EFFECTIVENESS AND COMPUTATIONAL AIDS

BY: MARTY WANIELISTA

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- **The Escambia County LID BMP Manual and the LID BMP Workshops were funded in part by a Section 319 Nonpoint Source Management Program Implementation grant from the U.S. Environmental Protection Agency through an agreement/contract with the Nonpoint Source Management Section of the Florida Department of Environmental Protection."**

BASIC PRINCIPLES FOR LOADING AND REMOVAL

- Loading depends on runoff and land use characteristics
- Runoff depends on rainfall and land use characteristics
- Removal depends on runoff and the use of LIDs and BMPs
- Thus must have reasonable estimates for
  - Rainfall
  - Runoff
  - Concentrations of pollutants in the runoff
  - Performance of BMPs and LIDs as individual units and in combination with others
  - Cost of the BMPs and LIDs.

RAINFALL CHARACTERISTICS ESCAMBIA COUNTY HISTORICAL DATA

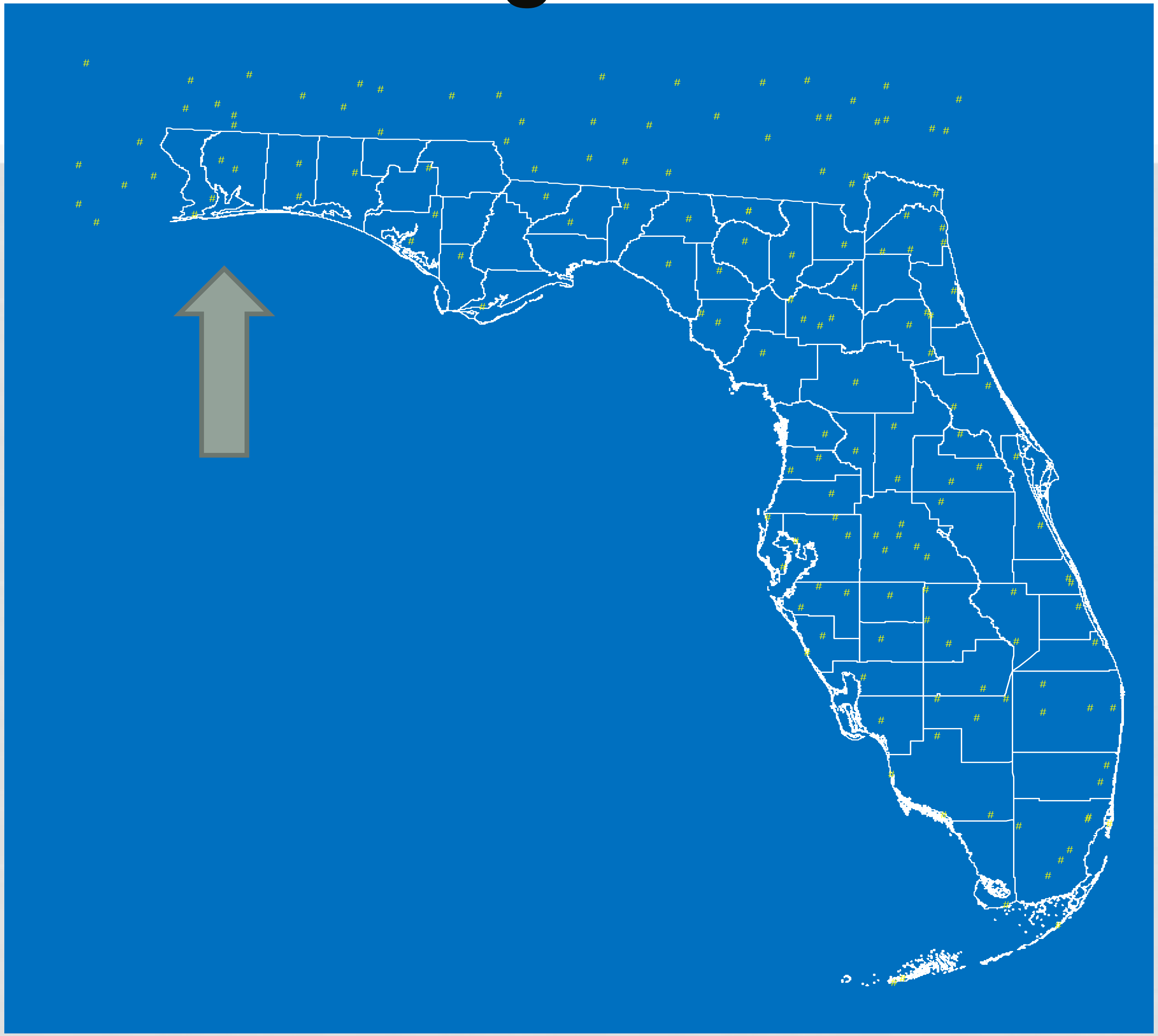
- A predictor of the future is the past
- Rainfall data are based on an evaluation conducted by Harper and Baker (2007) for FDEP which is summarized in the document titled "Evaluation of Current Stormwater Design Criteria within the State of Florida" A extension of the original work done by FDEP in the 1970s.
- Study included an evaluation of rainfall characteristics throughout the State, including
  - Rainfall depths
  - Rainfall variability
  - Inter-event dry periods

Available Meteorological Data

METEOROLOGICAL MONITORING SITES

- DATA OBTAINED FOR 1971-2000
- 160 SITES TOTAL
- 111 SITES IN FLORIDA
- 49 SITES IN PERIMETER AREAS
- OVERALL ANNUAL MEAN DEVELOPED FOR EACH SITE

Update: Rainfall volumes not changing with time, thus design criteria based on volumes remain useful.

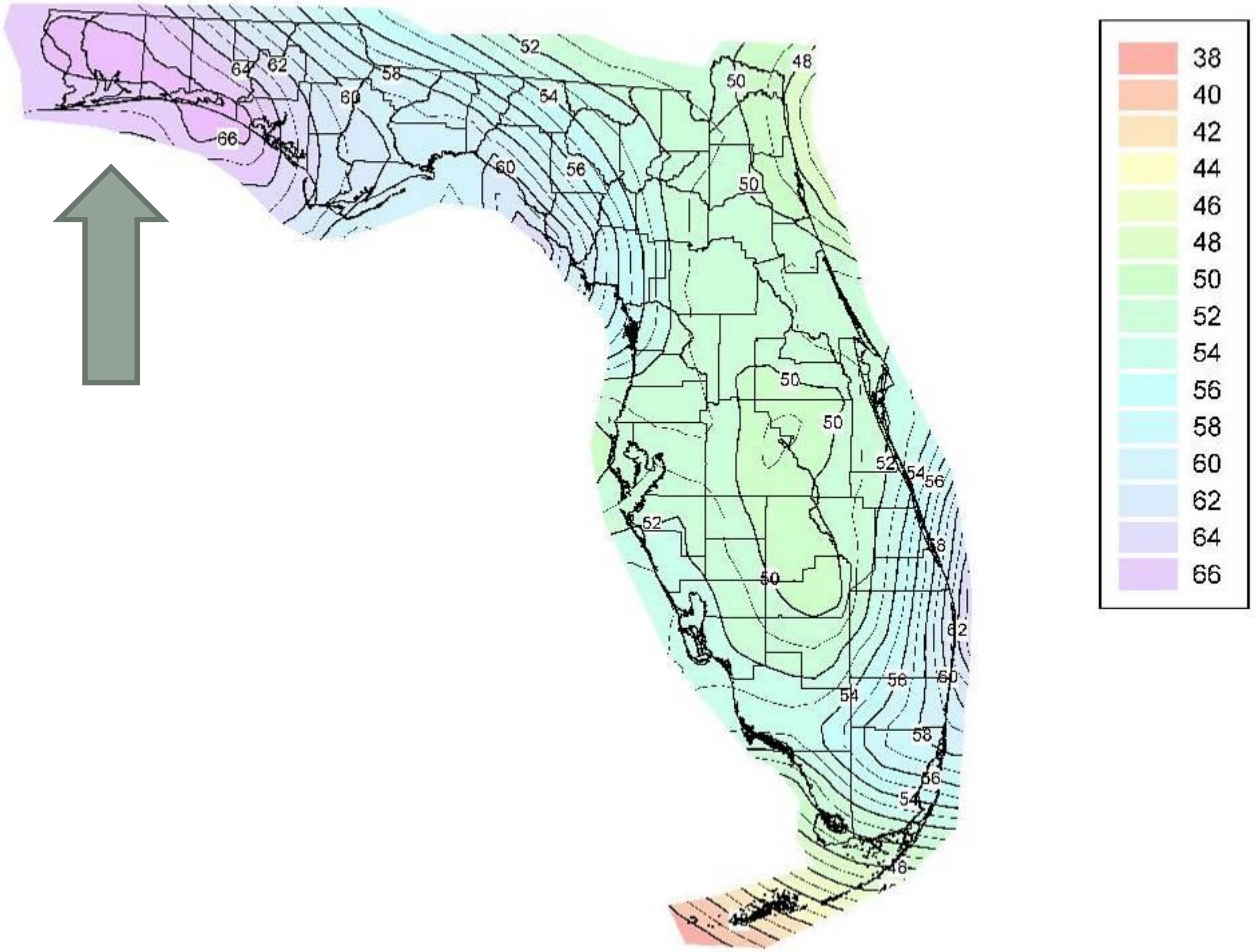


Average Annual Florida Precipitation 1971 – 2000

- Rainfall isopleths were developed for 1971 – 2000 based on the annual mean values

- Florida rainfall is highly variable ranging from ~ 38 – 66 in/yr, depending on location

- Isopleths are used to determine project rainfall in BMPTRAINS*



*Not available in any other models:

Available from www.stormwater.ucf.edu free of charge

ESCAMBIA COUNTY AVERAGE ANNUAL RAINFALL

- Expanded view plots are available in BMPTRAINS for the entire State

-If site specific data
-Use them, as examples:
1) for coastal rainfall and
2) 62.2" in Escambia Co.

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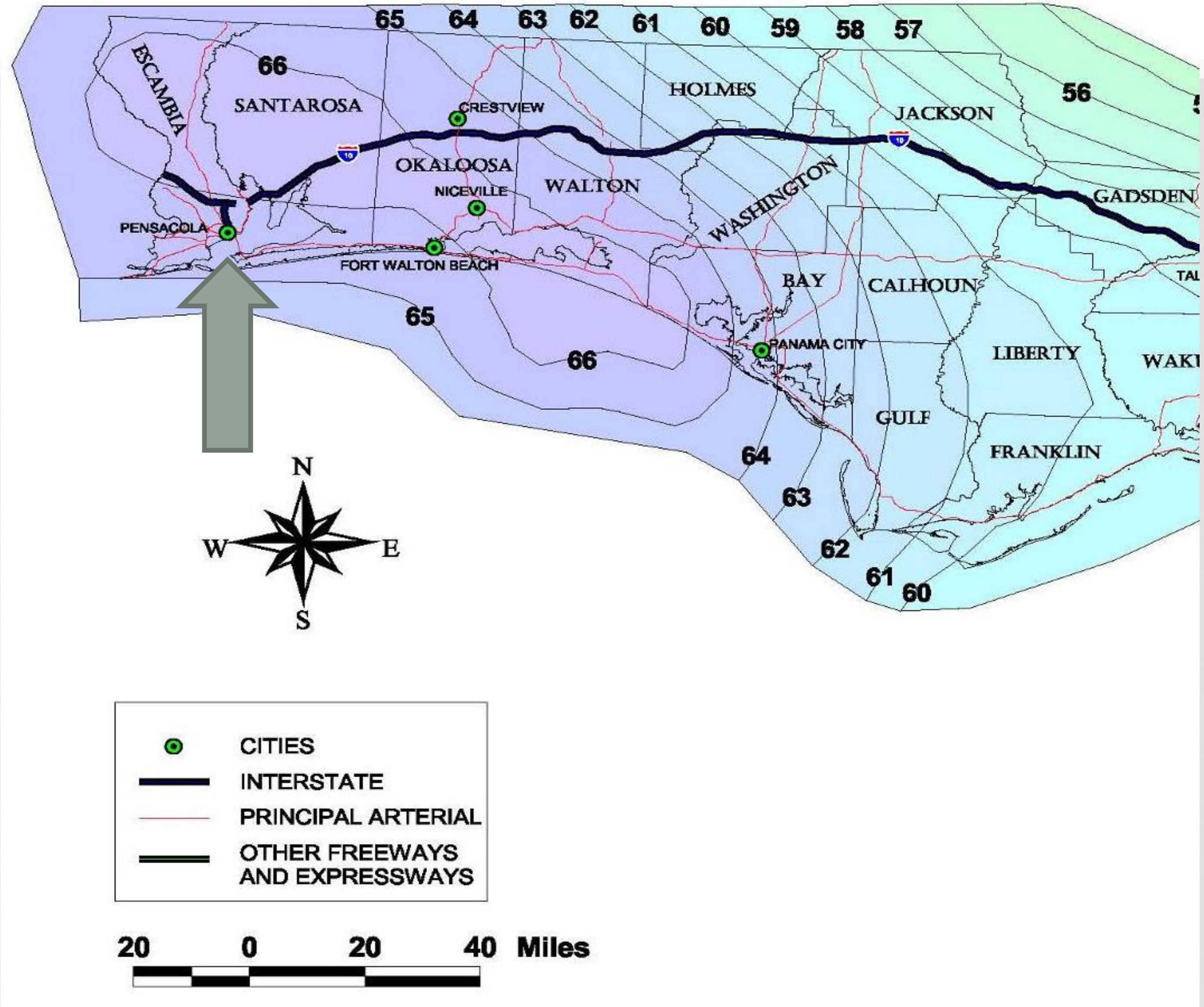

SIMILAR METEOROLOGICAL ZONES

- Cluster analysis used to identify areas with similar annual rainfall/runoff relationships (C values)

- Analysis identified 5 significantly different areas

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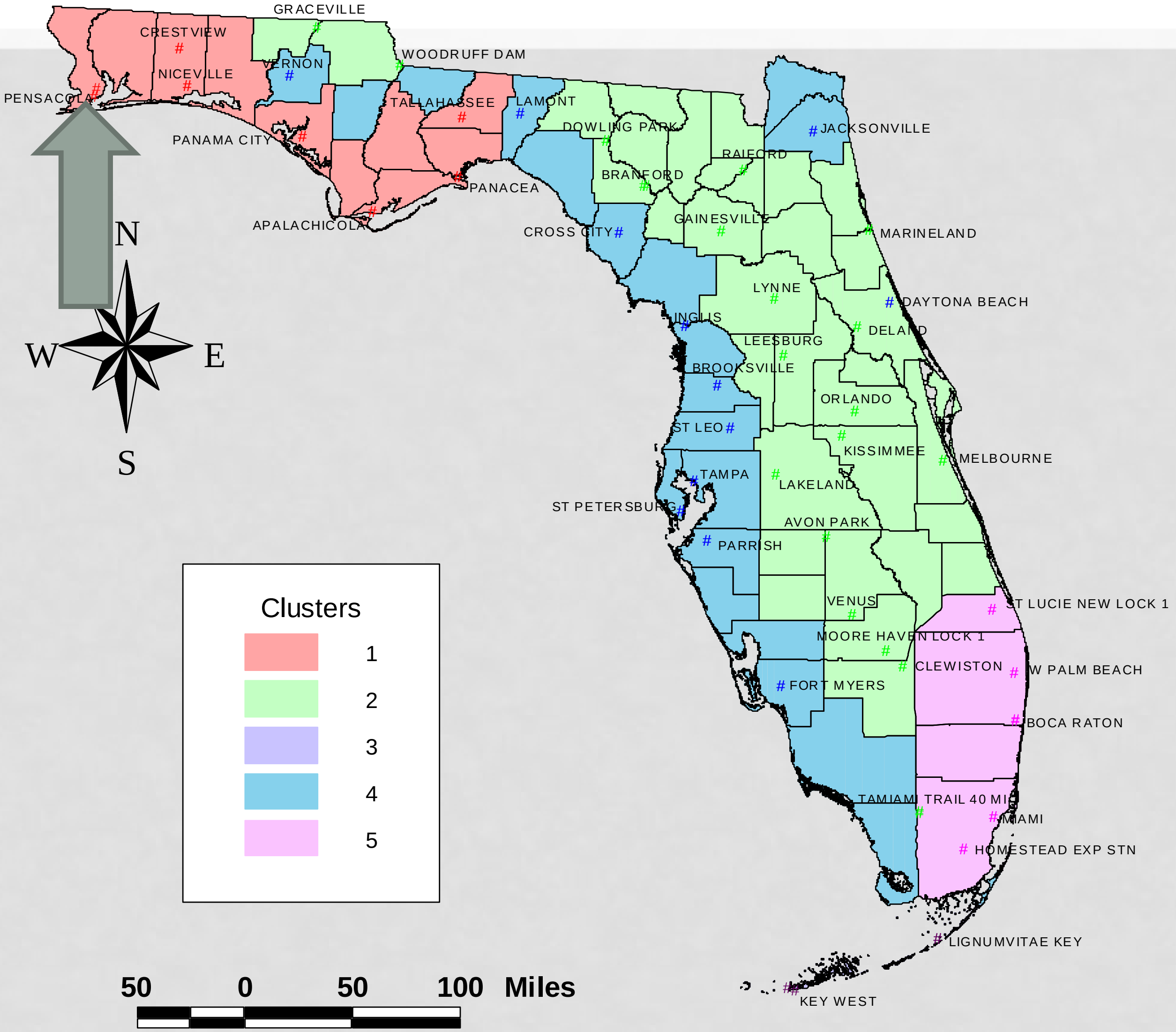
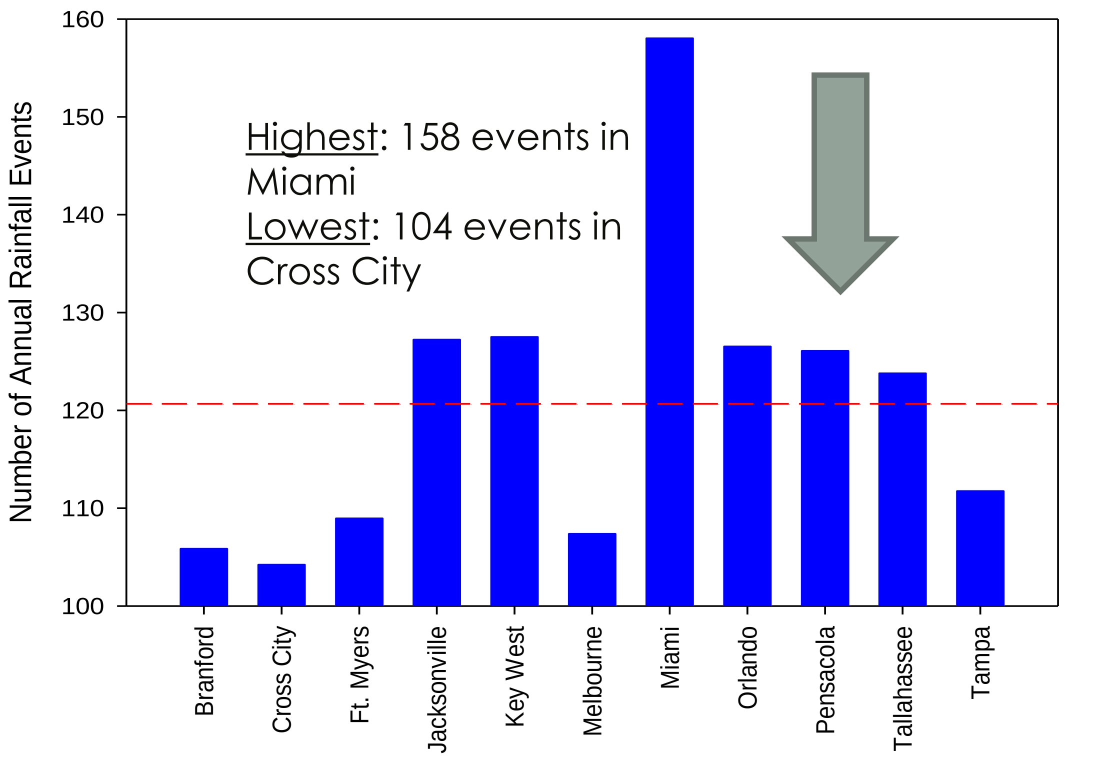
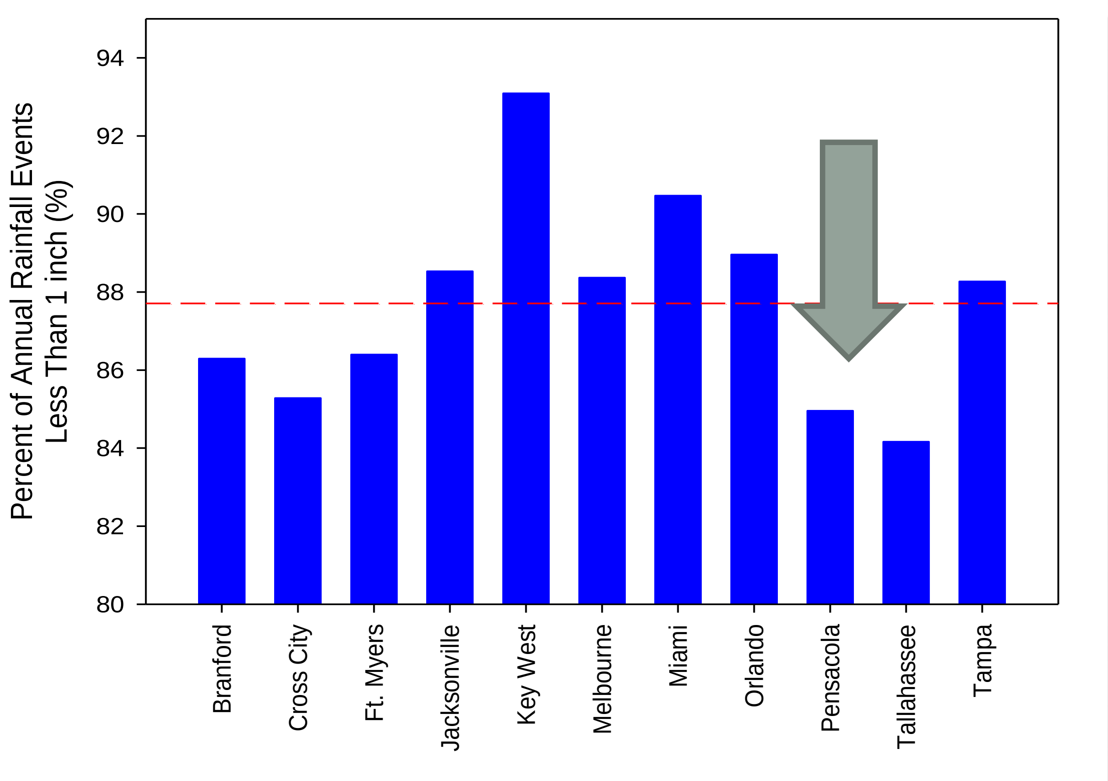


Characteristics of Rainfall Events at Selected Meteorological Sites





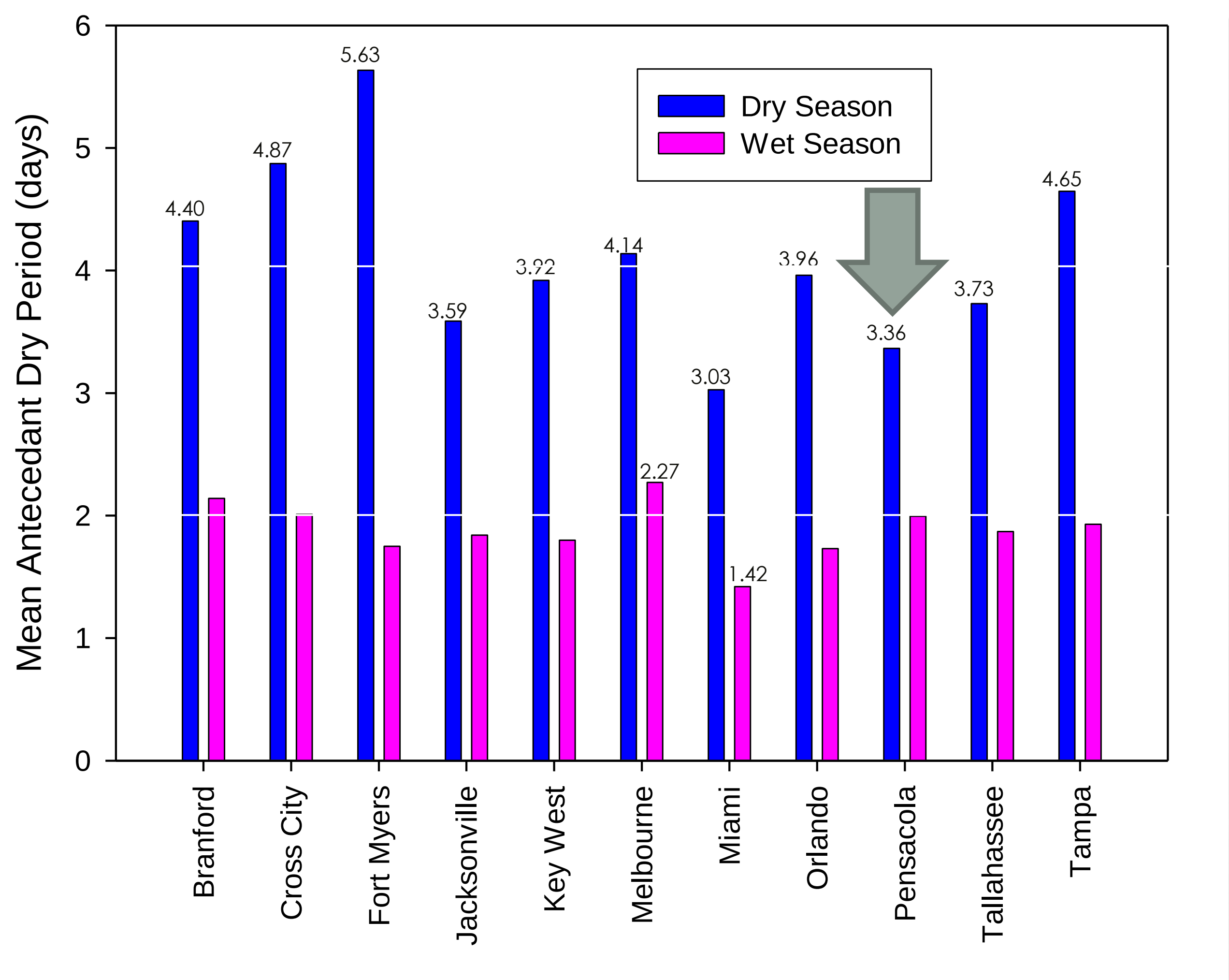
- Rainfall is highly variable in the number of "small" and "large" events

-This impacts both runoff generation as well as treatment system performance efficiency

VARIABILITY IN INTER-EVENT DRY PERIOD

Variability in rainfall inter-event times impacts:

- Runoff C values
- Recovery and performance efficiency of stormwater management systems, especially dry retention



SUMMARY RAINFALL CONDITIONS

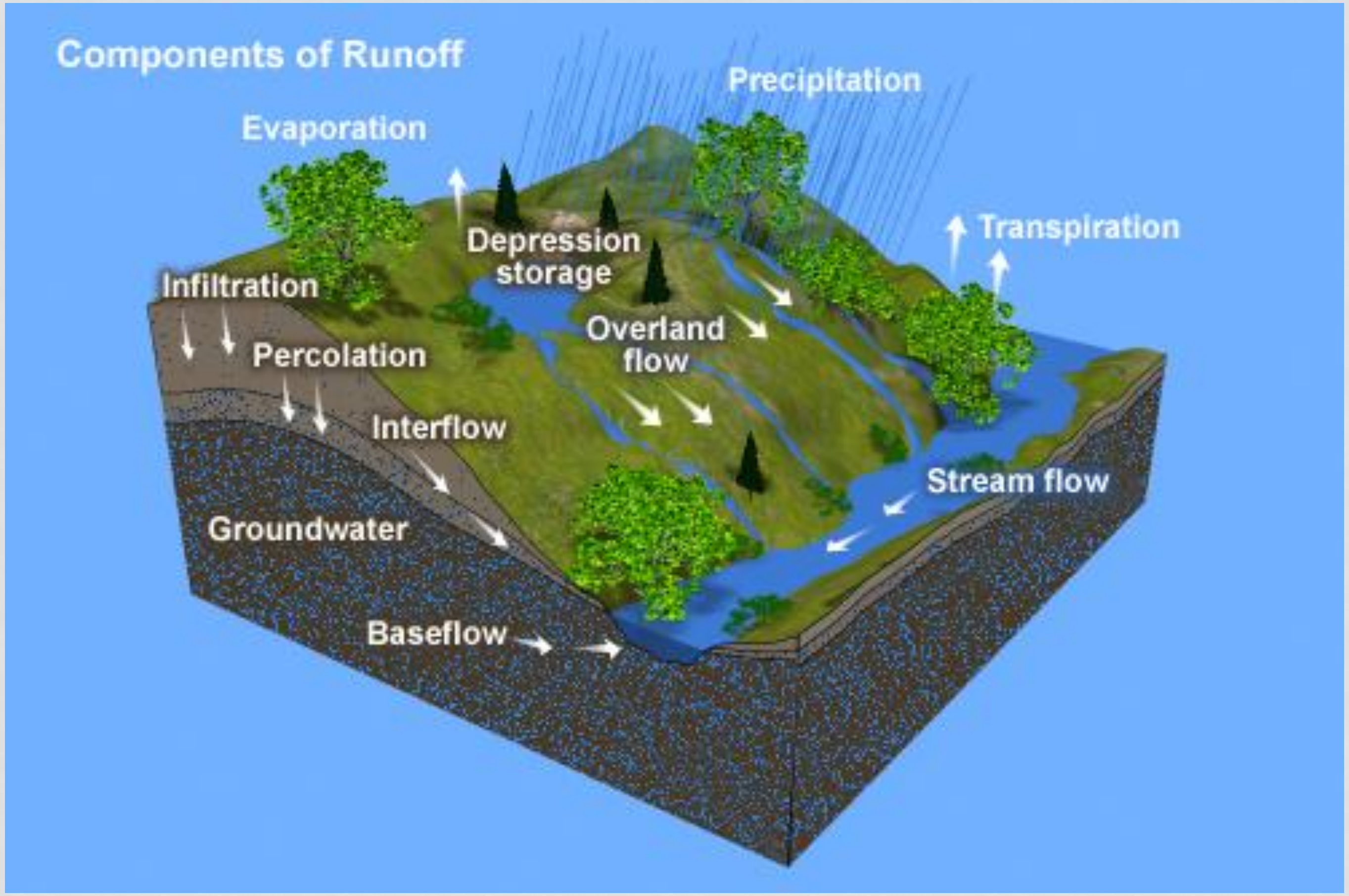
- Rainfall data in Florida is highly variable
  - Annual rainfall
    - Ranges from 38 in./yr. in the Keys to 68 in./yr. in north Florida areas
    - Number of events range from 104 in Cross City to 158 in Miami, ~125 in Escambia County.
  - Rain event depths
    - Most rain events in Florida are less than 0.5 inch, same for Escambia Co.
    - Approximately 84 – 94% are less than 1 inch, ~ 85% in Escambia Co.
    - Inter-event dry periods affect LID performance

      Wet season – 1.42 days (34 hrs.) – 2.27 days (54 hrs.), ~ 2 days in Escambia Co.
- Must simulate this rainfall variability to determine runoff volumes and LID efficiencies throughout the State

RUNOFF GENERATION

- Runoff generation is a function of:
  - Precipitation
  - Soil types
  - Land cover

- Understanding precipitation is essential to understanding and quantifying runoff



Runoff Coefficients
(depth of runoff from rainfall in a period of time)

Runoff coefficients (C values)

- Runoff coefficients reflect the proportion of rainfall that becomes runoff under specified conditions

- Runoff coefficients for stormwater management are based on annual data, not a storm related one.

SCS CURVE NUMBER (CN)METHODOLOGY

- Common methodology used in many public and proprietary models, Ref: NRCS TR-55 document titled “Urban Hydrology for Small Watersheds”
- Curve numbers are empirically derived values which predict runoff as a function of soil type and land cover
- Can be used to predict runoff depths and volumes
- Runoff generation based on impervious area, soil types, and land cover
- Model incorporates two basic parameters:
  - Directly connected impervious area (DCIA)
    - Percentage of impervious area with 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 (33 – 100)

TYPICAL CURVE NUMBERS (TR-55)

Cover Type and Hydrologic Condition	Curve Number			
	A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.):				
Poor condition (grass cover < 50%) …………………………........…	68	79	86	89
Fair condition (grass cover 50% to 75%) ……………...................	49	69	79	84
Good condition (grass cover > 75%) ………………………...........	39	61	74	80
Impervious areas:				
Paved parking lots, roofs, driveways, etc. (excl. ROW)	98	98	98	98
Streets and roads:				
Paved; curbs and storm (excl. ROW) ………………….. ……….	98	98	98	98
Paved; open ditches (including right-of-way) …………………...	83	89	92	93
Gravel (including right-of-way) …...	76	85	89	91
Dirt (including right-of-way) ……………..	72	82	87	89
Pasture, grassland, or range:				
Poor condition ..…………………………………………….............	68	79	86	89
Fair condition ..…………………………………………………..	49	69	79	84
Good condition ………………………………………………….	39	61	74	80
Brush—brush-weed-grass mixture:				
Poor …………………………………………………..............	48	67	77	83
Fair …………………………………………………………….	35	56	70	77
Good ……………………………………………………………..	30	48	65	73
Woods:				
Poor …………………………………………………………….	45	66	77	83
Fair …………………………………………………………….	36	60	73	79
Good ……………………………………………………………..	30	55	70	77

DIRECTLY CONNECTED IMPERVIOUS AREAS (DCIA)

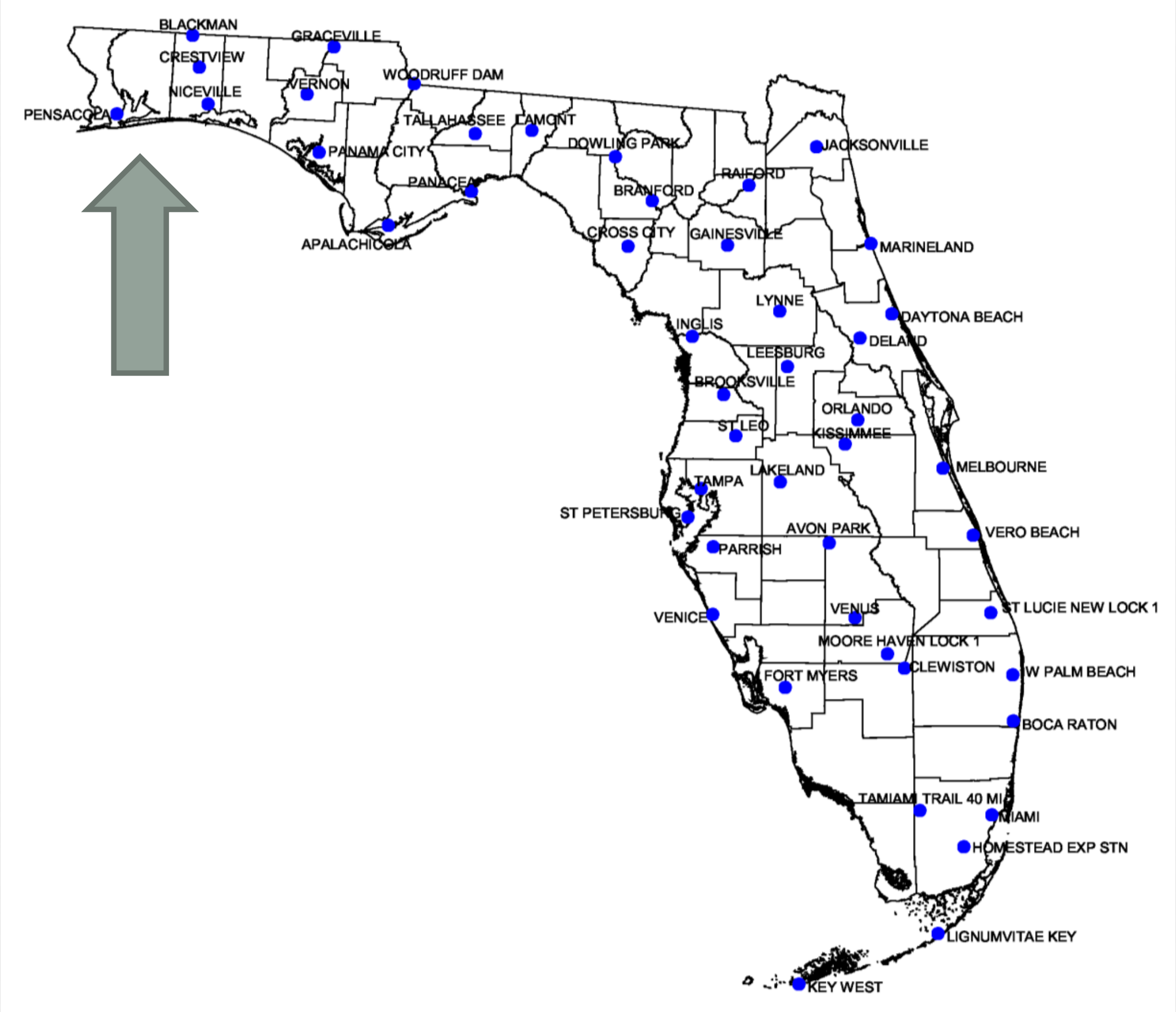
- Definition varies depending on the type of analysis
  - Flood routing – Major events
    - DCIA includes all impervious areas from which runoff discharges directly into the drainage system
    - Also considered to be DCIA if runoff discharges as a concentrated shallow flow over pervious areas and then into the drainage system
      - Ex. – Shallow roadside swales
    - Often generously estimated to provide safety factor for design
  - Annual runoff estimation – Common daily events
    - DCIA includes all impervious areas from which runoff discharges directly into the drainage system during small events
    - Does not include swales
    - Generally results in a lower DCIA value than used for flood routing

Meteorological Sites Included in Runoff Modeling

HOURLY RAINFALL SITES USED FOR RUNOFF MODELING

- 45 SITES TOTAL

- RUNOFF MODELING CONDUCTED FOR EACH RAIN EVENT AT EACH SITE OVER AVAILABLE PERIOD OF RECORD

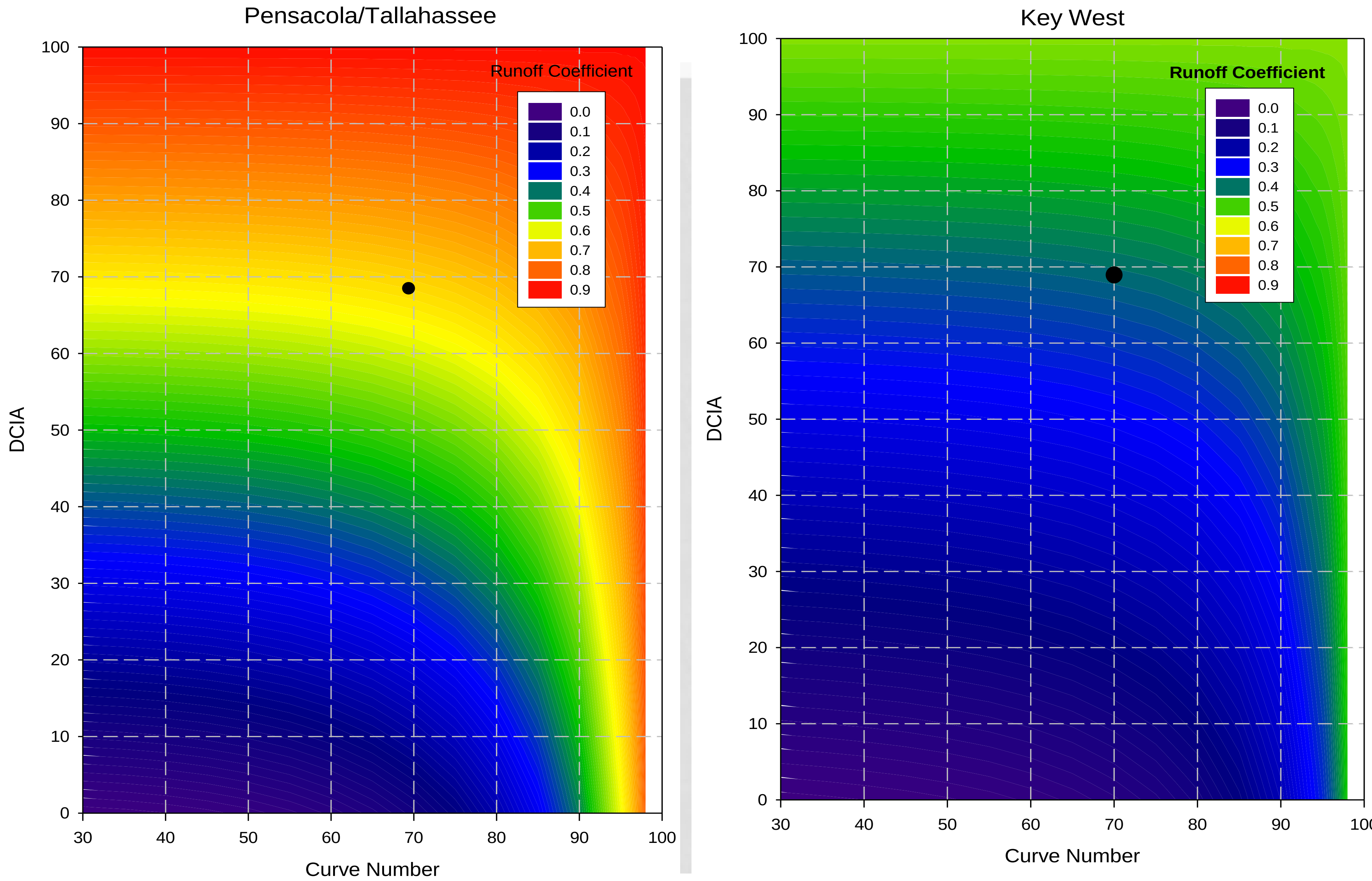


C VALUES FOR VARIOUS COMBINATIONS OF CN AND DCIA IN ESCAMBIA COUNTY

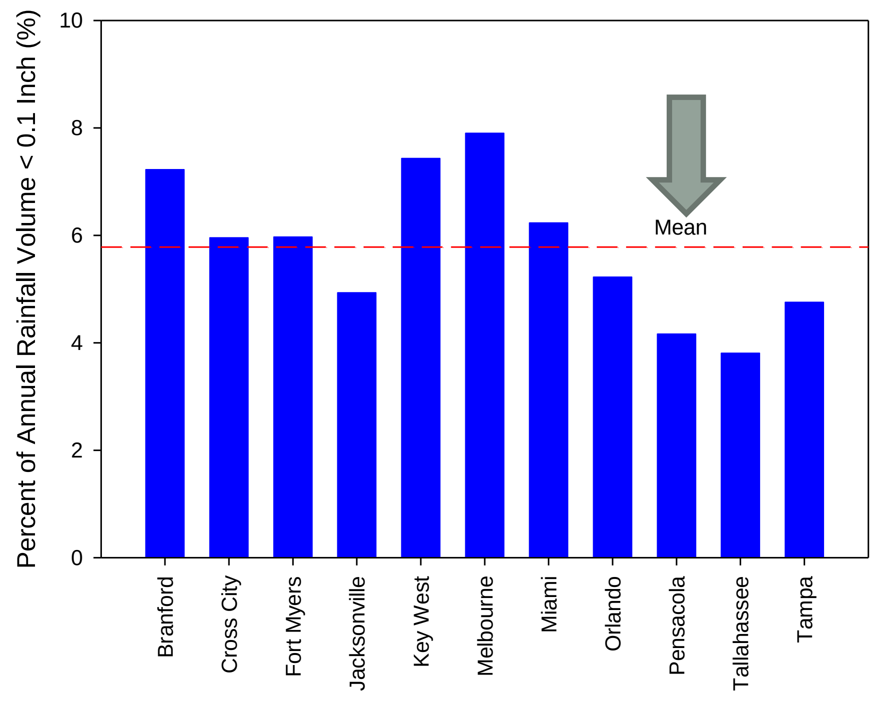
Zone 1
Mean Annual Runoff Coefficients (C Values) as a Function of DCIA Percentage and Non-DCIA Curve Number (CN)

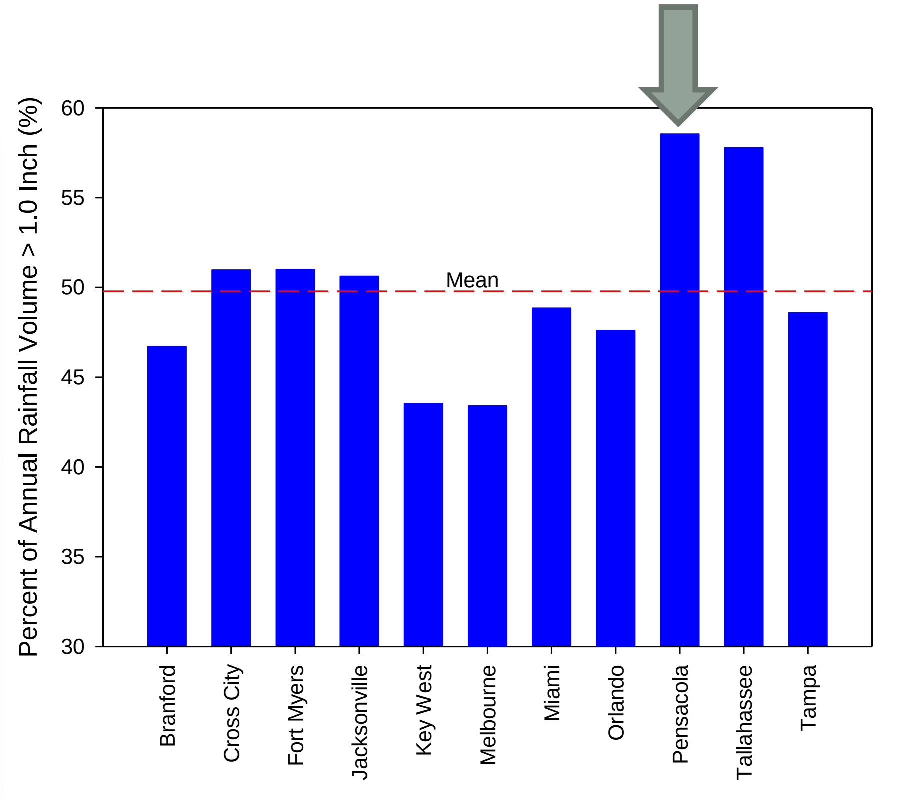
NDCIA	Percent DCIA																				
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
30	0.006	0.048	0.090	0.132	0.175	0.217	0.259	0.301	0.343	0.386	0.428	0.470	0.512	0.554	0.596	0.639	0.681	0.723	0.765	0.807	0.849
35	0.009	0.051	0.093	0.135	0.177	0.219	0.261	0.303	0.345	0.387	0.429	0.471	0.513	0.555	0.597	0.639	0.681	0.723	0.765	0.807	0.849
40	0.014	0.056	0.098	0.139	0.181	0.223	0.265	0.307	0.348	0.390	0.432	0.474	0.515	0.557	0.599	0.641	0.682	0.724	0.766	0.808	0.849
45	0.020	0.062	0.103	0.145	0.186	0.228	0.269	0.311	0.352	0.394	0.435	0.476	0.518	0.559	0.601	0.642	0.684	0.725	0.767	0.808	0.849
50	0.029	0.070	0.111	0.152	0.193	0.234	0.275	0.316	0.357	0.398	0.439	0.480	0.521	0.562	0.603	0.644	0.685	0.726	0.767	0.808	0.849
55	0.039	0.079	0.120	0.161	0.201	0.242	0.282	0.323	0.363	0.404	0.444	0.485	0.525	0.566	0.606	0.647	0.687	0.728	0.768	0.809	0.849
60	0.052	0.092	0.132	0.172	0.212	0.252	0.291	0.331	0.371	0.411	0.451	0.491	0.531	0.570	0.610	0.650	0.690	0.730	0.770	0.810	0.849
65	0.069	0.108	0.147	0.186	0.225	0.264	0.303	0.342	0.381	0.420	0.459	0.498	0.537	0.576	0.615	0.654	0.693	0.732	0.771	0.810	0.849
70	0.092	0.130	0.167	0.205	0.243	0.281	0.319	0.357	0.395	0.433	0.471	0.508	0.546	0.584	0.622	0.660	0.698	0.736	0.774	0.812	0.849
75	0.121	0.158	0.194	0.230	0.267	0.303	0.340	0.376	0.412	0.449	0.485	0.522	0.558	0.595	0.631	0.667	0.704	0.740	0.777	0.813	0.849
80	0.162	0.196	0.230	0.265	0.299	0.334	0.368	0.402	0.437	0.471	0.506	0.540	0.574	0.609	0.643	0.678	0.712	0.746	0.781	0.815	0.849
85	0.220	0.252	0.283	0.315	0.346	0.378	0.409	0.441	0.472	0.503	0.535	0.566	0.598	0.629	0.661	0.692	0.724	0.755	0.787	0.818	0.849
90	0.312	0.339	0.366	0.393	0.419	0.446	0.473	0.500	0.527	0.554	0.581	0.608	0.634	0.661	0.688	0.715	0.742	0.769	0.796	0.823	0.849
95	0.478	0.496	0.515	0.533	0.552	0.571	0.589	0.608	0.626	0.645	0.664	0.682	0.701	0.719	0.738	0.757	0.775	0.794	0.812	0.831	0.849
98	0.656	0.666	0.676	0.685	0.695	0.705	0.714	0.724	0.734	0.743	0.753	0.763	0.772	0.782	0.792	0.801	0.811	0.821	0.830	0.840	0.849

Annual C Values as a Function of DCIA and non-DCIA Curve Number



Impacts of Rainfall Characteristics on Runoff Generation



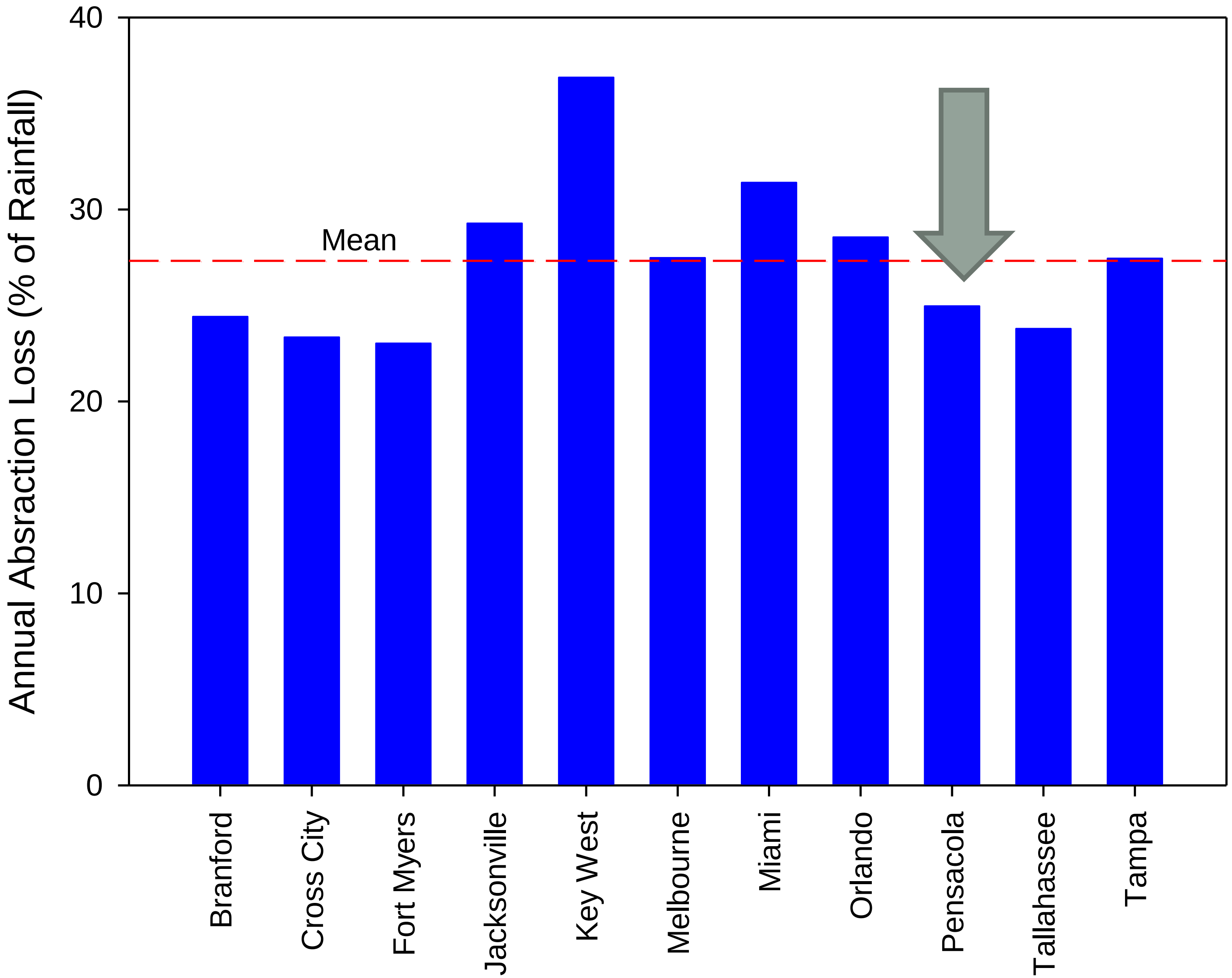


- Key West and Melbourne have a higher percentage of small rain events and a lower percentage of large rain events
  - Results in lower annual runoff coefficient (C value)
- Pensacola has a lower percentage of small events and a higher percentage of large events
  - Results in higher annual runoff coefficient (C value)

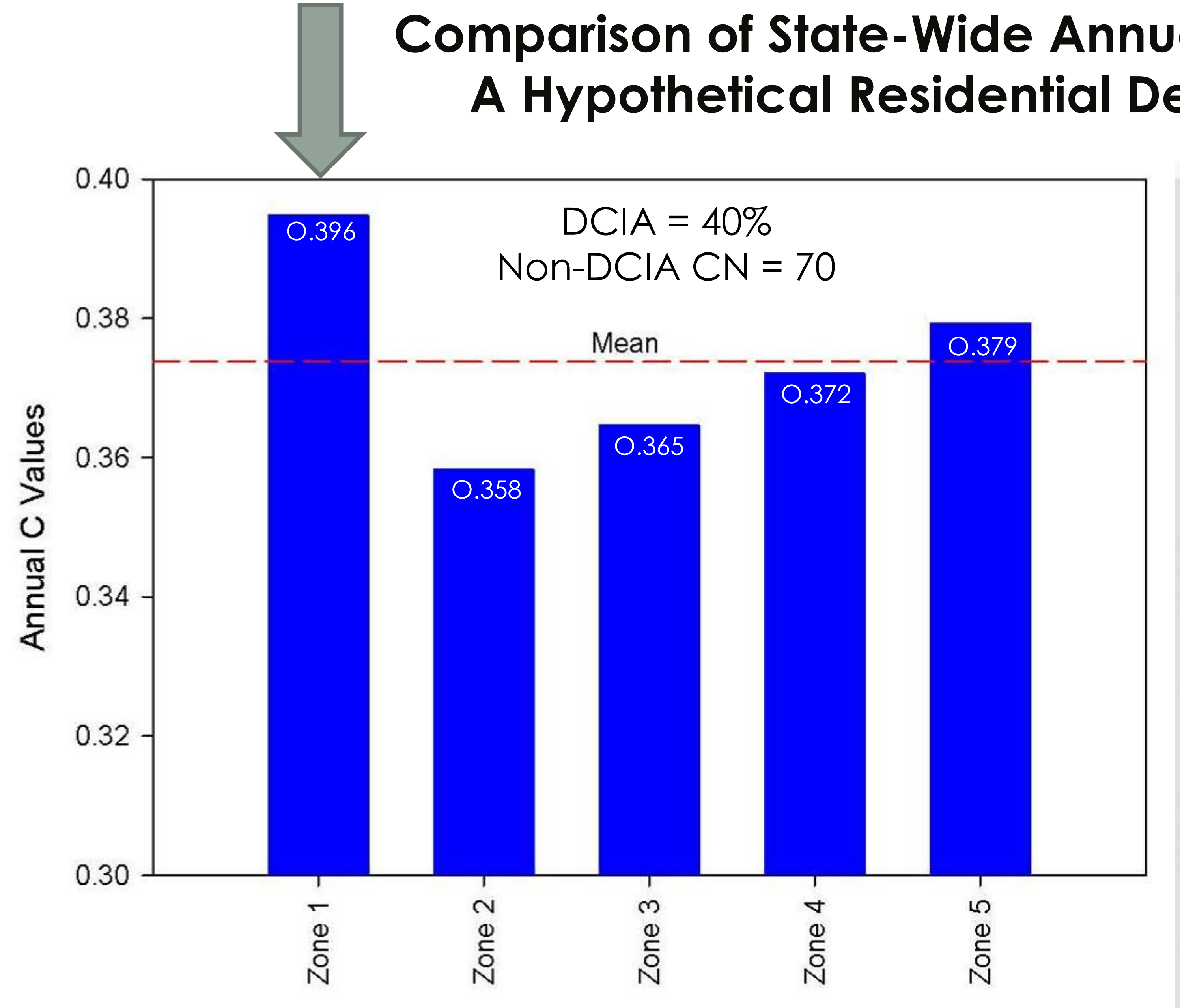
Comparative Abstraction from Impervious Areas for Meteorological Sites

- Approximately 37% of annual rainfall in Key West is lost to abstraction and does not generate runoff

- Approximately 25% of annual rainfall in Pensacola is lost to abstraction and does not generate runoff



Comparison of State-Wide Annual C Values for A Hypothetical Residential Development



SUMMARY RUNOFF CONDITIONS

- Like rainfall, runoff in Florida is highly variable, depends on
  - Impervious area
    - Direct relationship between runoff and impervious percentage
  - Non-DCIA CN value (soils and cover crop)
    - Exponential relationship between CN value and runoff
  - Characteristics of rain events
- BMPTRAINS Model is the only one that calculates annual C value and runoff volume based on site and rainfall characteristics characteristics of the project site.

HOW DO WE CALCULATED THE LOADINGS

- Runoff concentrations are commonly expressed in terms of an event mean concentration (EMC):

$$\textbf{EMC} = \frac{\text{pollutant loading}}{\text{runoff volume}}$$

- An annual emc value is generally determined by evaluating event emc values over a range of rainfall depths and seasons
  - Generally estimated based on field monitoring
  - Usually requires a minimum of 7-10 events collected over a range of conditions
- Annual mass loadings are calculated by:

Annual mass loading = annual runoff volume x annual EMC

HISTORY OF FLORIDA EMC DATABASE

- The original database was developed by ERD in 1990 in support of the Tampa Bay SWIM Plan
  - A literature review was conducted to identify runoff emc values for single land use categories in Florida
  - Approximately 100 studies were identified
    - Each study was evaluated for adequacy of the data, length of study, number of monitored events, completeness, and monitoring protocol
  - Original selection criteria
    - Monitoring site included a single land use category – most difficult criterion
    - At least 1 year of data collection; minimum of 5 events monitored in a flow-weighted fashion
    - Wide range of rainfall depths and antecedent dry periods included in monitored events
    - Seasonal variability included in monitored samples
  - 59 studies were selected for inclusion in the data base for post development
  - Values were summarized by general land use category
  - First known compilation of emc data for Florida
  - EMC values calculated as simple arithmetic means

FLORIDA DEVELOPED LAND STUDIES IN EMC DATA BASE

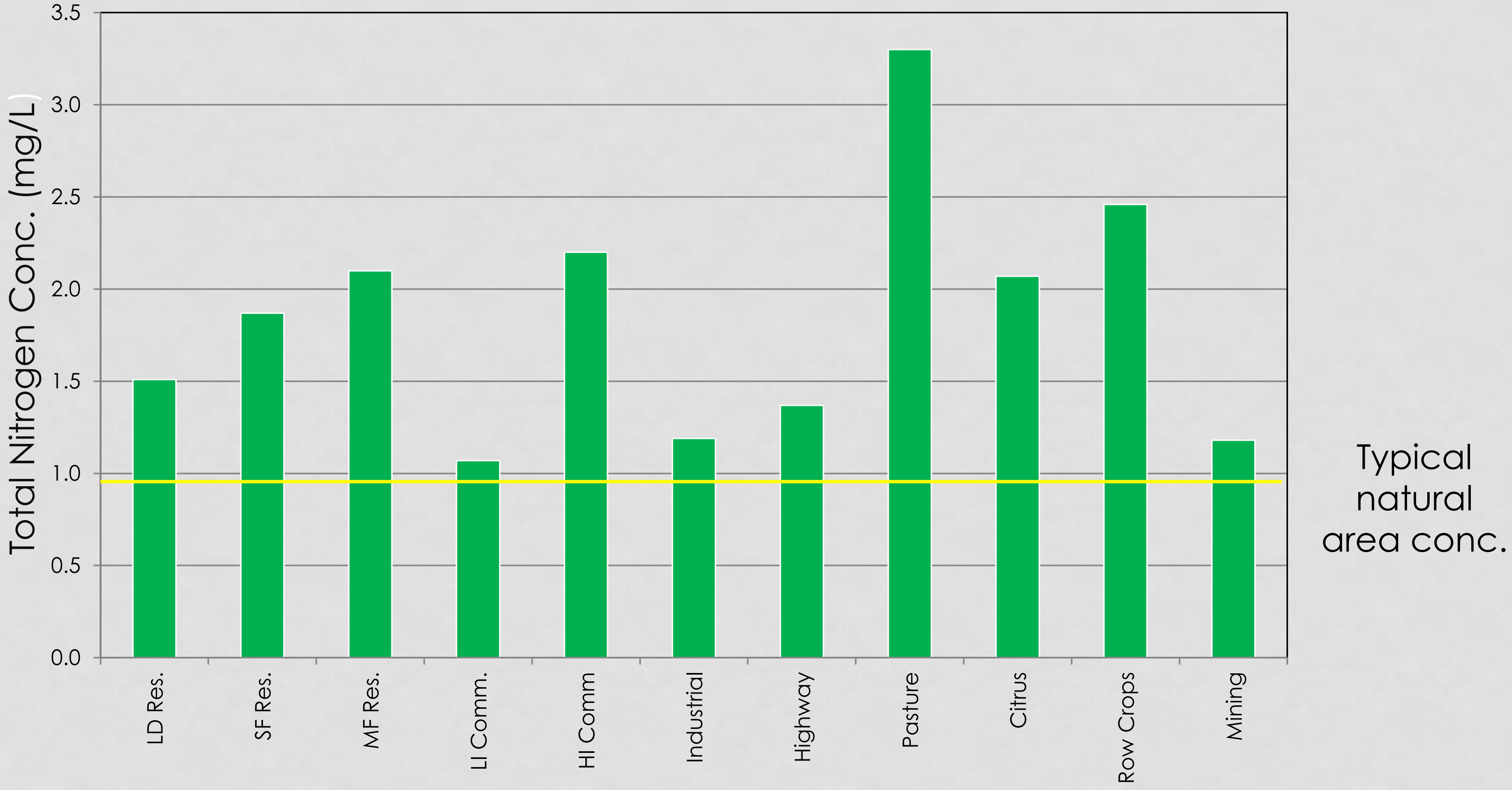
LAND USE	NUMBER OF STUDIES
Single Family Residential	17
Multi-Family Residential	6
Low Intensity Commercial	9
High Intensity Commercial	4
Industrial	4
Highway	15
Parks/open space	4

FLORIDA EMC VALUES

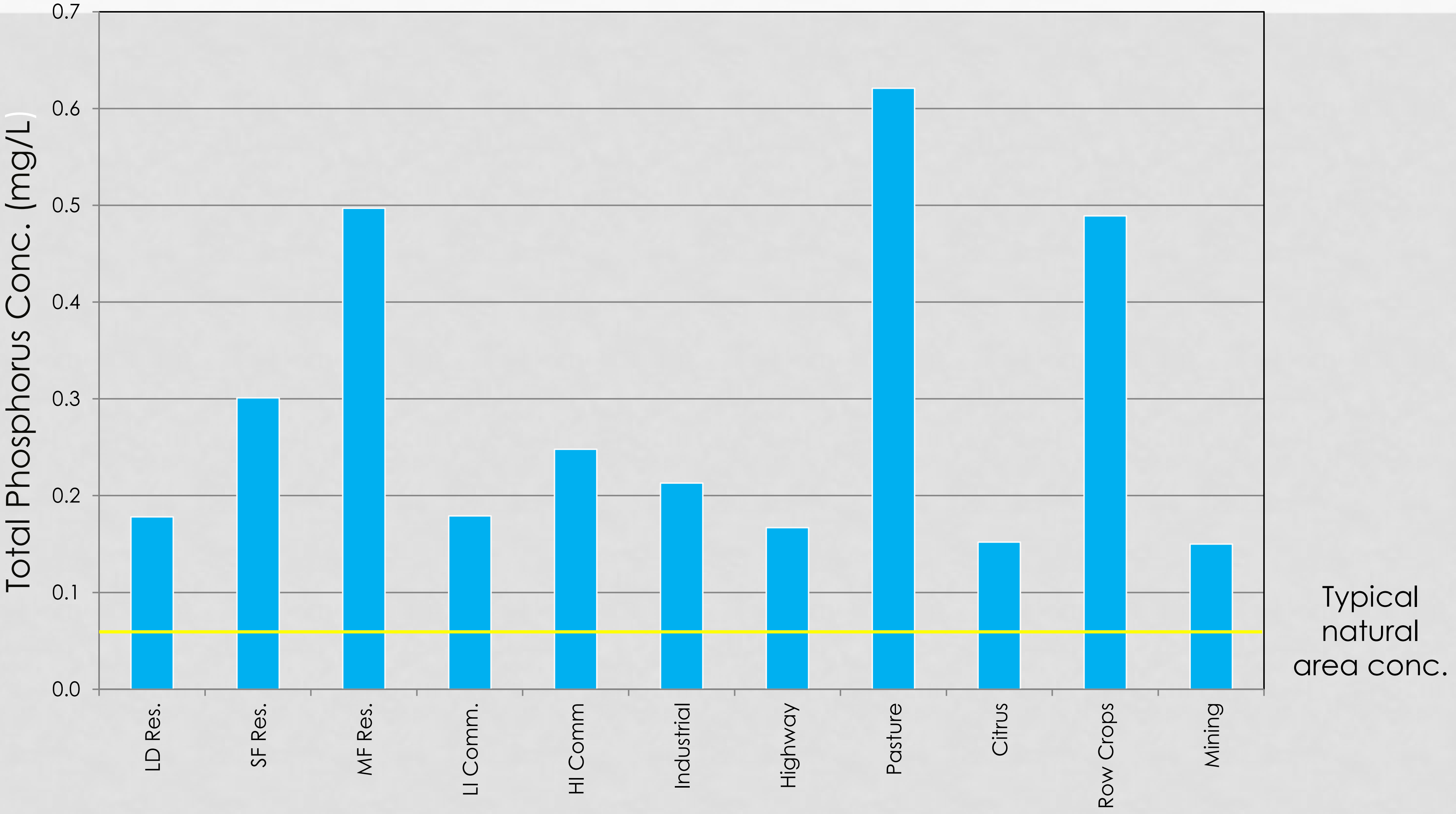
Land Use Category	EMC (mg/l)	
	Total N	Total P
Low Density Residential[1]	1.645	0.27
Single Family	2.07	0.327
Multi-Family	2.32	0.520
Low Intensity Commercial	1.13	0.188
High Intensity Commercial	2.40	0.345
Light Industrial	1.20	0.260
Highway	1.52	0.200
Agricultural		
Pasture	3.51	0.686
Citrus	2.24	0.183
Row Crops	2.65	0.593
Mining/Extractive	1.18	0.150
Range land/park land	1.15	0.055
Natural vegetative community	1.22	0.213

- Values reflect discharge concentrations without any pre-treatment

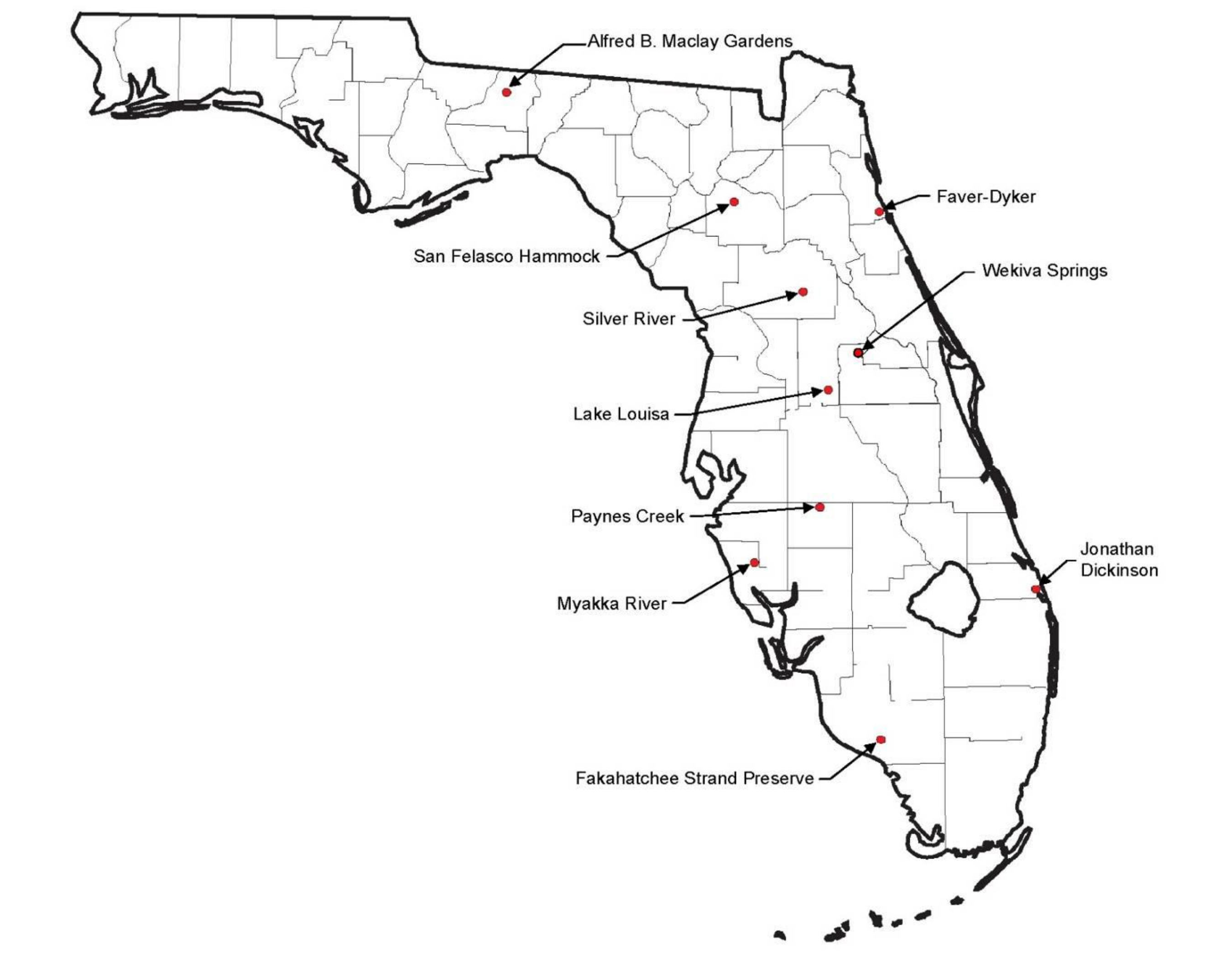
Comparison of Typical Nitrogen Concentrations in Stormwater from Developed Lands



Comparison of Typical Phosphorus Concentrations in Stormwater from Developed Lands



Monitored State Parks Used for Natural Area EMCs



SUMMARY OF FLORIDA UPLAND LAND USE CLASSIFICATIONS
(SOURCE: FFWCC)

Classification	Area (acres)	Percent of Total
Coastal Strand	15,008	0.1
Dry Prairie	1,227,697	11.4
Hardwood Hammock/Forest	980,612	9.1
Mixed Pine/Hardwood Forest	889,010	8.3
Pinelands	6,528,121	60.7
Sand Pine Scrub	194,135	1.8
Sandhill	761,359	7.1
Tropical Hardwood Hammock	15,390	0.1
Xeric Oak Scrub	146,823	1.4
Totals:	10,758,155	100.0

Monitored natural areas include more than 92% of upland land covers in Florida

Natural Land Use Runoff Concentrations

Land Type	N	Total N (µg/l)	Total P (µg/l)
Dry Prairie	12	2,025	184
Marl Prairie	6	684	12
Mesic Flatwoods	30	1,087	43
Ruderal/Upland Pine	5	1,694	162
Scrubby Flatwoods	13	1,155	27
Upland Hardwood	79	1,042	346
Upland Mixed Forest	55	606	1,166
Wet Flatwoods	76	1,213	21
Wet Prairie	23	1,095	15
Xeric Scrub	3	1,596	156

SUMMARY OF EMC AND LOADINGS

- Runoff emc values are available for a wide range of landuse categories in Florida
  - Urban land uses
  - Natural land uses
- Estimation of annual runoff loadings requires
  - Estimation of annual runoff volume
  - Runoff emc value which reflects runoff characteristics
- Any calculations should be based on user input data for
  - Location
  - Annual rainfall
  - Project physical land and soil characteristics
  - Pre/post Land use and cover

HOW DO WE ASSIGN EFFECTIVENESS TO THE FIVE LID BMPS WE FOCUS ON IN THE COUNTY?

All 5 reduce the volume of runoff, thus reduce TMDL

1. **Reduce impervious areas:** These reduce the area from which there is discharge and thus reduce the stormwater volume and the amount of mass discharged.
2. **Pervious pavements:** Storage in reservoir resulting in a reduction in the volume of discharge which reduces the pollutant loading.
3. **Bioretention areas:** promotes infiltration resulting in a reduction in volume discharge and pollutant loadings.
4. **Swales:** transport and infiltrate stormwater, thus a reduction in volume of discharge and pollutant loadings.
5. **Vegetated greenroofs,** promotes evapotranspiration and thus a reduction in the volume of discharge and pollutant loadings.

THREE LID RETENTION OPTIONS
PERVIOUS PAVEMENTS, SWALES, AND RAIN GARDENS

← All three together

Note: greenroofs also retain about 0.1 inch of water per inch of media depth

Street and Parking Lot Rain Gardens

RETENTION EFFICIENCY
WITH APPLICATION TO PERVIOUS PAVEMENTS AND BIO-RETENTION

- An evaluation of the efficiency of retention practices was conducted by Harper and Baker (2007) for FDEP which is summarized in the document titled "Evaluation of Current Stormwater Design Criteria within the State of Florida"

- Based on a continuous simulation of runoff

Modeled Dry Retention Removal Efficiencies

Tables were generated of retention efficiency for each meteorological zone in 0.25 inch intervals from 0.25 - 4.0 inches - 16 separate tables per zone, 80 tables

Mean Annual Mass Removal Efficiencies for 0.25-inches of Retention for Zone 1

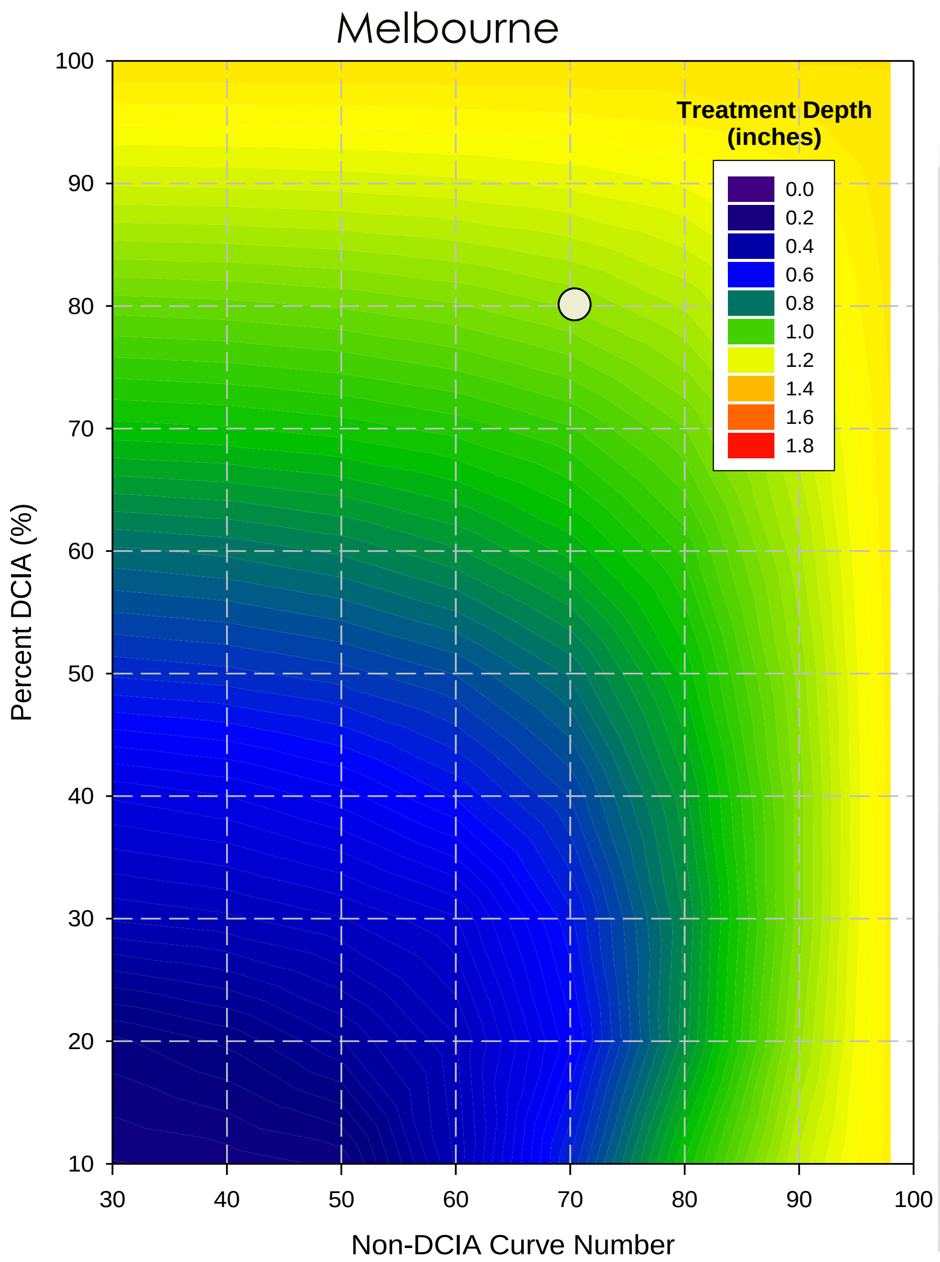
NDCIA	Percent DCIA																			
CN	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
30	86.2	81.3	73.3	65.5	58.7	53.0	48.3	44.2	40.8	37.9	35.3	33.1	31.1	29.4	27.8	26.4	25.1	24.0	22.9	21.9
35	81.6	78.7	71.7	64.5	58.0	52.5	47.9	44.0	40.6	37.7	35.2	33.0	31.0	29.3	27.8	26.4	25.1	23.9	22.9	21.9
40	76.4	75.5	69.6	63.1	57.1	51.9	47.4	43.6	40.3	37.5	35.0	32.9	30.9	29.2	27.7	26.3	25.1	23.9	22.9	21.9
45	70.7	71.7	67.2	61.4	55.9	51.0	46.8	43.1	40.0	37.2	34.8	32.7	30.8	29.1	27.6	26.3	25.0	23.9	22.9	21.9
50	64.7	67.5	64.2	59.4	54.5	50.0	46.0	42.6	39.5	36.9	34.6	32.5	30.7	29.0	27.5	26.2	25.0	23.9	22.9	21.9
55	58.6	62.8	60.9	57.0	52.7	48.7	45.1	41.8	39.0	36.5	34.2	32.3	30.5	28.9	27.4	26.1	24.9	23.9	22.9	21.9
60	52.8	57.8	57.1	54.2	50.7	47.1	43.9	40.9	38.3	35.9	33.8	31.9	30.2	28.7	27.3	26.0	24.9	23.8	22.8	21.9
65	47.3	52.6	53.0	51.1	48.3	45.3	42.5	39.8	37.4	35.3	33.3	31.5	29.9	28.4	27.1	25.9	24.8	23.8	22.8	21.9
70	42.2	47.3	48.6	47.6	45.6	43.2	40.8	38.5	36.4	34.4	32.6	31.0	29.5	28.1	26.9	25.7	24.7	23.7	22.8	21.9
75	37.8	42.2	43.9	43.7	42.4	40.7	38.8	36.9	35.1	33.4	31.8	30.4	29.0	27.8	26.6	25.5	24.5	23.6	22.7	21.9
80	34.0	37.5	39.1	39.4	38.8	37.7	36.4	34.9	33.5	32.1	30.8	29.5	28.3	27.2	26.2	25.2	24.3	23.5	22.7	21.9
85	30.8	33.1	34.3	34.8	34.7	34.2	33.4	32.5	31.4	30.4	29.4	28.4	27.4	26.5	25.7	24.8	24.1	23.3	22.6	21.9
90	27.9	29.2	29.9	30.3	30.3	30.2	29.8	29.3	28.8	28.2	27.5	26.8	26.2	25.5	24.9	24.2	23.6	23.0	22.5	21.9
95	25.3	25.6	25.8	25.9	26.0	25.9	25.8	25.6	25.4	25.2	24.9	24.6	24.3	24.0	23.6	23.3	23.0	22.6	22.3	21.9
98	23.8	23.8	23.8	23.7	23.7	23.6	23.5	23.4	23.3	23.2	23.1	23.0	22.9	22.8	22.6	22.5	22.4	22.2	22.1	21.9

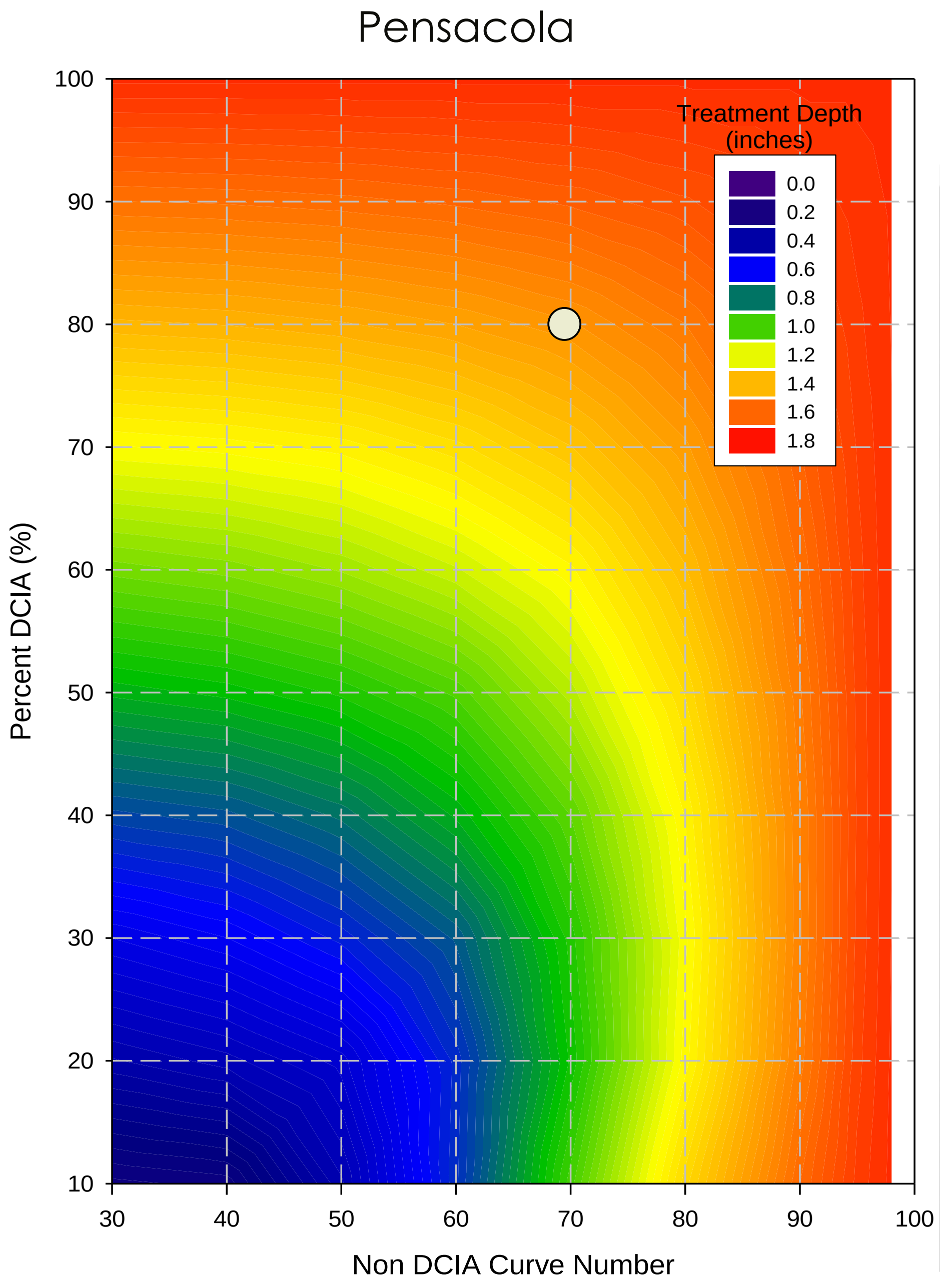
Mean Annual Mass Removal Efficiencies for 0.50-inches of Retention for Zone 1

NDCIA	Percent DCIA																			
CN	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
30	91.8	91.5	88.3	84.0	79.5	75.0	70.7	66.6	62.9	59.6	56.5	53.6	51.1	48.7	46.6	44.6	42.8	41.1	39.6	38.1
35	88.2	89.1	86.6	82.8	78.6	74.3	70.1	66.2	62.6	59.3	56.3	53.5	51.0	48.7	46.5	44.6	42.8	41.1	39.6	38.1
40	84.0	86.3	84.4	81.2	77.4	73.4	69.4	65.7	62.2	59.0	56.0	53.3	50.8	48.5	46.4	44.5	42.7	41.1	39.6	38.1
45	79.6	82.9	81.9	79.3	75.9	72.2	68.5	65.0	61.7	58.6	55.7	53.0	50.6	48.4	46.3	44.4	42.7	41.0	39.5	38.1
50	74.8	79.1	79.0	77.0	74.1	70.8	67.4	64.1	61.0	58.0	55.3	52.7	50.4	48.2	46.2	44.3	42.6	41.0	39.5	38.1
55	70.1	74.9	75.6	74.2	71.9	69.1	66.1	63.0	60.1	57.3	54.7	52.3	50.0	47.9	46.0	44.2	42.5	40.9	39.5	38.1
60	65.5	70.4	71.7	71.1	69.4	67.0	64.4	61.7	59.1	56.5	54.1	51.8	49.6	47.6	45.8	44.0	42.4	40.9	39.5	38.1
65	61.0	65.8	67.5	67.6	66.4	64.7	62.5	60.2	57.8	55.5	53.3	51.1	49.1	47.2	45.5	43.8	42.3	40.8	39.4	38.1
70	56.7	61.1	63.1	63.6	63.1	61.9	60.2	58.3	56.3	54.3	52.3	50.3	48.5	46.8	45.1	43.5	42.1	40.7	39.4	38.1
75	52.7	56.6	58.6	59.3	59.3	58.6	57.5	56.0	54.4	52.7	51.0	49.3	47.7	46.1	44.6	43.2	41.8	40.5	39.3	38.1
80	49.1	52.2	54.1	55.0	55.2	54.9	54.2	53.2	52.1	50.8	49.4	48.0	46.6	45.3	44.0	42.7	41.5	40.3	39.2	38.1
85	46.1	48.3	49.7	50.5	50.8	50.8	50.5	49.9	49.2	48.3	47.3	46.3	45.2	44.2	43.1	42.1	41.0	40.0	39.1	38.1
90	43.5	44.8	45.6	46.1	46.4	46.5	46.4	46.1	45.7	45.2	44.6	44.0	43.3	42.6	41.9	41.1	40.4	39.6	38.9	38.1
95	41.1	41.5	41.8	41.9	42.0	42.1	42.0	41.9	41.8	41.6	41.3	41.1	40.8	40.4	40.1	39.7	39.3	38.9	38.5	38.1
98	39.8	39.8	39.8	39.8	39.8	39.7	39.7	39.6	39.5	39.4	39.3	39.2	39.1	39.0	38.9	38.7	38.6	38.4	38.3	38.1

Source: Harper and Baker (2007) - Appendix D

Retention Depth Required for 80% Removal

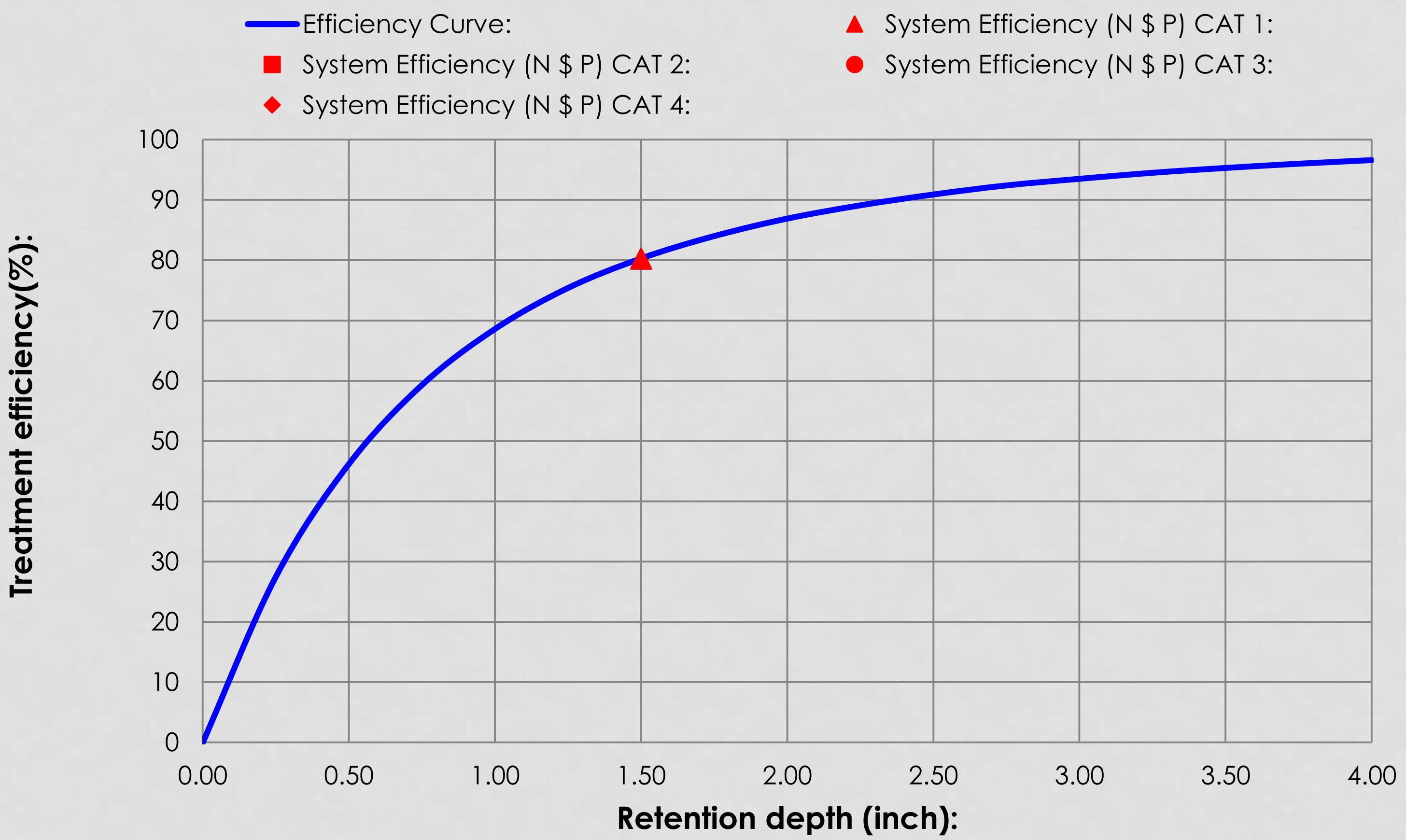




RETENTION EFFECTIVENESS
FUNCTION OF DEPTH: EXAMPLE 1.5 INCH STORAGE

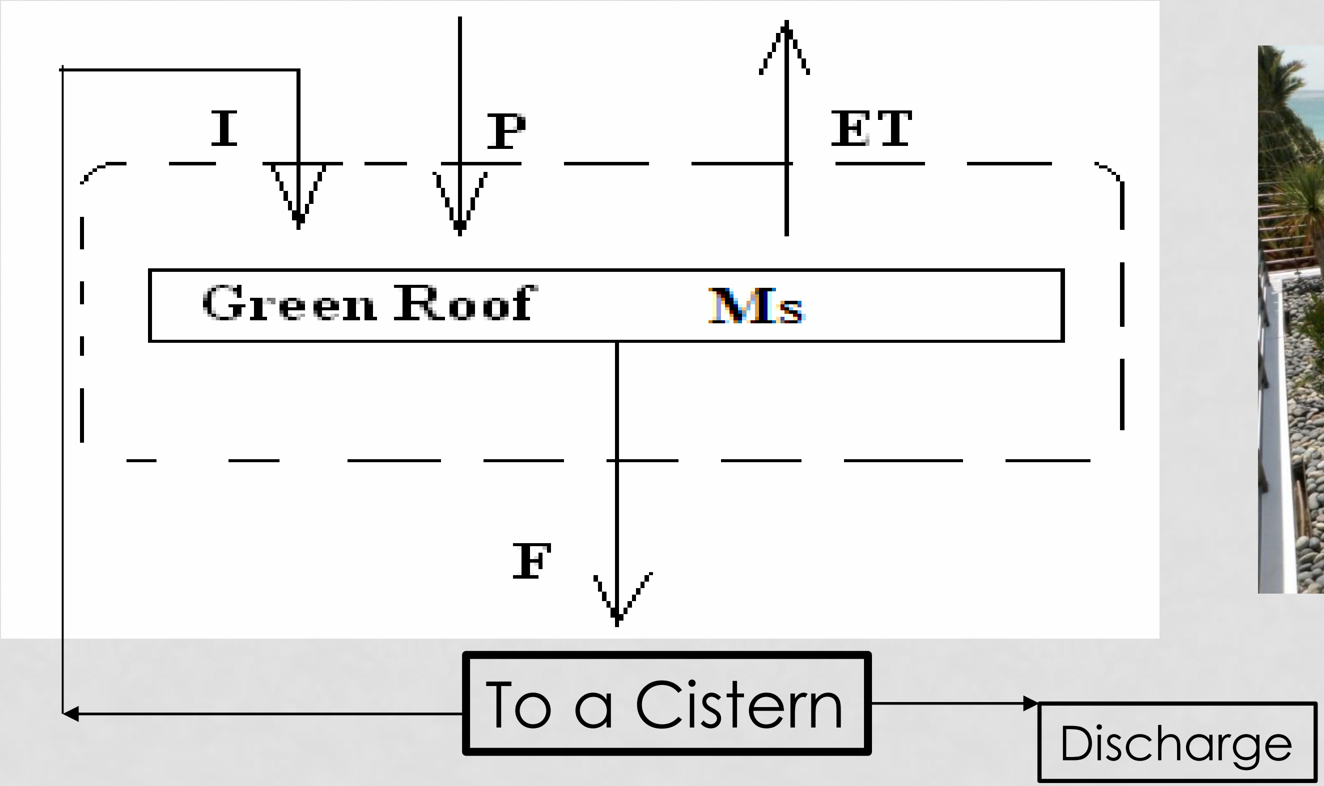
Going from a residential Area to a multifamily area with net improvement and sandy soils, need 68% TN and 77% TP removal.

Result using BMPTRAINS 80% removal for 1.5 inch Depth of treatment.



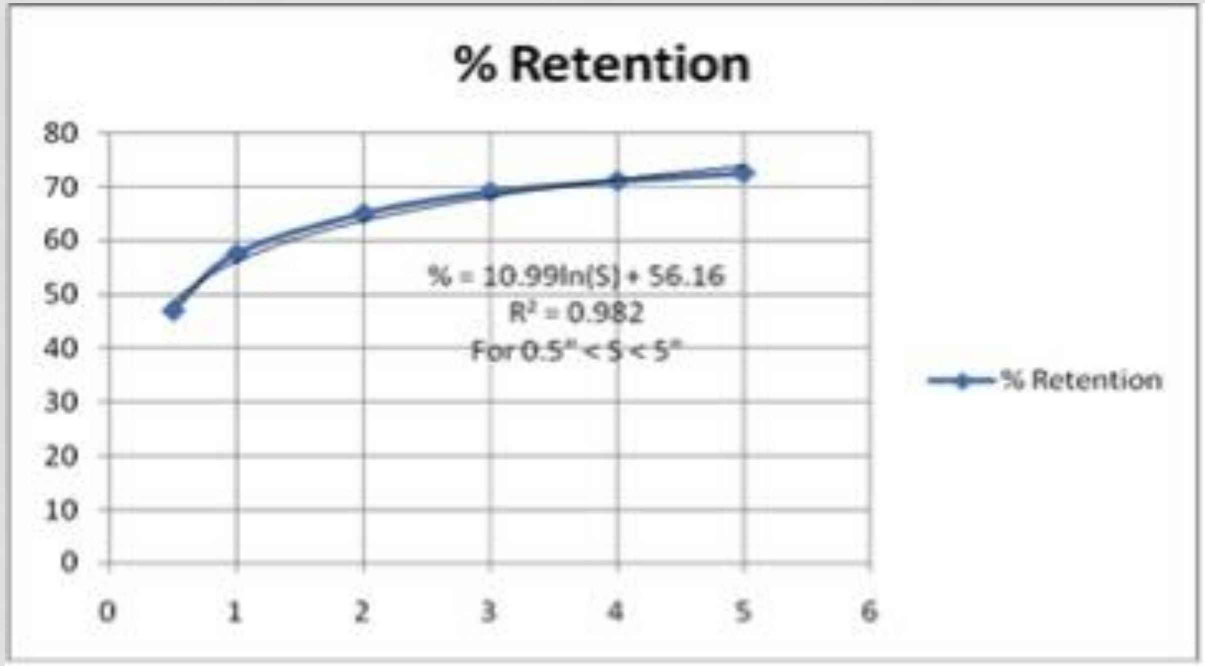
GREENROOF EFFECTIVENESS

- Based on a long term simulation (46 years) of operation with verification of operating parameters



GREENROOF EFFECTIVENESS
ESCAMBIA COUNTY

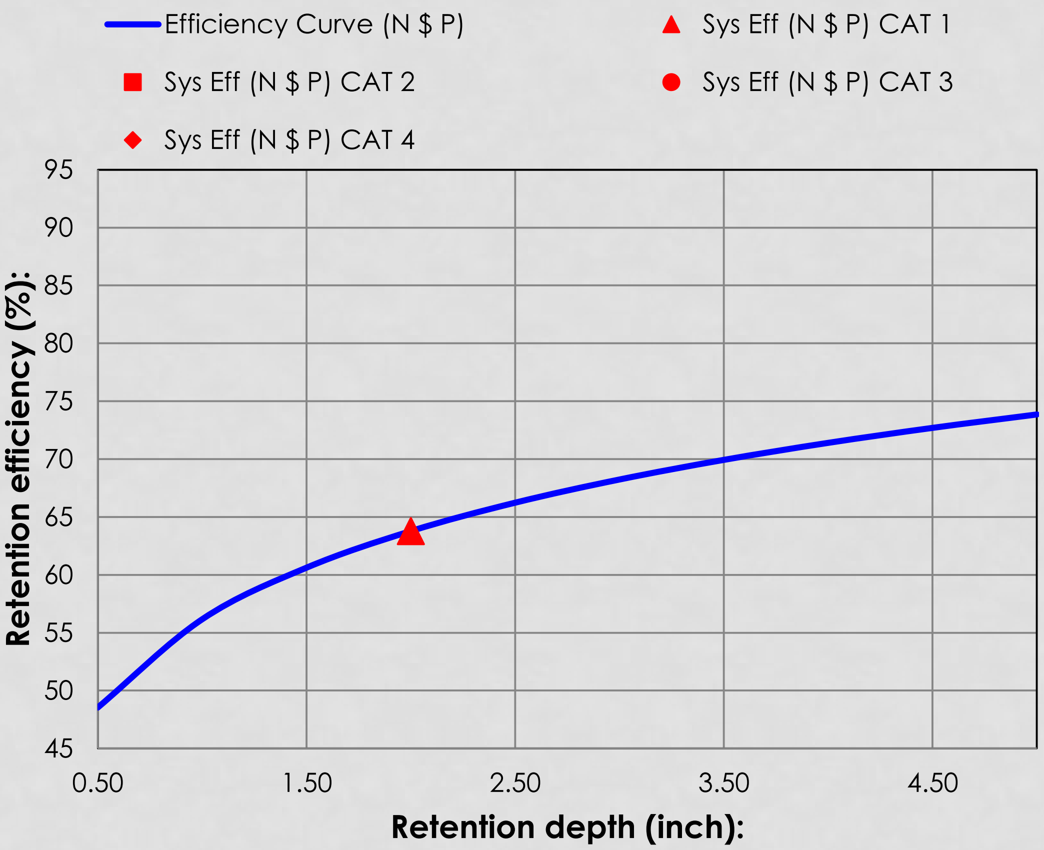
Percent Reduction in the mass of discharge is the (Y) axis
And as a function of cistern sizes (x) axis in inches.
There is a 33% capture if no cistern is used.



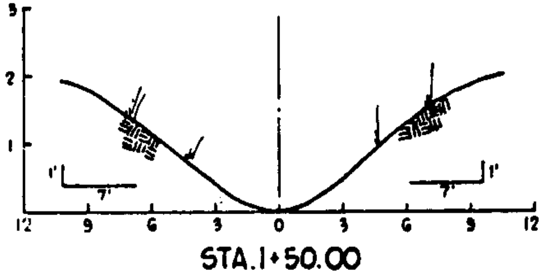
EXAMPLE OUTPUT GREENROOF DESIGN

(USING BMPTRAINS SCREEN CAPTURE)

2 inches of cistern storage
Escambia County location
With 62.2 inches of rain /year



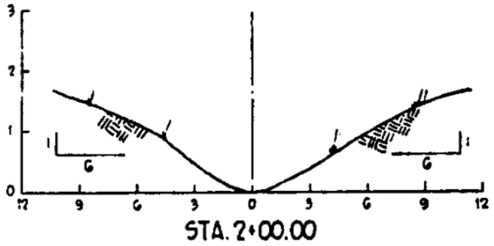
SAVE THE SWALES



Site Classification
C_u = 2.08
C_z = 1.33
K_d = 4.068 in/hr
Longitudinal Slope: 0.0279

Horizontal Scale: 6' =
Vertical Scale: 2' =

Figure 5. Swale at I-4 Maitland Interchange-East.



Site Classification
C_u = 1.81
C_z = 1.28
K_d = 3.118 in/hr
Longitudinal Slope: 0.0133

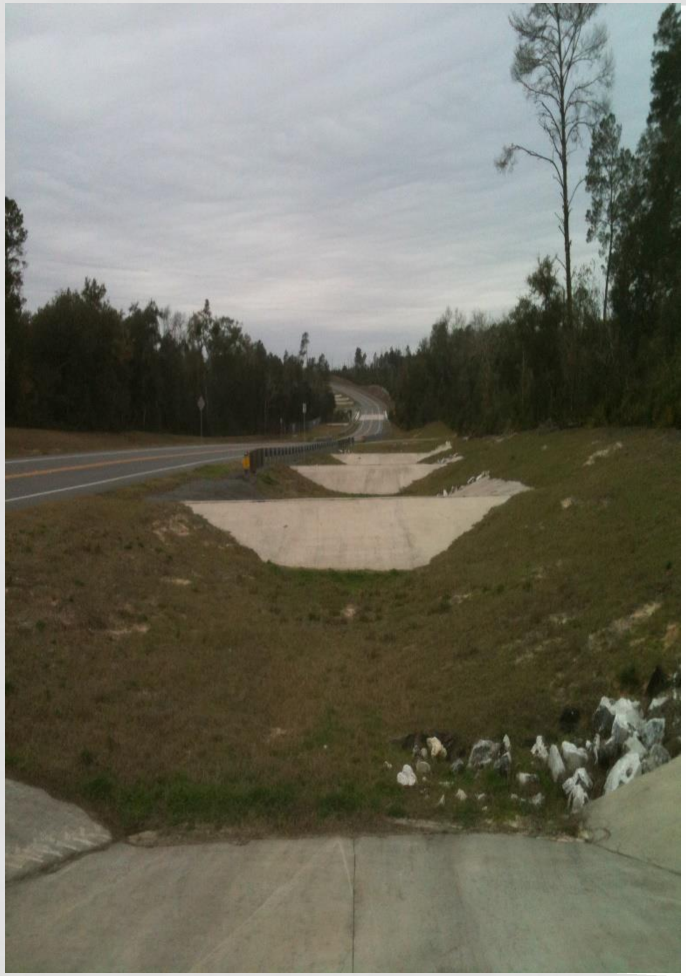
Horizontal Scale: 6' =
Vertical Scale: 2' =

Figure 8. Swale at Reed Road-Chuluota Area.

GRAPH TO AID IN SPACING

80% Capture

5% slope



Downstream

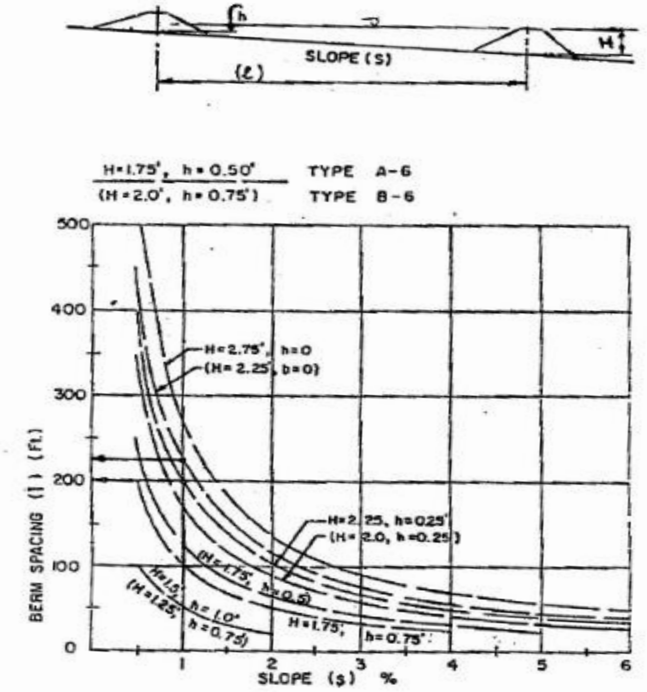


Figure 3 Berm Spacing (ℓ) as a Function of Berm Heights (H, h) and Slope (s) for Swale of Side Slope of 6 on 1

(from Pehmann-Koo, 1984)

Upstream

PROGRAMMING OF EQUATIONS
(AN EXAMPLE)

$$L = \frac{21{,}032\ Q^{5/8}\ Z^{5/8}\ S^{3/16}}{n^{3/8}\ (1 + Z^2)^{5/8}\ i} \tag{A-18}$$

where:

L = length of swale (ft)

Q = average flow rate to be percolated (cfs)

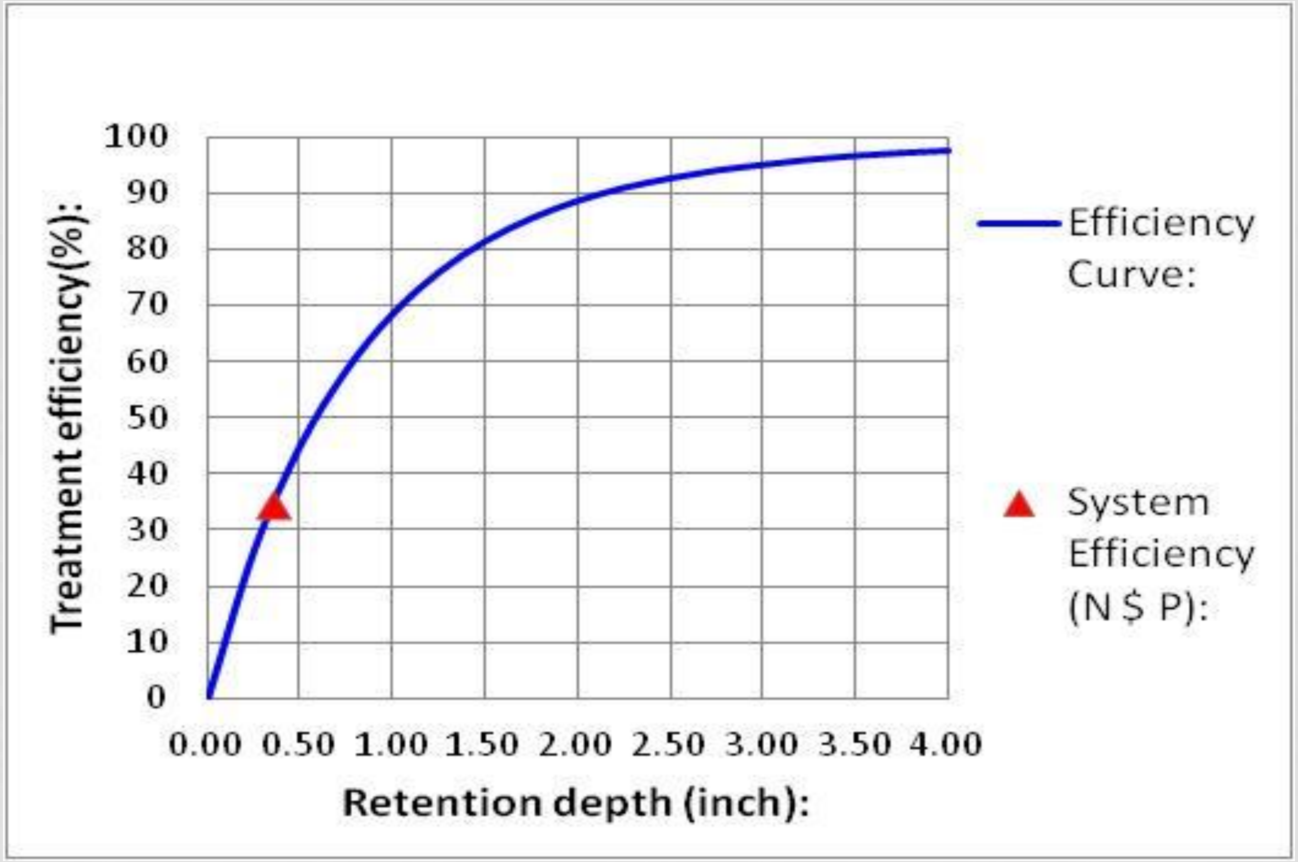
Z = horizontal distance per one foot of elevation change inside slope

S = longitudinal or flow slope

n = Manning's Roughness Coefficient

i = infiltration rate (in/hr)

EXAMPLE OUTPUT SWALE DESIGN
(SCREEN CAPTURE FROM BMPTRAINS)



REMOVE MORE TN & TP FROM SURFACE DISCHARGES

- Add Biosorption Activated Media (**BAM**)to the discharge of an LID, such as from rain gardens (depression areas), in swale blocks, and the discharge from wet detention ponds.
- Already being used in greenroofs, which specify the use pollution control media.


AVAILABLE BAM AND CAN ALSO USE OTHERS AS APPROVED

DESCRIPTION OF MEDIA		PROJECTED TREATMENT PERFORMANCE *			TYPICAL OPERATING LIMITING FILTRATION RATE (in/hr)
Media and Typical Location in BMP Treatment Train	**MATERIAL**	**TSS REMOVAL EFFICIENCY**	**TN REMOVAL EFFICIENCY**	**TP REMOVAL** ** **EFFICIENCY**	
B&G ECT (ref A) A first BMP, ex. Up-Flow Filter in Baffle box and a constructed wetland[#] (USER DEFINED BMP)	Expanded Clay[2] Tire Chips[1]	70%	45%	55%	96 in/hr
B&G OTE (ref A,B) Up-flow Filter at Wet Pond & Dry Basin Outflow (FILTRATION)	Organics[8] Tire Chips[1] Expanded Clay[4]	60%	45%	45%	96 in/hr
B&G ECT3 (ref C) After Wet Detention using Up-flow Filter	Expanded Clay[4] Tire Chip[1]	60%	25%	25%	96 in/hr
SAT (ref D) A first BMP, as a Down-flow Filter (FILTRATION)	Sand[3]	85%	30%	60%	1.75 in/hr
B&G CTS (ref E,F) Down-Flow Filters 12" depth*** at wet pond or dry basin pervious pave, tree well, rain garden, swale, and strips	Clay[6] Tire Crumb[5] Sand[7] & Topsoil[9]	90%	60%	90%	1.0 in/hr
B&G CTS (ref E,F) Down-Flow Filters 24" depth*** at wet pond or dry basin pervious pave, tree well, rain garden, swale, and strips	Clay[6] Tire Crumb[5] Sand[7] & Topsoil[9]	95%	75%	95%	1.0 in/hr

COMPUTATIONAL AIDS

- FDEP Harper Report (FDEP, 2007) addressing Florida conditions and average annual conditions, and is site specific, uses look up tables, does not address series and parallel configurations
- Computer Programs
  - SMADA, stormwater management and design aids.
  - SWMM , primarily hydraulic and peak flow oriented with additions for pollution control.
  - State Manuals, like from Virginia, New Hampshire, D.C., Colorado, Texas, etc.
  - Municipal Manuals, like from Orange, Duval and Pinellas Counties, Nashville, etc.
  - Proprietary usually regional and for one or a few BMPs separately.
  - None address BMP placement in series or parallel.
  - None or very limited calculations for TMDL, some event based.
  - BMPTRAINS, application of FDEP Harper Report of 2007 with evaluation and performance data for new BMPs since 2017

RETENTION EFFICIENCY CALCULATIONS

- Calculation of runoff in the BMPTRAINS model uses the tabular retention efficiency relationships developed by Harper and Baker (2007) – App. D

Mean Annual Mass Removal Efficiencies for 0.25-inches of Retention for Zone 1

NDCIA	Percent DCIA																			
CN	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
30	86.2	81.3	73.3	65.5	58.7	53.0	48.3	44.2	40.8	37.9	35.3	33.1	31.1	29.4	27.8	26.4	25.1	24.0	22.9	21.9
35	81.6	78.7	71.7	64.5	58.0	52.5	47.9	44.0	40.6	37.7	35.2	33.0	31.0	29.3	27.8	26.4	25.1	23.9	22.9	21.9
40	76.4	75.5	69.6	63.1	57.1	51.9	47.4	43.6	40.3	37.5	35.0	32.9	30.9	29.2	27.7	26.3	25.1	23.9	22.9	21.9
45	70.7	71.7	67.2	61.4	55.9	51.0	46.8	43.1	40.0	37.2	34.8	32.7	30.8	29.1	27.6	26.3	25.0	23.9	22.9	21.9
50	64.7	67.5	64.2	59.4	54.5	50.0	46.0	42.6	39.5	36.9	34.6	32.5	30.7	29.0	27.5	26.2	25.0	23.9	22.9	21.9
55	58.6	62.8	60.9	57.0	52.7	48.7	45.1	41.8	39.0	36.5	34.2	32.3	30.5	28.9	27.4	26.1	24.9	23.9	22.9	21.9
60	52.8	57.8	57.1	54.2	50.7	47.1	43.9	40.9	38.3	35.9	33.8	31.9	30.2	28.7	27.3	26.0	24.9	23.8	22.8	21.9
65	47.3	52.6	53.0	51.1	48.3	45.3	42.5	39.8	37.4	35.3	33.3	31.5	29.9	28.4	27.1	25.9	24.8	23.8	22.8	21.9
70	42.2	47.3	48.6	47.6	45.6	43.2	40.8	38.5	36.4	34.4	32.6	31.0	29.5	28.1	26.9	25.7	24.7	23.7	22.8	21.9
75	37.8	42.2	43.9	43.7	42.4	40.7	38.8	36.9	35.1	33.4	31.8	30.4	29.0	27.8	26.6	25.5	24.5	23.6	22.7	21.9
80	34.0	37.5	39.1	39.4	38.8	37.7	36.4	34.9	33.5	32.1	30.8	29.5	28.3	27.2	26.2	25.2	24.3	23.5	22.7	21.9
85	30.8	33.1	34.3	34.8	34.7	34.2	33.4	32.5	31.4	30.4	29.4	28.4	27.4	26.5	25.7	24.8	24.1	23.3	22.6	21.9
90	27.9	29.2	29.9	30.3	30.3	30.2	29.8	29.3	28.8	28.2	27.5	26.8	26.2	25.5	24.9	24.2	23.6	23.0	22.5	21.9
95	25.3	25.6	25.8	25.9	26.0	25.9	25.8	25.6	25.4	25.2	24.9	24.6	24.3	24.0	23.6	23.3	23.0	22.6	22.3	21.9
98	23.8	23.8	23.8	23.7	23.7	23.6	23.5	23.4	23.3	23.2	23.1	23.0	22.9	22.8	22.6	22.5	22.4	22.2	22.1	21.9

NOTE: There are 80 of these tables.

MODELS THAT CONSIDER LID BMPs
HOWEVER AVERAGE ANNUAL REMOVAL (TMDL) NOT ADDRESSED

Stormwater Model / BMPs	Retention Bioretention	Dry Detention	Swale	Green Roof	Filter Strip & Buffer	Permeable Pavement	Sand Filter	Water Harvesting	Wet Detention	Built Wetland	Rain Garden	Exfiltration
Jordan/Falls Lake Model	x	x	x	x	x	x	x	x	x	x		
BMP SELECT Model	x	x	x		x	x	x		x	x		
Clinton River SET	x	x	x	x	x	x	x		x			
Virginia Runoff Reduction	x	x	x	x		x			x			
DES Simple Method Pollutant Loading	x	x	x	x	x	x	x	x	x	x		
Colorado	x	x	x			x	x		x	x	x	
D.C. Green			x		x	x					x	
SMADA	x		x					x	x			
BMPTRAINS	x		x	x	x	x	x	x	x		x	x

WHAT WOULD BE NEEDED TO DESIGN EFFECTIVE STORMWATER BMP TREATMENT TRAINS AND QUANTIFY LOAD REDUCTIONS?

- **Current "presumptive BMP design criteria" do not achieve high level of treatment needed for discharges to impaired water bodies – need LID BMPs to expand toolbox**
- **Must be able to quantify the pre-development stormwater loadings**
- **Must be able to quantify the post-development stormwater loadings**
- **Must be able to quantify and demonstrate effectiveness of each BMP, including LID BMPs, in treatment trains**
- **AND.. Calculate relative costs of various BMP combinations**

WHY BMPTRAINS MODEL

- Model developed in cooperation with DEP, WMDs, consultants, and DOT
- Model is in the public domain
- Model incorporates the latest information relative to designing stormwater treatment systems in Florida:
  - Florida annual rainfall by zones and location
  - Includes local watershed soil and cover conditions
  - Statewide Event Mean Concentrations
  - Statewide stormwater BMP effectiveness data
  - Latest LID BMP effectiveness data
  - Stormwater LID BMP design criteria (developed for Statewide Stormwater Rule)

USE OF THE BMPTRAINS MODEL

- Evaluates whether a project is meeting Net Improvement
- Evaluates site planning/BMP treatment train options
- Evaluates load reduction of BMP treatment train options
- Evaluates costs of BMP treatment train options
- Used to evaluate ERP/BMP options for projects in Lee County, Pinellas County
- Used to evaluate BMP options for St. Joe Sector Plan in Bay County
- Used to evaluate LID options in ERP aps to DEP & WMDs
- Used by FDOT and their consultants

SUMMARY

- **The LID BMPs in the Escambia County LID Manual provide new tools that reduce the volume and pollutant loading of stormwater discharges.**
- **The five highlighted LID BMPs in the Manual reduce the volume of stormwater discharge thereby reducing stormwater pollutant loadings.**
  - ✓ Pervious pavements and rain gardens function as storage with infiltration areas.
  - ✓ The volume of runoff decreases when the impervious area is reduced or is disconnected using pervious areas for pre-treatment.
  - ✓ Greenroof storage adds to evapotranspiration, thus reduces discharge volume.
  - ✓ Swales partly infiltrate, and usually are part of the transport drainage system.
- **Efficiencies of LID BMPs and BMP treatment trains vary throughout the State due to variability in rainfall and runoff characteristics. Site specific data is available for Escambia County.**
- **Computational aids should simplify and validate the calculations for a project site. BMPTRAINS model satisfies all requirements for a reasonable prediction of performance.**

QUESTIONS, REMARKS AND DISCUSSION

BY: MARTY WANIELISTA AND ERIC LIVINGSTON

August, 2016
Escambia County