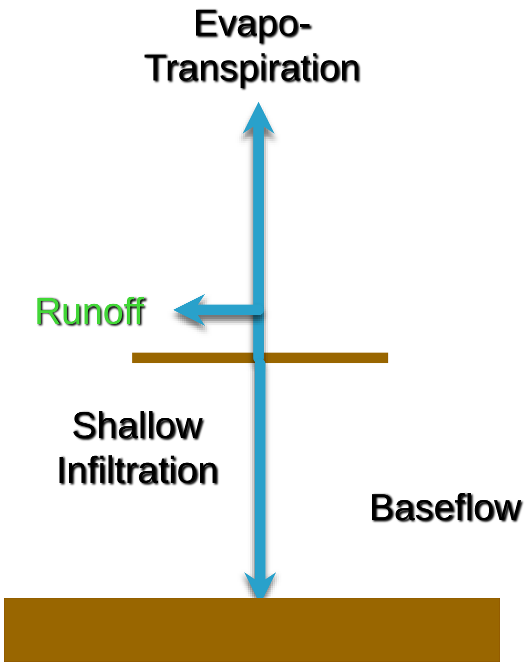


-Water migrates downward until reaching a confining layer then migrates horizontally into the IRL or ocean

-- Deep recharge does not occur, in fact there is evidence of upwelling

WATER BUDGET

Due to the confining layer which prevents downward movement of groundwater, the water budget equation becomes:



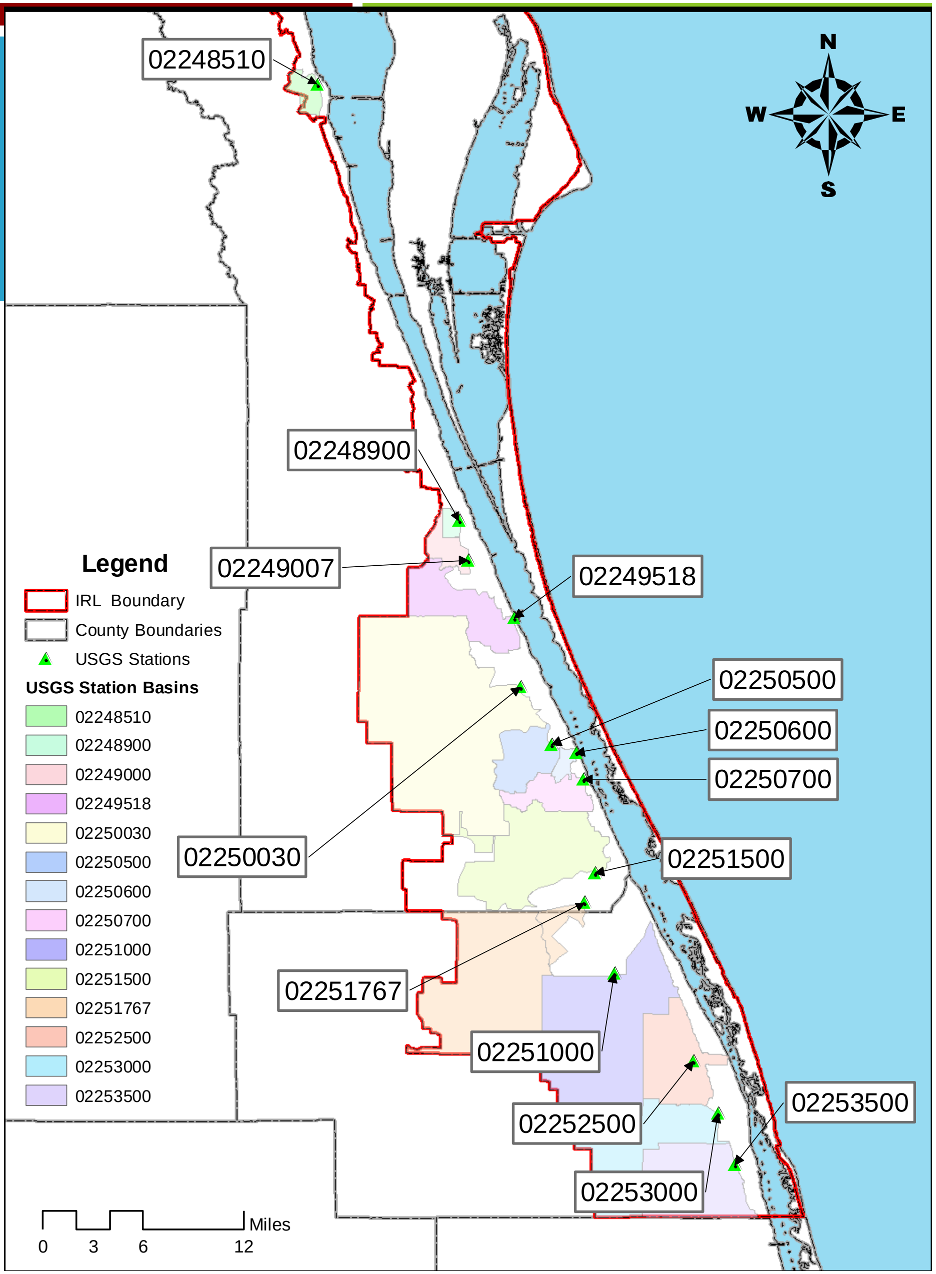
GW/Baseflow = Precipitation - ET - RO

BASEFLOW VOLUMES

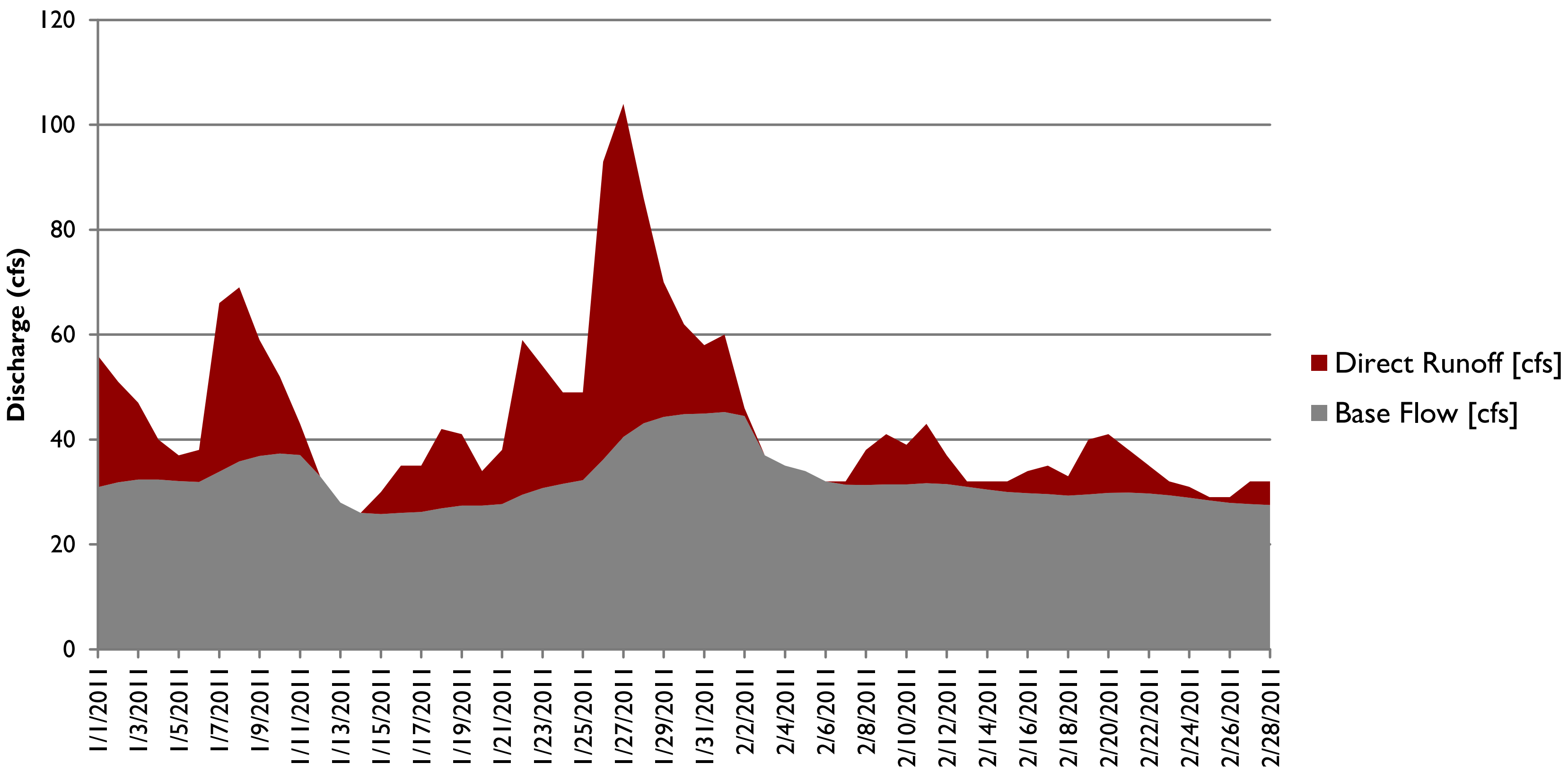
Used USGS tributary gauging sites and associated watershed areas

~ 42% OF OVERALL BASIN AREA

MOST OF THE AREAS ARE AGRICULTURE AND NATURAL AREAS



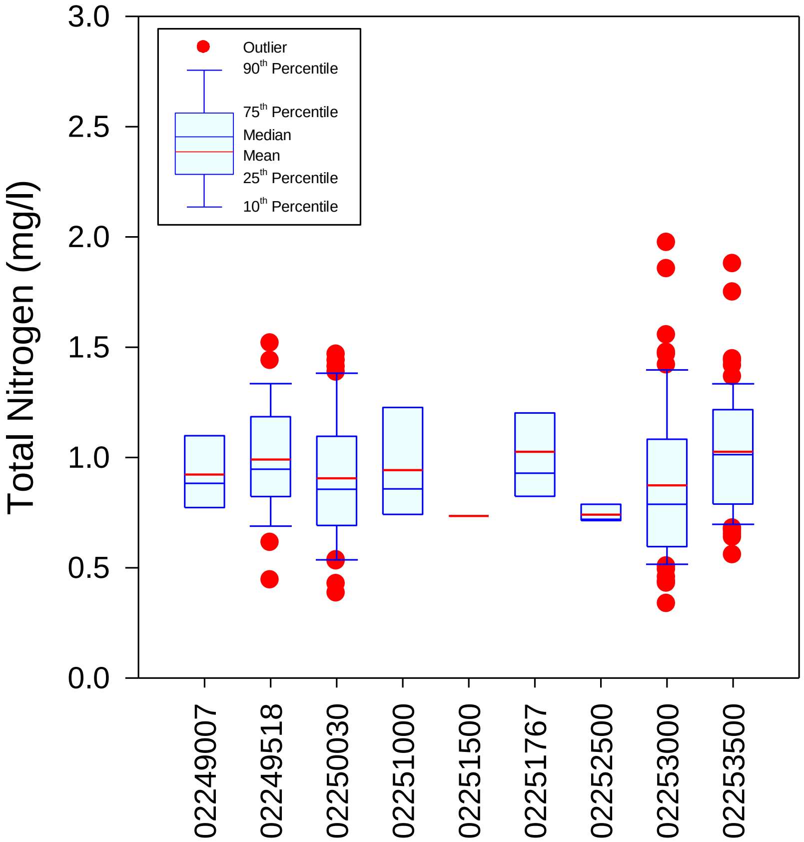
COMPARISON OF RUNOFF AND BASEFLOW AT USGS STATION 02251767



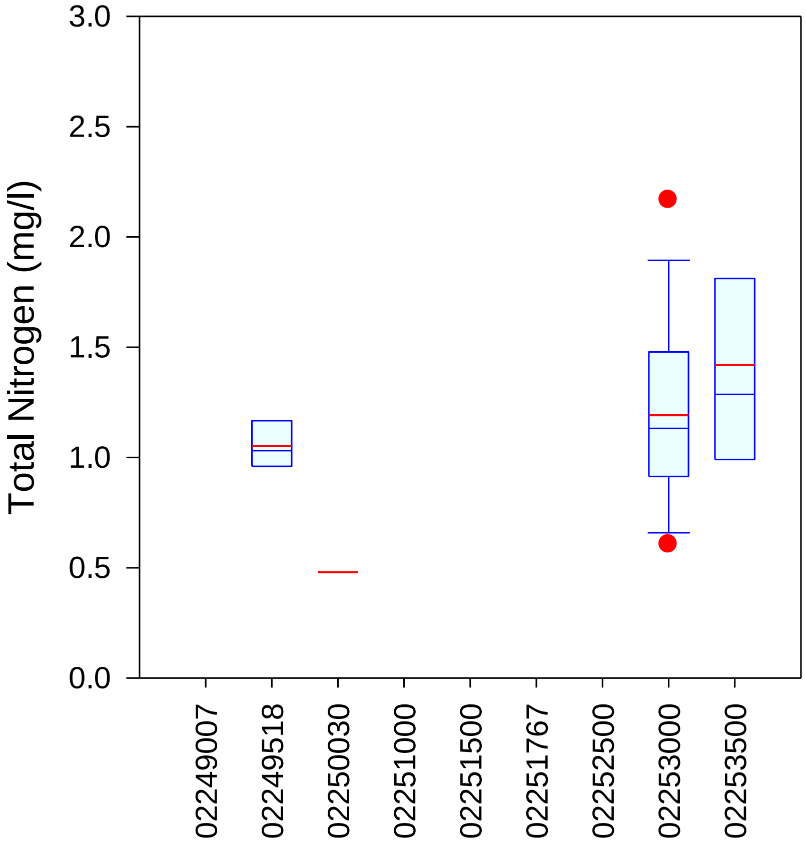
Runoff and baseflow separation conducted using the WHAT program from Purdue University

COMPARISON OF TN CONCENTRATIONS IN RUNOFF AND BASEFLOW

Base Flow Total Nitrogen

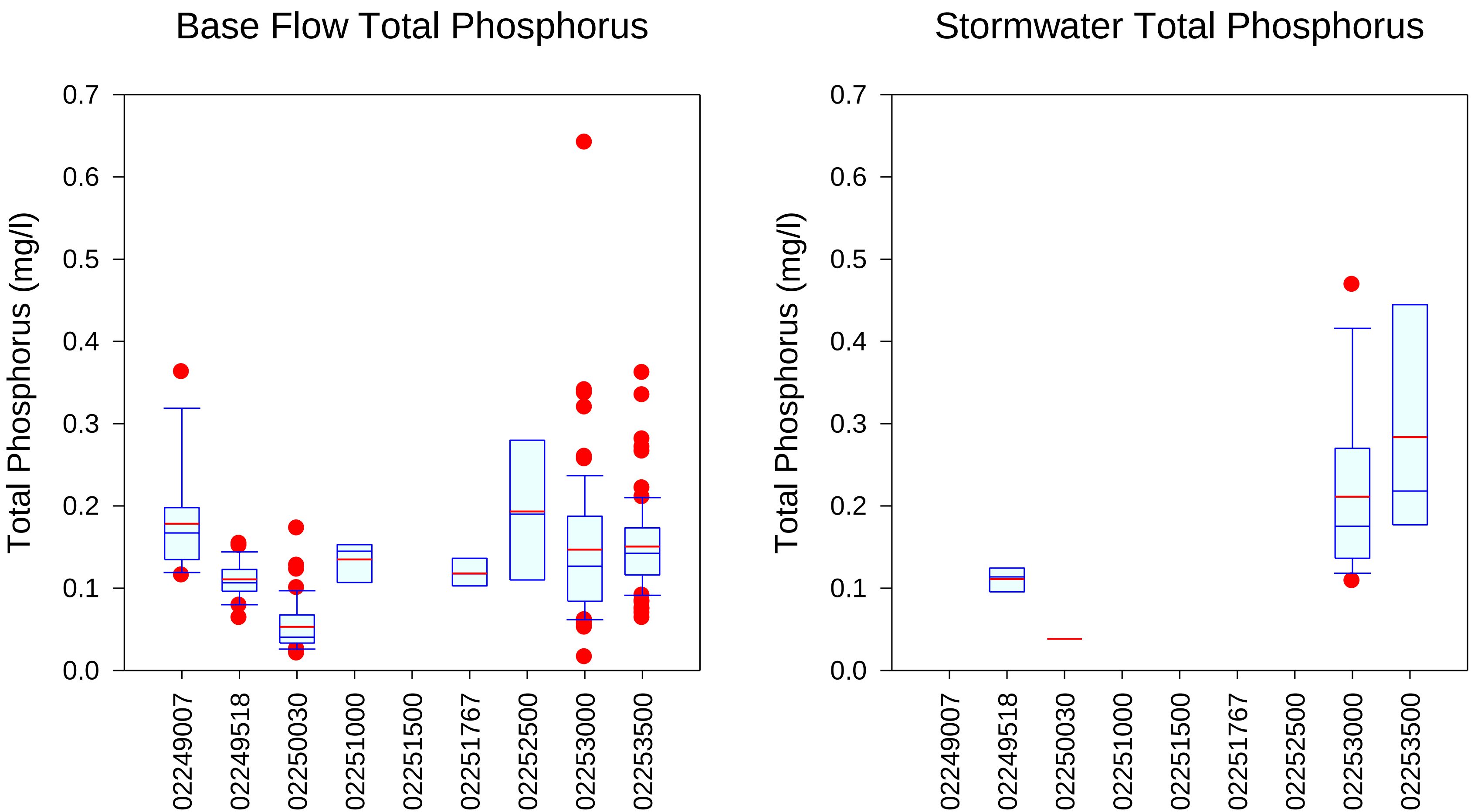


Stormwater Total Nitrogen



Model uses Baseflow TN 0.886 mg/L

COMPARISON OF TP CONCENTRATIONS IN RUNOFF AND BASEFLOW



Model uses Baseflow TP 0.112 mg/L

STORMWATER BMPS (AKA TREATMENTS)

MODEL INPUTS FOR SWIL 3.0

DEVELOPMENT OF BMP AREAS

- Spatial layer locating treated areas due to SJRWMD requirements after 1986 developed using Property Appraiser Data
- Residential property: first house developed year assigned to subdivision
- Other types of developed properties: year of development
- To use within appropriate model year:
  - Year 2000 land use: create treatments for 1986-2000
  - Year 2004 land use: create treatments for 1986-2004
- Stormwater Solutions: identified all treatments as either Dry Or Wet using photointerpretation

EVALUATION OF BMP EFFICIENCIES

- BMP efficiencies calculated for two different time periods
  - Prior to implementation of the Impaired Waters rule
    - BMP efficiencies calculated for general SJRWMD stormwater system design criteria
  - Following implementation of the Impaired Waters rule
    - BMP efficiencies calculated as removal required to achieve post < pre loadings

BMP EFFICIENCIES BY TREATMENT TYPE USED IN SWIL

Time Period	BMP Type	Assumed Annual Mass/Volume Removal (% of total)			Assumptions	Reference
		Runoff Volume	Total N Mass	Total P Mass		
Prior to Implementation of Impaired Water Design Criteria	Dry Retention (Dry Ponds)	75	75	75	Assumes that dry ponds are primarily dry detention designed to SJRWMD rules. Efficiencies reflect water volume which is infiltrated into the ground.	Harper and Baker (2007) [1]
	Wet Detention (Wet Ponds)	20	36	62	Based on relationships between removal eff. and detention time. Assume that ponds are designed with a 14 day wet season detention time, equivalent to 22 day annual detention time	Harper and Baker (2007)[1]

[1] "Performance Efficiency Evaluation of Stormwater Management Systems in Florida", Harper and Baker, 2007

SPOIL ISLANDS AND IMPOUNDMENTS

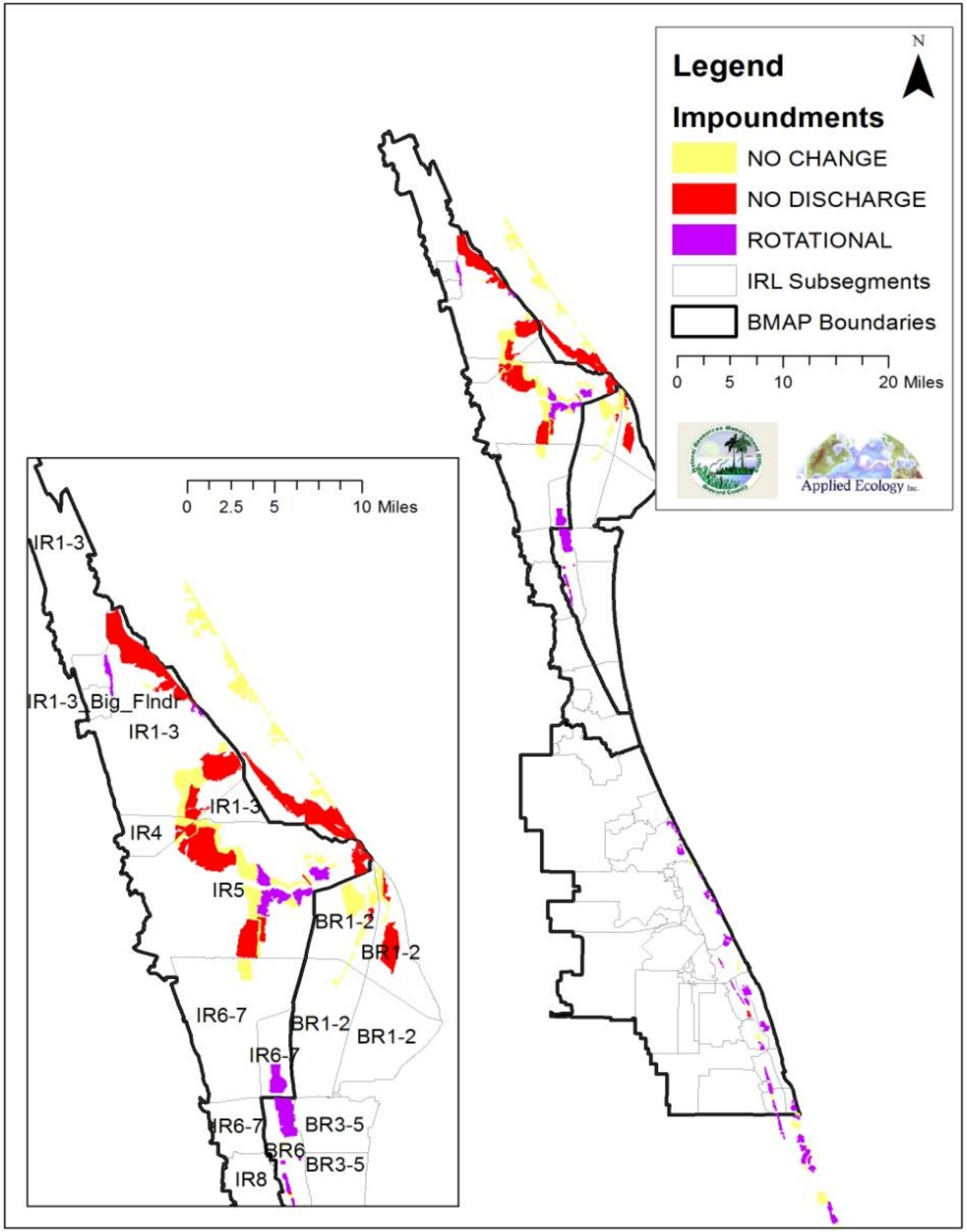
MODEL INPUTS FOR SWIL 3.0

SPOIL ISLANDS

- Land Use Code: 5474 (122 polygons only)
- In SWIL 1.0 aggregated with 5400, Bays and Estuaries, results in 0 loads
- Developed a separate Land Use code for spoil islands (only 122 polygons) and loads are provided separately from all previous categories
- Spoil island loads will not allocated/included with total loading

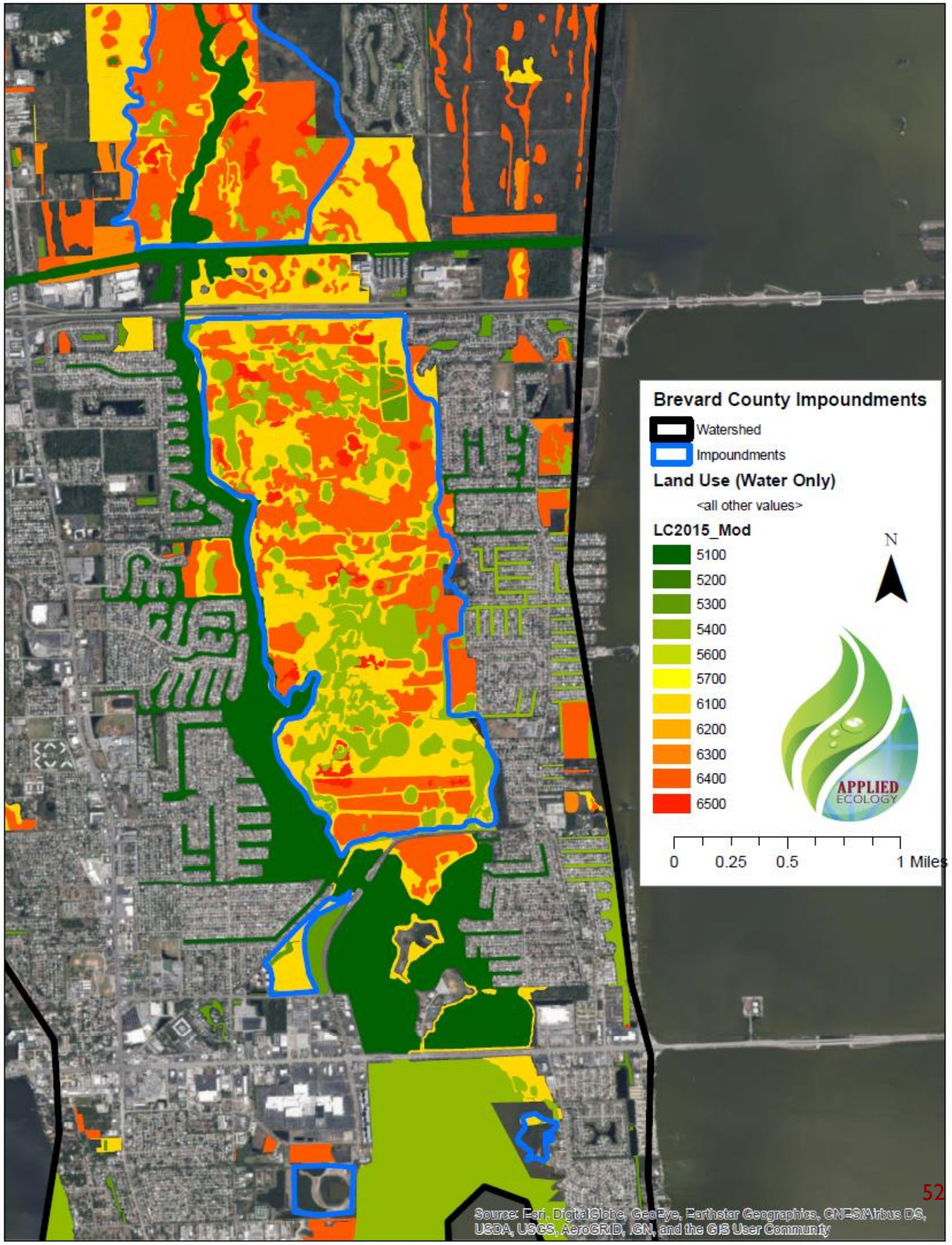
IMPOUNDMENTS

- 206 impoundments
- 41,000 acres
- Primarily in NIRL
- 80% NO DISCHARGE
- Management differs by year



IMPOUNDMENTS

- Most Impoundment areas have 5000 or 6000 land use codes
  - 53% - 6400
  - 20% - 5400
  - 16% - 6100
- Wetlands would be associated with load input



IMPOUNDMENTS BY TYPE AND METHODS

Based on most recent management scheme:

Total 40,978 acres impoundments:

- NO CHANGE (OPEN ALL YEAR): 89 impoundments (12,694 acres)
- NO DISCHARGE: 42 impoundments (17,618 acres)
- ROTATIONAL: 75 impoundments (10,622 acres)

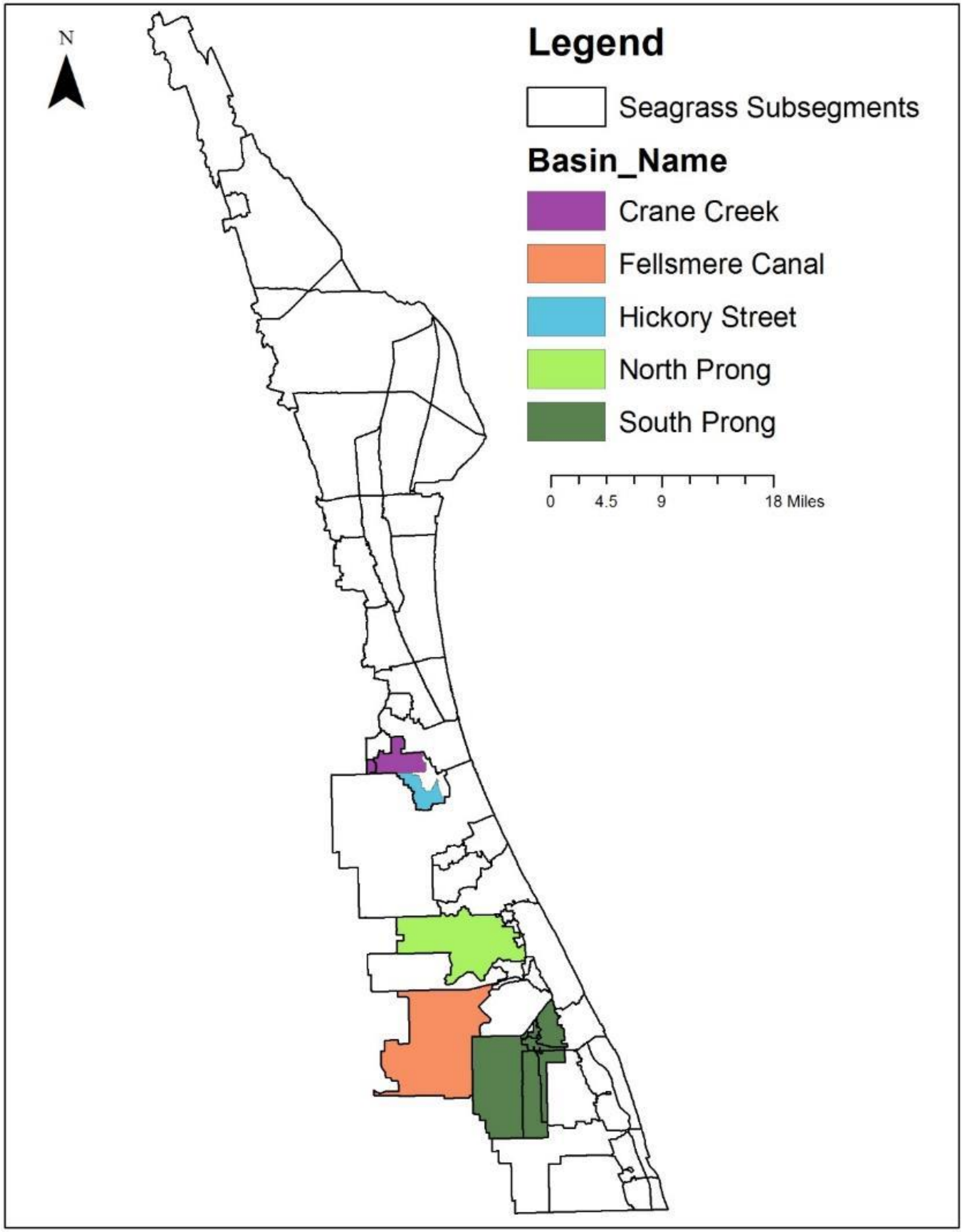
No direct discharge on the No Discharge ones

Rotational: No discharge during May-September, all loads added to October estimates

MODEL CALIBRATION

CALIBRATION MODEL RUN

- Used to reduce run-time when improving calibration
- 158,000 ACRES (31% SWIL 3.0)
- 5 drainage monitored basins were included in model run:
  - Crane Creek
  - Hickory Creek
  - South Prong
  - North Prong
  - Fellsmere Canal



SUMMARY CALIBRATION DRAINAGE BASINS

BASIN	TOTAL AREA (acres)	PERCENT IMPERVIOUS AREA (%)		PERCENT DCIA (%)	
	2000	2000	2004	2000	2004
Crane Creek	5,464	37	38	22	23
Hickory Street	3,443	26	30	15	17
South Prong	35,899	5	4	2	1
North Prong	23,967	4	4	2	2
Fellsmere Canal	36,362	3	3	1	2

LAND USE	PERCENT LAND USE FOR CALIBRATION BASINS (%)					MEAN (%)
	Crane Creek	Hickory Street	South Prong	North Prong	Fellsmere Canal	
Medium-Density Residential	29	29	6	4	5	15
High-Density Residential	6	15	0	3	0	5
Commercial	14	7	0	0	0	4
Wetlands / Wet Flatwoods	7	21	43	14	14	20
Citrus	1	0	21	13	48	17
Total	**58**	**73**	**70**	**34**	**68**	**61**

CALIBRATION METHODS

- Performed by ERD using a simplified spreadsheet for parameter optimization
- Used single weighted monthly values for rainfall and undeveloped pervious area ET per drainage basin
- Optimization Parameters: NSE (Nash-Sutcliffe efficiency) and percent bias (PBIAS) used as statistics

PERFORMANCE RATING	NSE	PBIAS
Very Good	$0.75 < NSE < 1.0$	$PBIAS < \pm 10$
Good	$0.65 < NSE < 0.75$	$\pm 10 < PBIAS < \pm 15$
Satisfactory	$0.50 < NSE < 0.65$	$\pm 15 < PBIAS < \pm 25$
Unsatisfactory	$NSE < 0.50$	$PBIAS > \pm 25$

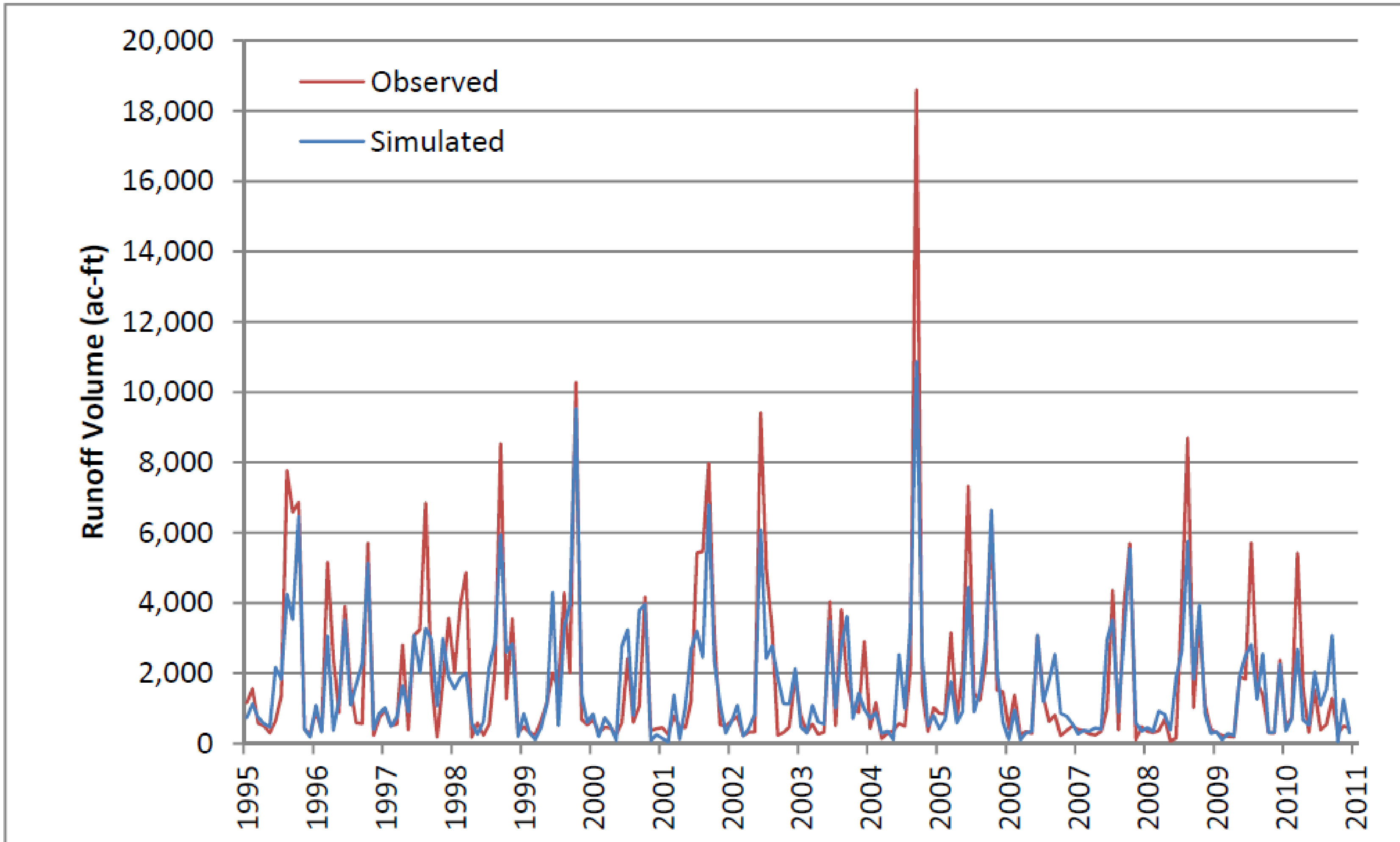
Source: Moriasi, et al. (2007).

SUMMARY OF OPTIMIZATION STATISTICS WITH BEST C-VALUE ADJUSTMENT

WETLAND / WET FLATWOOD C-VALUE ADJUSTMENT FACTOR = 1.90 CITRUS C-VALUE ADJUSTMENT FACTOR = 1.23			
Station	**Runoff**		**Absolute PBIAS**
	NSE	**PBIAS**	
Crane Creek	0.65	9.7	9.7
Hickory Street	0.62	-3.6	3.6
South Prong	0.62	13.1	13.1
North Prong	0.57	4.0	4.0
Fellsmere Canal	0.79	0.1	0.1
Mean	**0.65**	**4.67**	**6.11**

Good Very Good

RUNOFF VOLUMES CALIBRATION RESULTS: SOUTH PRONG SEBASTIAN RIVER EXAMPLE

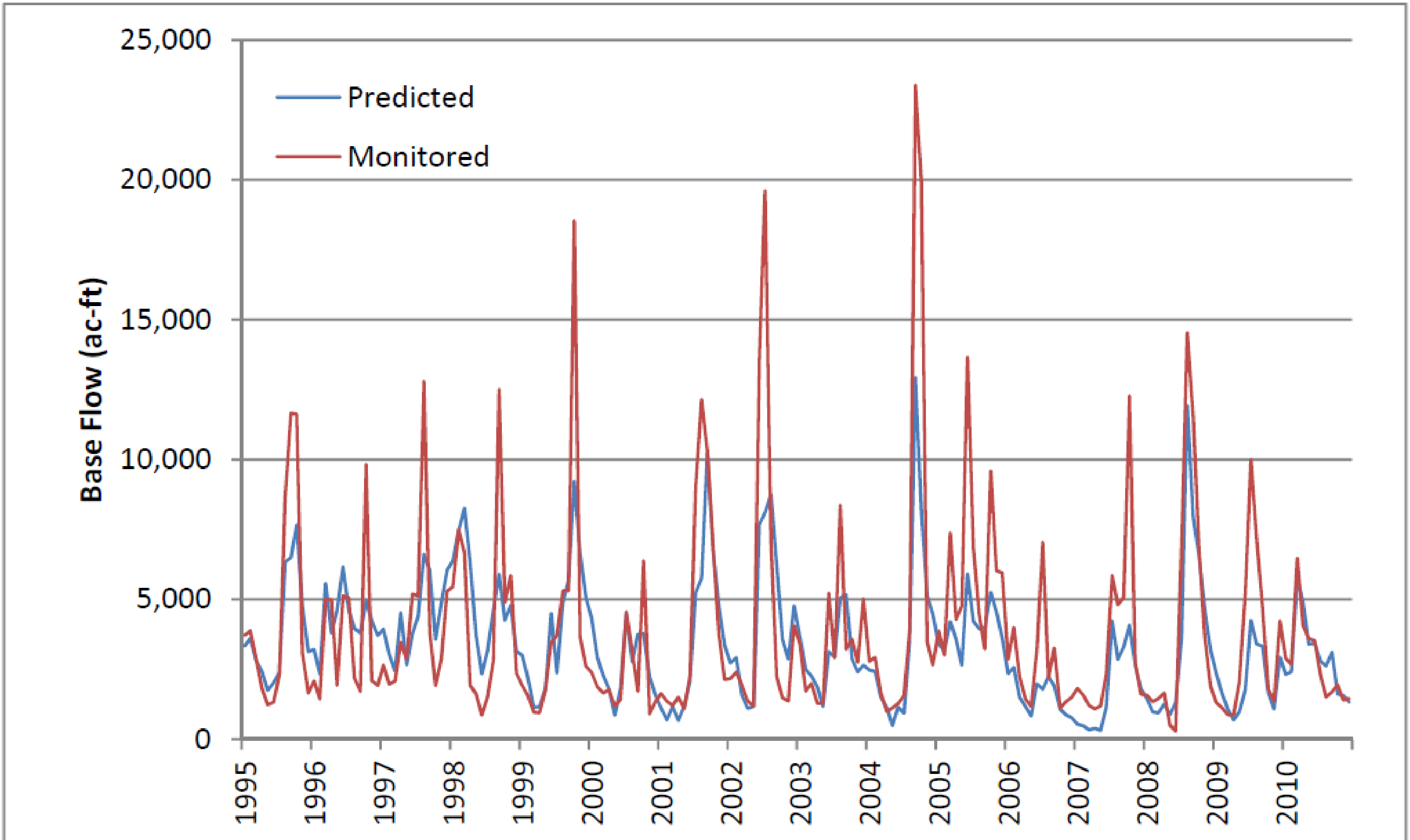


BASEFLOW CALIBRATION RESULTS

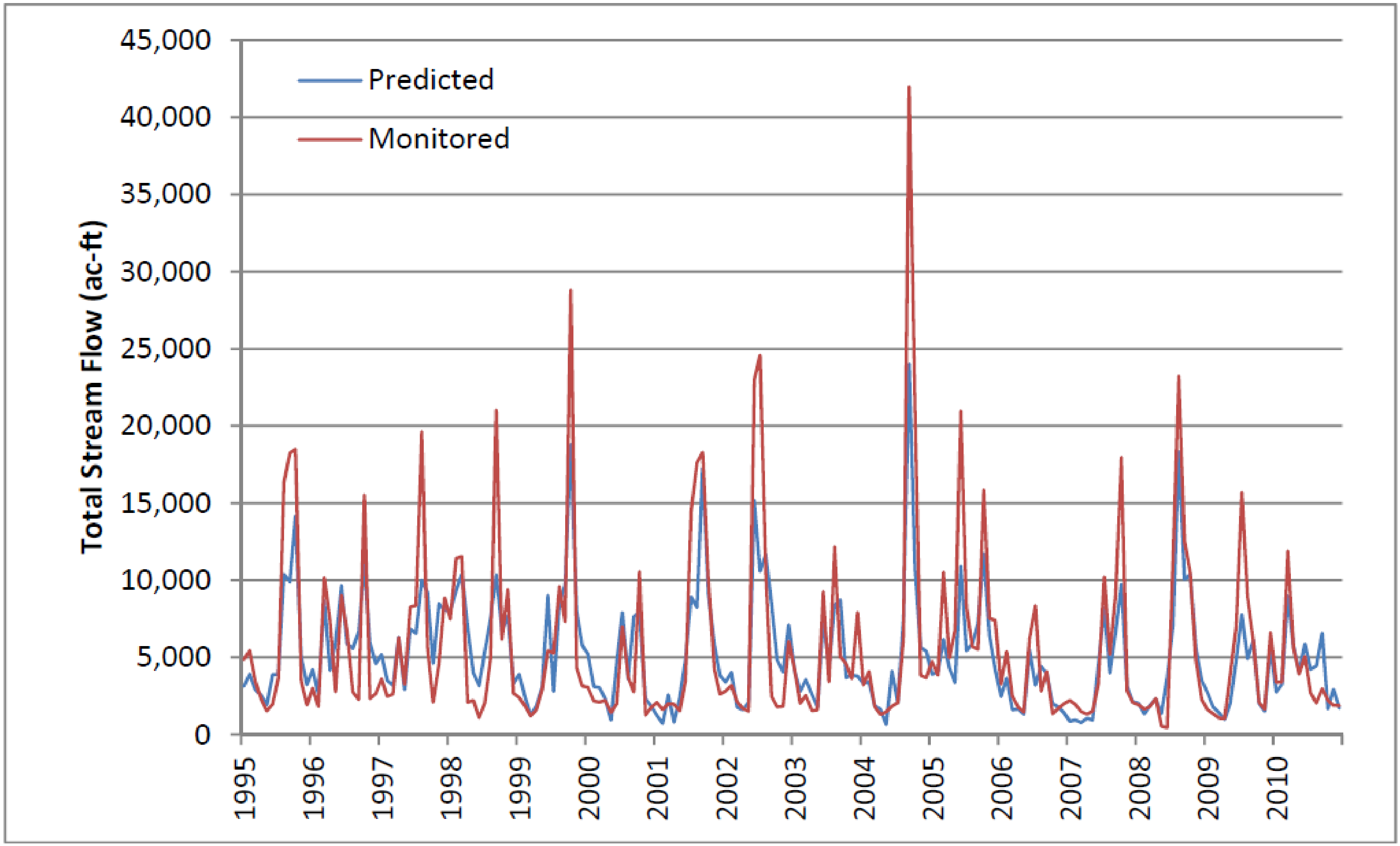
STATION	BASIN AREA (acres)	INITIAL STORAGE (ac-ft)	MEAN STORAGE DEPTH (ft)	NSE	PBIAS
Crane Creek	5,464	7,030	1.29	0.77	5.91
Hickory Street	3,443	4,267	1.24	0.65	-10.64
South Prong	35,899	33,502	0.94	0.55	-3.73
North Prong	23,967	19,229	0.79	0.63	-1.06
Fellsmere Canal	36,362	32,527	0.91	0.54	7.58
Mean		**19,331**	**1.03**	**0.62**	**-0.39**

- Baseflow slightly overestimated for Hickory Street, slightly under-estimated for Fellsmere Canal
- Baseflow Lag Factor used: 0.32

BASEFLOW VOLUMES CALIBRATION RESULTS: SOUTH PRONG SEBASTIAN RIVER EXAMPLE

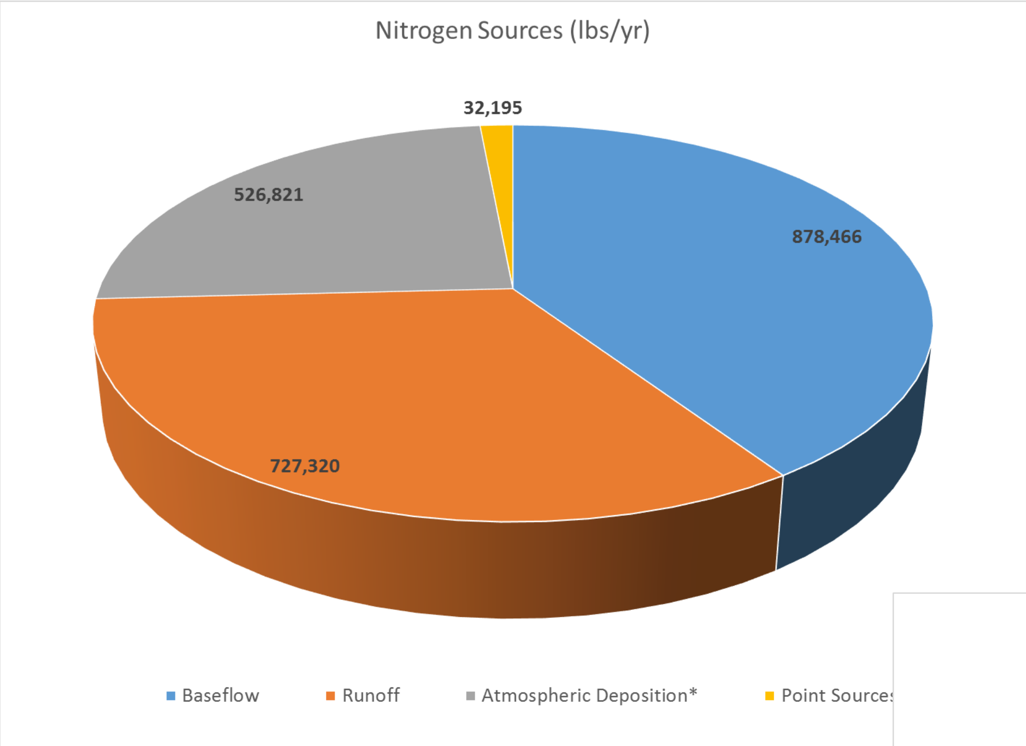


TOTAL FLOW CALIBRATION RESULTS: SOUTH PRONG SEBASTIAN RIVER EXAMPLE

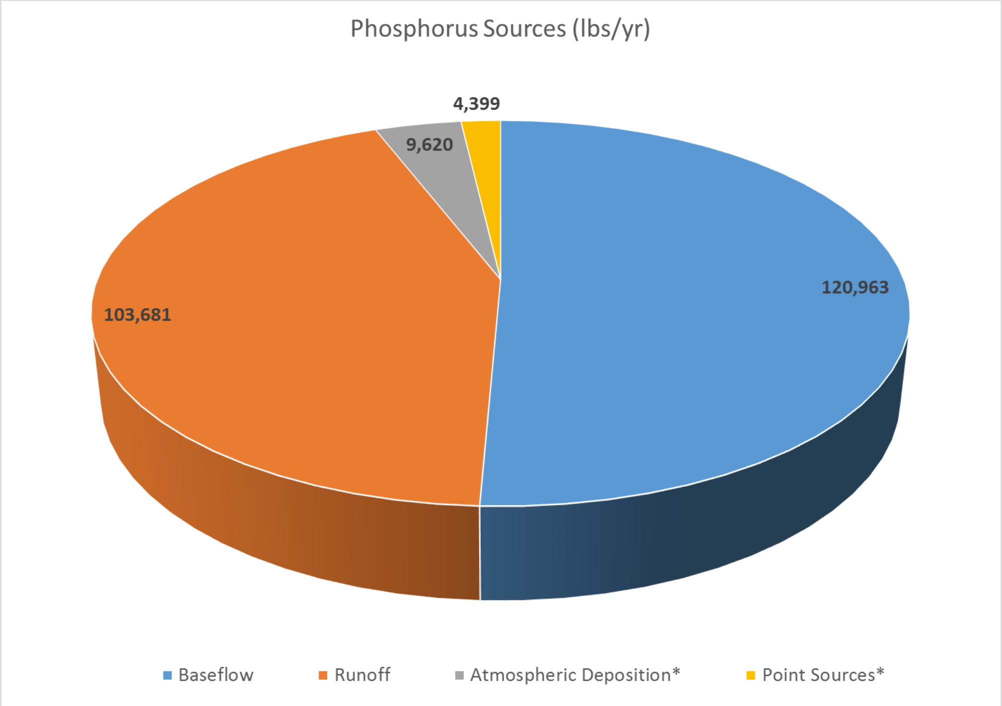


SWIL MODEL OUTPUTS

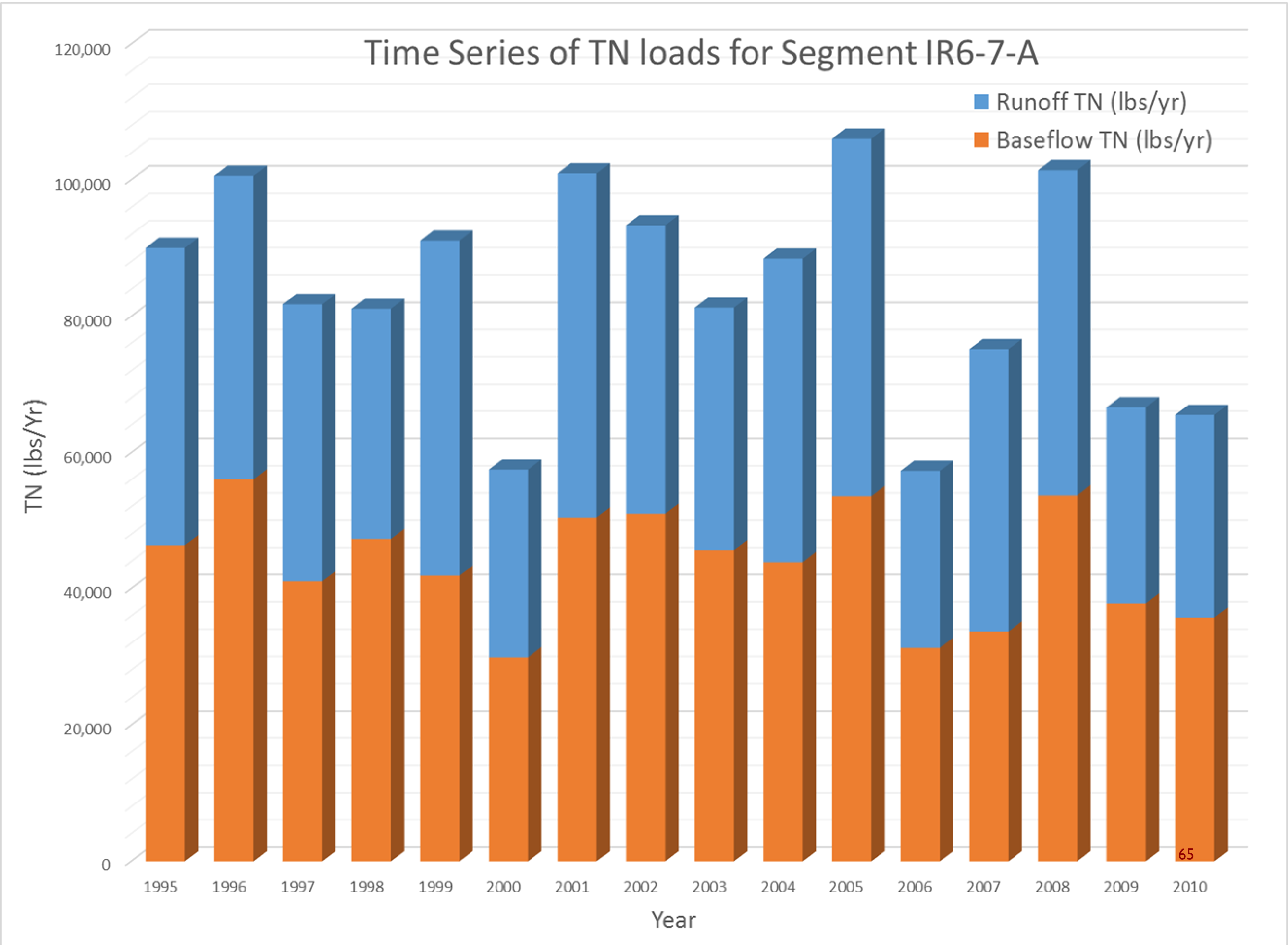
OFFICIAL SWIL 3.0 MODEL OUTPUTS



- TN Baseflow makes up 41% of total TN external loading

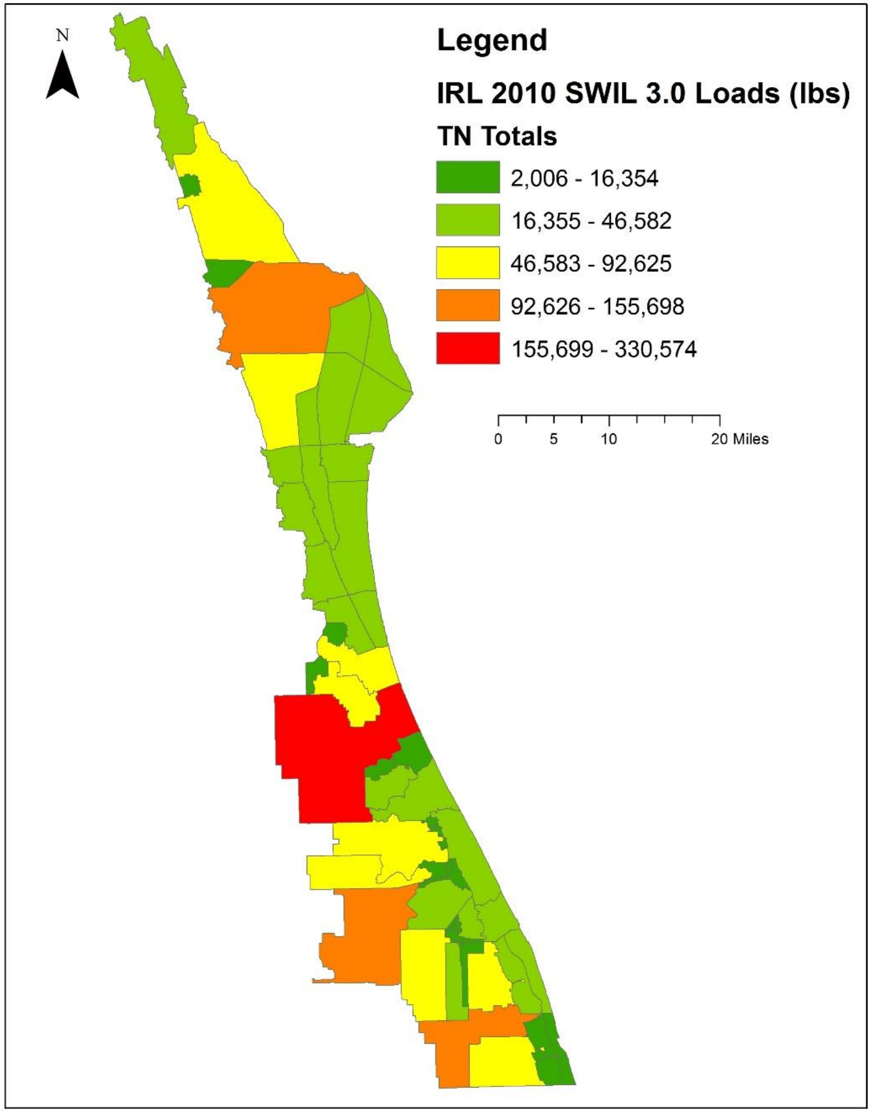


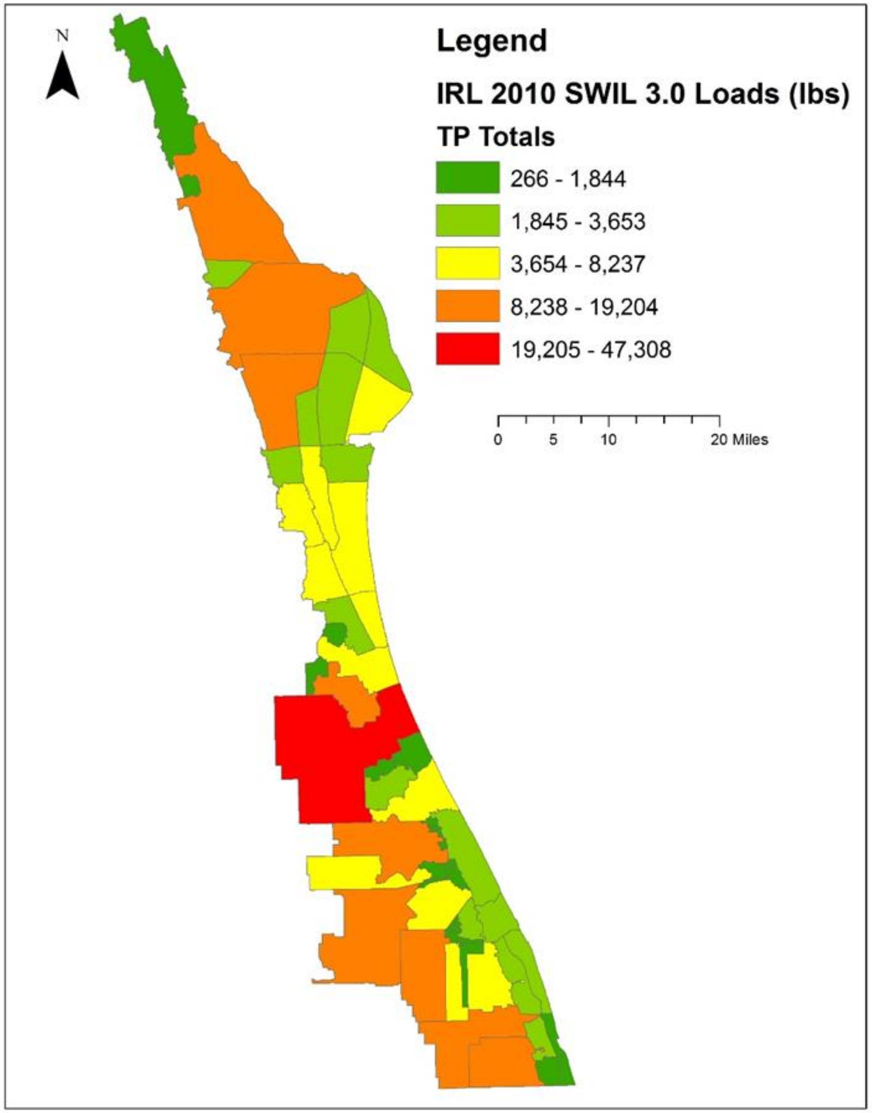
- TP Baseflow makes up 51% of total TP external loading



Time Series of TN loads for Segment IR6-7-A
Runoff TN (lbs/yr)
Baseflow TN (lbs/yr)
TN (lbs/Yr)
120,000
100,000
80,000
60,000
40,000
20,000
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

SWIL 3.0 ESTIMATED TN & TP LOADS



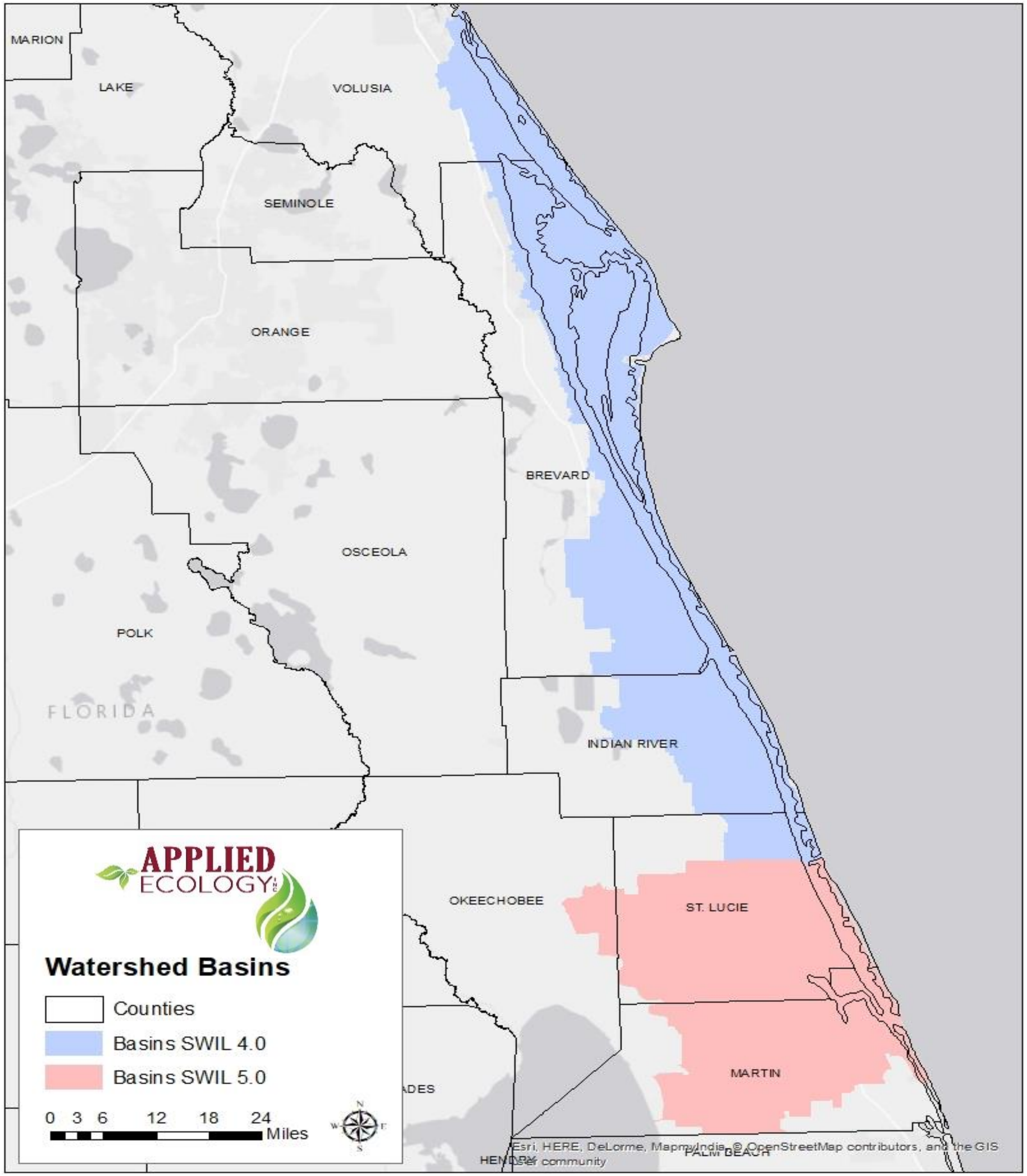


LATEST SWIL MODEL INPUTS AND OUTPUTS

SWIL 4B (OR 5) FUNDED BY FLORIDA TECH

SWIL 4.0 B (AKA SWIL 5.0)

Expanded model area by 75%



SWIL 4.0 B (AKA SWIL 5.0)

Increased rainfall stations for isopleths to 334 (259% increase)

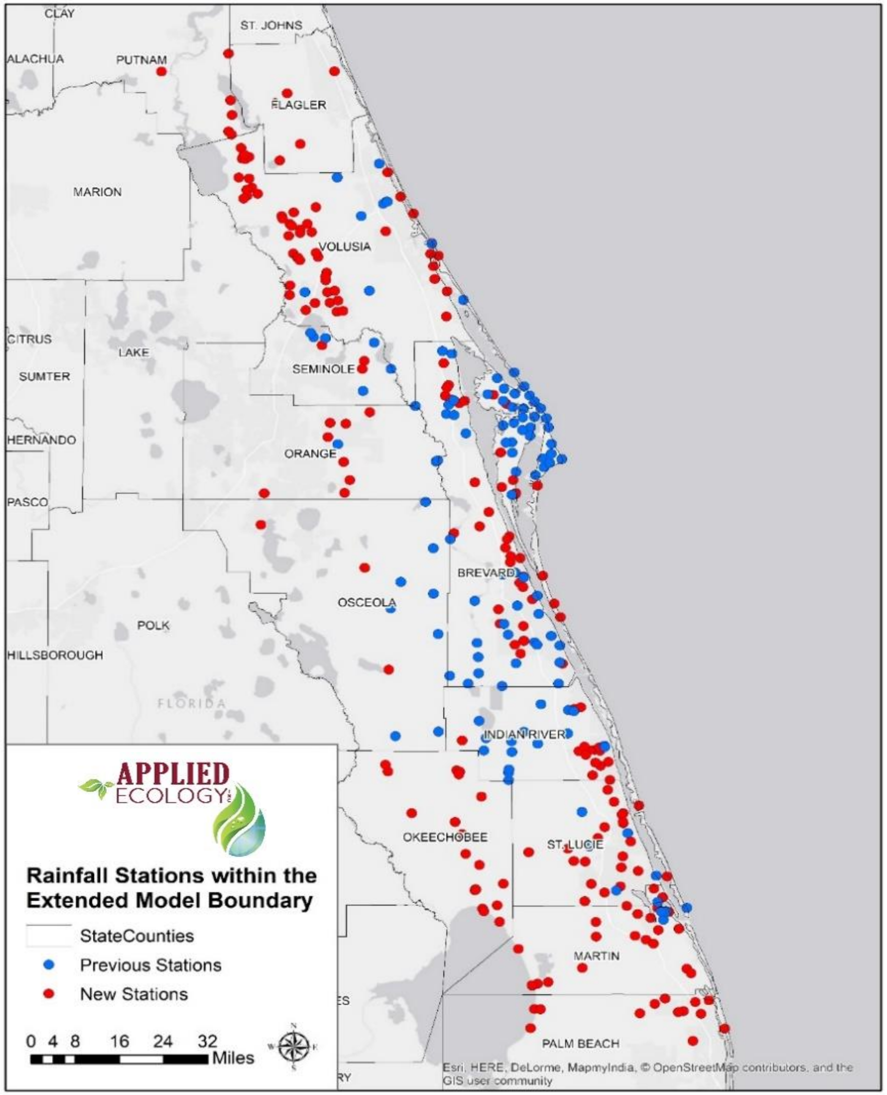
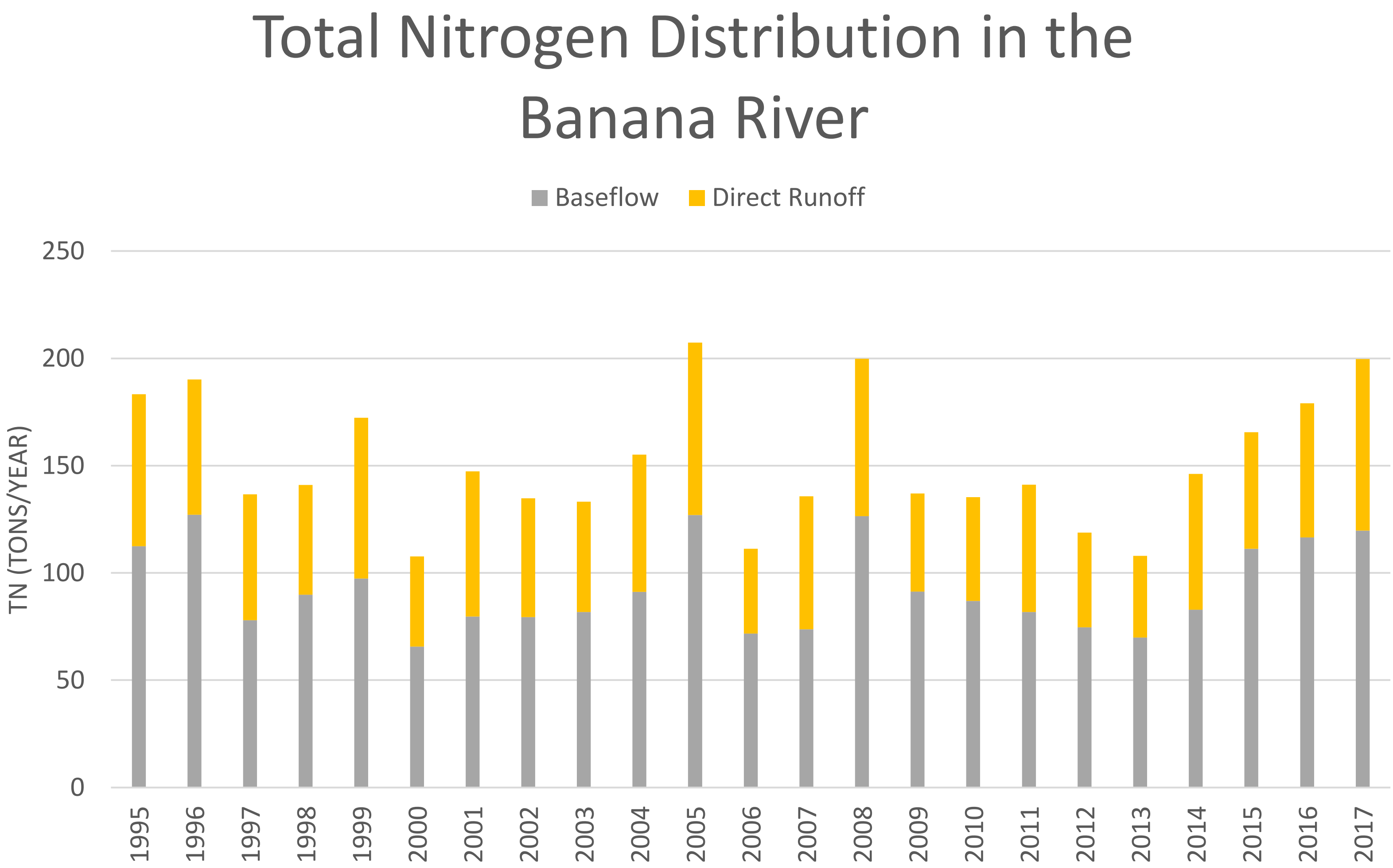
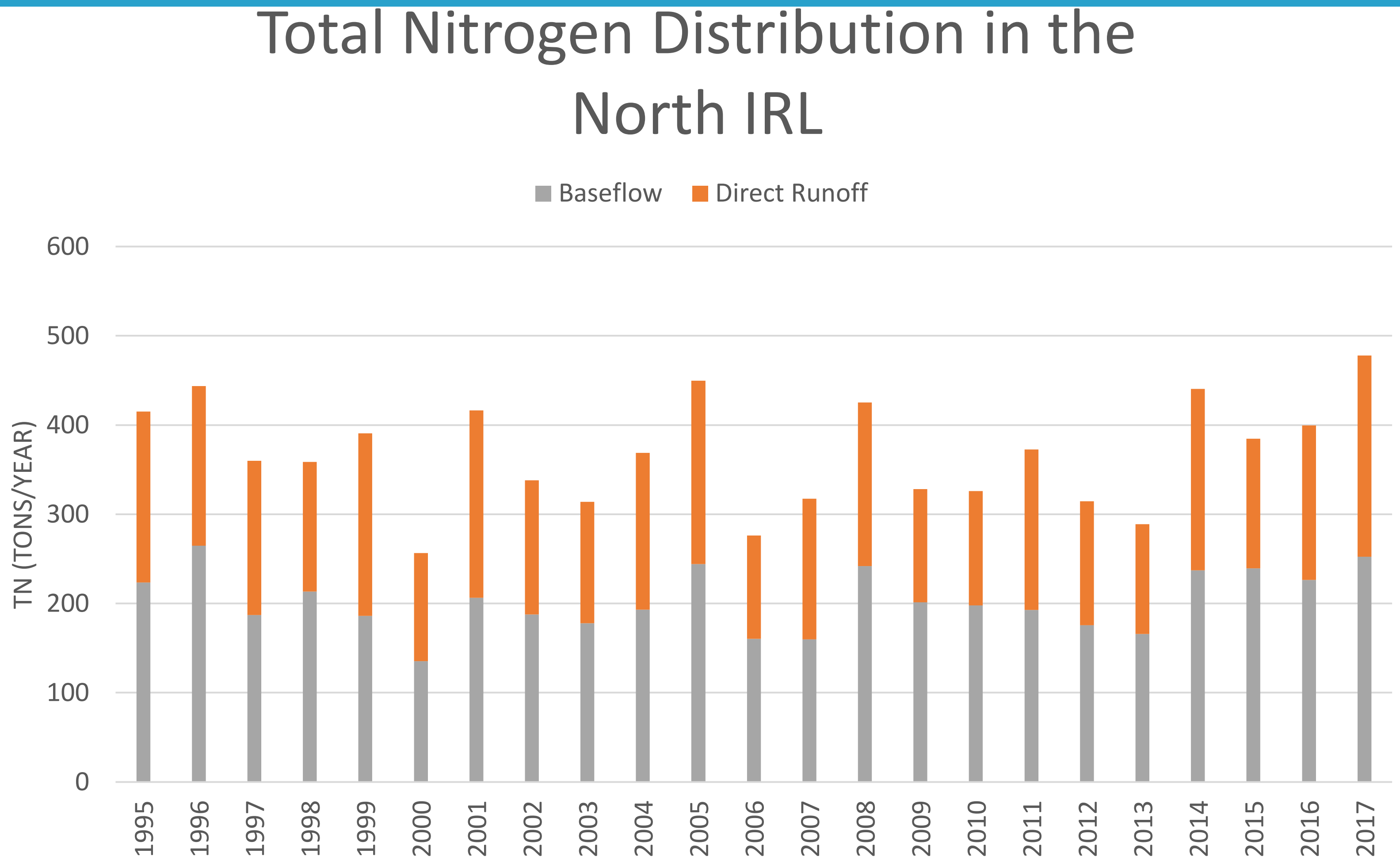


Figure A-2. The increase of the total number of rainfall stations for the SWIL 5.0 model.

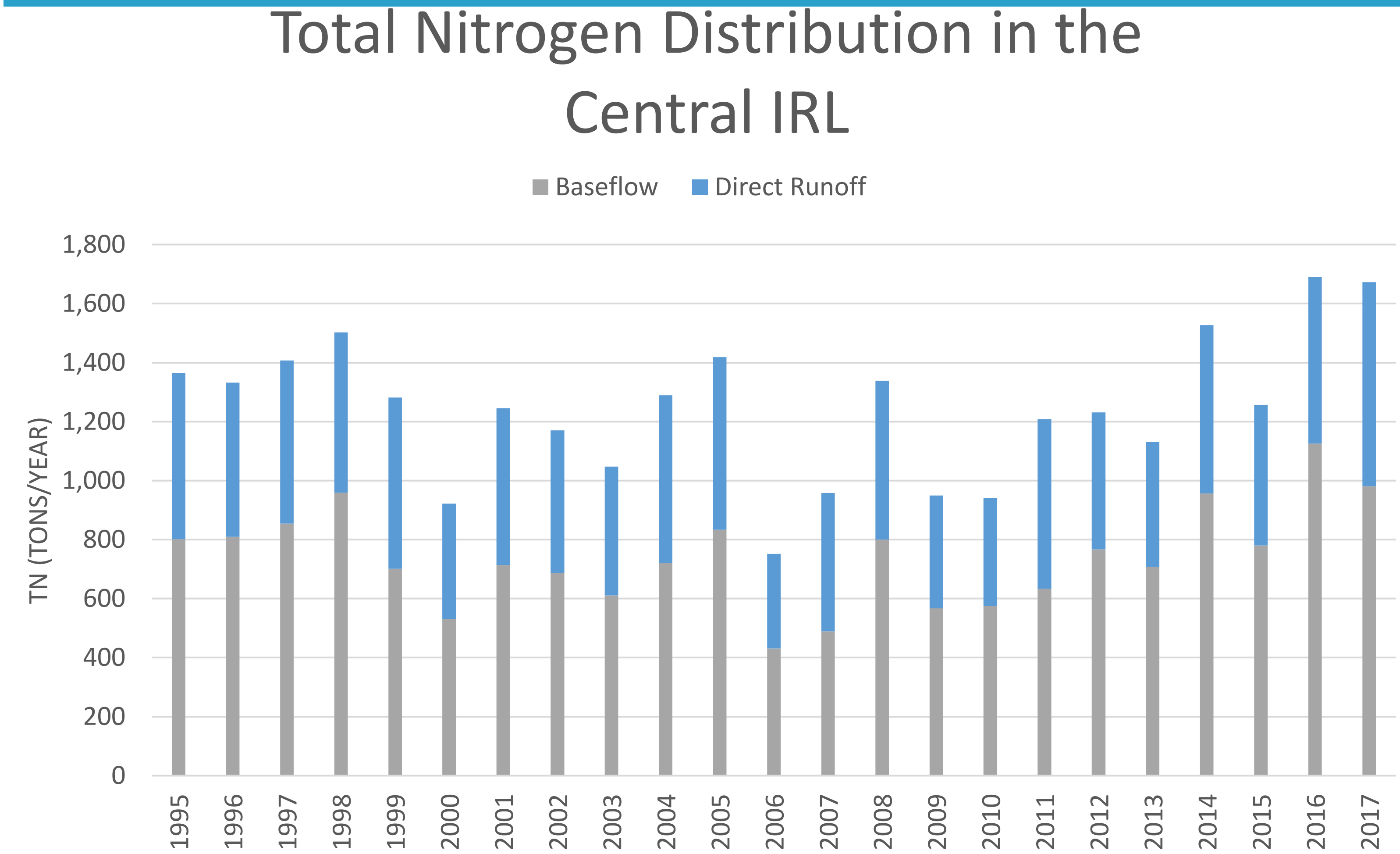
LATEST SWIL TN LOAD: BANANA RIVER



LATEST SWIL TN LOAD: NORTH IRL



LATEST SWIL TN LOAD: CENTRAL IRL



CUSTOM MODEL CALIBRATION FOR THE MILITARY BASES

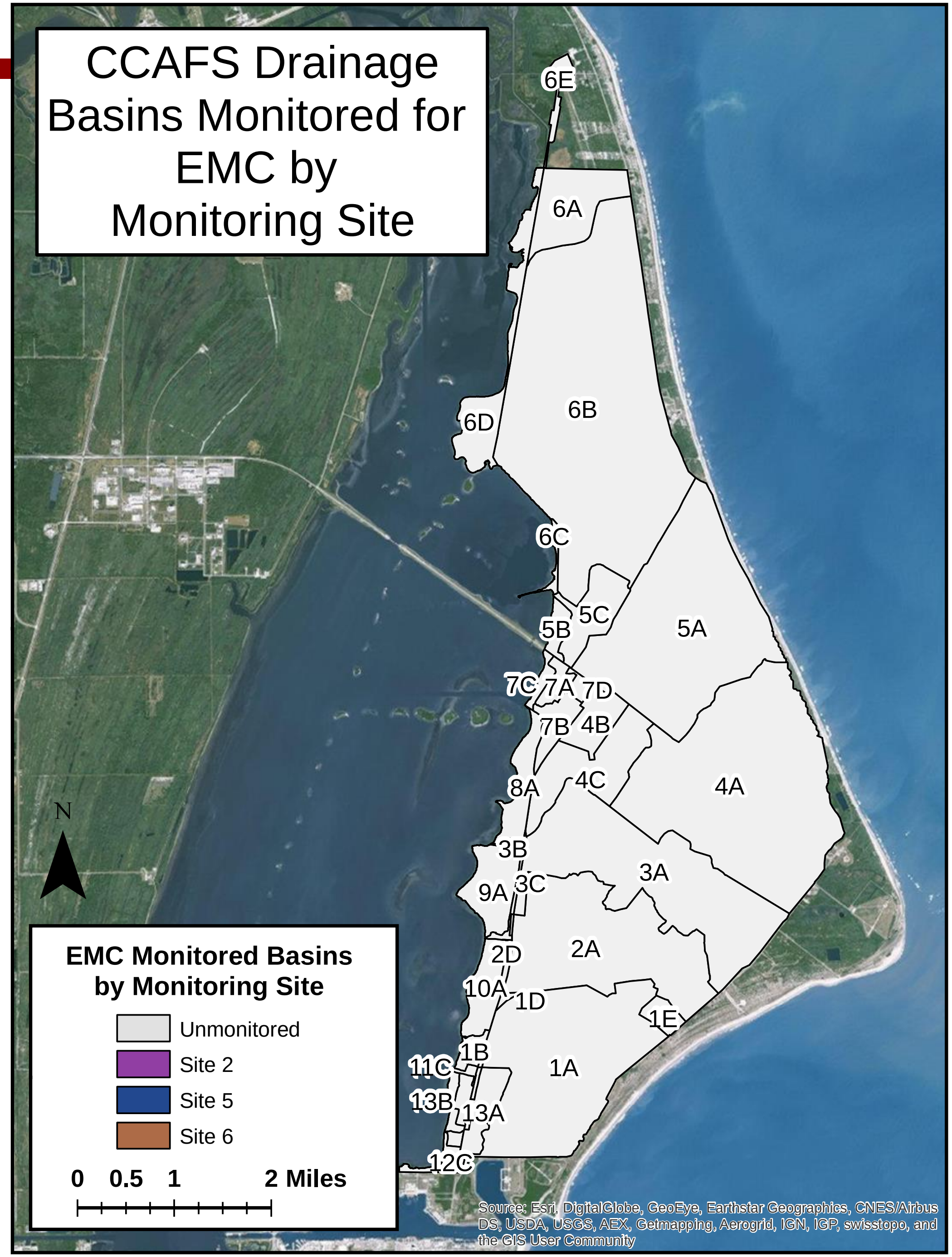
PAFB AND CCAFS

IN-SITU FIELD MONITORING FOR CUSTOM MODEL CALIBRATION

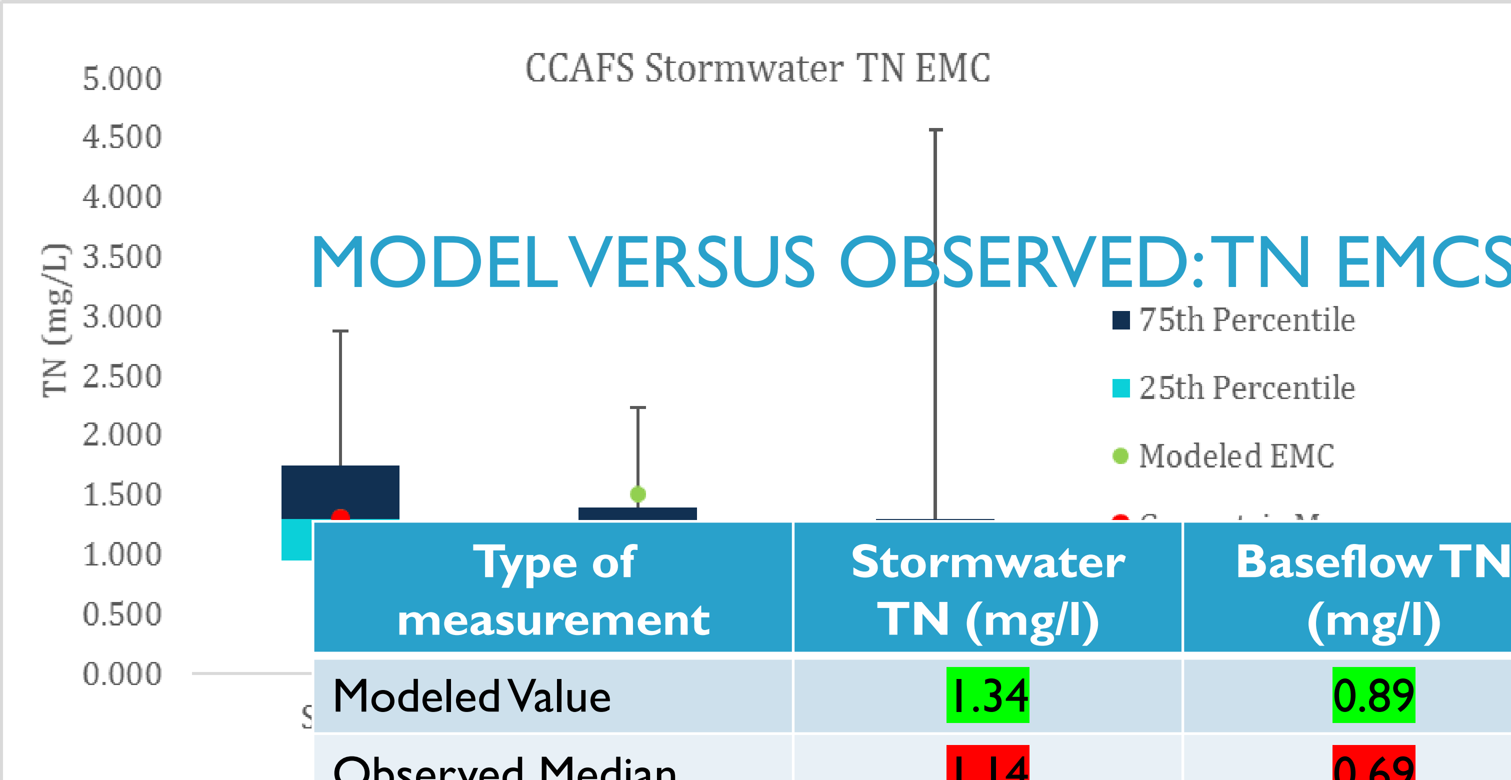
- Patrick Air Force Base (PAFB) and **Cape Canaveral Air Force Station (CCAFS)**
- Create a field validated site-specific model for updating a WQ Masterplan
- Comparison of original versus customized watershed loading models for the bases (PLSM and SWIL)
- Based on 5 years of field monitored runoff coefficients and mean event concentrations
- Includes extensive baseflow concentrations
- Includes field data from the Barrier Island

EVENT MEAN CONCENTRATIONS

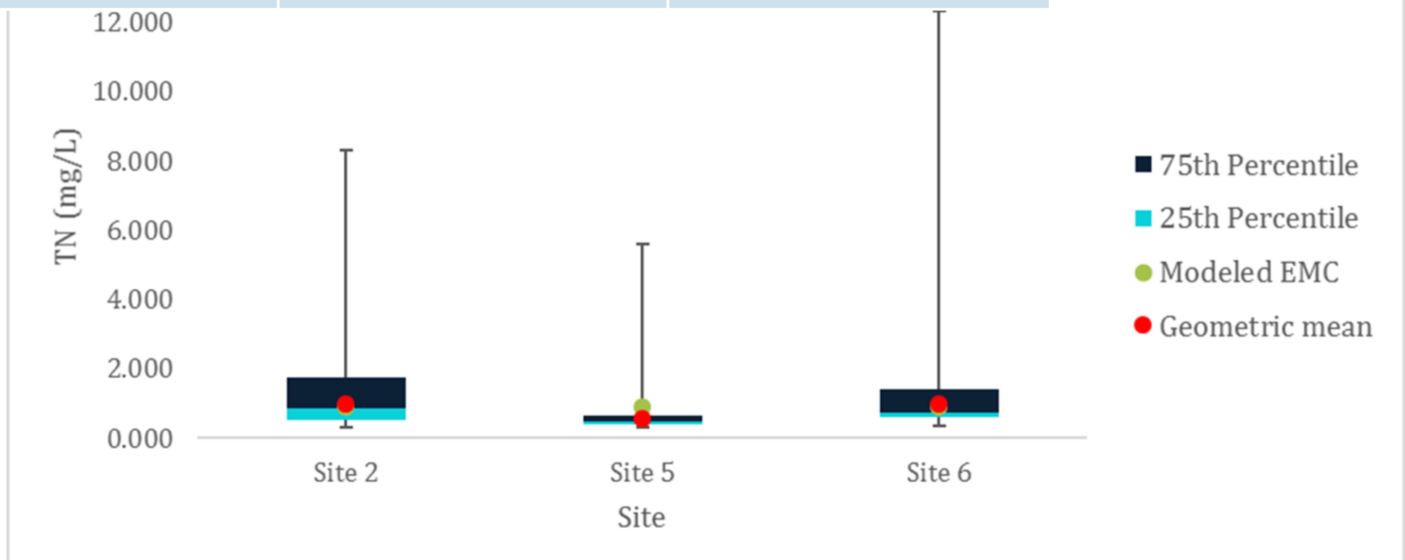
- Monitored since 2012, seasonal representation
- Separates stormwater EMCs and baseflows
- Monthly Baseflow EMCs are collected using 24-hour autosampler composites
- Stormwater EMCs collected after rainfall event using flow-paced autosampler
- TN, TP, TSS and constituents
- 3 Sites:
  - Site 2 – 16% developed, xeric hammock
  - Site 5 – 100% developed
  - Site 6 – 18% developed, upland flatwoods, xeric hammock



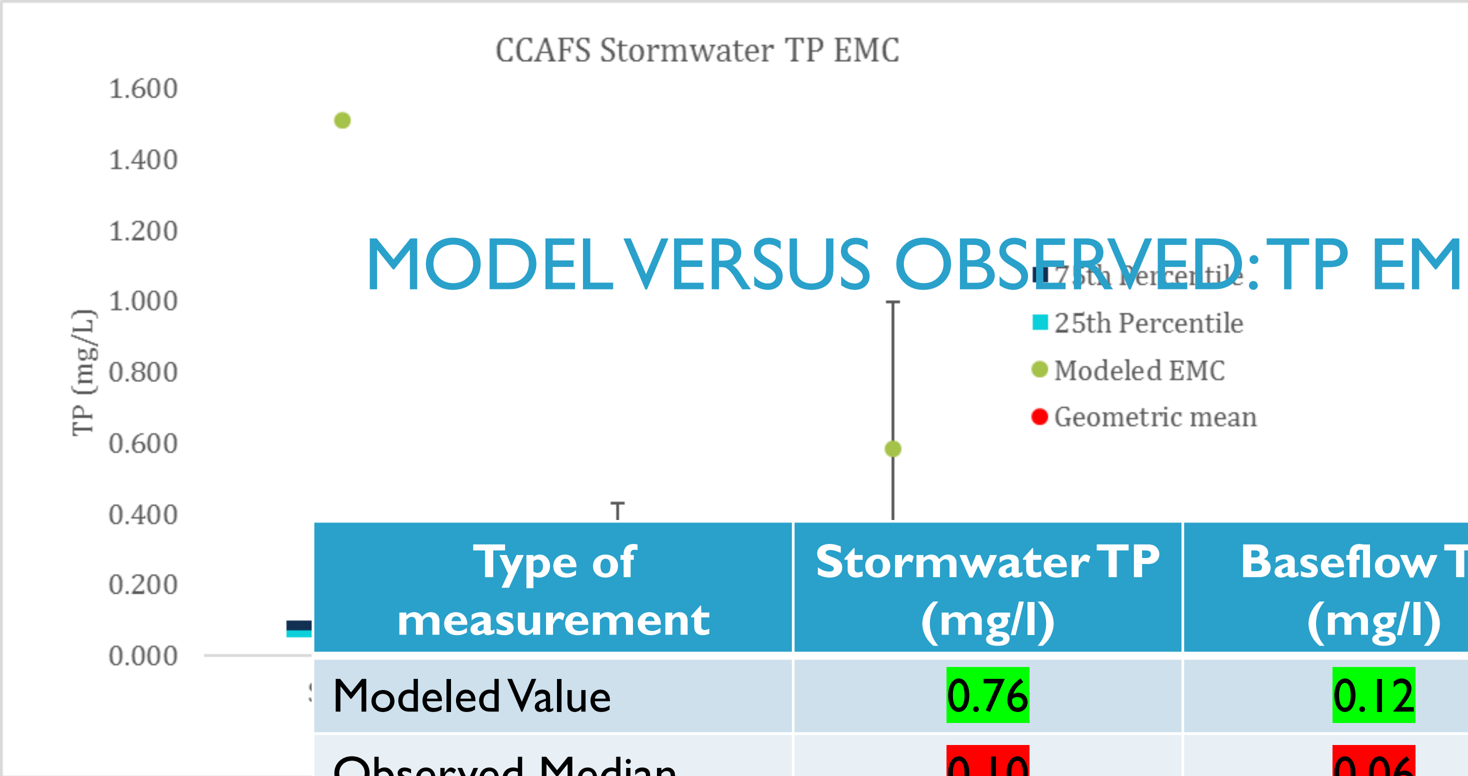
MODEL VERSUS OBSERVED: TN EMCS



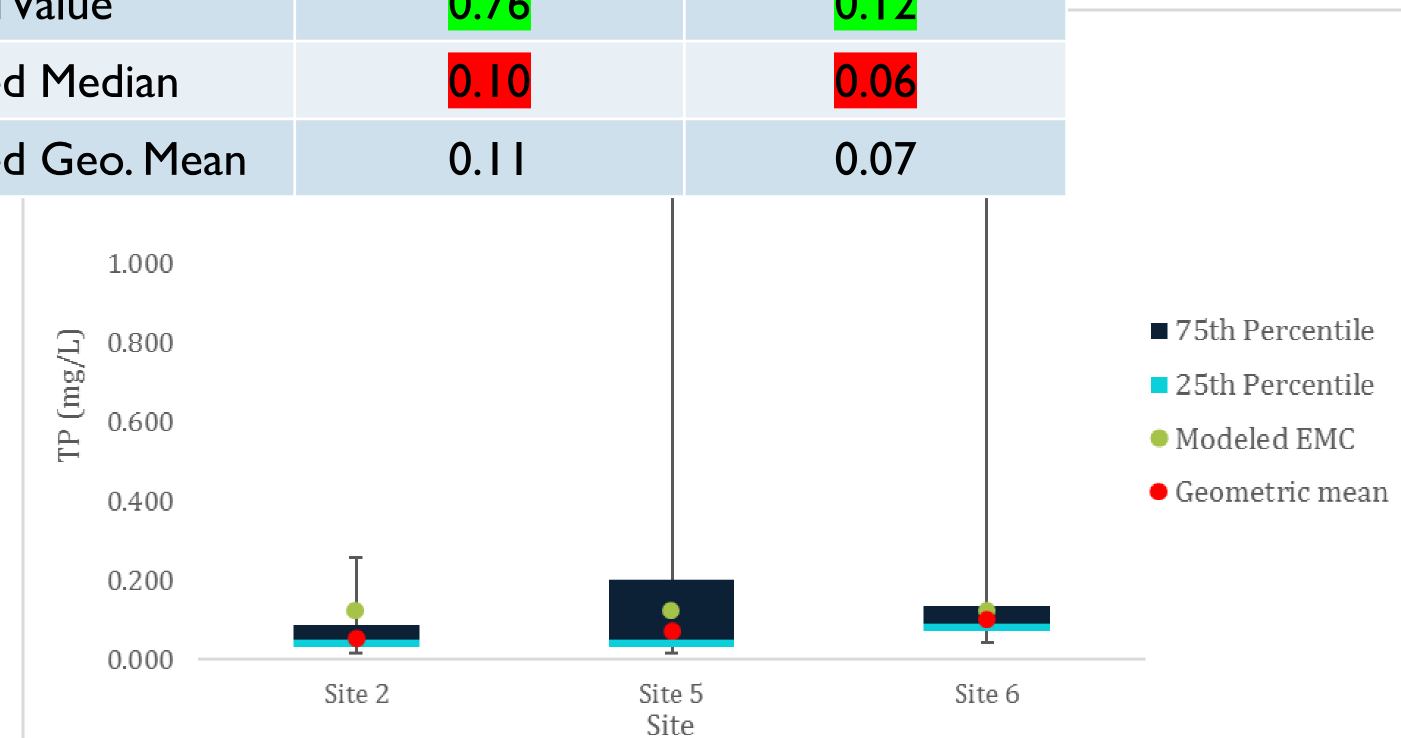
Type of measurement	Stormwater TN (mg/l)	Baseflow TN (mg/l)
Modeled Value	1.34	0.89
Observed Median	1.14	0.69
Observed Geo. Mean	1.11	0.84



MODEL VERSUS OBSERVED: TP EMCS

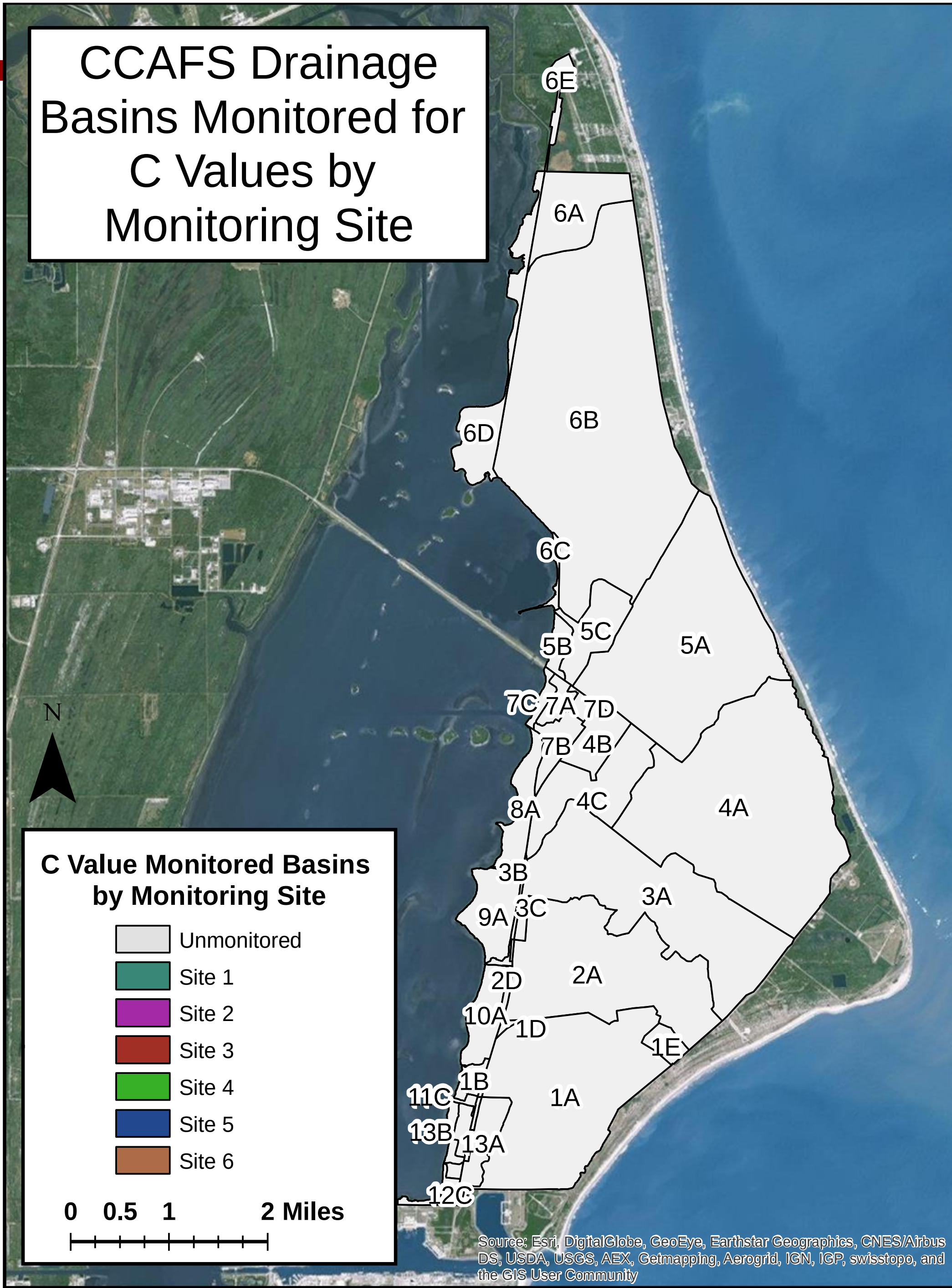


Type of measurement	Stormwater TP (mg/l)	Baseflow TP (mg/l)
Modeled Value	0.76	0.12
Observed Median	0.10	0.06
Observed Geo. Mean	0.11	0.07

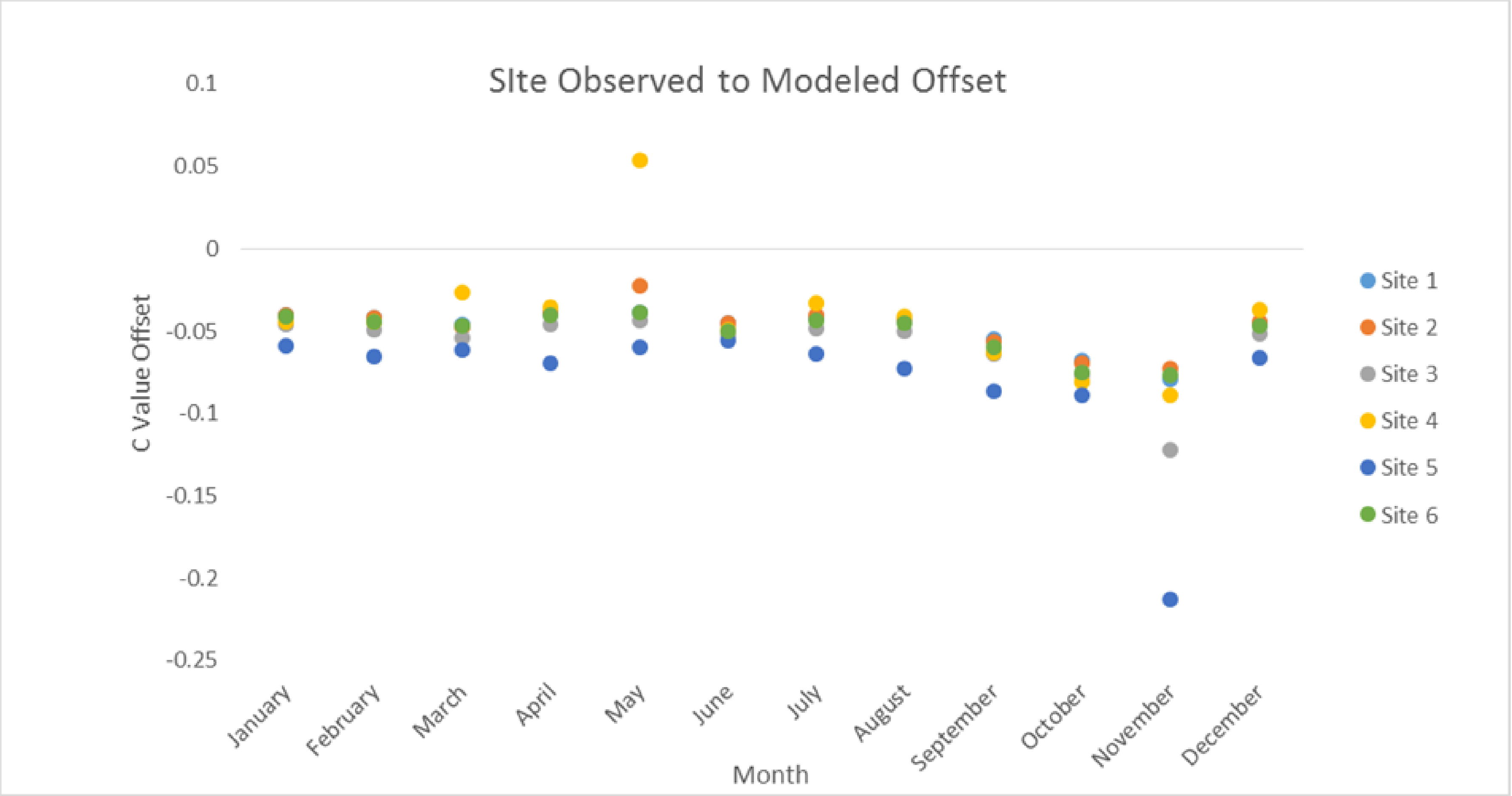


RUNOFF COEFFICIENTS

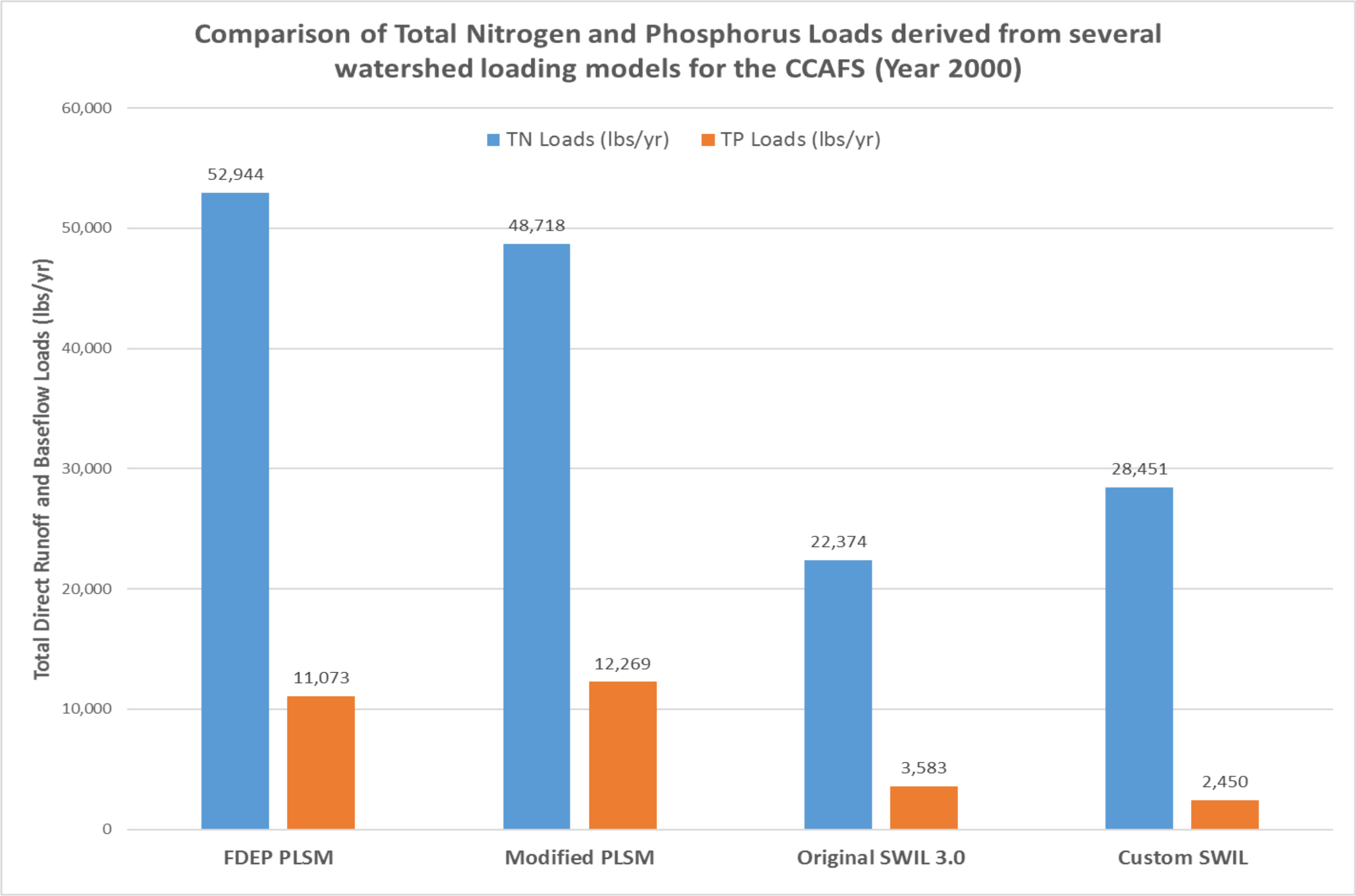
- Monitored since 2012, some stations changed/dropped
- Flow monitored with velocity flow meter or ultrasonic meter
- Rainfall gage near most sites, allowing C calculations
- EMCs collected throughout the year
- EMCS variety of rainfall event types (.25" to >1")
- **CCAFS: 6 sites**



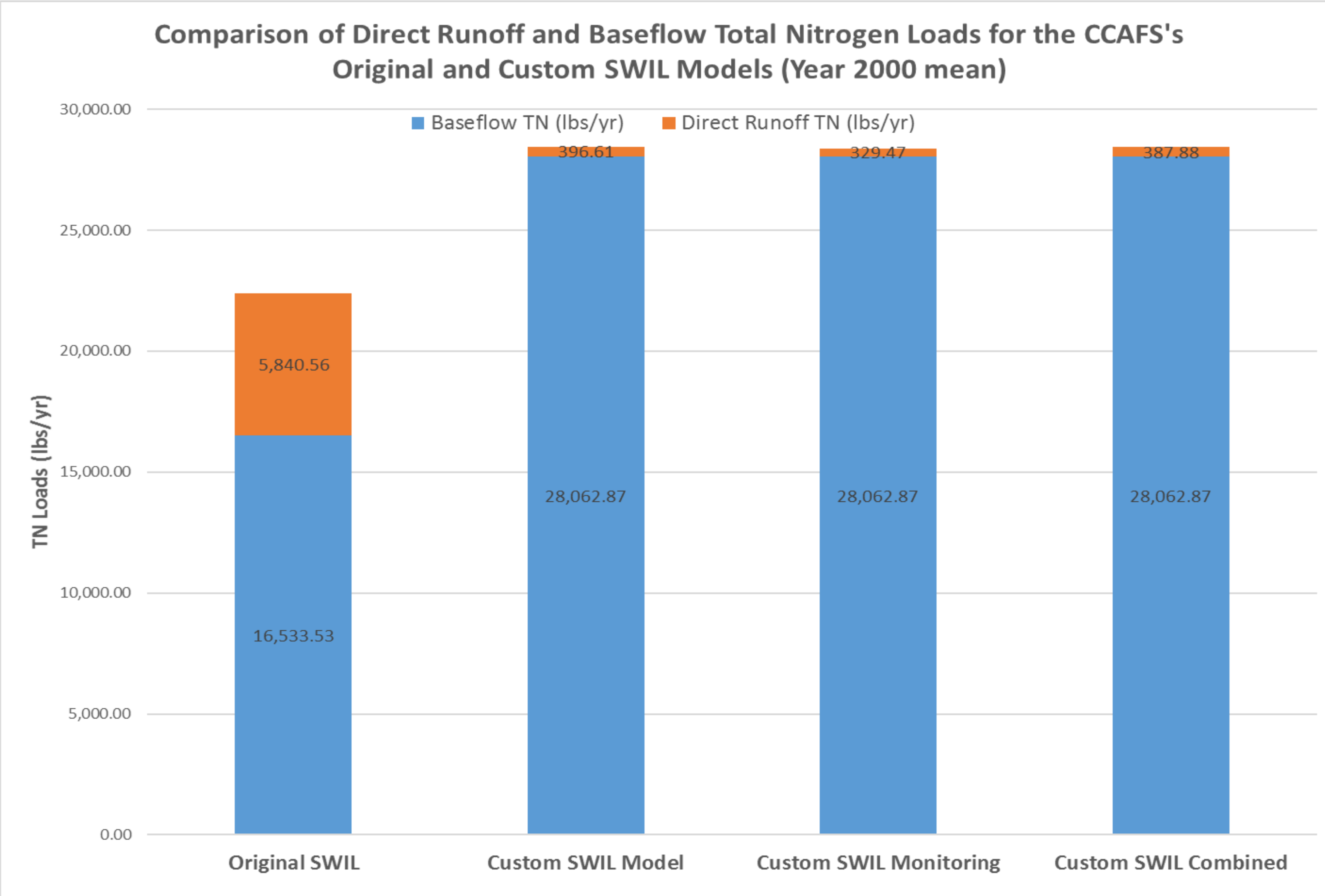
CCAFS RUNOFF COEFFICIENTS (C)



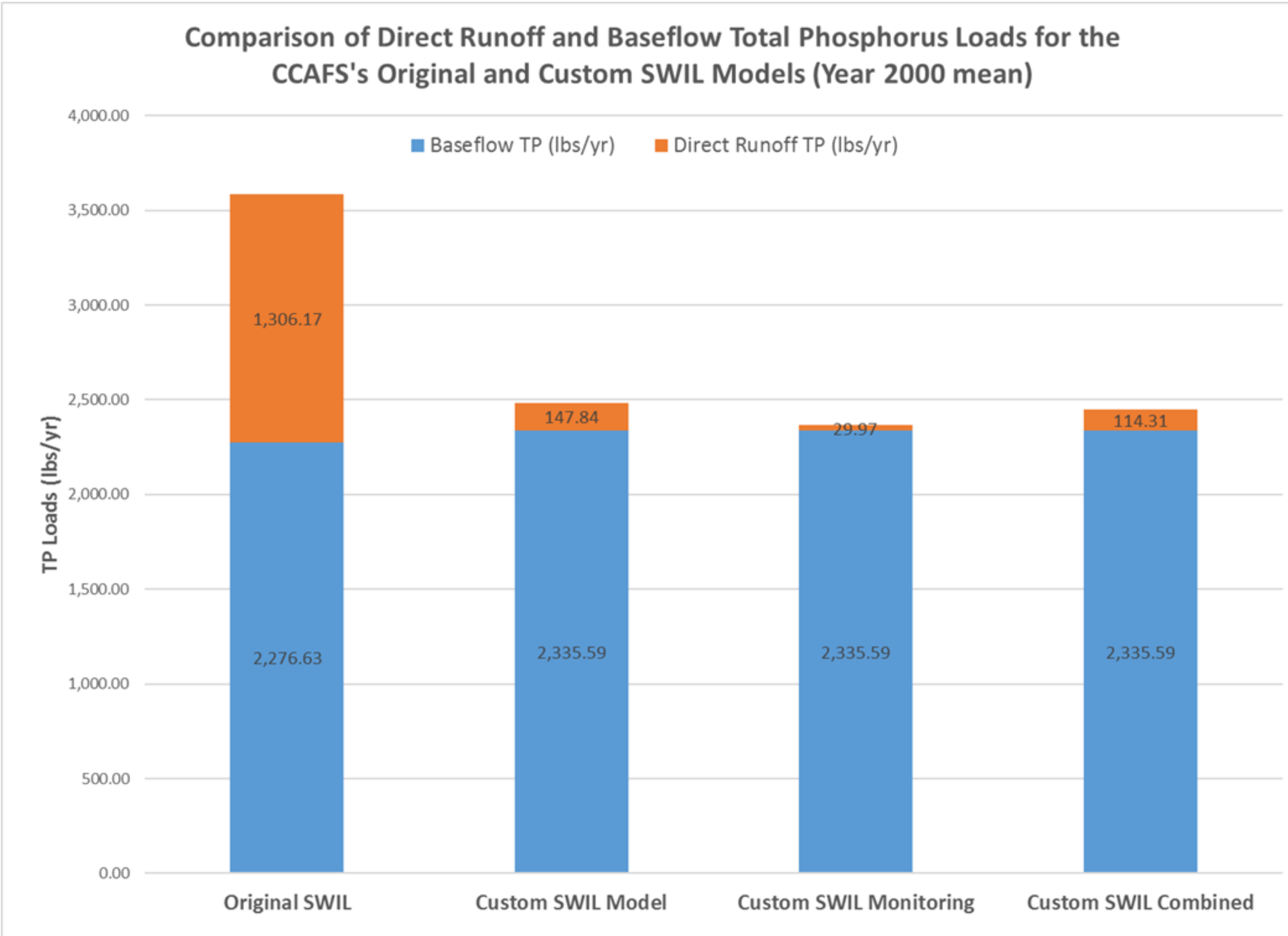
CCAFS MODEL RESULTS



DIRECT RUNOFF VERSUS BASEFLOW TN LOADS



DIRECT RUNOFF VERSUS BASEFLOW TP LOADS



WHAT IS NEXT?

SWIL USED FOR BMAP UPDATES: LOAD ESTIMATING TOOL

- 50 x 50-meter (m) cell size (higher resolution than PLSM)
- Land use is from 2015 and is derived from water management districts land use and property appraiser data and local government natural communities land cover, where available
- Treatment layer (BMPs) also in sync with land use (2015)
- Period of Record (POR) for Rainfall: 2004 - 2017
- Converted dynamic model run to static
- Output is a static mean annual total and dry season (Jan-May totals) for volumes, TN and TP loads by cell size per unit acre

Note: Retrofit projects are not included in the model and credit needs to be recalculated using the new model

MODEL REVISION COMING

- Data request and scoping of revisions input from stakeholder will be requested by FDEP
- Based on updated stakeholder data
- What should we update?
  - Groundwater component by location, treatment (septic, sewer, sewer w/reclaimed, natural), denitrification
  - BMP Efficiencies
  - Updated soil data
  - Update land use to current
  - Impoundments
  - Others