

Final Report

Task 3: Assess Contributions of Onsite Wastewater Treatment Systems Relative to Other Sources

Wekiva Onsite Nitrogen Contribution Study

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Background

The Florida Legislature assigned the Florida Department of Health (FDOH) to conduct the Wekiva Onsite Nitrogen Contribution Study that the Florida Legislature has assigned to the Department. The appropriation language reads:

“\$250,000 in non-recurring tobacco settlement funds are provided to the Department of Health to conduct or contract for a study to further identify and quantify the nitrogen loading from onsite wastewater treatment systems (OWTS) within the Wekiva Study Area. The objectives of the study shall be determined by the Department’s Research Review and Advisory Committee, which shall also have oversight of the study. The Department shall provide a report to the Executive Office of the Governor, President of the Senate, and the Speaker of the House of Representatives no later than June 30, 2007. The report shall assess whether OWTS are a significant source of nitrogen to the underlying groundwater relative to other sources and shall recommend a range of possible cost-effective OWTS nitrogen reduction strategies if contributions are significant.”

The study was divided into the following tasks:

Task 1: Field Study to identify and quantify nitrogen loading at a few sample onsite wastewater treatment systems (OWTS) in the Wekiva Study Area

Task 2: Categorization and Quantification of Nitrogen Loading from Onsite Wastewater Treatment System Types

Task 3 (subject to this RFQ): Assessment if OWTS are a significant source of nitrogen to the underlying groundwater relative to other sources; in particular enumeration and aggregation of OWTS loading

Task 4: Recommend a range of possible cost-effective OWTS nitrogen reduction strategies if significant

This is a report of the work conducted under Task 3. The task was divided into five components, plus deliverables:

1. Develop procedures for categorizing OWTS (septic systems) with regard to characteristics that are expected to influence their functioning and environmental impact.
2. Count the number of septic systems in each subcategory for each vulnerability zone, the Wekiva Study area, and the municipalities with area in the Wekiva Study area.
3. Estimate the nitrogen loading from the different subcategories of septic systems to the environment and to the water table.
4. Coordinating with MACTEC, St. John’s River Management District’s consultant working on the Wekiva Basin nitrogen loading, estimate the nitrogen loading

- from other sources of nitrogen, including atmospheric deposition, centralized wastewater facilities, fertilizer applications, and animals.
5. Determine the relative contribution of septic systems to the nitrogen load to the underlying groundwater and assess its significance.

Information for the first three components was obtained from Dr. Richard Otis. MACTEC supplied the data that were the foundation for completion of component 4. Results from the first four components were used to complete component five.

The Study Area

The Wekiva Study Area (WSA) is comprised of about 304,000 acres, covering portions of Lake, Orange, and Seminole Counties. A map of the land uses within the WSA, as identified by the 2004 Land Use Survey, is displayed in Figure 1. The proportions of land designated for categories of land uses are shown in Figure 2.

Figure 1: Map showing land uses within the Wekiva Study Area

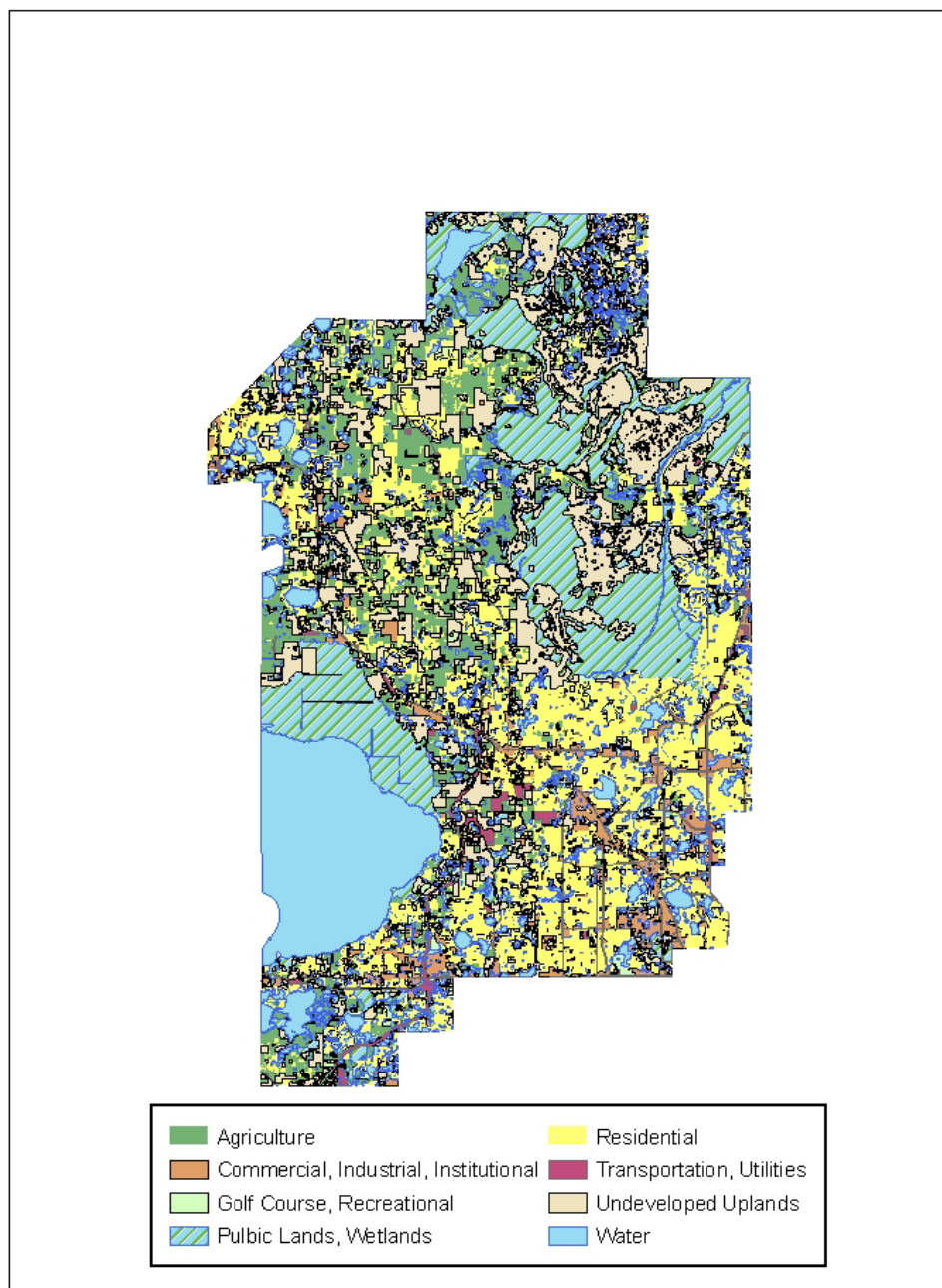
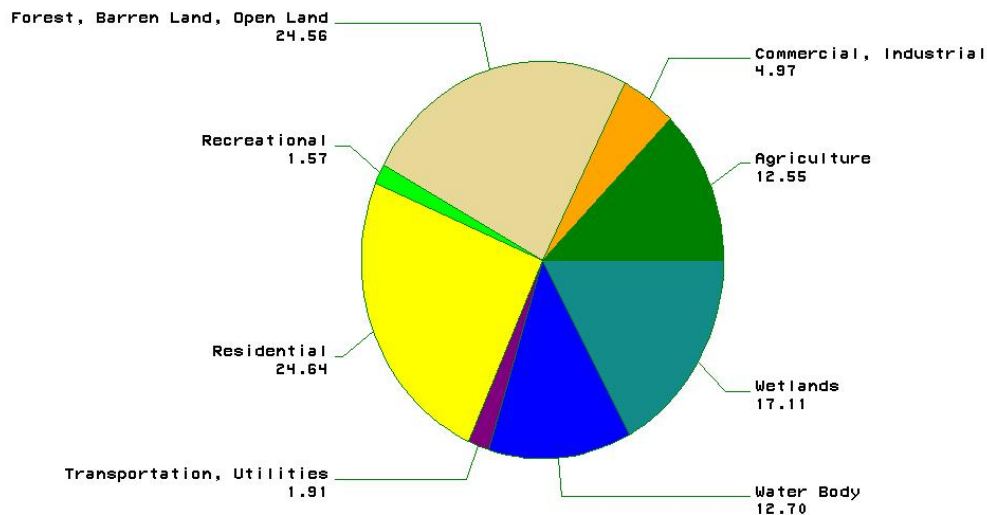


Figure 2. Land Uses in the Wekiva Study Area



Data Sources

GIS coverages with the location of septic systems in the WSA, 2004 Land Use, and Soils were provided by FDOH. Dr. Richard Otis developed the subcategories for the septic systems. He also provided factors for determining nitrogen inputs to the environment and loadings to the groundwater. MACTEC provided sections of its March 2007 report entitled “Phase 1 Report Wekiva River Basin Nitrate Sourcing Study” (referred to as FDEP 2007 Phase1 Report throughout this document) and supplementary materials used in their computations. The full report was obtained from the Florida Department of Environmental Protection (FDEP). The Wekiva Basin encompasses the WSA, but also includes other lands and waters. A major effort in this report went to adjusting the estimates for the Wekiva Basin to obtain those for the WSA.

An important difference exists between the septic system data and data from other sources. For all but septic systems, MACTEC considered *only nitrates*. MACTEC and Dr. Richard Otis both considered *total nitrogen* contributed by septic systems. This makes the relative contributions of septic systems compared to other sources less clear. Inorganic forms of wastewater are nitrate (NO_3), nitrite (NO_2), and ammonia (NH_4). Total Kjeldahl nitrogen (TKN or total nitrogen) is the combination of organic nitrogen and inorganic nitrogen (nitrate, nitrite, and ammonia). Although total nitrogen is probably of most interest, sufficient funding and time were not available to either adjust the MACTEC values or obtain new estimates of total nitrogen from other sources. This may be a worthy future effort. The reader should keep in mind the difference in types of nitrogen being quantified when comparing septic systems to other nitrogen sources.

Inputs represent the nitrogen delivered to the environment. Inputs from direct application of fertilizer, livestock waste (which is assumed to be released to the environment), atmospheric deposition (wet and dry) of total nitrate (nitrate + nitric acid); domestic and industrial wastewater effluents, and septic system discharges are estimated for WSA in this report. Not all nitrogen inputs reach the waters of the WSA. Loadings represent the portion of nitrogen inputs that do reach either the surface waters or ground water. Loading sources from groundwater recharge, atmospheric deposition, centralized wastewater facilities, storm water, and septic systems were considered. Recharge to groundwater was further attributed to fertilizer, livestock, or natural sources. Further, the estimated loadings from centralized wastewater facilities and storm water were separated into the loading to surface waters and that to ground water.

Inputs to the Wekiva Study Area

Inputs to the WSA include direct application of fertilizer, livestock waste (which is assumed to be released to the environment), atmospheric deposition (wet and dry) of total nitrate (nitrate + nitric acid); effluents from centralized wastewater facilities, and septic system discharges. Each source has been quantified. With the exception of septic systems, the methods and results from the FDEP 2007 Phase 1 Report have been followed here. Although a summary of the methods used will be given, the report should be consulted for a fuller explanation. For septic systems, the information was supplied by Dr. Richard Otis. A fuller explanation of the methods he used may be obtained from the final report for Task 2. Again, it should be noted that the estimate for septic systems is for total nitrogen and those for the other sources is for nitrates.

Fertilizer Use

Fertilizer was assumed to be applied at rates recommended by the University of Florida's (UF) Institute of Food and Agricultural Sciences (IFAS) unless it was determined that actual practice deviated from that. The following equation was used to estimate residential, commercial, institutional, and transportation land uses:

$$Fertilizer\ Use_{LU} = \frac{Pervious\ Fraction_{LU} \times Application\ Rate_{LU} \times Area_{LU}}{CF}$$

where $Fertilizer\ Use_{LU}$ = Nitrate contained in fertilizer applied for a specific land use (LU), totaled for that land use over the entire Wekiva Basin (MT/year);

$Pervious\ Fraction_{LU}$ = Fraction of the land use area that is not paved or under roof;

$Application\ Rate_{LU}$ = Application rate of nitrates in fertilizer (kg/ha/yr);

$Area_{LU}$ = Area within a given land use classification totaled over the entire Wekiva Basin (ha); and

CF = Conversion factor to achieve desired units of measurement, 1000 (kg/MT)

The application rate and impervious fraction by land use are taken from the FDEP 2007 Phase 1 Report's Appendix D, Table 2. These, as well as the total area within each land use and the fertilizer use in kg/year and MT/year, are displayed in Table 1. The estimated total input from fertilizer is estimated to be 5735.39 MT/year.

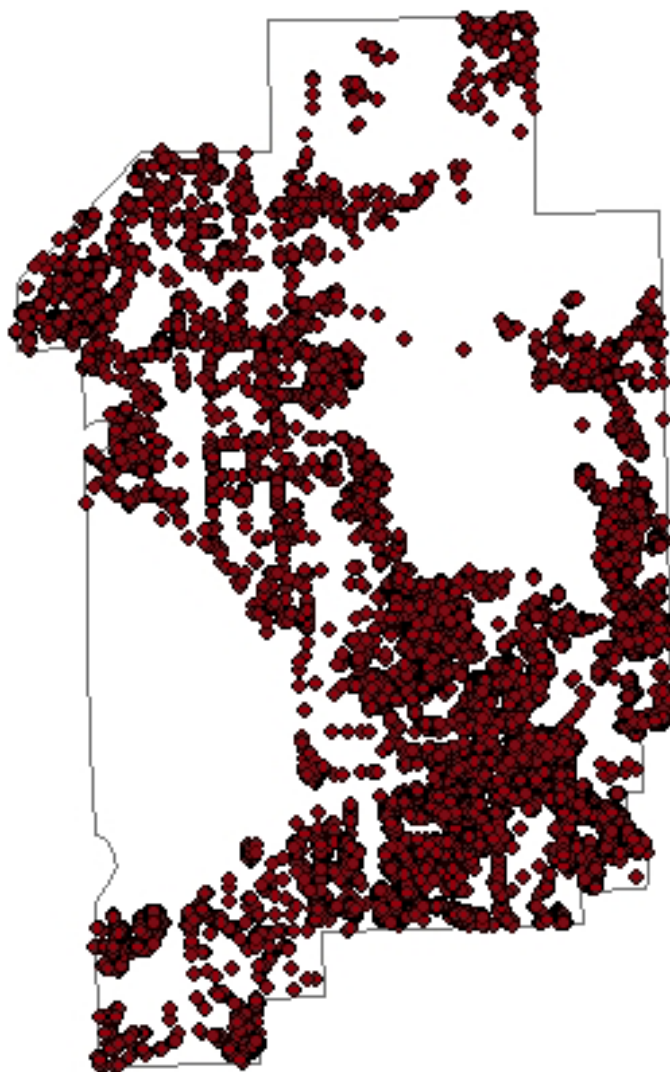
Livestock

From the FDEP 2007 Phase 1 Report, livestock waste on pasture land is 41 kg/ha/year and that on feedlot land uses is taken to be 4100 kg/ha/year. Based on these values, the input of nitrate from land use sources is estimated to be 652.55 MT/year (see Table 2).

Septic Systems

Over 55,000 septic systems are located in the WSA (see Figure 3). Each person living in the household is estimated to discharge 11.2 gms N/day to the septic system (Dr. Richard Otis, e-mail communication). Since an average of 2.6 people live in a household (2000 census), approximately 10.6 kg N/household enter the septic system each year. Assuming that 20% of the total nitrogen is removed in the septic system, Dr. Richard Otis has estimated the contribution of total nitrogen from septic systems to be 8.2 kg/home/year. The distribution of the 55,417 septic systems in the Wekiva Study Area by Drainage Class, Depth to Estimated Seasonal High Water Table Class, Organic Matter Class and Soil Series is shown in Table 3. (Note: Other factors, such as system age and type, affect the nitrogen inputs from septic systems. However, this type of information was not available for the majority of the systems, and only available data were used when deciding on the categories.) The nitrogen contributed by each category as well as the overall totals are also displayed in that table. Thus, the total nitrogen input to the Wekiva Study Area is estimated to be 454.42 MT/year.

Figure 3. Location of Septic Systems Within the Wekiva Study Area



Atmospheric Deposition

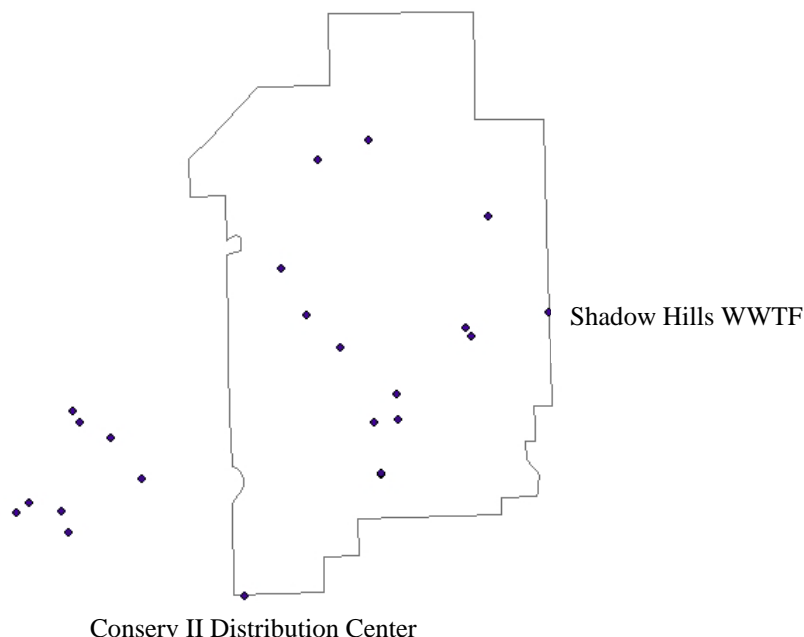
According to the FDEP 2007 Phase 1 Report, the nitrate input from acid deposition is estimated to be 2.57 and 4.18 kg/ha/year for rural and urban areas, respectively. The results by Land Use are shown in Table 4. Thus the estimated nitrogen input to WSA from atmospheric deposition is 263.78 MT/year.

Discharge by Centralized Wastewater Facilities

In the FDEP 2007 Phase 1 Report, permitted centralized wastewater discharge facilities within the Wekiva Basin were obtained from the FDEP Wastewater website. Three (3) industrial dischargers with the potential to emit nitrate and 53 permitted domestic dischargers within the Wekiva Basin were identified. MACTEC obtained permit records for the industrial dischargers from FDEP. The largest 26 centralized wastewater facilities

were found to account for 99% of the total permitted capacity within the Wekiva Basin, and the permit records for these facilities were obtained from FDEP. Of the facilities reviewed by MACTEC, eleven were located fully within the WSA. Two additional facilities were found to lie just outside the boundary of the WSA (see Figure 4). The facility with the largest input to the Wekiva Basin is one of the two lying just outside the boundary. After consultation with FDOH, it was decided to include the two boundary facilities in the computations, but to also provide estimates for those only within the WSA.

Figure 4. Permitted Centralized Wastewater Facilities with the Two Facilities Lying Immediately Outside the Boundary Identified



Effluents were segregated by disposal type (e.g., sprayfield, percolation basins, rapid infiltration basins (RIBs), surface water discharge), and subsequently separated into two categories: discharge to surface water and discharge to groundwater. In addition, several facilities have a reclamation/reuse disposal system. Wastewater effluent inputs to surface water, groundwater, and reclaimed/reused were estimated as follows:

$$Input = \frac{Actual\ Discharge \times Concentration\ (NO_3 - N)}{CF}$$

where

- $Input$ = Wastewater facility effluent (MT/yr);
- $Actual\ Discharge$ = Total Annual Discharge;
- $Concentration\ (NO_3 - N)$ = Average effluent concentration of nitrates-nitrogen during 2004 through 2006 (mg/L); and

$CF =$ Conversion factor to achieve desired units of measurement, 10^9 (mg/MT)

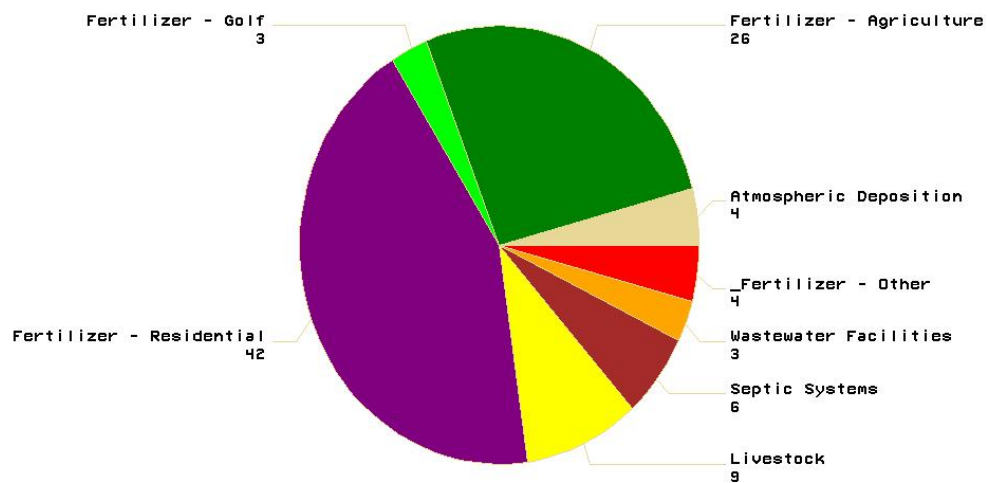
Based on the 26 facilities used to estimate wastewater inputs from the FDEP 2007 Phase 1 Report, total nitrate-nitrogen discharged to surface water from permitted facilities within the WSA was estimated at 8.9 MT/year, and nitrate discharges to groundwater from these same facilities were estimated to be 75.2 MT/year (Table 4). The amount of nitrate-nitrogen that is reclaimed/reused was estimated to be 55.7 MT/year. Effluent reclaimed/reused was assumed to replace or reduce fertilizer and thus provided no additional inputs to the area. If the two boundary facilities are included, the total nitrate-nitrogen discharged to surface water and to groundwater from the 13 facilities was estimated to be 8.9 MT/year and 36.8 MT/year, respectively. The amount of nitrate-nitrogen that is reclaimed/reused was estimated to be 27.3 MT/year.

It should be noted that only 11 facilities within the WSA were included in these computations. According to the report, *A strategy for Water Quality Protection: Wastewater Treatment in the Wekiva Study Area* (FDEP 2004), within WSA, there are 16 centralized wastewater facilities with permits for discharges of 100,000 gallons per day (GPD) or more, and 32 facilities with permits for discharges of less than 1000,000 GPD. Of the 11 considered here, seven have permits for 100,000 GPD or more and four have permits for less than 100,000 GPD. The total permitted capacity in millions of gallons per day is 20.796 for the eleven considered here and 42.502 for all facilities. Because the nitrate-nitrogen concentrations released vary with facility and data on these concentrations are only available for the eleven considered here, the nitrate contributions by the remaining facilities cannot be accurately assessed. An estimate of the nitrate contributions from all facilities within the WSA may be obtained by assuming that the contribution is proportional to the permitted GPD discharge. Using this approach, the nitrate-nitrogen discharged to surface water and to groundwater from the WSA facilities is estimated to be 18.3 MT/year and 75.2 MT/year, respectively. The amount of nitrate-nitrogen that is reclaimed/reused is estimated to be 55.7 MT/year. When the two boundary facilities are also included, the estimated nitrate-nitrogen discharged to surface water, groundwater, and reclaimed/reused is estimated to be 18.3 MT/year, 197.4 MT/year, and 137.0 MT/year, respectively. These last are the estimates used in the remainder of this report.

Total Inputs

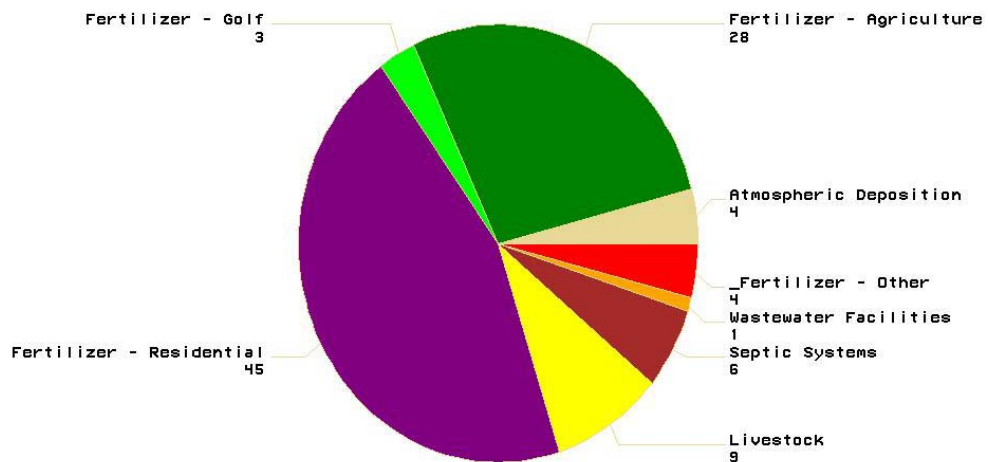
The total of the total nitrogen from septic systems and nitrates from all other sources input to WSA is estimated to be 7,359 MT/year, including the two boundary wastewater facilities, and 7239, if only wastewater facilities within the WSA are included. The relative contributions from all sources both including and excluding the boundary wastewater facilities, are shown in Figures 5 and 6, respectively.

Figure 5. Nitrate* Inputs to Wekiva Study Area by Source, Including Centralized Wastewater Facilities Immediately Outside the WSA



*The input from septic systems is total nitrogen, which includes nitrates.

Figure 6. Nitrate* Inputs to WSA by Source, Including Only Wastewater Facilities Inside the WSA



*The input from septic systems is total nitrogen, which includes nitrates.

Table 1. Nitrate Input to the Wekiva Study Area From Fertilizer Application by Land Use

| LU Code | Land Use | Acres | Hectares | Fertilizer (kg/ha/year) | Impervious (%) | Fertilizer Subtotal (kg/year)/ | Fertilizer (MT/year) |
|---------|-----------------------------------|----------|----------|----------------------------|-------------------|-----------------------------------|-------------------------|
| 2150 | Agriculture-Field Crops | 2627.96 | 1063.53 | 150 | 0.00 | 159530.20 | 159.53 |
| 2450 | Agriculture-Floriculture | 21.05 | 8.52 | 200 | 0.00 | 1703.73 | 1.70 |
| 2510 | Agriculture-Horse Farms | 2151.10 | 870.55 | 63 | 0.00 | 54844.55 | 54.84 |
| 2110 | Agriculture-Improved Pasture | 13267.69 | 5369.44 | 63 | 0.00 | 338274.46 | 338.27 |
| 2400 | Agriculture-Nurseries | 5564.90 | 2252.11 | 227 | 0.00 | 511229.87 | 511.23 |
| 2140 | Agriculture-Row Crops | 692.64 | 280.31 | 630 | 0.00 | 176596.17 | 176.60 |
| 2420 | Agriculture-Sod Farms | 120.32 | 48.69 | 200 | 0.00 | 9738.40 | 9.74 |
| 2500 | Agriculture-Specialty Farms | 86.60 | 35.05 | 200 | 0.00 | 7009.11 | 7.01 |
| 2200 | Agriculture-Tree Crops | 6016.14 | 2434.73 | 227 | 0.00 | 552684.54 | 552.68 |
| 8110 | Agriculture-Unimproved Pasture | 7505.32 | 3037.40 | 63 | 0.00 | 191356.30 | 191.36 |
| 1480 | Airports | 172.77 | 69.92 | 200 | 85.00 | 2097.56 | 2.10 |
| 1400 | Commercial | 8470.26 | 3427.91 | 200 | 94.25 | 39420.99 | 39.42 |
| 8200 | Communications | 128.85 | 52.15 | 200 | 85.00 | 1564.35 | 1.56 |
| 1820 | Golf Courses | 3174.04 | 1284.53 | 175 | 0.00 | 224793.61 | 224.79 |
| 1390 | High Density Residential | 7792.26 | 3153.53 | 148 | 67.00 | 154018.34 | 154.02 |
| 1700 | Institutional | 3311.45 | 1340.14 | 200 | 91.00 | 24122.57 | 24.12 |
| 1100 | Low Density Residential | 12739.00 | 5155.48 | 148 | 14.70 | 650847.79 | 650.85 |

| LU Code | Land Use | Acres | Hectares | Fertilizer (kg/ha/year) | Impervious (%) | Fertilizer Subtotal (kg/year)/ | Fertilizer (MT/year) |
|---------|---------------------------------|-------------------|------------------|----------------------------|-------------------|-----------------------------------|-------------------------|
| 1200 | Medium Density Residential | 44361.16 | 17952.96 | 148 | 27.80 | 1918381.69 | 1918.38 |
| 1800 | Recreational | 1807.25 | 731.39 | 200 | 1.50 | 144084.76 | 144.08 |
| 8100 | Transportation | 3319.16 | 1343.26 | 200 | 85.00 | 40297.94 | 40.30 |
| 8300 | Utilities | 2197.99 | 889.53 | 200 | 85.00 | 26685.81 | 26.69 |
| 1100 | Very Low Density Residential | 9906.01 | 4008.96 | 148 | 14.70 | 506107.39 | 506.11 |
| | Totals | 135,433.91 | 54,810.10 | | | 5,735,390.12 | 5,735.39 |

Table 2. Nitrate Input to the Wekiva Study Area From Livestock Waste by Land Use

| Land Use | Acres | Hectares | Livestock Waste (kg/ha/year) | Livestock Waste Subtotal (kg/year) | Livestock Waste (MT/year) |
|-----------------------------------|------------------|-----------------|---------------------------------|---------------------------------------|------------------------------|
| Agriculture-Feeding Operations | 162.06 | 65.59 | 4150 | 269458.29 | 269.458 |
| Agriculture-Horse Farms | 2151.10 | 870.55 | 41 | 35335.56 | 35.336 |
| Agriculture-Improved Pasture | 13267.69 | 5369.44 | 41 | 217945.40 | 217.945 |
| Agriculture-Unimproved Pasture | 7505.32 | 3037.40 | 41 | 123288.13 | 123.288 |
| Totals | 23,086.17 | 9,342.97 | | 652,552.91 | 652.55 |

Table 3. Total Nitrogen Input to the Wekiva Study Area from Septic Systems

| Drainage | Water Class | Organic Matter | Soil Series | Number of Septic Systems | Total Nitrogen (MT/year) |
|---|-------------|----------------|---|--------------------------|--------------------------|
| | <=3.5 Feet | <= 1% | | 434 | 3.559 |
| | <=3.5 Feet | <= 1% | URBAN LAND | 8070 | 66.174 |
| | > 3.5 Feet | <= 1% | PITS | 17 | 0.139 |
| Excessively Well/ Somewhat Excessively Well | > 3.5 Feet | <= 1% | LAKE FINE SAND Hyperthermic, coated Typic Quartzipsamments | 1126 | 9.233 |
| | | | PAOLA FINE SAND Hyperthermic, uncoated Spodic Quartzipsamments | 412 | 3.378 |
| | | | ST. LUCIE SAND Hyperthermic, uncoated Typic Quartzipsamments | 542 | 4.444 |
| | | > 1% | ASTATULA FINE SAND Hyperthermic, uncoated Typic Quartzipsamments | 2585 | 21.197 |
| | | | CANDLER SAND Hyperthermic, uncoated Lamellic Quartzipsamments | 22146 | 181.597 |
| Well | > 3.5 Feet | <= 1% | APOPKA SAND Loamy, siliceous, hyperthermic Grossarenic Paleudults | 52 | 0.426 |
| | | > 1% | ORLANDO FINE SAND Siliceous, hyperthermic Humic Psammentic Dystrudepts | 194 | 1.591 |
| Moderately Well | <=3.5 Feet | <= 1% | POMELLO FINE SAND Sandy, siliceous, hyperthermic Oxyaquic Alorthods | 934 | 7.659 |
| | > 3.5 Feet | <= 1% | ARCHBOLD SAND Hyperthermic, uncoated Typic Quartzipsamments | 133 | 1.091 |
| | | | ORSINO FINE SAND Hyperthermic, uncoated Spodic Quartzipsamments | 63 | 0.517 |
| | | | UDORTHENTS | 2 | 0.016 |
| | > 3.5 Feet | > 1% | FLORAHOME SAND Siliceous, hyperthermic Humic Psammentic Dystrudepts | 185 | 1.517 |
| | | | MILLHOPPER SAND Loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudults | 8 | 0.066 |
| | | | TAVARES FINE SAND Hyperthermic, uncoated Typic Quartzipsamments | 10120 | 82.984 |

| Drainage | Water Class | Organic Matter | Soil Series | Number of Septic Systems | Total Nitrogen (MT/year) |
|--|-------------|----------------|---|--------------------------|--------------------------|
| Somewhat Poorly/ Poorly/Very Poorly | <=3.5 Feet | <= 1% | ADAMSVILLE FINE SAND Hyperthermic, uncoated Aquic Quartzipsamments | 158 | 1.296 |
| | | | ARENTS | 316 | 2.591 |
| | | | CASSIA FINE SAND Sandy, siliceous, hyperthermic Oxyaquic Alorthods | 117 | 0.959 |
| | | | ZOLFO FINE SAND Sandy, siliceous, hyperthermic Oxyaquic Alorthods | 702 | 5.756 |
| Somewhat Poorly/ Poorly/Very Poorly | <=3.5 Feet | >1% | ANCLOTE SAND Sandy, siliceous, hyperthermic Typic Endoaquolls | 19 | 0.156 |
| | | | BASINGER FINE SAND Siliceous, hyperthermic Spodic Psammaquents | 959 | 7.864 |
| | | | BRIGHTON MUCK Dysic, hyperthermic Typic Haplohemists | 64 | 0.525 |
| | | | CANOVA MUCK Fine-loamy, siliceous, superactive, hyperthermic Histic Glossaqualts | 2 | 0.016 |
| | | | CHOBEE FINE SANDY LOAM Fine-loamy, siliceous, superactive, hyperthermic Typic Argiaquolls | 4 | 0.033 |
| | | | EAUGALLIE FINE SAND Sandy, siliceous, hyperthermic Alfic Alaquods | 49 | 0.402 |
| | | | EMERALDA FINE SAND Fine, mixed, superactive, hyperthermic Mollic Albaqualfs | 17 | 0.139 |
| Somewhat Poorly/ Poorly/Very Poorly | <=3.5 Feet | >1% | FELDA FINE SAND Loamy, siliceous, superactive, hyperthermic Arenic Endoaqualfs | 27 | 0.221 |
| | | | GATOR MUCK Loamy, siliceous, euic, hyperthermic Terric Haplosaprists | 1 | 0.008 |
| | | | IMMOKALEE FINE SAND Sandy, siliceous, hyperthermic Arenic Alaquods | 433 | 3.551 |

| Drainage | Water Class | Organic Matter | Soil Series | Number of Septic Systems | Total Nitrogen (MT/year) |
|----------|-------------|----------------|--|--------------------------|--------------------------|
| | | | MALABAR FINE SAND Loamy, siliceous, active, hyperthermic Grossarenic Endoaqualfs | 6 | 0.049 |
| | | | MYAKKA FINE SAND Sandy, siliceous, hyperthermic Aeric Alaquods | 645 | 5.289 |
| | | | NITTAW SANDY CLAY Fine, smectitic, hyperthermic Typic Argiaquolls | 128 | 1.050 |
| | | | OCOEE MUCK Sandy or sandy skeletal, siliceous, dysic, hyperthermic Terric Haplohemists | 1 | 0.008 |
| | | | OKEELANTA MUCK Sandy or sandy skeletal, siliceous, euic, hyperthermic Terric Haplosaprists | 3 | 0.025 |
| | | | ONA FINE SAND Sandy, siliceous, hyperthermic Typic Alaquods | 851 | 6.978 |
| | | | PLACID FINE SAND Sandy, siliceous, hyperthermic Typic Humaquepts | 45 | 0.369 |
| | | | POMPANO FINE SAND Siliceous, hyperthermic Typic Psammaquents | 202 | 1.656 |
| | | | SAMSULA MUCK Sandy or sandy skeletal, siliceous, dysic, hyperthermic Terric Haplosaprists | 88 | 0.722 |
| | | | SANIBEL | 68 | 0.558 |
| | | | SEFFNER FINE SAND Sandy, siliceous, hyperthermic Aquic Humic Dystrudepts | 152 | 1.246 |
| | | | SMYRNA SAND Sandy, siliceous, hyperthermic Aeric Alaquods | 2657 | 21.787 |
| | | | SPARR FINE SAND Loamy, siliceous, subactive, hyperthermic Grossarenic Paleudults | 22 | 0.180 |

| Drainage | Water Class | Organic Matter | Soil Series | Number of Septic Systems | Total Nitrogen (MT/year) |
|-----------------|--------------------|-----------------------|--|---------------------------------|---------------------------------|
| | | | ST. JOHNS FINE SAND Sandy, siliceous, hyperthermic TypicAlaquods | 287 | 2.353 |
| | | | WABASSO FINE SAND Sandy over loamy, siliceous, active, hyperthermic Alfic Alaquods | 339 | 2.780 |
| | | | WAUBERG FINE SAND Loamy, siliceous, active, hyperthermic Arenic Albaqualfs | 2 | 0.016 |
| | | | WAUCHULA FINE SAND Sandy over loamy, siliceous, active hyperthermic Ultic Alaquods | 1 | 0.008 |
| | > 3.5 Feet | > 1% | LOCHLOOSA FINE SAND Loamy, siliceous, semiactive, hyperthermic Aquic Arenic Paleudults | 29 | 0.238 |
| Totals | | | | 55,417 | 454.42 |

Table 4. Nitrate Input to the Wekiva Study Area From Atmospheric Deposition by Land Use

| Land Use | Acres | Hectares | Atmospheric Deposition (kg/ha/year) | Atmospheric Deposition (kg/year) | Atmospheric Deposition (MT/year) |
|--------------------------------|----------|----------|-------------------------------------|----------------------------------|----------------------------------|
| Agriculture-Aquaculture | 15.23 | 6.16 | 2.57 | 15.69 | 0.0157 |
| Agriculture-Feeding Operations | 162.06 | 65.59 | 2.57 | 166.87 | 0.1669 |
| Agriculture-Field Crops | 2627.96 | 1063.53 | 2.57 | 2705.95 | 2.7060 |
| Agriculture-Floriculture | 21.05 | 8.52 | 2.57 | 21.67 | 0.0217 |
| Agriculture-Horse Farms | 2151.10 | 870.55 | 2.57 | 2214.94 | 2.2149 |
| Agriculture-Improved Pasture | 13267.69 | 5369.44 | 2.57 | 13661.46 | 13.6615 |
| Agriculture-Nurseries | 5564.90 | 2252.11 | 2.57 | 5730.05 | 5.7301 |
| Agriculture-Row Crops | 692.64 | 280.31 | 2.57 | 713.20 | 0.7132 |
| Agriculture-Sod Farms | 120.32 | 48.69 | 2.57 | 123.89 | 0.1239 |
| Agriculture-Specialty Farms | 86.60 | 35.05 | 2.57 | 89.17 | 0.0892 |
| Agriculture-Tree Crops | 6016.14 | 2434.73 | 2.57 | 6194.69 | 6.1947 |
| Agriculture-Unimproved Pasture | 7505.32 | 3037.40 | 2.57 | 7728.06 | 7.7281 |
| Airports | 172.77 | 69.92 | 2.57 | 178.79 | 0.1788 |
| Barren Land | 9427.61 | 3815.35 | 2.57 | 9756.43 | 9.7564 |
| Cemetaries | 203.70 | 82.44 | 4.18 | 342.86 | 0.3429 |
| Commercial | 8266.56 | 3345.48 | 4.18 | 2097.61 | 2.0976 |
| Communications | 128.85 | 52.15 | 4.18 | 32.70 | 0.0327 |
| Extractive | 634.46 | 256.77 | 2.57 | 98.98 | 0.0990 |

| Land Use | Acres | Hectares | Atmospheric Deposition (kg/ha/year) | Atmospheric Deposition (kg/year) | Atmospheric Deposition (MT/hyear) |
|------------------------------|-------------------|-------------------|-------------------------------------|----------------------------------|-----------------------------------|
| Forest | 33070.72 | 13383.72 | 2.57 | 34224.18 | 34.2242 |
| Golf Courses | 3174.04 | 1284.53 | 2.57 | 2740.04 | 2.7400 |
| High Density Residential | 7792.26 | 3153.53 | 4.18 | 3822.71 | 3.8227 |
| Industrial | 2714.17 | 1098.42 | 2.57 | 423.44 | 0.4234 |
| Institutional | 3311.45 | 1340.14 | 2.57 | 1205.46 | 1.2055 |
| Low Density Residential | 12739.00 | 5155.48 | 2.57 | 9274.70 | 9.2747 |
| Marinas and Fish Camps | 28.89 | 11.69 | 2.57 | 29.89 | 0.0299 |
| Medium Density Residential | 44361.16 | 17952.96 | 4.18 | 47277.33 | 47.2773 |
| Open Land | 20202.82 | 8176.08 | 2.57 | 20907.47 | 20.9075 |
| Recreational | 1807.25 | 731.39 | 2.57 | 1870.29 | 1.8703 |
| Swimming Beaches | 2.38 | 0.96 | 2.57 | 2.46 | 0.0025 |
| Transportation | 3319.16 | 1343.26 | 2.57 | 0.00 | 0.0000 |
| Tree Plantations | 12098.73 | 4896.36 | 2.57 | 12457.80 | 12.4578 |
| Utilities | 2197.99 | 889.53 | 4.18 | 557.73 | 0.5577 |
| Very Low Density Residential | 9906.01 | 4008.96 | 2.57 | 8654.55 | 8.6545 |
| Water Body | 38687.88 | 15656.99 | 2.57 | 29172.88 | 29.1729 |
| Wetlands | 52103.30 | 21086.21 | 2.57 | 39288.87 | 39.2889 |
| Totals | 304,582.15 | 123,364.40 | | 263,782.80 | 263.78 |

Table 5. Surface Water, Groundwater, and Reuse Nitrate Discharge for Wekiva Study Area's Centralized Wastewater Facilities

| Facility ID | Name | Surface Water (MT/Yr) | Ground Water (MT/Yr) | Reused (MT/Yr) |
|---|---|-----------------------|----------------------|----------------|
| FL0036251 | Sanlando Utilities; Wekiva Hunt Club | 7.69606 | 5.435 | 16.6769 |
| FLA010818 | Apopka WRF – Project Arrow | 0.00000 | 1.326 | 4.3988 |
| FLA010798 | OCUD/Northwest Water Reclamation Facility | 1.24337 | 25.986 | 0.0000 |
| FLA010815 | Ocoee, City of | 0.00000 | 1.198 | 6.1892 |
| FLA010865 | Zellwood Station MHP | 0.00000 | 1.325 | 0.0000 |
| FLA295965 | Eustis – Eastern | 0.00000 | 0.699 | 0.0000 |
| FLA010851 | Clarcona Resort Condo | 0.00000 | 0.497 | 0.0000 |
| FLA010541 | Wekiva Falls Resort | 0.00000 | 0.274 | 0.0000 |
| FLA010498 | Seminole Springs Elementary School WWTF | 0.00000 | 0.017 | 0.0000 |
| FLA010833 | Monterey Mushroom Farm (Terry Farms) | 0.00000 | 0.025 | 0.0000 |
| FLA010855 | Coca-Cola/Apopka Facility | 0.00000 | 0.015 | 0.0000 |
| Totals of above (facilities in WSA) | | 8.9 | 36.8 | 27.3 |
| FLA010795 | Conserv II Distribution Center | 0.00000 | 121.403 | 81.2544 |
| FLA011105 | Shadow Hills WWTF | 0.00000 | 0.831 | 0.0000 |
| Total including two facilities immediately outside WSA | | 8.9 | 159.0 | 108.5 |

| Facility ID | Name | Surface Water (MT/Yr) | Ground Water (MT/Yr) | Reused (MT/Yr) |
|--------------------|---|----------------------------------|---------------------------------|---------------------------|
| FL0036251 | Sanlando Utilities; Wekiva Hunt Club | 7.69606 | 5.435 | 16.6769 |
| FLA010818 | Apopka WRF – Project Arrow | 0.00000 | 1.326 | 4.3988 |
| FLA010798 | OCUD/Northwest Water Reclamation Facility | 1.24337 | 25.986 | 0.0000 |
| FLA010815 | Ocoee, City of | 0.00000 | 1.198 | 6.1892 |
| FLA010865 | Zellwood Station MHP | 0.00000 | 1.325 | 0.0000 |
| FLA295965 | Eustis – Eastern | 0.00000 | 0.699 | 0.0000 |
| FLA010851 | Clarcona Resort Condo | 0.00000 | 0.497 | 0.0000 |
| FLA010541 | Wekiva Falls Resort | 0.00000 | 0.274 | 0.0000 |
| FLA010498 | Seminole Springs Elementary School WWTF | 0.00000 | 0.017 | 0.0000 |
| FLA010833 | Monterey Mushroom Farm (Terry Farms) | 0.00000 | 0.025 | 0.0000 |
| FLA010855 | Coca-Cola/Apopka Facility | 0.00000 | 0.015 | 0.0000 |
| Totals | | 8.9 | 36.8 | 27.3 |

Loadings to Waters of the Wekiva Study Area

Only a portion of the nitrate input to the Wekiva Study Area will reach ground and surface waters. As an example, a portion of the total nitrogen in fertilizers and wastewater effluents is volatilized as ammonia. A significant portion of nitrate applied as land fertilizer is used by plants in the root zone. Denitrification converts nitrate to nitrite, which is released to the atmosphere. The nitrate or, in the case of septic systems, total nitrogen delivered to waters of the Basin will be referred to here as loading.

In MACTEC's FDEP 2007 Phase 1 Report, information was considered sufficient to support estimation and portioning of loads to groundwater at the water table and to surface water. The portion of the groundwater load (at the water table) that eventually reaches the Floridian aquifer is expected to be significant (FDEP 2007 Phase 1 Report), but that portion cannot be quantified with the available time and resources.

Nitrate loadings to the groundwater from natural sources; septic systems; wastewater facilities; groundwater recharge, as a function of land use; and storm water, as a function of land use, are quantified. The groundwater recharge contribution was partitioned into that from atmospheric deposition and that from the primary source for the corresponding land use. Storm water and wastewater nitrate contributions to the surface waters were also estimated.

Groundwater Recharge

Various land use contributions to groundwater loadings were estimated by multiplying shallow groundwater concentrations (CGW) representative for each land use by the recharge rate (by location) using the following equation:

$$Groundwater\ Loading_{LU} = \frac{Recharge \times CGW_{LU} \times Area_{LU}}{CF}$$

where $Groundwater\ Loading_{LU}$ = Amount of NO₃-N reaching the water table from a specific land use (MT/year)

$Recharge$ = Downward flow of water to the Floridian aquifer (inch/year);

CGW_{LU} = Concentration of nitrate in recharging groundwater, estimated from concentrations near the water table (mg/L);

$Area_{LU}$ = Area within a given land use classification totaled over the entire Wekiva Basin (ha); and

CF = Conversion factor to achieve desired units of measurement, 3937 (mg inch ha/kg L)

The WSA land use (Figure 1) and recharge rate (Figure 7) coverages were overlaid in a Geographic Information System (GIS), and the area for each land use-recharge rate combination was determined. The recharge rates were not available for a small portion

of the WSA (Figure 8). The land uses in these areas were assigned recharge rates proportional to those observed in the region for which recharge rates are available.

In the FDEP 2007 Phase 1 Report, the groundwater concentration for each land use was estimated from relevant technical literature. The results of the groundwater load calculations, by land use, are displayed in Table 6. The estimated total of groundwater loading from recharge is 647.15 MT/year.

Groundwater nitrate loadings may be partitioned into that from atmospheric deposition and that from activities consistent with the land use. According to the FDEP 2007 Phase 1 Report, atmospheric deposition accounted for groundwater concentrations of 0.1 mg/L. Based on this and the recharge information, the atmospheric contribution to groundwater loading was estimated for each land use and totals 23.9 MT/year (Table 7). The remaining portion of each land use's groundwater recharge nitrate loading, if any, was attributed to the primary nitrate source for that land use. For most land uses, fertilizer use was assumed to be the source. For pasture, groundwater loadings were proportionately assigned to livestock waste and fertilizer use.

Figure 7. Recharge Rates Within the Wekiva Study Area

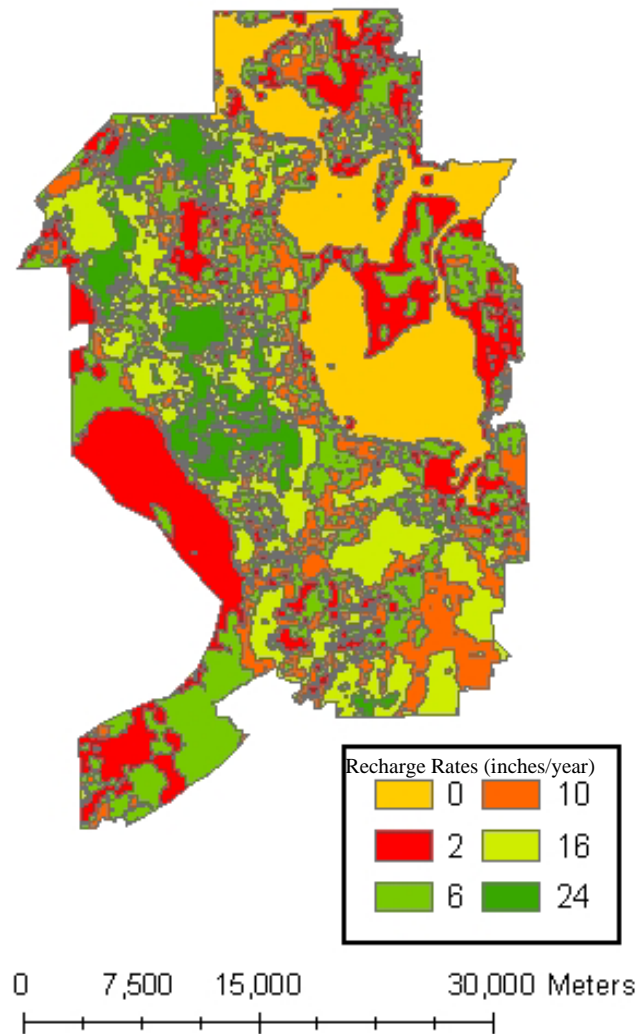
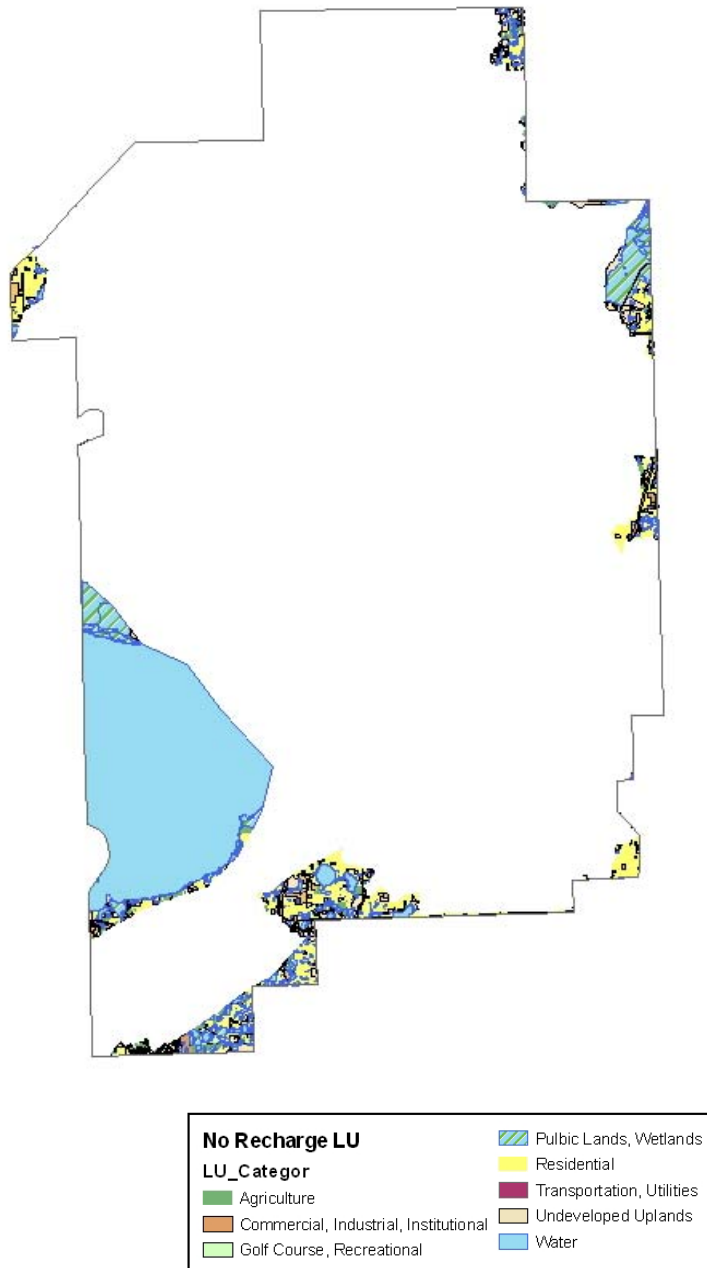


Figure 8. Areas Within the Wekiva Study Area Without Recharge Information



Storm Water

In developing the FDEP 2007 Phase 1 Report, MACTEC worked with the storm water pollutant loading model developed by CDM (2005) using the Watershed Management Model (WMM). Storm water run-off volumes and pollutant loadings within basins are estimated using the WMM. MACTEC updated the loading estimates to the 2004 land use baseline, extended the WSA results to include all of the Wekiva Basin, partitioned loadings by land use and source type, and distinguished between direct storm water loadings to surface waters and diffuse storm water loadings to groundwater. It was assumed that the loadings by land use, as determined by the CDM (2005) WMM application, were valid. MACTEC ran the WMM model for each land use to assess the respective contributions. For these runs, the sub-basins in the Wekiva Basin were identified as either open or closed. An open basin is one with an outlet, and it is assumed these basins deliver their loadings to surface water. Closed basins have no outlet and are assumed to deliver storm water loadings to groundwater.

Use of the WMM was beyond the scope of this work. To obtain the storm water loadings for the WSA, the contribution of each land use was assumed to be that proportion of the Wekiva Basin land use acres lying within the WSA. That is, the number of acres for each land use was determined for the Wekiva Basin and for the WSA. The proportion of the area associated with that land use lying in the WSA was determined. That proportion of the Wekiva Basin storm water loadings was taken as the estimate of the loadings for both direct and diffuse loadings. These results are displayed in Table 8.

Again following the approach in the FDEP 2007 Phase 1 Report, direct storm water loading to surface water by land use was taken as BMP-treated load from open basins. (BMP – best management practices). Diffuse storm water loading to groundwater by land use is untreated load in the WSA minus loading to surface water. This calculation is based on the conservative assumption that treatment by BMPs reduces the direct loading to surface water, but that all the nitrate-nitrogen treatment efficiency represents a true recycling of nitrate-nitrogen.

To partition storm water loadings by source type, it was assumed that nitrate-nitrogen loading from undeveloped lands was from “natural” sources. The storm water loading from the Forest/Open land use category was taken as this natural or undeveloped loading. After subtracting the natural or undeveloped loading that would be associated with each land use, any remaining loading was assigned to the most relevant source, such as fertilizer. The total fertilizer nitrate loads were the sum of the loads from groundwater recharge, after accounting for atmospheric deposition, and from storm water, after accounting for natural sources (see Table 9).

Septic Systems

Dr. Richard Otis provided the information for determining the groundwater loadings from septic systems. These loadings were found by multiplying the total nitrogen inputs to the environment by the proportion of that amount anticipated to reach groundwater. That

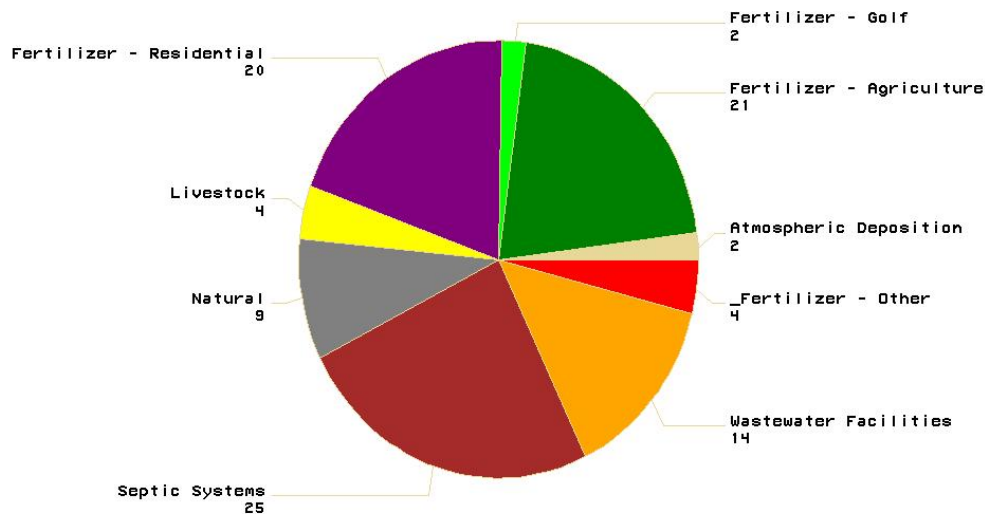
proportion depended on soil drainage, water level class, organic matter class, and soil series as shown in Appendix A. For poorly drained soils, the percentages of TKN and NO₃ (nitrate) removed by the soil differed. Whether TKN or NO₃ is appropriate depends upon septic system type, and Dr. Richard Otis supplied that information as shown in Appendix A. Using this information, the low, medium, and high estimates of groundwater nitrogen loadings due to septic systems for each soil series are displayed in Table 10, and the estimated low, medium and high estimated groundwater loadings of total nitrogen from septic systems are 348.9, 373.7, and 406.2 MT/year, respectively.

Totals

The loadings to waters of the WSA were separated into the following categories: Fertilizer due to agriculture, golf, residential areas, and other sources; Livestock; Atmospheric Deposition, Natural Sources, Wastewater Facilities, and Septic Systems. For the septic systems, consideration was given to the low, medium and high estimates. Graphs of the relative contributions of each of these sources, including the boundary centralized wastewater facilities are included, and for low, medium, and high estimates of the contribution of the septic systems are displayed in Figures 9, 10, and 11, respectively. Similar, graphs of the relative contributions of each of the sources, including only the centralized wastewater facilities within the WSA, and for low, medium, and high estimates of the contribution of septic systems are displayed in Figures 12, 13, and 14.

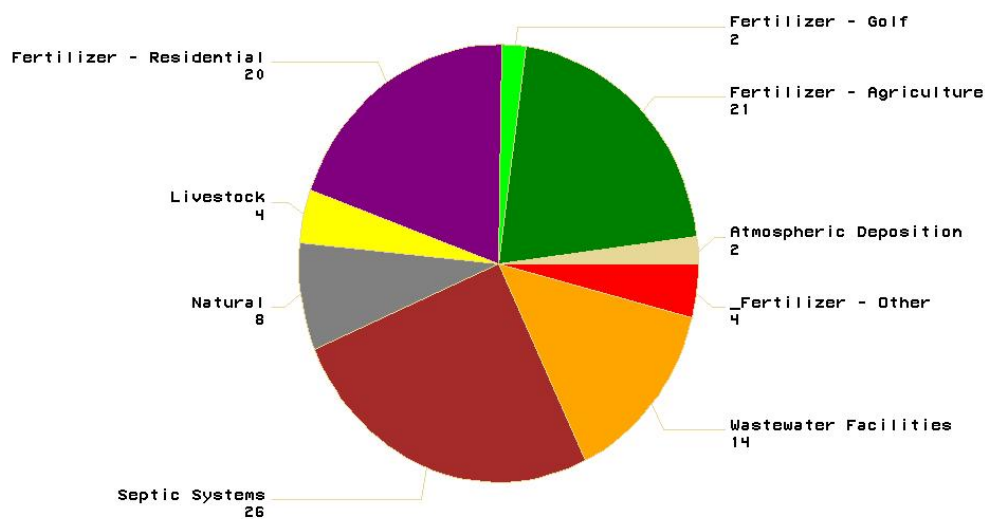
In constructing the graphs in Figures 9 to 14, only the loadings to groundwater from fertilizer, livestock, natural sources, atmospheric deposition, and septic systems are considered. Only that portion (diffuse) of storm water estimated to impact groundwater is included. The estimated nitrate loadings to surface waters from centralized wastewater facilities or from storm water are not included. In Figure 15, these additional sources are included for the median contribution from septic systems and for the boundary centralized wastewater facilities as well as those fully within the WSA.

Figure 9. Nitrate* Groundwater Loadings to the Wekiva Study Area by Source, Including Centralized Wastewater Facilities Immediately Outside the Area and Using Low Estimates for Septic Systems



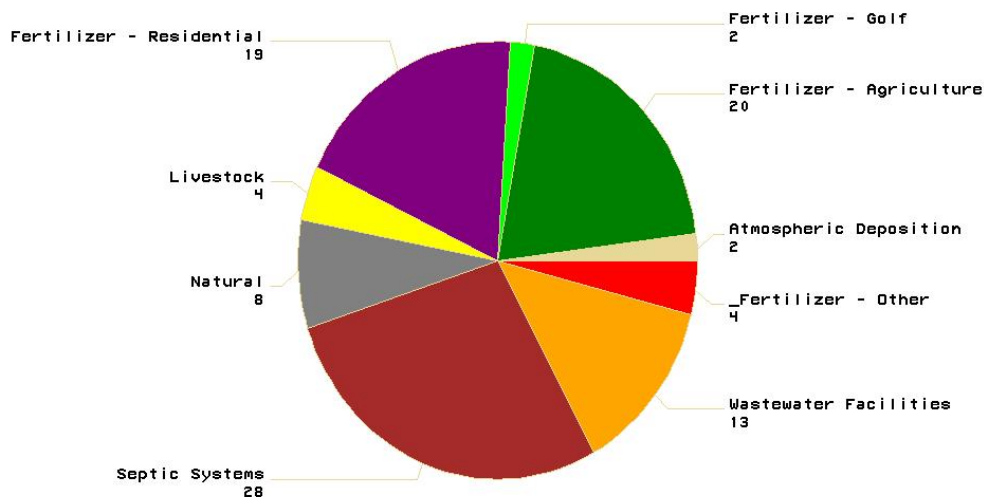
*The input from septic systems is total nitrogen, which includes nitrates.

Figure 10. Nitrate* Groundwater Loadings to the Wekiva Study Area by Source, Including Centralized Wastewater Facilities Immediately Outside the Area and Using Median Estimates for Septic Systems



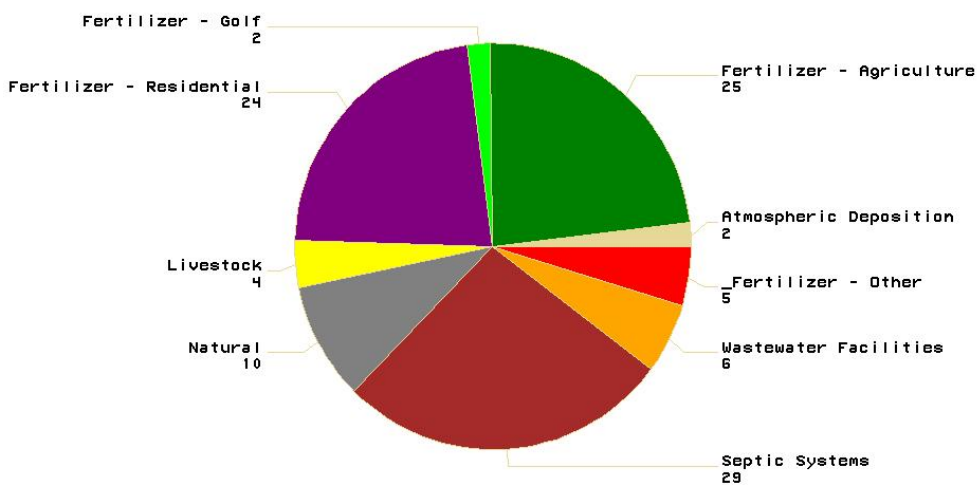
*The input from septic systems is total nitrogen, which includes nitrates.

Figure 11. Nitrate* Groundwater Loadings to the Wekiva Study Area by Source, Including Centralized Wastewater Facilities Immediately Outside the Area and Using High Estimates for Septic Systems



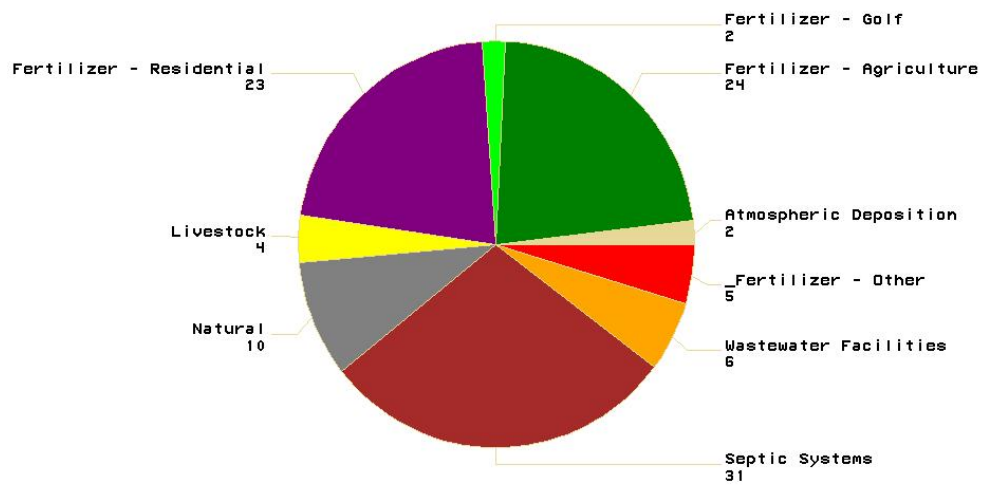
*The input from septic systems is total nitrogen, which includes nitrates

Figure 12. Nitrate* Groundwater Loadings to the Wekiva Study Area by Source, Including Only Centralized Wastewater Facilities Within the Area and Using Low Estimates for Septic Systems



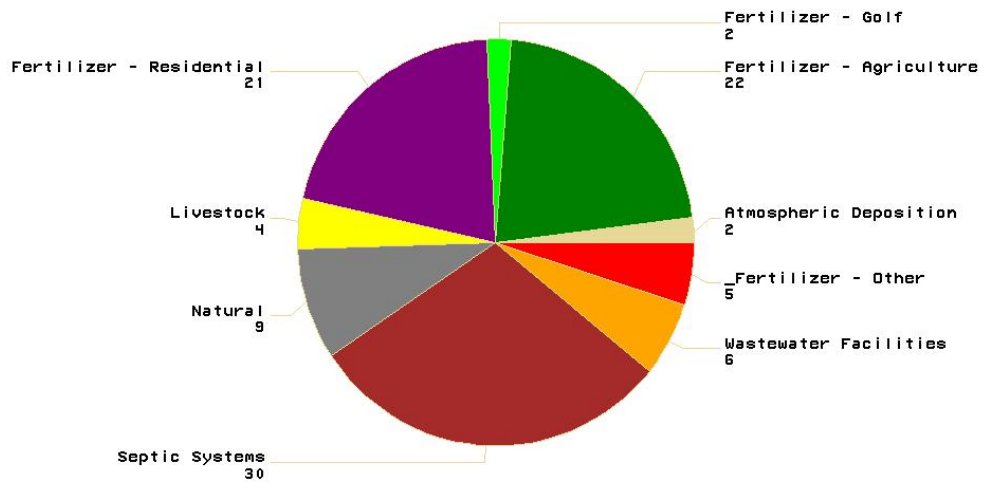
*The input from septic systems is total nitrogen, which includes nitrates.

Figure 13. Nitrate* Groundwater Loadings to the Wekiva Study Area by Source, Including Only Centralized Wastewater Facilities Within the Area and Using Median Estimates for Septic Systems



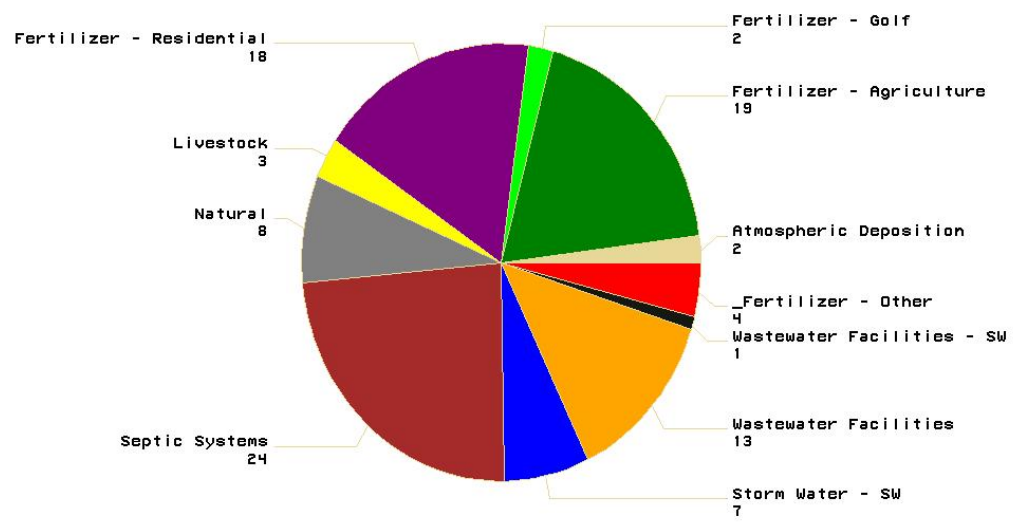
*The input from septic systems is total nitrogen, which includes nitrates.

Figure 14. Nitrate* Groundwater Loadings to the Wekiva Study Area by Source, Including Only Centralized Wastewater Facilities Within the Area and Using High Estimates for Septic Systems



*The input from septic systems is total nitrogen, which includes nitrates

Figure 15. Nitrate* Loadings to the Wekiva Study Area by Source, Including Centralized Wastewater Facilities Immediately Outside the Area and Using Median Estimates for Septic Systems



*The input from septic systems is total nitrogen, which includes nitrates.

Table 6. Nitrate Loads to the Wekiva Study Area From Groundwater (GW) Recharge by Land Use

| LU Code | Description | Acres | Hectares | Nitrate Loads From GW Recharge (MT/Year) |
|----------------|--------------------------------|--------------|-----------------|---|
| 1100 | Low Density Residential | 22645.01 | 9164.44 | 78.808 |
| 1200 | Medium Density Residential | 44361.16 | 17952.96 | 136.897 |
| 1300 | High Density Residential | 7792.26 | 3153.53 | 25.262 |
| 1400 | Commercial | 8470.26 | 3427.91 | 29.277 |
| 1500 | Industrial | 2714.17 | 1098.42 | 0.347 |
| 1600 | Extractive | 634.46 | 256.77 | 0.104 |
| 1700 | Institutional | 3311.45 | 1340.14 | 11.954 |
| 1800 | Recreational | 1836.14 | 743.08 | 5.081 |
| 1820 | Golf Course | 3174.04 | 1284.53 | 26.653 |
| 1900 | Open Land | 2841.58 | 1149.99 | 0.237 |
| 2100 | Crop Land and Pasture Land | 59.31 | 24.00 | 0.263 |
| 2110 | Agriculture-Improved Pasture | 13267.69 | 5369.44 | 80.194 |
| 2120 | Agriculture-Unimproved Pasture | 4225.56 | 1710.09 | 18.565 |
| 2130 | Woodland Pasture | 3279.75 | 1327.32 | 20.762 |
| 2140 | Agriculture-Row Crops | 692.64 | 280.31 | 8.680 |
| 2150 | Agriculture-Field Crops | 2568.65 | 1039.53 | 11.256 |
| 2200 | Agriculture-Tree Crops | 6016.14 | 2434.73 | 104.798 |
| 2300 | Agriculture-Feeding Operations | 162.06 | 65.59 | 3.037 |
| 2400 | Agriculture-Nurseries | 128.83 | 52.14 | 1.228 |
| 2410 | Agriculture-Sod Farms | 82.90 | 33.55 | 0.714 |
| 2420 | Agriculture-Floriculture | 120.32 | 48.69 | 0.156 |
| 2430 | Agriculture-Ornamentals | 5353.17 | 2166.43 | 45.068 |
| 2450 | Agriculture-Horse Farms | 21.05 | 8.52 | 0.113 |
| 2500 | Agriculture-Specialty Farms | 101.83 | 41.21 | 1.160 |
| 2510 | Agriculture-Horse Farms | 2151.10 | 870.55 | 9.843 |
| 2600 | Other Open Lands—rural | 265.72 | 107.54 | 0.023 |

| LU Code | Description | Acres | Hectares | Nitrate Loads From GW Recharge (MT/Year) |
|----------------|--|-------------------|-------------------|---|
| 3000 | Upland Nonforested | 17095.53 | 6918.56 | 1.327 |
| 4000 | Upland Forests (25% forested cover) | 45169.45 | 18280.08 | 3.761 |
| 5000 | Water | 38687.88 | 15656.99 | 1.890 |
| 6000 | Wetlands | 52103.30 | 21086.21 | 1.139 |
| 7000 | Barren land | 9427.61 | 3815.35 | 0.276 |
| 8000 | Transportation, Communication, and Utilities | 5818.77 | 2354.86 | 18.274 |
| Totals | | 304,582.15 | 123,374.40 | 647.15 |

Table 7. Nitrate Loads to the Wekiva Study Area From Atmospheric Deposition by Land Use

| LU | Description | Acres | Hectares | Nitrate Loads from Atmospheric Deposition (MT/Year) |
|------|--------------------------------|----------|----------|---|
| 1100 | Low Density Residential | 22645.01 | 9164.44 | 2.62692 |
| 1200 | Medium Density Residential | 44361.16 | 17952.96 | 4.56323 |
| 1300 | High Density Residential | 7792.26 | 3153.53 | 0.84207 |
| 1400 | Commercial | 8470.26 | 3427.91 | 0.97589 |
| 1500 | Industrial | 2714.17 | 1098.42 | 0.34709 |
| 1600 | Extractive | 634.46 | 256.77 | 0.10390 |
| 1700 | Institutional | 3311.45 | 1340.14 | 0.39847 |
| 1800 | Recreational | 1836.14 | 743.08 | 0.16938 |
| 1820 | Golf Course | 3174.04 | 1284.53 | 0.33316 |
| 1900 | Open Land | 2841.58 | 1149.99 | 0.23729 |
| 2100 | Crop Land and Pasture Land | 59.31 | 24.00 | 0.00658 |
| 2110 | Agriculture-Improved Pasture | 13267.69 | 5369.44 | 1.45807 |
| 2120 | Agriculture-Unimproved Pasture | 4225.56 | 1710.09 | 0.33754 |
| 2130 | Woodland Pasture | 3279.75 | 1327.32 | 0.37748 |
| 2140 | Agriculture-Row Crops | 692.64 | 280.31 | 0.03774 |
| 2150 | Agriculture-Field Crops | 2568.65 | 1039.53 | 0.28140 |
| 2200 | Agriculture-Tree Crops | 6016.14 | 2434.73 | 0.69865 |
| 2300 | Agriculture-Feeding Operations | 162.06 | 65.59 | 0.01687 |
| 2400 | Agriculture-Nurseries | 128.83 | 52.14 | 0.02047 |
| 2410 | Agriculture-Sod Farms | 82.90 | 33.55 | 0.01191 |
| 2420 | Agriculture-Floriculture | 120.32 | 48.69 | 0.00390 |
| 2430 | Agriculture-Ornamentals | 5353.17 | 2166.43 | 0.75113 |
| 2450 | Agriculture-Horse Farms | 21.05 | 8.52 | 0.00188 |
| 2500 | Agriculture-Specialty Farms | 101.83 | 41.21 | 0.01934 |
| 2510 | Agriculture-Horse Farms | 2151.10 | 870.55 | 0.22371 |
| 2600 | Other Open Lands—rural | 265.72 | 107.54 | 0.02319 |

| LU | Description | Acres | Hectares | Nitrate Loads from Atmospheric Deposition (MT/Year) |
|---------------|--|-------------------|-------------------|--|
| 3000 | Upland Nonforested | 17095.53 | 6918.56 | 1.32749 |
| 4000 | Upland Forests (25% forested cover) | 45169.45 | 18280.08 | 3.76089 |
| 5000 | Water | 38687.88 | 15656.99 | 1.89029 |
| 6000 | Wetlands | 52103.30 | 21086.21 | 1.13921 |
| 7000 | Barren land | 9427.61 | 3815.35 | 0.27550 |
| 8000 | Transportation, Communication, and Utilities | 5818.77 | 2354.86 | 0.60913 |
| Totals | | 304,582.15 | 123,374.40 | 23.87 |

Table 8. Diffuse and Direct Storm Water (SW) Nitrate Loads to the Wekiva Study Area by Land Use

| LU Code | Description | Acres | Hectares | % of WSA in Wekiva Basin | Wekiva Basin | | Wekiva Study Area (WSA) | |
|---------|--|----------|----------|--------------------------|--------------|------------|-------------------------|------------|
| | | | | | SW Direct | SW Diffuse | SW Direct | SW Diffuse |
| 1100 | Low Density Residential | 22645.01 | 9164.44 | 71 | 10.07 | 24.57 | 7.1208 | 17.3741 |
| 1200 | Medium Density Residential | 44361.16 | 17952.96 | 90 | 28.75 | 31.81 | 25.8595 | 28.6118 |
| 1300 | High Density Residential | 7792.26 | 3153.53 | 87 | 8.24 | 10.06 | 7.1912 | 8.7795 |
| 1400 | Commercial | 8470.26 | 3427.91 | 86 | 14.28 | 6.67 | 12.3328 | 5.7605 |
| 1500 | Industrial | 2714.17 | 1098.42 | 84 | 2.11 | 1.85 | 1.7727 | 1.5543 |
| 1600 | Extractive | 634.46 | 256.77 | 29 | 0.00 | 2.17 | 0.0000 | 0.6226 |
| 1700 | Institutional | 3311.45 | 1340.14 | 92 | 4.94 | 4.92 | 4.5525 | 4.5341 |
| 1800 | Recreational | 1838.51 | 744.05 | 66 | 0.30 | 0.12 | 0.1968 | 0.0787 |
| 1820 | Golf Course | 3174.04 | 1284.53 | 78 | 0.82 | 2.02 | 0.6434 | 1.5850 |
| 1900 | Open Land | 2841.58 | 1149.99 | 90 | 2.08 | 2.56 | 1.8819 | 2.3161 |
| 2110 | Improved pastures (monocult. Planted forage crops) | 13267.69 | 5369.44 | 47 | 5.69 | 11.30 | 2.6754 | 5.3133 |
| 2140 | Row crops | 692.64 | 280.31 | 84 | 0.00 | 0.10 | 0.0000 | 0.0844 |
| 2150 | Field crops | 2568.65 | 1039.53 | 70 | 0.32 | 0.97 | 0.2252 | 0.6827 |
| 2200 | Tree crops | 6016.14 | 2434.73 | 48 | 0.24 | 2.89 | 0.1148 | 1.3819 |
| 2300 | Feeding operations | 162.06 | 65.59 | 100 | 0.03 | 0.04 | 0.0300 | 0.0400 |
| 2400 | Nurseries and vineyards | 128.83 | 52.14 | 82 | 0.52 | 2.17 | 0.4267 | 1.7808 |

| LU Code | Description | Acres | Hectares | % of WSA in Wekiva Basin | Wekiva Basin | | Wekiva Study Area (WSA) | |
|---------------|--|----------|----------|--------------------------|--------------|--------------|-------------------------|-------------|
| | | | | | SW Direct | SW Diffuse | SW Direct | SW Diffuse |
| 2500 | Specialty farms | 101.83 | 41.21 | 79 | 0.32 | 0.92 | 0.2539 | 0.7301 |
| 4000 | Upland Forests (25% forested cover) | 45169.45 | 18280.08 | 60 | 9.41 | 6.97 | 5.6115 | 4.1564 |
| 5000 | Water | 38687.88 | 15656.99 | 100 | 2.94 | 3.07 | 2.9400 | 3.0700 |
| 6000 | Wetlands | 52103.30 | 21086.21 | 72 | 32.19 | 13.63 | 23.0402 | 9.7558 |
| 7000 | Barren land | 9427.61 | 3815.35 | 92 | 0.14 | 0.29 | 0.1283 | 0.2657 |
| 8000 | Transportation, Communication, and Utilities | 5818.77 | 2354.86 | 78 | 3.11 | 6.56 | 2.4163 | 5.0967 |
| Totals | | | | | 126.5 | 135.7 | 103.6 | 99.4 |

Table 9. Nitrate Loads to the Wekiva Stuy Area From Fertilizer and Natural Sources

| LU Code | Description | Fertilizer Nitrate Loads From Groundwater (MT/Year) | Fertilizer Nitrate Loads From Storm Water (MT/Year) | Total Fertilizer Nitrate Loads (MT/Year) | Nitrate Loads from Natural Sources (MT/Year) |
|----------------|--------------------------------|--|--|---|---|
| 1100 | Low Density Residential | 76.181 | 12.4434 | 88.624 | 12.0515 |
| 1200 | Medium Density Residential | 132.334 | 28.4885 | 160.822 | 25.9828 |
| 1300 | High Density Residential | 24.420 | 8.5763 | 32.996 | 7.3944 |
| 1400 | Commercial | 28.301 | 9.7161 | 38.017 | 8.3772 |
| 1500 | Industrial | 0.000 | 0.7486 | 0.749 | 2.5784 |
| 1600 | Extractive | 0.000 | 0.1401 | 0.140 | 0.4825 |
| 1700 | Institutional | 11.556 | 6.4060 | 17.962 | 2.6805 |
| 1800 | Recreational | 4.912 | 0.0000 | 4.912 | 0.2756 |
| 1820 | Golf Courses | 26.320 | 1.0385 | 27.358 | 1.1900 |
| 1900 | Open Land | 0.000 | 0.0000 | 0.000 | 4.1980 |
| 2100 | Crop Land and Pasture Land | 0.257 | 0.0000 | 0.257 | 0.0000 |
| 2110 | Agriculture-Improved Pasture | 78.736 | 3.7227 | 82.458 | 4.2660 |
| 2120 | Agriculture-Unimproved Pasture | 18.227 | 0.0000 | 18.227 | 0.0000 |
| 2130 | Woodland Pastures | 20.384 | 0.0000 | 20.384 | 0.0000 |
| 2140 | Agriculture-Row Crops | 8.642 | 0.0393 | 8.681 | 0.0450 |
| 2150 | Agriculture-Field Crops | 10.975 | 0.4231 | 11.398 | 0.4848 |

| LU Code | Description | Fertilizer Nitrate Loads From Groundwater (MT/Year) | Fertilizer Nitrate Loads From Storm Water (MT/Year) | Total Fertilizer Nitrate Loads (MT/Year) | Nitrate Loads from Natural Sources (MT/Year) |
|---------------|--------------------------------|---|---|--|--|
| 2200 | Agriculture-Tree Crops | 104.099 | 0.6974 | 104.797 | 0.7992 |
| 2300 | Agriculture-Feeding Operations | 3.021 | 0.0326 | 0.000 | 0.0374 |
| 2400 | Agriculture-Nurseries | 1.207 | 1.0287 | 2.236 | 1.1789 |
| 2410 | Tree Nurseries | 0.703 | 0.0000 | 0.703 | . |
| 2420 | Agriculture-Sod Farms | 0.152 | 0.0000 | 0.152 | . |
| 2430 | Agriculture-Ornamentals | 44.317 | 0.0000 | 44.317 | . |
| 2450 | Agriculture-Floriculture | 0.111 | 0.0000 | 0.111 | . |
| 2500 | Agriculture-Specialty Farms | 1.141 | 0.4586 | 1.599 | 0.5255 |
| 2510 | Agriculture-Horse Farms | 9.620 | 0.0000 | 9.620 | . |
| 2600 | Other Open Lands-Rural | 0.000 | 0.0000 | 0.000 | . |
| 3000 | Upland Non-Forested | 0.000 | 0.0000 | 0.000 | . |
| 4000 | Forest | 0.000 | 0.0000 | 0.000 | 9.7679 |
| 5000 | Water | 0.000 | 0.0000 | 0.000 | 6.0100 |
| 6000 | Wetlands | 0.000 | 7.3791 | 7.379 | 25.4169 |
| 7000 | Barren Lands | 0.000 | 0.0000 | 0.000 | 0.3939 |
| 8000 | Communications & Utilities | 17.665 | 1.6904 | 19.355 | 5.8226 |
| Totals | | 623.28 | 83.03 | 703.25 | 119.96 |

Table 10. Total Nitrogen Loads to the Wekiva Study Area From Septic Systems

| Drainage | Water Class | Organic Matter | Soil Series | Number of Septic Systems | High Estimate of Nitrogen to GW (MT/Yr) | Median Estimate of Nitrogen to GW (MT/Yr) | Low Estimate of Nitrogen to GW (MT/Yr) |
|--|-------------|----------------|--|--------------------------|---|---|--|
| | <=3.5 Feet | <= 1% | | 434 | 2.927 | 2.408 | 2.280 |
| | | | URBAN LAND | 8070 | 54.421 | 44.773 | 42.398 |
| | | | PITS | 17 | 0.139 | 0.132 | 0.125 |
| Excessively Well/ Somewhat Excessively Well | >3.5 Feet | <= 1% | LAKE FINE SAND Hyperthermic, coated Typic Quartzipsamments | 1126 | 9.233 | 8.772 | 8.310 |
| | | | PAOLA FINE SAND Hyperthermic, uncoated Spodic Quartzipsamments | 412 | 3.378 | 3.209 | 3.041 |
| | | | ST. LUCIE SAND Hyperthermic, uncoated Typic Quartzipsamments | 542 | 4.444 | 4.222 | 4.000 |
| | | >1% | ASTATULA FINE SAND Hyperthermic, uncoated Typic Quartzipsamments | 2585 | 21.197 | 20.137 | 19.077 |
| | | | CANDLER SAND Hyperthermic, uncoated Lamellic Quartzipsamments | 22146 | 181.597 | 172.517 | 163.437 |
| Well | >3.5 Feet | <= 1% | APOPKA SAND Loamy, siliceous, hyperthermic Grossarenic Paleudults | 52 | 0.426 | 0.405 | 0.384 |
| | | >1% | ORLANDO FINE SAND Siliceous, hyperthermic Humic Psammentic Dystrudepts | 194 | 1.591 | 1.511 | 1.432 |
| Moderately | <=3.5 Feet | <= 1% | POMELLO FINE SAND Sandy, siliceous, hyperthermic Oxyaquic Alorthods | 934 | 6.893 | 5.361 | 3.829 |
| | | | ARCHBOLD SAND Hyperthermic, uncoated Typic Quartzipsamments | 133 | 1.036 | 0.982 | 0.927 |

| Drainage | Water Class | Organic Matter | Soil Series | Number of Septic Systems | High Estimate of Nitrogen to GW (MT/Yr) | Median Estimate of Nitrogen to GW (MT/Yr) | Low Estimate of Nitrogen to GW (MT/Yr) |
|---|-------------|----------------|---|--------------------------|---|---|--|
| Well | >3.5 Feet | <= 1% | ORSINO FINE SAND Hyperthermic, uncoated Spodic Quartzipsamments | 63 | 0.491 | 0.465 | 0.439 |
| | | | UDORTHENTS | 2 | 0.015 | 0.012 | 0.010 |
| | | >1% | FLORAHOME SAND Siliceous, hyperthermic Humic Psammentic Dystrudepts | 185 | 1.365 | 1.289 | 1.214 |
| | | | MILLHOPPER SAND Loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudults | 8 | 0.059 | 0.056 | 0.052 |
| | | | TAVARES FINE SAND Hyperthermic, uncoated Typic Quartzipsamments | 10120 | 78.835 | 74.686 | 70.536 |
| Somewhat Poorly/ Poorly/ Poorly/Very Poorly | <=3.5 Feet | <= 1% | ADAMSVILLE FINE SAND Hyperthermic, uncoated Aquic Quartzipsamments | 158 | 1.231 | 1.166 | 1.101 |
| | | | ARENTS | 316 | 1.814 | 1.425 | 1.036 |
| | | | CASSIA FINE SAND Sandy, siliceous, hyperthermic Oxyaquic Alorthods | 117 | 0.863 | 0.815 | 0.768 |
| | | | ZOLFO FINE SAND Sandy, siliceous, hyperthermic Oxyaquic Alorthods | 702 | 5.469 | 4.893 | 4.317 |
| | | >1% | ANCLOTE SAND Sandy, siliceous, hyperthermic Typic Endoaquolls | 19 | 0.039 | 0.019 | 0.000 |
| | | | BASINGER FINE SAND Siliceous, hyperthermic Spodic Psammaquents | 959 | 7.471 | 6.881 | 6.291 |
| | | | BRIGHTON MUCK Dysic, hyperthermic Typic Haplohemists | 64 | 0.052 | 0.026 | 0.000 |
| | | | | | | | |

| Drainage | Water Class | Organic Matter | Soil Series | Number of Septic Systems | High Estimate of Nitrogen to GW (MT/Yr) | Median Estimate of Nitrogen to GW (MT/Yr) | Low Estimate of Nitrogen to GW (MT/Yr) |
|----------|-------------|----------------|---|--------------------------|---|---|--|
| | | | CANOVA MUCK Fine-loamy, siliceous, superactive, hyperthermic Histic Glossaqualts | 2 | 0.002 | 0.001 | 0.000 |
| | | | CHOBEE FINE SANDY LOAM Fine-loamy, siliceous, superactive, hyperthermic Typic Argiaquolls | 4 | 0.030 | 0.026 | 0.023 |
| | | | EAUGALLIE FINE SAND Sandy, siliceous, hyperthermic Alfic Alaquods | 49 | 0.321 | 0.281 | 0.241 |
| | | | EMERALDA FINE SAND Fine, mixed, superactive, hyperthermic Mollic Albaqualfs | 17 | 0.014 | 0.007 | 0.000 |
| | | | FELDA FINE SAND Loamy, siliceous, superactive, hyperthermic Arenic Endoaqualfs | 27 | 0.133 | 0.111 | 0.089 |
| | | | GATOR MUCK Loamy, siliceous, euic, hyperthermic Terric Haplosaprists | 1 | 0.007 | 0.007 | 0.006 |
| | | | IMMOKALEE FINE SAND Sandy, siliceous, hyperthermic Arenic Alaquods | 433 | 2.840 | 2.485 | 2.130 |
| | | | MALABAR FINE SAND Loamy, siliceous, active, hyperthermic Grossarenic Endoaqualfs | 6 | 0.044 | 0.039 | 0.034 |
| | | | MYAKKA FINE SAND Sandy, siliceous, hyperthermic Aeric Alaquods | 645 | 3.173 | 2.645 | 2.116 |

| Drainage | Water Class | Organic Matter | Soil Series | Number of Septic Systems | High Estimate of Nitrogen to GW (MT/Yr) | Median Estimate of Nitrogen to GW (MT/Yr) | Low Estimate of Nitrogen to GW (MT/Yr) |
|----------|-------------|----------------|--|--------------------------|---|---|--|
| | | | NITTAW SANDY CLAY Fine, smectitic, hyperthermic Typic Argiaquolls | 128 | 0.105 | 0.052 | 0.000 |
| | | | OCOEE MUCK Sandy or sandy skeletal, siliceous, dysic, hyperthermic Terric Haplohemists | 1 | 0.008 | 0.007 | 0.007 |
| | | | OKEELANTA MUCK Sandy or sandy skeletal, siliceous, euic, hyperthermic Terric Haplosaprists | 3 | 0.023 | 0.022 | 0.020 |
| | | | ONA FINE SAND Sandy, siliceous, hyperthermic Typic Alaquods | 851 | 6.280 | 5.583 | 4.885 |
| | | | PLACID FINE SAND Sandy, siliceous, hyperthermic Typic Humaquepts | 45 | 0.037 | 0.018 | 0.000 |
| | | | POMPANO FINE SAND Siliceous, hyperthermic Typic Psammaquents | 202 | 0.994 | 0.828 | 0.663 |
| | | | SAMSULA MUCK Sandy or sandy skeletal, siliceous, dysic, hyperthermic Terric Haplosaprists | 88 | 0.072 | 0.036 | 0.000 |
| | | | SANIBEL | 68 | 0.530 | 0.502 | 0.474 |
| | | | SEFFNER FINE SAND Sandy, siliceous, hyperthermic Aquic Humic Dystrudepts | 152 | 0.125 | 0.062 | 0.000 |
| | | | SMYRNA SAND Sandy, siliceous, hyperthermic Aeric Alaquods | 2657 | 2.179 | 1.089 | 0.000 |

| Drainage | Water Class | Organic Matter | Soil Series | Number of Septic Systems | High Estimate of Nitrogen to GW (MT/Yr) | Median Estimate of Nitrogen to GW (MT/Yr) | Low Estimate of Nitrogen to GW (MT/Yr) |
|---------------|-------------|----------------|--|--------------------------|---|---|--|
| | | | SPARR FINE SAND Loamy, siliceous, subactive, hyperthermic Grossarenic Paleudults | 22 | 0.018 | 0.009 | 0.000 |
| | | | ST. JOHNS FINE SAND Sandy, siliceous, hyperthermic TypicAlaquods | 287 | 1.883 | 1.647 | 1.412 |
| | | | WABASSO FINE SAND Sandy over loamy, siliceous, active, hyperthermic Alfic Alaquods | 339 | 2.224 | 1.946 | 1.668 |
| | | | WAUBERG FINE SAND Loamy, siliceous, active, hyperthermic Arenic Albaqualfs | 2 | 0.010 | 0.008 | 0.007 |
| | | | WAUCHULA FINE SAND Sandy over loamy, siliceous, active hyperthermic Ultic Alaquods | 1 | 0.008 | 0.007 | 0.007 |
| | >3.5 Feet | > 1% | LOCHLOOSA FINE SAND Loamy, siliceous, semiactive, hyperthermic Aquic Arenic Paleudults | 29 | 0.143 | 0.119 | 0.095 |
| Totals | | | | 55,417 | 406.2 | 373.7 | 348.9 |

Limitations

The FDEP 2007 Phase 1 Report identified a number of limitations, both from procedural issues and uncertainties in input parameters. These apply here as well. Only a few of these will be identified here, and the interested reader should refer to the report for a fuller discussion.

The parameters used in all of the computations are subject to uncertainty. As an example, the estimated amount of fertilizer applied to each land use was based on the technical literature and surely varies over the WSA. The atmospheric deposition was assumed to be the same for all rural and all urban lands. Because these uncertainties have not been quantified, it is not know how much uncertainty is associated with any of these estimates.

The nitrate effluent concentrations were available for only a portion of the centralized wastewater facilities. The permitted, and not the actual, discharge rates from the wastewater facilities were used in the computations for all but the 13 for which data were available. One of the two facilities just outside the WSA is the centralized wastewater facility with the largest contribution to nitrates in the groundwater in the Wekiva Basin. How much these two facilities impact the WSA is unclear.

The limitations of the septic system parameters are discussed by Dr. Richard Otis in his final report for Task 2. In addition, error is undoubtedly present in the location of at least some of the septic systems. For each septic system, the soil series associated with the corresponding map unit in the soils maps was assigned to the system, and any error in this assignment would affect the estimates of nitrogen loadings. Further, the septic system loadings were estimated in terms of total nitrogen whereas the inputs and loads from other sources included only nitrate.

Conclusions

Fertilizer is the major source of nitrate inputs to the WSA, accounting for 78 percent of all inputs. Although constituting a smaller portion, fertilizer is also the primary source of nitrate loadings to the groundwater of the WSA, accounting for an estimated 45 to 47 percent of all loadings. Among the sources of fertilizer, agriculture is the primary factor (24 percent) followed closely by residential use (23 percent). Livestock contribute nine percent of the inputs but only four percent of the nitrate loadings to the WSA.

Even though septic systems constitute only six to eight percent of the inputs, they are estimated to contribute 25 to 28 percent of the nitrate loadings to groundwater of the WSA. This estimate is based on total nitrogen while that from other sources considers only nitrates; however, the load contribution from septic systems is substantial.

The nitrate loading from natural sources is estimated to be nine to ten percent. The nitrate loadings from septic tanks is 250% that of natural, and the nitrate loadings from fertilizer is more than 400% that of natural.

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Appendix A

Information from Dr. Richard Otis

ESTIMATED DENITRIFICATION POTENTIAL OF SOILS IN THE WEKIVA STUDY AREA

| Drainage Class | Water Table Class 1=<3.5 ft 2=>3.5 ft | Organic Matter Class 1=<1.0% 2=>1.0% | Soil Series Taxonomy | Soil Series Description | NRCS "Suitability" Rating for Onsite Treatment | Applied Nitrogen | Estimated TN Removal Potential | Comments | Source Documents |
|---|---|--|--|--|--|---------------------|--------------------------------|--|------------------|
| Excessively / Somewhat Excessively | 2 | 1 | LAKE FINE SAND Hyperthermic, coated Typic Quartzipsamments | Excessively drained, rapidly to very rapidly permeable soils formed in thick beds of sand. Water table is >80" deep. | Slight | TKN/NO ₃ | <10% | Very low organic content Very low moisture content (aerobic) | |
| | 2 | 1 | PAOLA FINE SAND Hyperthermic, uncoated Spodic Quartzipsamments | Very deep, excessively drained, very rapidly permeable upland soils that formed in sandy marine deposits. Water table is >80" deep. | Slight | TKN/NO ₃ | <10% | Very low organic content Very low moisture content (aerobic) | |
| | 2 | 1 | ST. LUCIE SAND Hyperthermic, uncoated Typic Quartzipsamments | Very deep, excessively drained, very rapidly permeable soils formed in marine eolian sand. Water table >80" deep. | Slight | TKN/NO ₃ | <10% | Very low organic content Very low moisture content (aerobic) | |
| | 2 | 2 | ASTATULA FINE SAND Hyperthermic, uncoated Typic Quartzipsamments | Very deep, excessively drained, rapidly permeable soils formed in eolian and marine sands. Water table >80" deep. | Slight | TKN/NO ₃ | <10% | Very low organic content Very low moisture content (aerobic) | |
| | 2 | 2 | CANDLER SAND Hyperthermic, uncoated Lamellic Quartzipsamments | Very deep, excessively drained, rapidly permeable soils that formed in thick beds of eolian or marine deposits of coarse textured materials. Short, thin loamy lamella exist below 70". Water table >80" deep. | Slight | TKN/NO ₃ | <10% | Very low organic content Very low moisture content (aerobic) | |
| Well | 2 | 1 | AOPKA SAND Loamy, siliceous, hyperthermic Grossarenic Paleudults | Very deep, well drained, moderately permeable soils that formed in thick beds of sandy and loamy marine or eolian deposits. Water table >60" deep. | Slight | TKN/NO ₃ | <10% | Very low organic content Very low moisture content (aerobic) | |
| | 2 | 2 | ORLANDO FINE SAND Siliceous, hyperthermic Humic Psammentic Dystrudepts | Very deep, well drained, rapidly permeable soils that formed in thick deposits of sandy marine or fluvial sediments. Water table >72". | Slight | TKN/NO ₃ | <10% | Very low organic content Very low moisture content (aerobic) | |

| Drainage Class | Water Table Class 1=<3.5 ft 2=>3.5 ft | Organic Matter Class 1=<1.0% 2=>1.0% | Soil Series Taxonomy | Soil Series Description | NRCS "Suitability" Rating for Onsite Treatment | Applied Nitrogen | Estimated TN Removal Potential | Comments | Source Documents |
|---------------------------------------|---|--|---|--|--|---------------------|--------------------------------|--|------------------|
| Moderately Well | 2 | 1 | ARCHBOLD SAND Hyperthermic, uncoated Typic Quartzipsamments | Deep, well drained, very rapidly permeable sandy soils that formed in marine or eolian deposits. Seasonally high water table (June-November) at 42-60" but 60-80" the remainder of the year. | Moderate: wetness | TKN/NO ₃ | 5-15% | Very low organic content Low moisture content (aerobic) | |
| | 2 | 1 | ORSINO FINE SAND Hyperthermic, uncoated Spodic Quartzipsamments | Very deep, moderately well drained, very rapidly permeable soils that formed in thick beds of sandy marine or eolian deposits. Water table at 50-60" deep. Spodic horizon at 25". | Severe: wetness | TKN/NO ₃ | 5-15% | Very low organic content Low moisture content (aerobic) | |
| | 2 | 2 | FLORAHOME SAND Siliceous, hyperthermic Humic Psammentic Dystrudepts | Deep, moderately well drained, dark surfaced, rapidly permeable soils that formed in sandy marine and eolian deposits. Water table depth at 45-72" for 4-6 months each year receding to >72 in dry periods. | Moderate: wetness | TKN/NO ₃ | 10-20% | Low organic content Low moisture content (aerobic) Fluctuating water table | |
| | 2 | 2 | MILLHOPPER SAND Loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudults | Very deep, moderately well drained, moderately permeable soils that formed in thick beds of sandy and loamy marine sediments. Water table depth is 45-60" for 1-4 months and 60-72" for 2-4 months most years. | Moderate: wetness | TKN/NO ₃ | 10-20% | Low organic content Low moisture content (aerobic) Fluctuating water table | |
| | 2 | 2 | TAVARES FINE SAND Hyperthermic, uncoated Typic Quartzipsamments | Very deep, moderately well drained, rapidly permeable soils that formed in sand marine or eolian deposits. Zones of saturation at depths of 40-80". | Moderate: wetness | TKN/NO ₃ | 5-15% | Low organic content Low moisture content (aerobic) | |
| Somewhat Poorly / Poorly /Very Poorly | 1 | 1 | ADAMSVILLE FINE SAND Hyperthermic, uncoated Aquic Quartzipsamments | Very deep, somewhat poorly drained, rapidly permeable soils that formed in thick sandy marine sediments. Water table is at 20-40" for 2-6 months of most years and 10-20" for up two weeks in most years. It is within 60" for more than 9 months in most years. | Severe: wetness poor filter | TKN | 5-15% | Very low organic content below 4" Rapid permeability Fluctuating water table with aquic regime (anoxic) | |
| | | | | | | NO ₃ | 15-30% | | |
| | 1 | 1 | CASSIA FINE SAND Sandy, siliceous, hyperthermic Oxyaquic Alorthods | Very deep, somewhat poorly drained, moderately rapid permeable soils formed in sandy materials. Water table is at 18-42" for about 6 months during most years and will drop to >42" during the driest season. | Severe: wetness | TKN | 10-20% | Fine sand with shallow water table High organic content in spodic horizon at 2-3 ft. Fluctuating water table | |
| | | | | | | NO ₃ | 5-25% | | |
| | 1 | 1 | POMELLO FINE SAND Sandy, siliceous, hyperthermic Oxyaquic Alorthods | Very deep, moderately well to somewhat poorly drained soils, which are sandy to depths of >80" that formed in sandy marine sediments. Seasonally high water table is at depths of about 24-42" for 1-4 months during most years. | Severe: ponding poor filter | TKN | 10-40% | Freely draining Shallow, fluctuating water table at 2-3 ft Spodic horizon high in organic content at 3.5 ft | |
| | | | | | | NO ₃ | 10-50% | | |

| Drainage Class | Water Table Class 1=<3.5 ft 2=>3.5 ft | Organic Matter Class 1=<1.0% 2=>1.0% | Soil Series Taxonomy | Soil Series Description | NRCS "Suitability" Rating for Onsite Treatment | Applied Nitrogen | Estimated TN Removal Potential | Comments | Source Documents |
|--|---|--|--|---|--|------------------|---|---|------------------|
| Somewhat Poorly / Poorly / Very Poorly | 1 | 1 | ZOLFO FINE SAND Sandy, siliceous, hyperthermic Oxyaquic Alorthods | Very deep, somewhat poorly drained soils that form in thick beds of sandy marine deposits. Water table is at depths of 24-40" for 2-6 months of the year and up to 1024" deep for short periods. It is within 60" for more than 9 months most years. | Severe: wetness poor filter | TKN | 5-25% | Fine sand with shallow water table (2-3.5ft) Spodic horizon at 5-8 ft Fluctuating water table | |
| | | | | | | NO3 | 15-35% | | |
| | 1 | 2 | ANCLOTE SAND Sandy, siliceous, hyperthermic Typic Endoaquolls | Very deep, very poorly drained, rapidly permeable fine sandy soils in depressions, drainage way and floodplains. Water table is within 10" of the surface for 6 or more months during most years and rededes to >20" during the driest season. | Severe: ponding wetness poor filter | TKN | 5-20% | Very shallow water table (<1ft) High organic content in surface horizon | |
| | | | | | | NO3 | >75% | | |
| | 1 | 2 | BASINGER FINE SAND Siliceous, hyperthermic Spodic Psammaquents | Very deep, poorly drained and very poorly drained, rapidly permeable soils formed in sandy marine sediments. Found in sloughs, depressions, and low flats. Water table at depths of <12" 2-6 months annually and 12-30" for periods >6 months. Surface ponding is common. | Severe: wetness ponding poor filter | TKN | 5-20% | Very shallow fluctuating water table Very high organic content | |
| | | | | | | NO3 | >75% | | |
| | 1 | 2 | BRIGHTON MUCK Dysic, hyperthermic Typic Haplohemists | Very deep, very poorly drained, moderately rapid to rapidly permeable organic soils in depressions, freshwater marshes and swamps. Organic layer is >54" thick. Water table is above ground surface for 4-6 months. | Severe: subsides flooding wetness | TKN | 20-40% | Deep organic surface horizon Very shallow, fluctuating water table | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | CANOVA MUCK Fine-loamy, siliceous, superactive, hyperthermic Histic Glossaqualls | Very deep, very poorly drained, moderately slowly permeable fine sandy and loamy soils in depressions and fresh water swamps and marshes. They are formed in loamy marine sediments. Water table is at the surface or within 10" of the surface for more than 9 month during most years. The soil may be flooded for 36 months. | Severe: ponding | TKN | 20-40% | Very shallow water table (<1ft) High organic content in surface horizon and the Btg horizon at 32-43" | |
| | | | | | | NO3 | >90% | | |
| 1 | 2 | CHOBEE FINE SANDY LOAM Fine-loamy, siliceous, superactive, hyperthermic Typic Argiaquolls | Very deep, very poorly drained, slowly to vry slowly permeable soils in depressions, flats, and river flood plains that formed in thick beds of loamy marine sediments. Water table within 6" for 1-4 months of the year. | Severe: flooding wetness percs slowly | TKN | 10-30% | Very shallow water table High organic content in the surface horizon | | |
| | | | | | NO3 | >90% | | | |
| 1 | 2 | EAUGALLIE FINE SAND Sandy, siliceous, hyperthermic Alfic Alaquods | Deep or very deep, poorl or very poorly drained, slowly permeable soils in flats, sloughs, and depressionsthat were formed in sandy and loamy marine sediments. The water table rises to within 6-16" of the surface for periods of 1-4 months annually and within 40" for more than 6 months. | Severe: wetness | TKN | 20-40% | Shallow, fluctuating water table Moderately high organic content near surface in within a spodic horizon at depths >22" | | |
| | | | | | NO3 | >90% | | | |
| 1 | 2 | EMERALDA FINE SAND Fine, mixed, superactive, hyperthermic Mollic Albaqualls | Very deep, poorly drained, slowly or very slowly permeable fine sand to sandy clay soils in low areas near lakes and streams that were formed in clayey marine sediments. The water table is at depths of <10" for 6-9 months and saturated most of the year | Severe: flooding wetness percs slowly | TKN | 10-30% | Very shallow water table High organic content in the surface horizon | | |
| | | | | | NO3 | >90% | | | |

| Drainage Class | Water Table Class 1=<3.5 ft 2=>3.5 ft | Organic Matter Class 1=<1.0% 2=>1.0% | Soil Series Taxonomy | Soil Series Description | NRCS "Suitability" Rating for Onsite Treatment | Applied Nitrogen | Estimated TN Removal Potential | Comments | Source Documents |
|--|---|---|--|---|--|------------------|------------------------------------|---|------------------|
| Somewhat Poorly / Poorly / Very Poorly | 1 | 2 | FELDA FINE SAND Loamy, siliceous, superactive, hyperthermic Arenic Endoaqualfs | Very deep, poorly drained and very poorly drained, moderately permeable fine sandy soils in drainageways and depressions that formed in stratified, unconsolidated marine sands and clays. The water table is within 12" of the surface for 2-6 months each year. | Severe: ponding wetness poor filter | TKN | 10-30% | Very shallow water table Moderate to high organic content in the surface horizon | |
| | | | | | | NO3 | 40-60% | | |
| | 1 | 2 | GATOR MUCK Loamy, siliceous, euic, hyperthermic Terric Haplosaprists | Very poorly drained organic soils that formed in moderately thick beds of hydrophytic plant remains overlying beds of loamy and sandy marine sediments. These soils are always saturated at or above the surface except during extended droughts. | Severe: ponding percs slowly poor filter | TKN | 10-30% | Very shallow water table Low organic content below 34" | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | IMMOKALEE FINE SAND Sandy, siliceous, hyperthermic Arenic Alaquods | Deep and very deep, poorly drained and very poorly drained soils that formed in sandy marine sediments that occur in flintwoods and depressions. The water table is at depths of 6-18" for 1-4 months, 18-36" for 2-10 months and below 60" during dry periods. | Severe: wetness | TKN | 20-40% | Shallow, fluctuating water table Moderately high organic content near surface | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | MALABAR FINE SAND Loamy, siliceous, active, hyperthermic Grossarenic Endoaqualfs | Very deep, poorly to very poorly drained soils in sloughs, shallow depressions and along flood plains in sandy and loamy marine sediments. The water table is within depths of 10" for 2-6 months during most years. | Severe: wetness poor filter | TKN | 10-30% | Very shallow water table Low organic content | |
| | | | | | | NO3 | 40-60% | | |
| | 1 | 2 | MYAKKA FINE SAND Sandy, siliceous, hyperthermic Aeris Alaquods | Deep and very deep, poorly to very poorly drained soils formed in sandy marine deposit, which occur on flatwoods, flood plains, and depressions. The water table is at depths <18" for 1-4 month duration in most years and recedes to depths >40" during very dry seasons. | Severe: ponding wetness poor filter | TKN | 40-60% | Shallow, fluctuating water table Moderate organic content | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | NITTAW SANDY CLAY Fine, smectitic, hyperthermic Typic Argiaquolls | Very poorly drained, slowly permeable soils that formed in thick deposits of clayey sediments of marine origin, which occur in drainageways, swamps and marshes. They are subject to standing water above the soil surface for >6 months during late spring, summer and fall. | Severe: ponding percs slowly | TKN | 10-30% | Very shallow water table High organic content in O and A horizons but diminishing quickly with depth Soil permeability slow in the sandy clay below A horizon | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | OCOEE MUCK Sandy or sandy skeletal, siliceous, dysic, hyperthermic Terric Haplohemists | Deep, very poorly drained soils that formed in herbaceous organic material and sandy mineral material, which occur on flood plains, fresh water marshes, and depressions. | Severe: subsides flooding wetness | TKN | 5-20% | Very wet Deep O horizon from 0-38" | |
| | | | | | | NO3 | >90% | | |
| 1 | 2 | OKEELANTA MUCK Sandy or sandy skeletal, siliceous, euic, hyperthermic Terric Haplosaprists | Very deep, very poorly drained, rapidly permeable soils in large fresh water marshes and small depressional areas, which formed in decomposed hydrophytic non-woody organic material overlying sand. The water table is at depths of <10" below surface or ponded above surface. | Severe: flooding poor filter wetness | TKN | 5-20% | Very wet Deep O horizon from 0-31" | | |
| | | | | | NO3 | >90% | | | |

| Drainage Class | Water Table Class 1=<3.5 ft 2=>3.5 ft | Organic Matter Class 1=<1.0% 2=>1.0% | Soil Series Taxonomy | Soil Series Description | NRCS "Suitability" Rating for Onsite Treatment | Applied Nitrogen | Estimated TN Removal Potential | Comments | Source Documents |
|--|---|--|--|---|--|------------------|--------------------------------|---|------------------|
| Somewhat Poorly / Poorly / Very Poorly | 1 | 2 | ONA FINE SAND Sandy, siliceous, hyperthermic Typic Alaquods | Poorly drained, moderately permeable soils that formed in thick sand marine sediments, which occur in flatwood areas. The water table is at depths of 10-40" for periods of 4-6 months. It rises to depths of <10" for periods of 12 months and may recede to >40" during very dry seasons. | Severe: wetness poor filter | TKN | 10-30% | Shallow, fluctuating water table Moderate organic content above 20" | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | PLACID FINE SAND Sandy, siliceous, hyperthermic Typic Humaquepts | Very deep, very poorly drained, rapidly permeable soils on low flats, depressions, drainageways and flood plains. The soils formed in sandy marine sediments. The water table ranges in depths from 0-6" for >2 months in most years. | Severe: ponding wetness poor filter | TKN | 5-15% | Very shallow water table Moderately high organic content above 18" | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | POMPANO FINE SAND Siliceous, hyperthermic Typic Psammaquepts | Very deep, very poorly drained, rapidly permeable soils occurring in depressions, drainageways and broad flats. The soils were formed in thick beds of marine sands. The water table is at depths of >10" for 2-6 months each year and within depths of 30" for more than 9 months. | Severe: ponding poor filter | TKN | 5-15% | Very shallow, fluctuating water table Low organic content | |
| | | | | | | NO3 | 40-60% | | |
| | 1 | 2 | SAMSULA MUCK Sandy or sandy skeletal, siliceous, dysic, hyperthermic Terric Haplosaprists | Very deep, very poorly drained, rapidly permeable soils that formed in moderately thick beds of hydrophytic plant remains underlain by sandy marine sediments. They occur in swamps and flood plains. The water table is at or above the surface except during extended dry periods. | Severe: ponding poor filter | TKN | 5-15% | Very shallow water table Sapric soil materials from surface to 36" | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | SANIBEL FINE SAND Sandy, siliceous, hyperthermic Histic Humaquepts | Very poorly drained sandy soils with organic surfaces, that formed in rapidly permeable marine sediments, which occur on nearly level and depressional areas. The water table is <10" deep for 6-12 months and is above ground surface 2-6 months during wet seasons. | Severe: ponding poor filter | TKN | 5-15% | Very shallow water table High organic content in the O and A horizons to a depth of 10" | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | SEFFNER FINE SAND Sandy, siliceous, hyperthermic Aquic Humic Dystrudepts | Very deep, somewhat poorly drained, rapidly permeable soils on rims of depressions and on lower lying flats, which formed in sandy marine sediments. The water table is within depths of 18-42" for 2-4 months and within 60" for >9 months in most years. | Severe: wetness poor filter | TKN | 5-15% | Very shallow water table Moderate organic content to 20" | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | SMYRNA SAND Sandy, siliceous, hyperthermic Aeric Alaquods | Very deep, poorly to very poorly drained soils formed in thick deposits of sandy marine materials. The water table is at depths of >18" for 1-4 months and 1240" for more than 6 months | Severe: ponding poor filter | TKN | 20-40% | Shallow, fluctuating water table Moderate organic content to 35" | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | SPARR FINE SAND Loamy, siliceous, subactive, hyperthermic Grossarenic Paleudults | Very deep, somewhat poorly drained, moderate slowly to slowly permeable fine sandy soils on uplands. They formed in thick beds of sand and loamy marine sediments. The water table is at depths of 20-40" for 1-4 months. The water table is usually perch on the loamy layers. | Severe: ponding poor filter | TKN | 20-40% | Moderately shallow water table Low to moderate organic content | |
| | | | | | | NO3 | >90% | | |

| Drainage Class | Water Table Class 1=<3.5 ft 2=>3.5 ft | Organic Matter Class 1=<1.0% 2=>1.0% | Soil Series Taxonomy | Soil Series Description | NRCS "Suitability" Rating for Onsite Treatment | Applied Nitrogen | Estimated TN Removal Potential | Comments | Source Documents |
|--|---|--|--|---|--|------------------|--------------------------------|--|------------------|
| Somewhat Poorly / Poorly / Very Poorly | 1 | 2 | ST. JOHNS FINE SAND Sandy, siliceous, hyperthermic TypicAlaquods | Very deep, very poorly or poorly drained, moderately permeable soils on broad flats and depressional areas. These soils formed in sandy marine sediments. The water table is 0-15" below surface for 20-50% of the year but is at 15-30" during periods of low rainfall. | Severe: wetness | TKN | 20-40% | Shallow, fluctuating water table Spodic horizon with moderate organic content at 22-66" | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | WABASSO FINE SAND Sandy over loamy, siliceous, active, hyperthermic Alfic Alaquods | Deep or very deep, very poorly and poorly drained, very slowly and slowly permeable soils on flatwoods, flood plains, and depressions. They formed in sandy and loam marine sediments. The water table is at depths of 12-40" for more than 6 month and >40" during very dry seasons. | Severe: wetness poor filter | TKN | 20-40% | Moderately shallow, fluctuating water table Low to moderate organic content | |
| | | | | | | NO3 | >90% | | |
| | 1 | 2 | WAUBERG FINE SAND Loamy, siliceous, active, hyperthermic Arenic Albaqualfs | Poorly drained, very slowly permeable sandy soils that formed in thick beds of loamy marine sediments within large prairie areas and low areas within flatwoods. The water table is at depths of <10" for 3-5 months during most years. | Severe: wetness percs slowly | TKN | 5-15% | Very shallow water table Sandy clay loam restrictive horizon at 24" Low to moderate organic content to 24" | |
| | | | | | | NO3 | 40-60% | | |
| | 1 | 2 | WAUCHULA FINE SAND Sandy over loamy, siliceous, active hyperthermic Ultic Alaquods | Very deep, very poorly or poorly drained, moderately slow or slowly permeable soils formed in sandy and loamy marine sediments. The water table is at depths of 6-18" for 1-4 month and 10-40" for as long as 6 months but receding to depths of 40" during the driest season. | Severe: wetness poor filter | TKN | 5-15% | Shallow, fluctuating water table Low organic content | |
| | | | | | | NO3 | 40-60% | | |
| | 2 | 2 | LOCHLOOSA FINE SAND Loamy, siliceous, semiactive, hyperthermic Aquic Arenic Paleudults | Somewhat poorly drained, slowly permeable soils formed in thick beds of sandy and loamy marine sediments. The water table is at depths of 30-60" for 1-4 months and recedes to >60" during the drier seasons. | Severe: wetness | TKN | 20-40% | Moderately deep, fluctuating water table Low to moderate organic content | |
| | | | | | | NO3 | 40-60% | | |