ASSESSMENT OF THE PERFORMANCE AND MANAGEMENT OF ADVANCED ONSITE SYSTEMS IN FLORIDA

Elke L. Ursin[1] and Eberhard Roeder[2]

ABSTRACT

There are an estimated 12,000 advanced Onsite Sewage Treatment and Disposal Systems in Florida. "Advanced" systems for the purposes of this paper include: Aerobic Treatment Units, which generally add air to improve the wastewater treatment process, and Performance-Based Treatment Systems, which are designed by engineers to target specific performance levels for various wastewater components. Proper management of advanced systems is the key to protection of public health and the environment. The United States Environmental Protection Agency's Nonpoint Source grant program funded a statewide evaluation of the performance and management of advanced onsite systems in Florida. A comprehensive evaluation of the advanced systems currently permitted in Florida was performed. This included developing an inventory of advanced systems in Florida to determine system numbers, types, and locations and performing a detailed review of a mostly random subset of identified systems, conducting detailed site evaluations for 550 sites throughout Florida, sampling 350 advanced systems in at least one location along the treatment train, surveying various user groups regarding their perceptions of the systems, creating a monitoring protocol, and documenting best management practices. The data collected during this project were evaluated both from an administrative perspective (completeness of paperwork) and from the perspective of performance in the field. The majority of the estimated 12,000 advanced systems in Florida are located in five counties that generally have state or local requirements for advanced wastewater treatment, and the main treatment technology approach used in Florida is extended aeration. The main problems encountered during field visits were for issues related to mechanical aeration, e.g., systems that were turned off or the aerator was not working. The sampling results showed that these mechanical aeration issues had a direct effect on the performance levels of advanced systems. Analysis of the survey results revealed that almost eighty percent of homeowners were either very satisfied or satisfied with their advanced system. Groups; including regulators, installers, maintenance entities, manufacturers, and engineers; thought that the overall treatment performance of advanced systems was either good or excellent. A monitoring protocol was developed which stressed the importance of keeping the system paperwork up to date; assessing whether the system has power, that no sanitary nuisance exists, that aeration results in bubbles and mixing of sewage, and that there are no alarms sounding; having an easy to read site plan, easy access to the treatment unit(s), and taking a sample from an appropriate sample location; obtaining field screening results in lieu of laboratory sample analysis; being consistent with sampling requirements; and conducting inspections on a regular interval. Best management

[1] Elke L. Ursin, PMP, Environmental Health Program Consultant, Florida Department of Health, 4052 Bald Cypress Way, Bin A08, Tallahassee, FL 32399-1710. Elke_Ursin@doh.state.fl.us

[2] Eberhard Roeder, Ph.D., P.E., Professional Engineer III, Florida Department of Health, 4052 Bald Cypress Way, Bin A08, Tallahassee, FL 32399-1710. Eberhard_Roeder@doh.state.fl.us

practices are identified suggesting key steps to improve recordkeeping, system maintenance, enforcement, fiscal, and communication, This paper is a summary of the final project report (Roeder and Ursin, 2013) and presents the current condition of advanced systems in Florida and identified recommended best management practices.

INTRODUCTION

Onsite Sewage Treatment and Disposal Systems (OSTDS) serve approximately one-third of all households in Florida. While most OSTDS are conventional OSTDS, or septic tanks with drainfields, there are some systems that provide additional, or advanced, treatment before disposal. Advanced OSTDS are utilized in Florida for various reasons and require more maintenance and management than a conventional OSTDS. There are two main categories of advanced systems in Florida: Aerobic Treatment Units (ATUs), which generally add air to improve the wastewater treatment process and are approved based on certification to ANSI/NSF Standard 40, and Performance-Based Treatment Systems (PBTS), which are designed by engineers to target specific performance levels for various wastewater components. These two permitting categories can apply to the same treatment technology, with a common example being that an engineer designs a PBTS that includes an NSF-40 certified aerobic treatment unit as the main treatment component. Advanced systems in Florida require a maintenance entity (ME), which is a company that is certified by a system manufacturer to perform maintenance inspections on advanced systems and ensure proper functionality. Florida law currently requires the following basic requirements for advanced systems: biennial operating permit issued by Florida Department of Health (FDOH), current maintenance contract, annual inspection by FDOH, and two annual maintenance inspections by the ME.

Advanced systems are required by Florida state law in the Florida Keys and the Aucilla and Suwannee River floodplains. In these areas aerobic treatment units have been most frequent, with some PBTS to address nitrogen, and, in the Florida Keys, phosphorus requirements. Advanced systems, generally aerobic treatment units, have also been required by local regulations, to protect sensitive areas (e.g., parts of Brevard, Charlotte, Franklin, and Volusia counties). In addition, Chapter 64E-6, Florida Administrative Code, allows benefits for advanced treatment by a PBTS, sometimes including nitrogen and fecal coliform reduction, for lots where the required setback or authorized lot flow restrictions cannot be met. A property owner may also want an advanced system that produces a higher level of wastewater treatment for protection of the environment.

Since 2001, there had been no systematic assessment of operation and effluent quality of advanced systems in Florida. This study was executed to perform a comprehensive evaluation of both the operation and management of advanced systems in Florida.

Questions about performance, management, and monitoring of advanced systems come from several perspectives:

- What options are available to reduce the risk of pollution from onsite systems? This question arises frequently in the context of water quality protection and restoration discussions.

- How effective are commonly used technologies in reducing the risk of pollution? The use of advanced systems or a subset of them could potentially be considered a "best management practice" for onsite systems in the context of water quality restoration efforts. Quantification of the effectiveness of such a practice would be useful.

- How is the day-to-day management and operation of such systems working and how can it be improved? The operation and management of advanced systems in Florida differ in several ways from other OSTDS by requiring more active involvement from FDOH and maintenance entities.

- How are such systems perceived and accepted? Each group of people dealing with advanced onsite systems in some way manages a part of the life cycle of them, be it the design, permitting, selling, installation, operation, maintenance, use, repair, control, and eventual abandonment. Their opinions can influence the implementation of such onsite treatment options.

This project was funded largely through an interagency agreement with the Florida Department of Environmental Protection via a grant from the United States Environmental Protection Agency (EPA) Nonpoint Source Pollution program (Section 319), with additional funding by the FDOH. The emphasis of this study was to assess the effectiveness of treatment in advanced OSTDS before discharge to drainfields. The objectives of the overall project were to:

1. Determine the number, types, and locations of advanced OSTDS in Florida.

2. Assess the operational status of systems under the current management framework, including a comparison of system functioning to the expected permit levels of performance.

3. Quantify the reduced loading of contaminants from advanced OSTDS to the environment.

4. Survey perceptions of user groups regarding the management of such systems.

5. Validate elements of a monitoring protocol for consistent assessment of systems.

6. Document best management practices.

In order to achieve these objectives the following tasks were completed: develop an inventory of advanced onsite systems in Florida containing system numbers, types, and locations; select a subset of identified systems to perform detailed data file reviews; conduct a pilot study to develop site visit protocols and system assessment methods; visit a subset of identified sites, perform a site assessment, and collect samples; survey perceptions of user groups; evaluate all collected data; and document best management practices.

NUMBER, TYPES, AND LOCATIONS OF ADVANCED SYSTEMS IN FLORIDA

A project database of all advanced systems in Florida was created with data from the FDOH statewide OSTDS construction and operating permit database, a private inspection tracking database, and local records. A detailed review of a mostly random sample of 1,014 permit files was performed to confirm the existence of the advanced systems and to estimate statewide the fraction of abandoned and misidentified systems. These steps resulted in an estimate of about 12,000 advanced systems in Florida (Figure 1) (Ursin and Roeder, 2011). Over 60% of the advanced systems are in five counties: Monroe, Charlotte, Brevard, Franklin, and Lee. ATUs are the predominant category of advanced systems; PBTS are only a tenth as frequent. Advanced systems in Florida have a median installation year of 2006, coinciding with a time when Florida saw an abundance of new home construction. As of 2011, 56 of 67 counties in Florida have one or more properties with an advanced system. Twenty-five of the 56 counties that currently have one or more advanced systems did not have one eleven years ago, which is an increase of 37%.

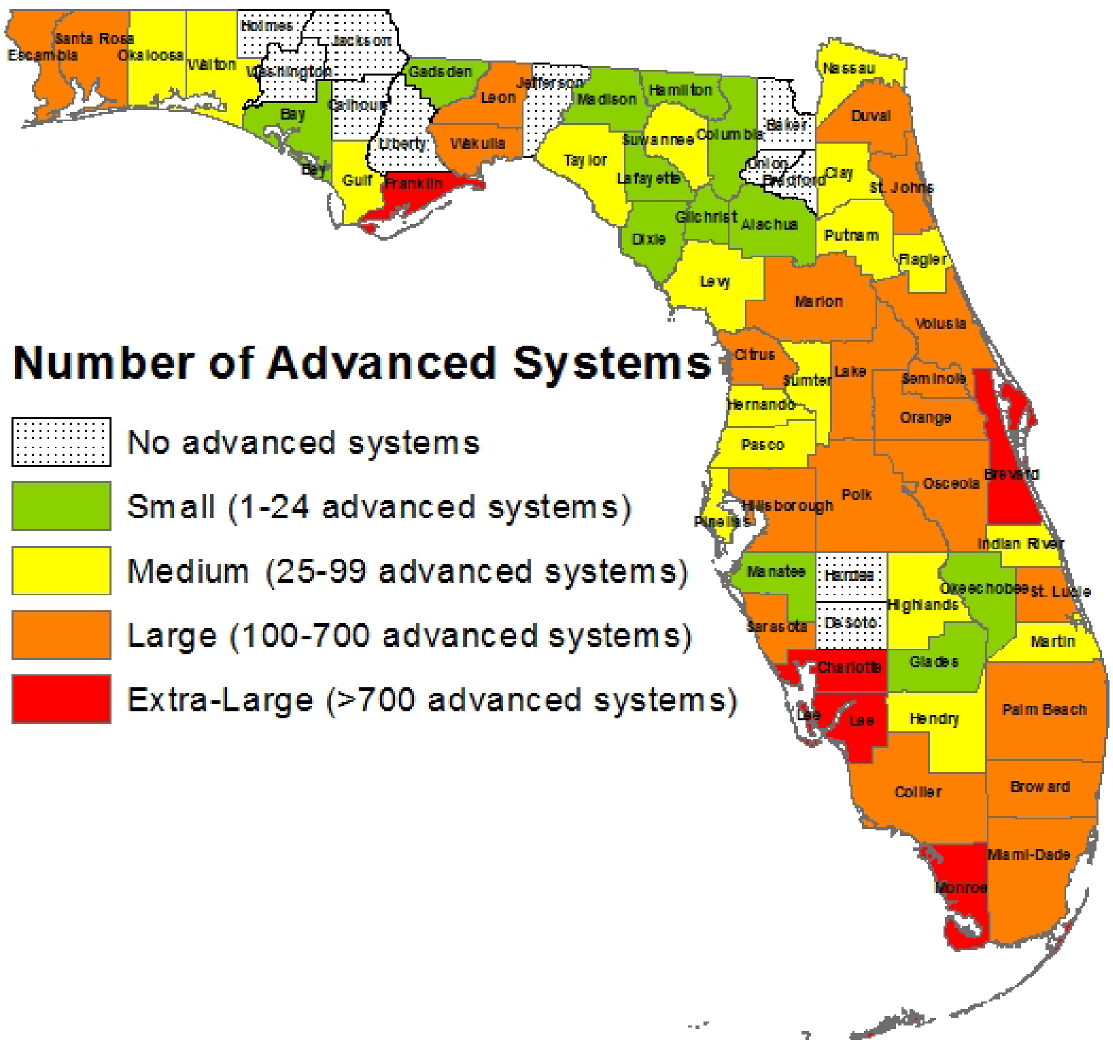

Figure 1. Total Estimated Number of Advanced OSTDS in Florida Grouped by County

The inventory of advanced systems provided records to select from for further permit review and site assessment. Sample selection was based on two main objectives. One objective was to get a representative random sample of all systems in Florida, resulting in an initial sample size of about 700. The second objective was to gather samples from different technologies to assess differences. For records where sufficient information about treatment system manufacturer and product lines existed, treatment technologies had been categorized. The treatment technologies were grouped as either: unsaturated fixed media, combined aeration and saturated fixed media, and extended aeration. While common technologies were well represented in the random sample, rare approaches would be too rare to provide meaningful sample sizes. Therefore, approximately 100 additional systems were targeted to evaluate differences in treatment technologies. Numbers of samples for each product line were proportional to the logarithm of the number of identified systems in the same category. Subsequently, in the early stages of requesting permit information from county health departments, it was discovered that a larger than anticipated number of systems were not active advanced systems (e.g. an abandoned system, a conventional system, system was connected to sewer). To address this, about 200 additional systems were drawn at random from the inventory. This brought the total sample size to 1,014 advanced systems.

After conducting a detailed permit file review, 715 of the original 1,014 advanced systems were confirmed, and became the sample population used to characterize advanced systems in Florida. Out of the sample population of 715, 629 systems were randomly selected and 86 were selected based on their treatment technologies. The main treatment technology approach used in Florida is extended aeration, with approximately 88% of the systems having this treatment technology approach. The top five treatment product lines / manufacturers used in Florida are Nayadic (which is made by Consolidated), Aqua-Klear, Hoot, Singulair (which is made by Norweco), and Clearstream. Some sort of primary pretreatment before aeration, either as a compartment within the ATU or as a separate trash tank, was found in 59% of the systems evaluated.

Ancillary information about construction practices and conditions for advanced systems was also obtained from the random sample. The majority of installations are for new residential single-family homes with an estimated sewage flow per regulations of 300 gallons per day (gpd). Similarly, the most common installed treatment capacity for advanced treatment systems is 500 gallons per day, which reflects both Florida's particular ATU-sizing requirements (500 gpd treatment capacity for a 300 gpd single family residence) and some of the more common smallest sizes offered by manufacturers. About 50% of the permitted drainfields associated with advanced systems were mounded drainfields (infiltrative surface above natural grade), with an additional 15% being filled drainfield systems (sidewall extends above natural grade), indicating they are more frequently on sites with high water tables than conventional systems. The top four drainfield product categories used for advanced systems were mineral aggregate systems (28%), chamber systems (24%), drip irrigation systems (15%), and multi-pipe rockless systems (15%).

OPERATIONAL STATUS AND SYSTEM CONTAMINANT LOADING

A detailed sampling protocol was developed, validated, and refined to obtain field observations and measurements (Florida Department of Health, 2011). The sampling protocol outlined detailed field observations and measurements, sample collection procedures, as well as laboratory chemical and microbiological analysis processes for a random sample of systems throughout the state. The forms developed for this purpose incorporated elements of checklists developed by the Consortium of Institutes of Decentralized Wastewater Treatment (http://www.onsiteconsortium.org/omspchecklists.html), and guidance documents by the Florida Department of Health, Division of Disease Control and Health Protection, Bureau of Environmental Health, Onsite Sewage Programs for the Florida Department of Health county offices. A pilot study in the Florida Keys focused on sampling procedures and variability of effluent sample concentrations. The results of this pilot study showed that there was no important difference between time-composite sampling and grab sampling (Roeder, 2011; Roeder et al., 2009). These results supported the use of grab samples in this study to characterize influent and effluent. The pilot study had also pointed to the need for more qualitative operational assessments to provide context for the results of chemical analyses.

The sampling protocol resulted in three groups of measurements. The initial system evaluation evaluated the existence, condition, and operation of the system as readily observable when visiting the site. When no access to effluent and the interior of the system could be obtained, the assessment ended there. The second group of measurements assessed the operation in the interior of the system. This included, as feasible and applicable, the condition of the tank interiors, a visual and olfactory assessment of sewage, and field parameter measurements (dissolved oxygen, pH, specific conductance, salinity, temperature, and oxygen reduction potential) with a probe (Yellow Springs Instruments) and obtaining influent samples from a pretreatment tank and effluent samples with equipment employing peristaltic pumps (Global Water and ISCO). Sampling and field parameter measurements were based on standard operating procedures of the Florida Department of Environmental Protection. The third group of measurements consisted of chemical or microbiological analyses of samples. Samples for chemical analyses (carbonaceous biochemical oxygen demand ($cBOD_5$), total suspended solids (TSS), total Kjeldahl nitrogen (TKN), nitrate and nitrite nitrogen (NO_x), total nitrogen (TN), total phosphorus (TP), and less frequently total alkalinity) were preserved as required by standard methods and shipped overnight to a NELAC-certified laboratory. A smaller number of samples for fecal coliform analysis were delivered to locally accessible NELAC-certified laboratories. Field screening analytical methods were employed to a limited extent to gather additional data and compare such methods to standard methods. These field screening tests included apparent color and turbidity, and to a lesser extent nitrate-nitrogen, ammonia-nitrogen, and reactive phosphorus (Hach DR/890), total alkalinity, and chlorine by titration (Taylor Kit K-2006).

The procedures of the sampling protocol were implemented by five sampling teams recruited from health departments in counties within proximity to a relatively large number of systems. Each team was initially trained in the procedures by project staff and issued equipment, except for one team that possessed already identical or very similar equipment from previous projects in that county.

Following the selection of systems for assessment discussed in the previous section, project staff performed a detailed review of construction and operating permit information. The information was complemented by the subsequent site visits. This review resulted in the determination that about 30% of sites were not active advanced systems, most commonly because systems had been hooked up to sewer or were misidentified. This left a total of 715 systems for potential sampling. Logistical and funding period constraints resulted in the visit of 550 of these advanced systems. The missing systems were concentrated in southeast Florida.

The core element of this project was the field assessment of systems by visiting the sites and evaluating operation both qualitatively and quantitatively. Qualitative measurements included assessments to determine if the power was on, if there was a sanitary nuisance (i.e. if there was evidence of past or present surfacing of sewage or if tank covers were broken or missing), if aeration was occurring, and if the alarms were working. Approximately 30% of all the visited sites (n=550) were not operating properly based on at least one of these measures. Seventy percent of the operational issues found during field visits were due to the power being turned off or aeration issues. Many properties where the power was turned off appeared unoccupied or vacant. Table 1 compares the proportion of operational problems found for apparently vacant or unoccupied houses with the proportion of problems in other houses. Further analysis showed that sample results were directly affected by whether the system had power and aeration. In particular, $cBOD_5$ and TN effluent concentrations were significantly higher when the power was off and/or aeration was not working. Table 2 shows that for non-vacant properties that were determined to be non-operational, the most common reasons were due to the power indicator being off (62%) and/or the aeration not working (57%).

Table 1. Vacancy as a factor in advanced system operation

Occupancy Status	Switched off	Power indicator off	Aeration off
Number Determined	485	258	420
Vacant (n=89)	54%	54%	59%
Non-Vacant (n=445)	6%	17%	14%

Table 2. Distribution of issues leading to a non-operational status for non-vacant advanced OSTDS

Reason for non-operational status	Number	Percent of total non-operational systems
Power switched off	54	43%
Power indicator off	79	62%
Aeration not working	73	57%
Sanitary nuisance	20	16%
Alarm issue	19	15%

Of the 550 total systems visited, 350 were sampled for carbonaceous biochemical oxygen demand ($cBOD_5$), total suspended solids (TSS), total Kjeldahl nitrogen (TKN), nitrate and nitrite nitrogen (NO_x), total nitrogen (TN), total phosphorus (TP), and occasionally for fecal coliform and total alkalinity. Up to 620 chemical analyses of samples were completed from various points along the treatment train. More than 95% of the chemical analysis results met laboratory standards, with the exception of $cBOD_5$ (63%). Both the field and equipment blanks were mostly below detection, with some low concentrations, and less than 10% having sporadic high concentrations. At least 70% of duplicate samples met the 20% relative percent difference target, and no systematic bias was observed.

During the project, samplers aimed to obtain quality wastewater samples. Florida regulations require installation of a sampling port for ATUs. While sampling ports in the form of cleanouts in the line between treatment units and drainfield have the advantage of sampling the flow after the treatment, they also have disadvantages. One disadvantage is that no flow may occur at the time of sampling and if there is no basin, no water may be available for sampling. Another concern is that flows are generally not high enough in gravity installations to scour the lines, so that some solids accumulation may occur that could impact samples. For these reasons, the project preferred pump chambers for sampling, and included flushing of sampling ports before sampling. Aeration chambers were only rarely sampled, mainly in combined aeration fixed media treatment units that did not include a clarifier.

To assess the impact of sampling location on effluent concentration results overall, a Kruskal-Wallis analysis was performed for the effluent samples from aeration chambers, clarifiers, pump chambers, and sampling ports. Analysis of these data indicated that there were significant differences (<5%) for $cBOD_5$, TSS, TKN, and fecal coliforms between these groups, but not for total nitrogen, total phosphorus, alkalinity, and odor intensity. Nitrate-nitrogen differences were nearly significant (5.4%). Inspections of rankings indicated that sampling ports showed higher TKN (and lower nitrate), higher $cBOD_5$, and higher TSS concentrations. Another Kruskal-Wallis analysis was performed, removing results obtained from sampling results, and only comparing aeration chambers, clarifiers, and pump chambers. These results indicated that only TSS concentration had significant differences between the three locations, with pump chambers tending to have lower concentrations. This suggests that for total nutrient analysis the sampling location does not make a significant difference. This confirms findings from the pilot study that found no significant differences in total nutrient concentrations between samples taken before and after an aggregate gravel filter and pump chamber. TSS was, as was also seen in the pilot study, most variable, with higher concentrations in sampling ports and lower concentrations in pump chambers.

Both influent (from pretreatment tanks or compartments) and effluent concentrations were variable. Six of forty-seven influent samples were excluded from further evaluation because they showed a nitrate-nitrogen concentration of at least 5 mg/L, inconsistent with anaerobic pretreatment. Treatment effectiveness was calculated from median, or typical, values. Table 3 shows median influent and effluent concentrations, and percent reduction for the random sample of systems, including non-operational ones. The influent values shown in Table 3, except for TSS, are considerably lower than concentrations found by other recent studies for septic tank effluent, including the pilot study in the Florida Keys. The effluent concentrations are generally consistent with the treatment steps employed, while the lower than expected TSS removal may be in part related to the effect of sampling from sampling ports as discussed previously. The generally effective treatment for $cBOD_5$ and TSS by advanced systems in Florida suggests that drainfields are less likely to fail for advanced systems than for conventional systems. This is consistent with the low number of drainfields with signs of drainfield failure observed during the study (1%).

Table 3. Median values for influent and effluent sample results for a random sample of advanced systems

Parameter	Units	Median Influent	Median Effluent	% Reduction
$cBOD_5$	mg/L	95	5.5	94%
TSS	mg/L	66	19	72%
TN	mg/L	45	30	33%
TP	mg/L	7.9	7.5	6%

Median effluent concentrations indicated about a 95 percent removal for $cBOD_5$, about three-quarters removal for TSS, one-third for TN, and nearly none for TP. Differences in effluent concentrations between operational and non-operational systems were significant for $cBOD_5$ and TN, but not for TSS and TP. The highest removal rates based on median concentrations were estimated for systems for which the power was on and the aerator was working (95% for $cBOD_5$, 73% for TSS, 89% for TKN, 36% for TN, and 7% for TP). The results were similar for median removal rates estimated based on influent and effluent concentrations of the same systems. Lack of aeration in treatment systems resulted in samples with median concentrations that indicated lack of nitrification, no nitrogen removal, and reduced $cBOD_5$ removal.

The concentrations of Table 3 can be compared to Florida's PBTS standards. These standards, based on treatment standards for larger wastewater treatment facilities, distinguish between annual average requirements and single sample or grab sample standards to account for temporary excursions. The median of the effluent sampling results showed that, for $cBOD_5$, TSS, TN, and TP, a typical system met the performance standards for advanced secondary grab samples (20, 20, 40, 20 mg/L, respectively), but not annual average requirements for TSS and TN (10 and 20 mg/L). This illustrates that one may not assume that because grab sample standards are met at a system, annual average standards for the same treatment level are met overall. Typical influent wastewater concentrations already meet the advanced secondary grab sample standard for TN (40 mg/L) and the annual average standard for TP (10 mg/L). This shows that meeting these standards is not a good indicator for treatment effectiveness.

A comparison of effluent sample concentrations with the required standards for that particular sampled system yielded the following results. In general, exceedance rates of average treatment standards increased with more stringent standards. To some extent this may reflect the overlap of treatment systems, where the same treatment technology can be used as an ATU or a PBTS. The exceedance trend was particularly pronounced for $cBOD_5$. Comparing ATUs to the monthly average for $cBOD_5$ and TSS required for NSF-40 ATUs (25/30 mg/L) indicated exceedances of 22% for $cBOD_5$ and 36% for TSS. Looking only at systems that appeared to be operating properly reduced the exceedance rates to 16% and 33%, respectively. PBTS of all treatment levels did not meet $cBOD_5$-standards, with only 37% meeting the standards, and TSS standards were only met 50% of the time. The exceedance rates for $cBOD_5$ in PBTS that appeared to be operating properly increased from 18% for secondary treatment (20 mg/L) over 26% for advanced secondary (10 mg/L) to 67% for advanced wastewater treatment (5 mg/L). About three quarters of PBTS did not meet their annual average TN and fecal coliform standards. For TN, the exceedance rate increased from 74% for a standard of 20 mg/L to 86% for a standard of 10 mg/L with little change when considering only operating systems. None of the PBTS with a TP performance standard stricter than 10 mg/L met that standard. The results indicated that average treatment standards for TN and TP treatment technologies are usually not met by PBTS.

Field screening test methods (Hach DR/890) were also used to assess whether these are a possible option to indicate system operational status and compliance with treatment standards without the expense of laboratory analysis. For apparent color and measured turbidity, rank order correlations were strong (Spearman's rho 0.7-0.8) with $cBOD_5$ and TSS laboratory results but further work is needed to assess if these methods are reliable enough for compliance assessments. For nutrients, the field screening methods did not include a digestion step and therefore the comparisons were between a fraction (nitrate, ammonia, and reactive phosphorus) measured by the field method and a total (nitrate+nitrite, TKN, and total phosphorus) measured by the laboratory. The rank correlation coefficients were strong for nitrate+nitrate (0.83) and TKN (0.8) and moderate to low (0.43) for TP. Among the results there were large groups of points suggesting a 1:1 correspondence. This indicates that the fraction determined by the field method is predominant in the total concentration determined by the laboratory method. But there were also groups of samples that indicated the possible influence of measurement ranges, unit conversion issues, and pronounced outliers. Future analyses may resolve some of these issues. For now, the results indicate that very close quality oversight is needed to make these screening tests routinely useful.

While fewer in number and fairly variable in quality, sampling results for fecal coliform reduction can be summarized as providing approximately one to two orders of magnitude reduction between influent and effluent. Effluent from aerobic treatment systems did not generally meet secondary treatment standards of 200 CFU/100 mL. To achieve such standards in PBTS, engineers typically rely on monitored treatment by two feet of unsaturated soil underneath the infiltrative surface of a drainfield. While limited in extent, a small number of drainfield monitoring points underneath drip drainfields were sampled and indicated that even under such conditions of controlled distribution of effluent, exceedance of treatment expectations occurred in two of five systems.

The study included a stratified random sample to evaluate differences between treatment approaches, namely extended aeration, fixed film, and combined aeration and fixed media approaches. Fixed film systems had significantly lower dissolved oxygen and higher total Kjeldahl nitrogen concentrations than either of the other two approaches. The relatively small number of systems in the stratified random sample (n=79) limited the results. Future analyses could attempt to characterize treatment results further by treatment technology.

To assess the variability of performance of treatment systems and influent strength, samplers repeated visits to 25 sites. The results indicate that while there is considerably more variability for both influent and effluent concentrations among repeat sample results than previously seen for diurnal variations, results for both influent and effluent predominantly stay within a factor of two, with TSS being the most variable. This similarity was surprising relative to an expectation that influent should be more variable than effluent given the averaging and mixing that occurs in the treatment unit. This suggests that variations in the loading occur that influence both influent and effluent. Estimates of treatment effectiveness based on the repeated samples were similar to estimates based on one sample per system, indicating that for the overall population of advanced systems, variability does not affect treatment effectiveness estimates.

USER GROUP PERCEPTIONS

Surveys were sent to advanced system homeowners, regulators, installers, maintenance entities, manufacturers, and engineers to allow a representative sample from each group voice their views and opinions as well as to measure the practices and perceptions of these user groups about the management of advanced onsite systems (FSU Survey Research Lab 2011). Also, one-on-one interviews were conducted with key stakeholders in FDOH county offices and MEs recommended by the county offices. The collected experiences and viewpoints from these groups outlined strengths as well as areas for further improvement in the management of advanced onsite systems.

For the system homeowners, 55 percent reported that they have not had any problems with their system over the previous year. For those that indicated they had a problem, the major sources of problems were system malfunctions such as pump failures, electrical malfunctions, faulty alarms, and bad motors. Almost 80 percent of all of the system homeowners indicated that they were either very satisfied or satisfied with their advanced system. When the responses from engineers, maintenance entities, installers, and FDOH regulators were compared regarding their overall perception of treatment performance for advanced systems, the majority of these groups said that both ATU and PBTS performance was either good or excellent. Advanced systems appear to be fairly well accepted among the user and management support groups.

A subsequent survey was given to homeowners at sites that were sampled as a part of this project. For those that responded, there was an association between systems that had an unsatisfactory operational status and systems that had results that exceeded performance standards for various pollutants. Additionally, the analysis indicated the perceptions of issues with the system by homeowners were linked to poor performance of the system.

Homeowners with advanced systems said that they would like to receive additional training on owner maintenance, system performance, and cost. Other topics included hooking up to sewer, environmental issues, permitting and regulation, contractors and maintenance entities, and operating instructions. Homeowners also indicated they would like to see changes or improvements to the program regarding the regulation, permitting, management, and cost of advanced onsite systems in Florida. Other changes and improvements that were commonly mentioned related to contractors and MEs, sewer availability, system performance, system maintenance by the owner, inspections, and consumer information and education. When system managers were asked what the most common complaints were from homeowners about advanced systems they said that cost of the maintenance contract and not being able to choose between several MEs were the most frequently received complaints.

When the user groups were asked for some general comments and suggestions about advanced systems, there were two main points that came up: the importance of consistency between county offices within FDOH and that advanced systems are expensive to install and maintain.

When the responses from engineers, maintenance entities, installers, and regulators were compared regarding their overall perception of treatment performance, all groups predominantly indicated that both ATU and PBTS performance was either good or excellent and based that decision on various criteria such as whether the blower was working and sample results. When comparing this result with how satisfied homeowners were this seems to indicate that advanced systems were fairly well accepted among the different user groups.

Many user groups indicated a desire for a simpler permitting process, reducing the amount of paperwork, evaluation, and/or inspection. Another issue that seemed to be common among the user groups was obtaining training from the manufacturer on how to permit, install, and service various advanced system products. Allowing more MEs to service different products was a common concern between the user groups. Additional MEs, assuming quality of service remains the same, could improve service to homeowners by increasing contract options, which could lead to competitive pricing.

MONITORING PROTOCOL FOR CONSISTENT SYSTEM ASSESSMENT

The results of the study provide information about the effectiveness of each element of the monitoring of advanced systems and where most problems occur.

Out of 629 reviewed permit files, 169 (27%) indicated that some sort of enforcement action by FDOH was required with many of these showing several or repeated violations. The violations and their frequencies are shown in Figure 2. Paperwork issues are the main reason for enforcement; with 86% of all enforcement issues being either that the maintenance agreement and/or the operating permit were expired. Having two completed ME visits in an annual cycle correlated positively to the operational status of an advanced system. In addition, there was a correlation between systems that had a current operating permit and their operational status being satisfactory, indicating the importance of keeping the system paperwork up to date.

A field evaluation procedure should assess whether the system has power, that no sanitary nuisance exists, that aeration results in bubbles and mixing of sewage, and that there are no alarms sounding. These data points provide an assessment of the operational status of a system and were found to correlate to sampling results. Also, having a standardized maintenance inspection form for maintenance entities and FDOH operating permit inspection form would ensure that there is more consistency in the minimum activities required at a site.

Knowing where the system was and what the system components were on an easy to read site plan would provide the inspector, ME, and homeowner valuable information that would assist these parties with maintenance and management of advanced systems. Only about 54% of the site plans reviewed during this project showed the system monitoring locations on the site plan. In the permitting stage for advanced systems, in particular for PBTS, it would be beneficial to have clear documentation and recording in the FDOH Environmental Health Database (EHD) regarding the specified and required treatment standards.

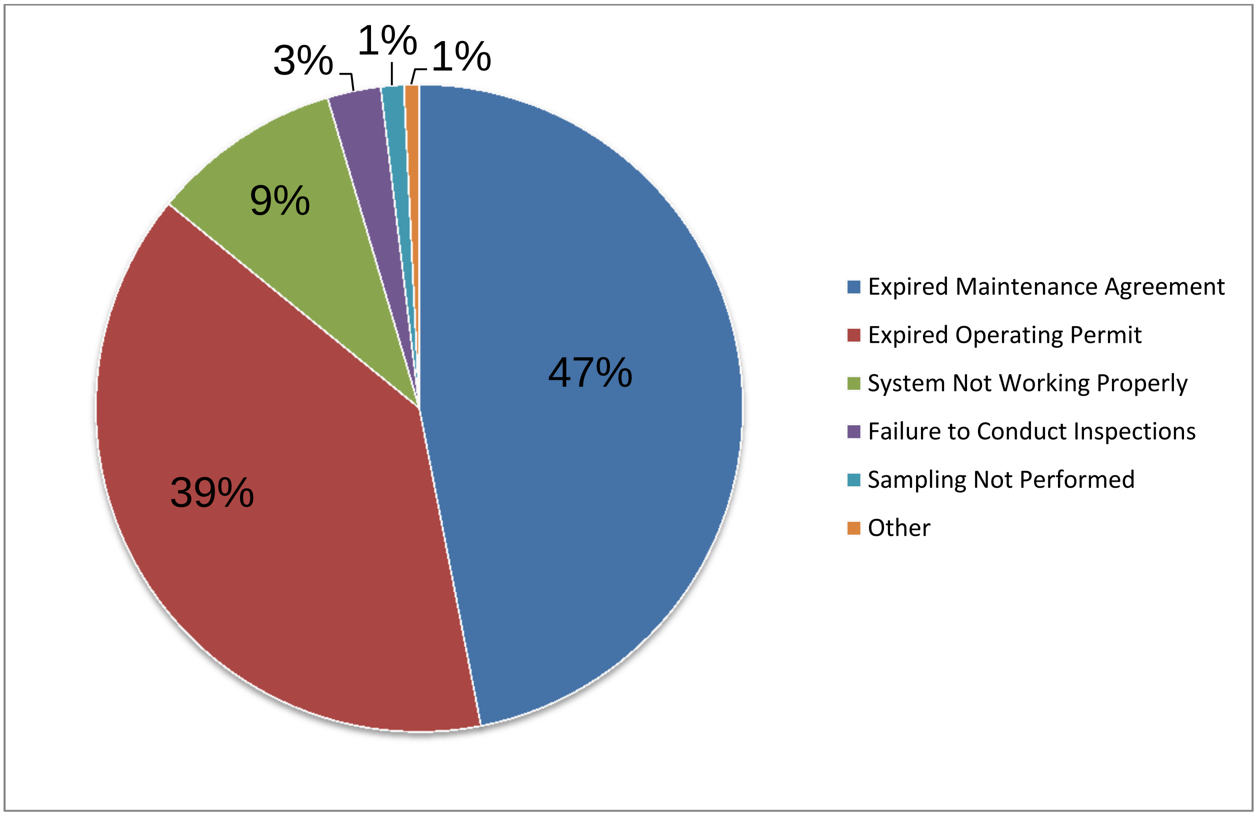

Figure 2. Distribution of Advanced OSTDS Permitting Violations Requiring Enforcement (n=262)

One problem encountered during the field evaluations for advanced systems during this project was limited access to the onsite system. Many of the systems had no risers or other access to grade. Having easy access to the treatment units, without excavation of the system, would have yielded more data points for in-situ measurements and subsequent samples. This would also allow for easier access to assess system performance utilizing field screening methods as well as easier access to repair mechanical malfunctions.

The effluent sampling location could be the clarifier; a pump chamber; a sampling port; or, for some combined or fixed film systems, the aeration chamber. The results of the study suggest that for nutrient monitoring, the sampling location was less important and that TSS was most sensitive to the sample location. While this bodes well for monitoring of nutrient concentrations, it was of concern that sampling ports resulted in apparently higher results for $cBOD_5$ and TSS, which are the design parameters for ATUs.

A common comment during the user group surveys and observation during the advanced system paperwork file review was that there was a lack of sampling for these systems. Only two percent of all ATU permit files reviewed during this project required some sort of monitoring, and these files seemed to be concentrated mainly in a handful of counties. For PBTS systems, though, 44 percent of them required some sort of monitoring which was spread over many counties. For PBTS systems that required monitoring, the power to the system was more likely to be on. A combination of easier access to treatment systems with clear and consistent sampling requirements tied to the system type and performance level would allow for a better and more transparent understanding of how these systems work under real-world conditions. Additional evaluation of screening methods may result in additional cost-effective tools to characterize performance. Sampling results could also be used to further evaluate the impact of routine maintenance of systems and installation of new technology (e.g., to improve nitrogen removal).

Besides having a clear understanding of what a monitoring inspection would consist of, there is a need to ensure that the inspection occurs on a regular interval. The current requirement is one annual inspection by FDOH and two annual inspections by the ME. For both FDOH and MEs, some of the things that affect whether a regular inspection occurs are the availability of enough people to do the job that needs to be done as well as a consistent and accurate system in place to notify when inspections need to be done. In counties with a large number of advanced systems there is a need to improve the logistics around monitoring and group systems together to increase travel efficiencies.

BEST MANAGEMENT PRACTICES

In order to evaluate best management practices (BMPs) for advanced systems in Florida, it is important to first define what is meant by "best". For the purposes of this analysis, some of the items used to evaluate "best" management practices include, but are not limited to:

1. Completeness and accuracy of documentation, and whether it is current
2. System operating conditions
3. System sampling results
4. User group recommendations

Data used to determine BMPs came from historical program evaluations for each FDOH county office and multiple components of this project (permit file reviews, field evaluation results, sample results, user group surveys, and one-on-one interviews with key stakeholders). Several consistent issues emerged from the review and methods to address these issues were noted.

The number of advanced systems a county or ME monitors has a substantial effect on how BMPs should be implemented. Those with fewer advanced systems may not need a complicated and detailed database to monitor their systems, while this may be essential for a county or ME with numerous advanced systems. However, there are many BMPs that are good to implement across the board, regardless of how many advanced systems are maintained. Each suggested BMP should be considered individually based on the current needs for the county or ME.

Five major categories of BMPs were identified and are discussed in detail:

1. Recordkeeping practices – Implementing good recordkeeping practices can be beneficial to multiple user groups by providing quick access to system details, tracking of compliance, data confidence, and improved communication.

2. System maintenance practices – Maintenance is the key to make sure advanced systems are working. A system that is not maintained can be very costly to the homeowner and to the environment.

3. Enforcement practices – Striving to reduce enforcement while making sure required enforcement is consistent and fair is the key to maintenance and management.

4. Fiscal practices – There is an economic element to the business of advanced systems. They should be affordable but must provide effective onsite sewage treatment.

5. Communication practices – Increased training/education and communication between user groups will lead to improved relationships, less enforcement, and increased protection of public health and the environment.

Recordkeeping Practices

1. A **central location** where statewide permit information can be stored and accessed. This is accomplished through the FDOH EHD web-based maintenance and compliance tracking database.
2. A **complete and accurate system file** on an advanced system in order to have the best information available for inspections and enforcement issues. The study found a relationship between having an **up-to-date advanced system file** and the likelihood that these systems are inspected, maintained, and operate properly.
3. **Recording sample/performance information** when available in a centralized database to assess the performance levels for advanced systems.
4. **Synchronization between data sources** such as EHD and other tracking databases to minimize data entry duplication and resulting errors/conflicts as well as to ensure there is access to data between multiple user groups.
5. An **online billing system** to allow for quick payment of bills and reduce the amount of paperwork and staff time spent processing payments.

System Maintenance Practices

1. **Increased homeowner awareness/education** regarding basic system care.
2. A **statewide standardized form with minimum maintenance and inspection requirements for advanced systems** which captures critical elements to assessing and maintaining system functionality.
3. **Quality maintenance inspections performed on a routine basis**. The study found that records of maintenance entity inspections improved the likelihood the system would have a satisfactory operational status.
4. Design and install systems to provide for **access to the system interior and monitoring locations**

5. **Access to appropriate equipment for inspections**. Equipment can include physical tools such as a tank lid lifter, Sludge Judge, flashlight, screwdriver, etc.; as well as basic site specific paperwork such as an accurate as-built site plan showing the location and configuration of all system components as well as monitoring locations.
6. **Sufficient access to resources** such as parts and certified maintenance entities for contractors and system users to ensure the system is maintained.
7. **Clear monitoring/sampling requirements printed on the operating permit.** This will help bring clarity to the homeowner, maintenance entity, and FDOH regarding what is required for this system.
8. **Notification of system malfunctions** between user groups to increase the likelihood that the issue is resolved quickly.
9. **Consistency between the FDOH county offices and MEs**.
10. Proactive measures to **keep track of vacant properties** (e.g., check the property appraiser, visit the property annually, or both) to improve system maintenance and distinguish between systems that are not in use and systems that are not operating properly.

Enforcement Practices

1. **Implementation of an effective, standardized, and consistently applied enforcement process.** This appears to be the most critical need of the advanced system program in the State of Florida.
2. **Documentation of advanced systems in the official property records** to inform new owners of their obligations and help avoid common enforcement issues such as failure to renew the operating permit.
3. **Implementation of a consistent pre-notification system** to notify homeowners and maintenance entities of upcoming permit renewal requirements as a simple and effective way of ensuring compliance with reduced enforcement effort.
4. **Establishment of a standard timeframe for reminder letters** notifying homeowners and maintenance entities that the system is no longer in compliance.
5. **Building good relationships between the FDOH county offices and local government** to benefit the enforcement process. Several FDOH county offices provided examples of the relationships they have: assistance from county code enforcement for sanitary nuisance response, legal assistance from a county special magistrate, incorporation of beneficial requirements for advanced systems in county ordinances, etc.
6. Many FDOH county offices and MEs suggested **simplifying the current rules** to make compliance more consistent and easier, and focus more on the environmental and public health impacts rather than paperwork issues. This could reduce the occurrence of illegal work.

Fiscal Practices

1. **Ensuring the availability of FDOH and ME staffing resources** to guarantee timely and effective management and maintenance of systems**.**
2. **Reduction in the cost of advanced systems** to increase the use of advanced systems. Advanced systems can be expensive to install and maintain. Homeowners would like to see options for lower-cost systems. FDOH is currently conducting a legislatively mandated study to develop cost-effective nitrogen reducing systems.
3. **Broadening current payment schedules to allow for installment billing and automatic payments** from homeowners. This practice could also reduce enforcement actions for paperwork issues by making the payment process more regular and automated.

Communication Practices

1. **Training and education for user groups** to make sure advanced systems are maintained properly. For homeowners, this includes basic care and use of the system, benefits to water quality, and the homeowner's legal responsibilities. Opportunities to provide education to realtors, planners, builders, and property managers could be realized so they can in turn educate future system users on the benefits and proper system maintenance of advanced systems. Outreach and education are activities that can improve communication and build relationships, which are both important to running the program effectively.
2. **Open communications between user groups** to reduce the amount of time spent on enforcement and improve system operation. FDOH, the homeowner, and the maintenance entities all need to work together to resolve operational issues with the system. Communication can help build the needed trust between user groups.

RECOMMENDATIONS FOR FURTHER EVALUATION

While the results of this study have answered many questions about the current performance and management of advanced OSTDS in Florida, there are several issues that deserve further consideration.

1. Further analysis of the large amount of data collected during this project including a more thorough validation of screening methods for nutrient analysis.

2. A detailed state-by-state review of existing code requirements for advanced systems and survey of experts on issues they face.

3. The proposed EHD and website enhancements.

4. The development of a statewide standardized form outlining minimum maintenance and inspection requirements for advanced systems that captures elements critical to assessing and maintaining system functionality.

5. An evaluation of the effectiveness and cost of effective nutrient reduction technologies. The FDOH Nitrogen Reduction Strategies Study will be completed in 2015, and results from that study can be considered in relation to the results of this study.

6. An assessment of program evaluation tools to determine whether they are measuring the right things, measuring unnecessary things, or if there are more effective things to measure.

7. A homeowner awareness and education campaign specifically targeted to advanced OSTDS, on basic care and use of the system, benefits to water quality, as well as the homeowner's legal responsibilities. An information sheet, brochure, website, or other marketing tool that can be sent or referenced with all notices from either FDOH or the maintenance entity was seen as being positively needed by interviewed groups.

8. A county pilot project to implement the best management practices developed as a result of this project and measure effectiveness.

9. Improve enforcement procedures to ensure that systems remain functioning.

10. Design and implement workshops to be held at the annual meetings for industry professional organizations such as the Florida Onsite Wastewater Association and the Florida Environmental Health Association, to discuss best management practices and how to improve the program.

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NOTICE

The information contained within this paper does not necessarily reflect the official opinion of the Florida Department of Health and no official endorsement should be inferred.

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