# Nitrogen Impact of Onsite Sewage Treatment and Disposal Systems in the Wekiva Study Area



June 30, 2007

Ana M. Viamonte Ros, M.D., M.P.H.
Secretary, Department of Health

Charlie Crist
Governor

# Nitrogen Impact of Onsite Sewage Treatment and Disposal Systems in the Wekiva Study Area

June 30, 2007



Authors: Gerald R. Briggs, M.S., Eberhard Roeder, Ph.D., P.E., and Elke Ursin
Bureau of Onsite Sewage Programs, Division of Environmental Health
Florida Department of Health
4052 Bald Cypress Way, Bin A08
Tallahassee, Florida 32399-1713 Telephone (850) 245-4070
Web site: http://www.MyFloridaEH.com/

## TABLE OF CONTENTS



## TABLE OF FIGURES

## Executive Summary

In May of 2006 $250,000 from the funds in Specific Appropriation 566 was allotted to the Florida Department of Health to assess whether onsite sewage treatment and disposal systems (OSTDS) are a “significant source of nitrogen to the underlying groundwater relative to other sources” and to recommend a range of cost-effective nitrogen reduction strategies. The Department, with direction from the Research Review and Advisory Committee (RRAC), contracted for the assessment in three tasks.

The first task collected field data from groundwater around drainfields from three sites in the area. This task found high concentrations of nitrogen from all three systems. The second task determined which factors impact nitrogen loading from OSTDS to the groundwater. The results were generally consistent with the assumptions of March 2007 MACTEC Phase 1 report on sources of nitrogen in the Wekiva springshed.

The third task was to determine whether onsite systems are a significant source of nitrogen to groundwater relative to other sources. This determination utilized data from the second task and the MACTEC study to develop pie-charts of inputs to the environment and of loading to groundwater from all sources of nitrogen in the area. Fertilizer accounted for 78 percent of all inputs and 47 percent of all loadings. Inputs to the environment from onsite systems were estimated to be 6 to 8 percent of the total. The percentage of the total loading of nitrogen from onsite systems to the groundwater in the Wekiva Study area ranged from 25 to 28 percent.

The results of this study show that onsite sewage treatment and disposal systems are a significant contributor of nitrogen to the groundwater in the Wekiva Study Area. The load to groundwater by onsite systems is only surpassed by fertilizer. The results of the field work portion of this study demonstrate that nitrogen movement in the environment is complex, and relying only on the soil for treatment is not a reliable method to achieve the target load reductions. Instead consideration should be given to a program of increased pre-treatment of wastewater prior to being released to the environment and more intense management of onsite systems. The department recommends the following strategies:

- Implement an onsite wastewater management utility (EPA Model 4) in which operation, maintenance, and inspection of systems are the responsibility of a responsible maintenance entity instead of the individual homeowner and utilize the funds collected to assist with repairs and upgrades of onsite systems in the Wekiva Study Area, or connection to a wastewater treatment facility, or
- Require that all onsite systems be inspected and pumped every five years, and a report with a fee. Use a portion of the fee for a grant program to assist lower income homeowners with upgrades.
- Require mandatory inspections of onsite systems during real estate transactions, unless inspected with satisfactory results during the previous five years.
- Amend Chapter 64E-6, Florida Administrative Code, to require all systems in need of repair or modification be upgraded to new system construction standards.
- Require that all new onsite systems in the Wekiva Study Area be performance based treatment systems providing nitrogen reduction pretreatment to 10 mg/L or 70% reduction.
- Create an inventory of all onsite systems in the Wekiva Area that can be maintained in cooperation between county health departments and county property appraisers.

## Introduction

This report was prepared for the Governor, President of the Senate, and Speaker of the House in accordance with the following provisos language in the 2006 Appropriations Act:

> From the funds in Specific Appropriation 566, $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.

Onsite Sewage Treatment and Disposal Systems (OSTDS) are an acceptable alternative to centralized wastewater treatment systems in the state of Florida. These systems are regulated by the Department of Health to ensure that they will be permitted and installed so as not to be detrimental to human health, or the health of the environment. Approximately 1/3 of the population of Florida is served by OSTDS. Onsite systems are one of the largest artificial groundwater recharge sources in the state, and approximately 93% of our drinking water comes from the groundwater.

Nitrogen is a common element that occurs in different forms in our environment, chiefly nitrate, ammonia, organic nitrogen, and relatively inert nitrogen gas. A brief review of the fate of nitrogen in the environment is given in the report of task 2 (Appendix B). Too much nitrogen in an aquatic system can cause ecological changes such as excessive algae growth which can in turn kill fish and other aquatic life. Too much nitrate in drinking water causes health effects, particularly in children. Conventional onsite systems generate approximately 20 pounds of nitrogen per year, which equates to about four bags of 10-10-10 fertilizer.

Much of Florida's geology is characterized by the presence of karst features, which is limestone that has been partially dissolved to create sinkholes, cracks, and caves. These features are pathways for groundwater to enter the aquifer.

Springs contribute 64% of the base flow for the Wekiva River as a 2003 report by the Florida Department of Environmental Protection (FDEP) determined. This spring flow mainly comes from the Floridan Aquifer. To quantify the vulnerability for contamination of the Floridan Aquifer in the state of Florida, the Florida Geological Survey (FGS) developed a geographic information system (GIS) map that considers karst features, confining layer thickness and soil permeability, and pressure difference between the surficial and Floridan Aquifer. This map is known as the FAVA (Floridan Aquifer Vulnerability Assessment). In 2004, the FGS developed a refined map specific to the Wekiva area, which is also known as the Wekiva Aquifer Vulnerability Assessment (WAVA). This map shows three different levels of concern: primary (more vulnerable), secondary (vulnerable), and tertiary (less vulnerable). The areas with very well drained soils generally are in the primary areas and reflect how quick a drop of water from the surface can make it down to the aquifer.

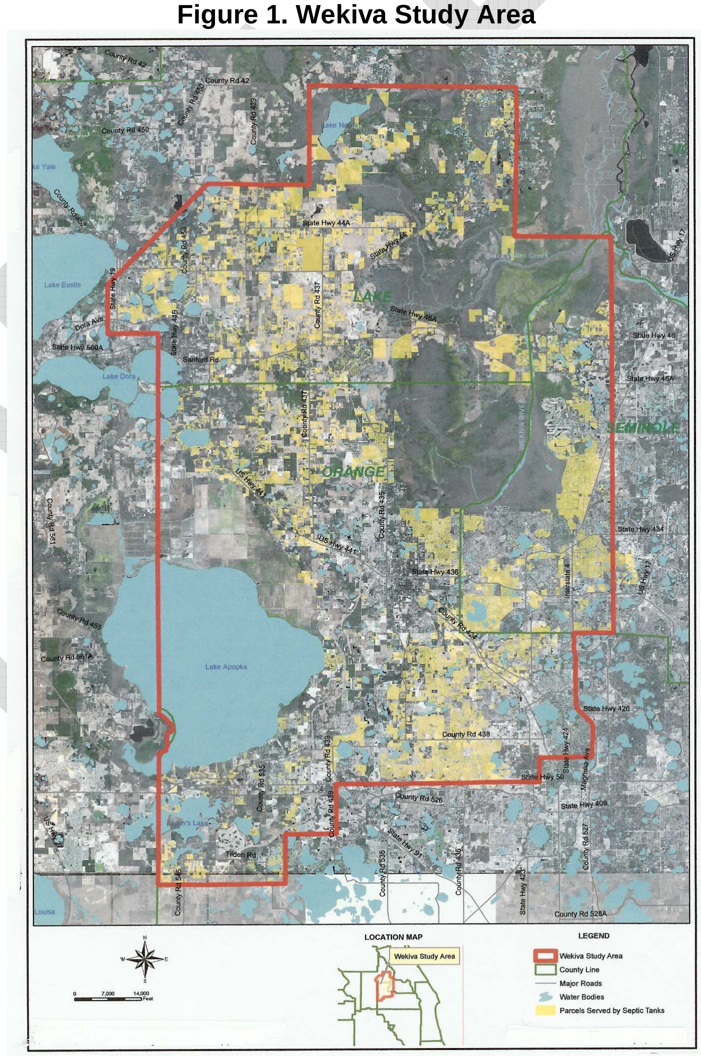
The Wekiva River, located in central Florida, is designated an Outstanding Florida Water, a State Canoe Trail, and has recently been added to the federal Wild and Scenic Rivers program. The majority of the source water for this river is from Wekiwa Springs and Rock Springs.

## BACKGROUND

In June of 2004, the Wekiva Parkway and Protection Act was signed into law, linking the relationship between development of the Wekiva Parkway, which is the final leg of the beltway surrounding greater Orlando, and the preservation of the Wekiva River System. This act was a regional collaborative approach. Each agency was tasked to look at their specific issues and report their outcomes to the Wekiva River Basin Commission, which was established to ensure implementation of the legislation.

The Wekiva Study Area (WSA) consists of approximately 304,000 acres that spans parts of Lake, Orange, and Seminole counties in central Florida. This study area incorporates data from various contributing sources to the Wekiva River System to define a boundary and can be seen in Figure 1.

**Figure 1. Wekiva Study Area**



The Florida Department of Health was tasked to study the how effective current onsite system standards are at achieving nitrogen reductions that will protect groundwater quality. The department reviewed past research projects done throughout the state of Florida. These results indicated that properly sited and constructed conventional onsite sewage systems work very well at removing disease-causing viruses, bacteria, and pathogens; but that they are less effective at removing nutrients such as nitrogen. This is especially true in karst environments like the Wekiva Study Area, as a recently completed study at Manatee Springs indicated.

**2006 Study Approach Task Summaries**

The 2006 study approach was developed through several public meetings of the department's Research Review and Advisory Committee (RRAC), incorporating industry expert opinions as well as ideas from the general public. The project was split into four tasks.

The first task and core element was a detailed field sampling (Appendix A) within the Wekiva Study Area (WSA) to determine the amount of nitrogen that makes it to groundwater from a septic tank. The question that the field work portion of the Wekiva project addressed was how much nitrogen makes it to the groundwater. This was accomplished by analyzing samples taken underneath a drainfield at the capillary fringe and in the shallow groundwater. Three onsite systems serving single-family residences were assessed. Each site location was within the boundaries of the WSA and chosen based on a comprehensive list of criteria that RRAC developed. Some of these criteria included being able to reach the actual water table with the equipment, choosing a location within each of the three affected counties, having a public water supply, and having a larger lot size to allow for identification of the wastewater plume. Samples were also taken to characterize the effluent plume as it moves away from the onsite system. The field work was designed to give a better understanding of what one onsite system in the WSA contributes to the groundwater and whether this contribution is different from literature values.

A second task (Appendix B) of the project reviewed applicable literature to refine the loading estimate from onsite systems. This task developed a classification system to incorporate the influence of soil conditions (e.g. drainage class, depth to saturated zone, and soil organic content) and wastewater characteristics (applied nitrogen species) on nitrogen loading to the groundwater. The study resulted in a range of estimated fractions of nitrogen removal as a function of soil characteristics and system type.

In a third task (Appendix C), this refined loading estimate for onsite systems was integrated with the loading estimates from other sources (wastewater treatment facilities, residential fertilizers, commercial fertilizers, etc.). Estimates for other sources were based on a recent study for the Florida Department of Environmental Protection and St. Johns River Management District (Tucker et. al. 2007) for the combined springsheds and river basins that contribute water to the Wekiva River. The result was an estimate of which fraction of overall nitrogen applied near the land surface stemmed from onsite systems, and what fraction of nitrogen loading to the groundwater stemmed from onsite systems.

The fourth task (Appendix D) consisted of the development and discussion of a range of cost-effective solutions for consideration if contributions of nitrogen from onsite systems are found to be significant. RRAC advised the department staff to perform this task.

**Task 1: Multiple Nitrogen Loading Assessments from Onsite Waste Treatment and Disposal Systems within the Wekiva River Basin**

The first task was to collect Wekiva Study Area specific field data from groundwater around drainfields. The criteria for site selection, as determined by the Research Review and Advisory Committee included one site in each county, reachable water table for sampling, variety of water table conditions, system age, lot size, minimum use of fertilizer, no use of reclaimed water for irrigation, public water, and single family residential. Three sites were selected that fully met the criteria with the exception of the Lake County site having an onsite well, which was metered during the study period.

The department obtained several existing geographic information system (GIS) data files which included information on parcels, subdivisions, Wekiva Aquiver Vulnerability Assessment, sewer connections, onsite systems, soil maps, and depth to groundwater. These were combined in a GIS project, used by the department to provide a list of potential subdivisions with lots meeting the selection criteria, and given to the provider (Ellis & Associates, Inc.) The provider contacted residents within these subdivisions to solicit volunteers. The estimates from the GIS data were field verified.

The sites were sampled extensively, with the results given in Appendix A. Piezometers were used to measure the groundwater levels and to help select suitable background sampling locations. Direct push technology was used to measure the groundwater quality to identify the wastewater plume both vertically and horizontally. This helped to show how groundwater that has been influenced by wastewater behaved as it moved down-gradient from the source. The effluent in the septic tanks at the three sites that were investigated had concentrations of nitrogen that fell within the expected range. The mass of total nitrogen that flows daily into the drainfield was larger than previously estimated for the Seminole and Lake county sites, and within the expected range for the Orange County site.

Ellis & Associates, Inc. performed mass loading calculations based on observed nitrogen concentrations. These calculations indicated that some nitrogen removal, presumably due to nitrification/denitrification, is taking place. Previous reviews of the literature have indicated that about 50 – 90% of the total nitrogen leaving the onsite system reach the groundwater as nitrogen load. The Seminole County site was estimated to load 68%, or 9.7 pounds of total nitrogen (TN)/person/year, with 32% being removed. The Lake County site was estimated to load 48%, or 7.1 pounds TN/person/year, with 52% being removed. The Orange County site was estimated to load between 54 - 77%, or between 4.0 – 5.6 pounds TN/person/year, with between 23 - 46% being removed.

In summary, between half and three quarters of the nitrogen from the onsite system was found in the shallow groundwater. The field results allow an estimate of what nitrogen load comes from a typical onsite system in the Wekiva Study Area. Using the Lake County as an intermediate case and an average of 2.6 people living in a home, the yearly load of nitrogen is about 18 lbs of nitrogen.

**Task 2: Categorization and Quantification of Nitrogen Loading from OSTDS Types**

The purpose of this task was to determine which categories are important to look at to determine loading from onsite wastewater systems to the groundwater in the Wekiva Study

Area.  Two performance boundaries were considered: the end of the last treatment system component prior to discharge to the drainfield, and at the groundwater boundary after the wastewater has passed through the unsaturated zone of the soil.

Otis Environmental Consultants, LLC, developed a table, utilizing existing literature data, which outlines the various soil series found in the Wekiva Study Area.  This table included the soil's drainage class, the depth to saturated conditions, and the availability of organic materials.  The drainage capacity of the soil can be related to how permeable the soil is, and how long the soil is likely to remain unsaturated.  The drainage classes were subdivided into excessively/somewhat excessively drained, well drained, moderately well drained, and somewhat poorly/poorly/very poorly drained.  Soils that are saturated do not allow for air to get to the wastewater, which does not allow it to convert from the organic and ammonia forms to the nitrate form.  The depth to saturated conditions was split into two categories: less than 3.5 feet and greater than 3.5 feet.  The more organic material is available to the wastewater, the more likely the nitrate will denitrify.  The table quantified whether the amount of organic matter was greater than or less than one percent in the soil.  The potential for denitrification distinguished if what was discharged to the soil was in the organic and ammonia forms or the nitrate form of nitrogen.   The estimated total nitrogen removal potential for each of the listed soil series was calculated with this information.

The amount of nitrogen that eventually makes it to the groundwater is dependant on the amount of nitrogen that enters the drainfield.  There are two factors that influence the nitrogen entering the drainfield: the raw wastewater and whether there is additional treatment beyond a septic tank.  Approximately 80% of the nitrogen from raw domestic wastewater comes from toilet wastes.  An additional treatment step such as a specialized aerobic treatment unit, would convert the nitrogen from the ammonia form to the nitrate form.  If the drainfield and underlying soils are sufficiently wet and contain organic matter, then the nitrate in wastewater can more readily be converted to nitrogen gas.

Soils that have a very deep water table contribute to very little denitrification due to organic matter being oxidized before it makes it to the groundwater.  The wastewater will also not be nitrified well in soils that have a very shallow water table and when the drainfield does not have a minimum of two feet separation from the estimated seasonal high water table.  If the soil goes through intermittent periods of wetness and drying, there is a greater potential for denitrification.  The soils found to have the greatest potential for denitrification were found to be moderately well drained to very poorly drained soils that have a fine loamy texture with clay fines, a shallow water table, and have some organic matter present deeper in the soil profile.  If the estimated seasonal high water table is at 3.5 feet below grade or greater, and a two foot separation is maintained from the bottom of the drainfield to the estimated seasonal high water table, this distance is expected to be sufficient for nearly complete nitrification of the nitrogen in the applied wastewater.

The design of the drainfield also plays an important role in converting the nitrogen.  Both the O-horizon and the A-horizon of soils have a high level of organic matter.  A subsurface system is installed below this horizon and does not gain the benefits of these layers.  At-grade and mound systems could possibly utilize this organic matter, but the *Florida Administrative Code* currently requires the removal of the O-horizon and any severely limited soils to allow the wastewater to drain.

The resulting table given in Appendix B lists the estimated denitrification potential of the soils found in the Wekiva Study Area.  A range of removal potentials are given.  The estimated total nitrogen removal potential ranged from 0 to 100 percent removal, depending on the soil series, with a median value ranging from 10 to 30 percent removal.

**Task 3: Assessment of Contributions of Onsite Sewage Treatment and Disposal Systems Relative to Other Sources**

The third task was to determine whether onsite systems are a significant source of nitrogen to groundwater relative to other sources. The provider (Dr. Young of the University of Florida) first determined which categories would be of importance to illustrate the factors that influence nitrogen input and loading to the groundwater. She then worked in coordination with Dr. Otis to determine the selected categories which are drainage class, water table class, organic matter class, soil series taxonomy, applied nitrogen, and estimated total nitrogen removal potential.

Next, Dr. Young utilized existing GIS data to count the number of septic systems in each category. Once that had been completed, calculations were done to estimate the nitrogen coming from each category to the environment (as an input) and to the groundwater (as a loading). Inputs are assumed to be released to the environment, and loadings are assumed to be the portion of the nitrogen inputs that makes it to the groundwaters and the surface waters of the Wekiva Study Area.

Dr. Young coordinated with MACTEC, a consultant for the St. Johns River Water Management District, who was tasked to identify and quantify sources of nitrogen loading in the Wekiva River Basin. The project MACTEC was working on was in response to a study tasked by the Florida Legislature to the Florida Department of Environmental Protection (FDEP) to determine the sources and loads of nitrogen in the Wekiva River Basin. The Wekiva River Basin has a different boundary than the Wekiva Study Area, so all of the estimates from MACTEC were adjusted. The MACTEC report (Tucker et. al. 2007) considered nitrates in their estimates for all of the sources except for septic systems, in which total nitrogen was considered and fertilizer inputs. The input sources included direct application of fertilizer, livestock waste, atmospheric deposition, and effluents from centralized wastewater facilities and onsite wastewater systems. The loading sources were defined as groundwater recharge, atmospheric deposition, centralized wastewater facilities, storm water, and septic systems. The recharge to groundwater was assumed to consist of inputs from fertilizer, livestock, and natural sources. The loading from centralized wastewater facilities and storm water were separated into the loading to surface waters and the loading to the groundwater. The same methods were used in these calculations as were used in the MACTEC report, with the exception of onsite wastewater systems, which utilized the methods described in the second task of the Wekiva Onsite Wastewater Nitrogen Contribution study. Finally, the provider determined the relative contribution of onsite systems to nitrogen loading to groundwater in the Wekiva Study Area, and determined that this loading is substantial.

This process lead to the following results: a pie-chart that outlines the percentage of inputs to the environment (Figure 2) and a pie-chart for the loading to the groundwater (Figure 3) for all sources of nitrogen in the Wekiva Study Area. A range of contributions was considered for the loading estimates of nitrogen to the groundwater. This range accounted for the range of nitrogen removal in each soil series. Fertilizer was found to account for 78 percent of all inputs, and 45 to 47 percent of all loadings. Inputs to the environment from onsite systems were found to constitute 6 to 8 percent of the total. The percentage of the total loading of nitrogen from onsite systems to the groundwater in the Wekiva Study area was found to range from 25 to 28 percent.

**Figure 2. Nitrate[1] Inputs to Wekiva Study Area by Source**

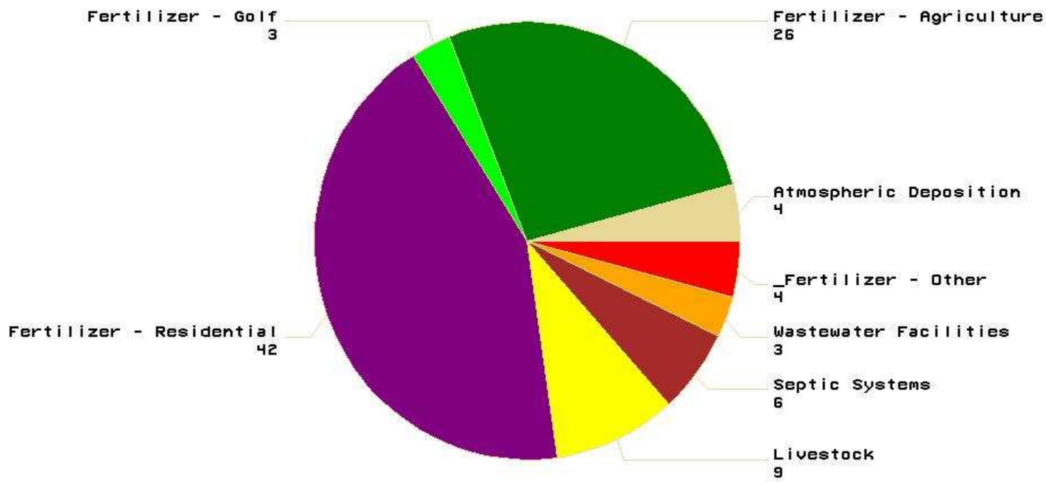
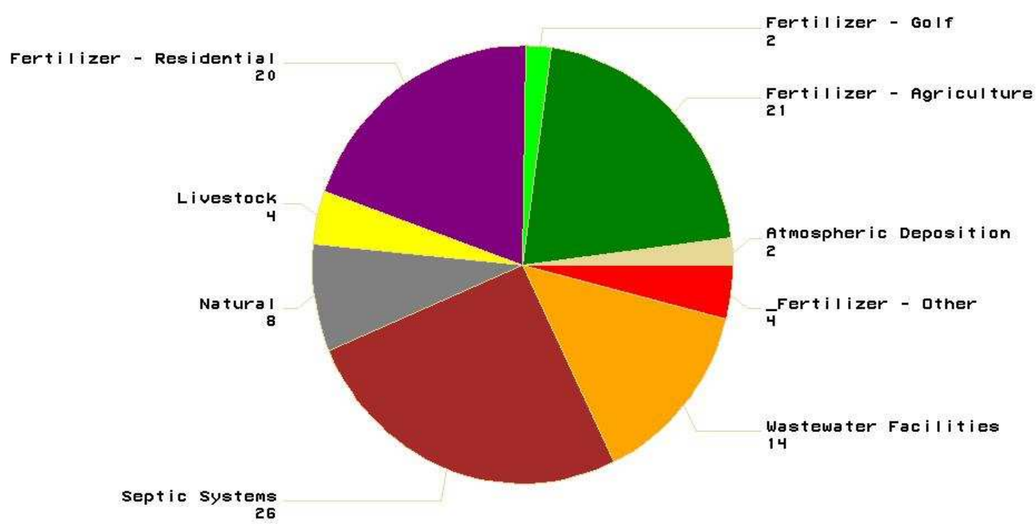



**Figure 3. Nitrate[1] Groundwater Loadings to the Wekiva Study Area by Source and Using Median Estimates for Onsite Systems**




[1] The input from onsite systems is total nitrogen, which includes nitrates.

**Task 4: A Range of Cost-Effective Strategies for Nitrogen Removal**

The department was charged to "recommend a range of possible cost-effective OWTS nitrogen reduction strategies if contributions are significant" as part of this study. The Research Review and Advisory Committee meeting discussions raised the issue whether this task would be approached before or after results of the other tasks were complete. When it became clear that the results of the other tasks would only be available close to the report deadline, and when the budget provided by the legislature was completely allocated to the field work and contribution assessments, RRAC recommended that department staff work on this task. The results of staff efforts on this task are provided in Appendix D of this report.

A comprehensive onsite sewage treatment and disposal program has to address nitrogen pollution where the contributions of onsite systems are significant in pursuit of the Florida Legislature's intent that, "the installation and use of onsite sewage treatment and disposal systems not adversely affect the public health or significantly degrade the groundwater or surface water." (381.0065(1), *Florida Statutes*) A range of strategies are proposed that complement each other in order to reduce nitrogen inputs and loads in the Wekiva Study Area,

The development of funding mechanisms to select the most cost-effective nitrogen reduction projects in the Wekiva Study Area is of critical importance. Two mechanisms are suggested. The first mechanism is a grant program to solicit cost-effective nitrogen reduction projects from any source in the Wekiva Study Area, funded by payments from dischargers of nitrogen such as onsite system owners. The discharge fee could be oriented on costs to remove the next few pounds of nitrogen. This mechanism would allow for continued monitoring of the increasing costs as the loading is reduced toward the target level to meet spring water-quality standards, which would allow for an adjustment of fees. The second mechanism consists of wastewater management entities that are funded by all onsite system owners to reduce the nitrogen load from onsite systems. These entities will be in a position to select the most cost-effective wastewater nitrogen reduction projects to address nitrogen in their service area. Both of these mechanisms could be combined to increase the rate at which nitrogen reduction projects are implemented, in order to eventually reach the pollution reduction goal. Costs to the system owners will depend on the extent and speed of nitrogen reduction. Estimates given in section two of Appendix D suggest about $60 per year and system initially for a grant program, and about $200 per year and system for a program of upgrading failing systems to nitrogen reduction.

In the context of a growing region, not increasing loads by onsite systems to the Wekiva Study Area will be an important program goal. This requires that new systems achieve nitrogen reduction, and that existing systems achieve some reduction, with an average total reduction of 40-50%. An analysis in section 5 of Appendix 4 for new systems indicates that given a choice of treatment standards that result in 30%, 60% or 70% reduction of nitrogen load, the average installation cost per pound removed is lowest for the 70% standard. Upgrades to existing or failing systems that can reuse either the tank or the drainfield, provide cost advantages, but the cost-effectiveness of upgrading to the 70% standard is very similar as for new construction.

Wastewater management entities can provide grants or loans to support repairs of failing systems and upgrades to new standards. While outside grants and loans can and should support such programs, pooling of the resources within the service area could move such a program forward even in the absence of outside support. These entities, either existing utilities, newly formed onsite wastewater management providers, or county health departments in an expanded role could be funded by an onsite system fee, which would cover costs of this function as well as periodic monitoring, inspection, and inventory of onsite systems.

A key element of a comprehensive onsite sewage program should be an inventory of all onsite systems. This takes on particular importance in the Wekiva Study Area because a large fraction of onsite systems were originally installed before current rules were in effect, with older systems being more likely not to have an adequate separation to the water table. In contrast the field work of Task 1 has focused on systems that were installed since current rules were substantially in effect. Lower separations to the water table will generally lead to less nitrogen reduction before reaching the groundwater and to higher loads of pathogen indicators and pathogens. An inventory program, either as a periodic inspection requirement, a point-of-sale inspection requirement, or a special project by the wastewater management-entity will provide more complete information about the current status of onsite sewage treatment and disposal systems.

Continued evaluation of watershed impacts by onsite sewage treatment and disposal systems, as well as the functioning and performance of individual systems or types of system, is recommended to collect information that can be used to adapt the nitrogen reduction program as needed.

**Conclusions**

Onsite sewage treatment and disposal systems are a significant source of nitrogen loading to the groundwater within the Wekiva Study area. The FDEP report and the attached FDOH task reports provide details on input and loading. Input is the term used here to describe the total amount of nitrogen going into the area, whereas loading is the term used here to describe that portion of the nitrogen input which reaches waters of the area. Only a portion of the nitrogen 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 large portion of nitrate applied as land fertilizer is used by plants in the root zone. Denitrification converts nitrate to nitrogen gas, which is released to the atmosphere. The nitrate or, in the case of septic systems, total nitrogen delivered to waters of the Wekiva Basin is referred to as loading.

There is consensus that the input from onsite systems should be based on the number of systems, average number of persons per household (2.6), and an average input of nitrogen per person per day. The amount of nitrogen per person is variable. The assumptions utilized by MACTEC and Dr. Otis resulted in an estimate of about 20 pounds per year per onsite system. The field work of Task 1 found a nitrogen input at two of the three sites that was higher than this estimate. Using the 20 pounds per year assumption, the total nitrogen input to the Wekiva Study Area is estimated to be 454 metric tons (MT)/year, representing 6 percent of the nitrogen input to the Wekiva Study Area.

However, when adjustments are made for groundwater loading from nitrogen sources, onsite systems are dramatically highlighted as a source of concern. 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 depends on soil drainage, water level class, organic matter class, and soil series (Task 3: Appendix A). For poorly drained soils, the fraction removed depends on the form of applied nitrogen.. Which form of nitrogen is appropriate depends upon septic system type. Using this information, the low, medium, and high estimates of groundwater nitrogen loadings due to septic systems for each soil series were calculated (Task 3: 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. The medium estimated amount of groundwater loading from onsite systems was calculated to represent 26 percent of the nitrogen loading in the area.

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 most of the nitrogen contribution by onsite systems is expected to be in the nitrate form as observed in two out of three field study sites. 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. Any solution to nitrogen loading in the area must address all sources, but most critically the issue of fertilizer.

Out of necessity, input and load assessments over such a large area require assumptions about what are typical contributions by any particular source type. The department's Wekiva study has complemented the desk-top assessment of inputs and loadings by MACTEC with field work (Task 1) and more detailed loading assumptions that incorporate soil variability into the loading estimates for onsite systems (Task 2 and Task 3). The more detailed assumptions result in a medium average load per system of 15 pounds per year, which is roughly the same as the 14 pounds per year assumed by MACTEC. The field work found definite nitrogen plumes stemming from onsite systems. Nitrogen concentrations in these plumes were far in excess of background concentrations that were likely affected by fertilizer use and atmospheric deposition. This supports the assumption that inputs from fertilizer and atmospheric deposition are more effectively reduced in soils than inputs from onsite systems. Atmospheric deposition was found overall to be such a small input, that minor changes in concentrations do not affect the larger picture.

Nitrogen impacts on springs are determined by the amount of nitrogen that arrives at the spring via groundwater. For this reason, loading to groundwater is seen as a better indicator of the relative importance of contributions than inputs.

The nitrogen load from onsite systems is a load that can be reduced significantly as demonstrated by a department research project in the Florida Keys. To reach the goal of reducing nitrogen levels to the levels required by the total maximum daily load, onsite systems, as well as all sources, particularly fertilizer, must be addressed. In addition to performance based treatment systems (PBTS) that reduce the nitrogen load before discharge to the drainfield, older systems, many of which may be in the wet season water table, can also be improved by providing two feet of unsaturated soil beneath the drainfield. Upgrading all existing systems to PBTS providing nitrogen reduction will further reduce the load. Due to the wide variations of factors that impact the effectiveness of nitrogen removal in the soil and the aquifer vulnerability, pre-treatment before discharge is the only reliable option. Routine inspections and maintenance are also critical to ensuring the satisfactory operation of onsite systems.

A large concern in the Wekiva Study Area has been initial installation cost. It is apparent that the largest increase in installation cost stems from the change from a passive system to a mechanical aeration system. Further treatment, excepting carbon additions, requires little additional cost under current market conditions. Consequently, the incremental cost to go beyond an ATU standard to a performance standard of 20 mg/L or 10 mg/L is low. Due to the variety of field conditions which may be encountered, installation costs can only be estimated to range roughly between $12,000 and $14,000 for a 400 gallon-per-day residential system. In addition to installation costs, there are ongoing maintenance and operating costs. These higher-performing systems require a maintenance contract and an operating permit. In addition, they require electricity either for pumping air into water or water through air.

**Recommendations**

The department is tasked by the 2006 legislative appropriation to recommend a range of possible cost-effective OWTS nitrogen reduction strategies if contributions are significant. Based on the conclusion that onsite systems are a significant nitrogen contributor, the department has developed a range of options (Task 4) and makes the following recommendations from those options:

**Nitrate Treatment Levels** – The department recommends a pretreatment discharge limit of 10 milligrams per liter of total nitrogen for new systems, systems being modified, and for existing systems in the Wekiva Study Area. This treatment level would achieve at least 70% reduction of nitrogen inputs from that onsite system. This level of treatment has been shown to be achievable through existing wastewater treatment technologies and would reduce the levels of nitrogen introduced to the environment by onsite sewage treatment and disposal systems by approximately 75 percent. Any plan for net reductions in nitrogen loading has to consider additional loading due to growth. While requiring upgrades in repair permits provide an avenue to reduce the impact of existing systems, new systems, even if installed to higher performance standards, add additional load. For the three counties, the five-year average numbers of repairs and newly permitted systems for fiscal years between 2000 and 2005 were determined from the department's county summary data. In order for nitrogen loading from OWTS to remain constant in the three counties a nitrogen reduction by about 41% is necessary for both new and repaired systems.

The department recommends that to protect the aquifer confining layer, the practice of removing severely limited soil layers (dig-outs) be prohibited in the entire study area.

The department recommends the prohibition of the land spreading of septage and grease trap waste in the study area. Septage waste would be required to be disposed of at wastewater treatment plants.

The department recommends that state and local planning agencies evaluate the economic feasibility of sewering versus nutrient removal upgrades to existing onsite sewage treatment and disposal systems. Areas with high densities of development will be better suited to central sewering, and lower density areas more suitable for nitrogen removing onsite sewage treatment and disposal systems. Since environmental and public health protection can be achieved by both options, sewage disposal costs should be the determining factor as to which disposal method is used. Existing systems in the WAVA primary and secondary protection areas should not be required to upgrade to the 10 milligram per liter nitrogen limit if central sewer will be made available by 2013.

**Upgrading Existing Systems** – The department recommends that existing systems located in the Wekiva Study Area be upgraded to meet new system standards**.** The upgrades should be phased in through the department's normally existing system repair and modification permitting process. In addition, systems should be inspected and upgraded in conjunction with real estate transactions.

Recommend that the legislature require mandatory inspections of onsite sewage treatment and disposal systems during real estate transactions. Systems found in failure or not in compliance with current separations to wet season water table or surface water setbacks or receptacles that are not watertight should be required to upgrade to current standards. The seller should be required to provide notification of this requirement and a copy of an inspection report for the system within the five years preceding the sale.

Recommend the department amend its rules to require that all existing systems requiring repair or modification meet current separations, setbacks, and system sizing. Current repair standards are less stringent than new standards. The year of the original installation determines the permitting requirements with regard to the septic tank capacity, drainfield size, separations and setbacks. All tanks should be assessed during the permitting process for watertightness and replaced where necessary. These changes should apply statewide.

**Establishment of a Maintenance Program** – Recommend the Florida Legislature consider adoption of one of the following requirements:

1. Implementation of U.S. Environmental Protection Agency Model 4, The Responsible Maintenance Entity (RME) Operation and Maintenance Model, for the Wekiva Study Area and other sensitive environmental areas in the State of Florida. Wastewater utilities or local governments would be authorized to collect a wastewater service fee from all developed properties in their service areas. For owners of onsite sewage treatment and disposal systems, the fee would be used to provide routine maintenance, repairs, mandated upgrades, or connection to sewer. The fee for onsite system owners would be assessed as if they were connected to sewer. These programs should take the privatization approach to the maintenance of onsite sewage treatment and disposal systems. Under this approach existing registered septic tank contractors, licensed plumbers, or licensed wastewater treatment plant operators would be contracted with for inspection and maintenance services. At a minimum, all systems should be inspected and pumped every five years. A similar program has recently been established in Maryland to protect the Chesapeake Bay. To lower nitrogen contributions, all households are assessed $30/year. For households served by central sewer, this money will be used to fund upgrades to wastewater treatment plants. Of the funds generated by households served by onsite sewage treatment and disposal systems funding can be awarded for agency projects of upgrades, repairs of individual failing systems, and individual upgrades to at least 50% nitrogen reduction.

2. Requirement for all onsite sewage treatment and disposal systems to be inspected and pumped out every five years to ensure the system's compliance with 381.0065, *Florida Statutes* and rules adopted under that section. Inspections should be conducted by a septic tank contractor licensed under part III of chapter 489. The contractor should be required to furnish the system owner with an inspection report and to file a copy with the Department of Health with an appropriate filing fee. The department should be required to adopt by rule the elements of

the inspection, the form for the report, and the filing fee. A portion of the filing fee should be used to fund and administer a grant program to assist owners of onsite sewage treatment and disposal systems to repair or upgrade a system serving a single-family, owner occupied, residence. Owners with an income equal to or less than 200 percent of the federal poverty level at the time of application would be eligible for a grant. The department should be required to adopt rules establishing the grant application and award process. The amount of the grant should be limited to the cost differential between replacement of the existing system and the upgrade. The grant should be in the form of a rebate to the owner for costs incurred in complying with requirements for onsite sewage treatment and disposal systems. The department is recommending this be a statewide mandate since the issues raised here are not unique to the Wekiva Study Area.

## References

1. FDEP. 2003. Basin Status Report. Middle St. Johns. Report prepared by the Florida Department of Environmental Protection, Tallahassee, FL. 345 pp. Available at: www.dep.state.fl.us/water/basin411/sj_middle/index.htm
2. Mattson, Robert A., Edgar F. Lowe, Ph.D., Carol L. Lippincott, Ph.D., Jian Di, Larry Battoe, Ph.D. 2006. Wekiva River and Rock Springs Run Pollutant Load Reduction Goals: Report to the Florida Department of Environmental Protection by the St. Johns River Water Management District, Palatka, FL. 70 pp. Available at: http://sjrwmd.org/programs/acq_restoration/s_water/msjr/pdfs/Wekiva_PLRG_Report_wo-appendices.pdf
3. Tucker, William A., Ph.D., Mark Diblin, PG. 2007. "Phase 1 Report Wekiva River Basin Nitrate Sourcing Study." March 2007. Prepared by MACTEC, Newberry, FL. MACTEC Project No. 6063060079 Available at: http://www.dep.state.fl.us/water/waterprojectfunding/2007/wekiva_nitrate_sourcing.htm

## Appendix

A. Task 1: Multiple Nitrogen Loading Assessments from Onsite Waste Treatment and Disposal Systems within the Wekiva River Basin

B. Task 2: Estimates of Nitrogen Loadings to Groundwater from Onsite Wastewater Treatment Systems in the Wekiva Study Area

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

D. Task 4: A Range of Cost-Effective Strategies for Nitrogen Removal