Developing a Custom Watershed Loading Model to Refine the Indian River TMDL

Part 1: Model Parameters

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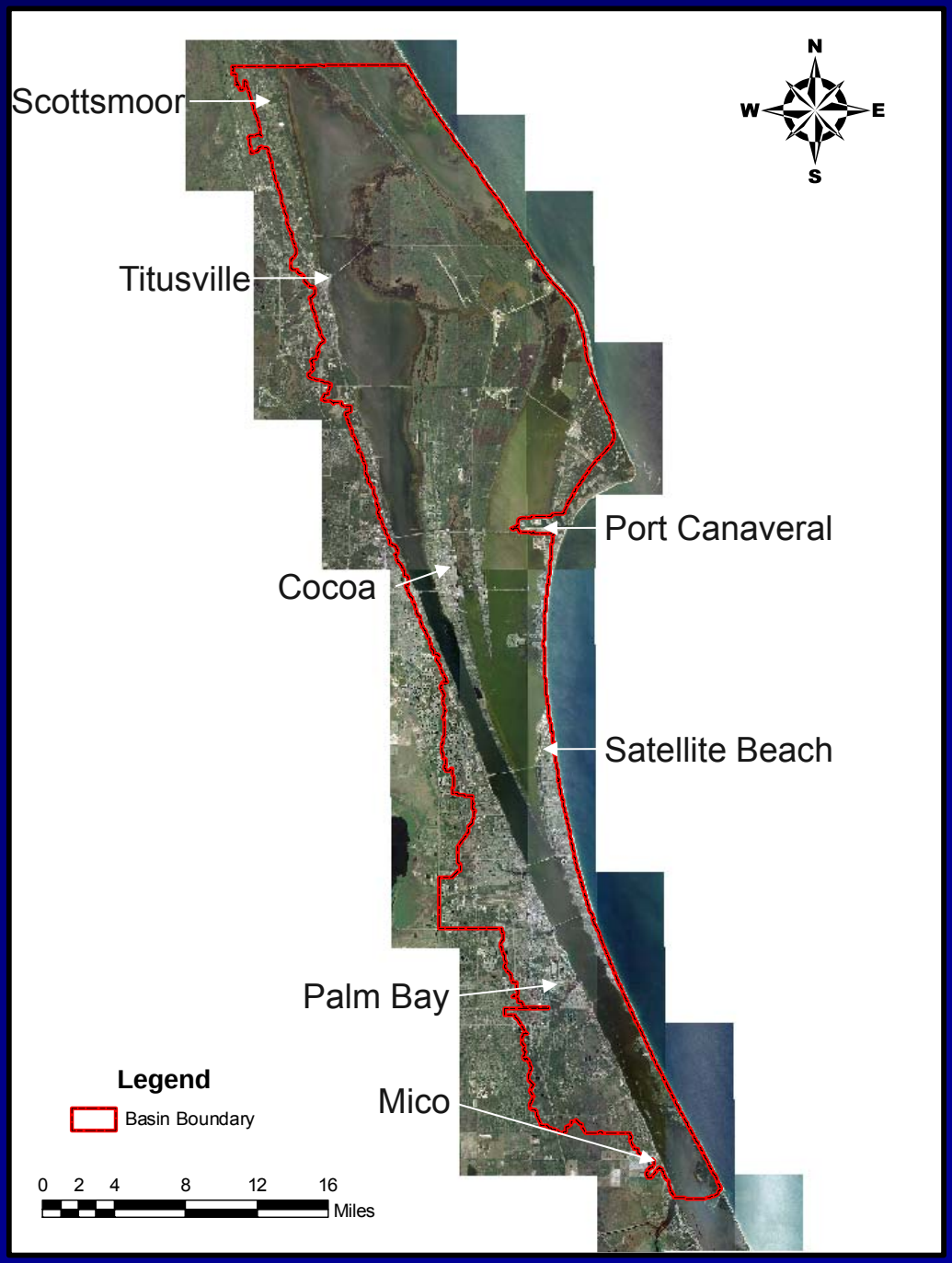
Brevard County IRL Watershed Boundary

~ 430,000 acres



Introduction

- A TMDL was issued by FDEP for the Indian River Lagoon (IRL) and Banana River Lagoon (BRL) on March 18, 2009
  - Both IRL and BRL listed as impaired for nutrients and DO
  - Nutrients said to stimulate algae which clouded seagrass and reduced the extent of coverage
- Watershed loadings were estimated by SJRWM using
  - Pollutant Loading Screening Model (PLSM) developed by SJRWMD
    - Uses emc concentrations and runoff coefficients (C values)
  - Hydrologic Simulation Program Fortran (HSPF)
  - PLSM provided better agreement and was selected
- Issues with TMDL
  - No separation of runoff and baseflow which resulted in excessively high C values
  - Soil layers did not conform to visual observations of soil characteristics
    - Ex. Much of the barrier island soils were listed in HSG D
- Brevard County spearheaded a project to revise the TMDL to address the perceived deficiencies

Pollutant Loading Screening Model (PLSM)

PLSM is based on the USEPA Simple Method which uses the following formula:

$$L_i = P \times R_i \times EMC_i \times A_i \times BMP$$

where:

L_i = mass loading

P = annual precipitation

R_i = runoff coefficient for land use i

EMC_i = runoff concentration

A_i = area of land use i

BMP_i = BMP removal

ERD Work Efforts

- ERD developed the input data and hydrologic algorithms for the revised IRL model
  - Revise soil characterization data
  - Develop land use/hydrologic characteristics
  - Calculate runoff coefficients
  - Develop runoff emc values
  - Evaluate baseflow contributions
  - Develop BMP efficiencies
  - Model calibration

1. Rainfall Characteristics

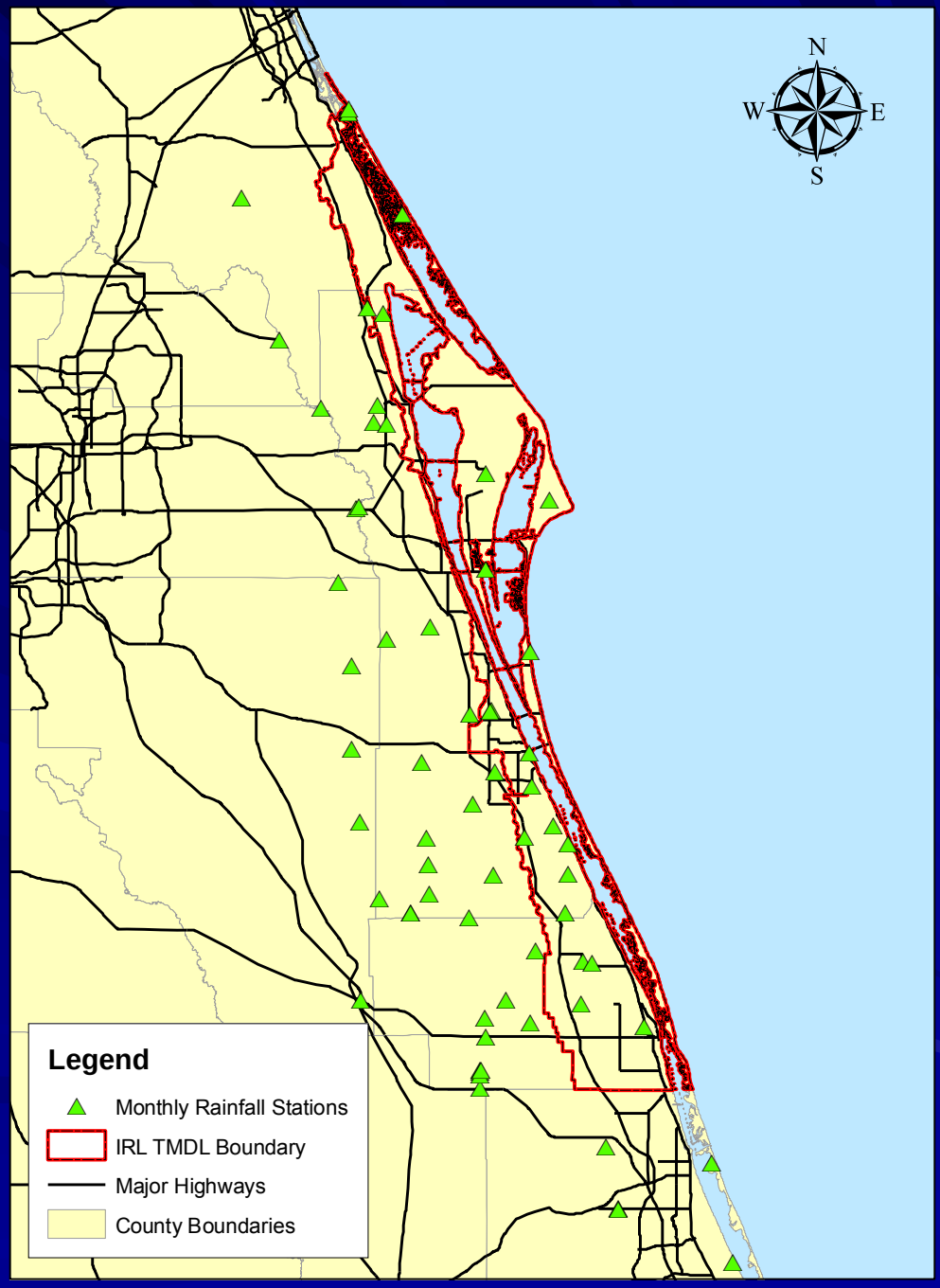
Historical Daily Rainfall Recording Sites in the IRL

-59 sites

- Period of record: 10 - >60 yrs

- Monthly rainfall data extracted from each site

- Used to develop monthly rainfall isopleths for period from 1995 – 2010 (16 year period)

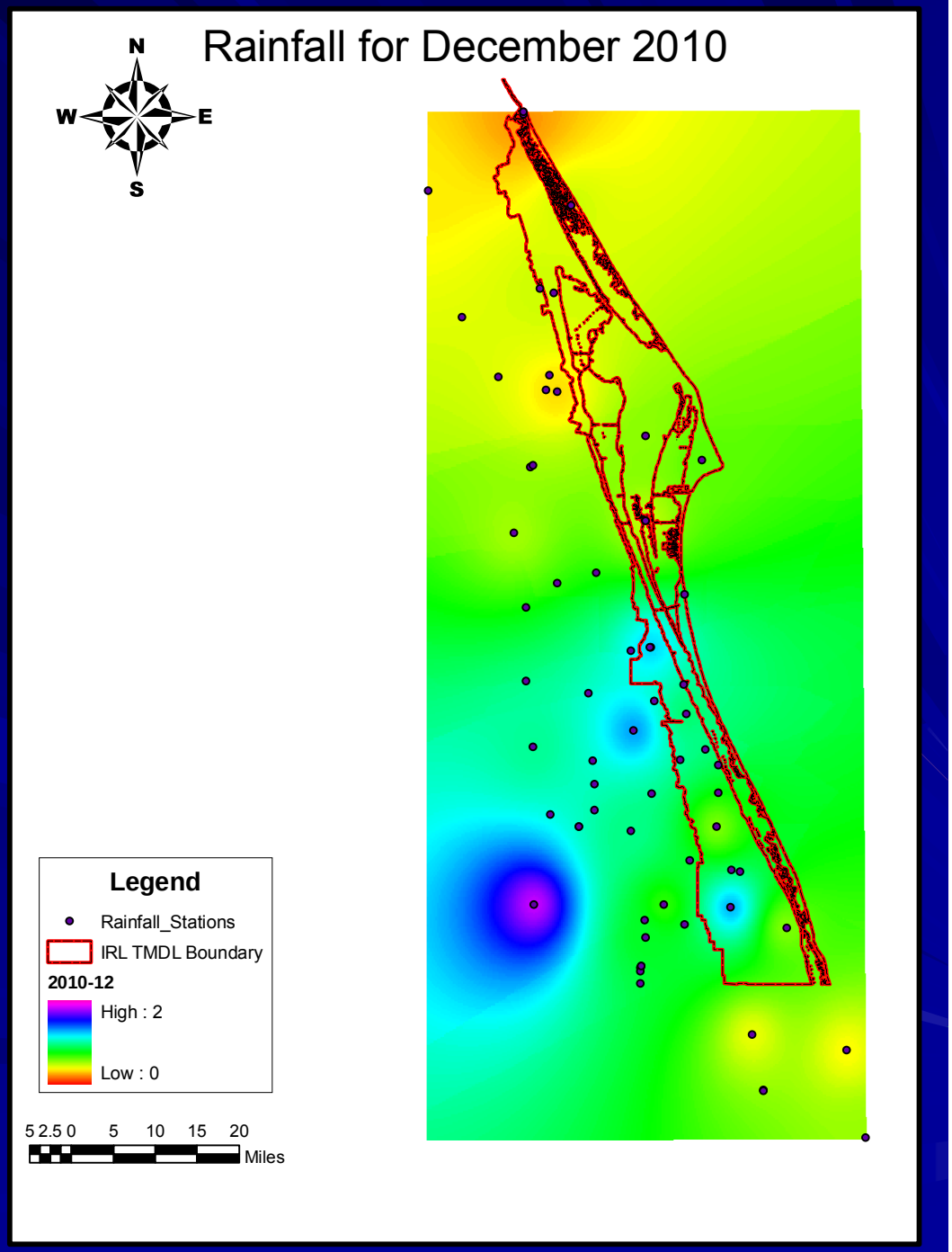


Example GIS-Based Monthly Rainfall Isopleth Map for December 2010

-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)



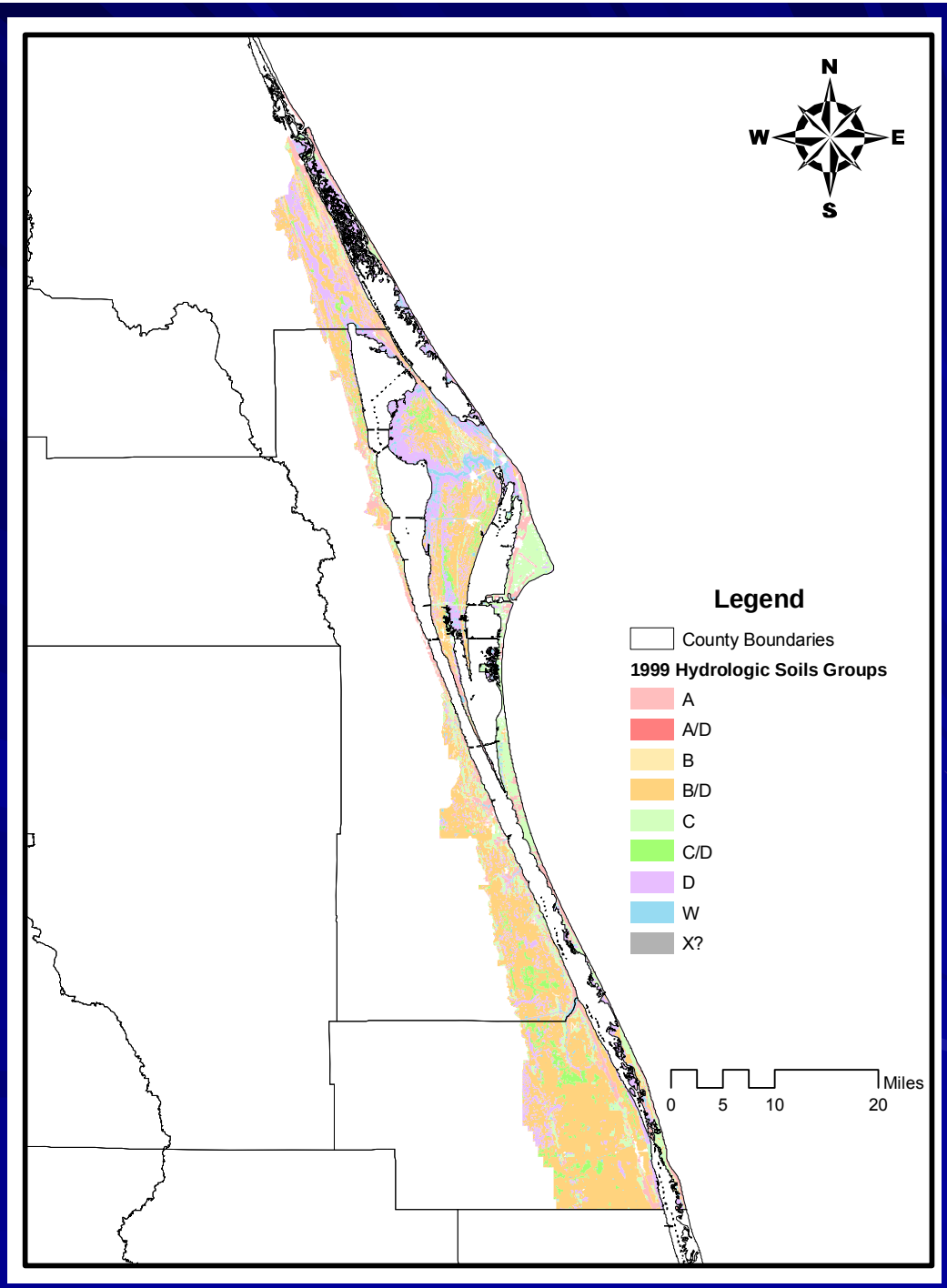
2. Soil Characteristics

1999 Hydrologic Soil Groups

Problems:

- Many areas appear to be incorrectly classified

- Large areas listed as “Urban” or “X” with no soil grouping

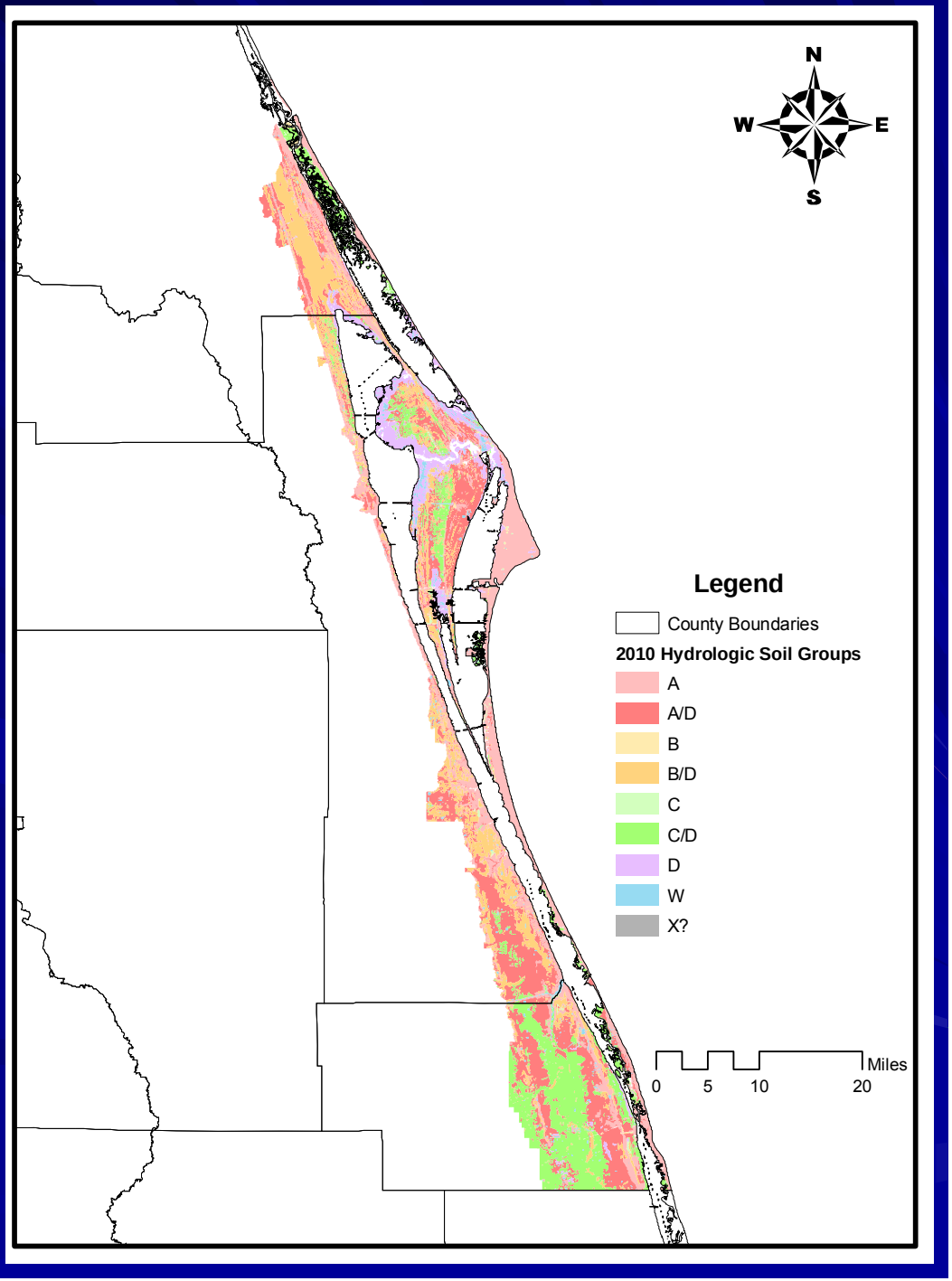


2010 Hydrologic Soil Groups

Improvements:

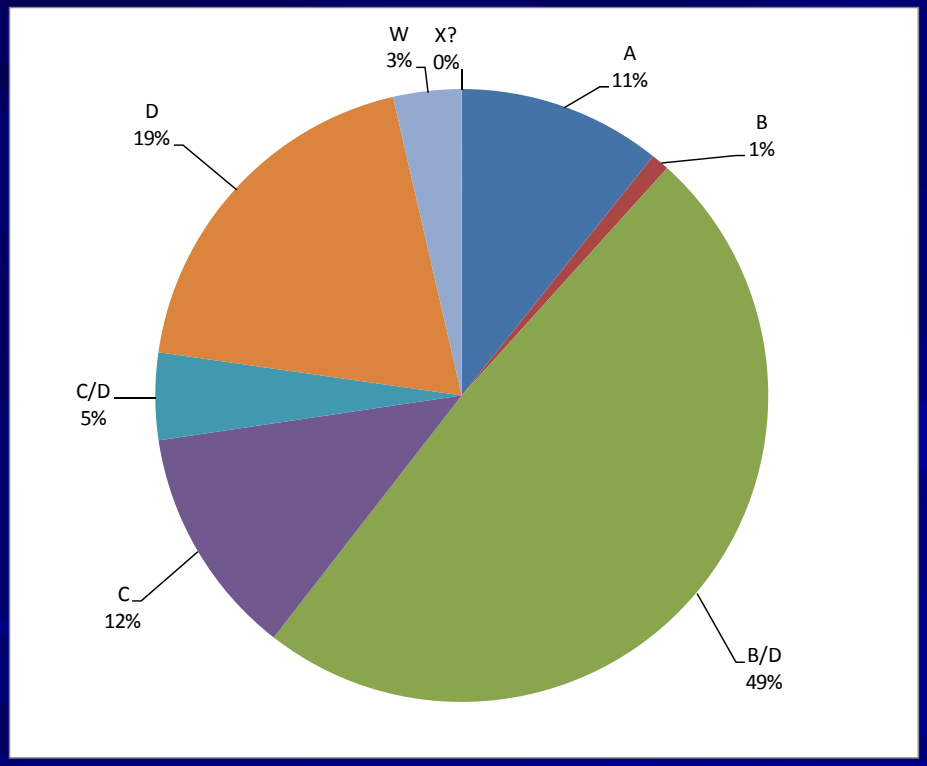
-Most incorrect classifications have been corrected

- Still have urban areas with no soil grouping (blank)

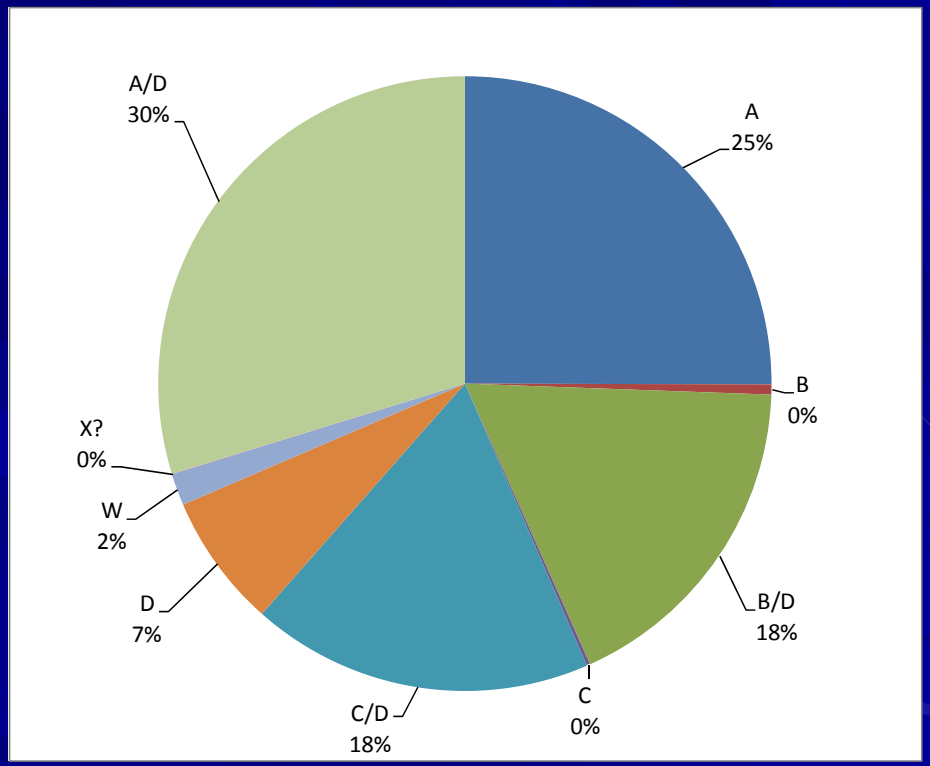


Comparison of 1999 and 2011 Hydrologic Soil Groupings

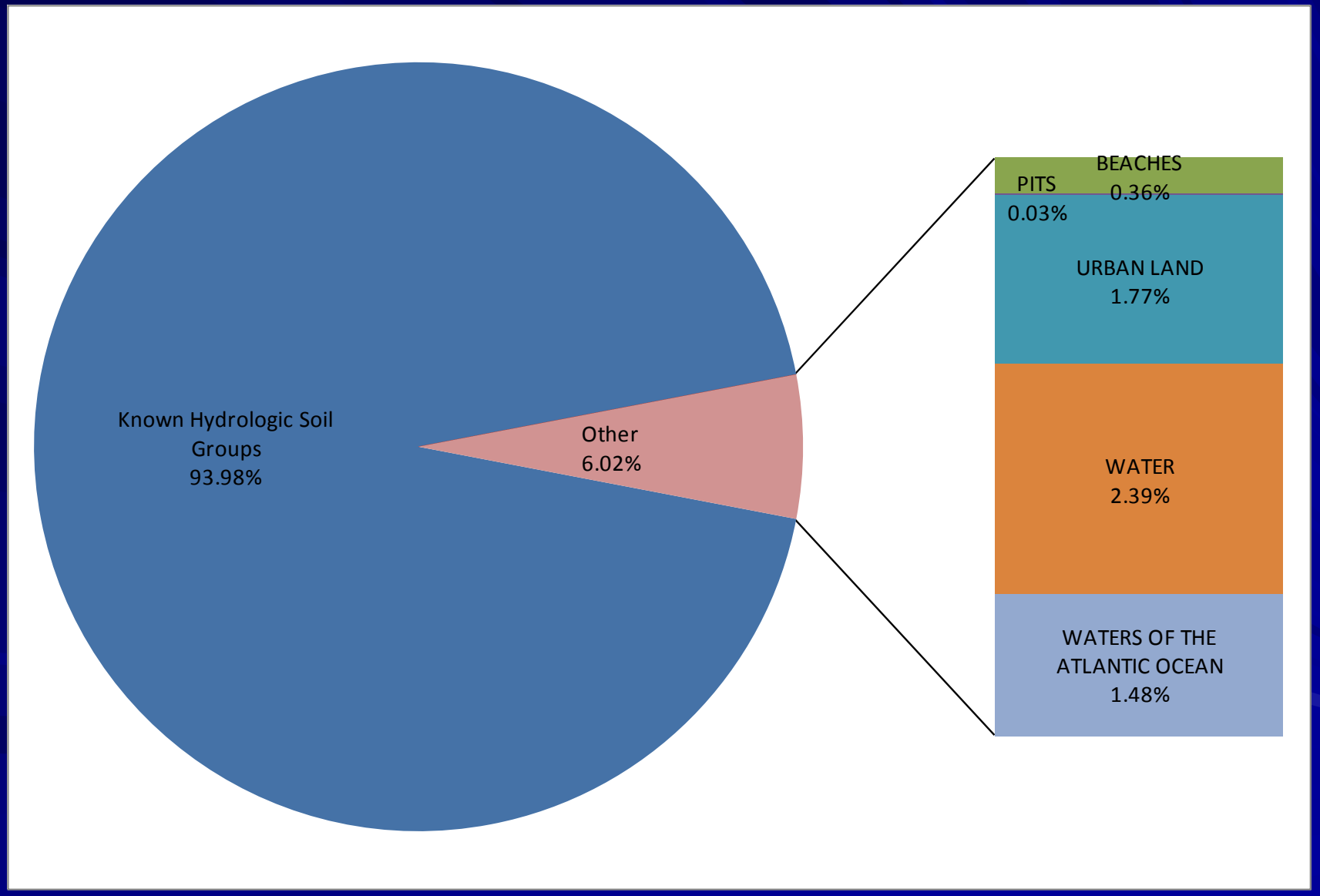
1999



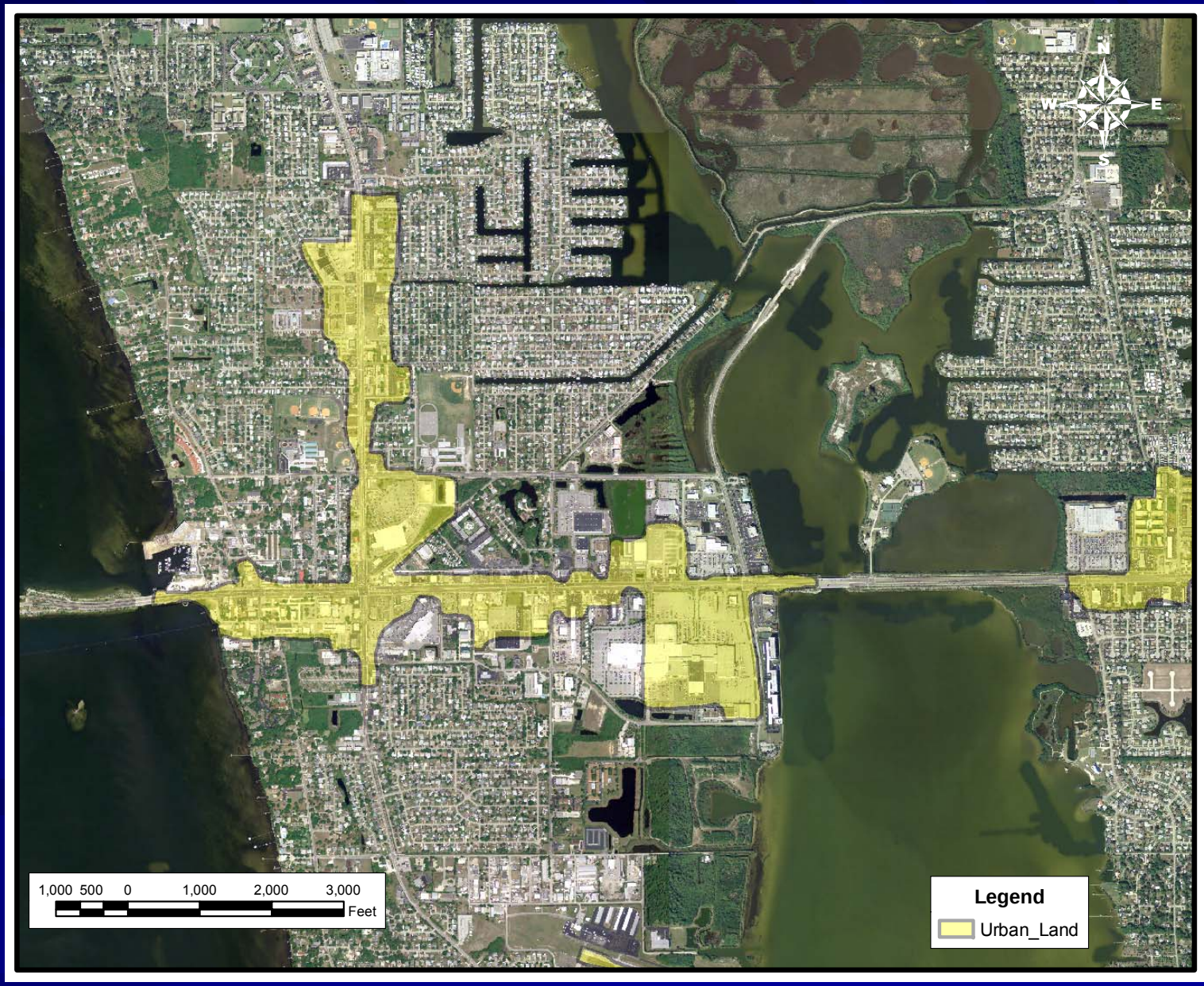
2010



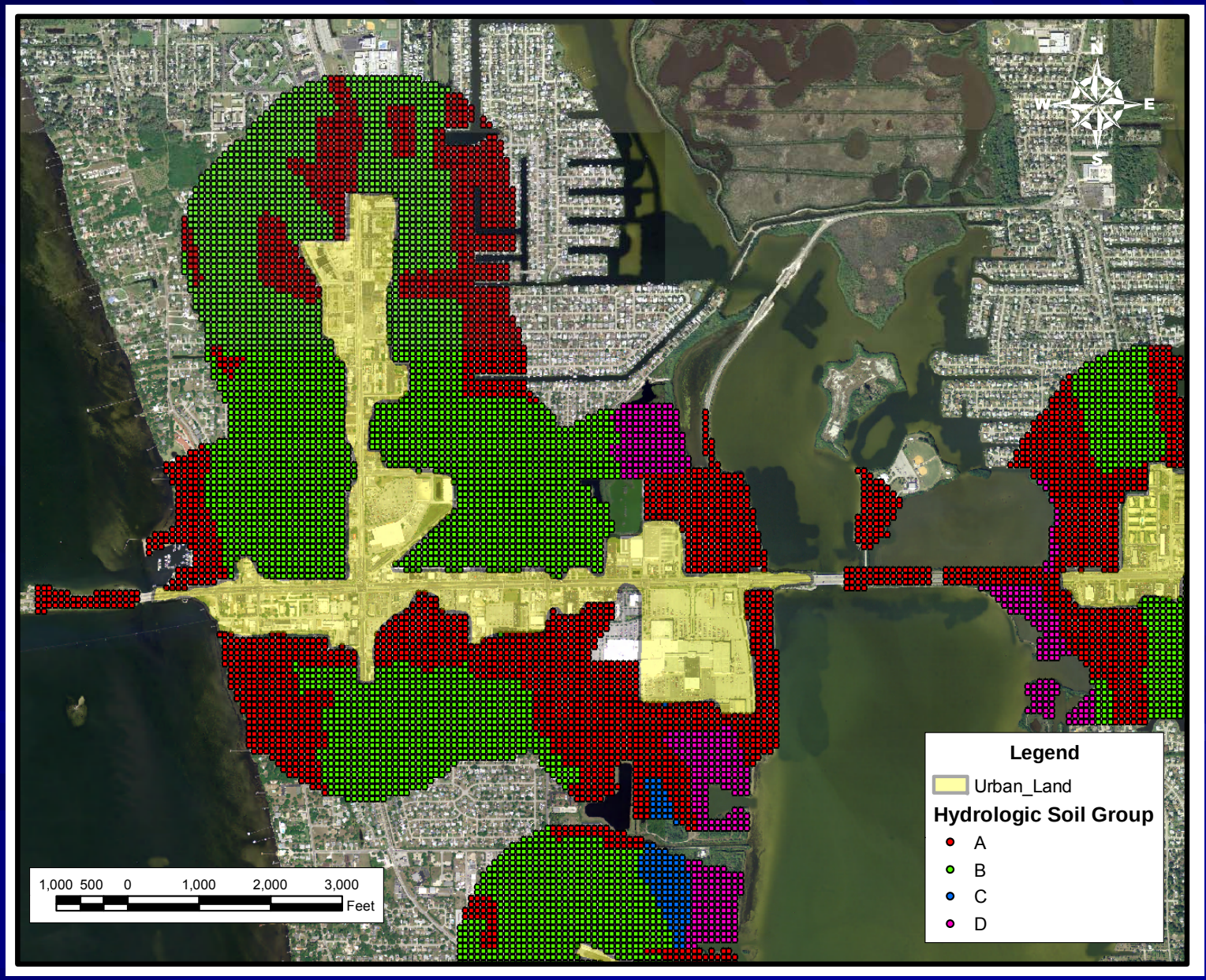
2010 Blank Hydrologic Soil Groups



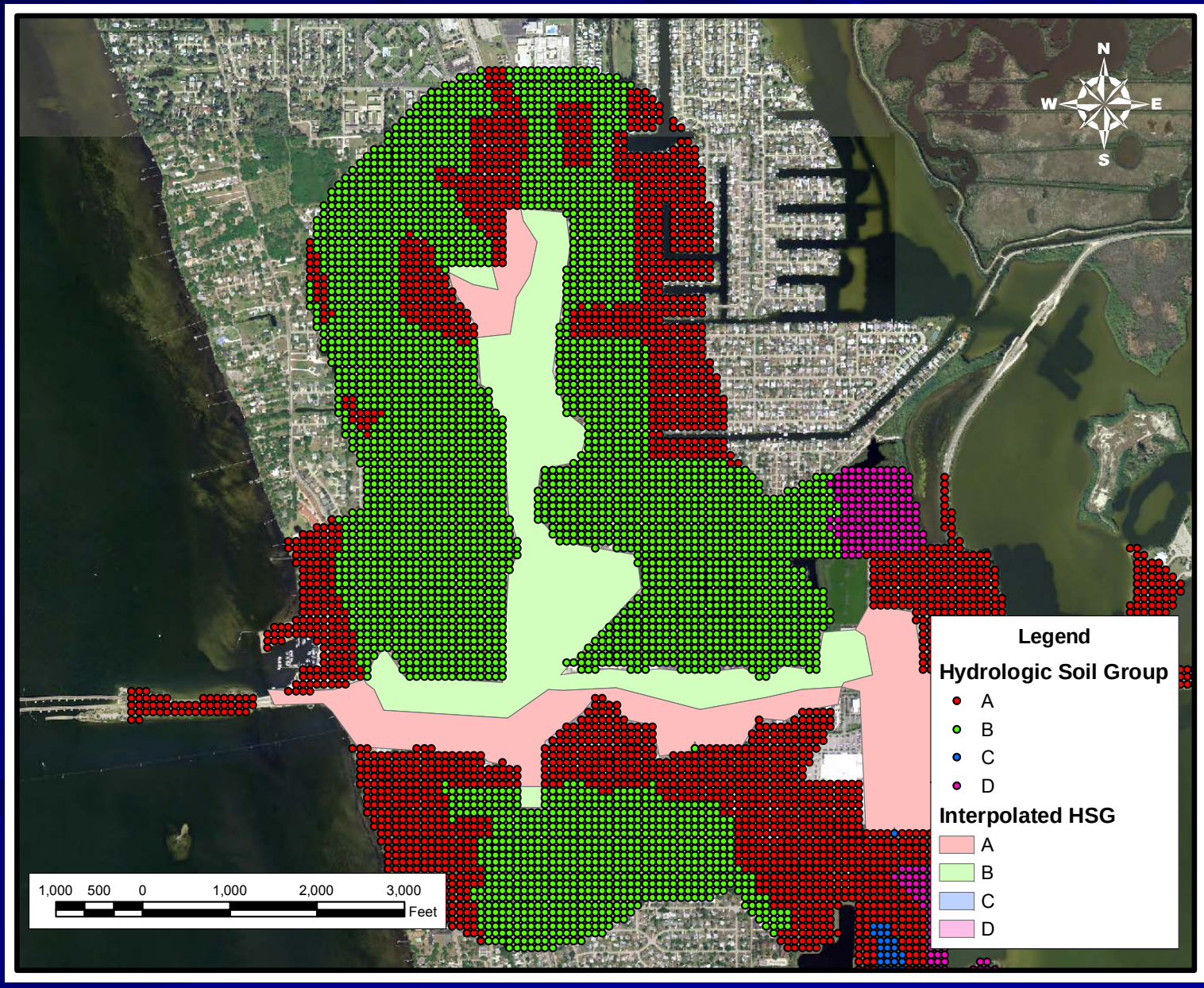
Examples of Urban or Blank Soil Groupings



HSG Estimation Methodology



HSG Estimation Methodology – cont.



Consolidated Land Use Summary for the IRL

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

Land Use	Area (acres)	Curve Number	
		1999	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**
	C Value	**0.377**	**0.250**

3. Land Use and Hydrologic Characteristics

Land Use Summary for the IRL

-Florida Land Use and Cover Classification System (FLUCCS)

-Very detailed land use breakdown

FLUCCS	Description	Area (ac)	Percent (%)	Cumulative Percent (%)
1200	Residential, Medium Density-Two-five dwellingunits per acre	4245.8	10.35	10.35
3200	Shrub and Brushland	3303.2	8.05	18.39
2210	Citrus groves	2872.1	7.00	25.39
4110	Pine flatwoods	2168.5	5.28	30.68
6170	Mixed wetland hardwoods	2100.3	5.12	35.80
6420	Saltwater marshes	2048.9	4.99	40.79
1100	Residential, Low Density-Less than two dwelling units/acre	1628.6	3.97	44.76
4340	Hardwood Conifer Mixed	1511.1	3.68	48.44
1300	Residential, High Density	1296.5	3.16	51.60
6460	Mixed scrub-shrub wetland	1246.5	3.04	54.64
2110	Improved Pasture	1225.8	2.99	57.62
1400	Commercial and Services	1009.3	2.46	60.08
6120	Mangrove swamp	990.6	2.41	62.50
6410	Freshwater marshes	960.8	2.34	64.84
3100	Herbaceous Dry Prairie	935.5	2.28	67.12
2120	Unimproved Pastures	903.4	2.20	69.32
3300	Mixed Rangeland	746.7	1.82	71.14
5400	Bays and estuaries	746.0	1.82	72.96
6300	Wetland Forested Mixed	712.9	1.74	74.69
5430	Enclosed saltwater ponds within a salt marsh	651.5	1.59	76.28
4200	Upland Hardwood Forest	630.7	1.54	77.82
6430	Wet prairies	591.4	1.44	79.26
4210	Xeric oak	585.3	1.43	80.68
1750	Governmental	551.2	1.34	82.03
5300	Reservoirs	551.1	1.34	83.37
6181	Cabbage palm hammock	518.5	1.26	84.63
8140	Roads and Highways	518.2	1.26	85.90
1700	Institutional (Educational,religious,health and military facilities)	469.8	1.14	87.04
1820	Golf Course	460.6	1.12	88.16
1180	Residential, Rural < or = 0.5 dwelling units/acre	448.0	1.09	89.26
1900	Open Land	354.9	0.86	90.12
6210	Cypress	307.7	0.75	90.87
8110	Airports	303.6	0.74	91.61
5100	Streams and waterways	299.8	0.73	92.34
2130	Woodland Pasture	268.6	0.65	93.00
7410	Rural land in transition without positive indicators of intended activity	207.2	0.50	93.50
1550	Other Light Industrial	198.3	0.48	93.98
2600	Other Open Lands - Rural	149.6	0.36	94.35
1290	Medium Density Under Construction	144.7	0.35	94.70
1730	Military	133.5	0.33	95.03
1850	Parks and Zoos	133.1	0.32	95.35

Land Use Summary for the IRL – cont.

Problems:

- Loading calculations require runoff characteristics for all identified land use categories
- Runoff characterization data are not available for all of the listed land use categories

FLUCCS	Description	Area (ac)	Percent (%)	Cumulative Percent (%)
8330	Water supply plants	7.9	0.02	99.79
8200	Communications	7.3	0.02	99.81
6500	Non-vegetated Wetland	7.2	0.02	99.83
1620	Sand and Gravel Pits	7.1	0.02	99.84
2200	Tree Crops	6.7	0.02	99.86
1800	Recreational	5.4	0.01	99.87
6110	Bay swamps	4.9	0.01	99.88
1530	Mineral Processing	4.7	0.01	99.90
1460	Oil and Gas Storage(except industrial use or manufacturing)	4.5	0.01	99.91
1520	Timber Processing	4.4	0.01	99.92
6172	Mixed Shrubs	4.2	0.01	99.93
1830	Race Tracks(horse, dog, car, motorcycle)	3.0	0.01	99.93
7200	Sand other than beaches	2.5	0.01	99.94
1540	Oil and Gas Processing	2.4	0.01	99.95
1870	Stadiums (not associated withhigh schools, colleges, or universities)	2.2	0.01	99.95
3210	Palmetto Prairies	2.1	0.01	99.96
1320	Mobile Home Units	2.0	0.00	99.96
8180	Auto parking facilities - when not directly related to other land uses	2.0	0.00	99.97
2610	Fallow cropland	1.6	0.00	99.97
5250	Marshy Lakes	1.6	0.00	99.97
1110	Fixed Single Family Units	1.6	0.00	99.98
2320	Poultry feeding operations	1.5	0.00	99.98
4280	Cabbage palm	1.2	0.00	99.99
2420	Sod farms	1.0	0.00	99.99
8130	Bus and truck terminals	0.9	0.00	99.99
1562	Prestressed concrete plants	0.8	0.00	99.99
5410	Embayments opening directly to the Gulf or Ocean	0.8	0.00	99.99
1310	Fixed Single Family Units	0.6	0.00	100.00
1590	Industrial Under Construction	0.5	0.00	100.00
2500	Specialty Farms	0.5	0.00	100.00
8115	Grass Airports	0.4	0.00	100.00
5710	Atlantic Ocean	0.3	0.00	100.00
5120	Channelized waterways, canals	0.2	0.00	100.00
2220	Fruit Orchards	0.1	0.00	100.00
	Total:	**41,039**		

Consolidated Land Use Summary for the IRL

- Listed land use categories all have runoff characterization data

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 land use

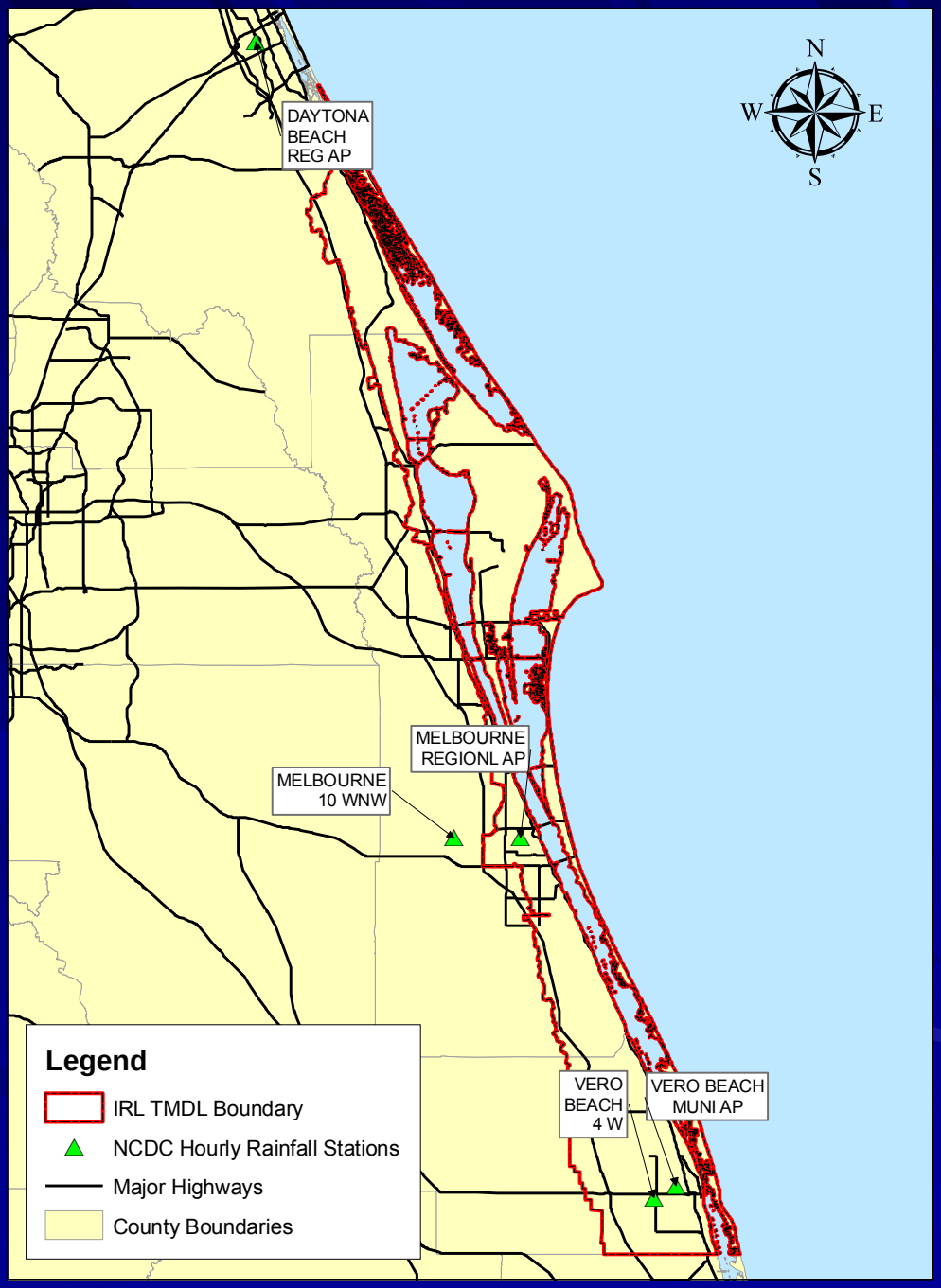
- Used to develop impervious and % DCIA

4. Runoff Coefficients

Historical Hourly Rainfall Recording Sites in the IRL

-3 hourly sites

- Used to develop continuous rainfall event data file over available period of record



Runoff Modeling

- 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

Pervious Area CN Values

Land Use	Hydrologic Soil Group									TR-55 Cover Type & Condition
	A	A/D	B	B/D	C	C/D	D	W	X?	
Commercial	39	39	61	61	74	74	80	98	0	Lawns, Good Condition
Low Density Residential	39	39	61	61	74	74	80	98	0	Lawns, Good Condition
Medium Density Residential	39	39	61	61	74	74	80	98	0	Lawns, Good Condition
High Density Residential	39	39	61	61	74	74	80	98	0	Lawns, Good Condition
Institutional	39	39	61	61	74	74	80	98	0	Lawns, Good Condition
Industrial	39	39	61	61	74	74	80	98	0	Lawns, Good Condition
Transportation	39	39	61	61	74	74	80	98	0	Lawns, Good Condition
Recreational 1	39	80	61	80	74	80	80	98	0	Lawns, Good Condition
Recreational 2	39	80	61	80	74	80	80	98	0	Lawns, Good Condition
Open	39	80	61	80	74	80	80	98	0	Lawns, Good Condition
Pasture	39	80	61	80	74	80	80	98	0	Grassland, Good Condition
Mining	39	80	61	80	74	80	80	98	0	Grassland, Good Condition
Agriculture	39	80	61	80	74	80	80	98	0	Grassland, Good Condition
Ruderal	45	83	66	83	77	83	83	98	0	Woods, Poor Condition
Citrus	32	79	58	79	72	79	79	98	0	Woods (Orchard), Good Condition
Row Crops	67	89	78	89	85	89	89	98	0	Row Crops, Good Condition
Dry Prairie	30	73	48	73	65	73	73	98	0	Brush, Good Condition
Wet Prairies	30	73	48	73	65	73	73	98	0	Brush, Good Condition
Scrub	30	73	48	73	65	73	73	98	0	Brush, Good Condition
Mesic Flatwoods	30	77	55	77	70	77	77	98	0	Woods, Good Condition
Hydric Hammock	30	77	70	77	70	77	77	98	0	Woods, Good Condition
Upland Flatwoods	30	77	55	77	70	77	77	98	0	Woods, Good Condition
Upland Mixed	30	77	55	77	70	77	77	98	0	Woods, Good Condition
Wet Flatwoods	30	77	55	77	70	77	77	98	0	Woods, Good Condition
Wetland	30	77	55	77	70	77	77	98	0	Woods, Good Condition
Xeric Hammock	30	77	55	77	70	77	77	98	0	Woods, Good Condition
Water	98	98	98	98	98	98	98	98	0	

Modeled Runoff C-Values for Daytona Beach During the Month of January

C Values for DAYTONA BEACH REG AP (2158) for the Month of January

NDCIA CN	Percent DCIA																				
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
30	0.000	0.038	0.075	0.113	0.150	0.188	0.225	0.263	0.301	0.338	0.376	0.413	0.451	0.488	0.526	0.564	0.601	0.639	0.676	0.714	0.752
35	0.000	0.038	0.075	0.113	0.150	0.188	0.225	0.263	0.301	0.338	0.376	0.413	0.451	0.488	0.526	0.564	0.601	0.639	0.676	0.714	0.752
40	0.000	0.038	0.075	0.113	0.150	0.188	0.226	0.263	0.301	0.338	0.376	0.413	0.451	0.489	0.526	0.564	0.601	0.639	0.676	0.714	0.752
45	0.001	0.038	0.076	0.113	0.151	0.188	0.226	0.264	0.301	0.339	0.376	0.414	0.451	0.489	0.526	0.564	0.601	0.639	0.676	0.714	0.752
50	0.002	0.040	0.077	0.114	0.152	0.189	0.227	0.264	0.302	0.339	0.377	0.414	0.452	0.489	0.527	0.564	0.602	0.639	0.677	0.714	0.752
55	0.005	0.042	0.079	0.117	0.154	0.191	0.229	0.266	0.303	0.341	0.378	0.415	0.453	0.490	0.527	0.565	0.602	0.639	0.677	0.714	0.752
60	0.009	0.047	0.084	0.121	0.158	0.195	0.232	0.269	0.306	0.343	0.380	0.418	0.455	0.492	0.529	0.566	0.603	0.640	0.677	0.714	0.752
65	0.018	0.055	0.092	0.128	0.165	0.202	0.238	0.275	0.312	0.348	0.385	0.422	0.458	0.495	0.532	0.568	0.605	0.642	0.678	0.715	0.752
70	0.032	0.068	0.104	0.140	0.176	0.212	0.248	0.284	0.320	0.356	0.392	0.428	0.464	0.500	0.536	0.572	0.608	0.644	0.680	0.716	0.752
75	0.051	0.086	0.121	0.156	0.191	0.226	0.261	0.296	0.331	0.366	0.401	0.436	0.471	0.506	0.541	0.576	0.611	0.646	0.681	0.716	0.752
80	0.080	0.113	0.147	0.180	0.214	0.248	0.281	0.315	0.348	0.382	0.416	0.449	0.483	0.516	0.550	0.584	0.617	0.651	0.684	0.718	0.752
85	0.123	0.155	0.186	0.218	0.249	0.280	0.312	0.343	0.375	0.406	0.437	0.469	0.500	0.532	0.563	0.595	0.626	0.657	0.689	0.720	0.752
90	0.197	0.225	0.253	0.281	0.308	0.336	0.364	0.391	0.419	0.447	0.474	0.502	0.530	0.558	0.585	0.613	0.641	0.668	0.696	0.724	0.752
95	0.345	0.365	0.385	0.406	0.426	0.446	0.467	0.487	0.507	0.528	0.548	0.568	0.589	0.609	0.629	0.650	0.670	0.690	0.711	0.731	0.752
98	0.534	0.545	0.556	0.566	0.577	0.588	0.599	0.610	0.621	0.632	0.643	0.654	0.664	0.675	0.686	0.697	0.708	0.719	0.730	0.741	0.752

Modeled Runoff C-Values for Vero Beach During the Month of January

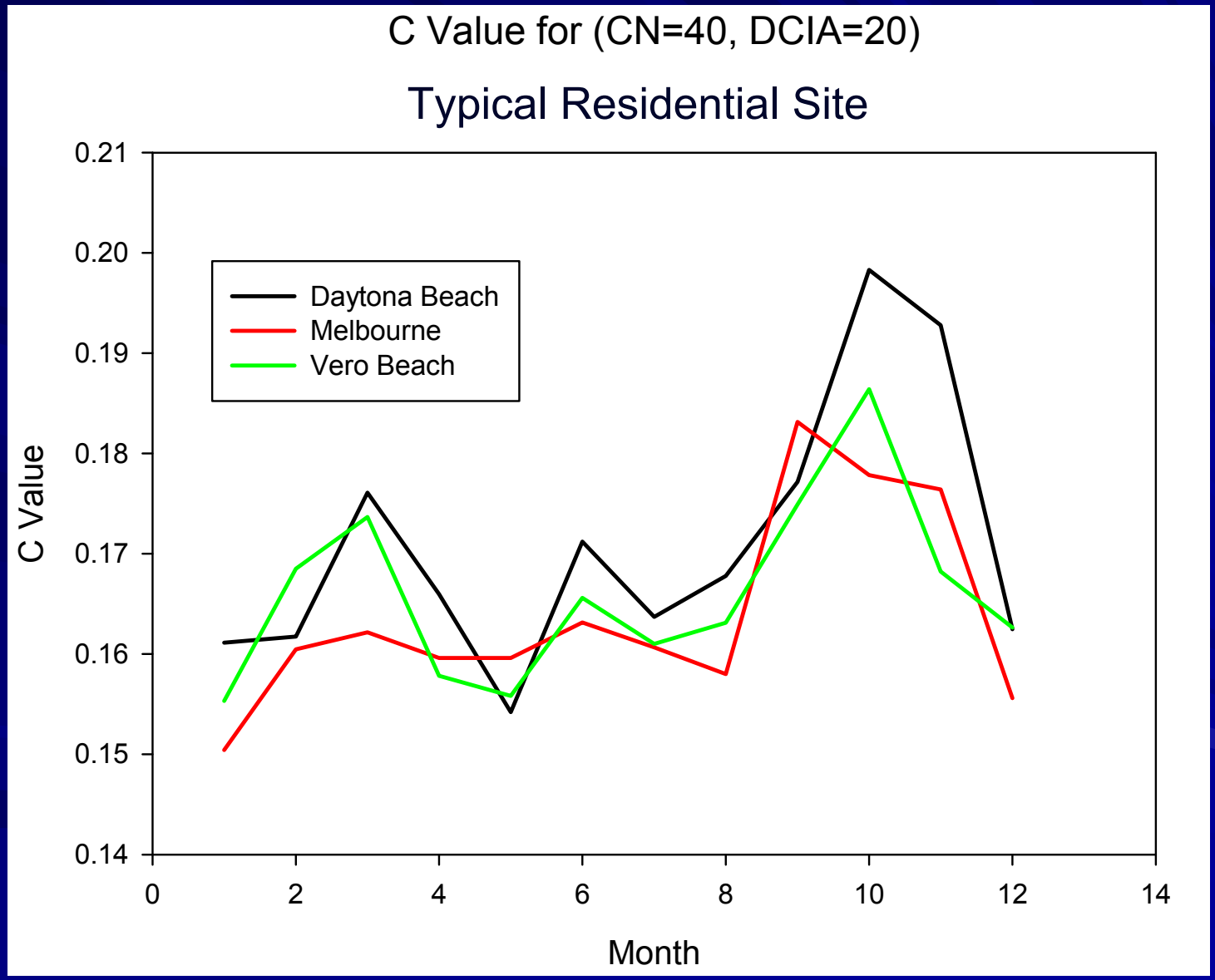
C Values for VERO BEACH MUNI AP (9214) for the Month of January

NDCIA CN	Percent DCIA																				
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
30	0.000	0.039	0.077	0.116	0.155	0.193	0.232	0.271	0.309	0.348	0.387	0.425	0.464	0.503	0.541	0.580	0.619	0.657	0.696	0.735	0.773
35	0.000	0.039	0.077	0.116	0.155	0.193	0.232	0.271	0.309	0.348	0.387	0.425	0.464	0.503	0.541	0.580	0.619	0.657	0.696	0.735	0.773
40	0.001	0.039	0.078	0.117	0.155	0.194	0.233	0.271	0.310	0.348	0.387	0.426	0.464	0.503	0.542	0.580	0.619	0.657	0.696	0.735	0.773
45	0.003	0.042	0.080	0.119	0.157	0.196	0.234	0.273	0.311	0.350	0.388	0.427	0.465	0.504	0.542	0.581	0.619	0.658	0.696	0.735	0.773
50	0.008	0.046	0.084	0.123	0.161	0.199	0.238	0.276	0.314	0.352	0.391	0.429	0.467	0.505	0.544	0.582	0.620	0.659	0.697	0.735	0.773
55	0.015	0.053	0.090	0.128	0.166	0.204	0.242	0.280	0.318	0.356	0.394	0.432	0.470	0.508	0.546	0.584	0.622	0.660	0.697	0.735	0.773
60	0.024	0.061	0.099	0.136	0.173	0.211	0.248	0.286	0.323	0.361	0.398	0.436	0.473	0.511	0.548	0.586	0.623	0.661	0.698	0.736	0.773
65	0.035	0.072	0.109	0.146	0.183	0.220	0.256	0.293	0.330	0.367	0.404	0.441	0.478	0.515	0.552	0.589	0.626	0.663	0.700	0.736	0.773
70	0.050	0.086	0.123	0.159	0.195	0.231	0.267	0.303	0.339	0.376	0.412	0.448	0.484	0.520	0.556	0.593	0.629	0.665	0.701	0.737	0.773
75	0.071	0.106	0.141	0.177	0.212	0.247	0.282	0.317	0.352	0.387	0.422	0.457	0.493	0.528	0.563	0.598	0.633	0.668	0.703	0.738	0.773
80	0.101	0.135	0.168	0.202	0.235	0.269	0.303	0.336	0.370	0.404	0.437	0.471	0.504	0.538	0.572	0.605	0.639	0.672	0.706	0.740	0.773
85	0.146	0.177	0.209	0.240	0.271	0.303	0.334	0.366	0.397	0.428	0.460	0.491	0.522	0.554	0.585	0.617	0.648	0.679	0.711	0.742	0.773
90	0.222	0.249	0.277	0.304	0.332	0.360	0.387	0.415	0.442	0.470	0.498	0.525	0.553	0.580	0.608	0.635	0.663	0.691	0.718	0.746	0.773
95	0.373	0.393	0.413	0.433	0.453	0.473	0.493	0.513	0.533	0.553	0.573	0.593	0.613	0.633	0.653	0.673	0.693	0.713	0.733	0.753	0.773
98	0.559	0.570	0.581	0.592	0.602	0.613	0.624	0.634	0.645	0.656	0.666	0.677	0.688	0.698	0.709	0.720	0.731	0.741	0.752	0.763	0.773

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



5. Emc Values

Selection of emc Values

- 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**	

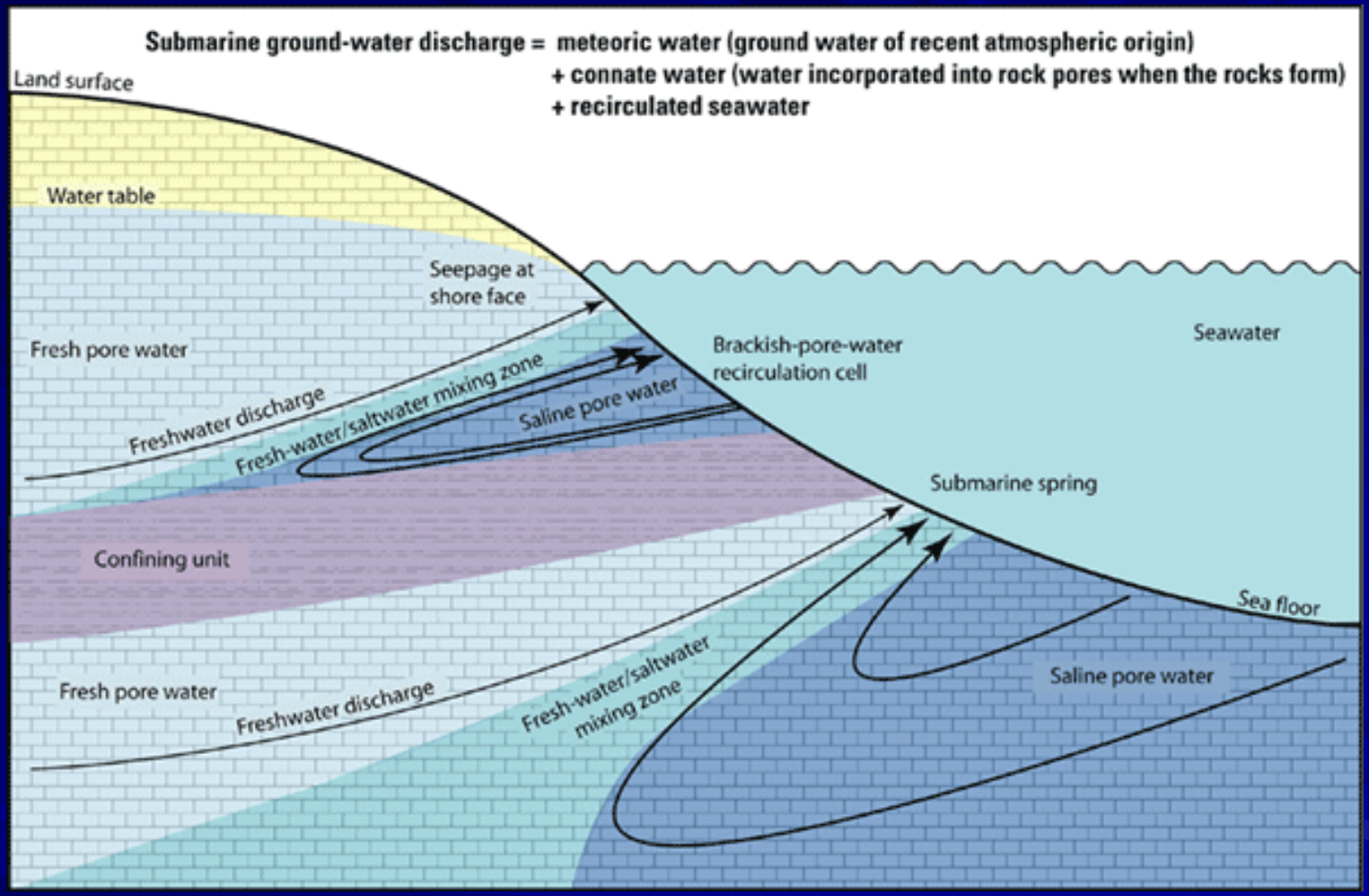
Updated version of runoff characterization data outlined in "Performance Efficiency Evaluation of Stormwater Management Systems in Florida", Harper and Baker, 2007

"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

6. Baseflow

Typical IRL Coastal Geology

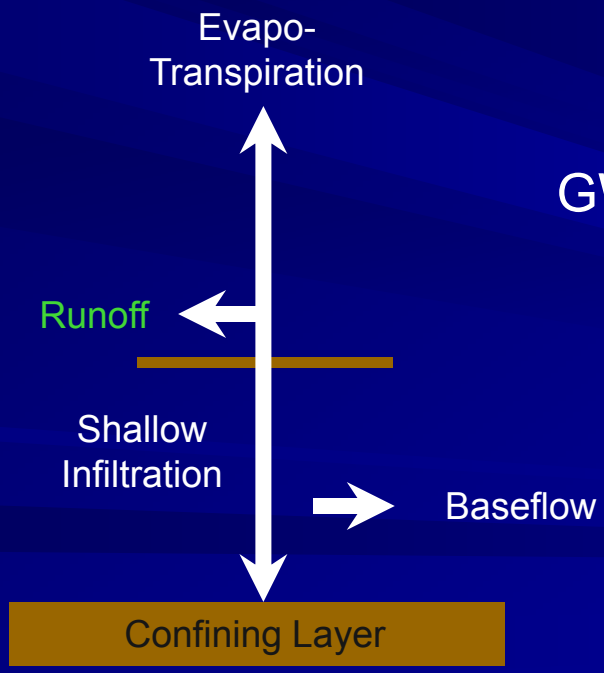


-Water migrates downward until reaching a confining layer then migrates horizontally into the IRL or ocean

-- 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:

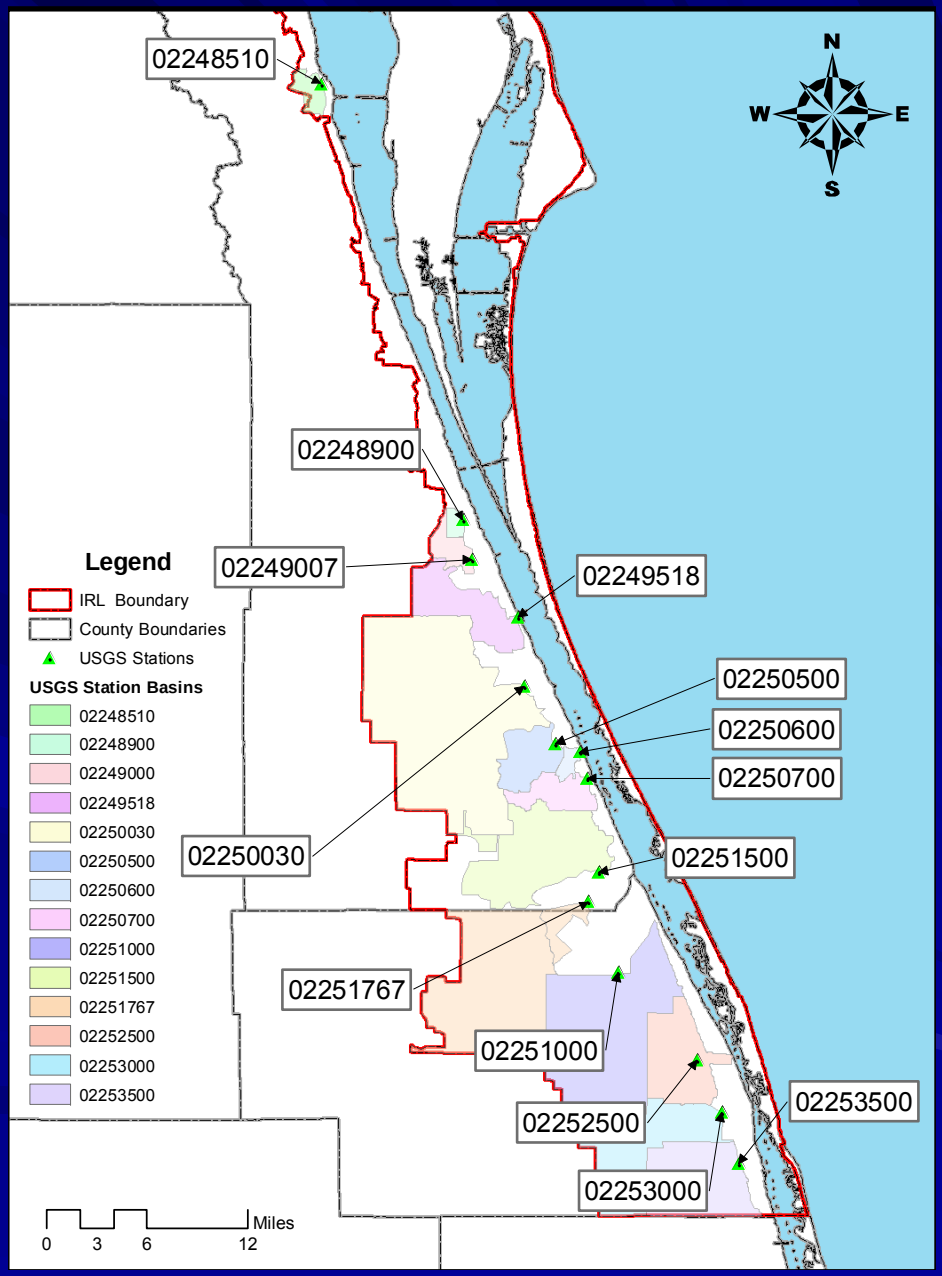


GW/Baseflow = Precipitation - ET - RO

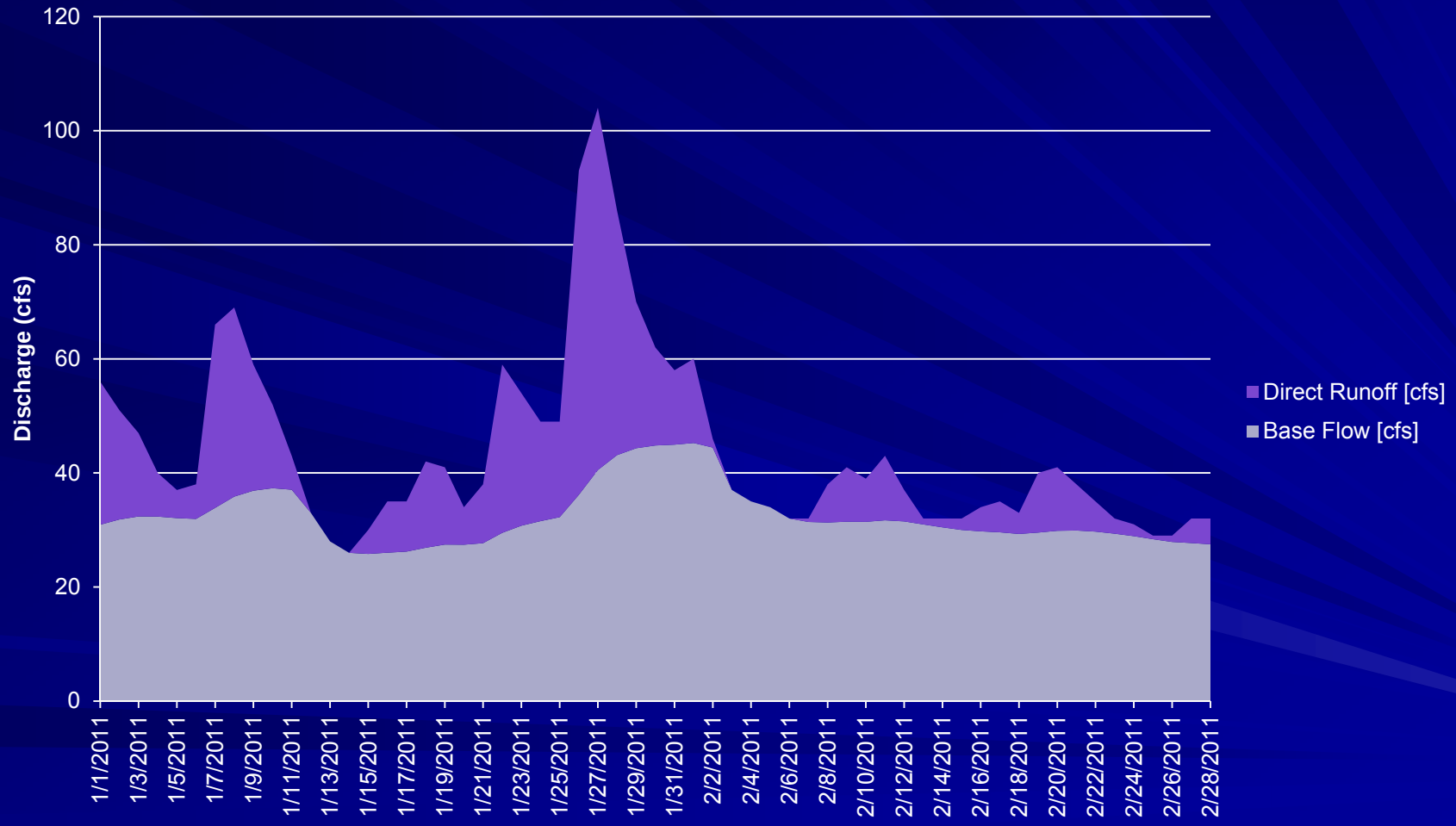
USGS Tributary Gauging Sites and Associated Watershed Areas

~ 42% of Overall Basin Area

- Most of the areas are agriculture and natural areas

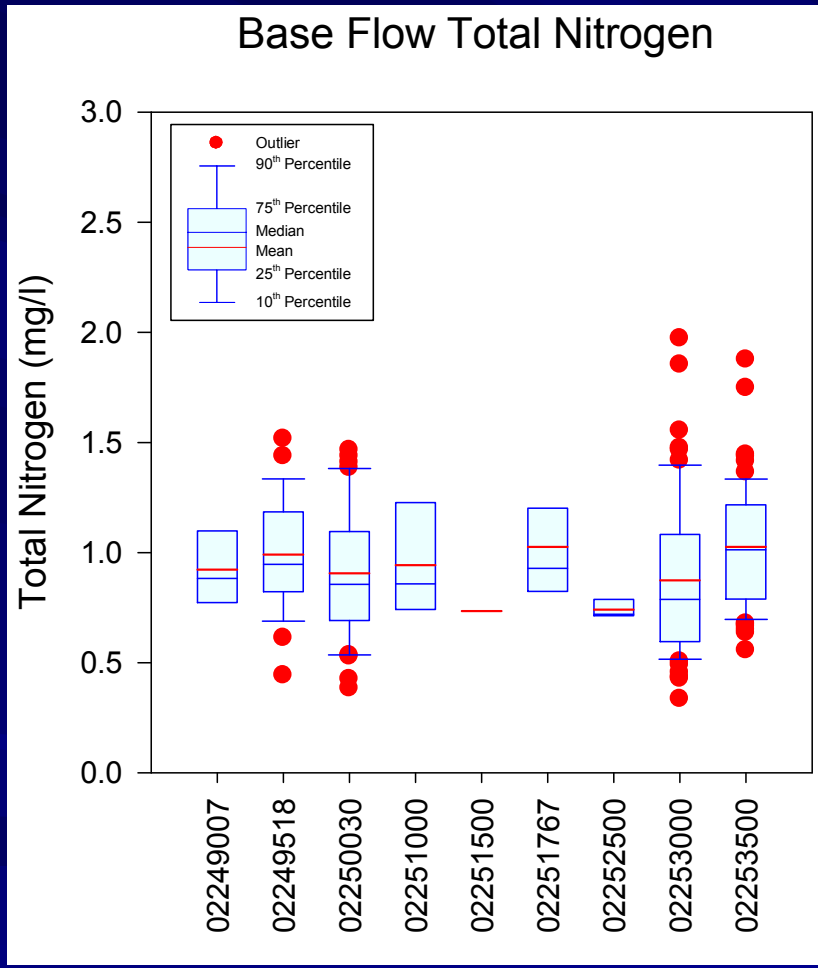


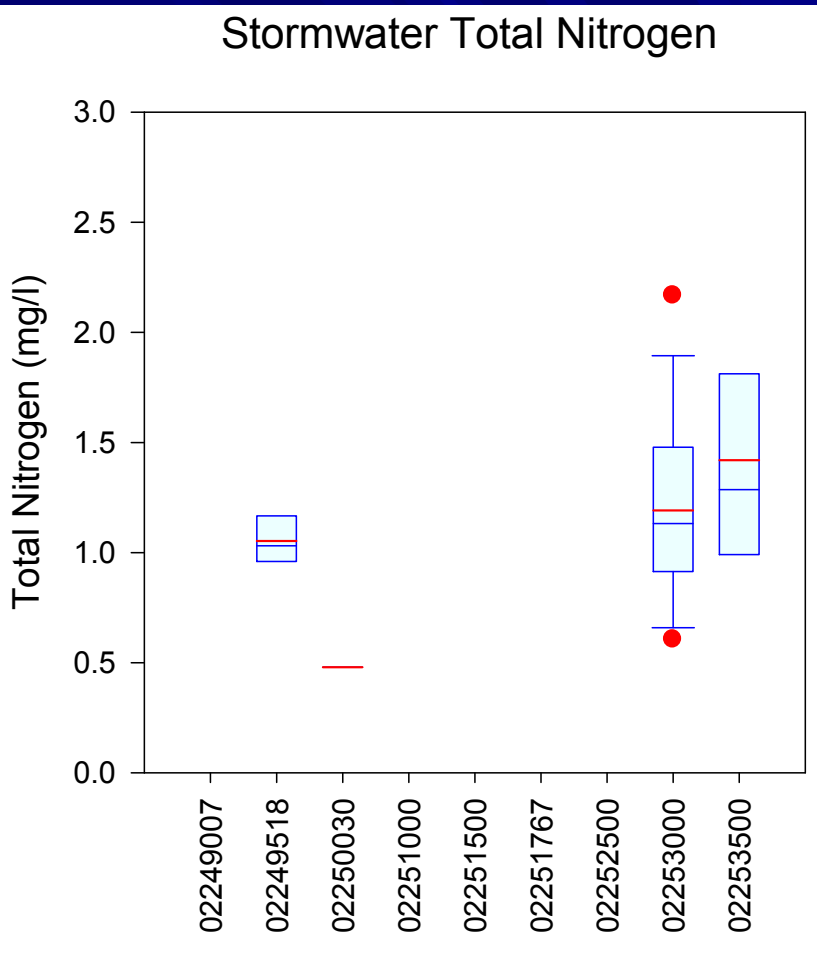
Comparison of Runoff and Baseflow at USGS Station 02251767



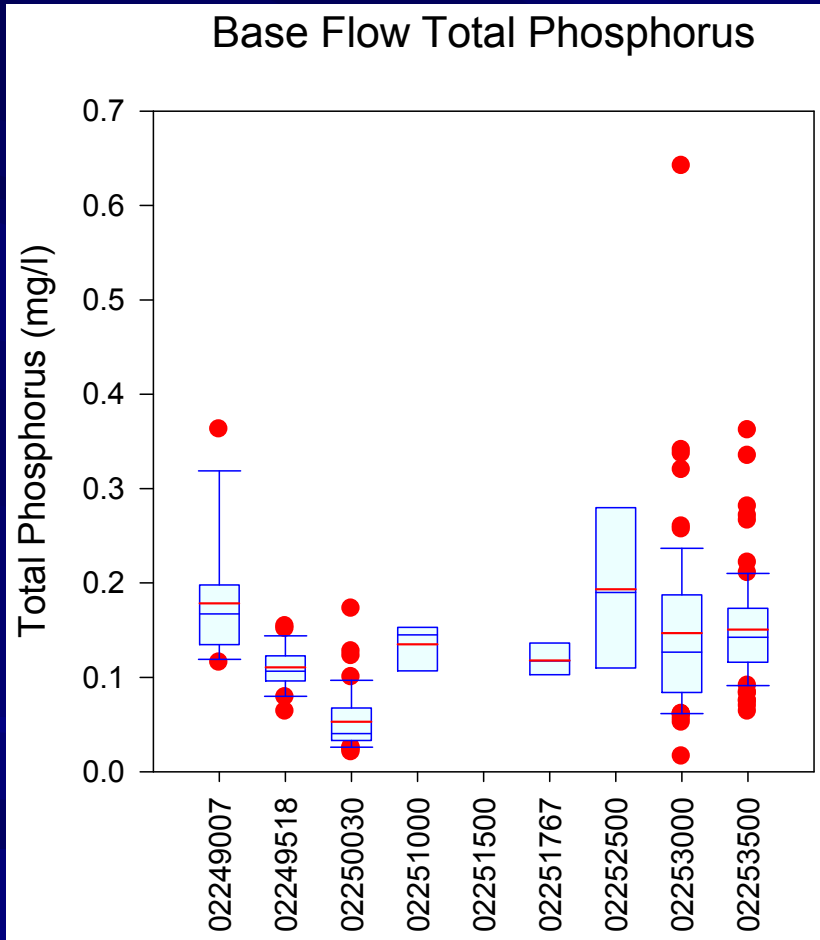
Runoff and baseflow separation conducted using the WHAT program from Purdue University

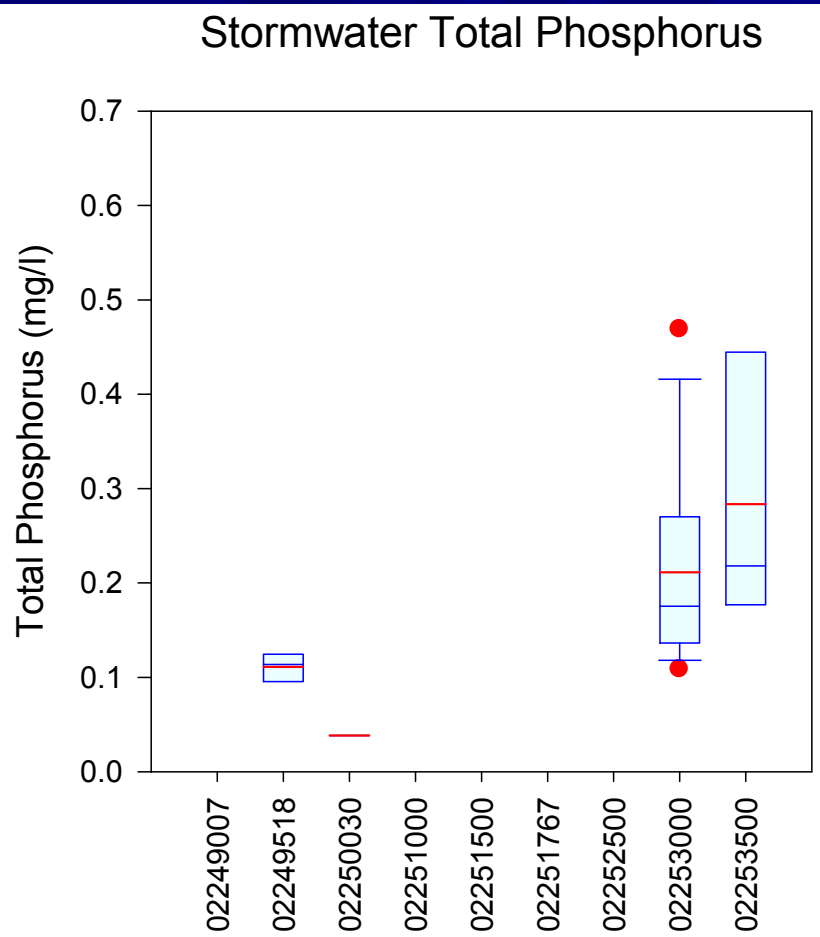
Comparison of Nitrogen Concentrations in Runoff and Baseflow





Comparison of Phosphorus Concentrations in Runoff and Baseflow





Calibration Data

Year	Month	Sampling Date	Measured Values					Modeled Values	
			Monthly Flow (ac-Ft)	TN Conc. (mg/l)	TP Conc. (mg/l)	TN Mass (kg)	TP Mass (kg)	TN Mass (kg)	TP Mass (kg)
2003	10	10/15/2003	778	1.070	0.094	1,026	90	992	139
2003	11	11/11/2003	555	0.875	0.107	599	73	881	122
2003	12	12/11/2003	609	0.698	0.073	524	54	1,006	139
2004	10	10/13/2004	2,376	1.081	0.138	3,168	404	2,207	309
2004	11	11/9/2004	863	1.025	0.107	1,091	113	1,199	166
2004	12	12/15/2004	926	1.101	0.062	1,258	70	1,544	213
2005	10	10/13/2005	3,572	0.758	0.139	3,340	610	4,242	603
2005	11	11/8/2005	1,791	1.035	0.180	2,287	398	1,638	227
2005	12	12/6/2005	1,297	1.120	0.069	1,792	110	1,483	204
2006	10	10/11/2006	1,281	1.240	0.139	1,960	220	432	61
2006	11	11/6/2006	1,109	0.870	0.096	1,190	131	1,025	144
2006	12	12/4/2006	604	1.078	0.106	803	79	503	70
2007	10	10/8/2007	1,847	0.763	0.099	1,738	225	2,178	311
2007	11	11/7/2007	696	0.803	0.023	689	20	516	71
2007	12	12/5/2007	512	0.993	0.114	627	72	437	60
2008	10	10/7/2008	3,039	0.765	0.114	2,867	427	3,713	524
2008	11	11/5/2008	1,347	0.963	0.088	1,600	145	1,857	257
2008	12	12/1/2008	885	0.794	0.053	866	57	1,163	160
2009	10	10/7/2009	861		0.081		86	922	129
2009	11	11/4/2009	445		0.083		46	483	67
2009	12	12/10/2009	658		0.073		59	1,932	267
2010	10	10/6/2010	1,033	0.825	0.096	1,052	123	323	45
2010	11	11/3/2010	610	0.878	0.127	661	96	710	99
2010	12	12/6/2010	543	1.194	0.084	800	56	428	59
		Mean	**1,177**	**0.949**	**0.098**	**1,426**	**157**	**1,326**	**185**

7. Stormwater BMP Efficiencies

Evaluation of BMP Efficiencies

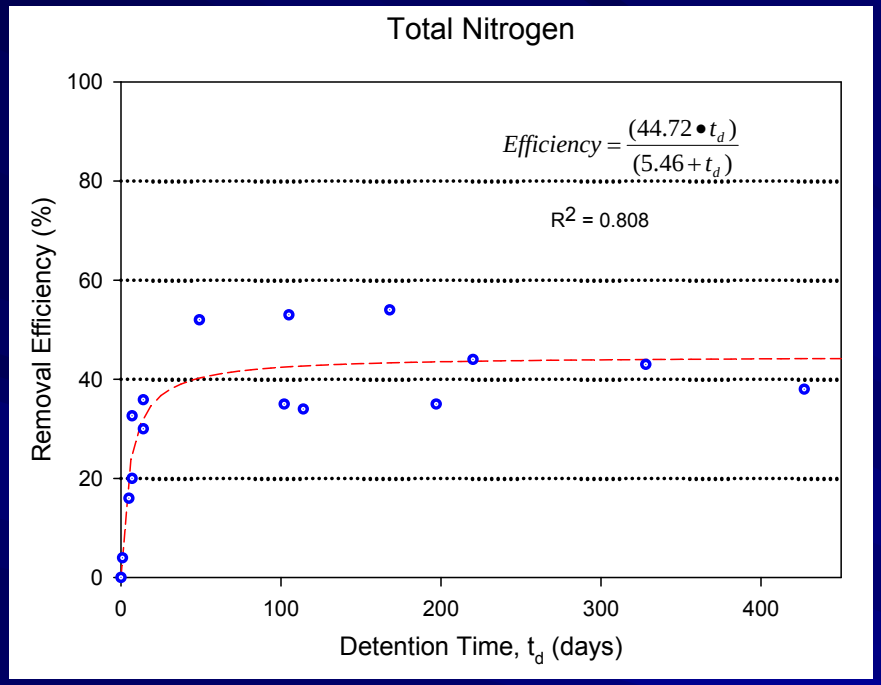
- BMP efficiencies calculated for two different time periods
  - Prior to implementation of the Impaired Waters rule
    - BMP efficiencies calculated for general SJRWMD stormwater system design criteria
  - Following implementation of the Impaired Waters rule
    - BMP efficiencies calculated as removal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

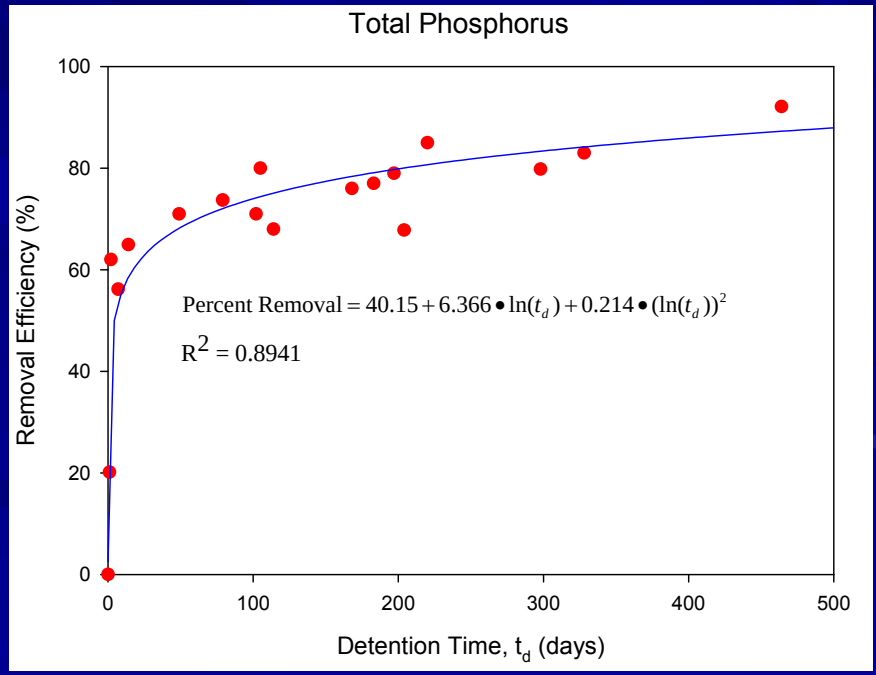
Recommended BMP Efficiencies for Use in the Indian River Lagoon TMDL Evaluation

a. Prior to implementation of impaired water rule

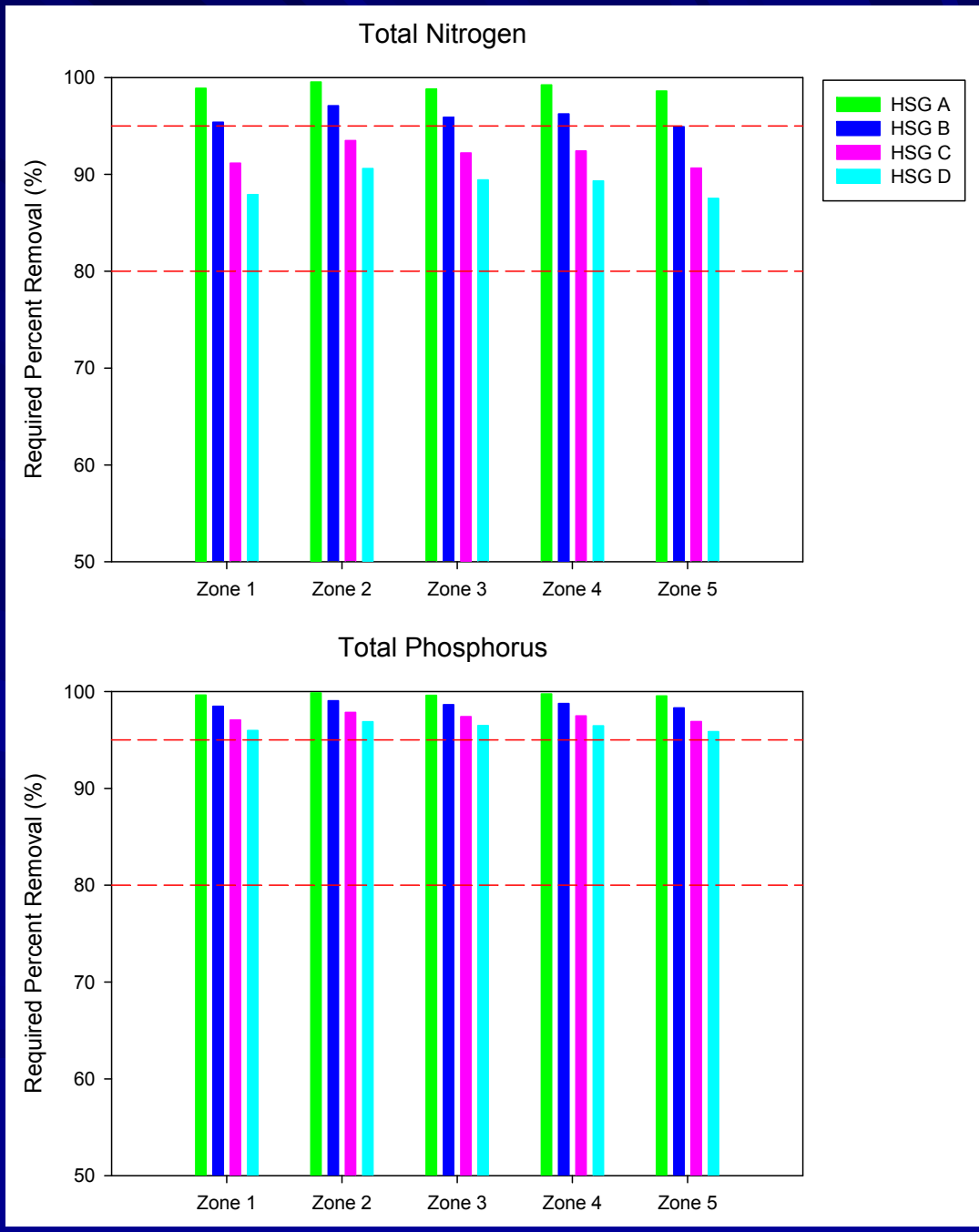
Time Period	BMP Type	Assumed Annual Mass/Volume Removal (% of total)			Assumptions	Reference
		Runoff Volume	Total N	Total P		
Prior to Implementation of Impaired Water Design Criteria	Dry Retention (Dry Ponds) 1-inch runoff	75	75	75	Assumes that dry ponds are primarily dry detention designed to SJRWMD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

Nutrient Removal in Wet Ponds is Primarily a Function of Detention Time





Required Annual Mass Removal Efficiencies To Achieve Pre<=Post Loadings for Commercial Development



Recommended BMP Efficiencies for Use in the Indian River Lagoon TMDL Evaluation

b. Following implementation of impaired water rule

Time Period	Developed Land Use Category	Assumed Annual Mass/Volume Removal (% of total)			Assumptions	Reference
		Runoff Volume	Total N	Total P		
Following Implementation of Impaired Water Design Criteria Requiring Post ≤ Pre Development Nutrient Loadings	Commercial	90	98.6	99.5	Assumes that constructed treatment systems achieve goal of post ≤ pre for nutrient loadings. Removals reflect efficiencies necessary for no net increase in loadings.	Harper and Baker (2007)
	High Density Residential	90	97.8	99.5		
	Industrial	90	86.5	94.6		
	Institutional	90	88.6	95.4		
	Low Density Residential	90	85.5	94.2		
	Medium Density Residential	90	95.2	98.6		
	Recreational 1	90	88.2	96.4		
	Recreational 2	90	88.7	95.5		
	Transportation	90	96.9	98.9		
	Overall Weighted Value:	**90**	**92.6**	**97.3**		

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