

## No Sweetener in Your Stormwater, But What About Your Reclaimed Water

The Efficacy of Selected Organic Microconstituents as Markers for Nitrogen and Phosphorus Loading from Reclaimed Water Plants in Florida

A WaterReuse Research Foundation Tailored Collaboration Project

April 17, 2012



## Outline

- Reclaimed Water in Florida
- Impacts of Nutrients Nationwide
- Florida's Numeric Nutrient Standards
- WaterReuse Study

2

## It Goes By Many Names – What is it?

Reclaimed Water  
Recycled Water  
Water Reuse

} Used interchangeably, but don't actually mean the exact same thing

The planned beneficial use of treated wastewater

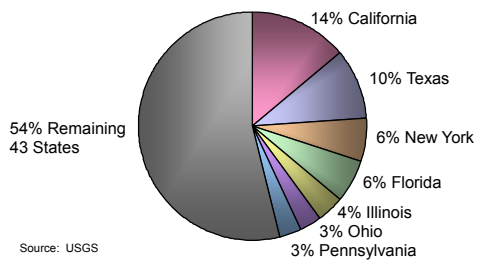
3

## Drivers for Implementation in United States

- Climate change
- Increasing potable water demands
- Conservation of water resources
- Drought proof source of supply
- Timing of development
- Effluent discharge regulations
- Improving interagency relationships

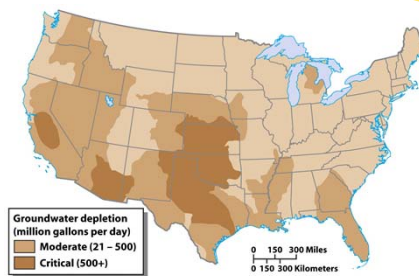
4

## Public-Supply Water Withdrawals

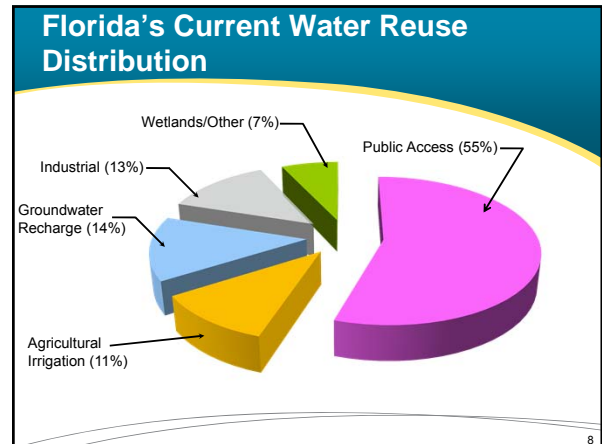
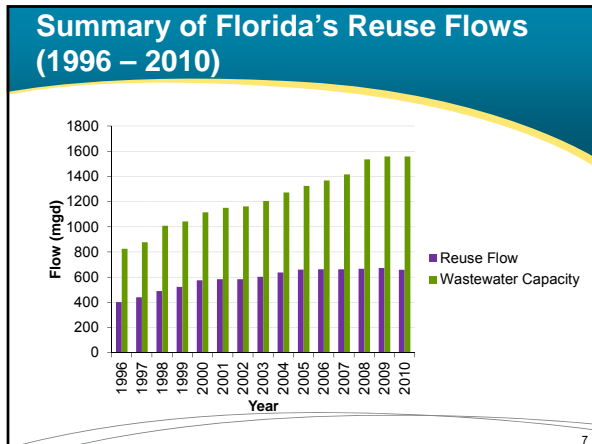


5

## Water Problems in the United States



6



### Why is the Control of Nutrients Important?

- Excessive nutrients can cause:
  - algae blooms
  - encourage growth of nuisance vegetation
  - reduce dissolved oxygen
- Public health concern – nitrate contamination of drinking water source
- Water quality characteristics of the receiving waters dictate sensitivity to nutrients

### Nutrients – Typically Associated with Surface Water Impacts

- Nitrogen and Phosphorus which are needed building blocks for all life, but in excessive amounts can cause excess growth of unwanted aquatic plant life (algae).

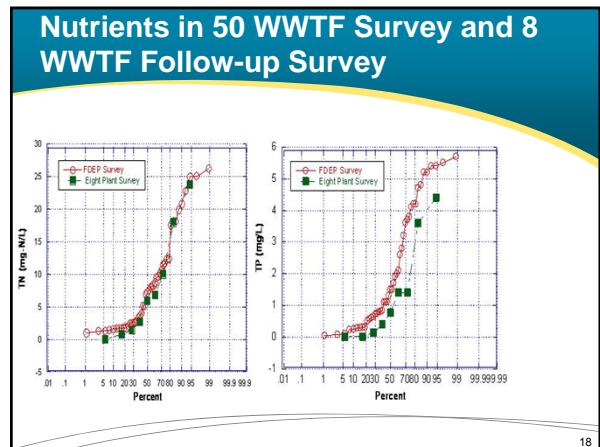
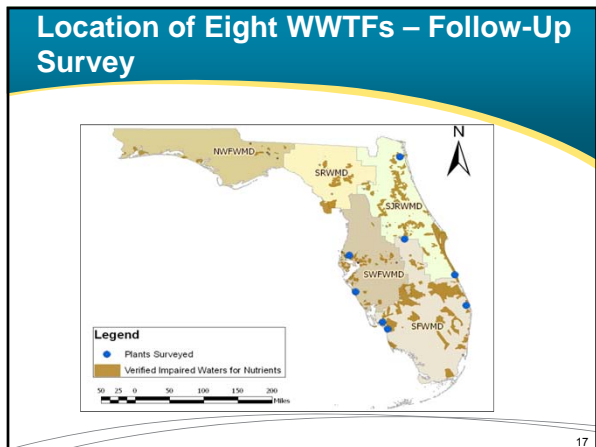
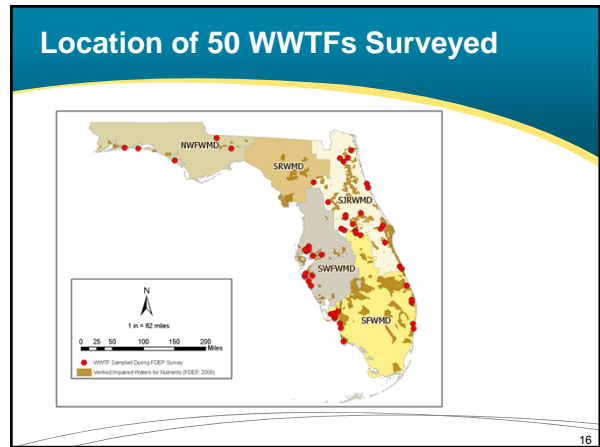
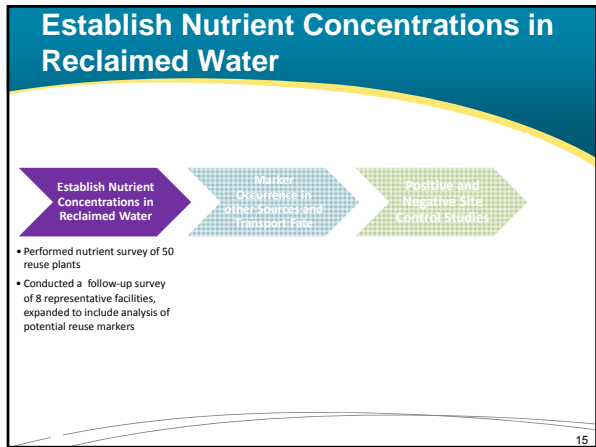
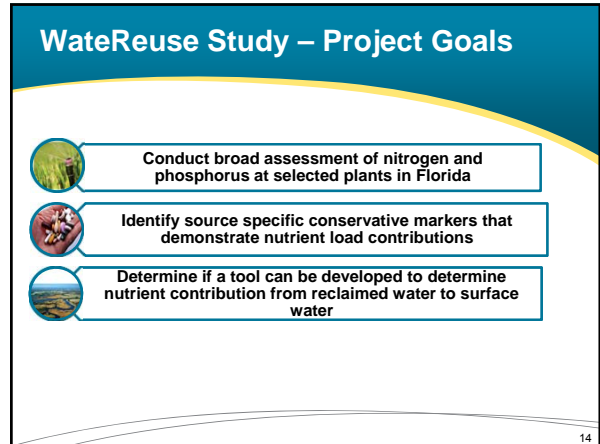
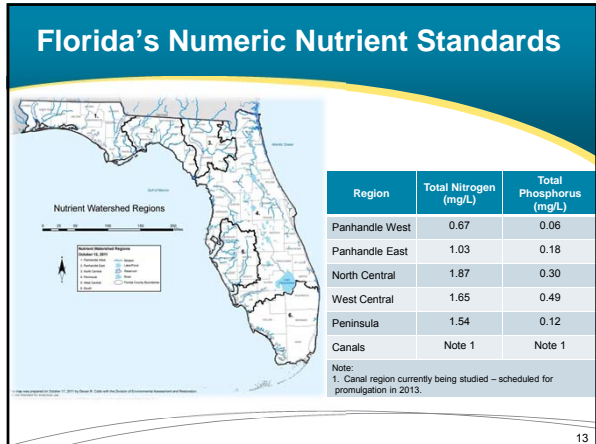
### National Scope of the Nutrient Problem

- 14,000 Nutrient-related impairment listings in 49 States
  - 2.5 million acres of lakes and reservoirs
  - 80,000 miles of rivers and streams
  - And this is an underestimate. . .
- Over 47% of streams have medium to high levels of phosphorus and over 53% have medium to high levels of nitrogen
- 78% of assessed continental U.S. coastal waters exhibit eutrophication

### Florida's Water Quality Requirements

Parameter	Public Access Reclaimed Water	Restricted Access Reclaimed Water	Advanced Wastewater Treatment
CBOD <sub>5</sub> , mg/L	20	20	5
TSS, mg/L	5	20 <sup>1</sup>	5
TN, mg/L	N/A	N/A	3 <sup>2</sup>
TP, mg/L	N/A	N/A	1 <sup>2</sup>
Cl residual, mg/L	1	1	N/A
Turbidity, NTU	2	N/A	N/A
Fecal coliforms, #/100 ml	Non-detect in 75% of samples <sup>3</sup>	Non-detect in 75% of samples <sup>4</sup>	N/A

Notes: 1. 10 mg/L for subsurface irrigation  
 2. Maximum value may be less based on TMDL investigation.  
 3. No sample result may be ≥ 25/100ml  
 4. No sample result may be ≥ 200/100ml



## Key Findings – Nutrient Concentrations in Reuse Water



- Florida reuse facility effluent 50<sup>th</sup> percentile TN is 6 mg/L
- Florida reuse facility effluent 50<sup>th</sup> percentile TP is close to 1 mg/L

19

## Marker Occurrence in Other Sources and Transport Fate



- Performed nutrient survey of 50 reuse plants
- Identified a set of potential markers and developed marker short-list
- Conducted a follow-up survey of 8 representative facilities, expanded to include analysis of potential reuse markers
- Assessed marker presence and concentrations in reuse effluent and other sources
- Determine marker presence/absence in selected waterways
- Evaluated environmental fate and transport of markers through bench-scale studies

20

## Desirable Characteristics of Potential Markers

- Baseline Analytical Requirement:
  - Ratio of source concentration(s) and analytical method detection limit exceeds environmental dilution factor(s)
- Two types of markers are desirable:
  - Conservative Source Markers: source specific stable concentrations with conservative transport behavior
  - Nutrient Fate Markers: mimic environmental fate properties of nutrients

21

## Short-list of Potential Markers

Marker	Usage
Atenolol	Beta blocker
Carbamazepine	Mood stabilizer
Gadolinium	NMR imaging compound
Galaxolide (HHCB)	Synthetic musk fragrance
Iohexol	X-ray contrast media
Sucralose	Sugar substitute (Splenda®)
Stable C,N,O Isotopes	Naturally present

22

## Marker Presence in US Waterways with and without Municipal Wastewater Discharges

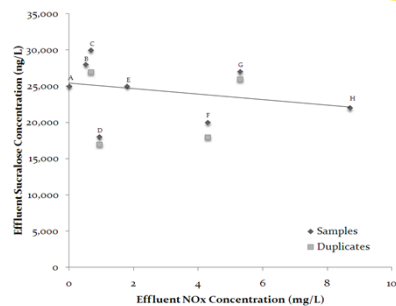
Compound (PQL, ng/L)	Wastewater Effluent Mean (ng/L)	Waterway with WW Discharges (% Detects)	Waterway without WW Discharges (% Non-detects)
Sucralose (100)	27,000	100	100
Carbamazepine (5)	416	36	100
Atenolol (5)	1310	45	92
Iohexol (10)	4780	45	100

PQL= Practical Quantification Limit

Oppenheimer et al. "Occurrence and suitability of sucralose as an indicator compound of wastewater loading to surface waters in urbanized regions", *Water Research*, 45:2011-4019-4027.

23

## Sucralose Presence in Reuse Effluent Independent of Treatment



24

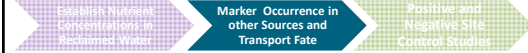
## Fate Behavior Suggested from Experiments



Compound	Adsorption	Biodegradation	Photodegradation
Atenolol	Yes	Yes	Yes
Carbamazepine	No	No	Yes
Gadolinium anomaly	Yes	No	No
Galaxolide	Yes	No data	No data
Iohexol	No	No	Yes
Sucralose	No	No	No

25

## Marker Occurrence in Other Sources and Transport Fate – Key Findings



- Florida reuse facility effluent 50<sup>th</sup> percentile TN is 6 mg/L
- Florida reuse facility effluent 50<sup>th</sup> percentile TP is close to 1 mg/L
- Sucralose (Splenda®) is the best conservative marker of reclaimed water and septic tank effluent
- Gadolinium anomaly and carbamazepine are two other good reclaimed water markers that occur infrequently in septic, so ratios of markers might work in distinguishing reuse and septic inputs
- Transport fate of these markers differ, but sucralose is most recalcitrant to all fate processes

26

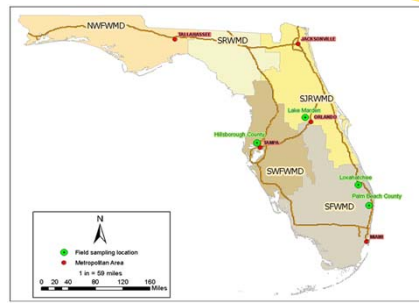
## Positive and Negative Site Control Studies



- Performed nutrient survey of 50 reuse plants
- Conducted a follow-up survey of 8 representative facilities, expanded to include analysis of potential reuse markers
- Identified set of potential markers and developed marker short-list
- Assessed marker presence and concentrations in reuse effluent and other sources
- Determine marker presence/absence in selected waterways
- Evaluated environmental fate and transport of markers through bench-scale studies
- Assessed marker and nutrient differences at sites irrigating or augmenting with reclaimed water and groundwater
- Assessed capability to distinguish reuse effluent from stormwater and septic infiltration

27

## General Location Map of Field Sampling Events



28

## Field Sampling Event 1 – Lake Marden, Orange County, FL



- Objective: Evaluate presence of reclaimed water markers in surface water bodies receiving only reclaimed water
- Receives reclaimed water previously treated through a wetland system
- Samples obtained at the end of wet season from:
  - Reclaimed water effluent
  - Wetland
  - Lake
- No septic influence
- RIBs located around the lake

29

## Field Sampling Event – Lake Marden Results

Compound	Units	Reuse Effluent	Wetland (Cell 3A)	Center of Lake
Total Nitrogen	mg/L	7.34	0.73	0.8
Total Phosphorus	mg/L	1.9	0.077	1.1
Sucralose	ng/L	14,000	4,100	13,000

30

## Field Sampling Event – Palm Beach County



- Objective: Compare levels of markers and nutrients in stormwater runoff and stormwater ponds from two golf courses
  - Golf Course A: Groundwater Irrigation
  - Golf Course B: Reclaimed Water
- Controlled irrigation
- Both golf courses apply fertilizer
- Samples obtained after rain event from:
  - Water used for irrigation (end of pipe)
  - Stormwater runoff
  - Stormwater pond

31

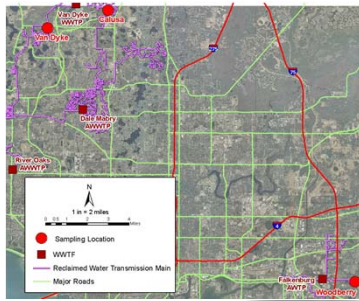
## Field Sampling Event – Palm Beach County Results

Compound	Units	Golf Course A- Groundwater			Golf Course B – Reclaimed Water		
		Irrigation water	Stormwater Runoff	Stormwater Pond	Irrigation Water	Stormwater Runoff	Stormwater Pond
Total Nitrogen	mg/L	0.91	3.4	0.83	98 <sup>(1)</sup>	0.8	1.2
Total Phosphorus	mg/L	ND	0.98	0.060	0.68	1.0	0.036
Sucralose	ng/L	ND	ND	ND	14,000	1,100	1800

Notes:  
 1. High levels of TN due to addition of water treatment additive containing urea to reclaimed water before irrigation.  
 2. ND = Non-detect

32

## Field Sampling Event – Hillsborough County Sampling



- Objective: Evaluate level of markers and nutrients in retention ponds located in residential areas irrigating with reclaimed water
- Uncontrolled irrigation
- Wastewater treated to advanced waste treatment levels - 5/5/3/1 mg/L (BOD<sub>5</sub>/SS/TN/TP)
- No septic influence

33

## Field Sampling Event – Hillsborough County Results

Compound	Units	Woodberry	Calusa	Van Dyke
Total Nitrogen <sup>1</sup>	mg/L	2.9	0.74	0.84
Total Phosphorus	mg/L	0.26	0.1	0.027
Sucralose	ng/L	3,300	4,400	5,500

Note:  
 1 Total nitrogen was present as organic nitrogen at all sites for exception of Woodberry that showed high levels of ammonia

34

## Field Sampling Event – Loxahatchee River District



- Objective: Assess the presence of markers and nutrients in the canals adjacent to areas with septic systems.
- Canals discharge into the Loxahatchee River, Florida's only Wild and Scenic River
- 29 sample locations plus two reference points located in a non-urbanized area
- Samples taken during Florida's dry and wet seasons

35

## Field Sampling Event – Loxahatchee River District Results

Compound	Units	Septic System	Canals Dry Season	Canals Wet Season
Total Nitrogen	mg/L	32 -130	0.67 - 18	0.74-1.84
Total Phosphorus	mg/L	5.3 -15	0.012 - 1.7	0.012-0.16
Sucralose	ng/L	40,000-80,000	ND-750	ND-310

ND=Non- Detect

36

## Project Next Steps

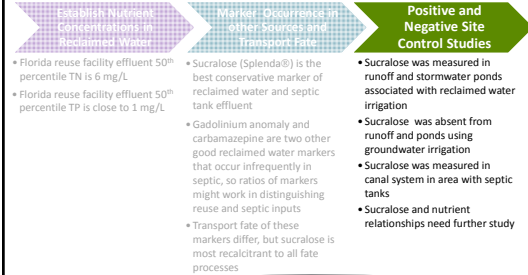
- Sucralose may be used to identify reclaimed water/septic in nutrient impaired water bodies
  - **NO** sucralose, **NO** reclaimed/septic influence

Oppenheimer et al. "Occurrence and suitability of sucralose as an indicator compound of wastewater loading to surface waters in urbanized regions", *Water Research* 45:2011-4019-4027.

- Sucralose can provide a conservative estimate of nutrient contribution into a waterbody

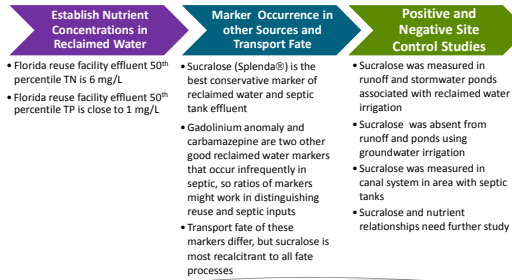
37

## Positive and Negative Control Studies – Key Findings



38

## WaterReuse Study Project Results – Key Findings



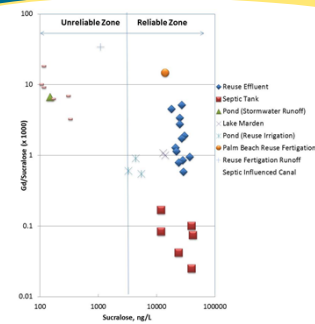
39

## Future Work – Assessment of Nutrient Impaired Water Bodies

- Conduct survey of representative statewide nutrient impaired water bodies to assess wastewater loading impacts by:
  - Analyze for presence of sucralose
  - Interpret data findings to approximate relative percentages of reclaimed water nutrient loading
  - Translate each source load to a worst-case nutrient load estimate
- Establish links between water quality models and proven markers
- Develop a potential monitoring scheme for assessment of impaired water bodies

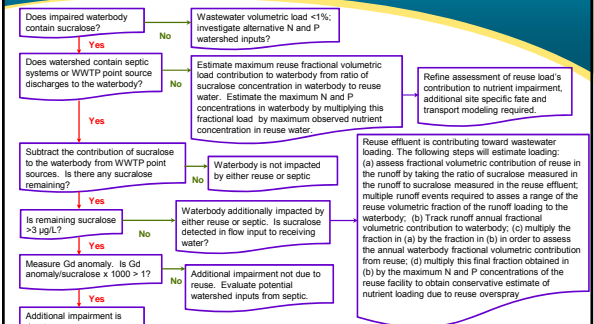
40

## Gd/Sucralose Ratio Analysis



41

## Potential Monitoring Scheme for Assessment of Impaired Water Bodies



42

## Acknowledgements


### WaterReuse Research Foundation

Utilities	Regulatory Agencies
City of North Port	Florida Department of Environmental Protection
City of Orlando	South Florida Water Management District
City of Pompano Beach	Southwest Florida Water Management District
Hillsborough County	St. Johns River Water Management District
JEA	
Loxahatchee River District	
Miami-Dade Water and Sewer Department	
Orange County	
Palm Beach County	

43

## Thank You

“The world will not evolve past its current state of crisis by using the same thinking that created the situation.” - Albert Einstein



Hal Schmidt  
MWH Americas, Inc.  
[hal.e.schmidt@mwhglobal.com](mailto:hal.e.schmidt@mwhglobal.com)

44