INTERIM STUDY AND REPORT ON THE FLORIDA ONSITE SEWAGE NITROGEN REDUCTION STRATEGIES STUDY

Bureau of Onsite Sewage Programs

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Table of Contents

List of Figures

List of Tables

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EXECUTIVE SUMMARY

The 2008 Legislature appropriated $1.0 million for phase 1 of an anticipated 3-5 year project to develop passive strategies for nitrogen reduction for onsite sewage treatment and disposal systems (OSTDS). This interim report is submitted in compliance with Line Item 471 Section 3, Conference Report on Senate Bill 2600, General Appropriations Act for Fiscal Year 2009-2010, which re-appropriated funding for the study.

The original 2008 legislative direction identified three areas of concern: (1) Quantification of life-cycle costs and cost-effectiveness of passive nitrogen reduction treatment technologies in comparison to more active technologies and to conventional treatment systems; (2) Characterization of nitrogen removal from effluent in the soil underneath the drainfield and in shallow groundwater; and (3) Development of simple models to describe the fate and transport of nitrogen from onsite sewage treatment and disposal systems.

The significance of this project is that it evaluates and develops strategies to reduce nitrogen impacts from OSTDS regulated by the Department of Health (DOH). Excessive nitrogen can have negative effects on public health and the environment. The primary motivations for this study are the environmental impacts that the increased levels of nitrogen in water bodies can cause. Programs within the Florida Department of Environmental Protection identify water bodies impaired by excessive nitrogen, establish targets for maximum nutrient loads, and develop management action plans to restore the water bodies. The relative contribution of OSTDS to total nitrogen impacts varies from watershed to watershed with estimates ranging from below five to more than 20 percent. There is widespread interest in the management of OSTDS and their nitrogen impacts.

The study contract was awarded in January 2009 to a Project Team led by Hazen and Sawyer, P.C., and was based upon an anticipated budget of $5 million over a 3 – 5 year project timeframe. As a result of the time required for contracting, unspent monies in fiscal year 2008-2009 were re-appropriated in 2009 to complete the initial tasks of the project. The contract identifies the following tasks:

Task A includes a literature review, technology evaluation, prioritization of technologies to be examined during field testing, and further experimentation with approaches tested in a previous DOH passive nitrogen removal study. Objectives of this task are to prioritize technologies for testing at actual home sites and to perform controlled tests at a test center to develop design criteria for new passive nitrogen reduction systems.

Task B includes installation of top ranked nitrogen reduction technologies at actual homes, with documentation of their performance and cost.

Task C includes several field evaluations of nitrogen reduction in Florida soils and shallow groundwater, and also will provide data for the development of a simple planning model in Task D.

Task D is to develop simple fate and transport models of nitrogen from OSTDS that can be used for assessment, planning and siting of OSTDS.

As of December 2009, the contractor, in coordination with the Research Review and Advisory Committee and DOH, had successfully completed parts of Task A, C, and D, including literature reviews, ranking of nitrogen reduction technologies for field testing, design of a test facility for effluent plume monitoring and further development of passive technologies, and preparation of quality assurance documents for the test facility work and groundwater monitoring to be completed during fiscal year 2010-2011. Installation of a test center for the evaluation of nitrogen reduction techniques and preparation for field sampling is planned for later in the fiscal year 2009-2010. Sampling and reporting of results would continue through subsequent years. Funding for fiscal year 2010-2011 is required to field-test the ranked technologies. Field-testing of technologies at home sites (Task B) will require additional funding.

The DOH and RRAC recommend that the Legislature provide at least $2 million to fund the next phase of the project, primarily for field monitoring over at least a one-year monitoring period of performance and cost of technologies at home sites, and of nitrogen fate and transport. This funding also will continue the development and monitoring work at the test facility, and of modeling. Additional funding will be needed from the 2011 legislative session to complete monitoring and other field activities, and final reporting with recommendations on onsite sewage nitrogen reduction strategies for Florida's future.

Recommendations for passive strategies for nitrogen reduction have not been the focus of the first phase of work. It is the intention of the FDOH and RRAC to include additional recommendations in the May 2010 report.

1 INTRODUCTION

1.1 Legislative Language

This report is submitted in compliance with Line Item 471 in Section 3, Conference Report on Senate Bill 2600, General Appropriations Act for Fiscal Year 2009-2010. The language instructs:

> From the funds in Specific Appropriation 471, $540,000 from the Grants and Donations Trust Fund is provided to the department to continue and complete the study authorized in Specific Appropriation 1682 of chapter (sic) 2008-152, Laws of Florida. The report shall include recommendations on passive strategies for nitrogen reduction that complement use of conventional onsite wastewater treatment systems. The department shall submit an interim study and report on February 1, 2010, and a final study and report on May 1, 2010, to the Governor, the President of the Senate, and the Speaker of the House of Representatives prior to proceeding with any nitrogen reduction activities.

The instructions refer to a study that was previously authorized by the legislature. This study was based on budget language in 2008 (Line Item 1682, House Bill 5001, General Appropriations Act for Fiscal Year 2008-2009) that instructed:

> …the Department of Health to further develop cost-effective nitrogen reduction strategies. The Department of Health shall contract, by request for proposal, for Phase I of an anticipated 3-year project to develop passive strategies for nitrogen reduction that complement use of conventional onsite wastewater treatment systems. The project shall be controlled by the Department of Health's research review and advisory committee and shall include the following components: 1) comprehensive review of existing or ongoing studies on passive technologies; 2) field-testing of nitrogen reducing technologies at actual home sites for comparison of conventional, passive technologies and performance-based treatment systems to determine nitrogen reduction performance; 3) documentation of all capital, energy and life-cycle costs of various technologies for nitrogen reduction; 4) evaluation of nitrogen reduction provided by soils and the shallow groundwater below and down gradient of various systems; and 5) development of a simple model for predicting nitrogen fate and transport from onsite wastewater systems. A progress report shall be presented to the Executive Office of the Governor, the President of the Senate and the Speaker of the House of Representatives on February 1, 2009, including recommendations for funding additional phases of the study.

Both instructions refer to nitrogen reduction and passive technologies or strategies for onsite sewage treatment and disposal systems. The following sections provide background information and discuss several terms that are important for this study.

1.2 General Background

Protection of public health and the environment is the mission of the Onsite Sewage Program of the Florida Department of Health (FDOH). Onsite Sewage Treatment and Disposal Systems

(OSTDS) are a permanent solution to wastewater treatment in many locations throughout the State of Florida. In Florida, an estimated 2.3 million OSTDS are in use statewide, serving approximately a third of the population. They create one of the largest artificial ground water recharge sources in the state. Ninety percent of the water used for drinking comes from ground water. It is necessary to protect this resource to protect public health and the environment.

Excessive nitrogen can have negative effects on public health and the environment. The primary impetus for this study is the increased level of nitrogen in the environment. Increased amounts of nitrogen in surface water bodies can cause eutrophication, which can lead to detrimental effects to sensitive aquatic ecosystems. Nitrogen sources to the environment include: atmospheric deposition; fertilizer from both agricultural and residential land uses; livestock wastewater; municipal wastewater treatment systems; onsite sewage treatment and disposal systems; and stormwater. The combination of these sources adds up to a cumulative nitrogen load to ground and surface waters. As land uses change and the population and the number of onsite systems increase, the relative contribution of onsite systems to nitrogen sources in an area may change.

Various investigators have evaluated the relative contribution of onsite systems to cumulative nitrogen impacts in specific watersheds and discussed opportunities to reduce this contribution. The FDOH has been most involved in such efforts in the Wekiva Study Area of central Florida and has provided reports on nitrogen and onsite systems to the Governor in 2004 and 2007. An increasing motivation for such evaluations is the need to maintain and restore water bodies to their designated uses, implemented through the total maximum daily load program of the Florida Department of Environmental Protection.

The 2008 legislative language addressed these concerns about the management of impacts from nitrogen from onsite systems on Florida's waters by providing initial funding for a research project. In the same line item, the legislature requested a report on an inspection program to address ongoing maintenance of conventional onsite systems and an inventory of onsite systems in Florida. The 2009 legislative language instructs the FDOH to submit recommendations for passive strategies for nitrogen reduction based on the work accomplished during the project.

1.3 Discussion of Terms

Florida has been a leader in the field of onsite wastewater treatment and disposal system (OSTDS) practices. Conventionally, OSTDS consist of a septic tank and a drainfield. Onsite system construction and use standards in the State date from 1921. A major revision occurred in 1984 from which time onward all drainfields in new onsite system construction had to be installed to provide two feet of separation from groundwater. Figure 1-1 illustrates a conventional onsite system. Research in Florida and elsewhere has shown that OSTDS installed to these modern standards effectively reduce the concentration of pathogens found in normal wastewater, but that nitrogen levels are only reduced to a limited extent.

Mass vs. Concentration of Nitrogen

Mass and concentration of nitrogen in sewage will influence the working of a nitrogen reduction system. The mass of nitrogen to be treated by an onsite system depends on the diet, number, and life patterns of users. On a per capita basis, data allowing estimates of the annual mass of nitrogen leaving septic tanks in Florida have resulted in a range from 7 to 15 lbs of nitrogen per person, with a mid-range value of 11 lbs per capita per year. This estimate is also between the median and mean value of a recent Water Environment Research Foundation (WERF) study that included septic tanks from Florida.

The concentration of nitrogen in sewage depends on the mass of nitrogen generated and the amount of water in which it is diluted. The water usage is again variable and influenced by socioeconomic status. Studies in Florida in the 1980s and 1990s, on which current regulations are based, indicated that a typical total nitrogen concentration leaving a septic tank was just under 40 mg/L. Studies in the last few years, such as the DOH's Wekiva study in 2007 and the WERF-study mentioned before, suggest that typical concentrations have increased to 60 mg/L or even 80 mg/L.

While the concentration appears to have increased, the mass loading of total nitrogen does not appear to have increased, which is consistent with water conservation being the main cause of the concentration increase. Total maximum daily loads are frequently expressed as a limiting concentration. For watershed assessments, such a concentration can be compared to the cumulative mass loading of the pollutant of interest relative to a characteristic flow of the water body of concern. For such estimates the mass loading, i.e. the product of both effluent concentration and flow, from onsite systems is more meaningful than effluent concentrations only. Correspondingly, to address problems of excess nitrogen on a watershed scale, mass loading reductions are more generally applicable than concentration reductions. Therefore, most of this report and most of the reports created by the contractor refer to reductions in mass loading rather than particular concentration values.

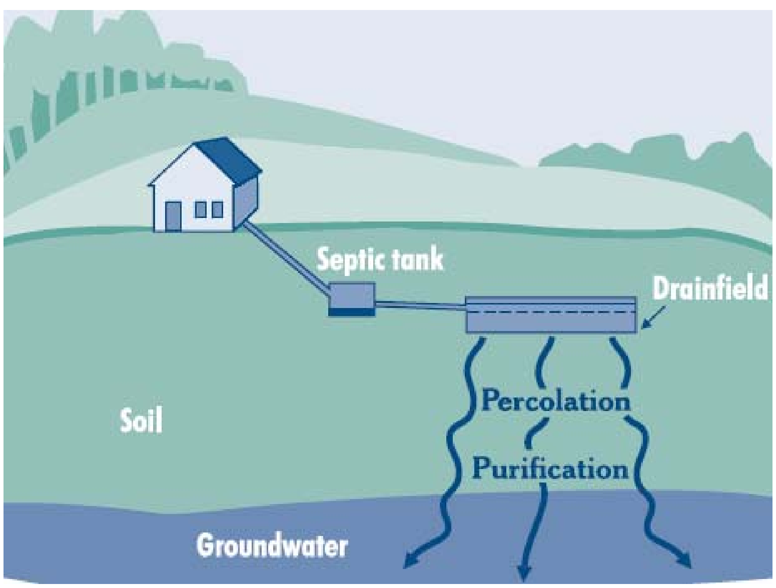

Figure1-1. Conventional onsite sewage treatment and disposal system (septic system) (from http://www.epa.gov/owm/septic/pubs/homeowner_guide_long.pdf)

"Advanced" Treatment Systems

Where local regulations require more treatment or where relatively small lots make it difficult to install a conventional system, more advanced treatment options exist. These fall generally into two permitting categories:

Aerobic treatment units add air to the sewage so that oxygen demanding compounds in the sewage can be digested before the sewage enters the drainfield. Aerobic treatment units are permitted based on a standardized technology test by a third-party that certifies that the technology functions in removing oxygen demanding compounds and solids.

Another permitting category is labeled performance-based treatment systems. A Performance-Based Treatment System, a type of OSTDS that has been designed to meet specific performance criteria for certain wastewater constituents as defined by Section 64E-6.025(10), FAC.

It should be noted that nitrogen is only one of the possible constituents in wastewater that can be addressed by performance-based treatment systems, oxygen demand and solids, total phosphorus, or fecal coliforms as pathogen indicator are others. Technologies used in a performance-based treatment system can have a range of complexity and energy intensity. Under current market conditions, most technologies used in performance-based treatment systems have been based on aerobic treatment units and include active aeration, whereby air is blown into the sewage.

The FDOH had undertaken in 2007-2008 a study of passive technologies for nitrogen removal. The definition used in that study and since then for “passive” is:

> Passive: A type of onsite sewage treatment and disposal system that excludes the use of aerator pumps and includes no more than one effluent dosing pump with mechanical and moving parts and uses a reactive media to assist in nitrogen removal.

Two elements are of significance in this definition. It excludes some approaches to achieving aeration (aerator pumps), one of the processes included in sewage treatment; and it requires a particular approach (reactive media) for nitrogen removal, another process in the treatment of sewage. These elements are based on an understanding that nitrogen removal from wastewater generally occurs in two steps. In the first step associated with aeration, nitrification occurs when nitrogen is converted to nitrate. In the second step, which occurs without air (anoxic conditions), denitrification occurs when nitrate is converted to nitrogen gas that then leaves the sewage. Figure 1-2 illustrates the sequence of processes occurring in a passive system. The same processes can be achieved by other, less passive technological approaches, too. Table 1-1 characterizes the current relationships between conventional, performance-based treatment systems, and passive systems.

Before a new technology becomes classified as performance-based treatment system for nutrient reduction it passes through a period of innovative system testing in Florida. To become an innovative system, a technology has to provide third-party testing data similar to those required for aerobic treatment units. During innovative system testing, a limited number of systems are installed and monitored in Florida. FDOH expects the field testing during task B of this project to be a useful component of such innovative system testing for some new technologies.

The addition of reactive media, or the dosing of other reactants in non-passive systems, to achieve treatment processes in onsite sewage treatment systems raises the question if such additions themselves can cause ground or surface water contamination. Florida regulations require a review of such compounds and their proposed dosing rates to prevent such contamination.

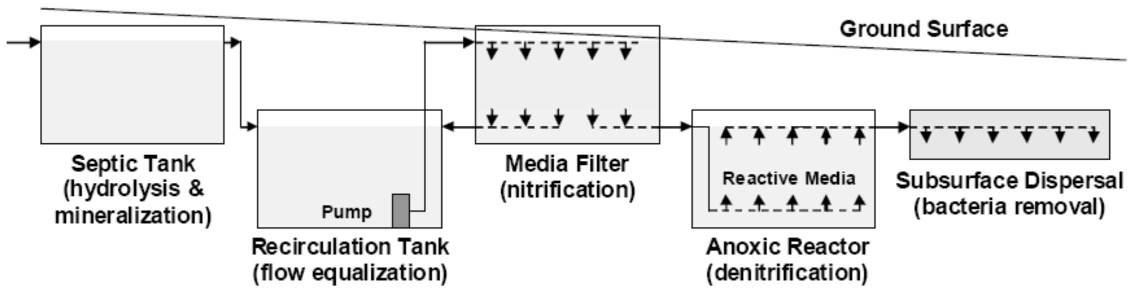

Figure 1-2. Sequence of processes in a passive system (Fig 4.9 of literature review for Task A)

Table 1-1. Relationships between the terms conventional system, performance-based treatment system, and passive system for the purposes of this study.

Characteristic	**Conventional system**	**Performance-based treatment system**	
How important is nitrogen reduction in system?	Nitrogen reduction is coincidental.	Nitrogen reduction is design goal.	
Where does nitrogen reduction take place?	Nitrogen reduction limited in drainfield, site-specific	Denitrification integrated with aeration process	Additional, separate denitrification stage
What treatment processes beyond a conventional system are included?	Not included	Aeration by blowers	Not included
			Denitrification by dosing reactants
			Denitrification by reactive media
		Aeration by sewage flow over media	Not included
			Denitrification by dosing reactants
			Denitrification by reactive media

"passive system" for the purposes of this study

2 PROGRESS OF THE MULTI-YEAR STUDY THROUGH DECEMBER 2009

2.1 Contractor Selection

The legislation was passed and signed into law by the Governor on June 11, 2008. In cooperation with the RRAC, the FDOH developed a request for proposals in the form of an invitation to negotiate (ITN) according to Florida Statute 287.054(3)(a). This ITN was advertised on September 26, 2008 as DOH 08-026 with the title "Florida Onsite Sewage Nitrogen Reduction Strategies Study: Technology Evaluation, Characterization of Environmental Fate and Transport, and an Assessment of Costs". Three teams submitted proposals. During the

RRAC meeting on November 6, 2008 all proposals were ranked, and the proposal by a project team led by Hazen and Sawyer was ranked highest.

The FDOH invited the top-ranked team to begin negotiations. After several negotiation sessions during which aspects of the proposals were clarified and a more detailed scope of work defined, and review of the best and final offer, the FDOH issued an intent to award letter on December 16, 2008, and the contract was executed on January 28, 2009.

The process from signing of the legislation to a completed agreement took approximately six months. This is comparable to the time requirements for soliciting and issuing contracts for smaller projects in the past.

2.2 Summary of Scope and Status for the Multi-Year Study as of December 2009

The resulting contract for the study split the project into five main tasks:

- Task A: Technology Evaluation for Field Testing: Review, Prioritization, and Development
- Task B: Field Testing of Technologies and Cost Documentation
- Task C: Evaluation of Nitrogen Reduction Provided by Soils and Shallow Groundwater
- Task D: Nitrogen Fate and Transport Modeling
- Task E: Project Management, Coordination, and Meetings

For each of these tasks, the contract defines more detailed subtasks and their objectives. The contract anticipates progress by establishing particular milestones at which the gathered knowledge will be used to further refine subsequent work.

The following subsections discuss the status and anticipated progress for the various tasks. Objectives that have been completely or partially accomplished are indicated in parentheses. Appendix A summarizes this information in tabular form.

2.2.1 Task A, Technology Evaluation for Field Testing: Review, Prioritization, and Development

The objectives of Task A, Technology Evaluation for Field Testing: Review, Prioritization, and Development, are given in the following listing.

- Perform literature review to evaluate nitrogen reduction technologies (completed)
- Develop technology classification scheme (completed)
- Formulate criteria for ranking of nitrogen reducing technologies for this project (completed)
- Rank and prioritize nitrogen reduction technologies for field testing in this project (completed)
- Conduct technology ranking workshop with RRAC (completed)
- Prepare innovative systems applications for highly-ranked technologies that are not yet innovative systems in Florida
- Conduct technology development in Passive Nitrogen Removal Study II (design completed, quality assurance project plan completed)

2.2.2 Task B, Field Testing of Technologies and Cost Documentation

The objectives of Task B, Field Testing of Technologies and Cost Documentation, are:

- Identify home sites and establish use agreements
- Establish vendor agreements
- Quality Assurance Project Plan
- Install field systems at home sites
- Operate and monitor field systems
- Compile results in report format
- Provide technical description of nitrogen removal technologies
- Acceptance of systems by homeowners
- Conduct Life Cycle Cost Analyses
- Final Report for Task B

As these objectives build on results of Task A, completion of this work is anticipated for the future.

2.2.3 Task C, Evaluation of Nitrogen Reduction Provided by Soils and Shallow Groundwater

The objectives of Task C, Evaluation of Nitrogen Reduction Provided by Soils and Shallow Groundwater, are:

- Critical characterization of nitrogen reduction in Florida soils and groundwater (completed)
- Develop Quality Assurance Project Plan (largely completed)
- Establish a controlled test facility (ongoing)
- Identify home sites and make use agreements
- Instrument field systems at test facility and home sites (design of test facility completed)
- Operate and monitor field systems
- Compile data in report format
- Close-out of home sites and controlled test facility
- Provide Final Report for Task C

2.2.4 Task D, Nitrogen Fate and Transport Modeling

The objectives of Task D, Nitrogen Fate and Transport Modeling, are:

- Literature review on fate and transport models (draft completed)
- Quality Assurance Project Plan
- Space time variable aquifer model with simplified soil treatment
- Development-scale aquifer model creation and calibration
- Space time variable model with complex soil treatment
- Development-scale model with aquifer and soil treatment
- Uncertainty analysis
- Validate and refine models using data from Task C
- Develop decision making framework
- Final Report for Task D

2.2.5 Task E, Project Management, Coordination and Meetings

The objectives of Task E, Project Management, Coordination and Meetings are:

- Conduct project kickoff meeting (completed)
- Prepare progress reports (four completed)
- Make presentations to Research Review and Adivisory Committee and Technical Review and Advisory Panel (one completed)

- Conduct Project Advisory Committee meetings

2.3 Expenditure Status

The proposed cumulative total funds anticipated to be spent on the contract with Hazen and Sawyer prior to the end of the 2009-2010 fiscal year are $774,000. Through December of 2009, Hazen and Sawyer has invoiced for deliverables valued at $328,000. The FDOH has spent about $25,000 through December of 2009 for two RRAC meetings in 2008 and six RRAC meetings in 2009, and other associated costs to discuss the scope of the project, to rank proposals, and to provide input into and updates on the project. It is anticipated at least quarterly RRAC meetings will be required to provide regular updates on the project.

2.4 Coordination with Advisory Committees of the FDOH

Implementation of this study requires close cooperation with the DOH's Research Review and Advisory Committee (RRAC), which the legislature charged to control the study.

The RRAC met to discuss this project for the first time on July 30, 2008 in the Orlando area. One item of discussion was a clarification of roles between: the FDOH that is to contract for the study, provide administrative support to the RRAC, review and accept the deliverables, and provide the report to the government; the RRAC which has been tasked with controlling the study; and the contractors that will perform the work, provide reports, and address comments. The RRAC voted unanimously that in controlling the study, RRAC will: rank proposals for contracts, review draft deliverables and provide comments, file a progress report, accept as completed the final report by contractors, and attach comments to the final report. The RRAC provided comments on the draft scope and directed FDOH staff to proceed further with development of a solicitation.

Additional meetings of the RRAC took place on December 02, 2008, when the first progress report for the project was discussed; January 5, 2009; February 3, 2009; May 27&28, 2009 when a workshop on prioritization of technologies for testing was held; July 1, 2009, September 10, 2009; and December 16, 2009.

FDOH staff presented a status report on August 27, 2008 to the DOH's Technical Review and Advisory Panel (TRAP), which advises the FDOH on onsite sewage rule making and policy per 381.0068 F.S. The TRAP voted to approve the project as presented to them and requested they be kept informed on the status of this project. The most recent update occurred at the TRAP meeting on August 27, 2009.

2.5 Anticipated Progress in Remainder of Fiscal Year 2009/2010

The tasks associated with this project will have a significant amount of work completed prior to the end of the 2009-2010 fiscal year. The following paragraphs describe the anticipated progress.

For Task A, the design for the test facility has largely been completed and bidding, construction and beginning of testing are anticipated. The quality assurance project plan outlining details of this sub-project is currently being finalized.

For Task B, preparations for testing at individual homeowner sites will be dependent on anticipated funding for subsequent years.

For Task C, a quality assurance project plan has been completed to outline the monitoring framework for field sites. The monitoring approach takes a three-pronged approach: detailed monitoring, including of the vadose zone, at small-scale drainfields at the test center; detailed monitoring of a large drainfield at the test center; monitoring of groundwater plumes at home sites. The design for the test facility will be completed and monitoring will commence. It is anticipated home sites will range across the State of Florida, including north Florida, central Florida (specifically the Wekiva area), and south Florida to capture diversity in site conditions.

For Task D, a literature review of nitrogen fate and transport models is currently being finalized. A quality assurance project plan will be developed to outline steps required to develop a model capable of predicting nitrogen concentrations at a specified location downgradient from the wastewater source. A simple model of nitrogen transport from the drainfield through unsaturated soil to the groundwater will be developed. This model will likely use the approach of specifying removal fractions that are dependent on soil conditions and effluent quality.

3 SUMMARIES OF MAJOR COMPLETED MILESTONES OF STUDY

3.1 Task A Technology Evaluation for Field Testing: Review, Prioritization, and Development

A summary of the literature review findings and recommendations for application of nitrogen reduction strategies in Florida are provided in this section. Subsequent sections that follow include a technology classification scheme to allow comparisons of an array of technologies, a ranking scheme to allow relative rankings of technologies based on criteria such as nitrogen reduction and treatment performance, system reliability and consistency, complexity of operation and maintenance, costs, aesthetics, and stage of development criteria, and a priority listing of the technologies for further testing and evaluation. It should be noted that the weights assigned to various criteria, the scores, and the resulting ranking were developed by the contractor for the specific purpose within this project: the selection of technologies for field testing. Other purposes might warrant other weighting or scoring approaches.

3.1.1 Literature Review (modified, edited and condensed from Section 6 of literature review for Task A)

The goal of the Florida Onsite Sewage Nitrogen Reduction Strategies Study is to develop cost-effective strategies for nitrogen reduction by OSTDS. This literature review provides a review and critical assessment of available literature on nitrogen reduction practices, treatment processes and existing technologies that appear suitable for use in individual home and small commercial onsite sewage treatment and disposal systems (OSTDS). The review catalogued well over 600 papers, proceedings, reports, and manufacturers' technical materials regarding existing and emerging technologies.

3.1.1.1 Categories of Nitrogen Reducing Technologies

A variety of nitrogen reducing technologies can be considered for possible Florida OSTDS applications. The technologies differ in availability of data on their effectiveness, stage of development, treatment approach and other characteristics. To simplify evaluation and provide a framework for further analysis, the available technologies were grouped by the treatment processes used to achieve nitrogen reduction. Four major categories were identified: source separation, biological nitrification/denitrification, physical/chemical, and "natural systems". Each of these categories was broken down further based on distinct process variations within a group (see Figure 3-1). The most prevalent nitrogen reduction processes used for onsite sewage treatment were found to be biological nitrification/denitrification and natural systems. Significant overlap exists between these two process types.

Biological nitrification/denitrification treatment processes are typically contained in treatment vessels, which allow access to observe and modify operation.

"Natural systems" effect treatment from combinations of biochemical processes that occur within the soil matrix and vegetative uptake/evapotranspiration. Conventional onsite sewage treatment and disposal systems and constructed wetlands, which are designed based on mimicking ecological communities, are also included within this group.

Physical/chemical processes, which do not rely on biological processes, are easier to control and are more consistent in treatment achieved, but they require more operator attention and are more costly. Originally thought to be more effective for municipal treatment, they were mostly abandoned as biological processes became better understood and controlled.

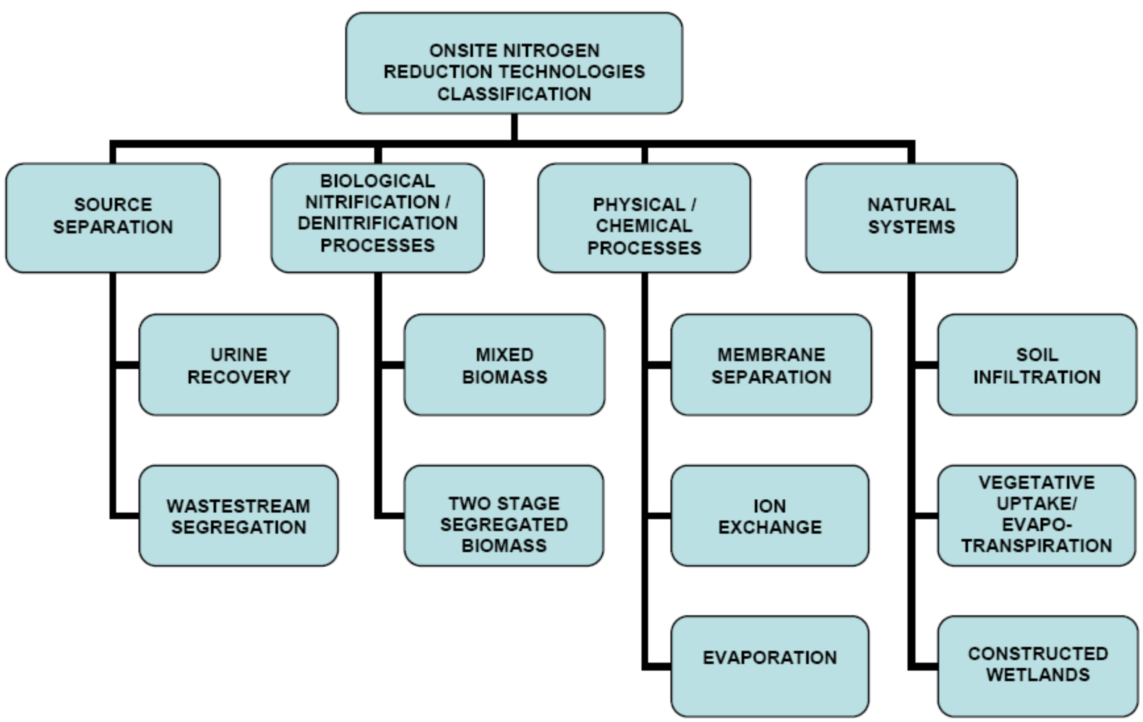

Figure 3-1. Categorization of treatment technologies for nitrogen reduction (Figure 4-1 of the literature review for Task A)

Source separation, on the other hand, is an emerging option for nitrogen removal. A promising practice is urine separation and recovery. Urine recovery can remove 70 to 80 percent of household generated nitrogen by installing urine separating toilets. If the infrastructure for urine collection and use as fertilizer is developed, this offers an effective, reliable and easy to implement option that is low in cost compared to the other identified nitrogen reduction technologies. It also provides a readily available source of fertilizer rich in nitrogen and phosphorus.

3.1.1.2 Process Performance

Data on the performance of OSTDS technologies are available for most biological nitrification/denitrification and natural systems processes. The majority of technologies are proprietary, but some public domain designs exist. Two large groupings of biological nitrification/denitrification processes are distinguished in these technologies: mixed biomass (single stage) and segregated biomass (two stage). The single stage process is the most frequently used process because it relies on organic carbon in the sewage to be the food or electron donor during denitrification as opposed to the two stage process, which requires an external source of food or electron donor. Nearly all of the treatment technologies designed for nitrogen removal can achieve close to 50 percent total nitrogen reduction, but as removal requirements increase, fewer technologies are available. Table 3-1 summarizes the performance capabilities.

Table 3-1. Biological Denitrification Processes and Typical Nitrogen Reduction Limits of OSTDS (modified Table 5-3 of literature review for Task A)

Biological Denitrification Processes and Typical Nitrogen Reduction Limits of OSTDS			
Process	**Mixed Biomass (Simultaneous)**	**Mixed Biomass (with Recycle)**	**Segregated Biomass (Two Stage)**
Electron Donor	Organic carbon from bacterial cells	Organic carbon from influent wastewater	External electron donor (Organic carbon; Lignocellulose; Sulfur; Iron, Other)
Typical N Reductions	40 to 65%	45 to 75%	70 – 96%
Typical Technologies	• Extended aeration • Pulse aeration • Recirculating media filters • Sequencing batch reactors • Reciprocating media beds • Membrane bioreactor	• Extended aeration with recycle back to septic tank • Recirculating media beds with recycle back to septic tank • Moving bed bioreactor	• Heterotrophic suspended growth • Heterotrophic packed bed fixed film • Autotrophic packed bed fixed film

The single stage process has been shown to achieve high removals of nitrogen in municipal wastewater treatment, but for this process the amount of organic carbon reaching the denitrification stage in OSTDS appears to be limiting the amount of nitrogen reduction that can be achieved. This phenomenon can be seen in the performance of OSTDS that use different methods of carbon management in the system. Those nitrogen reducing OSTDS that rely on organic carbon released by dying microorganisms in the active biomass of the system typically achieve 40-65 percent total nitrogen removal, while OSTDS that regularly recycle nitrified wastewater back to the anoxic septic tank to mix with organic carbon present in the raw wastewater typically achieve 45-75 percent total nitrogen reduction.

Segregated biomass or two stage processes, which do not rely on organic carbon in the system but rather add carbon or other food compounds to the denitrification stage from an external source, can achieve nearly complete removal of nitrate by adding carbon into the denitrification reactor. Examples of this approach include two technologies currently in innovative system status in Florida, the passive Nitrex™-reactive media and active dosing with Micro CG, both of which require nitrifying pretreatment. Another example is the “bold-and-gold”-media that is currently being developed at the University of Central Florida. A segregated biomass (two stage) biological nitrification/ denitrification process would be necessary where strict total nitrogen limits that require more than 70 percent removal prior to discharge to the drainfield.

Natural systems, which include the traditional OSTDS, also have inherent performance limitations. Application of septic tank effluent to unsaturated soil results in excellent oxygen demand (cBOD5) and fecal coliform removals. Soils with moderate to high hydraulic permeability with unsaturated (vadose) zones several feet deep below the system infiltrative surface are favored by onsite sewage regulations to achieve such treatment. Such soils are well aerated, which provide efficient and nearly complete nitrification of the influent nitrogen, but as a result of the aerobic soil atmosphere, the vadose zone is unable to retain organic carbon. This is a reason why nitrogen removals in conventional OSTDS are typically less than 40 percent. If aerobic pretreatment and nitrification were to be provided upstream of the infiltration system, slowly permeable soils, shallow organic soils, and soils with shallow perched saturated zones, which typically are restricted for OSTDS, would favor greater denitrification. Infiltration systems, such as mound systems, which could be constructed above the ground surface with the soil’s O and A horizons left intact, may provide nitrification through the sand fill and denitrification through the organic layers below, if anoxic.

The effect of timed dosing of septic tank effluent on nitrogen reduction appears to be not a settled matter. While the project team proposed in their literature review that such drip dispersal could enhance nitrogen reduction because of wetting and drying cycles with alternating aerobic and anoxic soil conditions, they assigned the lowest possible score to the nitrogen reduction performance of dosed septic systems, and the second lowest score to the performance of a drip irrigation system (see Table 3-4 below). Comments received on drafts of this interim report cited studies that did not find an enhancement of nitrogen reduction due to dosing. In reflecting on the cited studies, it appears that an enhancement has more frequently been found in fine-grained material, such as loam, while case studies that have found no enhancement tended to address coarser material such as sand.

Soil infiltration systems, particularly those that use drip dispersal, can also be constructed to create large “footprints” parallel to the lot’s contours, which reduce the mass of nitrogen loading per square foot of area to avoid unacceptable concentrations in the underlying groundwater. Like any of the natural systems though, carbon management is problematic and because the discharges are below the ground surface, compliance monitoring is difficult and costly. Therefore, OSTDS are usually only favored where strict nitrogen limits are not required.

3.1.1.3 Emerging Technologies

Few emerging technologies were identified in the literature. Most of those that were found have been variants to well-established processes. Others that could be considered new technologies for onsite treatment, such as distillation or ion exchange, are early in their development stages and are not yet proven effective.

The most promising new technology for consideration in Florida is urine recovery. This method of nitrogen reduction is already practiced in Scandinavia where urine separating toilets are commercially available. Implementation of this method of nitrogen reduction would be highly effective and far less costly if the necessary servicing and urine reuse infrastructure could be built and public objections to the idea of urine recovery could be overcome or avoided. In addition to ease of use and lower costs, urine recovery also has the added benefit of reducing phosphorus discharges.

3.1.1.4 Establishing Nitrogen Reduction Standards

The need for nitrogen reduction is not likely to be the same for all receiving environments. Therefore, because most nitrogen reduction options are more costly than traditional OSTDS, more complex, and require more attention to operate, the requirements for nitrogen reduction should be carefully considered. The considerations will result in the appropriate treatment requirement and the variations around that standard that will be allowed. Such an analysis should also consider the point of the standard's application. Several options exist. These include the end-of-pipe prior to discharge to the soil, the point below the system where the percolate enters the groundwater, at a property boundary, and/or at a point of use, e.g. a well, or a surface water. End-of-pipe points of application do not account for further treatment that might be attained in the soil. On the other hand, if the monitoring points are at poorly defined locations below the ground surface, compliance monitoring can be more costly and yield ambiguous results.

3.1.1.5 Technology Selection

The wide ranges of technological performance capabilities on the one hand and environmental sensitivities on the other suggest that appropriate solutions may be site-specific. The variety of available nitrogen reduction technologies and performance capabilities allows selection of a system design that can best meet the particular site conditions and nitrogen reduction requirements established for the area. For example, where the density of housing is low and far from high value surface or ground waters, natural systems, such as conventional OSTDS, might be appropriate. In poorly drained soils or where the soil underlying the system contains organic matter, a component designed to nitrify the wastewater before discharging to the soil could be added. In areas where surface waters are not considered threatened, but preventive measures are considered prudent, a technology using a mixed biomass nitrification/denitrification process that is capable of removing at least 50 percent might be most practical. In sensitive areas where protection of ground and surface waters is a high priority, a two stage nitrification/denitrification process could be the only acceptable alternative.

3.1.1.6 Management and Enforcement

Implementation of nitrogen reduction technologies will expand the DOH's monitoring and enforcement operations and the owners' responsibilities toward their systems. In Florida, a regulatory framework for aerobic treatment units and performance-based treatment systems already exists that provides a current framework for the management of nitrogen reducing technologies. This can serve as a starting point for further development.

The literature review did not address management in much detail. At this point in the study it is unclear if the current framework in terms of regulation or resources will be sufficient for new technologies. The following are some general concepts about management and enforcement from the literature review for Task A.

Thought must be given to how nitrogen reduction standards are to be stated and how compliance monitoring is to be performed. Nitrogen reduction standards may be stated as concentration limits or as percent removals. Nitrogen reduction standards will require water quality sampling to confirm compliance. Alternatively, rather than water quality sampling, compliance could be based on proper technology selection with processes that are known to meet the desired removal and routine maintenance and/or inspections to ensure the technology is functioning as intended. This latter approach to stating standards would likely be much less costly to monitor.

Monitoring of a sample of systems within the watershed rather than individual system monitoring to observe the aggregate impact of OSTDS on water resources could also be an effective alternative. Since impacts to watersheds have many sources and are tracked by multiple agencies, costs of monitoring could be shared between state and local water quality agencies.

Regardless of the choices made, system performance and maintenance tracking, inspections, monitoring and enforcement procedures should be available for deployment prior to permitting nitrogen reduction systems. Needed service provider qualifications and certification programs and sufficient service provider capacity also should be developed before widespread nitrogen reduction system implementation. A public awareness program will be needed also. Without these programs, requirements for nitrogen reduction systems are not likely to achieve the intended goals.

3.1.2 Technology Classification, Ranking and Prioritization of Technologies for Field Testing within this Project

(modified, edited and condensed based on the report for subtasks A7/8/9)

3.1.2.1 Classification

The results of the literature review (discussed in Section 3.1.1) led to development of a scheme for classifying nitrogen reduction technologies to allow comparisons between the many options that are available for use in onsite sewage treatment systems. This scheme consists of four categories for classification: source separation, biological treatment via nitrification/denitrification, physical/chemical treatment, and natural systems. In most available onsite nitrogen reduction technologies, it is typical that more than one of these processes are operative in any given treatment system. The classification followed largely the pattern developed for the literature review (see Figure 3-1).

3.1.2.2 Ranking Criteria

A simple numerical ranking system was developed to prioritize available nitrogen reduction system categories for testing in this project based on thirteen selected criteria. Each criterion was scored against its particular attribute using a scale ranging from 1 to 5. To account for relative differences in significance of each of the criteria, the criteria were assigned weighting factors indicating relative importance compared to the other criteria. The relative weights of the criteria were determined via a two stage process. First, each criterion was compared to every other criterion by the project team prior to the Technology Classification, Ranking and Prioritization Workshop and then by the RRAC at the workshop. Second, in order to reconcile the differences between the project team and RRAC weights, the weights for each criterion were averaged. Two criteria, construction and operational complexity, were added during the RRAC workshop. During subsequent discussions, RRAC concluded that the weight for energy requirements should be the same as for operation and maintenance cost. Table 3-2 shows the final criteria with their weights.

The scoring systems were created with the full knowledge that data would not be universally available. Scores were made using the given criteria and good engineering judgment, based on the experience of the team where data was not available. Data available for classifications or groupings of technologies were gathered and reviewed by the project team. Given the wide variety of sources and scales, the resulting score was informed by the data but not necessarily based on a particular statistic (such as median or average) of the available data. In one particular way did the criteria depart from the results of the literature review. While the literature review summarized performance as a fraction of nitrogen removed, which accounts for the variability of nitrogen concentrations in untreated sewage, the ranking criterion focused on effluent concentrations regardless of the nitrogen concentrations in the influent of the treatment system. Table 3-3 illustrates the scoring system for each criterion.

Table 3-2. Ranking criteria and weighting factors to evaluate technologies for testing (Table 3-1 from classification, ranking, and prioritization report)

Ranking Criteria and Weighting Factors			
Criteria	**Maximum Score S**	**Weighting Factor W**	**Total Possible Score SxW**
Effluent Nitrogen Concentration	5	11	55
Performance Reliability	5	10	50
Performance Consistency	5	9	45
Construction Cost	5	7.5	37.5
Operation and Maintenance Cost	5	7	35
Energy Requirement	5	7	35
Construction Complexity	5	5	25
Operation Complexity	5	5	25
Land Area Required	5	4.5	22.5
BOD/TSS Effluent Concentration	5	3.5	17.5
Restoration of Performance	5	3.5	17.5
System Aesthetics	5	2	10
Stage of Technology Development	5	0.5	2.5
		Total:	377.5

Table 3-3. Score assignments for ranking criteria (after Table 4-2 from classification, ranking, and prioritization report)

Criteria Scores

Criteria Number	Criteria	Score				
		1	2	3	4	5
1	Effluent Nitrogen Concentration (mg-N/L)	> 30	16 – 30	11 – 15	3 – 10	< 3
2	Performance Reliability	Monthly		Quarterly	Semi-Annually	Annually
3	Performance Consistency	Activated Sludge Nite/Denite	IFAS[2]	MBR/IMB[3]	Fixed Film	Physical/ Chemical & Source Separation
4	Construction Cost ($1,000's) [3)]	>20	16-20	11-15	5-10	<5
5	Operation and Maintenance Cost ($/year) [4)]	>500	401-500	301-400	200-300	<200
6	Energy Requirement (kW-h/year)	>2500	1501-2500	1001-1500	500-1000	<500
7	Construction Complexity	Complex installation, specialized training, sophisticated electrical and controls knowledge req., master septic tank contractor		Some specialized knowledge and training required		Simple to install by any Contractor
8	Operation Complexity	Complex operation with operator training required; Scheduled visits by manufacturer's representative required quarterly		Some specialized operator training required; Scheduled visits by manufacturer's representative required twice per year		Simple operation with limited operator requirements; annual manufacturer's representative scheduled visit
9	Land Area Required (ft2) [5)]	>2000	1001-2000	501-1000	250-500	<250
10	BOD/TSS Effluent Concentration (mg/L)	>50	30/30		20/20	10/10
11	Restoration of Performance	Activated Sludge Nite/Denite	IFAS [1)]	MBR [2)]	Fixed Film	Physical/ Chemical & Source Separation
12	System Aesthetics	Not Acceptable		Perceived Nuisance/ Displeasing		Acceptable
13	Stage of Tech. Development	Conceptual	Experimental	Demonstration	State Use	National Use

1) Integrated Fixed-Film Activated Sludge
2) Membrane Bioreactor
3) Construction cost assumes a standard septic tank cost of $2000 and drainfield cost of $4500 installed.
4) Operation and maintenance cost includes inspections, annual operating permit fee ($100), and maintenance entity, but it does not include power costs.
5) Land area is for a new entire system, and assumed standard septic tank 50 SF and drainfield 400 SF.

More details on the individual criteria and how their scores were determined can be found in the Hazen and Sawyer's report on Technology Classification, Ranking and Prioritization of Technologies. Comments on the report received by FDOH pointed out that the stage of technology development criteria was assigned a very low weight and disagreed with the scoring on this item.

3.1.2.3 Ranking Results to Prioritize Systems for Testing

A summary of the individual criterion scores for physical/chemical, biological, natural systems, and source separation technology classifications is presented in Tables 3-4 and 3-5. While the tables encompass the full range of possible systems contained in the classification, technology classifications that the project team deemed to lack sufficient data to make a criteria ranking determination were left blank. Technologies are summarized in broad categories. Scores for well established technologies reflect typical values from field installations, while scores for more experimental technologies tend to suggest the potential for the technology based on more controlled tests. In addition, the ranking of some of the technologies, in particular soil infiltration with reactive media, reflects the expectations of the project team extrapolated from other technologies more than from actual available data.

The rankings did not include a conventional septic system in which flow to the drainfield occurs by gravity. Such a system is likely to achieve a ranking slightly better than that of a dosed drainfield within the natural system category, based on lower construction and lower electrical costs, and have the same low score on effluent nitrogen concentration. It was not included separately due to the emphasis on prioritizing modifications and alternative technologies for testing during this project.

The top ranked pretreatment or pre-disposal technology classifications for testing (1 & 2) were biological systems with two stage segregated biomass employing autotrophic (chemical-fed) and heterotrophic (carbon-fed) denitrification. These systems are passive, expected to require little operator attention, and expected to provide high reliability. The total scores for autotrophic and heterotrophic denitrification technologies in two stage segregated biomass systems were sufficiently close that they were considered essentially equal. The third and fourth ranked technology classifications were mixed biomass fixed film biological systems with recycle and without recycle, respectively. The total scores for these systems were sufficiently close that they were considered essentially equal. These technology classifications are expected to have the stability advantages that are inherent in fixed film processes.

It is important to note that the natural systems should not be quantitatively compared, using these ranking criteria, to the groups of biological systems detailed in Table 3.4. Primary among considerations supporting this division of technologies is the need to consider separately the elements of each system that performs treatment. The soil infiltration units utilize the soil's ecology and physical characteristics to perform treatment, and all relevant data measures the treatment capacity within the soil to reduce nitrogen. However, it must be kept in mind that the vast majority of biological systems also discharge to the soil. In order to be able to rank each technology fairly, only the nitrogen reduction components were considered. Moreover, management of non-soil based technologies, though more expensive, is simplified because the units can be operated effectively to adjust to varying conditions and serviced easily, which may not be the case with soil-based nitrogen reduction technologies. When malfunctions occur with soil-based technologies, repairs may be necessary and could lead to expensive reconstruction. When the latter is necessary, available land area can become a severe constraint. Finally, while soils provide good treatment over a broad range of conditions, variability of characteristics among soil units can be large, creating significant uncertainty in predicting a soil's nitrogen reduction capacity.

Table 3-4. Project ranking results for pre-disposal treatment technologies based on ranking criteria (after Tables 4-3 and 4-5 from classification, ranking, and prioritization report)

Technology Classification	Criteria													Total Score
	1	2	3	4	5	6	7	8	9	10	11	12	13	
	Effluent TN Conc. (mg/L)	Performance Reliability	Performance Consistency	Construction Costs ($1000)	O&M Cost	Energy Req. (kW-h/yr)	Construction Complexity	Operation Complexity	Land Area Req. (ft^2)	BOD/TSS Effluent Conc (mg/L)	Restoration of Performance	System Aesthetics	Stage of Technology Development	
Weighting Factor	11.0	10.0	9.0	7.5	7.0	7.0	5.0	5.0	4.5	3.5	3.5	2.0	0.5	
Physical/Chemical														
Membrane Separation	Not Enough Available Data to Score													
Ion Exchange	Not Enough Available Data to Score													
Evaporation	Not Enough Available Data to Score													
Biological														
Mixed Biomass														
Suspended Growth	3	3	1	2	2	2	3	3	3	4	1	5	5	188.5
Fixed Film														
Fixed Film with recycle	2	4	4	2	3	2	3	3	3	5	4	5	5	235.5
Fixed Film without recycle	1	4	4	2	4	3	3	3	3	4	4	5	5	235
Integrated Fixed Film Activated Sludge	2	3	2	2	2	1	3	3	3	4	2	5	5	183
Two Stage (Segregated Biomass)														
Heterotrophic Denitrification	4	5	4	2	3	2	3	5	3	4	4	5	3	273
Autotrophic Denitrification	4	5	4	2	3	2	3	5	3	5	4	5	3	276.5
Source Separation Systems														
Urine Recovery	Not Enough Available Data to Score													
Wastes Segregation	Not Enough Available Data to Score													

The top ranked "natural system" was soil infiltration with reactive barriers, an approach for which the literature review had gathered little information. The second ranked natural system is traditional trench drainfield with timed dosing of septic tank effluent. However, this system received the lowest treatment score. Application of our ranking system to certain kinds of natural systems can be misleading from a purely quantitative perspective. In this instance, the score is high because of its passive characteristics and low operating costs, but does not address the difficulty of performance monitoring capabilities, the costs associated with correcting poor performance, and the low nitrogen treatment.

Table3-5. Project ranking results for "natural system" technologies based on ranking criteria (Table 4-5 from classification, ranking, and prioritization report)

Technology Classification	Criteria													Total Score
	1	2	3	4	5	6	7	8	9	10	11	12	13	
	Effluent of TN Conc. (mg/L)	**Performance Reliability**	**Performance Consistency**	**Construction Costs ($1000)**	**O&M Cost**	**Energy Req. (kW-h/yr)**	**Construction Complexity**	**Operation Complexity**	**Land Area Req. (ft^2)**	**BOD/TSS Effluent Conc (mg/L)**	**Restoration of Performance**	**System Aesthetics**	**Stage of Technology Development**	
Weighting Factor	11.0	10.0	9.0	7.5	7.0	7.0	5.0	5.0	4.5	3.5	3.5	2.0	0.5	
Natural Systems														
Soil Infiltration														
With dosing	1	5	4	5	4	5	5	5	3	5	4	5	5	305
With reactive barriers	5	5	4	3	3	5	3	4	5	5	4	5	3	320
With drip dispersal	2	4	4	4	3	5	3	3	3	5	4	5	5	271.5
Annamox	Not Enough Available Data to Score													
Constructed Wetlands														
Subsurface flow with pre-nitrification	3	5	4	2	4	5	3	3	3	3	3	5	5	274

3.1.2.4 Recommendations for Testing

The technology classification ranking provides the basis from which to formulate recommendations for the field testing to be conducted in Task B of the Florida Onsite Sewage Nitrogen Reduction Strategies Study. It is anticipated that up to 12 technologies can be tested, depending on funding and future extensions of the project. In addition to the ranking scores, the criteria used to consider in establishing priorities for testing include representation of several technology classifications, nitrogen effluent performance data, similarity of technologies, and maturity level of technologies. The purpose of prioritization was to select the more promising technologies that may not have sufficient prior testing or may be differently configured to improve performance, and to avoid duplicate testing where substantial experience already exists. The priority list for Task B testing is listed in Table 3.5 and discussed briefly below.

All of the technologies can be employed for new installations. Most of them (except the source separation systems 11 and 12) could possibly be inserted between an existing septic tank and existing drainfield in existing systems, if the existing tank is structurally sound and appropriately sized. For systems three and four, a retrofit might involve the addition of pumping and filter mechanisms and the installation of a new drainfield.

The two highest priorities for testing are biological systems with two stage segregated biomass employing autotrophic (system 1) and heterotrophic (system 2) denitrification. These systems are passive and expected to require little operator attention and provide high reliability

The first stage of each is a mixed biomass recirculating biofilter through which nitrification occurs. Significant denitrification also occurs due to the recirculation. The biofilters can employ a variety of fixed film media, many of which are in current use and are described in the literature review. Passive Nitrogen Reduction System Phase II (PNRS II) testing will provide additional data for biofiltration with recycle using clinoptilolite, expanded clay, and polystyrene. The best performing media from PNRS II testing will also be recommended for Task B testing.

The second stage of these hybrid systems will employ autotrophic denitrification and heterotrophic denitrification, respectively. Systems with heterotrophic (carbon addition) denitrification are commercially available. Two such systems, one employing a passive media and one employing more active dosing, already have received an innovative system permit in Florida. Treatment media being developed at the University of Central Florida also fall into this category of heterotrophic denitrification. The project team proposes to use sulfur as medium for autotrophic denitrification. This approach will be further evaluated during PNRS II testing, in continuation of the column studies performed during PNRS I. Comments received by FDOH on drafts of this report suggest a particular need to evaluate the environmental impact of the end products of the autotrophic reactions, such as sulfate.

System 3 is an experimental “natural system” that uses drip dispersal into amended soil of settled or secondary effluent. To enhance denitrification, an in-situ reactive media barrier will be constructed below the drip dispersal tubing. Effluent is dispersed within the root zone and percolates downward through the reactive media barrier containing high water retention materials such as expanded clay and lignocellulosic or elemental sulfur electron donors to support heterotrophic or autotrophic denitrification. The literature did provide few data on the merits of this approach. The design of this system will be based on the results of PNRS II, in which variants of this basic system will be evaluated to determine the design that results in the best nitrogen reduction performance. This system would meet the project definition of passive technology and has the potential to be a low cost in-situ system that can be applied for new installations or retrofits.

System 4 is a “natural system” using drip dispersal of settled or secondary effluent into the soil. By dosing septic tank effluent into the soil on timed cycles, alternating aerobic and anoxic conditions can be created in the soil near each emitter, which may create the necessary conditions for nitrification/denitrification to occur. This intermittent dosing of septic tank effluent has been shown by several studies to reduce the total nitrogen that migrates downward from the point of application. Other studies have shown a limited effect, and the performance score (see table 3-5) for this approach was relatively low. This approach has the potential of being a relatively low cost modification to conventional system that allows the reuse of wastewater for landscape irrigation. Secondary pretreatment is currently required for drip irrigation in Florida and the combination is frequently used in Florida, but a thorough evaluation of the nitrogen reduction benefits of drip irrigation is missing. This approach will also be tested under controlled conditions at the PNRS II test facility in direct comparison to a similarly sized system 3 and a pressure dosed system.

Systems 5 and 6 are similar to Systems 1 and 2, in that they are hybrid mixed/segregated biomass systems with a first stage fixed film bioreactor with or without recycle, followed by a heterotrophic (System 5) or autotrophic (System 6) denitrification filter. Systems 5 and 6 expand the evaluation of the hybrid mixed/segregated biomass systems over that provided by systems 1 and 2 alone.

Systems 7 and 8 are IFAS (Integrated Fixed-Film Activated Sludge) systems. They combine elements of both fixed film and suspended growth microbial communities, resulting in relatively stable treatment processes that achieve more reliable and consistent performance than other mixed biomass processes. Such systems are frequently used as aerobic treatment units in Florida. The performance of one fixed film activated sludge technology (FAST) was previously evaluated under controlled conditions in a study in the Florida Keys that helped to establish nitrogen treatment standards and has been frequently permitted for nitrogen reduction.

System 9 is a suspended growth system, specifically a Sequencing Batch Reactor (SBR). Theoretically, SBR’s should be able to control the loss of carbon better than other mixed biomass systems. While common elsewhere, sequencing batch reactors are largely absent from Florida’s advanced systems.

System 10 is a membrane bioreactor (MBR), which combines suspended growth with a membrane filtration unit. MBR has been applied for onsite treatment of multifamily residential wastewater and is an emerging treatment option for single family home systems.

Systems 11 and 12 are source separation systems. Source separation is an emerging onsite wastewater management option and may become increasingly prevalent in the future in keeping with needs for sustainability and resource recovery. With regard to nitrogen removal, source separation has the potential to be a particularly efficient option since 50 to 75% of household waste nitrogen is from urine. Accordingly, separating the waste streams allows for more efficient, dedicated treatment options for individual components of the wastewater stream. Composting and incinerating toilets can currently be permitted and the statute for the Suwannee and Aucilla flood plains treats composting toilets similar to a 50% nitrogen reduction system.

Table 3-6. Recommendations for technologies to be tested at the test center and in field installations (after Table 4.7 from classification, ranking, and prioritization report)

System	Technology	Project Team Comment	Comments on Previous Florida Experience and Testing Approach
1	Two stage (segregated biomass) system: Stage 1: Biofiltration with recycle (nitrification) Stage 2: Autotrophic denitrification with reactive media biofilter	Top ranked system capable of meeting the lowest TN concentration standard	-Column experiments performed during PNRS I -Further evaluation, including fate of sulfur, planned in PNRS II test facility (Task A)
2	Two stage (segregated biomass) system: Stage 1: Biofiltration with recycle (nitrification) Stage 2: Heterotrophic denitrification with reactive media biofilter	Top ranked system capable of meeting the lowest TN concentration standard	-Innovative System Permit for Nitrex after biofiltration pretreatment, a passive system per project definition -Innovative System Permit for Pura-Flo with Micro C-G addition, a biofiltration pretreatment with active carbon dosing -University of Central Florida is developing “bold and gold” treatment media and configurations
3	Natural system: Septic tank/Mound with in-situ reactive media layer	Lower cost natural system that is untested but appears capable of achieving 75-78% TN removal before reaching groundwater	-Initial evaluation, including fate of sulfur, planned in PNRS II test facility (Task A)
4	Natural system: Settled or secondary effluent with drip dispersal	Suitable for reducing TN impacts on groundwater through enhanced TN removal and reduced TN loading on soil	-Secondary effluent with drip is frequently used in Florida, more performance data needed -Secondary pretreatment currently required in Florida for drip -Evaluation at PNRS II test center in comparison to system 3 planned
5	Mixed biomass fixed film system with recycle followed by a heterotrophic denitrification with reactive media biofilter	High performance aerobic treatment with anoxia for enhanced TN removal followed by second stage heterotrophic denitrification for high nitrogen removal	See system 2
6	Mixed biomass fixed film system with recycle followed by an autotrophic denitrification with reactive media biofilter	High performance aerobic treatment with anoxia for enhanced TN removal followed by second stage autotrophic denitrification for meeting low TN concentration standard	See system 1
7	Mixed biomass integrated fixed film activated sludge system: with recycle	High performance aerobic treatment	-w/o recycle, common technology for aerobic treatment units (FAST, JET, Bionest) and nitrogen reducing systems (FAST) in Florida -FAST technology, including internal recycle, evaluated during previous Florida Keys test center study, preceding establishment of Keys nitrogen treatment standard
8	Mixed biomass integrated fixed film activated sludge system: Moving bed bioreactor	High performance aerobic treatment with simultaneous denitrification	-Very limited information from innovative system testing of one particular technology.
9	Mixed biomass suspended growth system: Suspended growth sequencing batch reactor	Aerobic treatment\	Common elsewhere, largely absent in Florida
10	Membrane process system: Membrane bioreactor (MBR)		New for single family residences in Florida
11	Source separation system: Dry toilet (evaporative or composting)	Eliminates liquid disposal of toilet wastes	-Several manufacturers approved based on NSF testing/certification -Suwannee/Aucilla statute treats this similar to 50% nitrogen reduction
12	Source separation system: Urine separating (recovery) toilet	-Innovative system that is capable of removing 70-80% of the household TN at little capital cost -Provides potential for sustainable recovery of nutrients	-Requires different plumbing -Need clarification on approval standards

3.1.3 Test Facility Selection

Two sites were evaluated by the provider: the University of South Florida (USF) Lysimeter Facility property and the University of Florida's Gulf Coast Research and Education Center (GCREC) near Wimauma, FL. Salient issues included space availability, site access, wastewater source of sufficient quantity and quality, subsurface hydrology, power supply and security.

Summary (edited from GCREC memo by Hazen and Sawyer)

Based on the cost and time associated with rehabilitating the USF facility, it has become apparent that proceeding with construction of two test facility sites will be costly and time consuming. The current budget in the FOSNRS contract for construction of a test facility at USF does not appear to be sufficient for both the rehabilitation work and the testing facility construction. In addition, the USF Lysimeter station can only be used for pilot tests of treatment technologies and unsaturated zone work, since the water table is extremely deep at the site (>25 ft.) and sufficient area for plume delineation and monitoring is not available. Management of two facilities once operational will also be more difficult and expensive in future phases of the project.

At GCREC, the preliminary soils, wastewater (STE) quality, and groundwater assessment appear to be conducive to performing the proposed work. While the flatwoods type soils at the site have a shallow groundwater that may be more likely to support in-situ denitrification, the soils of the Florida flatwoods land resource area make up approximately 55% of the area of the state, or over 60% if the Everglades land resource area is excluded. In contrast, soils of the central Florida ridge land resource area make up approximately 17% of the area of the state (Ayres Associates, 1987). Also, a site conducive to in-situ denitrification is desirable from a groundwater modeling perspective. To include denitrification in the models developed in Task D, a study site where denitrification can be measured will be more likely to provide the needed inputs and calibration data for model development. If the mechanisms of in-situ denitrification can be identified at the site, then the models developed should be able to predict whether such denitrification is likely to occur at any given site. Additionally, the individual home field sites for Task C will be chosen to include soils of different types, including well drained fine sands typical of the central Florida ridge recharge areas, and the models developed will be tested at these sites.

Treatment technology pilot testing and both the saturated and unsaturated zone investigations could be performed at the GCREC. Therefore, the Project Team recommendation is to conduct all test facility work at the GCREC.

3.1.4 Passive Nitrogen Reduction Study II (Test Center Technology Development and Testing)

The purpose of the PNRS II study is to extend and expand into field pilot testing the previous experimental studies of the two-stage biofiltration process that were conducted in a previous study for the FDOH. PNRS II will perform field testing of prototype passive nitrogen reduction treatment systems using a variety of candidate biofiltration media. The results of PNRS II may be used to develop and implement subsequent evaluations of full-scale systems that will be conducted under Task B of this project. The pilot test systems will consist of various configurations of in-tank biofilters and passive in-situ systems. In-tank systems will primarily employ variants of the two-stage biofiltration concepts elucidated in PNRS I. In-situ technology evaluation will include a drip irrigation system for effluent dosing, with emitters located in shallow root zones.

Two-stage biofiltration evaluation

Candidate media for evaluation in Stage 1 (unsaturated) biofilters and Stage 2 (saturated) biofilters are listed in Tables 3-6 and 3-7, with physical properties and their sources. Included are media with high water retention and porosity. Stage 1 media includes expanded clay and clinoptilolite. These have greater than 45% porosity and high water retention. Clinoptilolite also contains high ion exchange capacity to retain ammonia ions for enhanced ammonia removal under non-steady flows and higher loading rates. Livlite is an expanded clay with high water retention characteristics. Expanded polystyrene is a very lightweight, readily available, and low cost material that appears to be quite suitable as a biofilter media for aerobic treatment.

The Stage 2 anticipated electron donor media are: elemental sulfur, which will result in an autotrophic denitrification process in the anoxic biofilter; lignocellulosic materials, such as woodchips, which support heterotrophic denitrification; and glycerol, a readily available carbon source for heterotrophic denitrification.

Crushed oyster shell or sodium sesquicarbonate will be used as alkalinity sources in sulfur-based denitrification biofilters, as autotrophic sulfur-based denitrification will consume alkalinity. Expanded shale may be included as a Stage 2 option for its anion exchange capacity to enhance nitrate removal performance.

The biofilter systems will be operated over a twelve month period, dependent on additional funding, during which eight monitoring events will be conducted. A detailed description of analyses is included in the quality assurance project plan (QAPP) document. As outlined in QAPP Table A.1, there are 42 sampling points and a monitoring analyses structure that employs four analytical tiers.

Experimental in-situ simulators

In-situ testing will be conducted using in-situ simulators as shown in Figure 3-3. The simulators will consist of subsurface drip irrigation application to the root zone of surface vegetation, followed by downward transport through a 12-inch layer of filter sand. Underlying the filter sand is a 12-inch layer of engineered media containing electron donor, which is in turn underlain by natural soil. The test matrix consists of subsurface drip irrigation emitter dosing of primary effluent (i.e. septic tank effluent) or nitrified effluent into the root zone of St. Augustine grass. Other than the pumping of effluent by subsurface irrigation, the in-situ simulators are completely passive systems. An innovative feature of the in-situ simulator design is the use of mixed media in unsaturated mode that contains both a high water retention media (expanded clay) and heterotrophic and autotrophic electron donors. This potential for unsaturated in-situ treatment systems, including plant-assisted nitrogen transformations, has not been examined in Florida with innovative systems of this type but is of potentially high significance.

Table 3-7. Materials for Stage 1 Filters (Table 3.3 of PNRS II QAPP)

Stage 1 Vertical Unsaturated Biofilter Configuration and Initial Operation

Unsaturated Biofilters (Stage 1)					
No.	**Media**	**Biofilter**	**Media Depth (Inches)**	**Flow Regime**	**Recycle Ratio (α)**
1	Expanded Clay	UNSAT-EC-1	15	Single Pass	-
2		UNSAT-EC-2		Recycle	3
3		UNSAT-EC-3	30	Single Pass	-
4		UNSAT-EC-4		Recycle	3
5	Clinoptilolite	UNSAT-CL-1	15	Single Pass	-
6		UNSAT-CL-2		Recycle	3
7		UNSAT-CL-3	30	Single Pass	-
8		UNSAT-CL-4		Recycle	3
9	Polystyrene	UNSAT-PS-1	30 (NS)	Single Pass	-
10	Upper: Filter Sand	UNSAT-IS-1	12	Single Pass	-
11	Lower: Expanded Clay, Lignocellulosic, Sulfur	UNSAT-IS-2	12	Single Pass	-

EC: expanded clay, CL: clinoptilolite, PS: polystyrene, SU: sulfur, α: recycle flowrate/forward flowrate, NS: non-stratified

Table 3-8. Stage 2 Saturated Denitrification Biofilter Material, Configuration and Initial Operation (Table 3.6 in PNRS II QAPP)

No.	**Electron Donor**	**Biofilter**	**Media Composition (by volume)**	**Initial Surface Loading Rate, gal/day-ft[2]**	**Stage 1 Filter (Table 3-6)**
1[1]	Elemental sulfur	DENIT-SU-1	80% SU 20% OS	10.0	2,4,6,8
2[1]		DENIT-SU-2	80% SU 20% NS	10.0	2,4,6,8
3[2]		DENIT-SU-3	80% SU 20% OS	4.7	1
4[2]		DENIT-SU-4	80% SU 20% NS	4.7	7
5[1]	Lignocellulosic	DENIT-LS-1	70% LS 30% EC	10.0	2,4,6,8
6[2]		DENIT-LS-2	70% LS 30% EC	4.7	3
7[2]		DENIT-LS-3	50% LS 60% EC	4.7	5
8[2]		DENIT-LS-4	30% LS 70% EC	4.7	9
9[1]	Glycerol	DENIT-GL-1	100% EC	10	2,4,6,8

SU: elemental sulfur, LS: lignocellulosic, GL: glycerol, OS: oyster shell, NS: sodium sesquicarbonate, EC: expanded clay

1. Fed from common Stage 1 effluent collection tank

2. Directly connected to Stage 1 unsaturated biofilter

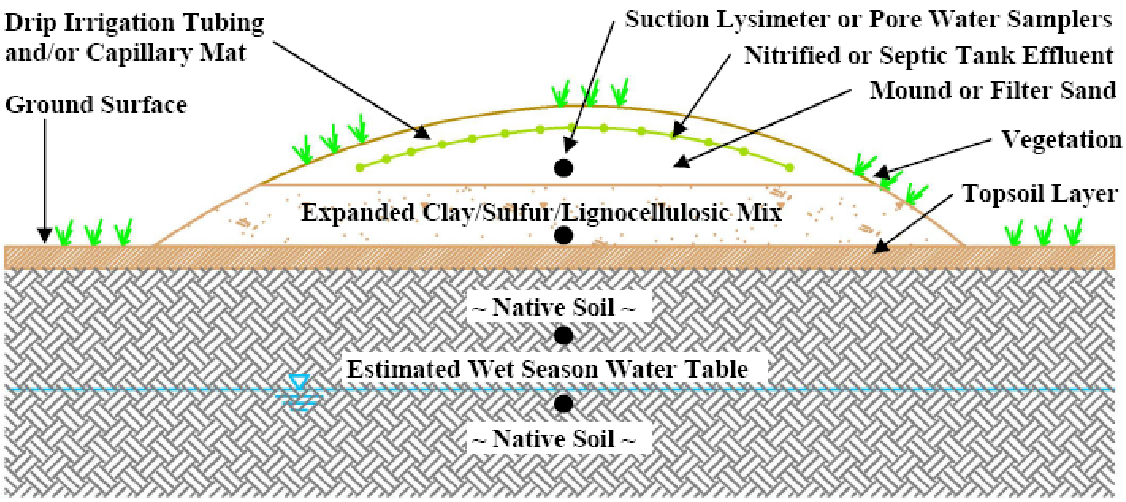

Figure 3-2. Conceptual drawing of in-situ simulators with engineered nitrogen reduction media (Figure 3-2. of Task A QAPP)

3.2 Task C Evaluation of Nitrogen Reduction in Soil and Shallow Groundwater

3.2.1 Literature Review (edited from conclusions of the literature review for Task C)

The literature review revealed numerous factors that may influence nitrogen impacts to groundwater resulting from the use of OSTDS. Transport and fate processes that are present in the OSTDS, vadose zone, and saturated zone all will influence the extent of nitrogen impacts to groundwater. Furthermore, these factors, along with factors related to groundwater/surface water interactions, will also determine if nearby surface water bodies are adversely affected. In doing site assessments, it is therefore important to develop sampling plans that can collect data for a majority of the factors described in the literature. Also, predictive efforts and efforts aimed at reduction of impacts should also consider the findings of the literature review. A brief summary of important points is as follows:

- Some studies identified lot size and location of water supply wells in relation to OSTDS as important factors in determining nitrate contamination to groundwater.
- OSTDS loading rates can significantly impact the performance of the soil and ultimately nitrogen concentrations in the aquifer.
- In certain cases, water table fluctuations may be a larger factor than the loading rate of nitrogen on the overall OSTDS performance.
- Nitrogen reduction in the vadose zone is an important determining factor for nitrate concentrations in the groundwater. This is a complex process dependent on numerous factors that need to be studied in depth.
- Nitrification can be influenced by soil type and appropriate loading of an OSTDS. Some literature indicates that coarse-textured strongly-aggregated soils favor nitrification while finer textured soils lead to the development of anaerobic conditions and inhibit the process.
- Sandy soil aquifers are particularly susceptible to nitrate contamination, particularly in the case of low carbon content aquifers with relatively high groundwater velocities. In

these cases, high concentrations and large areas of impact may be expected due to the lack of transformation and the distance nitrate can travel in a short time period.

- Denitrification occurs largely in anoxic soils and groundwaters with adequate carbon sources. In the soil column, denitrification may occur in systems with high or fluctuating water tables that allow the creation of anoxic conditions, providing the organic carbon content of the soil is adequate. In groundwater, dilution is often seen as the dominant mechanism for the reduction of nitrate, although some studies identify denitrification as the dominant factor. This is highly dependent on site-specific characteristics.
- Denitrification, while being a well-understood process, is poorly quantified and not correlated with other site characteristics, especially when considering the saturated zone. This should be a significant topic of further study.
- Some studies identified the relatively high denitrification capacity of river bed sediments, particularly if they contained high levels of organic carbon. This is especially relevant if the protection of adjacent surface water bodies is a key concern.

The literature review suggests reductions in groundwater nitrogen impacts associated with OSTDS are achievable with a few steps. Nitrate is highly mobile in groundwater and the only significant method of natural attenuation is denitrification, a process that the review indicates is not always present in natural aquifers (however, it should be noted that saturated zone denitrification can be enhanced with amendments as a potential treatment process). Therefore, reduction of nitrate contamination may be most efficiently approached in the design and installation processes when considering OSTDS as a treatment alternative. Appropriate land planning and density of OSTDS in new developments is a first step. OSTDS should be placed to maintain a protective distance for downgradient groundwater and surface water resources. Additionally, recognizing the importance of dilution for nitrate concentration reductions, appropriate lot size should be in the design to allow adequate dilution from recharge water. Within the design of OSTDS, appropriate loading rates and an understanding of OSTDS effluent can achieve lower levels of nitrogen entering the subsurface environment.

Additionally, the review indicates the performance value of appropriate treatment units can improve effluent quality by reducing nitrogen prior to infiltration. Additional optimization can be achieved by a thorough understanding of site characteristics and how these may influence OSTDS performance and ultimately nitrogen concentrations in groundwater. Certain water table conditions, soil types, and other subsurface characteristics, such as pH or temperature, can have an effect on the treatment ability of OSTDS by varying oxygen content and redox conditions. If detrimental conditions are seen at a site being considered for OSTDS, other methods of wastewater treatment may be appropriate. This can also be true for areas identified as “high-risk,” such as areas adjacent to a protected water body. Alternatively, it may be possible to amend the site conditions or use an effluent pre-treatment method to improve OSTDS performance. Future work may be needed to examine the data in such studies and make attempts to correlate hydraulic and reactive parameters to observed nitrogen impacts.

3.2.2 Quality Assurance Project Plan (QAPP) for Field Work for Task C

A three-pronged approach is anticipated for the field work.

Detailed monitoring, including of the vadose zone, under very controlled conditions will be performed to obtain a side-by-side comparison of drip and low-pressure dosed drainfields that are loaded with either nitrified or septic tank effluent. The in-situ simulators from Task A will be monitored in the same way. Table 3-8 shows the experimental design, and Figure 3-4 shows the cross section of the anticipated drainfields and their monitoring equipment.

Monitoring of a test center effluent plume in groundwater will be initially performed at a large mound on the test center. The test center provides somewhat controlled conditions and the size of the mound will make it easier to find the plume and gather insights on the effects of size. Elements of the groundwater monitoring are outlined in Table 3-9. The monitoring will extend for a year to capture seasonal variability. The location at the test center where monitoring will take place is shown in Figure 3-5.

Monitoring of effluent plumes in groundwater at individual home sites will utilize the same methodology as the monitoring of the mound at the test center. It is anticipated that home sites will range across the State of Florida, including north Florida, central Florida (specifically the Wekiva area), and south Florida to capture diversity in site conditions. The monitoring will extend for a year to capture seasonal variability.

Table 3-9. Experimental design of soil and shallow groundwater monitoring (Table 2.2 of Task C QAPP)

Test Area ID	Effluent Quality	Design Hydraulic Loading Rate (gpd/ft^2)	Soil Treatment Unit Design
TA1	STE (septic tank effluent)	0.8	pressure dosed mound
TA2	STE	0.8	Shallow drip dispersal
TA3	nitrified effluent	0.8	pressure dosed mound
TA4	nitrified effluent	0.8	Shallow drip dispersal
TA5	in situ nitrified effluent (Task A)	from PNRS II pilots	mounded drip dispersal over denitrification media
TA6	in situ STE effluent (Task A)	from PNRS II pilots	mounded drip dispersal over denitrification media

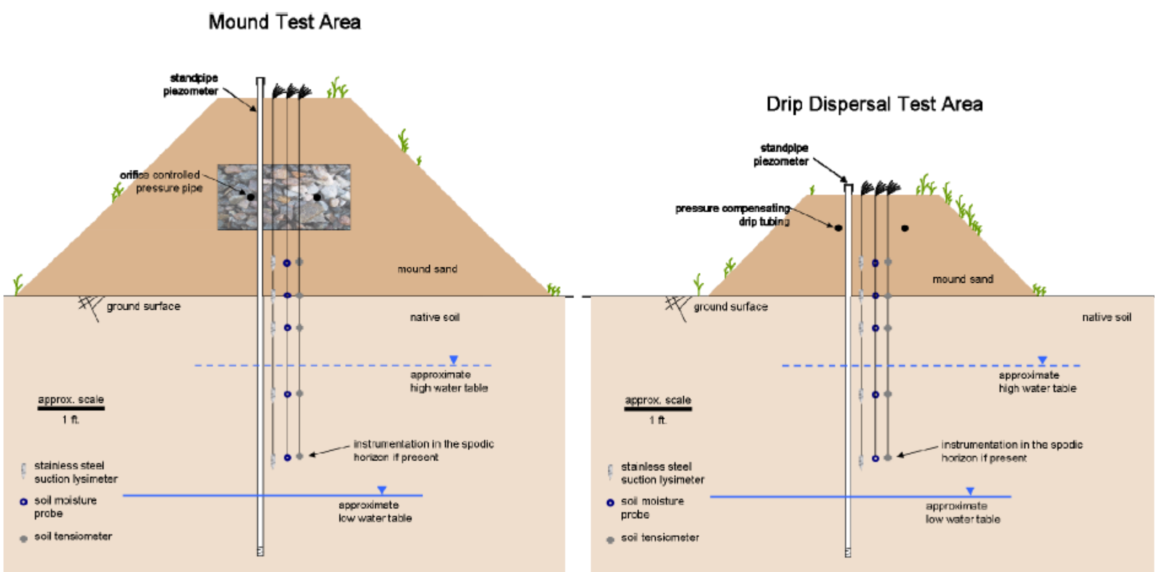

Figure 3-3. Conceptual cross sections of drainfields to evaluate soil nitrogen reduction (Figure 2-2 of Task C QAPP)

Table 3-10. Proposed steps in monitoring the effluent plume of an OSTDS (Table 2-3 of Task C QAPP)

Step	Purpose	Approach	Data to be Collected
1	Plume identification	sampling grid for groundwater screening	in-field measurements of groundwater specific conductance
2	Instrumentation	install multi-level drive point piezometers and shallow standpipe piezometers	soil properties determined from soil borings during standpipe piezometer installation
3	Aquifer characterization	conduct pump test and slug tests on standpipe piezometers	hydraulic gradient, saturated hydraulic conductivity
		baseline tracer test	establish groundwater velocity, dispersivity coefficients, and groundwater dilution
4	Routine monitoring	effluent quality, groundwater concentrations, water levels, climatic conditions	water quality parameters as necessary to determine nitrogen reduction
5	Additional instrumentation, testing, and/or monitoring	as warranted	refine denitrification rates, aquifer properties

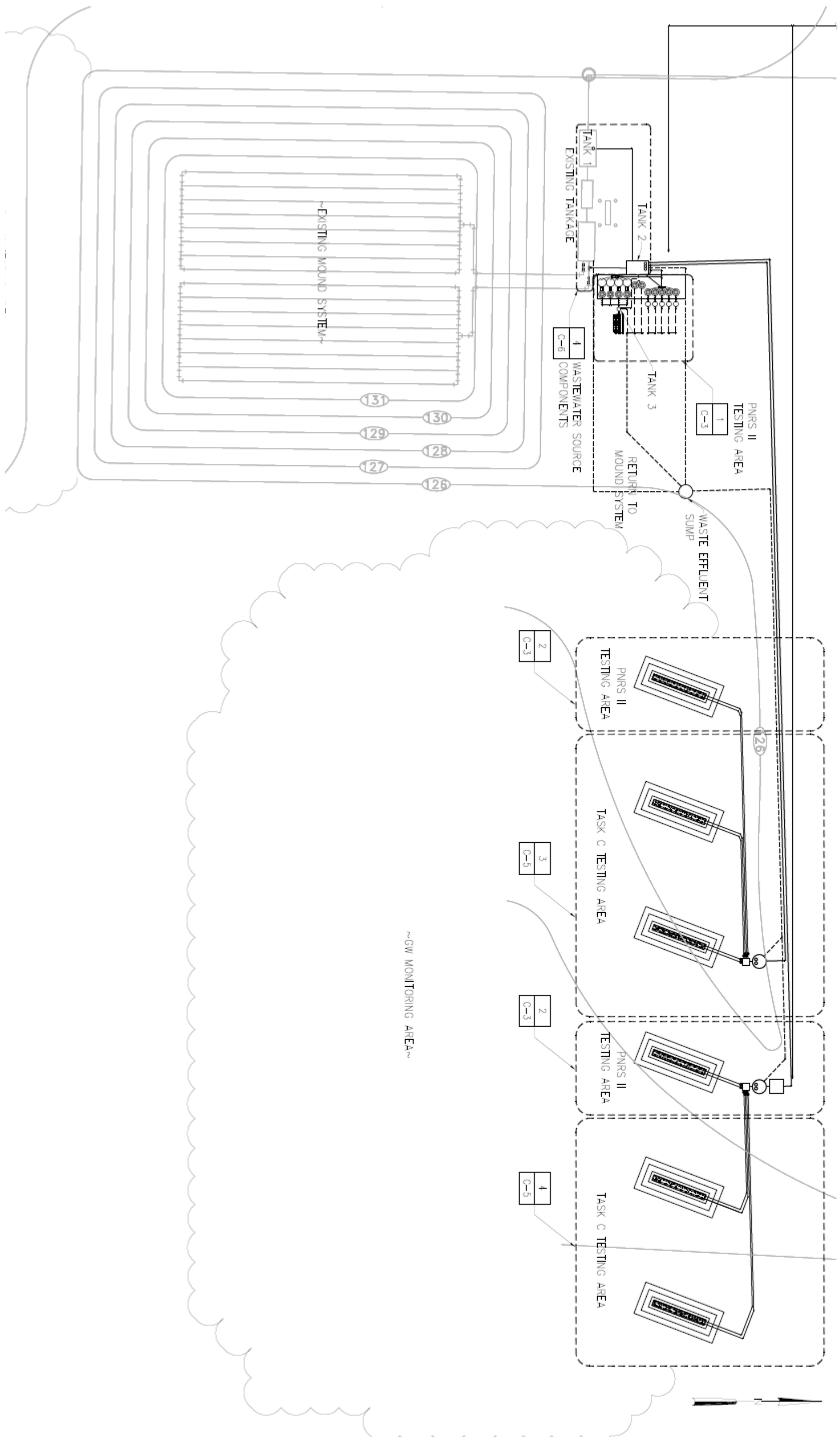

Figure 3-4. Outlay of the groundwater monitoring area at the test center. (Appendix B of Task C QAPP)

3.3 Task D, Nitrogen Fate and Transport Modeling

(edited from conclusions of the draft literature review for Task D)

A review of the literature, the conceptual understanding of the transport of nitrogen as related to OSTDS, and the goals of the project are all taken into consideration when beginning to describe the tool that will be developed. From this, several conclusions and some suggestions for the modeling tool can be developed. The literature review was intended to identify the state-of-knowledge of nitrate fate and transport modeling, identify past models that may provide good templates for the model developed by the FOSNRS Study, and assist in identifying key parameters and processes that need to be represented in a predictive tool.

As with any model development project, the appropriate approach can depend on numerous factors. When conceptualizing a model, several key questions need to be posed, such as:

- Will this model be constructed to represent a specific site of interest or be a predictive tool with broad applicability to a variety of sites?
- What is the desired output?
- What is the most appropriate method of calculating the output?
- Will this model require calibration to existing data sets?
- What, if any, regulatory requirements constrain the model choice?

The modeling tool that is being developed to simulate nitrate fate and transport will require certain features, some of which include:

- Ease-of-use;
- Ability to simulate time-variable OWTS inputs;
- Simulation of transport and fate in both the vadose zone and saturated zones;
- Representation of the numerous advective-dispersive and transformative processes that affect nitrate transport;
- Simulation of temporal and spatial concentrations and mass loading downgradient of the source;
- Include the impacts of seasonal rainfall variation on the source function; and
- Incorporate critical OWTS operating characteristics that strongly influence nitrogen reduction.

Based on the above questions and objectives, many conclusions about the models and model types in the research summary can be made. No simple model (analytical or mass-balance) identified in the literature can currently achieve all of the above-described goals. Also, numerical models are generally not considered a useful tool for system design or regulatory compliance where broad applicability is desired. Thus, development of a new modeling tool is likely required and rigorous numerical modeling may be needed as a first step to determine the most important parameters to include.

A strictly mass-balance modeling approach will likely be inappropriate, as it either does not consider the known physical processes that influence nitrate transport or makes simplifying assumptions about these processes. Furthermore, the output will not satisfy the objectives of the model (time-variable estimations of concentrations at specific spatial points). Nonetheless, these approaches have value in the conceptualization of model inputs and should not be ignored.

Transfer function models have not been widely applied and will likely encounter regulatory resistance, since they are based strictly on probabilities and do not directly consider measured site characteristics.

Both analytical and numerical modeling methods are the most promising approaches when considering the FOSNRS Study model to be developed. These approaches will have wide applicability, regulatory acceptance, and are capable of estimating the important hydrogeochemical properties associated with nitrate fate and transport.

The modeling tool will need to consider transport and transformation (chemical and physical) in the vadose zone, because the nitrogen transformations that occur in this zone have considerable influence on the mass-flux input into the underlying aquifer. This can be a numerical one-dimensional solution of the Richards' Equation. A one-dimensional formulation can likely be implemented in a spreadsheet. Additionally, the modeling will need to consider temporally and spatially variable inputs for multiple OSTDS, as would be found in a community development. This could be addressed through a series of one-dimensional vadose zone models that could provide input to a multi-dimensional groundwater flow and transport model. Both of these studies use the horizontal plane source model or some variation and are also capable of transient simulations. However, the models likely will not be capable of interacting with each other in the vadose zone (i.e., strictly vertical flow is assumed). Nonetheless, the value of including these model features is important when simulating the aerial distribution of OSTDS in a potential housing development and the temporal variation of source input due to changes in wastewater input rate and precipitation recharge. These combined models can likely be implemented in a spreadsheet or using Fortran or C++ programming while maintaining simple and straight-forward input requirements. Of course, no similar model is available to our knowledge, so considerable model research and development must be achieved by this project.

The literature review has suggested the most likely processes and parameters that will need to be considered when developing the modeling tool. The fate and transport of nitrogen products is a result of advective movement, retardation via adsorption, and the transformative processes of nitrification and denitrification. These processes are to be calculated in the model tool via the solutions of the appropriate equations using the necessary parameters, described below. Key parameters to consider for simulation should consist of:

- Physical parameters of the media, such as bulk density, water content, and soil characteristics;
- Advective-dispersive parameters, such as hydraulic conductivity, hydraulic gradient, porosity (or groundwater velocities), and dispersivity values;
- Retardation factor values for ammonium sorption; and
- Rate coefficients for transformative reactions, typically first-order rate constants

A majority of the parameter values needed for model input can be collected during site characterization. In a previous study by members of this project team cumulative frequency distributions (CFD's) were utilized for the estimation of initial parameter values from literature values. This approach results in an uncertain model output where the degree of uncertainty must be quantified. Even if site-specific values are obtained, uncertainty from measurement and subsurface variability remains.

Additionally, many analytical models were found in the literature review (nitrate-specific and general analytical solutions) that are appropriate for the modeling tool, since these can be programmed into a spreadsheet and can be user-friendly.

4 CONCLUSIONS AND RECOMMENDATIONS

The objective of the Florida Onsite Sewage Nitrogen Reduction Strategies Study is to examine nitrogen reduction strategies and technologies for onsite sewage treatment and disposal systems ("OSTDS" also known as "septic tanks") in the State of Florida. FDOH and its

Research Review and Advisory Committee (RRAC), with input from the general public, selected a contractor based on the direction given by the Legislature in the 2008 budget proviso and awarded the contract to a Project Team led by Hazen and Sawyer, P.C., in January of 2009. The contract was based upon an anticipated budget of $5 million over a 3 – 5 year project timeframe. The contract divides the project into the following tasks.

Task A – Technology Evaluation for Field Testing: Review, Prioritization, and Development: This task includes literature review, technology evaluation, prioritization of technologies to be examined during field testing, and further experimentation with approaches tested in a previous FDOH passive nitrogen removal study. Objectives of this task are to prioritize technologies for testing at actual home sites and to perform controlled tests at a test center to develop design criteria for new passive nitrogen reduction systems.

Task B – Field Testing of Technologies and Cost Documentation: This task includes installation of top ranked nitrogen reduction technologies at actual homes, with documentation of their performance and cost.

Task C – Evaluation of Nitrogen Reduction Provided by Soils and Shallow Groundwater: This task includes several field evaluations of nitrogen reduction in Florida soils and shallow groundwater and also will provide data for the development of a simple planning model in Task D.

Task D – Nitrogen Fate and Transport Modeling: The objective of this task is to develop a simple fate and transport model of nitrogen from OSTDS that can be used for assessment, planning and siting of OSTDS.

PROJECT STATUS: Funding for the first phase of this project has been appropriated. As of December 2009, the contractor, in coordination with the RRAC and FDOH, had successfully completed parts of Task A, C, and D described above, including literature reviews, ranking of nitrogen reduction technologies for field testing, design of a test facility for effluent plume monitoring and further development of passive technologies, and preparation of quality assurance documents for the groundwater monitoring and test facility work to be completed during the fiscal year 2010-2011. Installation of a test center for the evaluation of nitrogen reduction techniques and preparation for field sampling is planned for later in the fiscal year 2009-2010. Sampling and reporting of results would continue through subsequent years. Funding for fiscal year 2010-2011 is required to field-test the ranked technologies. Field-testing of technologies at home sites (Task B) is on hold pending future funding.

Anticipated Progress in 2010/2011: During the 2010-2011 fiscal year, the tasks associated with this project are anticipated to include a significant amount of treatment and monitoring system installation and sampling. For Task A, the test facility will have been installed and pilot testing will continue for various passive nitrogen removal technologies. For Task B, several onsite systems will be installed at home locations throughout the State of Florida, and monitoring of the performance of these systems in the field will begin. For Task C, instrumentation of home sites that have been selected to evaluate nitrogen movement in the soil and groundwater will occur and monitoring will begin. The installation of a facility to allow side-by-side evaluation of multiple drainfield configurations and the resulting nitrogen groundwater fate and transport in a common environment will have been completed and monitoring will continue. For Task D, an initial simple model will have been developed, and more complex models that allow evaluation of multiple OSTDS, such as on a development scale, will be developed. An alternative, more complex soil transport model that incorporates a more detailed analysis of transport through unsaturated soil will be developed and integrated with the groundwater transport models. These models will in subsequent years be compared to the data obtained during this project.

Funding Needs: Activities in fiscal years 2008-2010 prepared the framework for rapid implementation of a field sampling program in fiscal year 2010-2011. Funding for fiscal year 2010-2011 is required to reap the benefits of this preparation. The remaining years of the project still require funding in order to complete the goals of this project. For the 2010-2011 budget year $2-million dollars is required to fund the continuation of this study.

Project Tasks (described above) are broken down further into funding phases as follows:

Initial Funding in 2008-2010 (Phase I): Approximately $900,000 already appropriated (in 2008 and 2009 state budgets, see Section 1 of the report) – status: largely complete. The initial funding, as noted in the project status above, has been targeted to prioritize systems for testing, summarize existing knowledge, develop testing protocols, and establish a test facility for detailed soil and groundwater monitoring and preliminary testing of pilot scale passive nitrogen reduction systems.

Funding in 2010/2011: At least $2 million will need to be appropriated during the 2010 legislative session to adequately fund the next phase of the project, primarily for field monitoring over at least a one-year monitoring period of performance and cost of technologies at home sites, and of nitrogen fate and transport. This funding also will continue the development and monitoring work at the test facility, and of modeling.

Future Funding: Future funding will be needed from the 2011 legislative session to complete monitoring and other field activities, additional testing as deemed appropriate by the Legislature, and final reporting with recommendations on onsite sewage nitrogen reduction strategies for Florida's future.

The results of this project will help characterize and refine strategies for cost-effective nitrogen reduction from onsite sewage treatment systems that will protect our environment, as well as, provide cost effective options for citizens of this state.

Recommendations

Recommendations for passive strategies for nitrogen reduction have not been the focus of the first phase of work. It is the intention of the FDOH and the RRAC to include additional recommendations in the May 2010 report.

The FDOH and its Research Review and Advisory Committee recommend the legislature:

- Provide funding and budget authority to the FDOH in the amount of $2 million for the fiscal year 2010-2011 for continuation of the contract and associated tasks.
- Allow the FDOH to carry over any remaining funds from fiscal year 2009-2010 into 2010-2011.

Continued support for this project will ultimately benefit Florida's onsite system owners and will improve environmental and public health protection.