Irrigation with Reclaimed Wastewater- Good Intentions Gone Awry?

by

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Wastewater Reuse

- Beneficial use of treated wastewater (reclaimed water)
- Reclaimed water is used for non-potable applications in place of potable water or as a supplement to potable water
  - The most common reuse of wastewater is for irrigation
- Concept is known as “source substitution” since it substitutes reuse for other sources
- Concept initiated in 1970s
  - Developed in direct response to more stringent water quality standards for discharges to surface waters
  - Amendments to the Clean Water Act made surface disposal of wastewater effluent more difficult
  - Originally developed as an alternative disposal method to avoid expensive treatment necessary for surface discharges
  - Early reuse projects used agricultural or open areas for disposal
  - Reuse has now expanded to recreational and urban areas

Wastewater Reuse

- Wastewater reuse in the U.S. is a large and growing industry

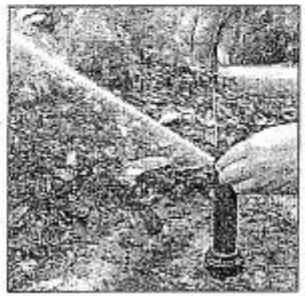
FLORIDA VOICES

Water reuse holds key to our environmental future

By MICHAEL W. SOLE

I would like to speak to the critical role that "reuse" water can play in Florida's future. It is important that I and others in government "lead by example" in encouraging citizens and businesses to help protect our water resources by practicing conservation and using reclaimed water efficiently and effectively.

Florida is home to more than 18 million residents, welcomes



Reuse leader

gallons per day are used for ground water recharge. Projects such as this have paved the way for Orange County as one of the leading metropolitan areas in the state for reuse, at a 99 percent reuse rate, which puts the county amid the very top of Florida's 67 counties in this category.

So while Florida is a national leader, we still reuse only 41 percent of our domestic wastewater every day as a statewide average. Some counties and local governments are undeniably

-Reuse is uniformly accepted by governmental, industrial, and environmental groups

-Reuse systems have received many awards

Extent of Reuse Use

- In 2002, the U.S. used 1.7 billion gallons/day (1700 mgd) of reuse water
  - Use of reuse water is increasing at 15% per year
- The largest amount of reuse occurs in Florida – 660 mgd
  - Florida has a goal of 1000 mgd of reuse by 2010
  - Orange County has a 99% reuse rate
- California is second at 525 mgd
  - Goal of doubling use by 2010
- Other significant users of reuse water include Texas (230 mgd) and Arizona (200 mgd)

Reuse in Florida

- Florida leads the nation in reuse
  - Florida's Water Reuse Program was the first recipient of the federal Water Efficiency Leader Award
  - Reclaimed water in Florida is used to irrigate:
    - 201,465 residential lawns
    - 462 golf courses
    - 572 parks
    - 251 schools
- One of first large scale reuse projects is CONSERV II
  - Located in Orange County
  - Reclaimed wastewater is pumped 20 miles to irrigate 10,035 acres of citrus, nurseries, tree farms and golf areas
    - 20 MGD used for irrigation
  - Also includes extensive network of rapid infiltration basins
    - 16.7 MGD infiltrated into ground

Reuse Applications

- One of the first cities to establish a dual piping system for distribution of reuse water was St. Petersburg, Florida
  - 260 miles of pipe
  - Serves 10,000 homes and businesses
  - 51 schools
  - 86 parks
  - 6 golf courses

Reuse Applications

- Reuse water is used for a variety of purposes in Florida:
  - Irrigation of public parks and recreational fields
  - Irrigation of landscaped areas around residential, commercial and industrial areas
  - Irrigation of golf courses
  - Wash water for commercial laundries
  - Vehicle washing
  - Ornamental uses for water features
  - Dust control
  - Fire protection
  - Concrete mixing
  - Water for ice rinks
- Most reclaimed systems use dedicated piping networks

Risk Assessment

- A “Risk Impact Statement” for use of reclaimed wastewater was issued by FDEP in 1998
- Primary issues addressed in this report were impacts on groundwater supplies and human health issues
- Recommended system design criteria include:
  - Nitrogen species – TN < 10 mg/l
  - Coliform bacteria – ND in 75% of samples
  - Other constituents must meet drinking water standards
  - No mention of phosphorus
- EPA states that the nutrients contained in reuse water are beneficial when used for irrigation
  - “Nitrogen, phosphorus, and potassium are essential nutrients for plant growth, and their presence normally enhances the value of the water for irrigation”
  - Nutrients not removed by the vegetation are removed by adsorption in the soil

Reuse Characteristics

- The chemical characteristics of reuse water are highly variable, depending on location and level of treatment
  - Secondary treatment – minimum level of treatment required
  - Filtration – turbidity < 2 NTU, TSS < 5 mg/l
  - Disinfection
- Typical concentrations
  - Nitrogen ~ 3-20 mg/l, mostly as NO_3^- and NH_4^+ (2-15 times higher than runoff)
  - Phosphorus ~ 0.5-15 mg/l (2-60 times higher than runoff)
  - On average, reuse water is similar in characteristics to septic tank leachate
- Conclusion – Reuse has the potential to significantly impact water quality in surface waters

Regulation of Wastewater Reuse

(Chapter 62-610 F.A.C.)

- Application must be preceded by an engineering study
  - Identify physical, chemical and biological characteristics of reuse
  - Detailed water and nutrient budget
  - Methods of harvesting/maintaining vegetation
  - Evaluation of long-term environmental impacts
  - Concentrations of constituents entering groundwater
  - Surface water impacts
- Part III addresses Slow Rate Application in Public Access/Residential Areas
  - Minimum STP capacity of 0.1 MGD
  - Minimum secondary treatment and high level disinfection
  - If application volume is reduced during wet weather, then 3 day non-use storage must be provided
  - No setbacks for surface waters or developed areas

Regulation of Wastewater Reuse – cont.

(Chapter 62-610 F.A.C.)

- Commingling with other waters
  - Specifically allows commingling of reuse and stormwater in lakes and ponds used for stormwater treatment as long as it does not impact the stormwater function
  - Reclaimed water may be supplemented with surface water, groundwater, stormwater or drinking water
- Design criteria and loading requirements
  - Hydraulic loading based on ability of soil-plant system to remove pollutants
  - Maximum loading of 2” per week unless higher value is recommended
  - Nitrogen loading shall promote vegetation uptake and nitrification/denitrification in soil
  - No surface runoff or ponding allowed
  - Groundwater monitoring not required
- If the reuse is discharged into a wetland, it must be treated to AWT standards
  - TSS - < 5 mg/l
  - Nitrogen - < 3 mg/l
  - Phosphorus - < 1 mg/l
- Some water management districts exempt reuse systems from watering restrictions

Loading Comparison –
Reuse vs. Septic Tank

- Phosphorus loading from septic tank leachate:
  - Assume single family home with 4 persons
  - Wastewater production = 125 gal/person-day = 500 gal/day total = 3500 gal/week
  - Assume a TP concentration in the leachate of 8 mg/l
  - Weekly TP load = 0.11 kg TP/week

- Phosphorus loading from reuse irrigation:
  - Assume an irrigated area of 0.25 acre
  - Irrigation applied at a rate of 0.75 inch, 2 times each week
  - Weekly application = 10,182 gal/week
  - Assume a TP concentration of 4 mg/l in the reuse water
  - Weekly TP load = 0.15 kg TP/week
  - A portion of the TP loading in the reuse water will be adsorbed by the soil and taken up by plants
  - However, a portion will be lost to groundwater seepage and direct runoff onto paved or saturated surfaces

Loading Comparison –
Reuse vs. Fertilizer

Nutrient	Fertilizer Load		Reuse Irrigation Load				
	App. Rate[1] (lbs/1000 ft^2-yr)	Annual Load (kg)	Volume[2] (gal/week)	Volume[2] (gal/year)	Reuse Conc. (mg/l)	Annual Load (kg)	% of Fertilizer Load
Nitrogen	3-6 Assume 4.5	22.2	13,576	705,952	8	21.4	96
Phosphorus	1-2 Assume 1.5	7.4	13,576	705,952	4	10.7	145

1. Recommended rate for St. Augustine grass
2. Assumptions:
   a. Irrigated area of 0.25 acre
   b. Reuse applied at rate of 1 inch, 2 times/week

Loading Comparison –
Reuse vs. Fertilizer - Proposed Rule

Nutrient	Fertilizer Load		Reuse Irrigation Load				
	App. Rate (lbs/1000 ft^2-yr)	Annual Load (kg)	Volume[2] (gal/week)	Volume[2] (gal/year)	Reuse Conc. (mg/l)	Annual Load (kg)	% of Fertilizer Load
Nitrogen	2-5[1] Assume 3.5	17.3	13,576	705,952	8	21.4	124
Phosphorus	0.5[3]	2.47	13,576	705,952	4	10.7	433

1. DACS recommended rate for St. Augustine grass in Central Florida
2. Assumptions:
   a. Irrigated area of 0.25 acre
   b. Reuse applied at rate of 1 inch, 2 times/week
3. DACS Consumer Fertilizer Task Force maximum recommendation

Conclusion: Fertilizer use may not be necessary when reuse is used for irrigation

Loading Comparison –
AWT Reuse vs. Fertilizer - Proposed Rule

Nutrient	Fertilizer Load		AWT Reuse Irrigation Load				
	App. Rate (lbs/1000 ft^2-yr)	Annual Load (kg)	Volume[2] (gal/week)	Volume[2] (gal/year)	Reuse Conc.[3] (mg/l)	Annual Load (kg)	% of Fertilizer Load
Nitrogen	2-5[1] Assume 3.5	17.3	13,576	705,952	3	8.02	46
Phosphorus	0.5[3]	2.47	13,576	705,952	1	2.67	108

1. DACS recommended rate for St. Augustine grass in Central Florida
2. Assumptions:
   a. Irrigated area of 0.25 acre
   b. Reuse applied at rate of 1 inch, 2 times/week
3. AWT criteria: TN = 3 mg/l, TP = 1 mg/l
4. DACS Consumer Fertilizer Task Force maximum recommendation

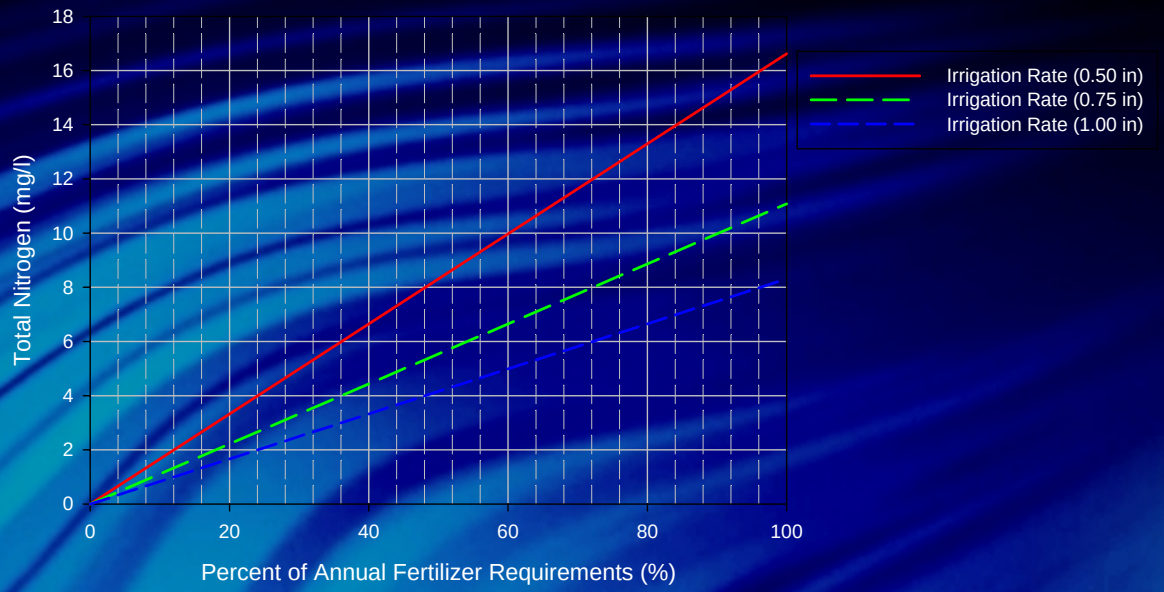
Reuse Characteristics Required to Meet Fertilizer Requirements

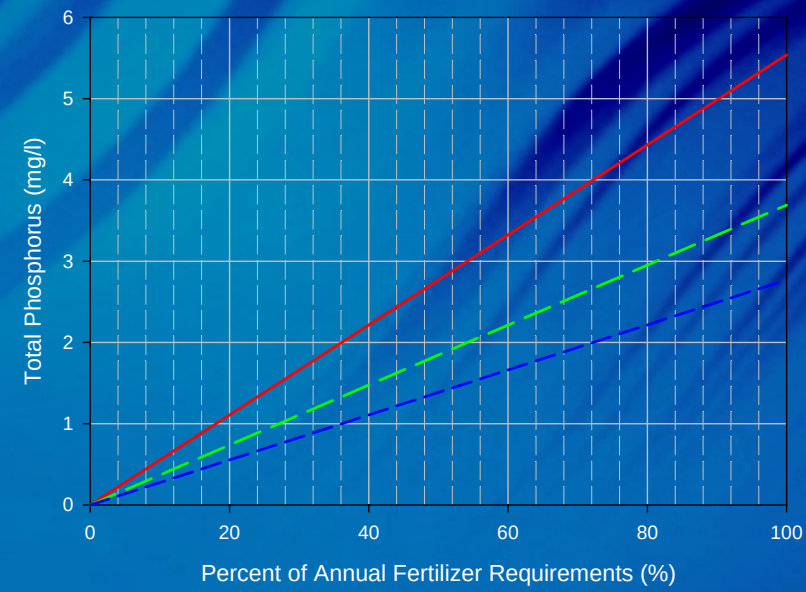
Nutrient	Current Fertilizer Application Rates			Proposed Fertilizer Application Rates		
	Typical App. Rate (lbs/1000 ft^2-yr)	Annual Load (kg)	Reuse Conc. Req. to meet Annual Load (mg/l)	Typical App. Rate (lbs/1000 ft^2-yr)	Annual Load (kg)	Reuse Conc. Req. to meet Annual Load (mg/l)
Nitrogen	4.5	22.2	8.31	3.5	17.3	6.47
Phosphorus	1.5	7.4	2.76	0.5	2.47	0.92

Reuse Application Rate – 2 Times/week
Current Recommended Fertilizer Rates

Annual fertilizer requirements for St. Augustine lawns supplied by reuse irrigation as a function of irrigation rate and frequency

Based on current IFAS recommendations





Reuse Application Rate – 2 Times/week
Proposed DACS Fertilizer Rates

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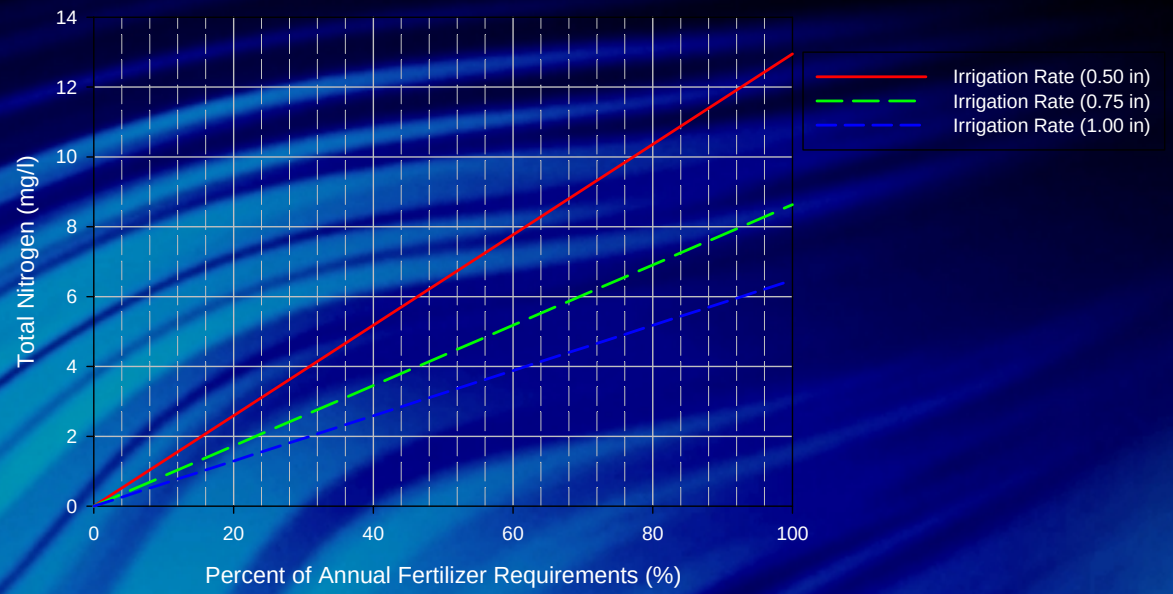

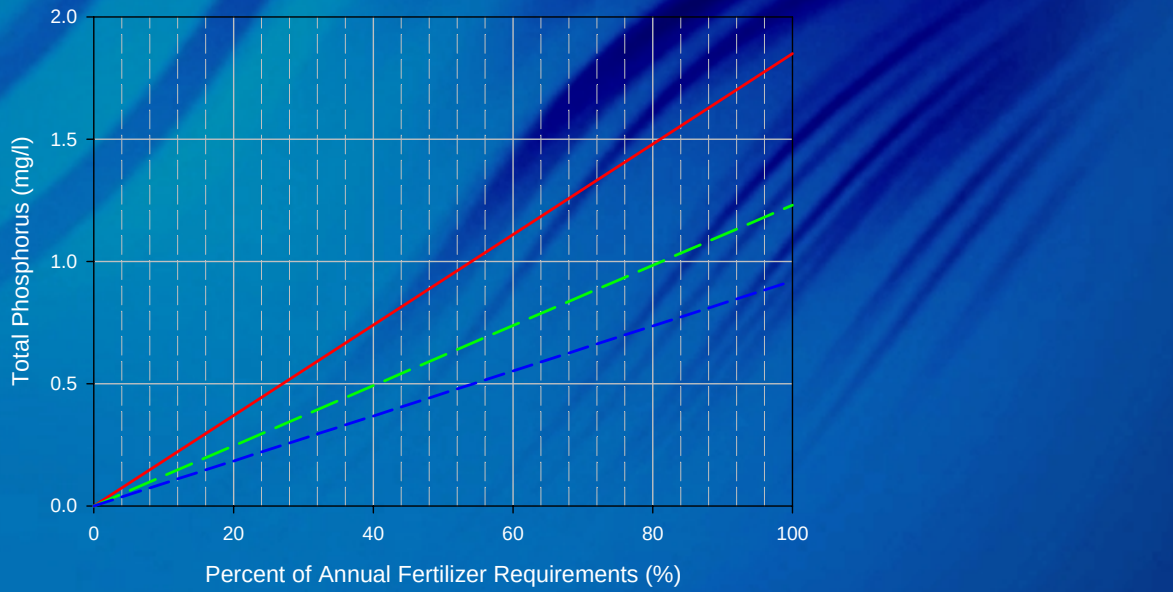

Irrigation Overspray

Reuse overspray accumulates on roadways and in gutters.

Excess reuse flows to stormsewer system.

Irrigation System Maintenance

Broken Line Discharges Into Gutter

Water Travels to Stormsewer Inlet

Reuse Accumulates in Gutters

Reuse is Splashed and Transported by Cars

Impacts of Reuse Overspray

Nutrient	Loading from Runoff		Loading from Reuse Overspray				
	Volume[1] (gal/year)	Annual Load (kg)	Volume[2] (gal/week)	Volume[2] (gal/year)	Reuse Conc. (mg/l)	Annual Load (kg)	Percent of Runoff Load (%)
Nitrogen	67,881	0.64	13,576 gal/day x 0.05 = 679 gal/week	35,308	8	1.07	167
Phosphorus	67,881	0.077	13,576 gal/day x 0.05 = 679 gal/week	35,308	4	0.53	688

1. Assumptions:
   a. Lawn area of 0.25 acre
   b. Rainfall of 50"/yr and C=0.2
   c. Runoff TN=2.5 mg/l, TP=0.3 mg/l

2. Assumptions:
   a. Irrigated area of 0.25 acre
   b. Reuse applied at rate of 1 inch, 2 times/week
   c. Approx. 5% of reuse is lost to overspray or runoff

Conclusion: Overspray of reuse may cause mass loadings which exceed runoff generated loads

Overview of Lake Tibet Sub-basin 01

Characteristics

- Large sub-basin (446 ac)
- Elevated TP load (176.4 kg/yr) and conc.
- Contributes 10.4% of TP load to Lake Tibet
- Area consists of subdivisions and golf courses

-Reuse applied to golf course and landscaped areas at constant rate throughout year
-Creates constant discharge from basin which is independent of rain in basin
-These additional inputs are not considered in normal loading analyses

Conclusion: Loading impacts from reuse water need to be considered in nutrient budgets and TMDL allocations

Problems with Reuse

- Relatively constant supply with highly variable demand
  - Many users, such as golf courses, apply a fixed amount each day or week regardless of rainfall or irrigation needs
  - Many users are bound by contracts which specify how much reuse must be used each day
- Reuse contains elevated levels of TN and TP which are often much higher than in runoff
  - Excess nutrients enter shallow groundwater or runoff from saturated soils into lakes or water bodies
  - Nutrients from reuse applications have been implicated in numerous water quality impacts to surface waters from both surface and sub-surface flows
- Reuse systems have won numerous awards and managers and politicians view reuse as a problem which has been successfully solved
  - Criticism of reuse practices is often ignored

Problems with Reuse

- Reuse has been elevated from a annoying disposal issue to an income generating resource for many municipalities
  - Municipalities have begun to sell reuse water to other cities or counties to supplement:
    - Irrigation deficits for urban and agricultural uses
    - Potable water supplies
- Water quality issues related to reuse are likely to become more visible in the future
- As current practices become more entrenched, it becomes increasingly difficult to modify thinking and criteria for reuse
- Use of wastewater reuse eliminates potential for using stormwater for irrigation

Recommendations

- All reuse water applied on areas where there is a potential to enter a waterbody must be treated to AWT standards
  - However, even when water is treated to AWT standards, the concentrations are still as much as 5 times greater than runoff
- Irrigation systems on golf courses should use pond water for irrigation with reuse water used to supplement water levels only
  - This will reduce the volume of water applied
  - The pond will provide additional opportunities for nutrient uptake and reduction before use
- Strict guidelines should be developed which prohibit overspray of reuse onto paved surfaces
- Wet weather storage should be provided so that irrigation patterns can be modified in response to rainfall
  - Contracts should be modified to eliminate required daily consumption of reuse
- “Pay me now or pay me later”
  - Managers must weigh cost of AWT vs. cost of multiple surface water quality improvement projects

Questions/Comments?

Reuse Application Rate – 1 Time/week
Current Recommended Fertilizer Rates

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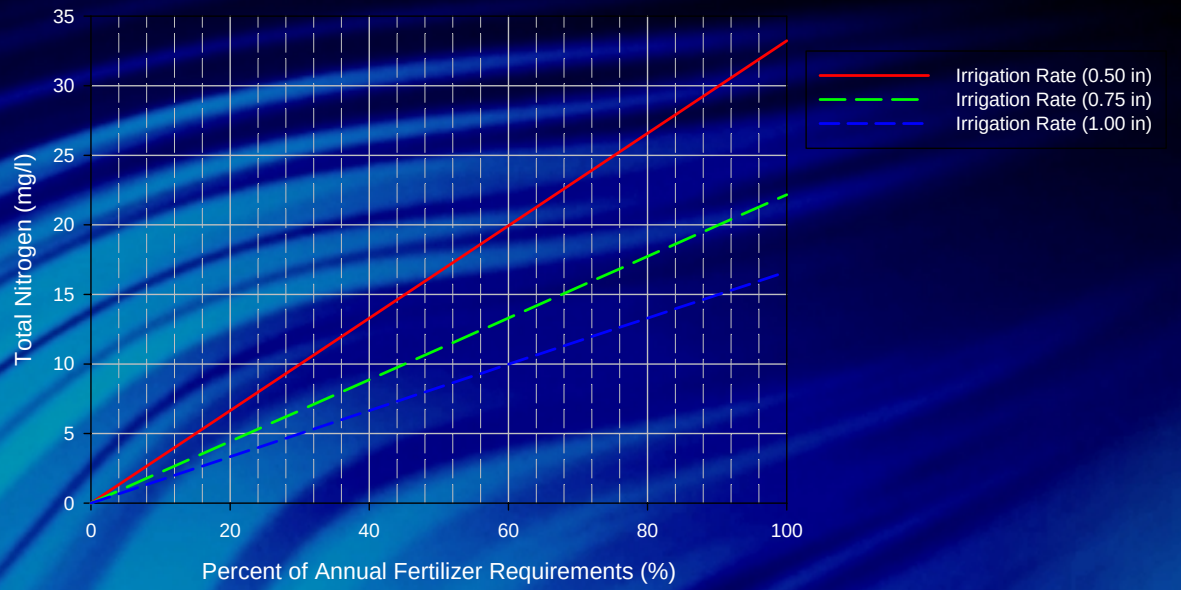

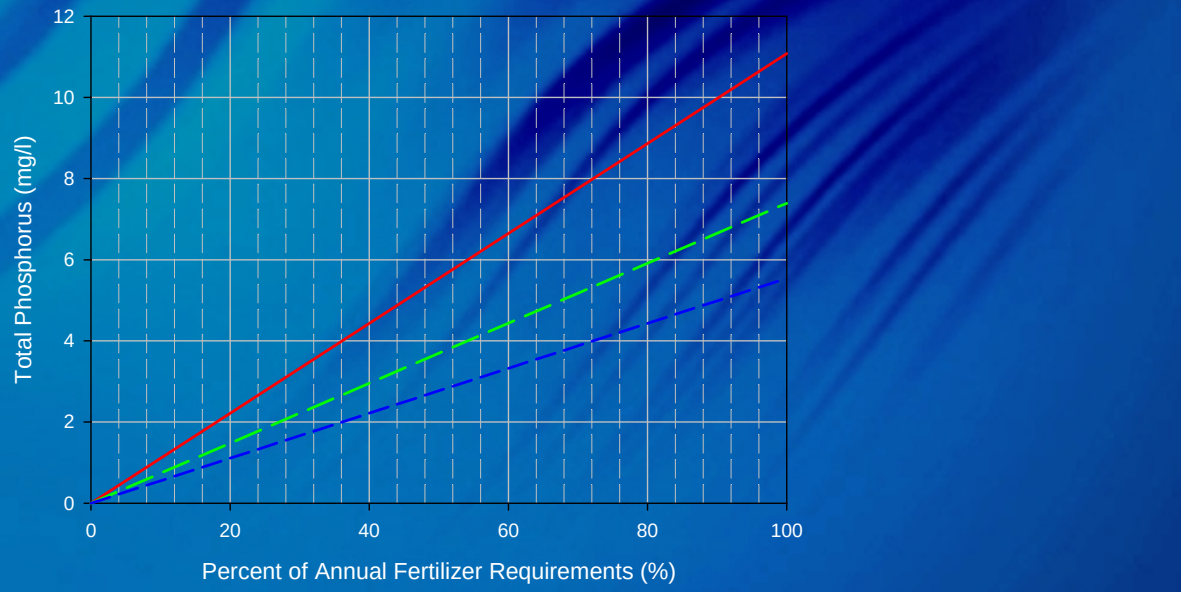

Reuse Application Rate – 1 Time/week
Proposed DACS Fertilizer Rates

Annual fertilizer requirements for St. Augustine lawns supplied by reuse irrigation as a function of irrigation rate and frequency

Based on proposed DACS recommendations