FLORIDA DEPARTMENT OF HEALTH

Florida Onsite Sewage Nitrogen Reduction Strategies Study

Task B Field Testing Quality Assurance Project Plan

Draft Report

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AET
Applied Environmental Technology

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Florida Onsite Sewage Nitrogen Reduction Strategies Study

TASK B.3
DRAFT REPORT

Task B Field Testing
Quality Assurance Project Plan

Prepared for:

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Section 1.0
Introduction

1.1 Project Background

Nitrogen is an important concern for water quality and nitrate-nitrogen represents perhaps the most common groundwater pollutant. Animals, crops, ecosystems, and human health can be adversely impacted by the presence of nitrogen in water supplies. The environmental effects of nitrogen on groundwater and surface water can ultimately lead to the degradation of surface waters in watershed systems that have strong groundwater/surface water interactions. Nitrogen that enters surface water bodies via these interactions can lead to algal blooms and eutrophication. These processes lead to oxygen depletion in surface waters which can be harmful to natural aquatic life. In Florida, the protection of watersheds, in particular surface water bodies, has led to the legislation of protection of these areas (i.e., the Wekiva River Protection Act).

The Florida Onsite Sewage Nitrogen Reduction Strategies (FOSNRS) Project is implementing a multi-pronged approach to address nitrogen loading to the Florida environment from onsite sewage treatment and disposal systems (OSTDS). A central component of the FOSNRS project is the experimental evaluation of onsite wastewater nitrogen reduction technologies at field and home sites. A goal of the FOSNRS project is to evaluate technologies that are appropriate for onsite deployment and which achieve a high degree of nitrogen reduction. The classifications of onsite technologies that will be evaluated in Task B have been identified and prioritized in FOSNRS Tasks A.1 through A.9 and include two stage biofiltration using solid phase electron donor media for denitrification, addition of denitrification biofilters to existing aerobic nitrifying systems, and in situ vertical flow biofilters (Hazen and Sawyer, 2009a, 2009b, 2009c, 2009d). Technologies to be evaluated include passive two stage nitrogen reduction systems initially evaluated at bench-scale in the Florida Passive Nitrogen Removal Study (Smith, 2009; Smith, 2008a, Smith, 2008b, Smith et al., 2008).

1.2 Project Scope and Purpose

The overall goal of Task B is to perform field experiments under full scale actual operating conditions to critically assess nitrogen reduction technologies that have been identified in FOSNRS Task A.9. To accomplish this goal several objectives are identified:

1. Identify homeowner test sites and establish homeowner agreements,
2. Identify specific technology vendors and establish vendor agreements,
3. Install technologies at test sites and document installation issues,
4. Document installation costs of technologies,
5. Monitor performance of treatment systems for nitrogen and other water quality parameters and assess performance,
6. Monitor the energy used and other operational costs associated with system operation,
7. Monitor routine and non-routine maintenance costs to support life cycle economic analysis, and
8. Site closure.

To meet these objectives a combination of field testing and monitoring is planned at various residential field sites. Field sites will be selected from regions in north Florida, the Wekiva area, and in other locations on the Florida peninsula. Monitoring at each site will include influent, effluent and intermediate treatment locations where possible or applicable. The data sets generated will enable quantification of hydraulic, organic and nitrogen loading rates, average influent and effluent concentrations and removal efficiencies for nitrogen and other parameters, and effluent nitrogen concentrations achieved. Documentation of installation, operation, and maintenance costs will enable comparative life cycle cost estimates to be made. The project approach is described in detail in Section 2.0.

1.3 Project Organization

Task B is comprised of several interrelated subtasks that fall within six primary categories:

1) Selection of field test sites and technologies,
2) Agreements with homeowners and vendors,
3) Installation and operational verification,
4) Field monitoring and laboratory analyses,

5) Performance assessment and reporting, and
6) Site closure.

FOSNRS Tasks B.1 and B.2 entail establishment of test sites and vendor technology agreements. This Quality Assurance Project Plan (QAPP) under Task B.3 describes the proposed testing and monitoring framework for onsite technologies. While the work described in this QAPP encompasses the entire scope of the FOSNRS project, funding for the entire project has not been totally established. However, the general procedures described in this QAPP will be followed at all field sites. The project work scope is described in Section 2. The methods of data collection and handling to ensure the data quality objectives are met are described in Section 3. Finally, health and safety precautions required during project activities are described in Section 4.

1.4 Key Project Personnel and Responsibilities

Mr. Damann Anderson of Hazen and Sawyer is the FOSNRS Manager responsible for project management and oversight. Mr. Anderson and Dr. Daniel Smith of Applied Environmental Technology are co-Task B leaders responsible for day-to-day operations and activities. The Task B leaders are also responsible for ensuring that this project plan is completed and the data quality objectives (DQOs) are met.

Personnel from Hazen and Sawyer and other subcontractors will be responsible for conducting field activities and monitoring. A field team leader will be identified for each field site and responsible for interfacing with subcontractors and task leaders as well as providing daily coordination of field activities. Field personnel involved in onsite operations are responsible for notifying the field team leader of any nonconforming field events or problems and ensuring that all co-workers are aware of such problems. Field personnel are to perform only those tasks that they can do safely and immediately report any accidents and/or unsafe conditions to the field leader and/or Task leader. Field personnel include all individuals performing field tasks and will demonstrate the experience and/or ability to perform the assigned tasks. Equipment operators (e.g., drillers, backhoe operator, etc.) shall be able to verify training and experience for the required capabilities.

Prior to initiating field work, all field personnel will be required to attend a brief site orientation given by the field team leader that will cover the description of work to be performed (task orientation), standard operating procedures (SOPs), QA/QC measures, and safe work practices. In addition, periodic “tailgate” meetings will be held to discuss potential concerns and refresh personnel on work task, QA/QC measures, and safe work practices. These field meetings will be documented in the field team leader’s logbook.

All project personnel are responsible for taking all reasonable precautions to prevent injury to themselves and to their fellow employees. The qualifications for key Task B personnel were provided in the proposal (Mr. Anderson, Dr. Smith, Dr. Stanley, Mr. Mark Mechling, and Mr. Harmon Harden).

Section 2.0
Task B Description

Field testing will be conducted at residential sites established in various Florida locations. The number of individual installations implemented over the entire project is contingent on the total funding ultimately available. The testing of individual technologies will each follow a similar sequence of activities that are described in this Section 2.0. An overview of the technology evaluation process is presented in Table 2.1. The following sections describe the approaches to be taken in implementing the technology evaluation process.

Table 2.1
Technology Evaluation Process at Residential Field Sites

General Step	Action	Approach/Activities	Product
Activities Prior to Installation			
1	Identify residential field sites	Availability of sites with homeowners amenable to testing; pre-existing technologies; sensitive sites; geographic distribution; site access; power supply	Establish homeowner agreement
2	Identify specific technology vendors	Task A.9 Technology Prioritization List for Testing; vendor contacts	Establish vendor agreement
3	FDoH notification	Summarize site, technology	Memo to FDoH
Technology Procurement			
4	Procure technology	Vendor contract purchase, component purchase orders, or donation	Purchased, donated or fabricated technology
Installation at Residential Sites			
5	Install technologies at field sites	Site preparation; vendor installation procedures; design of new technologies; site specific features; verify operation; document costs	Documentation of issues with installation and operational verification, costs
Operation and Monitoring			
6	Monitor performance of treatment systems for nitrogen and other water quality parameters	Twelve month or greater period of operation; water quality flowrate or volume; sample influent and final effluent ; sample intermediate treatment steps where applicable; monitor nitrogen species, physical and chemical parameters	Comprehensive datasets
7	Monitor operational costs of system operation	Electrical meter, chemical/additive use, routine operational checks	Documentation of operational costs under actual conditions
8	Track routine and non-routine maintenance	Record keeping of all routine and non-routine operation and maintenance issues	Operation and maintenance under actual field conditions

Table 2.1 (con't)
Technology Evaluation Process at Residential Field Sites

General Step	Action	Approach/Activities	Product
Performance Assessment			
9	Removal efficiencies; effluent concentrations achieved; water quality parameters	Spreadsheet based data management system; data analysis.	Performance assessment under actual field conditions
Site Closure			
10	Site closure	Provide homeowner with operating instructions or remove technology	Closure agreement; transfer of technology to homeowner or removal

2.1 Activities Prior to Installation

Activities prior to installation include site identification and selection, technology identification and selection, completion of agreements with homeowner and vendor, and notification to FDoH.

2.1.1 Site Identification and Selection

The project team will identify residential field sites that will enable the objectives of Task B to be achieved. Site features to be evaluated include general geographic location, availability of a pool of homeowners who are amenable to testing, site access, pre-existing technologies at site, and energy availability. Practical considerations favor several groups of sites, with individuals in each group located in relatively proximate locations. It is anticipated that sites will be identified in the following locations: North Florida (Wakulla County), West Central Florida (Hillsborough County and environs), and Wekiva Study Area. One feature of site selection is the desirability of locating several of the sites with pre-existing technologies to which Task B technologies could be added. Examples are addition of denitrification filters to the back end of commercial fixed film or suspended growth biotreatment systems to increase total nitrogen reduction.

2.1.2 Technology Identification and Selection

Technology identification will be guided by the recommendations presented in the previous Task A.9 report (Hazen & Sawyer, 2009c) and summarized in Table 2.2. The list of technologies recommended for testing is based on the ranking of technologies that was conducted in Task A.9. However, the actual number and order of system deployments may differ from Table 2.2 due to availability of funding, suitable test sites with amenable homeowners, geographical location of sites, vendor agreements, and readiness of technology. Passive two stage biofiltration systems and in-situ vertical flow systems containing denitrification media are currently being evaluated in PNRS II (Hazen & Sawyer, 2009d). Evaluation of these systems at field sites will be initiated based on PNRS II test results.

Table 2.2
Technologies Recommended for Testing in Task B (from Hazen & Sawyer, 2009c)

System	Technology	Comment
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 • Suitable for new systems or retrofit
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 • Suitable for new systems or retrofit
3	Natural system: Septic tank/Drainfield 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 • Suitable for new systems or replacing existing systems at end of useful life
4	Natural system: Primary or secondary effluent with drip dispersal	• Suitable for reducing TN impacts on groundwater through enhanced TN removal and reduced TN loading on soil • Suitable for new systems or retrofit

Table 2.2 (con't)
Technologies Recommended for Testing in Task B (from Hazen & Sawyer, 2009c)

System	Technology	Comment
5	Mixed biomass fixed film system with recycle followed by heterotrophic denitrification with reactive media biofilter	• High performance aerobic treatment with anoxia for enhanced TN removal followed by second stage hetero-trophic denitrification for high nitrogen removal • Suitable for new systems or nitrogen reduction upgrades
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 • Suitable for new systems or nitrogen reduction upgrades
7	Mixed biomass integrated fixed film activated sludge system: Suspended growth with recycle	• High performance aerobic treatment • Suitable for new systems or nitrogen reduction upgrades
8	Mixed biomass integrated fixed film activated sludge system: Moving bed bioreactor	• High performance aerobic treatment with simultaneous denitrification • Suitable for new systems or nitrogen reduction upgrades
9	Mixed biomass suspended growth system: Suspended growth sequencing batch reactor	• Aerobic treatment • Suitable for new systems or nitrogen reduction upgrades
10	Membrane process system: Membrane bioreactor (MBR)	• Suitable for new systems or nitrogen reduction upgrades
11	Source separation system: Dry toilet (evaporative or composting)	• Eliminates liquid disposal of wastes
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 re-covery of nutrients

2.1.3 Homeowner Agreement

For each test site, a homeowner agreement will be finalized that specifies the terms and conditions under which site testing will be performed. The project team will relay to the homeowner the type of technology, its physical and operational characteristics, and other pertinent features of the systems. The project will generally agree to pay for all expenses related to site preparation specific to the wastewater treatment system, procurement of technology, installation, operation and maintenance during the study, energy, and monitoring. Homeowner requirements include site access and spatial needs during testing, non-tampering provisions, and understanding of site closure options.

2.1.4 Technology Vendor Agreement

For each vendor-supplied technology, a vendor agreement will be finalized that specifies the terms and conditions under which the technology will be procured, installed and tested. The vendor agreement must specify exactly what is provided by the vendor and what is not. Vendor will supply written cost estimate including delivery to the site. Vendor requirements include providing full description of technology and requirements for installation, operation and maintenance. Vendors may advise or inspect installation but will not be allowed to independently change or manipulate any aspect of technology once the testing has been initiated. Full or partial equipment donations by vendor will be subject to same rules and considerations as if the equipment were purchased on the open market.

2.1.5 FDoH Notification

FDoH will be notified of individual test site and technology combinations that have been chosen for testing by the project team.

2.2 Technology Procurement

Vendor supplied technology will be procured through purchase agreement as per 2.1.4, paid by project funds. For non-vendor systems, the project teams will purchase materials and components and fabricate technologies for deployment. Detailed cost records will be maintained to enable system cost estimates to be made.

2.3 Installation at Residential Field Sites

Installation activities include site preparation, technology delivery and installation, and verification of operation.

2.3.1 Site Preparation

Site preparation includes site work conducted prior to delivery of the technology the site and may include providing access, clearing, excavating, surfacing, and power supply.

2.3.2 Technology Delivery and Installation

The project team will provide personnel at the site to accept delivery of the technology. Installation will be conducted according to vendor recommendations or according to installation requirements formulated for non-vendor equipment such as systems being tested in PNRS II.

2.3.3 Verification of Operation

Operational verification includes testing of all features pertinent to individual technologies such as control panels, pumps, and blowers; testing of flow/volume and electrical meters, and if necessary manual verification of flows and volumes.

2.4 Operation and Monitoring

The general operating and monitoring schedule is shown in Table 2.3. Operation and monitoring includes monitoring of flowrate or volume treated; energy, chemical, or additives consumption; chemical and microbiological analyses; and routine and non-routine maintenance. The general operating and monitoring schedule is shown in Table 2.3.

Table 2.3
General Monitoring Framework

Task	Frequency	Actions	Product
Site Inspection	2 time/month	Visual inspection; ascertain operability; odors; read meters	Inspection checklist filled out; log entry; meter readings
Flow/volume	2 time/month	Record flow/volume meter; spreadsheet entry	Update flow/volume record; average daily volume calculation
Energy, chemical, or additives consumption	2 time/month	Record energy meter; chemical or additives use; make spreadsheet entry	Update energy, chemical or additives record; average daily use and use per volume calculation
Routine maintenance	Per vendor recommendations or recommendations of project team	Perform routine maintenance actions	Maintenance log entry
Non-routine maintenance	As needed	Identify problem and perform non-routine maintenance actions	Maintenance log entry: document cause of problem, action taken, cost of parts and labor
Chemical and microbiological monitoring	1 sampling event per 2 months; maximum of 8 full monitoring events	Monitor chemical and microbiological parameters in influent, effluent and intermediate process points where applicable	Data set of chemical and microbiological parameters; spreadsheet entries; continuous log of removal efficencies and effluuent concentrations for total nitrogen, nitrogen species, and other water quality parameters

2.4.1 Flow and Volume

A flow/cumulative volume meter will be placed on the forward flow of septic tank effluent to the treatment system if possible. Optionally, flow/volume meters will be placed on water supply lines in a fashion that will allow estimates of interior water use.

2.4.2 Energy, Chemical and/or Additives Consumption

Energy consumption will be monitored using an electrical meter installed on the power line to provide cumulative kW-hour used for all energy requiring system components. Any chemical and/or additives use will be tracked by recording the volume or mass of these items supplied for system operation.

2.4.3 Chemical and Microbiological Analyses

The sample collection follows generally the approach that was initially implemented in PNRS I and is being continued in PNRS II. Monitoring will be based on manually collected grab samples. Samples will be collected of the influent to the treatment system, which is onsite primary effluent, also known as septic tank effluent (STE). Influent for treatment technologies that do not utilize a septic tank will be sampled from the primary treatment zone of the unit. Effluent samples (i.e. final effluent) are collected from the final treatment system component (e.g. denitrification biofilter effluent in a two stage passive biofiltration process) and result in the final effluent quality for total nitrogen and individual nitrogen species. Intermediate sample collection can occur from one or more intermediate process points if they are amenable to sampling and enables the performance to be assessed for specific nitrogen species. For example, monitoring the effluent from an aerobic biological process before it enters a denitrification biofilter is used to assess nitrification performance and reduction in $CBOD_5$.

Chemical and microbiological parameters to be analyzed are listed in Table 2.4. The parameter list includes total kjeldahl nitrogen (TKN), ammonia nitrogen (NH_4^+-N), and oxidized nitrogen (NO_3+NO_2)-N for delineation of nitrogen speciation; total and volatile suspended solids (TSS, VSS); bulk organic matter as five day carbonaceous oxygen demand ($CBOD_5$) and chemical oxygen demand (COD); phosphorus as macronutrient for biological processes; sulfur species for technologies employing sulfur based biofiltration for denitrification; and fecal coliform (fc) and *E. Coli* as microbiological indicators. Supporting inorganic parameters include temperature, pH, alkalinity, dissolved oxygen, and oxidation reduction potential.

For multiple point monitoring, sample collection will generally be conducted starting with the downstream point and proceeding to the upstream point. This eliminates the effects of upstream sampling on downstream effluent quality. Liquid effluent samples will contact at most one sample bottle before being placed in pre-prepared sample bottles. Field parameters that employ probes may be conducted if possible by direct probe placement into locations within the process train as opposed to samples collected in external con-

tainer. Sample collection, handling and analysis methods will be in accordance with FDEP SOPs and are discussed in Section 3.0. Varied sample collection and additional sample analysis may be conducted for specific research purposes based on ongoing performance monitoring; these may entail additional analytes and/or instrumentation.

Table 2.4
Chemical and Microbiological Parameters

Systems	Sample points	Analytes
All systems	Influent, effluent, intermediate point(s) where applicable	Temperature
		pH
		DO
		ORP
		Alkalinity
		TKN
		NH_3-N
		(NO_3+NO_2)-N
		TSS
		VSS
		C-BOD_5
		COD
		Total phosphorus
		E. Coli
		Fecal Coliform
Sulfur denitrification biofilters	Influent and effluent	Sulfate
		H_2S

2.4.4 Routine and Non-routine Maintenance

Full documentation will be maintained of routine and non-routine maintenance activities under the actual operating conditions. Routine maintenance refers to scheduled activities that are recommended by the vendor or by the project team for non-vendor systems. Non-routine maintenance relates to equipment breakdowns and malfunctions requiring operator attention.

2.5 Performance Assessment

The performance assessment will be enabled by the acquisition of sufficient data to determine:

- flowrates or cumulative volumes treated;
- concentration of nitrogen species in influent, effluent, and intermediate process points where applicable;
- nitrogen removal efficiencies;
- concentrations of other organic and inorganic water quality parameters in influent, effluent, and intermediate process points where applicable;
- pH, alkalinity and dissolved oxygen in influent, effluent, and intermediate process points where applicable, and changes of these parameters that occur from influent to effluent of treatment components;
- energy, chemical, and/or additives consumption under actual application conditions, and
- routine and non-routine operational and maintenance requirements.

Successful completion of the monitoring program will enable determination of the removal efficiencies of systems and components for total nitrogen and individual nitrogen species, determination of the effluent concentrations of total nitrogen and individual nitrogen species under the given design and operation, identify how the treatment technologies perform under given hydraulic and nitrogen loading rates, and provide understanding of mechanisms of individual treatment components in multi-step treatment systems. Monitoring of energy, consumables and maintenance requirements will enable the project team to provide life cycle costs estimates which include the non-installation costs of the technologies.

2.5.1 Flow and Volume

Flow and or volume data will be used to estimate average daily volumes, ranges and variability; hydraulic loading rates, and retention times in treatment systems. These operating features will provide correlative aspects for assessment of nitrogen reduction performance.

2.5.2 Energy, Chemical and/or Additives Consumption

Energy, chemical, and/or additives consumption under actual operating conditions will be used to estimate average consumption and consumption per volume treated. These estimates will be used in life cycle cost estimates for the technology that include both the cost of installation as well as the continuing operational costs that are needed to maintain effective performance.

2.5.3 Chemical and Microbiological Performance

Chemical and microbiological results will be used to assess performance. The concentration of nitrogen species in influent, effluent and intermediate process points will be used to assess nitrogen removal efficiencies. Other organic and inorganic water quality parameters also be used to assess performance and to facilitate evaluation of the nitrification and denitrification processes occurring.

2.5.4 Routine and Non-routine Maintenance

Documented maintenance requirements for the technology at the residential field sites will be used to develop system maintenance costs. System maintenance costs will be input into life cycle cost estimates that include all costs of system deployment, including initial installation and all recurring and non-routine costs that are needed to maintain effective performance.

2.6 Contingency Measures

An adaptive management strategy for technical decision making will be employed during all testing. This method is a continuous, integrated, process of monitoring, data evaluation and performance assessment that enables modifications to be incorporated into the testing framework as appropriate. The technologies to be installed at residential field sites will be generally well understood and characterized prior to installation. Therefore, the evaluation of technologies at these sites will be one of choosing a design and deployment; then verifying and documenting treatment performance and salient features of operation under that chosen condition. The need for adaptive management decision making will be manifest only in the event of unexpected results and unforeseen outcomes. Examples of modifications could include adjustment in operational strategies, such as modification of recommended recirculation flowrates; modification of dosing distribution systems to unsaturated biofilter surfaces; or perhaps other hydraulic modifications. These types of changes will always be evaluated from the perspective of the general desirability of providing continuous datasets under given operational conditions and minimizing manipulation of treatment processes. Operational modifications would then be implemented only if they would be felt advantageous to the overall testing objectives.

During Task B, corrective actions may also be required for two other types of problems: analytical or equipment problems and nonconformance problems. Analytical or equipment problems may occur during sampling, sample handling, sample preparation, field measurements, laboratory analysis, and data review. Nonconformance problems may develop at any time during these activities and are often discovered during data review. Analytical laboratory contingency measures are discussed in Section 3.3.

Members of the field team will monitor ongoing work performance as a normal part of their daily responsibilities. All project personnel will promptly identify, report, and solicit approved correction for conditions adverse to quality. All findings and actions concerning equipment problems and nonconformance problems will be documented in field or office logbooks.

Equipment problems or nonconformance problems should be reported to the Hazen and Sawyer project manager. The field team will then document the condition, its cause, any other related information, and the proposed corrective action. The field team will implement the corrective actions and document them in the field logbook. If appropriate, the field team will ensure that no additional work that is dependent on the nonconforming activity is performed until the corrective actions are completed.

Examples of corrective actions for field measurements include:

- Repeat the measurement to check the error;
- Check for all proper adjustments for ambient conditions, such as temperature;
- Check instrument batteries;
- Recalibrate instrument or device; and
- Replace the instrument or measurement device.

Section 3.0
Quality Assurance and Quality Control

3.1 Data Quality Objectives (DQOs)

The general quality assurance (QA) objective for Task B is to ensure that the field data collected are of known and acceptable quality. When available, FDEP SOPs will be used for conducting field sampling to ensure that representative data will be collected, including FDEP-SOP-001/01 and FDEP-QA-002/02 (FDEP, 2010). Specific DQOs for Task B are to:

- ensure that the overall sample collection, preservation, analyses, and data reporting are correct and sufficient to meet Task B objectives;
- characterize the septic tank effluent quality at residential field sites to confirm that it is representative of typical household effluents from Florida residences (Lowe et al., 20099; Lowe et al., 2007);
- provide a systems check by verifying that the expected biochemical reactions are occurring in treatment units, and identify unforeseen operational conditions; and
- produce quality data sets of influent, effluent and intermediate monitoring point water quality that enable critical evaluation of process effectiveness for removal of nitrogen and other constituents;

Of key importance is to define the removal efficiency of total nitrogen; measure concentrations of individual nitrogen species in process effluents; measure effluent levels of biodegradable organics (C-BOD_5); and to measure levels of water quality parameters that are indicative of favorable environments for nitrogen transforming biochemical reactions and which change as a result of those bioreactions (i.e. pH, alkalinity, dissolved oxygen, oxidation reduction potential). This data will enable critical performance evaluation of the treatment technologies under the regimes in which they are operated.

Data quality indicators will be used to collectively define the quality of the submitted data. These indicators include both qualitative and the quantitative quality control (QC) measures. Task B activities that affect data quality include the sampling methodology, laboratory analysis, and data analysis. The specific methods and quantitative data QA measures (e.g., accuracy, precision, completeness and detection limit) are described in

the following sections. In addition, specific qualitative control measures to be used both field and the laboratory are also described (e.g., data type, frequency of use, handling of failed QC measures).

3.2. Field Activities

The Task B sampling framework and methodology were described in Section 2. The following descriptions pertain to the field methods to be used. Laboratory activities are described in Section 3.3.

3.2.1 Sample Methods

To preserve the sample integrity, proper sample handling procedures will be employed from the time of sample collection in the field through sample analysis. Table 3.1 lists the FDEP SOPs that are pertinent to Task B. The SOPs will be used by field personnel performing field work for the project.

Table 3.1
List of FDEP SOPs for Task B

SOP	Description
FC 1000	Cleaning / Decontamination Procedures
FD 1000	Documentation Procedures
FQ 1000	Field Quality Control Requirements
FS 1000	General Sampling Procedures
FS 2400	Wastewater Sampling
FT 1000	General Field Testing and Measurement
FT 1100	Field Measurement of pH
FT 1200	Field Measurement of Specific Conductance
FT 1400	Field Measurement of Temperature
FT 1500	Field Measurement of Dissolved Oxygen
FT 1900	Field Continuous Monitoring

3.2.1.1 Sample Collection

As described in Section 2, several different types of samples will be collected in Task B. The monitoring program consists primarily of manually collected grab samples of treatment system influent (primary effluent, or septic tank effluent), final system effluent, and samples from intermediate process points (Section 2.4.3). Routine monitoring will include several field measurements including temperature, pH, dissolved oxygen (DO), and oxidation-reduction potential (ORP). Sampling methods will be in accordance with FDEP-SOPs (FS 1000). The sample collection frequency and analytes are described below and are summarized in Table 3.2. Associated QC samples are summarized in Section 3.2.1.4.

Table 3.2
Task B Measurements

Sample frequency	Systems	Sample points	Analytes
One event per two months, maximum of eight full monitoring events	All systems	Influent, final effluent, intermediate point(s) where applicable[1]	Temperature
			pH
			Alkalinity
			DO
			ORP
			TKN
			NH_3-N
			(NO_3+NO_2)-N
			TSS
			VSS
			C-BOD_5
			COD
			Total phosphorus
			E. Coli
			Fecal Coliform
	Sulfur denitrification biofilters	Influent and effluent	Sulfate
			H_2S

[1] Intermediate monitoring points will be established based on technology and sampling access

Samples of influent (primary effluent), system effluent, and intermediate wastewater will be collected in accordance with FS 2400, Wastewater Sampling. Samples will be collected into a single sample container, immediately subdivided into prepared sample storage and preservation containers for different analytes, and placed in a cooler on ice. All non-dedicated sampling equipment will be decontaminated (soap wash, triple DI rinse, and acid wash as required) between sampling locations in accordance with FDEP-SOPs (FC 1000) by a NELAC certified analytical laboratory.

3.2.1.2 Sample Handling and Custody

Sample handling procedures include the use of correct sample containers, labeling, documentation, preservation, and transport. Sample bottles will be precleaned and provided by a NELAC certified laboratory; certificates of cleanliness will be maintained in the project file. The bottles will be stored in a secured area to maintain integrity. Preservatives will consist of reagent grade chemicals and will be placed in the bottles prior to sample collection. Selection of sample containers is governed by sample type and size

and the required analyses. Each sample aliquot will be labeled with the site ID, sample ID, date, time, and sampler initials and logged into laboratory notebooks. Duplicate samples will be designated with a “D” or “dup” after the last character of the sample designation. Equipment rinsates will be designated with an “ER” after the last character of the last sample collected prior to the equipment rinsate. Field blanks will be numbered consecutively.

Due diligence will be exercised to minimize the time between sample collection at the site and transport to the laboratory for analysis. After the samples have been collected, labeled and preserved, the samples will be placed in a cooler and transported on ice or frozen Blue Ice® to a NELAC certified laboratory for analyses. Sample containers will be secured in packing material as appropriate to prevent damage and spills. Sample delivery will be conducted on a daily basis corresponding to executed sampling event.

A sample will be considered under custody if it is in:

- actual possession of a member of the sampling crew,
- in view of the sampling crew (constituting actual possession by the crew), or
- in actual possession of the sampling crew and locked in a secured area or vehicle in a manner such as to prevent tampering.

Chain of custody forms will be provided by the NELAC certified laboratory and used to document the transfer of samples from field personnel to the certified analytical laboratory. One chain of custody form will be filled out for each set of samples and placed inside the cooler.

The chain of custody form will list the following:

- regional location,
- sampler(s),
- sample identification,
- sample type,
- date and time of collection,
- analyses requested,
- preservative (if applicable),
- signature and date, and

- remarks.

Sample custody for samples received by the analytical laboratory will be performed according to the laboratory procedures. The analytical laboratory will be in compliance with the FDOH Environmental Laboratory Certification Program (ELCP) and ensure that all samples are properly stored, handled, and analyzed within the required holding time (see Section 3.3). The laboratory will be notified of upcoming field sampling activities and the subsequent transfer of samples to the laboratory. This notification will include information concerning the number and type of samples to be shipped, as well as the anticipated date of arrival.

3.2.1.3 Sample Analysis

Tables 3.3 and 3.4 list the analytical methods, target analytes, sample containers, preservatives, and holding times for samples of influent, system effluent and intermediate process points that are anticipated to be conducted during Task B. Constituents of interest will be analyzed following standard methods as described in Table 3.3 (FDEP 2008, APHA 2005, Hach 1998). Laboratory analysis of the samples shall be performed within the appropriate holding times as specified in individual analysis methods (Table 3.4). An analytical template for total samples to be analyzed for a single test site is summarized in Table 3.5 for four treatment system monitoring cases: systems with and without an intermediate monitoring point and with and without sulfur based denitrification. System influent and final effluent are to be measured in all cases.

Sample aliquots for microbial analyses will be collected, placed into sterilized containers, and immediately placed on ice for microbial analyses. Studies have shown that sample holding times of up to 24 hours have little impact on bacterial counts or coliphage numbers (Van Cuyk 2003, Selvakumar *et al*. 2004). Both fecal coliforms and *E. coli* will be enumerated using a modified version of the enzyme substrate test or membrane filtration (APHA 2005, 9222D). For the enzyme substrate test, samples are diluted and added to a chromogenic and flourogenic substrate. After adding sample to the substrates, the mixture is incubated at 45°C for 24 hours, the system then provides the concentrations of both fecal coliforms and *E. coli* through a most probable number result based on the substrate color change or UV fluorescence. Note that the incubation temperature has been modified from the manufacturer's recommendation of 35°C in order to enumerate only fecal coliforms rather than total coliforms. However, several groups (Yakub *et al.*, 2002; Chihara *et al.*, 2005) have shown similar fecal coliform counts when comparing the above method to the membrane filtration method.

Table 3.3
Sample Analyses Methods

Parameter	Detection Limits[1]	Method
Flow	Manufacturer. Specification	Water meter
Temperature	0.1 ^{o}C	Field method - (APHA method 2550B)
pH	0.1	Electrode - (APHA method 4500-H^{+}B)
Alkalinity	2.0 mg-$CaCO_3$/L	Titration - (APHA method 2320B)
DO	0.1 mg-DO/L	Membrane Electrode - (APHA method 4500-O G)
E_h	25mV	Electrode - (APHA method 2580B)
C-BOD_5	1.0 mg/L	Carbonaceous 5-day test - (APHA method 5210B)
COD	3.0 mg/L	Closed reflux, colorimetric method (APHA method 5220D and HACH method 8000 U.S. EPA-approved)
TSS (non-filterable residue)	5.0 mg/L	Gravimetrically, dried at 103–105°C - (APHA methods 2540D)
VSS (volatile non-filterable residue	5.0 mg/L	Gravimetrically, dried at 103–105°C and muffle furnace at 550C - (APHA methods 2540D and 2540E)
TKN	0.03 mg-N/L	Block digestion, flow injection analysis - (APHA method 4500N_{org} D)
Ammonia nitrogen	0.6 mg-N/L	Nessler method - (HACH method 8038, U.S. EPA-approved) Distillation and titration - (APHA method 4500-NH_3 C)
NO_x-nitrogen (nitrate + nitrite)	0.2 mg-N/L (nitrate) 0.005 mg-N/L (nitrite)	Spectrophotometric, chromotropic acid method (nitrate) and diazotization (nitrite) - (HACH method 10020 and 10207, both U.S. EPA-approved) Ion chromatographic method - (APHA method 4110)
Total phosphorus	0.06 mg-P/L	Nitric acid-sulfuric acid method - (APHA method 4500-P) Persulfate oxidation method - (U.S. EPA 365.2)
Fecal coliform	1cfu/100mL	Enzyme substrate test - (APHA method 9223B, modified by incubation at 45°C)
E. coli	1cfu/100mL	Enzyme substrate test - (APHA method 9223B)

[1] Detection limits are for wastewater samples. Actual minimum detection limits may vary due to sample concentrations and subsequent dilutions. The detection limit will be reported with the data.

Table 3.4
Sample Analyses Requirements[1]

Parameter	Minimum Volume (mL)	Container Requirements	Preservative and Holding Time
Flow	NA	NA	NA
Temperature	5	Pre-cleaned plastic or glass	None, analyze immediately
pH	5	Pre-cleaned plastic or glass	None, analyze immediately
Alkalinity, total	50	Pre-cleaned plastic or glass	<6°C, 24 hours
DO	5	Pre-cleaned plastic or glass	None, analyze immediately
E_h	5	Pre-cleaned plastic or glass	None, analyze immediately
C-BOD_5	60	Pre-cleaned plastic or glass	<6°C, 6 hours
COD	2	Pre-cleaned glass	<6°C, 24 hours with H_2SO_4 to <pH2, 28 days
TSS (non-filterable residue)	20	Pre-cleaned plastic or glass	<6°C, 7 days
VSS (volatile non-filterable residue)	20	Pre-cleaned plastic or glass	<6°C, 7 days
TKN	5	Pre-cleaned plastic or glass	<6°C, 24 to 48 hours with H_2SO_4 to <pH 2, 28 days
NO_x-nitrogen (nitrate + nitrite)	10	Pre-cleaned plastic or glass	<6°C, 24 to 48 hours with H_2SO_4 to <pH 2
Ammonia-nitrogen	5	Pre-cleaned plastic or glass	<6°C, 24 hours with H_2SO_4 to <pH 2, 28 days
Total phosphorus	5	1:1 HCl acid washed glass	<6°C, 24 hours H_2SO_4 to <pH 2, 28 days
Fecal coliform	5	Sterile plastic or glass	<6°C, 24 hours
E. coli	5	Sterile plastic or glass	<6°C, 24 hours

[1] Requirements are consistent with: FDEP-SOP-001/01, General Sampling Procedures; APHA 2005, Standard Methods; and U.S. EPA Test Methods.

Table 3.5
Analyses Template for Monitoring Configuration

Sample frequency	Analyte	Influent (STE), final effluent, with sulfur	Influent (STE), final effluent, intermediate point, with sulfur	Influent (STE), final effluent, non-sulfur	Influent (STE), final effluent, intermediate point, non- sulfur
One event per two months, eight full monitoring events	Temperature	12	18	12	18
	pH	12	18	12	18
	Alkalinity	12	18	12	18
	DO	12	18	12	18
	ORP	12	18	12	18
	TKN	12	18	12	18
	NH_3-N	12	18	12	18
	(NO_3+NO_2)-N	12	18	12	18
	TSS	12	18	12	18
	VSS	12	18	12	18
	C-BOD_5	12	18	12	18
	COD	12	18	12	18
	Total phosphorus	12	18	12	18
	E. Coli	12	18	12	18
	Fecal Coliform	12	18	12	18
	Sulfate	12	12	0	0
	H_2S	12	12	0	0

3.2.1.4 QC Samples

Routine QC checks of sampling and analysis procedures will be in accordance with FDEP-SOP FQ 1000 and consist of two parts: 1) field QC samples and 2) laboratory QC samples. The primary goal of the QC samples is to ensure that all data are of known quality, and that the expected quality is appropriate for the desired use of the data. Field QC samples will be collected to ensure proper sample collection and handling. Laboratory QC samples will be analyzed to ensure proper sample preparation and analytical techniques (see Section 3.3). Non-routine QC checks will include laboratory testing as needed to assure SOPs do not affect the sample quality. A summary of the QC samples is presented in Table 3.6.

Table 3.6
Summary of QC Samples Collected and Analyses Conducted

QC Sample	Frequency
Field duplicate	10% of samples collected
Laboratory duplicate	per laboratory SOPs
Field blank	one per sampling event per region
Equipment rinsate	one per sampling event per region
Split sample	10% of samples collected
Laboratory blank	per laboratory SOPs
Laboratory spike	per laboratory SOPs
Non-routine method check	as necessary

Field QC samples will include duplicates, equipment rinsates, and field blanks. Duplicate samples will be collected with the regular samples. Field duplicate samples will be collected from the same grab sample container. Duplicate grab samples will be collected at the same location in immediate succession with a regular sample. The number of duplicates collected will be 10% of the total samples collected. The identification numbers and locations of the duplicate and regular samples will be clearly indicated on Chain of Custody forms. Duplicate samples will undergo the same laboratory analyses as regular samples.

Field blanks are samples of the source water used for decontamination. These field QC samples are collected to ensure that constituents of interest (i.e., nitrogen) are not introduced into the sample during decontamination. The rinse water used for decontamination is typically organic-free deionized water. The water used for washing is potable tap water. At a minimum, one sample from each source of water for a given sampling event will be collected for analysis. The field blanks will be analyzed for the same parameters as the associated sample medium. The water used for decontamination will be resampled whenever the source or supplier is changed. Equipment rinsate samples will be collected for probe rinsing to determine the effectiveness of decontamination procedures. These samples will be collected by pouring deionized water into or through the sampling device.

3.2.2 Field Testing

Field testing will include operational monitoring using field instruments. The field equipment for Task B includes flow meters, meters for measuring temperature, pH, DO and E_h. Equipment used in the field will be maintained and calibrated in accordance with the manufacturers specifications (FDEP-SOP FT 1900). Field instruments will be thoroughly

checked and calibrated before they are transported to the field. These instruments will be inspected for damage once they have arrived in the field. Damaged instruments will be immediately replaced or repaired. Service and repair of field instruments will be performed by qualified personnel and will be recorded in the field logbook.

Instruments and equipment used to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications. Calibration or calibration checks of field instruments and equipment will be performed at least daily or at more frequent intervals as specified by the manufacturer. Calibrations may be performed at the start and completion of each test run. However, calibrations will be reinitiated as appropriate after a period of elapsed time due to meals, work shift change, or if damage has occurred. Records of calibration procedures, frequencies, lot numbers of standard reference solutions used as calibration standards, and any repairs or replacements will be recorded in the calibration log and/or field logbook.

3.3 Laboratory Activities

All laboratory activities will meet the minimum QC as specified in the FDEP-SOPs which meet the National Environmental Laboratory Accreditation Program (NELAP) requirements. However, if a certified laboratory is not identified, a waiver may be requested based on the research nature of this project (DEP 62-160.600 (1)(d) and (3)(f)). Regardless of if a waiver for the laboratory certification is obtained, all laboratories conducting work for this project will operate and maintain a QA Program consistent with NELAP standards. All laboratory methods to be utilized during Task B are standard methods. Should any non-standard laboratory methods be required, an addendum to this QAPP will be prepared.

Analytical methods, target analytes, sample containers, preservatives, and holding times for system influent (primary effluent, aka septic tank effluent), final system effluent, and intermediate sample points are discussed in Section 3.2.1.3 and listed in Tables 3.3 and 3.4. Once samples are received, the laboratory will have a document-control system including: sample labels, analysis logbooks, computer printouts, and raw data summaries. The analytical laboratory will be in compliance with the FDOH ELCP and ensure that all samples are properly stored, handled, and analyzed within the required holding time. A qualitative assessment of each sample container will be performed to note any anomalies, such as broken or leaking bottles and any labeling or descriptive errors. In the event of discrepant documentation, breakage, or any condition that would compromise sample integrity, the laboratory will immediately contact the field team. The samples will be stored at a temperature of approximately <6°C (as applicable) until analyses are performed.

The analytical laboratory will have approved SOPs for preventative maintenance for each instrument system and for required support activity. These records will be reviewed by auditors who perform internal and external system audits of the laboratory. All laboratory instrumentation maintenance and calibration will be performed and documented in accordance with the laboratory SOPs.

Laboratory QC procedures will include split samples, method blanks, spikes, and duplicate samples. The analytical laboratory will be in compliance with the FDOH ELCP and routinely analyze QC samples in accordance with their approved SOPs. Split samples will be sent to an outside commercial analytical laboratory for 10% of the nitrogen samples. Reagent blanks will be run for all appropriate analyses to verify that the procedures used do not introduce contaminants that affect the analytical results. Surrogate spike analysis is used to determine the efficiency of recovery of analytes in sample preparation and analysis. Calculated percent recovery of the spike is used as a measure of the accuracy of the analytical method. A surrogate spike is prepared by adding to an environmental sample (before extraction) a known amount of pure compound similar in type to the one to be assayed in the environmental sample. Surrogate spike recovery must fall within certain limits; if the recovery is not within these limits, corrective action will be implemented. Duplicate samples will be used to confirm laboratory method precision. Replicate samples should have a relative standard deviation of <10%. If the recovery is not within these limits, corrective action will be implemented. Laboratory duplicate samples will be prepared from the same sample in immediate succession with a regular sample. A summary of the QC samples is presented in Table 3.6 (Section 3.2.1.4).

Corrective actions at the analytical laboratory are required whenever an out-of-control event or potential out-of-control event is noted. Corrective action procedures are often handled at the bench level by the analyst, who reviews the preparation or extraction procedure for possible errors and checks the instrument calibration, spike and calibration mixes, instrument sensitivity, and other parameters. If the problem persists or cannot be identified, the matter is referred to the laboratory supervisor, manager, and/or QA department for further investigation. Each certified laboratory has written SOPs specifying the corrective action to be taken when an analytical error is discovered or when the analytical system is determined to be out of control.

3.4 Documentation, Assessment, and Reporting

To ensure representative data is collected to meet the DQOs, the following documentation, assessment, and reporting methods will be performed.

3.4.1. Documentation

Information to be documented will be in accordance with FDEP-SOPs (FD 1000). Logbooks will be used by the project team members and subcontractors responsible for sample collection and analyses. Each team member will be responsible for recording daily activities and/or significant events, observations, and measurements. Enough information will be recorded such that clarification, interpretations, or explanations of the data and activities are not required from the originator of the documentation. Checklists and FDEP forms will be used as appropriate and maintained in the project files. Specifically, forms FD 9000-7, FD 9000-8, FD 9000-9, FD 9000-22, FD 9000-23, and FD 9000-24 are expected to be used. All logbooks will be bound books with entries signed and dated. All field data will be protected to prevent loss. All Task B documentation will be retained for a minimum of 5 years.

Entries in the logbooks will include the following when applicable:

- description of activity,
- date and time,
- location,
- weather conditions,
- names and affiliations of field team,
- work progress,
- test area and operational condition of treatment system(s),
- field measurements and observations,
- equipment maintenance and calibration (Section 3.2.2), and
- any unusual occurrences, depending upon the nature of the occurrence, such as:
    - delays,
    - unusual situations,
    - departure from established field procedures,
    - equipment breakdown and repairs,
    - instrument problems, and
    - accidents.

Minimum information on the sample bottle labels will include:

- unique sample identification number,
- analyses required,
- preservative used (if any),
- name or initial of sample collector(s), and
- date and time of sample collection.

All original data recorded in field logbooks, standard checklists, and sample labels will be written with black indelible ink. If a previously recorded value is discovered to be incorrect or if blank lines are left, the wrong information or blank lines will be crossed through with a single line, the correct value written in, and the change initialed and dated. If the change is made by someone other than the original author or if the change is made on a subsequent day, the reason for the change will be recorded at the current active location in the logbook, with cross reference to the original entry. All monitoring results will be entered into an electronic database such as Microsoft Access or Excel.

Laboratory documentation will be in accordance with FDOH ELCP requirements and at a minimum include:

- project information (e.g., client name, project number, etc.),
- sample information (e.g., source, location of sample, matrix, etc.)
- analysis results (e.g., analyte, result, units, comment, etc.),
- laboratory QC information (e.g., blank results, matrix spike information, RPD, etc.)
- instrumentation/equipment maintenance performed, and
- instrument calibration results.

The laboratory records shall contain sufficient information to allow independent reconstruction of all activities related to generating data that are submitted in data reports to the client (Hazen and Sawyer). All analytical results will be entered into an electronic database such as Microsoft Access or Excel.

3.4.2 Data Assessment

The data collected in Task B will be evaluated for precision, accuracy, representativeness, comparability, and completeness. When using these parameters as indicators of data quality, only precision and accuracy can be expressed in purely quantitative terms. The other parameters are mixtures of quantitative and qualitative expressions. All of

these parameters are interrelated can be difficult to evaluate separately. Primary data will also be graphically examined to identify obvious effects and trends and then subjected to classic statistical analyses such as multifactor analysis of variance, principal components analysis, and/or multivariate regression analyses (e.g., Snedecor and Cochran 1980, Minitab 2000).

3.4.2.1 Precision

Measurements of data precision are necessary to demonstrate the reproducibility of the data. Precision objectives for field instruments are included in the SOPs for the instruments. To the extent possible, one set of field instruments will be used for the duration of the project.

All laboratory measurements will be made with high-purity materials, by knowledgeable laboratory personnel, and following internal QC. Duplicate samples will be collected and analyzed to assess the overall precision of laboratory procedures. Analytical precision may be expressed in terms of the standard deviation or RPD. RPD is calculated as follows:

$$RPD = ((X_1-X_2)/X_{avg})(100)$$

where:

X_1 = analyte concentration of first sample

X_2 = analyte concentration of a duplicate sample

X_{avg} = average analyte concentration of first and duplicate samples.

3.4.2.2 Accuracy

The accuracy of a measurement is based on a comparison of the measured value with an accepted reference or true value. Accuracy of a procedure is best determined on a known quantity or quality. The accuracy of field measurements will be assessed through the use of calibration standards (e.g., pH standards), by comparing the measurement of a field instrument against a known standard. All calibration and instrument operations will be carried out using traceable standards and specified materials and methods.

Sampling accuracy can be estimated by evaluating the results obtained from blanks. The types of blanks to be used for this evaluation are field blanks and rinsates. The accuracy of laboratory measurements can be expressed as percent recovery (PR) and is calculated as follows:

$$PR = ((A-B)/C)(100)$$

where:

A = spiked sample concentration
B = sample concentration
C = concentration of spike added.

3.4.2.3 Representativeness

All data obtained should be representative of actual conditions. The field procedures and laboratory analyses outlined in Section 2.0 were selected to provide data representative of process conditions. The representativeness of all field data will be qualitatively assessed by determining if the data are consistent with known or anticipated water quality in the treatment system samples and accepted scientific and engineering principles. Field measurements will also be checked for completeness of procedures and documentation of procedures and results.

To preserve the integrity of water quality data, water quality samples will be collected using appropriate collection and handling methods. Field measurements will be conducted either external to the treatment process with grab samples or if possible by probe insertion into the flowing process water (i.e. a flow-through cell). Additionally, to protect the quality of samples, the sampling equipment and field instruments will be kept clean.

3.4.2.4 Comparability

Consistency in the acquisition, handling, and analysis of samples is necessary so the results may be compared. Factors that will affect comparability are sample collection and handling techniques, sample matrix, field measurement techniques, and analytical methods. Results from two or more sampling events may be compared by specifying and standardizing these factors as much as possible. To ensure the comparability of field measurements made throughout the duration of the project, all field samples will be measured immediately, and the same field instruments and measurement techniques will be used consistently. To ensure the comparability of analytical laboratory results, all samples will be transported to the laboratory promptly to ensure holding times are met, and the instruments and techniques used for sample collection will be used consistently. Calibrations will be performed in accordance with the manufacturer's specifications and/or approved SOPs.

3.4.2.5 Completeness

Field measurements will also be checked for completeness of procedures and documentation of procedures and results. Completeness of field efforts will be defined by comparing the planned scope to the actual field work completed (e.g., by comparing the total

number of samples planned to be taken with the number of samples successfully received by the laboratory) and by evaluating the quality of the field work completed (e.g., by establishing that valid field data have been obtained through the use of proper procedures for field measurements and sample collection, etc.).

3.4.2.6 Validation

Field measurements will be made by competent engineers, environmental scientists, and/or technicians. Field data and analytical results will be validated using five primary procedures:

- Routine checks will be made during the processing of data to check for errors in data records.
- Internal consistency of a data set will be evaluated by plotting the data and testing for outliers.
- Comparison checks of related analytical results (e.g., ammonium-nitrogen + nitrate-nitrogen is less than 120% of TKN).
- Checks for consistency of the data set over time will be performed by visually comparing data sets against gross upper limits obtained from historical data sets, or by testing for historical consistency. Anomalous data will be identified.
- Checks will be made for consistency with parallel data sets, that is, data sets obtained from the similar home sites.

The purpose of these validation checks is to identify outliers or anomalies (i.e., an observation that does not conform to the pattern established by other observations). Outliers may be the result of transcription errors or instrumental breakdowns. Outliers may also be manifestations of a greater degree of spatial or temporal variability than expected. After an outlier has been identified, obvious mistakes in data will be corrected. If no plausible explanation can be found for an outlier, it may be excluded, but a note to that effect will be included in data reporting. In addition, an attempt will be made to determine the effect of an outlier when both included in and excluded from the data set.

3.4.3 Reporting

Reports of analytical results for Task B (Deliverable B.7, Monitoring Report) will contain data sheets and the results of analysis of QC samples. Sample reports will include a log of the sample identification numbers designated in the field and the corresponding laboratory sample numbers. Analytical reports will contain the following items:

- project identification,
- sample number,
- sample matrix description,
- date of sample collection,
- location of sample collection,
- date of sample receipt at the laboratory,
- analytical method and reference citation,
- date of analysis (extraction, first run, and subsequent runs),
- individual parameter results,
- quantification limits,
- dilution or concentration factors, and
- corresponding QC report.

Electronic data will be tab-delimited. The final project report will contain a compilation of all the QA/QC data generated, a discussion of out-of-control events, and any corrective actions taken.

3.5 QA Surveillance

The Hazen and Sawyer project manager will be responsible for QA/QC and will ensure compliance with this QAPP. Field surveillances and assessments will be performed by the field leader at the initiation of sampling associated with the controlled test site and again at the initiation of home site sampling. These QA surveillances of the field activities will focus on verifying proper use of field procedures for sample collection and documentation. All surveillances and necessary corrective actions will be documented in the field logbook. QA reports will include a discussion of the methods used for field activities and any items that differ from those described in this QAPP. QA reports will also include a short discussion of the quality of field documentation of data, instrument calibration, corrective actions, and other field information pertinent to the field effort.

Performance audits of the analytical laboratories will be conducted on a regular basis to verify the effectiveness and implementation of the laboratory QA/QC plan as specified in the laboratory SOPs. Results of the internal audits shall be documented and kept on file at the laboratory.

Section 4.0
Health and Safety

4.1 Hazard Assessment

Field activities will consist of test site preparation, installation of treatment technologies, operation and maintenance of treatment systems, water quality sampling and delivery of samples to analytical laboratories. An activity hazard analysis table will be available in the field at all times (see Appendix C). All field activities will be conducted in areas without inherent chemical hazards. Biological hazards are associated with exposure to high concentrations of microorganisms in household sanitation water. The most common bacterial pathogens found in untreated wastewater are *Salmonella* and *Shigella,* while other bacterial microorganisms include *Vibrio*, *Campylobacter*, and *Leptospira* (Bitton 1999). The following are general personnel hazards with the potential to occur during Task B field work:

1) Infectious disease exposure;
2) Potential for contact with preservation chemicals;
3) Slip, trip, and fall potential;
4) Potential for pinch points and striking objects due to mechanical hazards;
5) Potential electric shock from improperly grounded equipment; and

Proper personal hygiene and use of personal protective equipment (PPE) will significantly reduce or eliminate biological and chemical safety hazards. Constant attention will be given to physical hazards encountered during work activities, which will be most present during installation. Qualifications (i.e., demonstrated experience and ability) with respect to the installation tasks to be performed will be required. Only qualified, competent personnel with prior experience will perform installation tasks. Slip, trip and fall potential during operation, maintenance and monitoring will be minimized by eliminating site or installation features that increase the potential of these mishaps and by conducting site work solely during daylight hours whenever possible.

Biological Hazards Three general categories of pathogenic organisms that may be present in wastewater include bacteria, viruses and parasites (including protozoans and helminths). The principle pathogenic organisms found in STE and untreated wastewater and the corresponding infectious dose are shown in Table 4.1. Microorganisms of concern commonly found in STE include pathogenic bacteria at sustained high concentra-

tions and virus at highly variable and episodically released levels (Bicki *et al*., 1984; Van Cuyk *et al*., 1999). The most common pathogenic viruses found in groundwater are hepatitis, Norwalk-like agent, echovirus, poliovirus and coxsackie virus. Enteric virus includes 72 types of virus (e.g. polio, echo and coxsackie virus) that can cause gastroenteritis, heart anomalies and meningitis. The diseases caused by common pathogens in wastewater are summarized in Table 4.2.

Table 4.1
Microorganisms Found in STE and Untreated Wastewater (in MPN/100mL)

Organism		Conc. in STE	Infectious Dose
Bacteria	Total Coliform	10^6-10^9	
	Fecal Coliform	10^5-10^8	10^6
	Clostridium perfringens	10^3-10^5	1-10^{10}
	Enterococci	10^4-10^5	
	Fecal streptococci	10^3-10^6	
	Pseudomonas aeruginosa	10^3-10^4	
	Shigella	10^0-10^2	
	Salmonella	10^2-10^4	
Protozoa	*Cryptosporidium* oocysts	10^1-10^3	1-10
	Entamoeba cysts	10^{-1}-10^1	10-20
	Giardia cysts	10^3-10^4	<20
Helminths	Ova	10^1-10^3	
	Ascaris lumbridcoides		1-10
Viruses	Enteric Virus	10^3-10^4	1-10
	Coliphage	10^1-10^4	

(US EPA 2002; Crites and Tchobanoglous, 1998; Anderson et al., 1994; Brown et al., 1980; Ziebell et al. 1974). The most probable number (MPN) method is not an actual concentration, but a statistical estimate of concentration using serial dilutions.

Table 4.2
Pathogenic Microorganisms Found in STE and Untreated Wastewater
(Lowe et al., 2007)

Organism		Disease Caused	Symptoms
Bacteria	Salmonella typhi	Typhoid fever	High fever, diarrhea
	Shigella	Bacillary dysentery	Dysentery
	Vibrio cholerae	Cholera	Diarrhea, dehydration
	Yersinia enterocolitica	Gastroenteritis	Diarrhea
	E. coli (pathogenic)	Gastroenteritis	Diarrhea
	Legionella pneumophila	Legionnaires' disease	Malaise, acute respiratory illness
	Leptospira spp.	Weil's Disease	Jaundice, fever
	Campylobacter jejuni	Gastroenteritis	Diarrhea
Virus	Adenovirus	Respiratory disease	
	Enteroviruses	Gastroenteritis, menin-gitis, heart anomalies	
	Poliovirus		
	Echovirus		
	Coxsackie virus	Infectious hepatitis	
	Hepatitis A	Gastroenteritis	Jaundice, fever
	Norwalk	Gastroenteritis	Vomiting
	Parvovirus	Gastroenteritis	Diarrhea
	Rotavirus	AIDS	Diarrhea
	HIV		
Protozoa	Cryptosporidium parvum	Cryptosporidiosis	Diarrhea, low-grade fever
	Giardia lamblia	Giardiasis	Diarrhea, nausea, indigestion
	Balantidium coli	Balantidiasis	Diarrhea, dysentery, intestinal ulcers
	Entamoeba histolytica	Amoebic dysentery	Diarrhea, dysentery
	Cyclospora	Cyclosporasis	Severe diarrhea, nausea, vomiting, severe stomach cramps

Partially adapted from Bitton (1999) and from Crites and Tchobanoglous (1998)

Cold and Heat Stress Personnel will be monitored for heat stress during all monitoring activities. The length of periods of active work without a break will be adjusted as the weather dictates. Anyone exhibiting signs or symptoms of heat-related illness will be removed to a controlled temperature location immediately.

Noise Hearing protection will be available for all field workers. Hearing protection is required at 85 decibels or above, on the A-weighted scale on a slow response scale as per American National Standards Institute (ANSI).

Electrical All temporary, 120V, single-phase, 15- and 10-ampere receptacles and cord sets will be protected by approved ground fault circuit interrupts (GFCIs) as prescribed in 29 CFR 1926.404(b)(ii). Prior to setting the drilling rig at location for piezometer installation, the field leader will determine the distance to electrical transmission lines. If the voltage of electrical transmission lines is unknown, a distance of 20 ft. will be maintained. If the voltage is known, the equipment will not be operated when any part enters a minimum radial distance of 10 ft. to electrical transmission lines as specified in 29 CFR 1910.181.

Other Physical Hazards Other physical hazards may be present. These hazards may include buried water lines; equipment movement; and equipment malfunctions. Improper lifts will be avoided. Tripping, slipping and falling hazards and specific hazards pertaining to the operation of the drilling equipment will be evaluated. Equipment guards will be used on any mechanical equipment, as mandated by Occupational Safety and Health Administration (OSHA) regulations, to minimize personnel exposure to moving parts during piezometer installation. OSHA safety mandates and guidelines will be implemented by personnel that work near potentially dangerous drilling equipment.

The following are general health and safety standard operating procedures.

1) Wear designated PPE and safety equipment at all times while in the work area.

2) Do not eat, drink, chew gum or tobacco, smoke, or apply cosmetics in the work area.

3) Do not work with open wounds, including bandaged wounds, or other injuries that could provide a route of entry for possible microorganisms.

4) Prevent spillage. If a spill occurs, contain wastewater and dispose properly.

5) Practice good housekeeping. Keep everything orderly and out of potentially harmful situations.

6) Be familiar with the physical characteristics of the site, including:
   a. nearest emergency assistance;
   b. accessibility to associates, equipment, and vehicles;
   c. communication facilities at and near the site; and
   d. site access and egress.

7) Keep the number of personnel and equipment in the work area to a minimum but only to the extent consistent with work force requirements of safe site operation.

8) Dispose of all waste generated properly.

9) Report all injuries, no matter how minor, to the field leader.

10) Do not wear loose clothing and jewelry while working with or near drilling equipment.

11) If desired, wear gloves or other equipment for protection against physical hazards in addition to the above-mentioned PPE.

12) Be continually aware of potentially dangerous situations (e.g., presence of strong, irritating, or nauseating odors) and immediately take precautionary measures to ensure the safety of everyone.

4.2. Personal Protection Requirements

During Task B, the primary exposure risk is ingestion through splashes that contaminate food, drinks and/or hands (most common); inhalation of infectious agents or aerosols, and contact with unprotected cuts and abrasions. There is no airborne exposure pathway associated with the microbiological constituents present in residential STE or nitrified effluent. To mitigate these exposure routes for workers, eating, drinking or smoking will prohibited in the field during monitoring. Good personal hygiene such as avoiding touching the mouth, frequent hand washing, and use of disposable gloves (latex or nitrile) will be implemented. During routine field activities, personal protection equipment will include long pants, close-toed shoes, and appropriate gloves. Hard hats and safety glasses will be worn when equipment is being set up and when in the proximity of the drilling rig or other overhead hazards.

The primary potential public and environmental exposure risk is the discharge of STE or nitrified effluent to the ground surface or groundwater underlying the site. To mitigate public exposure risk, all STE released to the environment will occur below ground; there will be no surface application of wastewater effluent. In addition, access to the test site will be controlled (fencing, locking caps on monitoring points, etc.).

4.3 Emergency Response

The following procedures will be implemented in the event of an emergency during field activities. In case of emergency dial 911. The location of the nearest medical facility will be made available prior to field activities. Notify the Hazen and Sawyer project manager of any emergencies. Maps consisting of directions to the nearest medical facility and hospital will be posted at the job-site.

Section 5.0
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Appendix A

Activity Hazard Analysis

Appendix A
Activity Hazard Analysis

Job: FOSNRS Task B	**Occupation**: Field Personnel	**Date**: June 2010
Specific Work Location: Home Sites	**Analyzed by:** D.P. Smith	**Reviewed by**: D. L. Anderson
Tools Required:	**PPE Required**: Gloves, and eyewear.	
Contact: Damann Anderson, FOSNRS Project Manager: 813-630-4498 office, 813-340-7976 cell phone. Daniel Smith, Task B co-leader: 813-283-9908 office and 249-678-3843 cell phone.		

Job Activity	Potential Risks/Hazards	Control Measures
General	Slip, trip, and fall hazards	1. Work will be performed during daylight hours. 2. Personnel will visually survey the site and avoid hazardous areas to the degree feasible 3. No smoking, eating or drinking at the drilling rig during operation. 4. Use ground fault circuit interrupts (GFCIs). 5. Use proper lifting techniques (use legs not back, do not exceed individual physical capability, use lifting devices where appropriate). 6. First aid kit will be available (access to shower will remain open). 7. Report all injuries to Damann Anderson (813-630-4498). 8. In case of emergency call 911.
Environmental Sample collection	Spills/splashes/leaks Contact with wastewater Electrical	1. Check and address spills/leaks of wastewater. 2. Check and address potential contact of water/wastewater with electrical cords. 3. Decontaminate work areas and cleaned spills using 70% ethanol. 4. Recognize potential bacterial, virus or blood borne pathogens and eliminate exposure through adequate PPE and work practices. PPE: gloves, close-toed shoes, eyewear. Waste Management (WM): Clean spills/leaks. Segregate trash. Place contact waste bins. Excess effluent will be returned to the septic tank/holding basin.
Sample Analyses	Spills/splashes Contact with wastewater and/or reactive chemicals (e.g., acids) Broken glass Hot surfaces	1. Clean all spills immediately. Ensure proper spill kits are available. Broken glass should be immediately swept. 2. Properly store incompatible materials and flammables (e.g., separate storage for acids and bases). 3. Close chemical containers when not in immediate use. PPE: lab coat, gloves, close-toed shoes, eyewear. WM: Clean spills/leaks. Segregate trash.
Emergencies	Heat stress	1. Breaks will be taken to minimize potential for heat stress. 2. Drinks and a cool location (i.e., truck) will be available near the work area. 3. The buddy system will be used. PPE: Gloves and other PPE to prevent direct contact with metal equipment and prevent exposure to weather conditions.
	Injuries	1. The fire department will be summoned for all injuries that need more than first aid by calling 911.
	Blood borne pathogens	1. One field member will be trained in first aid and blood borne pathogens, but will not provide first aid unless necessary to stabilize a serious injury. 2. If blood is present, the area will be controlled to prevent exposure to blood and potential blood borne pathogens. 3. All injuries and treatment will be documented as described above under General Field Activities.
	Fire	1. Call the fire department. 2. If personnel are trained in the use of fire extinguishers, and it is safe to do so, incipient stage fires may be extinguished using portable fire extinguishers.