A Range of Cost-Effective Strategies
for
Reducing Nitrogen Contributions
from
Onsite Sewage Treatment and Disposal Systems

Task 4 of the 2006/2007 Wekiva Study
by the Florida Department of Health

June 27, 2007

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1 Introduction

This appendix of the 2007 Wekiva Study Report suggests a range of strategies that can be employed as a part of a comprehensive onsite sewage treatment and disposal system management program to reduce their particular nitrogen contributions and generally their environmental impact in the Wekiva Study Area, in the event that onsite sewage treatment and disposal systems are found to be significant relative to other sources. For the purposes of the following, onsite sewage treatment and disposal systems (OSTDS) or onsite systems are those systems that are regulated by the Florida Department of Health, which generally do not transport wastewater beyond the property before treatment. Centralized wastewater treatment systems are those treatment facilities that are regulated by the Florida Department of Environmental Protection, which generally involve collection and transport of wastewater to a central location for treatment and disposal. Either transport or treatment approach can be managed by a management entity, which can take on different legal forms.

The strategies discussed here address different aspects of the life-cycle of onsite systems. Building on the voluntary onsite management guidelines published by EPA (2003, 2005b), the strategies are separated into strategy elements that cover administration, installation and operation and compliance of such systems.

In order to reduce nitrogen inputs and loads in the Wekiva Study Area, a range of strategies are proposed that together:

- Provide funding mechanisms to select the most cost-effective nitrogen reduction projects in the Wekiva Study Area
- Hold the line on nitrogen loadings from onsite sewage treatment and disposal systems or achieve slight reductions by increasing the percentage of nitrogen-reducing onsite sewage treatment and disposal systems or connections to nitrogen-reducing centralized wastewater treatment systems.
- Provide for funding mechanisms to make upgrades less burdensome on the individual onsite sewage treatment and disposal system owner
- Provide for continued evaluation of watershed impacts by onsite sewage treatment and disposal systems
- Provide for routine maintenance and inspection of onsite sewage treatment and disposal systems.
- Keep track of the location and condition of all onsite sewage treatment and disposal systems

For each strategy element, this document presents a range of strategies, including a discussion of the status and how this strategy element can contribute to effective management of onsite systems.

2 Integration of nitrogen reduction into the economics of onsite wastewater treatment

2.1 Components of a framework focused on nitrogen

The objective of this strategy element is to introduce an institutional and financial framework that discourages nitrogen inputs and loads and funds effective measures to reduce them. This institutional framework includes sub-elements with the following functions:

2.1.1 Overall goal setting for nitrogen pollution reduction using a springshed approach

This function is fulfilled by the Pollution Load Reduction Goal process of the St. Johns River Water Management District and the Total Maximum Daily Load process of the Department of Environmental Protection and the U.S. Environmental Protection Agency. The five-year rotation interval of the Total Maximum Daily Load program provides a mechanism to update information and requirements periodically.

2.1.2 Source trading or cost transfer to encourage the most cost-effective measures

Such a function allows sources for which nitrogen reduction is more costly to encourage sources for which nitrogen reduction is less costly to implement cost-effective nitrogen-reduction measures. This function can take the form of a competitive grant program under the Wekiva River Basin Commission, regional planning council, St. Johns River Water Management District, or the Department of Environmental Protection to reduce nitrogen inputs and loadings. Such a grant program introduces an auction mechanism, in which entities with the lowest cost for nitrogen reduction compete for subsidies by other entities for which nitrogen reduction costs are higher. The auction mechanism will serve to observe the development of nitrogen reduction prices over time. The grant program will be funded by a yearly nitrogen discharge fee. The initial fee can be based on the costs of nitrogen reduction in centralized wastewater treatment plants as assessed in the 2004 report of the Department of Environmental Protection (FDEP, 2004) and here estimated as between $22 per pound and $3 per pound for upgrades to nitrification and denitrification to an effluent standard of 3 mg/L total nitrogen for small and large plants, respectively. The fee should be updated every five years, to reflect the changes in the cost of nitrogen reduction measures. The fee can be based on inputs or on average loads from that source in the Wekiva Study Area.

For onsite sewage treatment and disposal systems the assessments of the current studies indicate that difference between inputs and loads is not very large. For 20 lbs/year discharge per system, the yearly discharge fee will be between $440 and $60 per house. As the level of detail of the inventory of OSTDS allows, two additional pricing elements can be considered. An element of equity can be introduced by setting fees proportional to the permitted estimated sewage flow of the establishment, with a base case of 400 gpd/system. An incentive for onsite nitrogen reduction can be provided by discounting fees proportional to the fraction of nitrogen reduction achieved in the onsite sewage treatment and disposal system.
The fees can be collected as special assessment, or as yearly bill by the entities discussed in the next section. To achieve equity between all sources of nitrogen, a similar fee needs to be in place for other sources. This is in particular important for those that have currently no mechanism to financially contribute to nitrogen reduction measures, such as residential and commercial uses of fertilizer.

2.1.3 Cost sharing or insurance for upgrading wastewater infrastructure

This function provides a means to support the upgrade of the level of wastewater treatment of existing establishments served currently by onsite sewage treatment and disposal systems. Such an upgrade can either be achieved onsite or by connecting to a more centralized wastewater treatment system. Priorities for this fund will be to assist in the upgrade of systems when existing system evaluations show that they do not meet current code, or when repairs or modifications to the system are necessary. Spring or aquifer vulnerability could also serve as elements of prioritization. The cost of such a program will depend on the intensity of system evaluation and the extent of upgrade requirements, which are the same factors that influence the effectiveness of such a program. With such a program in place, it is relatively easy to address questions of affordability for low-income populations by increasing the cost share rate depending on income. With such a program it will also be feasible to incorporate outside funding, such as state revolving loan funds or grants to reduce costs. For simplicity the following assumes uniform cost, uniform share amount and complete funding from within the Wekiva Study Area.

2.1.3.1 Intensity of Program

2.1.3.1.1 Repair upgrades

At the low end is a program that provides a partial grant for upgrades undertaken as part of repairs. Assuming a 2% repair rate (slightly higher than historical averages), an average cost of $13,000, and a 75% rate of cost share, each system owner will have to contribute yearly 1.5% of the average upgrade price, or about $200/year for upgrades to performance based treatment systems. Under this scenario, about 10-20% of existing systems will be upgraded after 10 years resulting in a slight reduction of nitrogen load. This reduction will be largely offset by new growth.

A similar program could focus on the public health perspective and pathogen indicator removal and support upgrade of failing systems to current construction and water table separation standards. Such upgrades may provide some nitrogen reduction for those systems that currently discharge into wet soils without achieving nitrification first. The same assumptions as stated above result in an estimated cost between $70/year and $100/year.

2.1.3.1.2 Upgrade of all systems within 10 years

At the high end is a program that aims to upgrade every system in existence to a nitrogen-reducing onsite sewage treatment and disposal system or sewer connection within 10 years. Assuming again the same cost per system and a 75% rate of cost sharing, each existing system owner will have to contribute yearly about 7.5% of the upgrade cost or about $1000/year for performance-based treatment systems. Such a program would come close to achieving the load reduction discussed for OSTDS in the MACTEC (2007) report and require statutory changes. Again, new growth will partly negate the reduction in loading from onsite sewage treatment and disposal systems as a whole, but the load per system will be effectively reduced through such a program. When the upgrade of existing systems is completed, after about ten years, the yearly contribution can be reduced.

2.1.3.2 Management Entity

Three options are suggested for organizing such a cost-spreading function. All will include the payment of regular contributions by owners of onsite sewage treatment and disposal systems to an entity that provides infrastructure upgrade grants:

2.1.3.2.1 Regulated Wastewater Management Utility

One option is that the cost-sharing entity is the regulated wastewater management utility for all onsite sewage treatment and disposal systems within the service area of the utility. An advantage of involving utilities is their opportunity to find cost-effective solutions that look beyond the single lot to economies of scale in the service area.

2.1.3.2.2 County Health Departments

A second option is that the cost-sharing entity is the county health department for all onsite sewage treatment and disposal system owners. This option creates the question of how to distinguish financially between an upgrade and a connection to sewer, which may have similar effectiveness for nitrogen reduction. If cost contributions are based on an average cost over twenty years, all current onsite owners would need to contribute over twenty years, even if they connect to sewer. Without addressing this issue, over time there will be fewer and fewer onsite system owners among which to share the cost of upgrades or connections. Possibilities include either using different funding for such upgrades or establishing a transfer payment from the utility to the county health department to account for the lost contributions. Without such a mechanism this program would change from a cost share to a subsidy program for sewer utilities.

2.1.3.2.3 Insurance Program

A third option could be a more formalized insurance coverage in which rates are distinct by system age, type and perceived risk of failure, which could be determined through an initial system inspection. One drawback to such a scheme is that it requires very detailed information up front. Such an approach, if contingent on the risk of failure, also provides more incentives to keep an existing system in working condition than to initiate nitrogen reduction and thus is more appropriate to set rates after upgrades are complete. On the positive side, a formalized insurance mechanism would provide protection for the individual system while the pay-as-you-go approach envisioned under the other two approaches is more susceptible to program interruption.

2.1.4 Minimizing new loads of nitrogen in the Wekiva Study Area

The discussion of 2.1.3 has focused on upgrades to existing systems. New land developments with new onsite sewage treatment and disposal system construction add to the nitrogen load instead of reducing it. A requirement for nitrogen reduction in new systems is relatively easy to implement for new systems because no changes in existing construction or previous permits are necessary. One approach is to simply require nitrogen reducing treatment from new permits to minimize their load to the Wekiva Study Area. Construction loans provide a mechanism for funding such systems, therefore a particular onsite grant program for new construction is not recommended. Any support or subsidy for new systems should instead be funded from other sources and be available to upgrades and connections to septic systems as well.

2.1.5 Performance evaluation function.

This function allows evaluations of the nitrogen-reduction performance and sanitary functioning of onsite sewage treatment and disposal systems both individually and as a source type. Such a function complements and refines the assumption that all onsite sewage treatment and disposal systems behave the same as a typical, recently installed and well functioning onsite sewage treatment system. There is a wide range in the level of detail and the relevance to nitrogen reduction that can be covered as part of this function. Two particular areas of concern are recommended here:

2.1.5.1 Nitrogen contributions on the watershed scale.

Such evaluations can range from further literature review and very limited studies ($1/system year) over further field and modeling work to address typical conditions or particular questions ($5/system year) to field studies of each individual system ($50,000/system). For comparison, a five-dollar contribution by each onsite sewage treatment and disposal system in the Wekiva Study Area would provide more funds for such projects than the statewide onsite sewage research program has available, which is funded by a surcharge on new construction permits. This program aspect could either be administered as a grant program of the Wekiva River Basin Commission; a special research program tasked to the Department of Health and its research review and advisory committee, part of the non-point source pollution program of the Department of Environmental Protection, or the St. Johns River Water Management District.

2.1.5.2 Performance and condition of individual systems relative to standards.

Such evaluations provide information about the satisfactory condition and, more importantly, the lack thereof of individual systems. Currently, such information is provided to county health departments for the bulk of the systems at an estimated rate of less than 2% per year in the form of complaints about sanitary nuisances, repair permit applications, and existing system evaluations. The mechanical functioning of more complex treatment systems or systems with more challenging or variable wastewater characteristics is monitored yearly by the county health department and in the cases of more complex treatment systems by a maintenance entity. The costs are borne generally by the system owner. In the balance between cost aversion of owners and lack of funding for county health departments, a “deemed to comply” regulatory approach is the predictable outcome, in which all systems upon satisfactory installation and absent obvious malfunctioning are assumed to work as intended. As the intention shifts from a focus on sanitary disposal of sewage to a stronger emphasis on watershed-scale nitrogen pollution, existing systems should be reevaluated. As existing systems are replaced with nitrogen-reducing systems such a reevaluation will become less important. Until then, three elements of such a reevaluation program are recommended.

2.1.5.2.1 A required evaluation whenever the property served by an onsite sewage treatment and disposal system is transferred between owners.

This evaluation provides important information for the real estate transaction and can provide an avenue for the county health department to update its records on the system. Two Florida counties have implemented such a program and the 2007 legislative session began to consider such a program for statewide use.

2.1.5.2.2 A periodic inspection and maintenance requirement for existing systems.

Such a program can be implemented either by the county health department, a maintenance entity or utility for a service area in two ways: The entity could staff or contract to provide for regular inspections in the whole area. By doing many inspections and pumping only where needed, the entity can organize such a program effectively. Alternatively, each system owner is required to show to the tracking entity that inspection and maintenance has occurred and arranges and pays for this service individually. This requires a smaller role for the tracking entity. Such a program has been implemented in parts of two counties but covers only new systems there. To be effective in an area such as the Wekiva Study Area with a large number of existing systems, a periodic inspection and maintenance program has to address all systems.

2.1.5.2.3 A sampling program to assess the performance of each system that is intended to reduce nitrogen loading to groundwater.

Due to the large number of factors that determine the performance of onsite sewage treatment and disposal systems it is likely that not all will perform equally well. There are two general approaches to deal with this issue: either the performance standards for all systems can be set stricter than needed to ensure that the average performance will be close to the goal; or educational, enforcement and engineering effort can be focused on those systems that do not perform well. The first option is currently not available because the available technology does not go much beyond the pollution load reduction goals for the Wekiva Study Area. The second option could be organized either as a program funded jointly by the OSTDS owners, or as a permit requirement for the system owners. The regulatory agency, i.e. the county health department, the maintenance entity, or a third party could be responsible for sampling. Sampling requirements should be dependent on past performance of the individual system to provide another incentive for proper operation. In the initial period of the nitrogen reduction efforts in the Wekiva Study Area, cost sharing will be more important because most systems will not be intended for nitrogen reduction but the information will be integrated in the overall nitrogen reduction strategies for the Wekiva Study Area. When a large majority of systems are intended for nitrogen reducing the responsibility for the operation and performance of systems can determine who in particular should be paying for sampling. Adding sampling and laboratory analysis to an existing inspection increases the cost, depending on the number of samples overall and the pollutants measured. Under the assumption that initially 1% of systems will be tested twice a year at a cost of $100, the additional cost amounts to $2 per system.

2.1.6 Inventory of all onsite sewage treatment and disposal system data.

Such a function will be necessary to implement the previous strategies. As discussed in the section "inventory", such a function can be accomplished by combining parcel and permitting records and could be kept by either the parcel recording agency, the property appraiser, the permitting agency, or a to be established onsite wastewater management utility for the Wekiva Study Area.
The level of detail of the inventory depends on the financing strategies chosen. For a population count, the mere existence of a parcel with an onsite sewage treatment and disposal system is sufficient. Such an estimate is recommended as an initial step, which would need start-up funding. The inventory can then be maintained by updating it regularly with new system construction, existing system evaluations, existing system maintenance, and abandonment permitting information. To assess the quality of onsite systems with respect to nitrogen loading in a more detailed manner, the inventory must include additional information beyond its location. Design size and nitrogen reduction performance requirements and recent performance evaluations are types of information that can be tracked with more detailed inventories.
There is a variety of existing software packages available that allow implementation of such inventory.

2.2 Discussion of strategy element

2.2.1 Groundwater nitrogen as a challenge for water quality protection.

The pollution of springs is an indication that the existing sets of rules, understood here more broadly as standards of behavior, fail to protect this resource to the desired level. These standards have established which patterns of behavior are expected, who monitors behavior and how progress can be made. Specialized agencies are managing aspects of human use of the hydrological cycle based on legislative direction, available information and perceived cause-and-effect relationships. In regard to water quality several aspects can be distinguished. Generally, surface water quality has been thought to be impacted by water flowing into them from on or near the surface, such as direct discharges, rainwater runoff from various land uses, and shallow groundwater impacted by land uses adjacent to the water body (EPA, 2005a, CDM 2005). Because it does not take water very long to flow through a water body, pollution reduction can be effective soon. Direct discharges have been addressed by a permitting process that involves the Florida Department of Environmental Protection as the permitting authority and regulated utilities as representatives of wastewater producers in the area contributing sewage to the water body. More recently, impaired surface water bodies have been assessed by FDEP to determine the total maximum daily load that a surface water body can handle and develop basin management action plans to reduce actual loading to that goal. Onsite sewage treatment and disposal systems in this context are only of concern when they are failing and contribute sewage via overland flow, or if they are too close to the water body, so that insufficient treatment takes place. Surface water quality goals frequently address ecological in addition to human health considerations (e.g. goal of fishable and swimmable waters).

Groundwater quality protection has focused on the use of the resource as drinking water and implied that some treatment of contamination occurs in the shallowest groundwater. For nitrogen the quality goal of 10 mg/L in the nitrate form stems from a public health perspective. For onsite systems, density limitations and setback requirements to wells imply that sufficient dilution and treatment in shallow groundwater occurs to avoid drinking water standard violations at the point of consumption. Because groundwater generally travels slowly, which is different in karst, combined with the difficulty of identifying sources, a different approach has evolved to address groundwater quality problems. If drinking water problems are found, the urgency of the public health consideration requires increased treatment or an alternate source to protect the user quickly, generally implemented by the larger community (financial assistance through state, or hookup to a central water systems) while much slower processes address the ground water quality problem itself.

The disconnect between surface water quality protection that focuses on surface water and groundwater quality protection that focuses on drinking water use has allowed ground water to become a source of pollution for surface water. Increased knowledge about how water flows towards springs makes it clear that both are connected. The governance structure that has grown to address two distinct and separate sets of problems is challenged to adapt to a new interaction between the people and institutions that add nitrogen to ground water and the people and agencies that protect surface water quality (Scholz and Stiftel, 2005).

2.2.2 Economic consequences of imperfect standards

The nitrogen pollution problem is one of unintended and unconsidered consequences. Currently, the positive effects of nitrogen inputs are privatized, in the form of enjoyment of agricultural sales, development profits, green lawns, and living, working and driving in the Wekiva Study Area. If negative effects were internalized by the people who input nitrogen, each would also live in, eat and drink the leftover nitrogen. Instead, effects of nitrogen are shared widely. This is in part due to the fact that nitrogen, once released, travels through space and time to a point where the effects are apparent. In the case of the Wekiva Study Area, some nitrogen travels beyond private property boundaries through groundwater, stormwater or wastewater to the springs and rivers of the Wekiva Study Area. Effects can take many forms, from high risk of sickness for people to changes in the plants and animals of the river.
Only in very few situations is it possible to find and address a direct link between a source of nitrogen and its effect on the same property. An example could be a private well that exceeds the drinking water standard for nitrate due to excessive fertilization or accidental installation of a shallow well downstream from an onsite sewage treatment and disposal system or the stable. More frequently, a neighboring land use is implicated in well contamination. In a hypothetical pure and perfect market economy, such a problem can be easily addressed if ranking of groundwater resource use rights is clearly established, i.e. a higher priority for the right to dump nitrogen into the water, or the right to drink clean water. In such a case the user of the nitrogen and the user of the well could reach an agreement in which either the polluter compensates the well owner for the reduction in water quality from the well or the well owner pays the polluter to reduce pollution so the well water remains usable to the extent desired. In an ideal market economy the level of pollution would be the same under each set of property rights. Such a level would be considered an economically efficient level of pollution (e.g. Randall, 1987). Several assumptions in this scenario are not met under realistic conditions such as in the Wekiva Study area:

Rights to resource use are initially contentious and not clearly specified. There is the conflict between water quality goals for springs and the Wekiva River and the amount of nitrogen that arrives from a variety of sources at the springs. In addition, no clear priority or limit on pollution exists among the many different sources of nitrogen in the Wekiva Study Area.

The assumption that all aspects of nitrogen pollution are included in the decisions and transactions that lead to nitrogen pollution is not met. Such externalities stem from the conditions that exclusive rights to water quality are not instituted and that, somewhat different from water quantity, water quality can be enjoyed by a multitude of users without changing the quality. If a party external to the agreement is affected by the nitrogen, for example the next neighbor downstream, this additional effect of nitrogen is an externality that is not accounted for in the agreed upon level of pollution. The decision to buy and use fertilizer or to build a house served by either onsite sewage treatment and disposal system or sanitary sewer does not include an agreement by other parties to accept the downstream pollution. Such externalities can be reduced by multiple agreements or if multiple concerned parties form a few collective entities that then can reach an agreement. Such agreements would form the new institutional framework. Without such an agreement, the situation remains that benefits of nitrogen use are private, but negative effects are externalized. Thus, the individual's cost-benefit considerations can lead towards more pollution. Moral appeals to good stewardship and resource protection have limited reach if "immoral" people can continue to access the resource and reap the benefits. An example for this effect is given in the Mactec (2007, 2-6) report, where the desirable behavior by some people not to fertilize is negated in effect by over fertilizing by another set of people.

The assumption that it is easy and cheap to reach an agreement is not met. With a population of close to 500,000 in the Wekiva Study Area and a multitude of local jurisdictions and special purpose agencies, agreement on a collective course of action is difficult. If the costs to obtain information about sources and effects, to reach, ratify and enforce agreements is not free but substantial, then these transaction costs would tend to shift the agreed upon level and cost of pollution to the disadvantage of the entity that assumes these costs. For example, the intensity of required monitoring and maintenance effort on nutrient-reducing systems may adversely affect the willingness of onsite sewage treatment and disposal system owners to upgrade to better technology, or the ability of county health departments to monitor and confirm the effectiveness of that particular system.

The assumption that equal partners are involved that are willing to come to an agreement over some small part of their life might hold at the end of a collaborative process to solve the conflict but rarely at the beginning. If the costs are substantial relative to the available budget of the parties then the outcome will be a substantial difference between the amount somebody might accept to be willing to give up their right and the amount that they would be willing to pay somebody else to give up a right, in particular when rights are under contention. The result is a substantial incentive to resist efforts to change the existing regulatory framework.

If effects, such as health effects, or just the appearance of a contaminant are not instantaneous but delayed, the agreement reflects the extent to which a present benefit is preferred to a future cost. In the case of short-term benefits and long-term costs, such a preference puts future generations at a disadvantage. If effects are uncertain and variable then the outcome will also depend on whether the common preference is for the prevention of any harm or on remaining below a level of some significant harm.

Detection of persistent water quality problems as shown in studies such those leading to the establishment of pollution load reduction goals of the St Johns River Water Management District is an indication that the historic pattern of standards and behaviors influencing nitrogen pollution of groundwater were insufficient to protect water quality in the springs.

2.2.3 Challenges to change

To address the water quality problems in the Wekiva Study Area, currently acceptable standards of pollution behavior must be changed, by changing existing institutions or by creating new ones. A program of change must take into account the scientific uncertainty of information about and natural variability of the processes involved in pollution. Such change can include a change in the expected standards of behavior, charging resource users for nitrogen input or for mitigation, or agreements between groups of resource users to achieve cost-effective solutions. In most cases, internalizing or privatizing costs previously hidden or externalized to the larger public will increase costs of pollution to the polluter.

Faced with such possible rule changes and cost increases from zero to a positive value, three responses are economically rational from the perspective of resource users but ineffective in solving the problem: blaming others, delay rule changes, require payment by the public.
The blaming of others allows each resource user to claim that their contribution is negligible or that other resource users could achieve the same goal much cheaper. Such blaming games can take many forms that invoke standards of equity: new against old residents, new land uses against old land uses, uses that claim a higher purpose against “frivolous” ones, natural against unnatural uses. While some of the technical arguments may not be completely without merit, this strategy fails to solve the problem. The underlying purpose is to shift the cost from the preferred group to another group or at least to delay a solution. In effect this strategy serves to stake a claim for priority rights to pollution for the preferred group.

Delay of rule changes allows each resource user to continue reaping private gains while resource use continues and increases. In 2004 and 2005 the Department proposed marginal rule changes, which would have allowed the overall nitrogen contribution by onsite sewage treatment and disposal systems to remain constant or decrease slightly. During the more than two years that have passed since the septic system inventory used in these studies was completed about 1200 new onsite systems have been permitted without nitrogen reduction consideration. This constitutes an additional input of about 24,000 pounds or 11 metric tons per year into the Wekiva Study Area. Further study, while it can be framed in the context of technical and scientific uncertaintycan have the effect of delaying approaches to solve the problem.

Requesting payment by others or the public in the absence of a funding mechanism is not leading to a long-term solution and in effect serves as another method of delay. Such a request presupposes that polluters had a higher priority pollution right than others and if granted may provide incentives to increase nitrogen loading before being paid to stop. Such a request also assumes that the public has a dedicated funding source to pay for nitrogen reduction measures to the necessary extent. This is not the case, as it is precisely the lack of a mechanism to charge a cost to pollution that has contributed to the existing problem. Instead, competition for general revenue funding at the state or local level will make it difficult to provide for a consistent new program beyond an occasional study. In 2006 the tobacco users of the USA provided each onsite system of the Wekiva Study Area with about a $5 subsidy for further study, which resulted in this report. In the abstract, societal resources are limited to tackle any particular hypothetical problem. But, a concrete funding mechanism is needed to identify the real limits of the available resources and to begin implementing cost-effective nitrogen reduction measures.

2.2.4 Example of adaptation

One example of an existing institutional framework that has adapted fairly easily to Wekiva protection is the permitting scheme of large wastewater treatment plants administered by FDEP. This scheme sets discharge limits for each discharging entity in a renewable permit. The standards can change during renewal, allowing for adaptation to new information. The costs for treatment are paid for largely by the users of that entity, with limited subsidies by federal or state funding. This creates incentives to find cost-effective solutions to achieve the required level of treatment. In response to the Wekiva challenge, DEP was able to modify treatment performance standards. The permittees are now in a position that allows them to plan ahead and determine the most cost-effective solution to meet the new standards in preparation of permit renewal. The solutions can include increased treatment at their own treatment facility or increased cooperation with other entities, such as joining two sewer line networks.

2.2.5 Toward more perfect rules

2.2.5.1 A springshed approach

To effectively address sources of groundwater pollutions, a springshed approach is promising. A watershed is the area from which water flows through a common point. A springshed consists of those areas that contribute to the discharge (=flow) of the spring (after Copeland, 2003). Such an approach transcends political boundaries and brings all parties involved into a common framework that focuses on addresses and clarifies the identified problems (EPA, 2005a, Tonning, 2006). With such an approach, one cause of externalities, the unknowing neglect of effects by or on a group of users, is addressed. In the case of the Wekiva, the springshed is legislatively approximated as the Wekiva Study Area. Most of the springshed as delineated by the St Johns River Management District is in this area, with the exception of some areas in southern Lake County around Clermont. Two coordinating fora exist already now: the Wekiva River Basin Commission and the Basin Management Action Plan development process of the Florida Department of Environmental Protection. To meet water quality criteria at the springs, water pollution in the whole springshed must be addressed.

2.2.5.2 Searching for low-cost solutions and addressing a free-rider problem

Among the multitude of sources and contributors the cost of nitrogen reduction varies depending on many factors, such as site conditions, extent of nitrogen reduction required and opportunities for joint projects that can be utilized. A strategy that focuses exclusively on very high reductions goals from one particular source type risks overlooking more cost-effective alternatives. FDEP has begun exploring water quality credit trading as an opportunity to find and implement low cost options for nutrient reduction projects. Such water quality credit trading, within the area impacting the water body of concern, allows consideration of projects beyond those that have been traditionally regulated by any one agency (FDEP, 2006).

A strategy that would purely focus on requiring the sources with the least cost to implement nitrogen reduction would artificially set a cost-effectiveness limit and reward those sources with higher costs with an allowance to do nothing. In this way, sources with a high cost of nitrogen reduction get a free ride on the efforts of others, who provide the nitrogen reduction service. To avoid this and to provide inducements for nitrogen reduction all contributors of nitrogen should continually also contribute funding to address the problems caused by it. The proposed framework does this at two levels: A contribution to the Wekiva Study Area and all sources of nitrogen, and a more local contribution to the onsite sewage treatment and disposal system management entity, which could be a utility, district or county health department, to address upgrades to existing systems. Over time, as the most cost-effective nitrogen reduction projects will have been implemented, the contributions could be adjusted to reflect the extent and cost of additionally needed ones.

A similar program that combines the two aspects proposed here 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 and collected by counties, 60% is allocated to treatment system upgrades and 40% to implement an agricultural management practice of cover crops. Treatment system upgrades funding can be awarded for agency projects of upgrades, repairs of individual failing systems, and individual upgrades to at least 50% nitrogen reduction (MDE, undated).

2.2.5.3 Funding for monitoring, enforcement, and future planning

In order to provide information of how effective the nitrogen reduction measures undertaken are a sustained monitoring program is needed. Because such a program is providing information for all about aspects of their nitrogen contributions, that aspects should be captured in a financial contribution by all. The amount of this function relative to the amount spent on implementing nitrogen reduction projects provides an estimate of the relative cost of information and actual nitrogen reduction. A current inventory is essential, both as a monitoring tool and as a means to assess financial contributions equitably.

3 Recordkeeping, Inventory

3.1 Create and maintain current inventory of OSTDS

Currently, no continuous inventory of OSTDS in the Wekiva Study Area exists. Two sets of databases of onsite wastewater systems existed for use in Wekiva Study Area projects over the last two years: The first was snapshot of parcels with onsite sewage treatment and disposal systems in the Wekiva Study Area. This snapshot was developed based on the location of lots shown as improved in property tax records, which indicated the generation of wastewater, and a lack of sewer service for that property. The snapshot characterized the situation in the Wekiva Study Area as of approximately November 2004. Since then, new construction and repair permits have been issued.

Inclusion of manner of wastewater disposal and identifying location of wastewater service in property records is one method of approaching such an inventory in currently maintained databases. An alternative could be to build on the Department's permitting record database. The Department of Health gathers summary statistics of permits issued for each county, which can be found at: http://www.doh.state.fl.us/environment/ostds/statistics/NewInstallations.htm. Repair permits have only been tracked since 1997. The estimated total number of onsite sewage treatment and disposal systems installed starts with 1970 census numbers for the number of systems in each county and adds new permits to the population. This number could be affected by the fact that new systems are added but the discontinued use of old systems, e.g. due to connection to sewer is not subtracted. In spite of this, the US census estimate for the number of systems in 2000 is very close to the estimate in this statistic. Thus, it can provide an estimate of the relative age of original installation of OSTDS in the three counties that are part of the Wekiva Study Area. One should note that some of these systems may have been modified or repaired since the original construction. Table 1 shows the fraction of 2004/2005 onsite systems in the three counties that were initially installed before certain years.

COUNTY	1970(census)	1982	1990	1997-98
Lake	26%	50%	65%	83%
Orange	43%	57%	87%	95%
Seminole	37%	59%	83%	93%
TOTAL	36%	55%	79%	91%

Table 1. Percent of the total number of OSTDS at end of fiscal year 2004/2005 that had been originally installed by 1970, 1982 (water table separation requirement), 1990, and 1997/1998 (prior to permitting database).

The data in table 1 can be compared with census data about house age in the Wekiva Study Area. These data indicate a somewhat younger age of the housing stock in the Wekiva Study Area with 24% of the 2000 housing stock built by the end of 1969 and 74% by the end of 1989 (www.ecfrpc.org/docs/Wekiva_Information_Clearinghouse/pop_housing2000Wekiva.xls). Both data sets suggest that about half of the systems were originally installed before there was a requirement to keep the drainfield 24" above the seasonal high water table.

More information about construction details is available in the permitting record database of the Department of Health, which contains data from permits issued since late 1998. Permitting records constitute only a sample of the OSTDS in existence. The comparison of estimated total number of onsite systems and systems in Centrax indicates that about a quarter (Orange and Seminole) to a third (Lake) of the systems have a record in Centrax, which is consistent with the age of systems when accounting for the number of repair and other permits issued. The higher proportion of systems in Lake County reflects the younger housing stock. Permitting records contain address information that is used for finding OSTDS for inspection purposes. This address information can be used in a process called geocoding to locate permitted systems on a map. Between 10% and 15% of permit records could not be matched automatically to a location. The precision of matching was best for Seminole and Orange County, while in Lake County only slightly more than half of the systems could be matched to a street level address. Reasons for this include factors such as data entry errors and the absence of street names at the time of permit application. By selecting the systems that are located within the Wekiva Study Area one can obtain a sample of OSTDS permitted over the last eight years in the Wekiva Study Area.

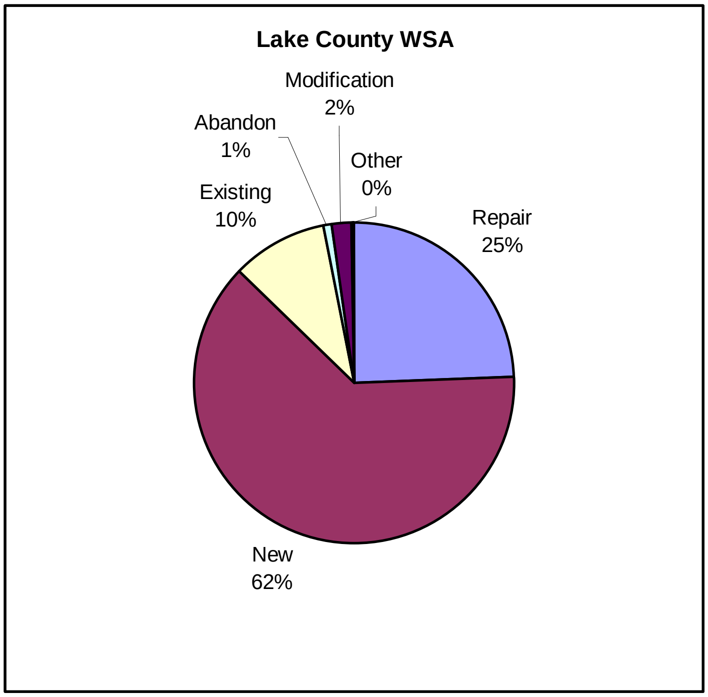
County	Estimated number of systems (6/2005)	Total systems In Centrax (1/2007)	Not matched to a geocoded address	Matched to street level location (geocode S5)	Permits WSA by zip or better	Permits WSA to street level location (geocode S5)	In WSA based on parcel data
Lake	71,733	23,432	3,094	12,760	3,198	1,801	9,214
Orange	103,361	26,070	3,465	21,055	7,328	6,892	32,975
Seminole	39,013	10,508	1,086	9,211	3,204	3,173	13,228

Table 2. Permitting database sample of onsite systems in the three counties and the Wekiva Study Area.

3.2 Integrate geospatial information, such as location, parcel and permitting information

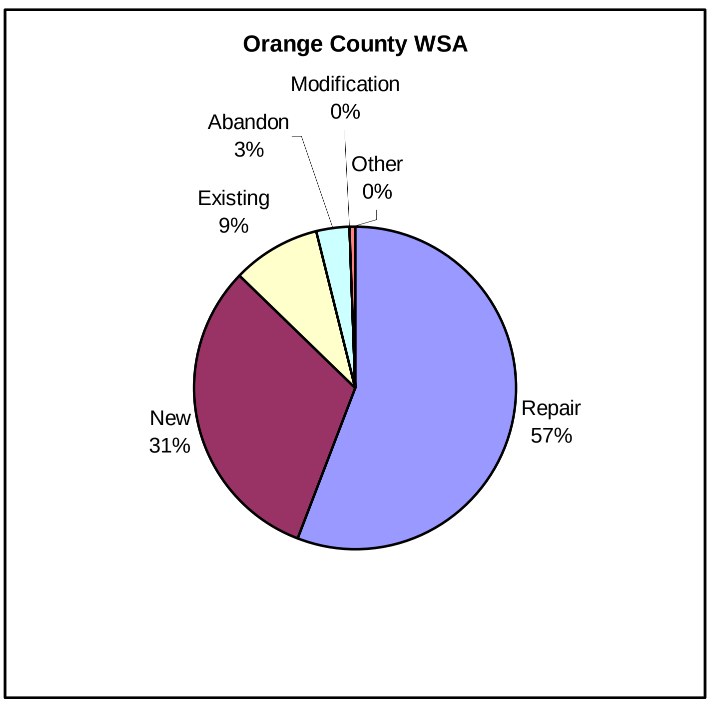
The extent to which such a project can be a useful tool depends on the intensity of managing the distributed wastewater infrastructure. In the current management scheme the infrastructure maintenance of OSTDS is the responsibility of the individual system owner subsequent to construction permitting according to statewide standards. The location of the county where the OSTDS has been permitted provided usually sufficient information for the purposes of the Health Department. Now, issues related to springs protection and the Wekiva Study Area require more detailed locational information. Geocoded permit records provide a sample of more detailed information in the Wekiva Study Area. The utility of this information is illustrated with the following examples:

- **What is the proportion of residential to commercial OSTDS in the Wekiva Study Area?** The permitting records show that onsite permits in the Wekiva Study Area are almost purely for residences. Of the permit records that contained information on the type of establishment served by an OSTDS, between 95% (Orange County) and 98% (Lake County) indicated residences.
- **What is the relative frequency of new, repair, existing, modification, or abandonment permits in the Wekiva Study Area?** New and repair permits make up the overwhelming majority of permits issued by County Health Departments. In Seminole and Orange Counties, with their somewhat older development, repairs of system have become more common than new systems. Lake County still sees predominantly new systems. These patterns hold both countywide and for the WSA in particular. In all counties abandonments are less than four percent of yearly records.



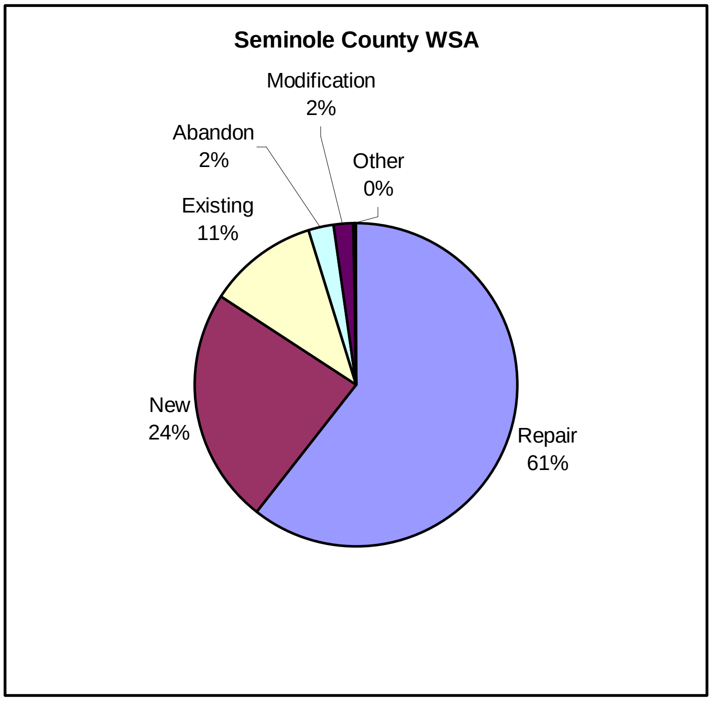
Lake County WSA
Modification
2%
Abandon
1%
Other
0%
Existing
10%
Repair
25%
New
62%

a)



Orange County WSA
Modification
0%
Abandon
3%
Other
0%
Existing
9%
New
31%
Repair
57%

b)



c)

Figure 1. Average (2001-2005) distribution of OSTDS permit types geocoded to the Wekiva Study Area in a) Lake, b) Orange, and c) Seminole County.

- **What is the design flow for a typically permitted system?** For those systems that had design flow records, a weighted average was calculated for the design flow by multiplying the percentage of systems of a size category with the midpoint of the design flow of that category. The overall average flow was nearly the same when either considering all systems or excluding the relatively few non-residential systems. Figure 2 shows how each size category contributes to the overall average flow per system in the Wekiva Study Area. While most systems are permitted for a design flow of 300 or 400 gpd, it is striking that Seminole County has a larger contribution by larger systems.

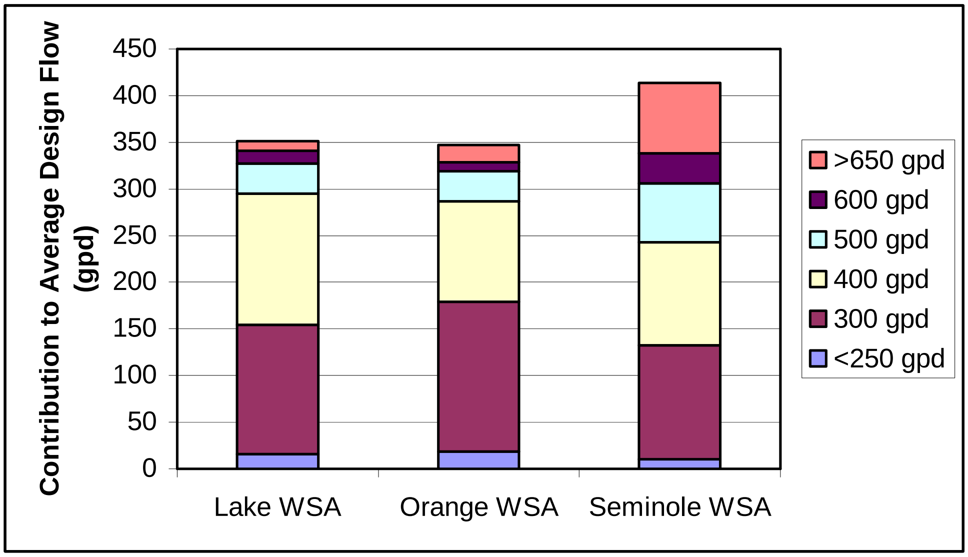


Figure 2. Contribution of different permit design flow classes to the overall average design flow in the Wekiva Study Area.

A slightly different analysis of the same data provides an indication that newly installed OSTDS tend to be larger than older systems. Table 3 shows average design flows. A typical new permit is around 400 gpd, while a typical repair permit is for 300 gpd. Table 4 shows the percentage of all permits that fall into these design flow classes. The lower percentage of typical systems for new permits and in particular for Seminole County reflects a larger variability of design flow in new systems.

	County	WSA	County	WSA
average design flow (gpd)	repair	repair	New	New
Lake	321	316	361	363
Orange	327	313	471	420
Seminole	361	370	455	533

Table 3. Weighted average design flows for new system and repair permits in the three counties and the Wekiva Study Area.

	300 gpd	300 gpd	400 gpd	400 gpd
Percent of issued permits that are "typical systems"	County Repairs	WSA Repairs	County New	WSA New
Lake	58%	55%	34%	37%
Orange	53%	61%	34%	36%
Seminole	50%	50%	31%	21%

Table 4. Percentage of all issued new construction and repair permits that are for "typical system" design flow.

3.3 Inventory systems that have no current permitting records

More than two thirds of systems in the Wekiva Study Area have no electronic permitting record. Questions such as "how many systems were installed with the drainfield in the water table, or with less than currently required separation to water table, or illegally even by outdated standards" can not be readily answered. Existing system evaluations provide a pathway to characterize existing systems and include them in the inventory. An existing system evaluation can be used to determine whether an existing system is sized adequately and is performing in a sanitary manner. The method for performing such an evaluation is outlined in 64E-6 F.A.C.

3.4 Manage inventory by tracking additions and subtractions

An inventory can only stay current when it contains the capability to account for additions and subtractions. A parcel-based database may be best suited for this purpose. This inventory should link to a database that focuses on permitting, construction and maintenance actions, such as the Department's permitting database.

3.5 Check inventory periodically

A periodic check of OSTDS allows assessing how they are working to complement information on how they were installed. Florida's onsite sewage rules outline that such checks are required for all systems with operating permits, such as ATUs, performance-based treatment systems, some OSTDS in industrial/manufacturing zones, and some OSTDS serving systems generating commercial strength sewage waste. They are not required for the vast majority of systems in existence. For most systems, application for repair permits, which are usually a result of failure to dispose sewage, is the reporting mechanism on the condition of the infrastructure.
Three questions that can be answered by periodic checks are:

- **How many systems are failing in such a manner that they discharge to the surface at a given time?** Field surveys tend to find a higher number of sanitary issues than indicated by repair permits (e.g. HRS, 1994; CDM 2005)
- **Is the separation of the drainfield bottom from the estimated seasonal high water table and the observed water table sufficient to achieve satisfactory treatment, now that recharge by sewage is occurring?**
- **How full of sludge are septic tanks?**

4 Planning

4.1 Build on existing assessments of the vulnerability of receiving waters

Three recent studies provide assessments of the vulnerability of receiving waters: the Wekiva Aquifer Vulnerability Assessment, the 2006 Pollution Load Reduction Goal study by the St Johns River Water Management District, and EPA's Total Maximum Daily Load report.
The Wekiva Aquifer Vulnerability Assessment performed by the Florida Geological Survey in 2004 resulted in three classifications of relative vulnerability of the Floridan aquifer. This study refined the Floridan Aquifer Vulnerability Assessment with similar results. Relatively high vulnerability exists in the higher elevations where recharge to the groundwater of the Floridan aquifer and sandy soils are higher. Lower vulnerability exists generally in the wetlands of the northern Wekiva Study Area, which tend to be groundwater discharge areas. This study did address surface water vulnerability only indirectly, in so far as springs groundwater discharge is a substantial contribution to the flow of the springs rungs and Wekiva River. The 2006 Pollution Load Reduction Goal study by the St Johns River Water Management District recommended reductions in nitrogen loading for the main springs and rivers in the Wekiva Study area and reductions in phosphorus, and total coliforms for the main rivers. The reduction goals are

shown in table 5. EPA performed a total maximum daily load assessment in the Wekiva Study Area, resulting in lower target levels than the SJRWMD study did.

Table 5. SJRWMD recommended percent reductions in loading of nitrate, TP, and total coliform bacteria for the Wekiva River and Rock Springs Run from all sources. Reproduced from the Executive Summary from the PLRG (Mattson, et. al. 2006) with permission from the author

	Nitrate	Total Phosphorus	Total Coliform Bacteria
Wekiva Spring	82%	- - -	- - -
Upper Wekiva River (to Little Wekiva River)	69%	50%	49%
Lower Wekiva River (to Blackwater Creek)	36%	50%	30%
Rock Spring	85%	- - -	- - -
Rock Springs Run	52%	29%	50%

4.2 Integrate land use, wastewater management, and aquifer vulnerability

For the Wekiva Study Area, the Florida Department of Environmental Protection and the Department of Health in their 2004 studies utilized the Wekiva Aquifer Vulnerability assessment as the tool to align wastewater management and aquifer vulnerability. The FDEP study led to performance standards for facilities permitted by that agency that were implemented by rule in 2005.

The DOH study recommended that wastewater management entities address nitrogen reduction in their service areas and provided for performance and design standards in those areas where the property owner was the responsible entity.

One approach to prioritize levels of water protection consists of a risk-based approach. Such an approach could combine the probability of groundwater contamination given surface and subsurface hydrogeology, as the WAVA map does, with a measure of the strength of sources of pollutants of concern. One such measure is the density or number of systems per area. This results in an approach similar to the "probability of environmental impact" proposed by Otis (EPA, 2002 3-47). As an illustration, Figure 3 shows the density of septic systems, as the number of systems that are within 90 meters of a 90 m square on the map. The result of multiplying this density with the probability of aquifer contamination is shown in Figure 4, with the darker areas representing the highest probability of aquifer impacts as a result of the combination of building density and aquifer vulnerability.

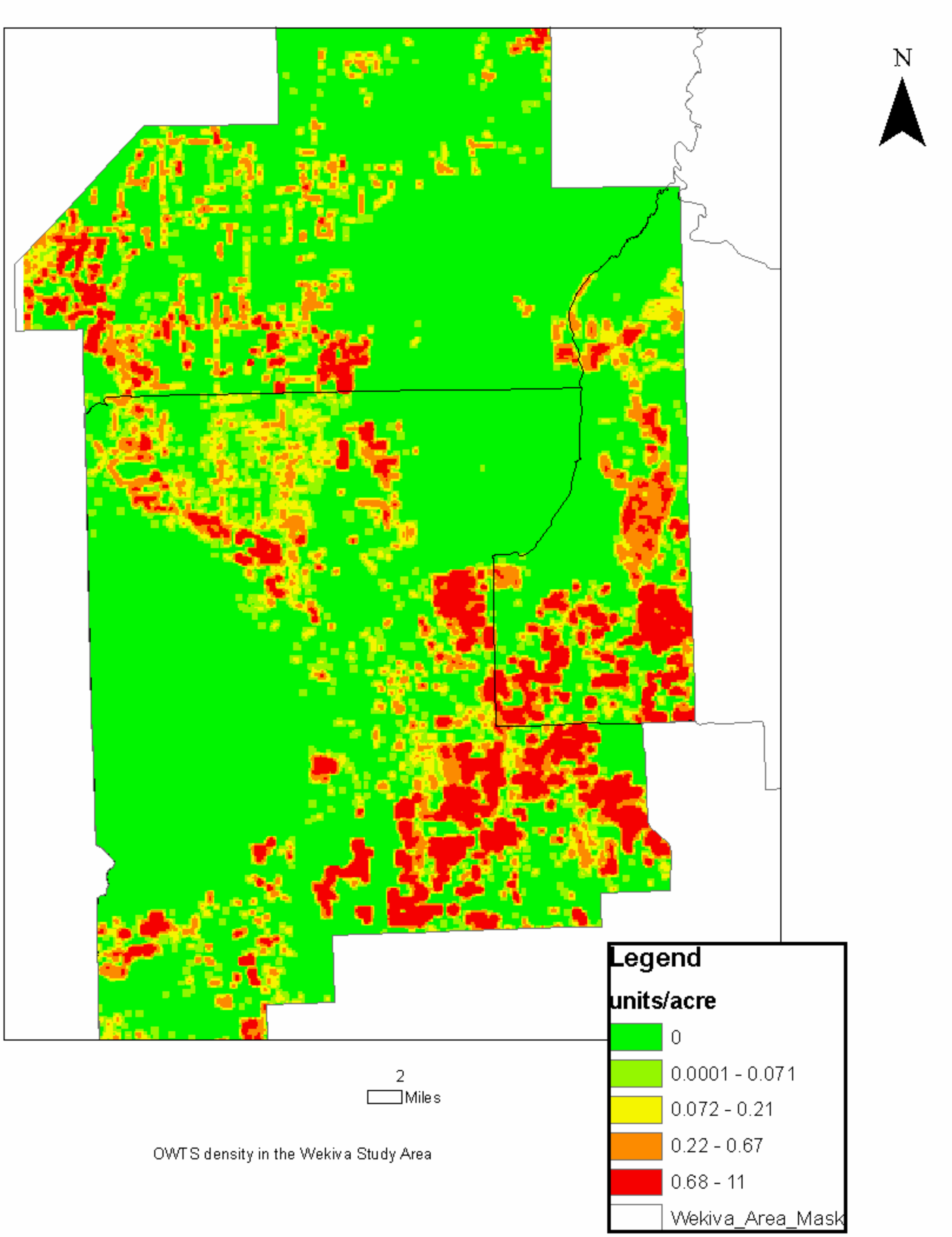


Figure 3. Density of OSTDS in the Wekiva Study area. 90m search radius, 90x90 m (~2acre) cell size.

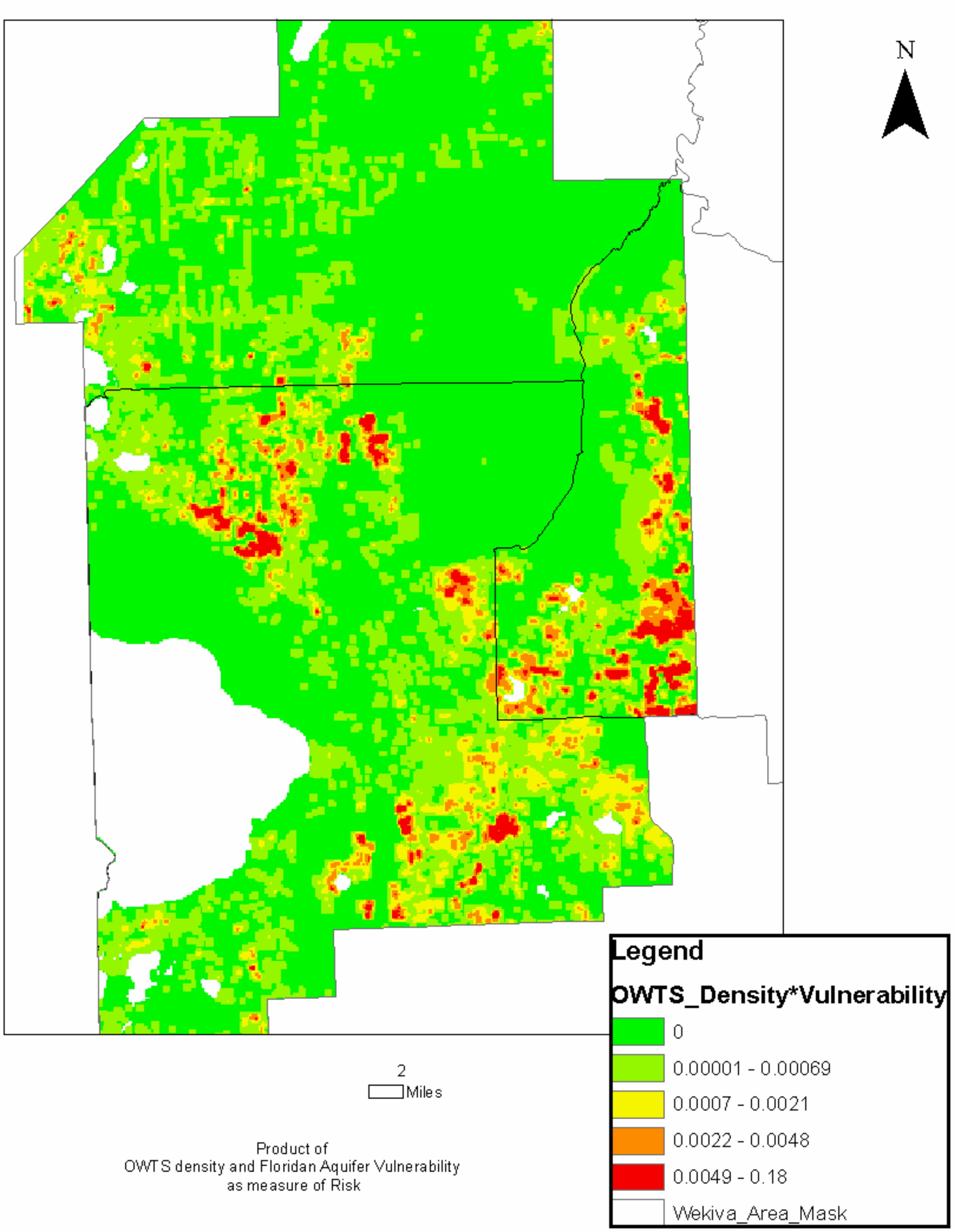


Figure 4. Product of Floridan aquifer vulnerability and OSTDS (=OWTS) density. 90x90 m (~2acre) cell size. (preliminary map, accuracy of raster orientation and calculation needs to be checked)

4.3 Evaluate the effect of changes in DOH-regulations on OSTDS loading

Performance standards are discussed in more detail in section 5. This section will discuss the effectiveness of only changing the performance standards and nothing else in the onsite sewage program. A Department of Health strategy focusing solely on systems that require DOH-permits at any given time has a limited reach. Without new authority for the Department of Health to require upgrades to systems compliant with nitrogen reducing regulations, this reach is limited to new system permits, repair permits, and modification permits.

Figure 5 illustrates the annualized repair rates in the three counties under the current regulatory requirements, where repairs are prompted by a mix of self-reporting, applications by septic contractors, and complaints. The repair rates show some variability but average around 1.5% in Orange and Seminole counties and around 1% in Lake county. Under the assumption of no repeat repairs, one can multiply the annual repair rate with the length of the period of interest to estimate how many systems will be affected by changes in the repair regulations. Over a period of 20 years approximately a third of the existing systems in Orange and Seminole Counties and approximately a fifth of existing systems in Lake County would be upgraded to whatever the repair standard is. The rate of repairs may be influenced by the presence of financial assistance, increased costs of new repair standards relative to old repair standard systems, and changes in the extent existing systems are monitored. Average ages at failure in the Wekiva Study Area were for Lake County 26 years, for Orange and Seminole County 30 years.

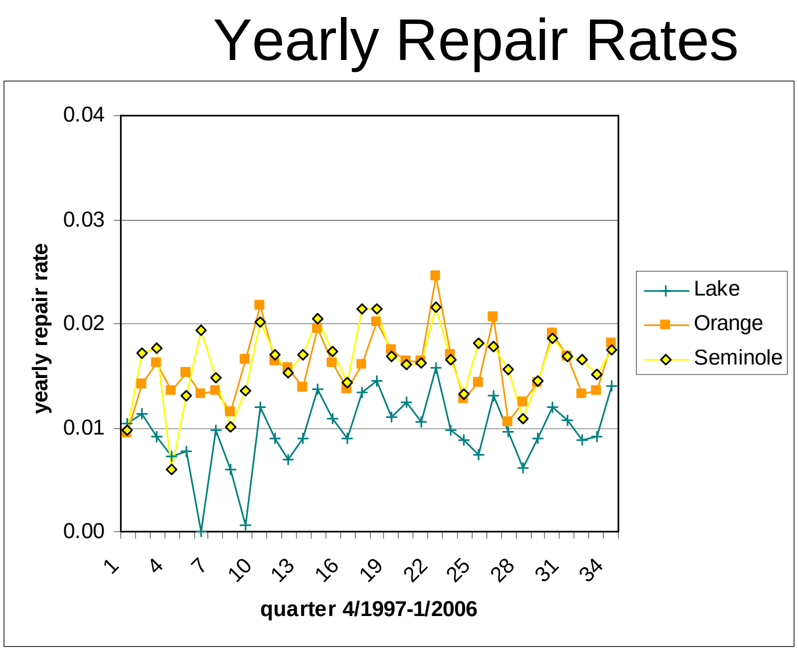


Figure 5. Yearly repair rates in the three counties over the time period fall 1997 to winter 2006 based on reports by County Health Departments to the State Health Office. Horizontal axis is the quarter since fall 1997, the vertical axis is the yearly rate (multiply by 100 to obtain %)

4.4 For DOH-regulated systems, establish performance standards

Baseline Scenario: No load increases from OSTDS
Any plan for net reductions in nitrogen loading has to consider additional loading due to growth. While upgrades requirements 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. All three counties experience growth and permit new systems.
Under a scenario similar to the one envisioned by DOH's 2004 recommendations, the same performance standards would apply to repair and new permits. A rough approximation of the performance standard needed to not have additional loads from onsite systems in any year is as follows:

Performance = 1 - (#of repairs / (#of repairs + #of new - #of abandonments))

Equation 1

This assumes the same performance standard for repair and new systems, the same nitrogen load per system, and the same environmental impact per system. The performance requirement could be decreased by the fraction of new systems that replace an existing system without an increase in loading before treatment. 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. Equation 1 indicates that in order for nitrogen loading from OSTDS to remain constant in the three counties a nitrogen reduction by about 50% is necessary for both new and repaired systems.

The Wekiva Study Area permitting records processed in the calendar years 2001-2005 include a number of system abandonments, which are not included in county summary data. An onsite system abandonment decreases the nitrogen load from onsite systems, even though the load may just be transferred to the source category domestic wastewater treatment plant. The net increase in onsite systems is obtained by subtracting the abandonments from the new system permits. This effect is small, with the numbers of abandonments being about 10% of the number of new permits in Orange and Seminole County and 2% of new permits in Lake County. Using these more specific records, a reduction by two fifths is necessary to avoid load increases.

County	Countywide New permits	County wide Repair permits	Countywide permit load reduction required for constant load	WSA new permits-abandonments	WSA repairs	WSA permit load reduction required for constant load
Lake	1670	598	74%	278	111	72%
Orange	848	1211	41%	268	537	33%
Seminole	281	447	39%	88	253	26%
TOTAL	2798	2256	55%	636	901	41%

Table 6. Load reduction required from all systems changed in a year to reach no net increase from new systems. 5-year permitting averages for fiscal 2000-2005 from http://www.doh.state.fl.us/environment/ostds/statistics, and for calendar years 2001-2005 from permitting database records. Totals may differ from sums due to rounding.

4.5 Consider alternatives for wastewater management for new development

New development brings with it additional wastewater nitrogen loading. The development planning stage provides the most flexibility to provide for cost-effective nitrogen reduction, ranging from on the lot, to clustered systems, to hookup to a central sewer plant. It is also at this stage where relatively few people can come to an agreement under which institutional arrangement the future wastewater will be managed and ensure accountability and financing, before houses are sold to individuals. Clustered systems provide opportunities to protect natural areas, open spaces and pervious area and thus have additional benefits beyond nitrogen reduction.

4.6 Designate priority areas for upgrades to existing onsite systems and management

The assessment illustrated in 4.2 provides a tool to prioritize specific areas, in which additional measures, either higher standards or larger number of upgrades, can be most effective. In particular, in more densely populated areas, an improvement in effectiveness is possible through the creation of a wastewater management entity. Such a management entity can realize economies of scale and be more effective by upgrading systems in a larger scale of neighborhoods and including a range of shared system sizes, rather than upgrading individual systems at random when they fail or the property owner decides to agree to such an upgrade. EPA's management guidelines give suggestions for such entities (EPA, 2003, 2005b). Recently, Harrington and Guo (2007) reviewed options for the organizational form that such an entity could take in Florida, ranging from the county health department, over local governments, private utilities, and special district to government utility authorities. Etnier et al. (2006) suggested combining all water and wastewater services into a "water resources provider" to encourage system thinking. The 2004 recommendations of DOH included the creation of such wastewater management entities or the expansion of existing entities to address OSTDS.

5 Performance

5.1 Re-evaluate loading per system

People living in standard houses contribute with their wastewater about 10-12 lbs of nitrogen per person per year to the environment (Crites and Tchobanoglous, 1998, 179). Discharge through a particular onsite system depends on the number of people living in the house and their usage habits, such as how much time they spend in the house. The discharge from a house can be estimated by multiplication of the household flow (number of persons times per capita flow) with the concentration found typically in septic tank effluent. This is complicated by the fact that both concentrations and flow rates are variable and not always measured at the same time. Previous studies have used a variety of sources to estimate either one, resulting in a range of estimates for the typical per capita and per household loading to the environment. Some of these values are shown in table 7.

The total nitrogen concentration mentioned in Florida's onsite sewage treatment rule is less than 45 mg/L TN. This number is based on concentrations found in studies in Florida (Ayres Associates, 1993a). The same study also summarized previous literature and that range and those typical values have been combined with other estimates of flow and household sizes for loading estimates in Florida (Chellette et al., 2002; Kuphal, 2005). A discharge of 20 lbs of total nitrogen per person per year to the drainfield has been assumed in the Wekiva Study Area work so far (DOH, 2004; Mactec 2007; Otis, 2007; Young, 2007).

This environmental loading number can be re-evaluated in light of the field measurements of flow and concentration that were obtained as part of this overall study. The per capita load of nitrogen was in two of three study sites about 50% higher than previously estimated, but similar to what was observed by Anderson (1998) in a Florida study. The third system had an estimated loading rate that is closer to the previously estimated per capita loadings. One can use the mid-range of the estimated per capita TN loading estimates obtained from this study, that is, 11 pounds of nitrogen per capita and year. This value is close to per capita estimates from other recent literature reviews (McCray et al., 2005; Lowe et al., 2007). The average size of a household in the Wekiva Study area is 2.6 people, which yields a load per house of 29 lbs/ year. This is considerably higher than the initial estimates and thus both numbers are used in the following calculations.

Table 7. Estimated nitrogen load as septic tank effluent based on various studies

TN concentration	Flow	Household size	household flow	load/house	load/capita	Data sources
mg/L	gal/capita day	Capita/house	Gal/day	lb TN/year	lb TN/year capita	
39	68.6	2.46	169	19.7	8.0	Florida study: Ayres Associates 1993a 2000 census
44			150	20.1	4.8-13.7	Review: EPA 2002; Crites&Tchobanoglous 1997
		2.6		20.0	7.7	Wekiva estimate: Otis , 2007
50			178	27.1		Florida estimate: Kuphal, 2005
67.5	45	2.34	105	21.6	9.2	Florida estimate: Chellette et al., 2002
68	60	2.6	156	32.3	12.4	Review: McCray et al, 2005
55.4		2.6	161	27.1	10.4	Review: Lowe et al., 2007
57	80	5	400	69.4	13.9	Florida study: Anderson, 1998
74	63	5	315	70.9	14.2	Wekiva Study: Seminole Site
43	112.5	4	450	58.9	14.7	Wekiva Study: Lake Site
69	35	1	35	7.3	7.3	Wekiva Study: Orange Site
		2.6		28.7	11	(mid-range per capita load observed in Wekiva)

5.2 Evaluate technology for nitrogen removal

5.2.1 Source Separation

Of the typically 13-14 g/capita/day of nitrogen produced by a person, about three quarters comes from urine and about four fifths is typically flushed down the toilet (Whitmyer et al., 1991; Palmquist and Joensson, 2003; Magidy et al, 2004). Thus urine separation or waterless toilet technologies could be methods to reduce the discharge of nitrogen as wastewater. The question remains what the eventual handling and fate of this nitrogen will be. Urine separation may require specialized treatment facilities or a holding tank, and regular transport of nitrogen to where it will be used, e.g. as fertilizer. Waterless toilets require removal of solids in some intervals. For example, sanitary concerns have led to the requirement that the compost in composting toilets has to be limed, bagged and deposited with garbage, precluding a reuse of the nitrogen, but also removing it from the watershed. Blackwater separation has been explored in one treatment approach, in which the blackwater is nitrified first and is then mixed with greywater as food source for denitrification. Nitrogen removal effectiveness for this type of system has been estimated at around 50% (e.g. Whitmyer et al, 1991). Because source separation approaches require a different plumbing system they may be more of an option for new construction.

Removal of nitrogen via pumping of tanks is unlikely to be a significant removal process. Assuming a 900 gallon septic tank with a septage concentration of 200 mg/L TN (64E-6 FAC) a five-year pumping interval results in 0.3 lbs/year removal. Even if the concentration were close to 600 mg/L (EPA, 2002) less than one pound per year per household will be removed as septage.

5.2.2 Increased Treatment

For the conventional approach to plumbing, treatment of the mixed wastewater provides the point of comparison. Nitrogen removal in treatment systems generally involve at least two steps summarized here. In the first, the nitrification step, the ammonia and organic nitrogen is oxidized by bringing the wastewater in contact with air. This contact can be achieved either by blowing air into the wastewater or by lifting water and dripping it through air. The result is that nitrogen is now in the nitrate form, which is very soluble and mobile in water and includes oxygen. To turn the nitrogen into a gas, the oxygen must be removed. The denitrification process can be achieved in environment with food but without air supply, where microorganisms reduce the nitrogen to a gas form, and then this gas can move into the atmosphere. The source of food can be raw or less treated wastewater. This is a reason why many treatment systems include an element of recirculation.

The effectiveness of sewage treatment and disposal systems in consuming food can result in a lack of food for the denitrification process. For very high desired nitrogen removal rates, a food can be added to the treated effluent. Nitrogen removal technology has been reviewed frequently over the last 15-20 years. Technological development over this time has included variations in the treatment media of recirculating media filters, process control, including the development of sequencing batch reactors, and inclusion of recirculation in treatment systems that previously were single-pass treatments.
Single-pass extended aeration treatment plants have been judged to achieve a quarter to a third removal of nitrogen as a byproduct (Whitmyer et al., 1991; Anderson and Otis, 2000). For the purposes of further discussion, a 30% removal rate is assumed subsequently.

Recirculating media filters have had a wide range of effectiveness, from 40-70% (Whitmeyr et al., 1991). One result of the onsite wastewater nutrient reduction study in the Florida Keys was the finding that more than 70% TN removal was achievable with biological processes alone without carbon addition (Ayres, 1998, 2000). Subsequently, the range of effectiveness has been extended to 40-75% (Anderson and Otis, 2000).

Carbon addition or a different electron donor can provide for further nitrogen reduction. This treatment step can follow a previous nitrification process step. Results from the OWNRS study suggested that overall an 85% reduction in TN is achievable (Ayres Associates, 1998). Such systems are not commonly used, yet and data are sparse, therefore they are not considered in much detail here.

5.3 Establish performance standards for concentration and load reduction

Performance standards currently listed in Chapter 64E-6 of Florida's Administrative Code for onsite sewage and disposal systems are concentration based. If the influent concentration is about 40 mg/L TN, the advanced secondary treatment standard of 20 mg/L translates to a 50% load reduction, and the 10 mg/L TN standard used in the Keys translates to a 75% load reduction. A complication arises when influent concentrations increase, e.g. as a result of water conservation measures. The same load reduction would result in a higher effluent concentration. To address such issues, performance standards that are aimed at load reduction should make this explicit. For example, Marion County passed recently an ordinance requiring 70% TN removal on a subset of systems.

To estimate load reduction from different levels of treatment, Figure 6 shows the results of technology testing at test center sites. At these sites, influent concentrations are measured, flow variations are controlled in a specific manner, and effluent concentrations are measured. This allows a comparison of effluent concentrations and concentration reduction. The fraction removed equals one for zero effluent concentration and equals zero when the influent concentrations exits untreated. Therefore, a downward trend in the figure is expected and seen. Differences in influent concentrations result in a vertical shift for the same effluent concentration. For example, an increase in influent concentrations represents an increase in removal. Environmental Technology Verification (ETV) tests have been conducted at one facility with a narrow range of influent concentrations (upper 30s), and the test results are close to linear. Tests at NSF-facilities have occurred at more varied influent concentrations. The OWNRS/FAST results in contrast to tests on the same type of system at a NSF-facility suggest that the TN-removal fraction rather than the effluent concentration remains fairly constant.
An approximation of TN-removal for systems that meet a given effluent standard is as follows: Systems that achieved below 10 mg/L in any test reduced TN by about 70%. Systems that achieved between 10 mg/L and 20 mg/L achieved about 60% TN reduction.

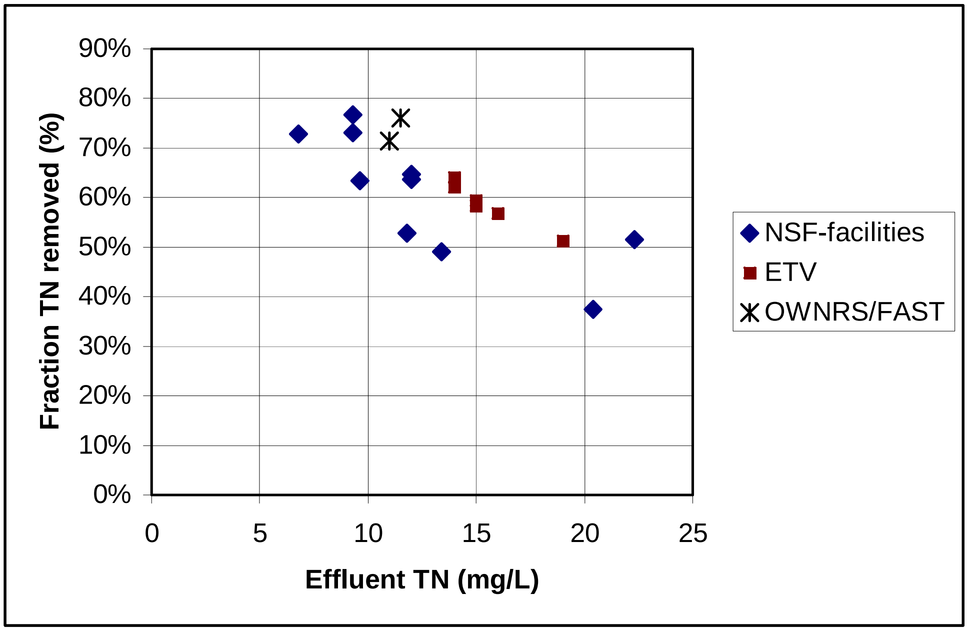


Figure 6. Effluent concentrations and nitrogen removal in technology evaluation

Overall load reduction due to technology assumes that the density of systems does not change. Currently, Florida onsite rules allow an increase in density for advanced secondary treatment. From a watershed load perspective, this negates the effect of installing advanced treatment. Conversely, lowering the density of existing onsite systems would constitute a reduction in loading to the surface area.

5.4 Evaluate cost effectiveness of nitrogen removal performance requirements

To evaluate the cost-effectiveness of increasing levels of nitrogen removal effectiveness and costs needed to be estimated. To assess the cost and effectiveness for various levels of treatment, the construction standard conventional systems, the design standard ATU, and the performance standard TN=20 mg/L and TN=10 mg/L were used. To control for two likely variables that influence costs, a range of typical systems needs to be addressed. One factor is the amount of fill needed on a site, which depends on the estimated seasonal high water table and the size of the system. To capture the range of seasonal high water tables, the scenarios of a Myakka soil with a required infiltrative surface at 22” above ground surface and an Astatula soil with an estimated infiltrative surface at 30” below ground surface were considered. For Astatula soils, Otis (2007, task 2) estimated an N-removal of <10%, taken here to be 5%. For Myakka soils, Otis distinguished between discharge of organic (TKN, 40-60% ~50%) or oxidized (Nitrate, >90% ~95%) nitrogen to the drainfield. For the following calculations the assumption is made that these removal rates are independent of incoming concentrations and that ATUs and higher treatment levels achieve nitrification.

A large concern in the Wekiva Study Area has been initial installation cost. To estimate this installation cost, a survey approach was used. A typical system size was estimated from the permit records discussed previously, 400 gpd for a new system, and 300 gpd for a repair. Correspondents were asked to include all costs associated with construction, e.g. engineering and the required first two years of the maintenance agreement. County Health Departments, distributors and installers that were identified as having installed advanced systems in the past were contacted. Responses to have been sparse, and installers have given a variety of reasons for this: The installers have been very busy, cost estimates are permit specific and installers were not comfortable with the scenario approach, and installers were concerned that price information could be used in some fashion against them.

5.4.1 New Systems

Figure 8 illustrates the considerable variability of results of the survey for new construction. The lack of difference between a 20 mg/L and a 10 mg/L system stems from the fact that a 10 mg/L system also meets the 20 mg/L standard and may be closely related to an ATU, which is the case for all systems currently used in Florida. The results are noticeably lower than a cost of $15,000 mentioned in a recent news report (WFTV, 2007) for advanced systems. This is reasonable when one considers that under current permitting conditions such systems are generally installed for conditions similar to Myakka and for houses in which the design flow is larger and requires a larger treatment system.

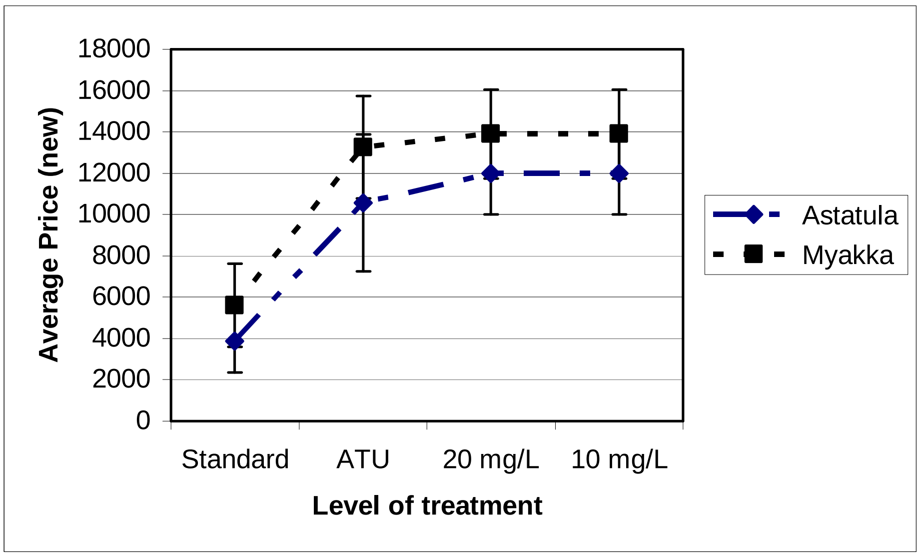


Figure 7. Surveyed prices for new (400 gpd) system construction. Bars indicate standard deviation.

Given these costs and effectiveness assumptions, measures of cost-effectiveness can be determined. The following table 9 summarizes this information. While each of the point estimates is considered typical of the available information, there is also considerable variation around that value.

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. Looking at the average cost for nitrogen removal under different levels of pretreatment, the higher treatment levels have lower costs for Astatula soils. For Myakka soils, there is a big jump in effectiveness associated with ATU treatment levels because the assumed effectiveness of the soil in treating nitrate. Higher treatment levels bring only little additional removal, so that the average cost-effectiveness stays about the same.

Table 8. Assessment of cost-effectiveness for initial system installation cost for new 400 gpd systems.

Load to drainfield (lb TN/system year)		Treatment System			
	Soil(%removal)	Conventional	ATU	20 mg/L	10 mg/L
		pretreatment effectiveness	30	60	70
		Average Cost ($)			
	Astatula	3886	10566	12000	12000
	Myakka	5602	13263	13900	13900
		Incremental Cost Difference ($)			
	Astatula		6680	1434	0
	Myakka		7661	637	0
		Load to groundwater (lb TN/system year)			
20	Astatula (5%)	19.0	13.3	7.6	5.7
20	Myakka (50%/95%)	10.0	0.7	0.4	0.3
29	Astatula (5%)	27.6	19.3	11.0	8.3
29	Myakka (50%/95%)	14.5	1.0	0.6	0.4
		Incremental Cost-Effectiveness ($/additional lb TN/year removed)			
20	Astatula (5%)		1172	252	0
20	Myakka (50%/95%)		824	2125	0
29	Astatula (5%)		808	174	0
29	Myakka (50%/95%)		568	1465	0
		Overall Cost-Effectiveness ($/lb TN/year removed compared to conventional)			
20	Astatula (5%)		1172	712	610
20	Myakka (50%/95%)		824	864	855
29	Astatula (5%)		808	491	421
29	Myakka (50%/95%)		568	596	590

5.4.2 Repairs/Upgrades

Repair costs for a complete repair (tank and drainfield) were very similar to costs for new systems, and thus the cost-effectiveness numbers are roughly the same. Two special cases of partial repairs/upgrades will be discussed here. In the case of a drainfield failure in existing developments in Myakka or similarly poorly drained soils, it is possible to find the infiltrative surface of the drainfield beneath the seasonal high water table. In such a case, the septic tank discharges directly into the groundwater during parts of the year, with no additional treatment. Providing separation from the seasonal high water table can provide for increased nitrogen removal, in addition to the treatment for pathogens and possibly phosphorus. For this reason Anderson (2006) has suggested to make upgrades to old systems in the water table a priority. In the following table, options for such a 300 gpd system are considered. They consist of the current unsanitary condition that requires a repair, a mound upgrade to repair standards (at least 6" separation from seasonal high water table if the system was originally installed before 1972), and complete replacement of the system with further pretreatment systems and a new mound. In the following the assumption is made that an ATU achieves nitrification, so that nitrate is discharged to the drainfield and readily available for denitrification. But one should keep in mind that this is not a requirement for ATUs, and performance-based treatment system might be required.

The results show two steps in costs, the mound, and mechanical aeration system (ATU). The overall cost-effectiveness is best (lowest cost) for the new mound. Installation of a completely new system, including tank and drainfield for a repair is overall somewhat more cost-effective than increased performance requirements for a new construction. This stems from the point of comparison consisting of an old system in the groundwater table instead of a code-compliant system that is expected to experience some nitrogen reduction.

Table 9. Assessment of cost-effectiveness of repair installation for a drainfield repair in Myakka soil.

Load to drainfield (lb TN/system year)	Treatment System Option for a Drainfield Repair in Myakka Soil				
	Currently	New mound	new ATU	new 20 mg/L	new 10 mg/L
	Average Cost ($)				
		5497	13633	13633	13633
	Incremental Cost Difference ($)				
		5497	8137	0	0
	Load to groundwater (lb TN/system year)				
20	20	10	0.7	0.4	0.3
29	29	14.5	1.0	0.6	0.4
	Incremental Cost-Effectiveness ($/additional lb TN/year removed)				
20		550	875	0	0
29		379	603	0	0
	Overall Cost-Effectiveness ($/ lb TN/year removed)				
20		550	706	696	692
29		379	487	480	477

A further option exists for systems for which the tank is structurally sound and the drainfield is either gravity fed or dosed from a pump tank. In such a case a retrofit kit may be inserted into the tank. At this time only one such kit has obtained an innovative system permit in Florida, for which ETV testing has shown 50% nitrogen reduction. A preliminary analysis of this case can build on the Astatula estimates. The following table 11 compares the retrofit option to increasing standards of tank replacement while reusing the drainfield (subtracted drainfield only repair cost of $3750 from average system replacement cost). Under these assumptions, the retrofitting is somewhat more cost-effective than a system replacement. But the system replacement with a10 mg/L performance-based treatment system is as cost-effective as a 10 mg/L standard for new systems. If the old drainfield is not suitable or allowable for reuse in the system repair, costs would increase for either scenario.

Table 10. Assessment of cost-effectiveness of retrofitting systems in Astatula soil if drainfield can be used in retrofit system.

Load to drainfield (lb TN/system year)	Treatment System Option for a Retrofit in Astatula Soil keeping drainfield				
	Currently	50% retrofit	new ATU	new 20 mg/L	new 10 mg/L
	Average Cost ($)				
		4500	7917	7917	7917
	Incremental Cost Difference ($)				
		4500	7917	0	0
	Load to groundwater (lb TN/system year)				
20	19.0	9.5	13.3	7.6	5.7
29	27.6	13.8	19.3	11.0	8.3
	Incremental Cost-Effectiveness ($/additional lb TN/year removed)				
20		474	1389	0	0
29		326	952	0	0
	Overall Cost-Effectiveness ($/ lb TN/year removed)				
20		474	1389	694	595
29		326	952	477	409

Not surprisingly, being able to reuse part of an existing system for nitrogen-reducing measures increases cost-effectiveness compared to having to construct a completely new system

The costs so far have only considered installation costs. These are most directly comparable to the cost of bringing central sewer infrastructure into an area.

In addition to installation costs, there are ongoing maintenance and operating costs. These are similar for the treatment systems assumed for new construction. ATUs and 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. The electricity requirements vary, depending on technology, between about 2 and 14 kWhr/day (Ayres Associates, 1998). For mound systems, some electricity is generally required to pump effluent to the mound. Ayres Associates (1998) suggested that in the Florida Keys the total annualized costs of advanced treatment systems are about three to five times as high as the costs for a mound system. This ratio is somewhat higher than estimated by another in North Carolina (EPA, 2002) that suggests a factor of about two to three.

5.5 Consider density reduction as a means to achieve lower nitrogen loading

5.6 Establish performance standards that encourage improvements

6 Ensuring Performance

After performance standards have been established, onsite systems will be permitted to meet such standards. Following the permitting they will be installed and operate from then on. A question is what strategies can be used to ensure that most if not all systems meet the performance standards. There are many parties involved in this process, the onsite system owner, the site evaluator, the designer, frequently the manufacturer or supplier, the installer, the inspector, the operator, and the maintenance entity. With so many parties, establishing accountability for good performance, and for documenting good performance, involves choices in the responsibility assigned to each party. Most of these choices revolve around the concept of the responsible management entity and the amount of oversight required. The choices include trade-offs between required levels of assurance before installation and performance-monitoring after installation. These questions are best addressed as part of the statewide onsite sewage code.

6.1 Training and Certification

The training and certification requirements for nitrogen-reducing systems differ somewhat from conventional systems. A key choice is if the treatment system should be certified in addition to or even instead of the people involved in the permitting and operation. Currently, licensed engineers are required to design nitrogen-reducing systems. Beyond the general professional licensing requirement engineers are currently essentially self-certified for expertise in onsite-sewage treatment systems. Trained and certified site evaluators, installers, inspectors and maintenance entities are involved in the installation and operation of the treatment system. The owner, who as the generator of wastewater flows has considerable influence on the treatment system's functioning, is least involved in the process. Additional education for all involved parties about the requirements for effective nitrogen reduction will be necessary for the success of a nitrogen reducing program

6.2 Site Evaluation

The importance of site evaluation depends on the sensitivity of the treatment technology to site conditions. If the effluent standard is based on a performance boundary of the discharge to the drainfield, soil evaluations become somewhat less important because the increased pretreatment lessens the load on the drainfield. If, on the other hand, soil is to be included in the treatment concept, then more detailed assessments in regard to the nitrification and denitrification capacity of the soil and their interactions with hydraulic loading and pathogen removal are necessary. At the same time, inclusion of soil in the treatment process removes one safety factor that is present for systems designed on a discharge standard. Therefore, site evaluations for soil-based treatment systems should include an additional level of detail to address design assumptions.

6.3 Design and Construction

A key choice for the strategies related to design and construction is where balance between construction-based standards and performance-based standards should lie. Without an effective monitoring and inspection program, design and construction will be of necessity based on the assumption that systems work similarly if they are constructed similarly , supported by available test results. This is the approach taken for conventional septic systems. A draw-back is that this requires very specialized skills in assessing "similarly" with the likely result that either systems are designed and constructed that are not going to perform, or that systems are not permitted that are designed and constructed effectively but in a different manner.

6.4 Operation and Maintenance

While all onsite system need some maintenance, this requirement is more important for more complex systems. Current regulations require the owner to contract with a maintenance entity for each system that is expected to meet effluent standards beyond a conventional septic tank. This approach, which includes at least two maintenance checks a year produces a larger fraction of performing systems than an approach in which no maintenance contract and no maintenance visits are required. Therefore, it is recommended to require at least the current level of maintenance. Still, this level of maintenance is much less than required for slightly larger plants that use similar technology but are regulated by the Florida Department of Environmental Protection. This lower level of maintenance can be addressed partly by designing largely passive treatment systems.
Higher levels of operational control for onsite systems could likely be achieved at lower cost compared to an increase in maintenance visits to individual onsite visits by remote monitoring or by clustering, in which the fixed maintenance costs per owner could be used for additional maintenance on a shared system.

6.5 Inspection and Monitoring,

A complication of advanced treatment systems is that failure definitions may still be easy to define but become harder to assess. The problem of treatment failure does also exist for conventional systems but has not received much attention. For a conventional septic system sewage on the ground surface is the most obvious failure criterion, nitrogen reduction is less obvious to see and requires additional training, expertise and equipment. The following describes a range of monitoring intensities that could be utilized:

- Every system is inspected and sampled regularly during either the maintenance entity visit, a county health department inspection, or 3rd party visit.
- Every system is inspected and initially sampled regularly. Once satisfactory functioning is established, e.g. after a year, sampling frequency can be reduced.
- All systems are inspected and a random sample of systems is sampled. If problems are found that indicate design flaws, further testing is done at other systems with the same design.
- Every system is inspected and monitored for mechanical functioning. A standardized qualitative assessment of wastewater quality in the treatment unit and in the effluent is performed.
- Every system is inspected and monitored for mechanical functioning.
- Some systems are inspected and monitored for mechanical functioning. Other systems are assumed to comply with performance standards.

Experience in several jurisdictions suggests that without inspection and monitoring by the county health department or a similar agency, the incentives of the system owner and maintenance entity are in the direction of less maintenance and less treatment performance. Therefore, no less intensive inspection and monitoring program than listed here should be considered. Sampling can be conducted by the maintenance entity, county health department or a specialized third party.

Florida onsite system regulations currently prescribe the second to least intensive inspection and monitoring schedule for aerobic treatment units and performance-based treatment systems, with the exception of some of systems that were installed to address lot restrictions. Funding would be required for a sampling program.

The question of how best to ensure treatment performance of onsite systems is important for all advanced onsite systems in Florida and should be addressed as part of the statewide regulations governing aerobic treatment units and performance-based treatment systems.

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