How Will Nutrient Management Planning Impact Biosolids Land Application?

Douglas Jones

The latest revision to biosolids rules (Chapter 62-640, Florida Administrative Code) has been in the works since 2002, with final adoption by the Environmental Regulatory Commission in 2010. The goals of the revised rules are to: (1) reduce nutrient loading in water bodies and groundwater by requiring nutrient management for all sites; (2) improve accountability and land application site management; and (3) address continuing public concerns of biosolids.

Under the old rules, biosolids were land-applied based on the vegetation's nitrogen demand. In the past, the Florida Department of Environmental Protection (FDEP) rules allowed nitrogen application based on the nitrogen loading table in Rule 62-640.750(2)(a), FAC. For Bahia and Bermuda grasses, FDEP routinely allowed nitrogen loading of 360 to 500 lbs/acre-year. Rule 62-640.750(2)(a), FAC has since been repealed. The new rules require the crop nitrogen demand to be fully documented. In addition, the new rules require similar documentation for crop phosphorus demand. These changes have the potential to significantly reduce the quantity of biosolids that can be applied to sites.

Significant Rule Changes and Nutrient Management Plan Requirements

The FDEP has prepared an overview of the new rule changes. This document can be obtained online at http://www.dep.state.fl.us/ water/wastewater/dom/docs/new-biosolids-rule-overview.pdf. The more significant changes are summarized below:

- All land application sites must be permitted under the new rules.
- Site permits must be renewed every five years.
- Wastewater treatment facilities must identify permitted sites before beginning biosolids application at the site.
- Site permitting requires a site-specific, five-year nutrient management plan (NMP). The plan must be prepared by a professional engineer or certified nutrient management plan-

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Table 1. P Index Interpretation

P Index Value	Interpretation
< 75	Low potential for phosphorus transport from site. Nitrogen-based planning is satisfactory.
75 – 150	Medium potential for phosphorus transport from site. Nitrogen-based planning is satisfactory with conservation methods.
151 – 225	High potential for phosphorus transport from site. Phosphorus management practices required.
> 225	Very high potential for phosphorus transport from site. Remedial action required to reduce risk of phosphorus movement.

Table 2. Phosphorus Potential Due to Site and Transport Characteristics: Part A

Site and Transport Characteristic	Phosphorus Transport Rating					Value
Soil Erosion (tons/acre)	No Surface Outlet	< 5	5 - 10	10 - 15	> 15	
	0	1	2	4	8	
Runoff Potential	Very Low	Low	Medium	High	Very High	
	0	1	2	4	8	
Leaching Potential	Very Low	Low	Medium	High	Very High	
	0	1	2	4	8	
Potential to Reach Water Body	Very Low	Low	Medium	High		
	0	1	2	4		
	Total for Part A					
If the sum for Part A is zero, then change sum to one.						

Table 3. Transport Potential Due to Phosphorus Source Management: Part B

Phosphorus Source Management	Phosphorus Loss Rating				Value
Fertility Index Value	Soil Fertility Index x 0.025 (_____ ppm P x 2 x 0.025)				
P Application Source and Rate	0.05 x (____ lbs. P_2O_5) for fertilizer, manure or compost 0.015 x (____ lbs. P_2O_5) for biosolids 0.10 x (____) lbs. P_2O_5) for wastewater				
Application Method	No surface outlet or solids incorporated immediately	Applied via irrigation or solids incorporated with 1 day	Solids incorporated with 5 days	Solids not incorporated	
	0	2	4	6	
Wastewater Application	0.20 x ___ acre inches/year				
	Total for Part B				

P Index = Total Part A (___) x Total Part B (___)

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ner. The NMP replaces the old agricultural use plan, but is much more comprehensive.

- The NMP determines whether biosolids loading may be based on nitrogen or phosphorus. This determination may have a significant impact on the quantity of biosolids that may be applied to a site.
- Application rates must consider phosphorus assessment, all nutrient sources, nitrogen mineralization, crop yields, and calcium carbonate equivalency.
- Soil testing for fertility and background metals is required.
- Groundwater monitoring of sites may be required under certain circumstances.
- New requirements for alkaline-treated biosolids include a ¼-mi setback to property lines for surface application or a waiver from adjacent property owners.

The NMP must identify each application zone and include aerial photographs, maps, soil survey, and setback distances to vulnerable resources such as wells, wetlands, and other critical habitats. The NMP must provide guidance for implementation of nutrient planning, site operation, maintenance, and recordkeeping. Application rates are to be based on soil fertility testing, biosolids analyses, and site-specific conditions. The NMP must identify crops, method of biosolids application, harvesting method, and realistic anticipated crop yields. All nutrient sources must be accounted for in the NMP. Changes to crop type, application method, or nutrient sources require the NMP to be revised and approved by FDEP. The following sources can provide valuable guidance in preparation of NMPs:

- United States Department of Agriculture (USDA) Natural Resources Conservation Service Florida Field Technical Guide – Nutrient Management, Code 590
- University of Florida Institute of Food and Agricultural Sciences (IFAS) Nutrient Management Series

Phosphorus Index

The Phosphorus Index (P Index) is a site-specific tool used to provide a qualitative assessment of sites that are vulnerable to off-site movement of phosphorus. The P Index is used as a decision-making tool for nutrient management planning. Specifically, for biosolids assessment, it is used to assess the vulnerability of specific application zones and determine whether a zone can be loaded based on a nitrogen or phosphorus budget.

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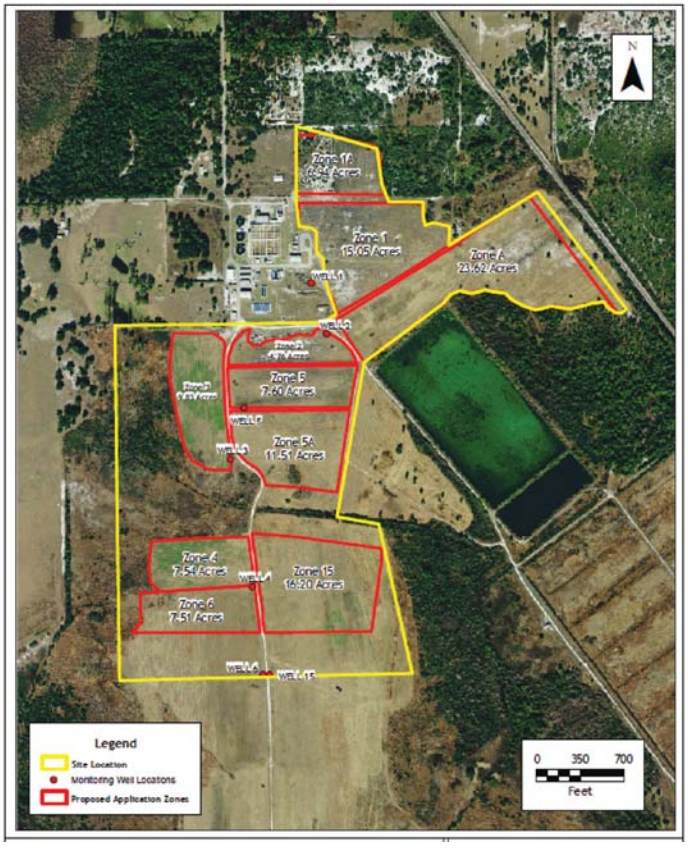

Figure 1. Winter Haven Biosolids Application Site

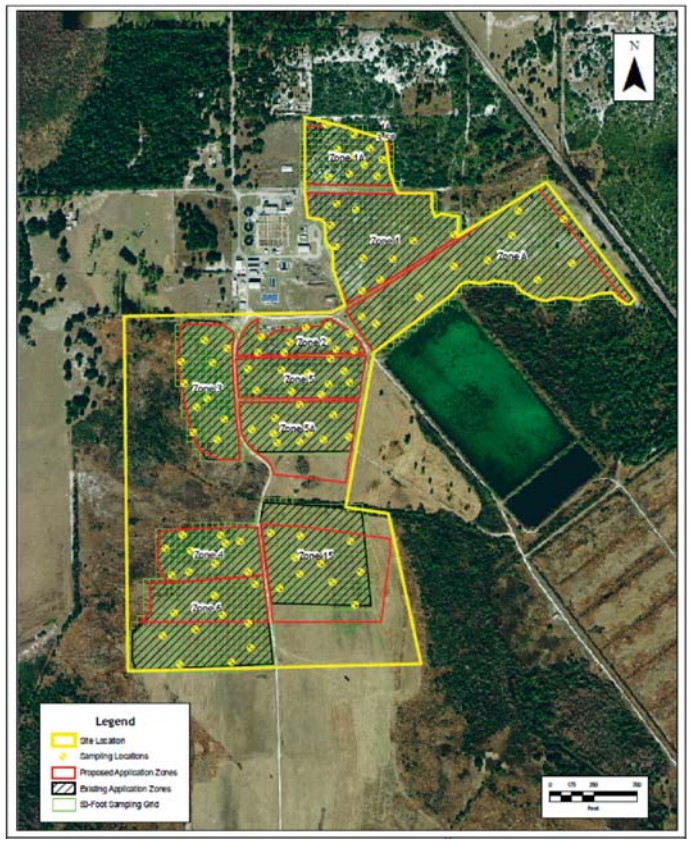

Figure 2. Location of Soil Samples

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The result of the P Index is a unitless value that provides generalized assessment of phosphorus transport potential. Table 1 provides the four categories for transport potential. It has been shown that FDEP will allow nitrogen-based loading for zones with a "low" or "medium" potential for phosphorus transport. Conservation methods, such as strict adherence to buffer zones and more frequent fertility testing, can lessen the chance of phosphorus transport for "medium" zones. For application zones with a "high" potential, an effective conservation method is to reduce biosolids (or total nutrient) application. This method will reduce the P Index for the zone by reducing the total phosphorus applied.

The P Index assesses what is risk-based on those characteristics related to the specific site and transport (Part A) and those related to phosphorus source and management (Part B). The P Index is determined by multiplying the values obtained in Part A (Table 2) and Part B (Table 3).

In Part A, the soil erosion is the product of the rainfall factor, soil erodibility factor, slope length of the site, cover management factor, and the conservation support practice factor. These factors may be obtained and/or calculated by consulting the IFAS nutrient management series. Runoff and leaching potentials are determined based on the National Resources Conservation Service (NRCS) hydrologic soil groups, slope, and any artificial drainage at the site. The FDEP has been allowing the use of NRCS soil maps, rather than obtaining soil borings of the site. The "potential to reach water body" is determined based on site characteristics and the availability of buffers to attenuate discharge. The sum of the four sites and transport characteristics provides the total value for Part A.

In Part B, the Fertility Index is defined as Mehlich-1 extractable phosphorus in parts per mil (ppm) of a 0-6 in. depth soil sample multiplied by two to convert to pounds per acre. The 0.025 multiplication factor is used to provide a value range similar to other parameters in the P Index. The P application source and rate is based upon the planned nutrient source and quantity to be applied to the site. The sum of the Fertility Index Value, P application source and rate, application method, and amount of wastewater applied to the site provides the total value for Part B.

Case Study

Biosolids from the City of Winter Haven's two wastewater treatment plants (WWTP #2 and WWTP #3) are applied on city-owned land at WWTP #3. The site is divided into 10 application zones totaling 110.56 acres of Callie Bermuda grass (Figure 1). The site was previously approved for a nitrogen loading rate of 500 lbs/acre-year with no limit on phosphorus.

The NMP established new loading rates based on agronomic crop demand, biosolids analyses, and soil testing results. Ten soil samples were collected from each zone and composited into one sample per zone according to the IFAS soil testing protocol. The location of the samples were randomly selected (Figure 2). The application rates are based on Callie Bermuda grass and haying operations. No other sources of nutrients are applied to the site.

Nitrogen application rates are based on guidelines published in IFAS Document No. SS AGR 60, "Bermudagrass Production in

Florida." For hay production, the IFAS recommends a nitrogen application rate of 80 lbs/acre and an additional 80 lbs/acre after each cutting, except for the last cutting in the fall. The FDEP method was utilized to determine the nitrogen application rate. This method is based on the assumption that only 50 percent of the nitrogen in biosolids is available as plant-available nitrogen (PAN). The FDEP method consists of a multiplication factor of 1.5 times the crop demand, which accounts for mineralized nitrogen. Based on this method, two harvestings per year, and IFAS recommendations, the maximum annual nitrogen application rate was established at 240 lbs/acre-year or less than 50 percent of that previously approved for the site.

The maximum phosphorus application rate was calculated on the initial assumption that biosolids application to all zones would be based on the maximum nitrogen application rate of 240 lbs/acre-year. The calculated phosphorus application was then utilized to calculate the P Index for each zone. The P Index was used to determine whether a nitrogen-based budget could be used. Calculation of the maximum phosphorus loading was based on the four-year average biosolids nitrogen and phosphorus concentrations (4.85 percent and 4.19 percent, respectively).

Those zones with an initial P Index rating greater than 150 (high or very high) were re-evaluated based on a phosphorus budget. Crop demand for phosphorus was evaluated based on the *Agricultural Waste Management Field Handbook*, which states that phosphorus comprises 0.19 percent of dry harvested Bermuda grass and the typical yield is 16,000 lbs/acre-year of plant part.

Bermuda grass demand for phosphorus (as total P) was then calculated as:

- 16,000 lbs/acre-year x 0.19 percent = 30.4 lbs P/acre-year

Bermuda grass demand for P_2O_5 was calculated as:

- 30.4 lbs P/acre-year x 2.2915 (conversion factor) = 69.7 lbs P_2O_5/acre-year

This P_2O_5 demand was then input into the P Index worksheet under "P Application Source and Rate." If the revised P Index rating was 150 or less (low or medium), then the maximum quantity of biosolids to be applied to the zone was calculated as:

- Crop demand for P (percent P in biosolids)) x zone acreage = lbs biosolids/zone-year

Figure 3 shows the calculations for Zone 1 based on a nitrogen loading of 240 lbs/acre-year. Using a nitrogen budget, the zone could be loaded with 74,474 lbs of biosolids, to reach a nitrogen loading of 240 lbs/acre. However, based on the average phosphorus concentration of the biosolids, the resulting P Index would be 154 (high potential for phosphorus transport from the site). Therefore, the P Index was recalculated based on a phosphorus budget (30.4 lbs P/acre-year or 69.7 lbs P_2O_5/acre-year) shown in Figure 4. The resulting P Index was 106 (medium potential for phosphorus transport from the site). Using a phosphorus budget, the zone could be loaded with 10,919 lbs of biosolids to reach a P_2O_5 loading of 67.7 lbs/acre, which is an 85 percent reduction in the biosolids capacity of the zone.

Table 4 shows the P Index for each application zone when calculated based on a

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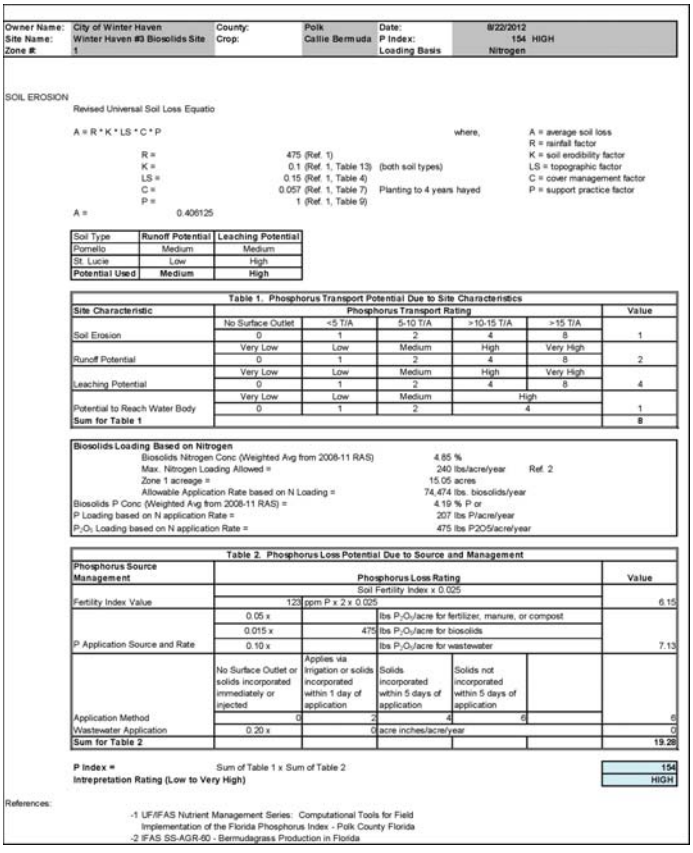


Owner Name: City of Winter Haven | County: Polk | Date: 8/22/2012
Site Name: Winter Haven #3 Biosolids Site | Crop: Callie Bermuda | P Index: 154 HIGH
Zone #: 1 | Loading Basis: Nitrogen

SOIL EROSION

Revised Universal Soil Loss Equatio

A = R * K * LS * C * P where, A = average soil loss; R = rainfall factor; K = soil erodibility factor; LS = topographic factor; C = cover management factor; P = support practice factor

R = 475 (Ref. 1)
K = 0.1 (Ref. 1, Table 13) (both soil types)
LS = 0.15 (Ref. 1, Table 4)
C = 0.057 (Ref. 1, Table 7) Planting to 4 years hayed
P = 1 (Ref. 1, Table 9)
A = 0.406125

Soil Type	Runoff Potential	Leaching Potential
Pomello	Medium	Medium
St. Lucie	Low	High
Potential Used	Medium	High

Table 1. Phosphorus Transport Potential Due to Site Characteristics

Site Characteristic	Phosphorus Transport Rating					Value
	No Surface Outlet	<5 T/A	5-10 T/A	>10-15 T/A	>15 T/A	
Soil Erosion	0	1	2	4	8	1
Runoff Potential	Very Low 0	Low 1	Medium 2	High 4	Very High 8	2
Leaching Potential	Very Low 0	Low 1	Medium 2	High 4	Very High 8	4
Potential to Reach Water Body	Very Low 0	Low 1	Medium 2	High 4		1
Sum for Table 1						8

Biosolids Loading Based on Nitrogen
Biosolids Nitrogen Conc (Weighted Avg from 2008-11 RAS) = 4.85 %
Max. Nitrogen Loading Allowed = 240 lbs/acre/year Ref. 2
Zone 1 acreage = 15.05 acres
Allowable Application Rate based on N Loading = 74,474 lbs. biosolids/year
Biosolids P Conc (Weighted Avg from 2008-11 RAS) = 4.19 % P or
P Loading based on N application Rate = 207 lbs P/acre/year
P_2O_5 Loading based on N application Rate = 475 lbs P2O5/acre/year

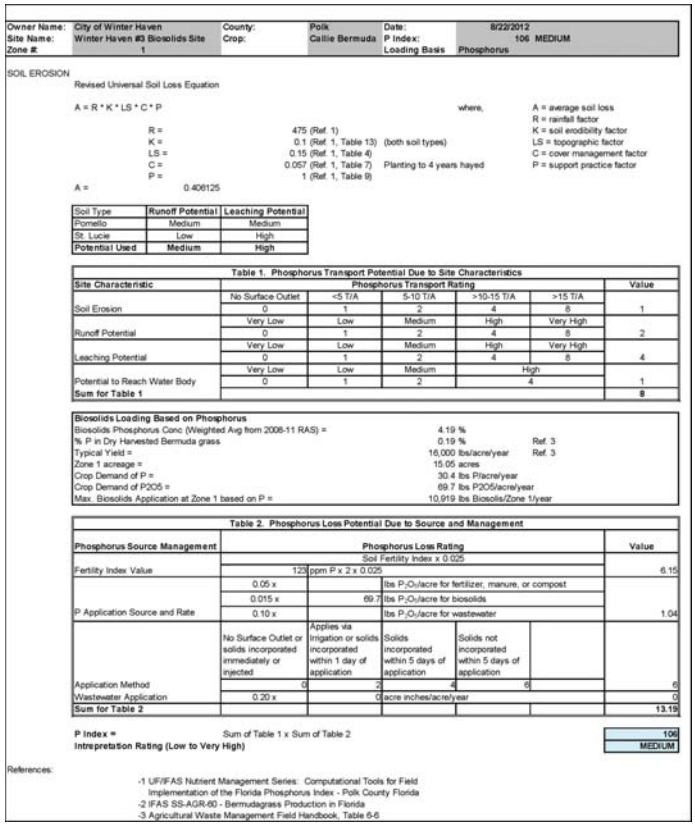
Table 2. Phosphorus Loss Potential Due to Source and Management

Phosphorus Source Management	Phosphorus Loss Rating					Value
	Soil Fertility Index x 0.025					
Fertility Index Value	123	ppm P x 2 x 0.025				6.15
P Application Source and Rate	0.05 x		lbs P_2O_5/acre for fertilizer, manure, or compost			
	0.015 x	475	lbs P_2O_5/acre for biosolids			
	0.10 x		lbs P_2O_5/acre for wastewater			7.13
Application Method	No Surface Outlet or solids incorporated immediately or injected 0	Applies via irrigation or solids incorporated within 1 day of application 2	Solids incorporated within 5 days of application 4	Solids not incorporated within 5 days of application 6		6
Wastewater Application	0.20 x	0	acre inches/acre/year			0
Sum for Table 2						19.28

P Index = Sum of Table 1 x Sum of Table 2 = 154
Intrepretation Rating (Low to Very High) = HIGH

References:
-1 UF/IFAS Nutrient Management Series: Computational Tools for Field Implementation of the Florida Phosphorus Index - Polk County Florida
-2 IFAS SS-AGR-60 - Bermudagrass Production in Florida

Figure 3. Zone 1 P Index Calculation Based on Nitrogen Budget



Owner Name: City of Winter Haven | County: Polk | Date: 8/22/2012
Site Name: Winter Haven #3 Biosolids Site | Crop: Callie Bermuda | P Index: 106 MEDIUM
Zone #: 1 | Loading Basis: Phosphorus

SOIL EROSION

Revised Universal Soil Loss Equation

A = R * K * LS * C * P where, A = average soil loss; R = rainfall factor; K = soil erodibility factor; LS = topographic factor; C = cover management factor; P = support practice factor

R = 475 (Ref. 1)
K = 0.1 (Ref. 1, Table 13) (both soil types)
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P = 1 (Ref. 1, Table 9)
A = 0.406125

Soil Type	Runoff Potential	Leaching Potential
Pomello	Medium	Medium
St. Lucie	Low	High
Potential Used	Medium	High

Table 1. Phosphorus Transport Potential Due to Site Characteristics

Site Characteristic	Phosphorus Transport Rating					Value
	No Surface Outlet	<5 T/A	5-10 T/A	>10-15 T/A	>15 T/A	
Soil Erosion	0	1	2	4	8	1
Runoff Potential	Very Low 0	Low 1	Medium 2	High 4	Very High 8	2
Leaching Potential	Very Low 0	Low 1	Medium 2	High 4	Very High 8	4
Potential to Reach Water Body	Very Low 0	Low 1	Medium 2	High 4		1
Sum for Table 1						8

Biosolids Loading Based on Phosphorus
Biosolids Phosphorus Conc (Weighted Avg from 2008-11 RAS) = 4.19 %
% P in Dry Harvested Bermuda grass = 0.19 % Ref. 3
Typical Yield = 16,000 lbs/acre/year Ref. 3
Zone 1 acreage = 15.05 acres
Crop Demand of P = 30.4 lbs P/acre/year
Crop Demand of P2O5 = 69.7 lbs P2O5/acre/year
Max. Biosolids Application at Zone 1 based on P = 10,919 lbs Biosolis/Zone 1/year

Table 2. Phosphorus Loss Potential Due to Source and Management

Phosphorus Source Management	Phosphorus Loss Rating					Value
	Soil Fertility Index x 0.025					
Fertility Index Value	123	ppm P x 2 x 0.025				6.15
P Application Source and Rate	0.05 x		lbs P_2O_5/acre for fertilizer, manure, or compost			
	0.015 x	69.7	lbs P_2O_5/acre for biosolids			
	0.10 x		lbs P_2O_5/acre for wastewater			1.04
Application Method	No Surface Outlet or solids incorporated immediately or injected 0	Applies via irrigation or solids incorporated within 1 day of application 2	Solids incorporated within 5 days of application 4	Solids not incorporated within 5 days of application 6		6
Wastewater Application	0.20 x	0	acre inches/acre/year			0
Sum for Table 2						13.19

P Index = Sum of Table 1 x Sum of Table 2 = 106
Intrepretation Rating (Low to Very High) = MEDIUM

References:
-1 UF/IFAS Nutrient Management Series: Computational Tools for Field Implementation of the Florida Phosphorus Index - Polk County Florida
-2 IFAS SS-AGR-60 - Bermudagrass Production in Florida
-3 Agricultural Waste Management Field Handbook, Table 6-6

Figure 4. Zone 1 P Index Calculation Based on Phosphorus Budget

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nitrogen budget of 240 lbs/acre-year. Five of the ten zones showed either a high or very high potential for phosphorus transport from the site.

Table 5 shows the P Index for each application zone when recalculated based on the controlling nutrient (240 lbs/acre-year for nitrogen or 30.4 lbs/acre-year for phosphorus). The P Index for the four "high" potential zones was reduced to less than 150 by basing the biosolids application on a phosphorus budget. Zone 3 continued to show a very high potential to transport phosphorus off site even when application was based on a phosphorus budget. This is due the excess phosphorus concentration in the soil samples (451 ppm P for Zone 3 versus an average of 124 ppm P for the remaining nine zones). At this time, no source of phosphorus may be applied to Zone 3.

Table 6 shows the estimated biosolids capacity for each zone under the old rules and the current NMP. The capacity of the zones with a nitrogen budget was reduced by approximately 52 percent, with the maximum nitrogen application rate decreasing from 500 lbs/acre-day to 240 lbs/acre-day. The zones with a phosphorus budget were reduced by approximately 94 percent. Overall, the capacity of the biosolids site was reduced by 79 percent.

Conclusions

The case study demonstrates the significant impact that the new biosolids rules may have on land application in Florida. It will be interesting to determine the overall reduction in capacity once existing application sites have been permitted. It can be expected that there will be a shortage of application sites, which will drive the cost of biosolids disposal higher, either through increased land application costs or further movement to Class AA biosolids.

References

- Institute of Food and Agricultural Sciences Circular DIR239 – "Soil Testing."
- Institute of Food and Agricultural Sciences Nutrient Management Series: Computational Tools for Field Implementation of the Florida Phosphorus Index – Polk County, Florida.
- Institute of Food and Agricultural Sciences SS-AGR-60 – "Bermudagrass Production in Florida."
- USDA NRCS Florida Field Technical Guide – Nutrient Management, Code 590.
- USDA NRCS *Agricultural Waste Management Field Handbook.*

Table 4. Initial P Index Results Based on Nitrogen Budget

Application Zone #	Acres	P Index	Potential for Phosphorus Movement	Controlling Nutrient	Maximum Application Rate of Controlling Nutrient (lbs/acre-year)
A	23.62	167	High	N	240
1	15.05	154	High	N	240
1A	6.94	144	Medium	N	240
2	4.76	135	Medium	N	240
3	9.83	285	Very High	N	240
4	7.54	139	Medium	N	240
5	7.60	191	High	N	240
5A	11.51	108	Medium	N	240
6	7.51	132	Medium	N	240
15	16.20	161	High	N	240

Table 5. Final P Index Results Based on Controlling Nutrient

Application Zone #	Acres	P Index	Potential for Phosphorus Movement	Controlling Nutrient	Maximum Application Rate of Controlling Nutrient (lbs/acre-year)
A	23.62	119	Medium	P	30.4
1	15.05	106	Medium	P	30.4
1A	6.94	144	Medium	N	240
2	4.76	135	Medium	N	240
3	9.83	237	Very High	P	0
4	7.54	139	Medium	N	240
5	7.60	148	Medium	P	30.4
5A	11.51	108	Medium	N	240
6	7.51	132	Medium	N	240
15	16.20	113	Medium	P	30.4

Table 6. Impact of NMP on Biosolids Application at Winter Haven Site

Application Zone #	Biosolids Loading (tons/zone)	
	Under Old Rules	Under Current NMP
A	121.8	8.6
1	77.5	5.5
1A	35.7	17.2
2	24.5	11.8
3	50.7	0
4	38.9	18.7
5	39.2	2.8
5A	59.3	28.5
6	38.7	18.9
15	83.5	5.9
Total	**569.8**	**117.9**
Reduction		**79 %**