July 5, 2005

Innovative / Alternative Systems in North Carolina

Town of Nags Head, Decentralized Wastewater Management Plan

Stone Project # 041477-W

Prepared For:

Town of Nags Head
P.O. Box 99
Nags Head, North Carolina 27959
Phone / 252.441.5508

Prepared By:

Stone Environmental, Inc.
535 Stone Cutters Way
Montpelier, Vermont 05602 USA
Phone / 802.229.4541
Fax / 802.229.5417
E-Mail / sei@stone-env.com

TABLE OF CONTENTS

1. INTRODUCTION

The Dare County Health Department made a presentation to the Town of Nags Head on May 10, 2004. This presentation provided general information about the two peat biofilter systems being used in Nags Head, and how use of these systems has increased since 2000. These systems require inspection and effluent quality sampling to be reported annually to the Dare County Health Department. During the presentation, several issues with these systems were discussed including sampling difficulties, noncompliance with sampling and inspection requirements, and problems apparently related to excessive water use. At the time, over half of the peat biofilter systems in Dare County were not in compliance with permit requirements. This information led the Town to request that Stone Environmental gather additional information about the performance of alternative systems in other states, in North Carolina, and in Nags Head.

Alternative wastewater treatment systems are used in many areas of the United States where site conditions, such as shallow water tables, small lot sizes, or nearby sensitive natural resources, preclude the use of conventional onsite wastewater treatment systems (OWTS). This report contains both general information about alternative wastewater treatment technologies, and specific information about permitting requirements and the application of these technologies in North Carolina and in Nags Head.

While a variety of technologies are approved for use in North Carolina, this report will focus on the technologies currently installed in Nags Head:

- Puraflo® and Ecoflo® peat biofilters
- Bioclere® and AdvanTex® trickling filters
- Low-pressure pipe (LPP) distribution systems

Throughout the report, North Carolina's TS-1 treatment performance standard (Treatment Standard for tertiary treatment without nitrogen reduction) is used to evaluate the performance of different alternative technologies. This performance standard is specified in the State's individual innovative wastewater system approval documents and in individual operating permits. More information about treatment performance standards is included in Section 3.4 of this report.

2. INNOVATIVE/ALTERNATIVE SYSTEMS: TECHNOLOGY OVERVIEW

Alternative wastewater treatment systems are used in many areas of the United States where site conditions, such as small lot sizes, shallow water tables, or nearby sensitive natural resources, preclude the use of conventional onsite wastewater treatment systems (OWTS). This section provides general information, including technology overviews and performance evaluations, for alternative OWTS technologies that are currently in use in Nags Head.

2.1. Peat Filter Pretreatment Systems

Peat filters are used for onsite wastewater treatment in many areas of the US as an alternative to conventional septic systems (McKee and Brooks, 1994). Peat consists mainly of lignin and cellulose and its characteristics, including its high exchange capacity, adsorptive properties, and large surface area, make it an effective filter for wastewater treatment (Coupal and Lalancette, 1976; Rock et al., 1984). The use of peat filters for wastewater treatment in a residential setting was first reported in Maine in the mid-1980s (Brooks et al., 1984). The systems in this study and many of the peat filter systems tested in the field through the early 1990s were constructed in place by excavating native material, then placing peat in the excavation. In these systems, the peat filter essentially serves as the leach field. Instead of being laid in a bed of gravel, the perforated pipe that distributes the effluent is laid in a bed of compacted sphagnum peat.

Within the last 15 years, a second generation of peat biofilters has been developed where peat is placed into self-contained modules that are periodically dosed with wastewater, either by gravity or by pressure distribution using an effluent pump (Talbot et al. 1996, 1998; O'Driscoll et al., 1998). These systems are generally smaller and easier to install, making them appropriate for small lots and areas where access is difficult (Lindbo and MacConnell, 2002). There are two major manufacturers of self-contained peat biofilter systems: The Puraflo® Peat Biofilter System is manufactured by Bord na Mona Environmental Products US Inc. of Greensboro, North Carolina (http://www.bnm-us.com/index.html), and the Ecoflo® Peat Biofilter System is manufactured by Premier Tech Environment Inc. of Rivière-du-Loup, Québec (Canada) (http://www.premiertech.com/ecoflo/biofilter/index.htm). The following sections will focus primarily on these two peat biofilter systems.

2.1.1. Peat Biofilter Locations and Permitting Requirements

Both Puraflo® and Ecoflo® peat biofilter systems are currently approved and installed in many states, mostly in the eastern half of the U.S. Both manufacturers require that installers be trained and certified by the specific manufacturer before installing any systems, and approved installers are listed on the manufacturers' websites. Thus, these lists of approved installers may be used as a rough proxy for states in which peat biofilter systems are currently installed. A summary of the business locations of approved installers for both manufacturers is shown on Table 1.

Product approval and permitting processes for peat biofilters and other innovative technologies vary widely from state to state. Some states have outlined rigorous approval processes for alternative technologies, while others have implemented more generalized processes.

Virginia's Department of Health, for instance, requires that peat biofilter systems and other alternative technologies advance through a rigorous three-phase process before they can be granted a General Approval for use throughout the state. The first phase includes a detailed application for "provisional approval", where the manufacturer submits information about the technology's operation principles, siting criteria, design and construction requirements, operation and maintenance needs, proposed performance standards, and documentation of at least 50 systems installed in Virginia or elsewhere of identical design that have performed at least as well as a conventional system for at least three years. In the second phase, during the first year of the provisional approval, no more than 100 systems can be installed. Once at least 50 of these systems are installed and demonstrate operational competency, additional permits may be allowed (no more than 1000 systems total in the first five years under provisional approval). In the final phase, after an evaluation period of at least 5 years, if the technology is determined to perform according to the specifications and standards submitted in the original application, then the technology is granted a General Approval and an unlimited number of systems may be installed.

In contrast, the Vermont Department of Environmental Conservation requires manufacturers to submit an application that includes information about operation principles, treatment and performance claims (including independent testing results), approvals or denials in other states, siting criteria, design and construction requirements, operation and maintenance needs, monitoring requirements, and cost. Applicants can seek experimental, pilot, or general approval; once a general approval is awarded an unlimited number of systems may be installed.

2.1.2. System Components and Construction / Installation Requirements

The Puraflo® and Ecoflo® peat biofilters are both preceded in the treatment train by a septic tank, and are both followed by soil-based dispersal of the treated effluent. The overall installation processes for these two systems are fairly similar: After the site is prepared and the appropriate gravel base or adsorption field is installed, the peat biofilter module is placed level on the gravel bed. Inlet and/or outlet pipes are connected, and the excavation containing the module is carefully backfilled and graded.

There are some differences, however, between the systems' components and in the installation procedures for the two types of biofilter modules. Puraflo® peat biofilters are pressure-dosed, so a pump tank must be installed between the biofilter modules and the septic tank (a schematic of a typical Puraflo® system is shown in Figure 1). The Ecoflo® peat filters may be dosed either by gravity or by using an effluent pump, but effluent is distributed by gravity within each module by a tipping bucket and a set of metal distribution plates. The Puraflo® modules are usually filled with peat by the manufacturer and are completely self-contained, while the Ecoflo® filters require some assembly onsite, including filling the modules with peat.

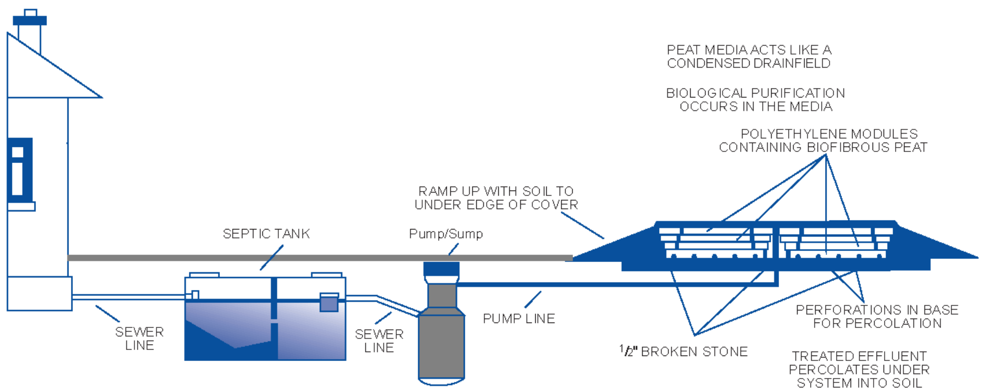

Figure 1. Schematic diagram of a typical Puraflo® peat biofilter system. Source: National Small Flows Clearinghouse, 2005.

2.1.3. Operation and Maintenance Requirements

Premier Tech includes annual preventive maintenance for the expected life of the peat filter material (eight years) in the purchase price of the Ecoflo® biofilter. Preventive maintenance provided includes a visual inspection of the internal components and raking of the peat filter to ensure the system is operating properly, to optimize treatment efficiency, and to extend the life of the system. Premier Tech also offers a transferable two-year warranty on the fiberglass shell, other components of the biofilter, and the filter bed. Maintenance contracts may be renewed after the initial eight-year period.

Bord na Móna guarantees the Puraflo® biofilter for one year from the date of installation. Thereafter, the system owner may maintain an annual service agreement with the manufacturer to ensure regular inspection and maintenance of the system. This agreement includes visual inspection of the septic tank, pumps and alarms, control panel, and the biofilter modules. Sludge and scum levels are also checked in the septic tank, and the effluent filter is cleaned.

2.1.4. Peat Biofilter Performance

The Ecoflo® and Puraflo® systems evaluated in the scientific literature generally demonstrated a high level of wastewater treatment (White et al., 1995; Talbot et al., 1998; Monson Geerts et al., 2001; Lindbo and MacConnell, 2001; Rich et al., 2003). Performance evaluations for systems located in several areas of the US are summarized in Table 2, and the following discussion refers extensively to this table.

Overall, peat biofilters appear to be quite efficient at reducing the concentrations of 5-day biological oxygen demand (BOD_5) and total suspended solids (TSS), two commonly measured indicators of wastewater strength, from septic tank effluent. Only one study reported in the literature noted BOD_5 concentrations in excess of North Carolina's performance standard, and no values that exceeded the TSS performance standard were noted. Peat biofilter performance for fecal coliform removal was slightly more variable, with three studies reporting values in excess of the fecal coliform performance standard. However, these high values are all arithmetic means, and thus may be unfairly biased towards the higher values in individual datasets. If only geometric mean fecal coliform values are considered, the peat biofilters performed well within North Carolina's performance standard for fecal coliform bacteria.

When aerobic conditions are maintained in the biofilters, they are also efficient at converting ammonia-nitrogen and organic nitrogen from septic tank effluent to nitrate. However, several studies reported problems with sustaining aerobic conditions in the biofilters due to wastewater loading at 100% or more of design flow (Monson Geerts et al., 2001; Ebeling et al, 2003), groundwater infiltration (Lindbo and McConnell, 2001), or other unexplained problems (O'Driscoll et al., 1998). Five of the performance studies evaluated reported average ammonia-N concentrations in peat biofilter effluent at or above the original North Carolina TS-I performance standard of 10 mg/L.

The Alabama Department of Public Health conducted two performance studies near the Weeks Bay Estuary that used Puraflo® peat biofilters to treat wastewater on 20 sites where the original septic systems had failed (White et al., 1995; O'Driscoll et al., 1998). The primary goal of this study was to determine whether the systems would reduce levels of fecal coliform bacteria entering nearby shell-fishing areas. Ten of the 20 replacement systems were monitored for a year after installation (November 1993-October 1994), and four of these 10 systems were monitored again after three years (June-October 1997). During the initial one-year monitoring period, the Puraflo® biofilters removed an average of 92.6% (median 97.6%) of the fecal coliform bacteria present in the wastewater effluent (White et al., 1995). Five-day BOD and ammonia were also monitored during two months of the initial study; BOD_5 was generally less than 20 mg/L, and ammonia-N was less than 1 mg/L. Average fecal coliform reductions improved during the initial monitoring period, suggesting that the systems need time to mature. A few operational problems occurred during the first year of operation, including sludge carryover into the filters due to electrical failures and settling of the peat media in the biofilter modules. Performance improved once these problems were corrected. After the systems had been operating for more than three years, they still produced effluent with low BOD and TSS concentrations (average of 4 mg/L BOD and 13 mg/L TSS) (O'Driscoll et al., 1998). While percentage reductions in fecal coliform bacteria averaged 96% and were similar to those observed initially, the average effluent fecal coliform concentration of 23,769 col./100 mL is higher than North Carolina's performance standard for peat biofilter systems. Effluent ammonia-N levels averaged 11 mg/L, suggesting that organic nitrogen in the effluent was no longer being efficiently nitrified. These systems were performing reasonably well considering that no homeowners renewed their service contracts after the two-year warranty period expired and thus little maintenance was performed (O'Driscoll et al., 1998).

The Deschutes County Environmental Health Division, Oregon Department of Environmental Quality, and the US Geological Survey were awarded a demonstration grant by the US EPA to address the issue of groundwater contamination (primarily nitrate) from onsite systems in Deschutes County, Oregon (Rich et al., 2003). As part of this project, a variety of innovative systems, including three Puraflo® peat filter systems, were installed to serve existing and new single-family homes. The Puraflo® systems were sampled approximately once a month between December 2001 and December 2004, and the results were compared to the project's performance standards (10 mg/L BOD, TSS, and total nitrogen, and a 2-log reduction in fecal coliform bacteria from septic tank effluent concentrations). After a two-month to five-month startup period, all three systems met the project's performance standards for all parameters except total nitrogen (Rich, 2005; Rich et al., 2003). Ammonia-N concentrations generally remained well below 10 mg/L, although total nitrogen from the systems was higher than the project's 10 mg/L performance standard. Maintenance visits for these systems ranged from two to six scheduled and unscheduled visits per year (Rich et al., 2003).

2.2. Trickling Filter Systems

A trickling filter is an aerobic treatment system that utilizes microorganisms attached to a filtering medium to remove organic matter from wastewater (US EPA, 2000). In contrast to peat biofilters, trickling filters typically use a coarser filter material with a large surface area, such as crushed rock, specialized plastic or foam media, or textile rolls or sheets. This type of system is common to a number of technologies, including two proprietary technologies (Bioclere and AdvanTex®) that are currently used in Nags Head. These two technologies are briefly discussed in the following sections.

2.2.1. Bioclere™

The Bioclere™ Modified Trickling Filter System is manufactured by Aquapoint, Inc. of New Bedford, Massachusetts. These systems are currently permitted in 24 states, with the greatest number of installed systems concentrated in states along the Atlantic coast (Aquapoint Inc., 2003). While this technology can be used in a single-family residential application, it is more commonly applied to challenging design conditions such as schools, nursing homes, restaurants, or clusters of residences.

The Bioclere™ is preceded in the treatment train by a septic tank, and is followed by soil-based dispersal of the treated effluent. The pretreatment unit itself is a large, cylindrical, self-contained chamber (Figure 2). Wastewater flows by gravity from the septic tank into the clarifier in the bottom half of the unit. A pump periodically doses the filter media in the top half of the unit with wastewater. Within the filter, aerobic microorganisms consume the organic material in the wastewater. Some of the treated wastewater is recirculated back to the septic tank, while the rest is released to the dispersal system. Any biomass that sloughs off the media filter settles to the bottom of the clarifier and is pumped back into the septic tank.

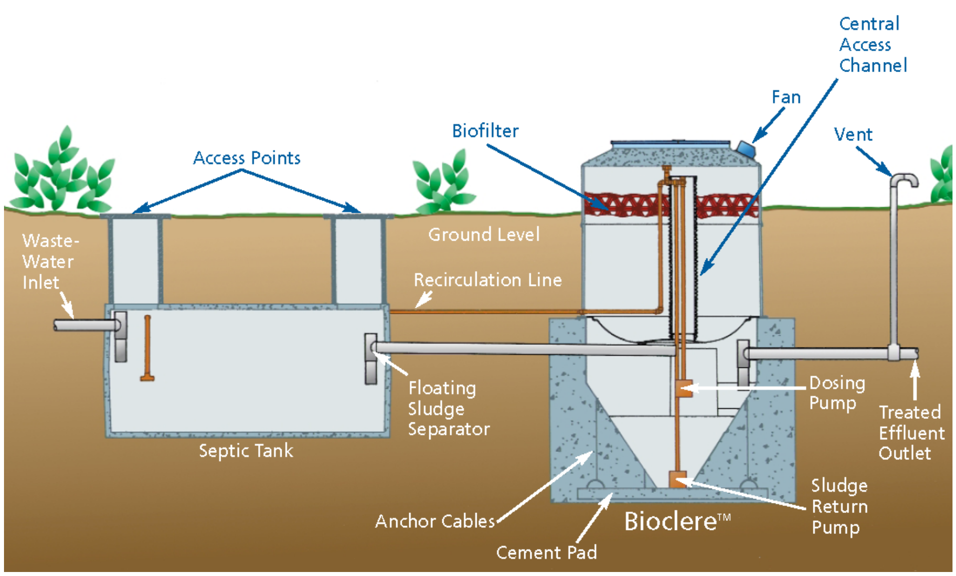

Figure 2. Schematic drawing of a Bioclere™ pretreatment unit. Source: Aquapoint, Inc. website, 2005.

Since the Bioclere™ units are self-contained, the installation process is similar to that for peat filters. After the site is prepared, including a concrete base for the Bioclere™, the pretreatment unit is lifted onto the pad. The unit is leveled using four adjusting cables from the top of the clarifier to the rings on the cement pad. Inlet and/or outlet pipes are connected, and the excavation containing the module is carefully backfilled and graded.

Aquapoint, Inc. recommends that a certified operator or septic hauler be contracted to provide regular maintenance. Preventive maintenance includes checking the septic tank and grease trap (if any) every 3-6 months and pumping as needed. The only routine procedures required for the Bioclere™ unit itself are periodic pump and fan maintenance and less frequent cleaning of the distribution system.

The Bioclere™ systems evaluated independently generally demonstrated a reasonable level of wastewater treatment. The Bioclere™ is certified under ANSI/NSF Standard 40 for biological wastewater treatment with nitrogen reduction (NSF International, 2003), meaning that at least one treatment unit successfully completed a rigorous independently conducted monitoring program. Independent verification testing of the Bioclere™ for NSF certification was conducted over a thirteen-month period at the Massachusetts Alternative Septic System Test Center (MASSTC), located in Bourne, Massachusetts. The verification test included monthly sampling of the influent and effluent wastewater, and five test sequences designed to test the unit response to differing load conditions and power failure. Overall, the Bioclere™ effluent showed an average BOD_5 of 14 mg/L with a median $CBOD_5$ of 10 mg/L. The average TSS in the effluent was 16 mg/L and the median TSS was 10 mg/L. These values are well within the NSF Class I effluent quality performance standard, but are very close to North Carolina's TS-1 standard of 15 mg/L (Table 6). The Bioclere™ system was capable of removing ammonia nitrogen in the aerobic unit; effluent ammonia-N concentrations averaged 6.2 mg/L and the median was 2.8 mg/L. Pathogen removal was not evaluated during the verification testing. Only routine maintenance and system checks were performed for most of the test, except when a nozzle –plugging problem occurred. The plugged nozzles impacted treatment performance, but performance improved quickly once they were cleared.

Two Bioclere™ units were tested as part of a 14-month project in Gloucester, Massachusetts that evaluated the performance of several different alternative onsite treatment systems in difficult site conditions, including sandy soils and nearby sensitive coastal waters (Jantraina et al., 1998). Average treated effluent BOD_5 values at the two sites were 29 and 51 mg/L, while average TSS values were 33 and 42 mg/L. These values are above both the NSF Standard 40 and North Carolina

TS-1 performance standards (Table 6). The systems removed some total nitrogen from the effluent, but ammonia-N concentrations were not published. Average fecal coliform concentrations in Bioclere™ effluent for the two systems were 7,000 and 100,000 col./100 mL, respectively; one system's average fecal coliform concentration was above the TS-1 performance standard of 10,000 col./100 mL.

2.2.2. AdvanTex®

The AdvanTex® -AX Treatment System is manufactured by Orenco Systems, Inc. of Sutherlin, Oregon. These systems are currently permitted in at least 20 states, with installed systems located throughout the country (Orenco Systems Inc., 2001). This technology is used both in single-family residential applications and in more challenging or complex design conditions.

The AdvanTex® is preceded in the treatment train by a processing tank that combines a septic tank and pump chamber, and is followed by soil-based dispersal of the treated effluent. The pretreatment unit itself is a rectangular, self-contained fiberglass chamber (Figure 3). Wastewater is pumped from the second compartment of the septic tank through a distribution system at the top of the textile filter unit. Effluent percolates through the textile media and collects at the bottom of the filter. The filtered effluent flows back to the splitter valve, where it is automatically split between the septic tank and final discharge. A control panel monitors the pump on/off times and alarm conditions, and can include a telephone connection to a web-based monitoring application monitored by the maintenance provider and the manufacturer.

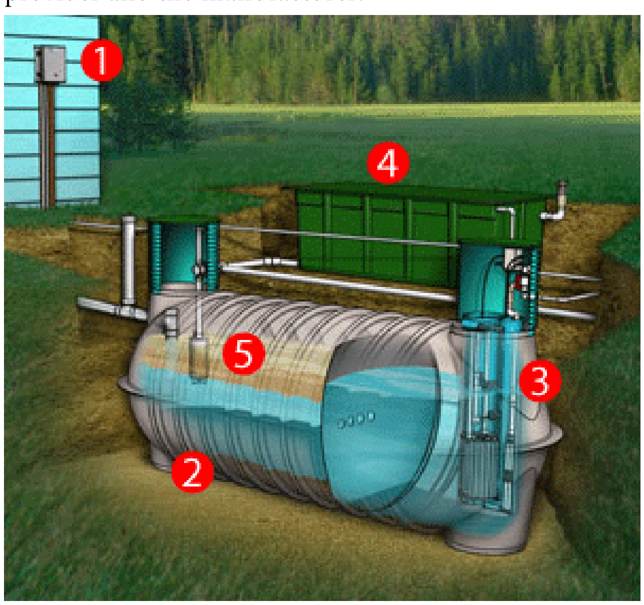

Figure 3. Schematic drawing of a system with an AdvanTex® pretreatment unit. Components include (1) Web-based monitoring system, (2) septic tank, (3) pump

chamber, (4) AdvanTex filter, and (5) recirculating splitter valve. Source: Orenco, Inc. website, 2005.

Since the AdvanTex® units are self-contained, and the processing tank is an integral part of the system, the installation process is slightly more complex than that for peat filters. After the site is excavated, the processing tank and textile filter unit are placed and leveled. Access risers are installed, and inlet and/or outlet pipes are connected. The pump package is installed, floats are set appropriately, the system is checked for watertightness, and the excavation containing the system is carefully backfilled and graded.

Orenco Systems, Inc. requires regular inspection and maintenance of AdvanTex® systems as a condition of purchase. Maintenance activities should be performed three months after system startup, and then every twelve months thereafter. Preventive maintenance includes inspection and operation checks of pumps, alarms, and the control panel; inspection of the pumping system, processing tank, and textile filter; and exercising all mechanical valves.

The AdvanTex® systems evaluated in the scientific literature generally demonstrated a high level of wastewater treatment. The Deschutes County, Oregon National Demonstration Project (described in Section 2.1.4) also installed three AdvanTex® AX-20 textile filter systems to serve existing and new single-family homes. The systems were sampled approximately once a month between December 2001 and December 2004, and the results were compared to the project's performance standards. After a two-month startup period, the three systems met the project's performance standards for BOD_5 (average of 6.9 mg/L) and TSS (average of 5.7 mg/L), and approached the performance standard for total nitrogen (average of 16 mg/L) (Rich, 2005; Rich et al., 2003). Ammonia-N concentrations generally remained well below 10 mg/L. These results also meet North Carolina's TS-1 performance standard. The systems generally did not meet the demonstration project's performance standard for pathogen reduction. Maintenance visits for these systems ranged from two to four scheduled and unscheduled visits per year (Rich et al., 2003).

An AdvanTex® system was installed at an elementary school in Warren, Vermont as part of the Town of Warren's National Demonstration Project (Stone Environmental, Inc. 2005). During the needs assessment phase of this project, it was found that the elementary school's system was failing and potentially impacting the school's water supply, a drilled well. The replacement system was used to create a pilot project using alternative technologies to highlight how such technologies can save on dispersal area size and vertical separation requirements to groundwater and bedrock. This system was the first "alternative" technology approved for construction in Vermont. Installed in early 2001, the system currently undergoes regular operation and maintenance, annual engineering inspections, and effluent sampling after the treatment system. The results of the sampling to date indicate this system produces consistently low BOD_5 (average of 9 mg/L) and TSS (average of 6 mg/L), remaining well within its permit requirements. After the first few months of operation, ammonia-N concentrations stabilized near 9 mg/L. Fecal coliform levels were not monitored during the demonstration project. There have been no major problems with this system since installation.

3. NORTH CAROLINA PERMITTING PROCESS AND REQUIREMENTS

All onsite systems in North Carolina are regulated through the state Title 15A – Department of Environmental Health, and Natural Resources, Chapter 18 – Environmental Health, Subchapter 18A – Sanitation, Section .1900 – Sewage Treatment and Disposal Systems (Rules). These Rules were originally effective July 1, 1977, and certain sections have been recently amended with an effective date of February 1, 2005.

The following sections discuss site and soils requirements, design considerations, and system performance standards for alternative treatment systems in North Carolina.

3.1. Permit Process for Alternative Systems

The permitting process for alternative systems is the same as for regular OWTS. The Dare County Health Department administers the program in the Nags Head area (Figure 4, next page). This office conducts a preliminary review of an application, conducts a soil and site evaluation, issues a denial letter when the site is denied from use, or a site approval letter stating the conditions under which the site is approved, and specifies the system type. The design is then submitted to the Health Department, and an Improvement Permit (Site Approval) is issued. Concurrently or just following, the Health Department issues an Authorization for Construction based on the system design. Once the system is installed and inspected by the Health Department, an Operation Permit is issued. The operation permit specifies the maximum number occupants in a building.

3.2. Approved Alternative Technologies

A number of alternative technologies, including options for septic tanks, pretreatment units, and dispersal technologies, are approved for use in North Carolina. A summary of the available approved technologies is shown in Table 3. Only a subset of the potential range of pretreatment options shown in this table is currently used in Nags Head.

3.3. Design Benefits of Alternative Systems

3.3.1. Soil Requirements

Soils are grouped based on soil particle size and distribution. Textural classes range from sands (Soil Group I), which is the predominant soil group for Nags Head, to loams and clays (Soil Groups II-IV). This grouping determines the range of long-term acceptance rates of the soil used in sizing the dispersal field. In Nags Head, these rates are in the range of the highest permeability, so systems can be sized smaller due to the permeable soil.

The depths to bedrock, saprolite (a type of permeable bedrock), and wetness (seasonal high groundwater table) determine the type of system that can be

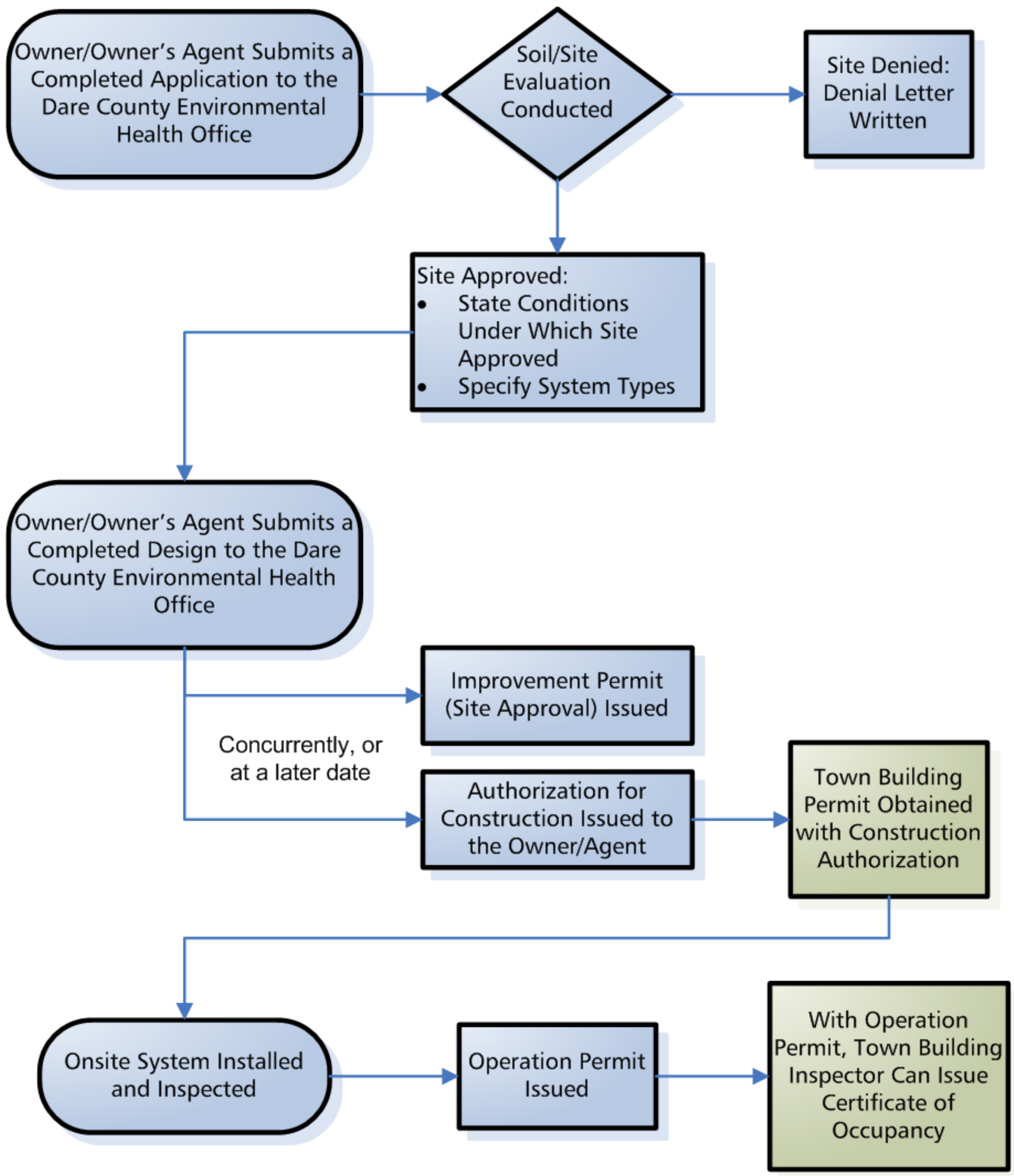

Figure 4. Flowchart of the permitting process for onsite wastewater treatment systems in Nags Head.

installed on a property and the maximum depth to the bottom of the dispersal area. While bedrock is only present at great depths in Nags Head, and saprolite is not present in the town, there are scattered areas throughout town where shallow groundwater is a concern. Soil depths to wetness greater than 48 inches are considered suitable for conventional systems. Soil depths between 36 and 48 inches to wetness are considered provisionally suitable, and soil depths less than 36 inches are considered unsuitable unless additional investigation shows that a modified or alternative system can be installed in accordance with the Rules.

In North Carolina, the required separation from the bottom of a conventional leachfield to wetness or seasonal groundwater table is 18 inches for group I soils, the predominant soil group in the Nags Head area. For low-pressure pipe systems (LPP systems), which are considered alternative systems, the minimum separation between the bottom of the dispersal field and wetness is 12 inches. For systems using pretreatment technologies such as aerobic sewage treatment units (ATUs), sand or trickling filters, or peat biofilters, the required vertical separation between the bottom of the dispersal system and wetness is usually 12 inches, but may be as little as 6 inches for some approved technologies (Table 4).

3.3.2. Setback Requirements

The features of a site, including the presence of steep slopes, surface waters, structures, and other nearby properties, help determine the location and layout of OWTS. Horizontal setbacks specified in the Rules include distances between the OWTS and property lines (10 feet), water supply wells and sources (100 feet), coastal water classified as SA (100 feet from mean high water mark); and other coastal waters (50 feet from mean high water mark). More restrictive setbacks are required for systems with design flows over 3,000 gpd. Systems that provide treatment to TS-I or TS-II standards before dispersing the wastewater effluent, including aerobic treatment units (ATUs), peat filters, and trickling filters, may be designed using horizontal setbacks that are reduced by as much as 50% (Table 5).

3.4. Performance Standards for Alternative and Experimental Systems

Most of the alternative wastewater treatment systems that are allowed under the North Carolina Rules, including peat filters and trickling filters, must meet wastewater treatment performance standards for 5-day BOD, TSS, NH_4-N, and fecal coliform bacteria. The TS-I treatment performance standard (tertiary treatment without nitrogen reduction) for peat filters and trickling filters is $<$ 15 mg/L BOD_5 and TSS, plus reductions in ammonia-N and fecal coliform densities, and is specified in approval documents and individual permits. Additional nitrogen reduction beyond the baseline performance standard is required for system designs to take maximum advantage of reductions in some horizontal setbacks. Table 6 summarizes the treatment performance standards. Throughout this report, these standards are used to evaluate system performance data from literature reports, case studies, and other sources.

Table 6 also includes general values for wastewater effluent quality three to five feet below a standard OWTS drainfield. These general values are equivalent to or slightly higher than the TS-I performance standard. If adequate vertical separation between the bottom of the OWTS and groundwater exists, a properly sited and operated standard OWTS can perform as well as an alternative system that meets the TS-I standard. The Town's water quality monitoring program (described in detail in the Technical Report) includes a number of groundwater monitoring wells that are directly downgradient of the leachfields of standard OWTS and have adequate separation between the bottom of the leachfield and groundwater, particularly in the area near the finger canals. The Town does not monitor for BOD and TSS as part of the monitoring program. However, water quality monitoring program results for fecal coliform and ammonia in groundwater wells that are 5-15 feet downgradient from standard OWTS leachfields with 4-6 feet of vertical separation between the bottom of the leachfield and the groundwater consistently meet the TS-I performance standard for both parameters.

Although LPP dispersal systems are often considered “alternative” systems and qualify for reduced separation distances between the bottom of the systems and wetness, there is no regulated performance standard for wastewater effluent distributed by LPP systems.

4. PEAT BIOFILTER SYSTEMS IN NORTH CAROLINA

The On-site Wastewater Section of NCDENR's Environmental Health Division has approved two self-contained peat biofilter systems for permitting by local health departments. The Puraflo® Peat Biofilter System, manufactured by Bord na Mona Environmental Products US Inc. of Greensboro, North Carolina, was initially approved in 1998 (NCDENR, 2003a). The Ecoflo® Peat Biofilter System, manufactured by Premier Tech Environment Inc. of Rivière-du-Loup, Québec, was initially approved in 2000 (NCDENR, 2003b). These systems consist of a septic tank, followed by a pump tank that doses septic tank effluent to the peat modules at regular intervals. There are two major types of peat biofilters. Type A biofilters are open on the bottom, and effluent from the peat modules percolates into a gravel pad beneath the modules and then into the surrounding soil (Figure 5, top). Type B biofilters are completely enclosed; effluent is collected from the bottom of the filter modules and sent to a gravity or pressure dosed subsurface disposal system (Figure 5, bottom). Currently, only Type A biofilters are used in Dare County. Although these systems provide additional treatment beyond the septic tank and are required to meet TS-I performance standards, they do not remove all pollutants from wastewater effluent and thus they rely on native soils to provide final treatment (Lindbo and MacConnell, 2002).

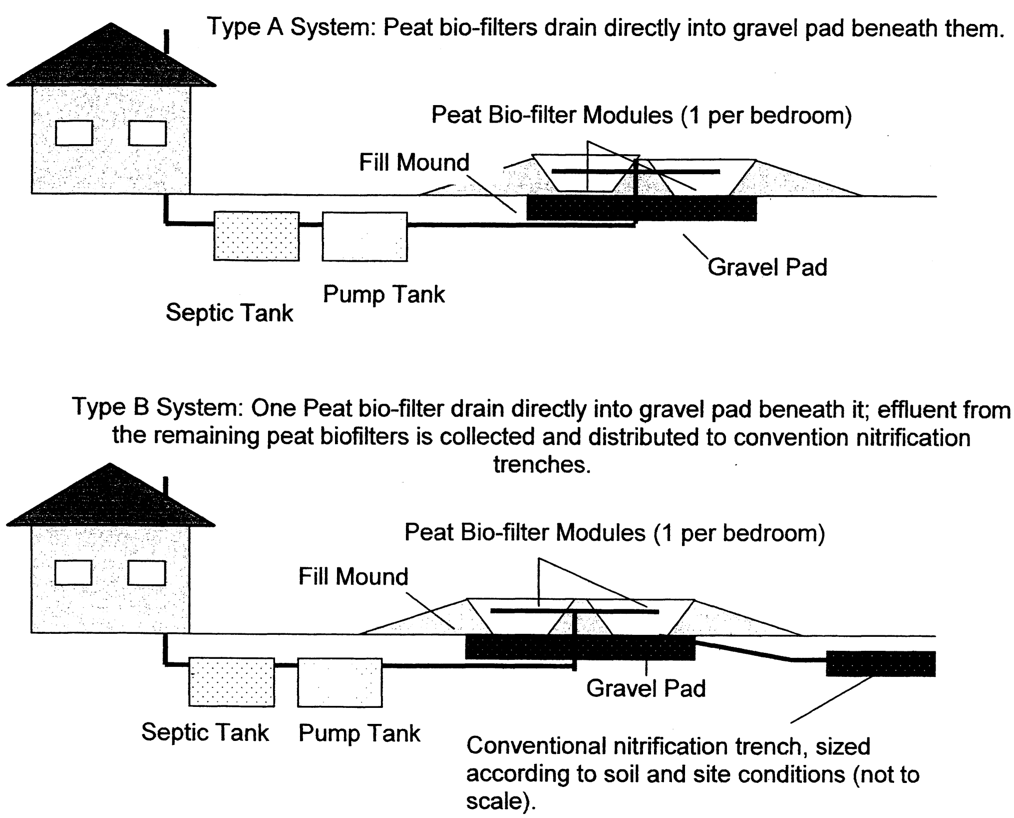

Figure 5. Schematic diagram of Type A and Type B Peat Biofilter systems in North Carolina (not to scale). Details of the septic tanks and pump tanks omitted for clarity. Source: Lindbo and MacConnell, 2001.

4.1. Construction and Installation Requirements

The construction and installation processes for peat biofilter systems in North Carolina are similar to those suggested by the manufacturers (Section 2.1.2). An on-site preconstruction meeting attended by the system designer, installer, local health department, licensed soil scientist, and property owner or owner's representative must be held prior to beginning system construction. System components are located so that horizontal setbacks are met and water inflow/infiltration is prevented. The peat biofilter modules are installed level on a rock bed as appropriate for the designed system type. For Type A systems, the bed is constructed as an elongated berm parallel to the ground slope. The parts of the rock bed that are not under the peat modules are covered with geotextile fabric to prevent fine particles from entering the bed. For Type B peat biofilter systems, the gravel or sand bed must be installed level, and must extend at least six inches beyond the ends of the modules in all directions.

Once the modules are installed, the excavation is backfilled, with the module tops remaining at least six inches above finished grade. A 24-hour hydrostatic leakage test is performed to demonstrate that all tanks and risers are watertight prior to system startup.

4.2. Operation and Maintenance Requirements

The management, inspection, and operation and maintenance requirements for peat biofilters are specified in the individual approvals and in the operating permit for each system. These systems are classified at a minimum as Type Va systems according to Table V(a) of Rule .1961(b). Both the local health department and the Operator-in-Responsible Charge (ORC) must conduct monitoring inspections of peat biofilter systems at a minimum frequency as specified in Table V of Rule .1961(b) and in each system's Operation Permit. Inspection and monitoring frequencies specified for Type IV, V, and VI systems are summarized in Table 7.

4.2.1. System Inspection Requirements

Currently, an operator must inspect each peat filter system at least two times a year. During each peat filter inspection, the ORC observes:

- Wastewater level in the tanks,
- Septic tank outlet filter or screened pump vault for clogging,
- Watertightness of tanks, risers and pipe connections,
- Operation of pumps, floats, valves, electrical controls and alarms,
- Pumping frequency from pump impulse counters and elapsed run time meters,
- The peat modules and the earthen mound and/or landscape retaining wall for any structural damage,

- Accessibility, adequate ventilation, excess odors, insect infestations,
- Vegetative growth over the drainfield,
- The drainfield area for surfacing of effluent,
- A sample of peat biofilter effluent collected from the sampling point to check for effluent clarity and odor, and
- Any additional observations, measurements, monitoring, and maintenance activities specified in the Operation Permit or recommended by the manufacturer.

In addition, during each inspection the following parameters must be measured and reported to the health department:

- Sludge and scum levels in the septic tank,
- Sludge level and grease presence in the pump tank,
- Pump delivery rate (drawdown test), and
- Dosing volume and measured or calculated average pump run time.

Within 30 days after each system inspection, the operator will provide a report to the system owner and the local health department. At a minimum, this report contains:

- The date and time of inspection,
- System operating conditions observed and/or measured as described above,
- Results from any laboratory analysis of any effluent samples,
- Maintenance activities performed since the last inspection report,
- An assessment of overall system performance,
- A determination of whether the system is malfunctioning, and the specific nature of the malfunction, and
- Recommendations for repair or for other maintenance activities.

Once a year, the peat filter modules must be opened for inspection of the peat media surfaces and maintenance in accordance with the manufacturer's maintenance protocols. Effluent ponding at the peat surface or in the sample chambers are indications of system failure and must be reported to the health department within 48 hours.

4.2.2. Effluent Sampling Requirements

Effluent sampling and analysis for peat biofilter systems must also be conducted once a year. For coastal counties, sampling of septic tank effluent and peat filter effluent must occur between June 1 and July 15. As of June 2004, systems that are at least a year old and have design flows of 600 gpd or less may use a pre-screening test for ammonia-N to determine whether the peat biofilter effluent is meeting the treatment performance standards. If the biofilter effluent has an ammonia-N concentration less than 15 mg/L, sampling is considered to be complete. If the peat filter effluent ammonia-N concentration exceeds 15 mg/L, the site fails the pre-screening test and additional actions are necessary:

- If this is the first concurrent pre-screening test failure, the system must be resampled within 15 days; or
- If this is the second concurrent pre-screening test failure, Full Compliance Testing and a flow study must be initiated within 15 days.

Peat biofilter systems that have design flows of greater than 600 gpd, or that previously failed the ammonia-N pre-screening test or any other performance standard, must undergo "Full Compliance Testing" once a year that includes at least the following elements:

1. Grab sampling of septic tank effluent.
2. For Type A peat systems, a 24-hour composite sample or grab sample of peat filter effluent is taken (composite sampling is encouraged to maximize the likelihood of complying with performance standards). For Type B peat systems, a peat filter effluent sample may be obtained by sampling effluent as it enters the pump tank, grab sampling from 12-to 18-inches below the liquid surface in the pump tank, or collecting a sample at a sampling port in the pump discharge line.
3. Laboratory analysis of septic tank effluent sample for BOD, TSS and TKN; laboratory analysis of peat filter effluent sample for BOD, TSS, ammonia-N, and fecal coliform.
4. Systems are considered to be in violation of performance standards if any parameter (BOD, TSS, ammonia-N, or fecal coliform) exceeds the standards even after resampling, or if daily flow is in excess of system design.
5. If peat filter effluent sample results exceed any of the performance standards, the Operator must complete a flow study to verify actual wastewater usage during the 1 to 30 day period after the sampling visit. If a 24-hour composite sample is collected, a flow study shall be concurrently performed during the 24-hour sampling period. As part of the "flow study", details on occupancy, use patterns, and observed activities are collected as available.

The system owner is issued a Notice of Violation by the local health department for violations of performance standards, or if the system otherwise is found to be malfunctioning. The owner and the system operator are responsible for diagnosing the reasons for the violation, although assistance can be sought from the manufacturer and the local health department. The owner has 60 days to respond to the local health department regarding steps being taken to alleviate any problems. The health department may require system maintenance or repairs or take other enforcement actions as needed.

4.2.3. Local Health Department Responsibilities

The local health department is currently required to conduct inspections of peat biofilter systems at least once per year (Table 7). After each inspection, the local health department provides a completed inspection report to the system owner, the manufacturer, and the State within 30 days. The local health department also provides an annual summary each January to the State including:

- The name of the environmental health specialist in the health department with primary responsibility for the peat biofilter program in the county/district,
- The number of improvement permits, construction authorizations, and operation permits issued for systems the prior year in the county/district,
- The total cumulative number of systems installed in the county/district, the percentage of operator reports due to the health department that have been received from the operators, and
- The percentage of systems that malfunctioned during the prior year, the nature of the malfunctions, and any remedies implemented or needed.

4.3. Peat Biofilter Performance in North Carolina

A performance study of four Puraflo® peat biofilter systems was recently conducted in eastern North Carolina (Lindbo and MacConnell, 2001). The systems were located in Gates, New Hanover, and Dare counties, and were chosen to represent a range of difficult site conditions, including organic soils, massive and/or poorly drained soils, and limited space. Both Type A and Type B systems (four systems total) were monitored for approximately two years, and were generally found to effectively reduce wastewater strength. Testing results improved during the first six months of the monitoring, suggesting that the systems require a maturation period in order to perform optimally. All tested parameters were within North Carolina's performance standards, and all of the biofilters were consistently aerobic (Table 2). Little reduction in total nitrogen or phosphorus concentrations was observed, but these results are similar to those reported elsewhere in the literature. Despite the overall high level of performance of these four systems, the Type B system experienced significant groundwater infiltration into the pump tank and septic tank that ultimately led to hydraulic overload in the soil and effluent ponding in the peat biofilter unit.

A study of Ecoflo® peat biofilters was conducted in North Carolina in the summer of 2003 with the objective of evaluating ammonia-N concentrations in peat biofilter effluent as a pre-screening indicator of system performance (Belanger et al., 2004). Twenty percent of the

Ecoflo® peat biofilters installed in the state (22 systems located in Dare and Brunswick counties) were sampled twice between July 1 and August 31, 2003, corresponding to the peak period of system usage in these areas. The average performance of the combined 22 systems generally met the North Carolina performance standards (Table 2). Although this finding is not emphasized in the study, it is worth noting that 10 of 42 BOD samples (24%), 2 of 42 TSS samples (5%), 26 of 42 ammonia-N samples (62%), and 5 of 35 fecal coliform samples (14%) were above their respective performance standards. These results indicate that a potentially significant number of systems in coastal communities may not be meeting performance standards during peak usage periods.

4.4. Failures and Replacement

Other coastal counties in North Carolina, where peat biofilter systems have been installed for longer periods of time, began to see failing systems approximately 3-5 years after the first systems were installed (Rob Crawford, pers. comm., 2005). Most of the peat biofilter systems in Nags Head are just reaching this age range, as the majority of the systems in town were installed after 2001.

All systems permitted by the County are designed and approved with identified replacement areas that can be used if a system fails. If a Type A peat biofilter system fails, it may be difficult to replace the system with anything except another Type A peat system. The dispersal field for Type A systems is located immediately beneath the peat biofilter modules. Since reductions in the size of dispersal fields are allowed for these systems and the systems are usually located on very small lots or in areas with other site limitations, replacement of the peat system with a conventional system may not be possible. In some cases, replacement of a peat system with an AdvanTex™ or other innovative system may be possible but would involve significant additional costs for the installation of the new system. Type B peat systems have a separate dispersal field located after the peat biofilter modules in the treatment train; thus, they require more land area and may be more amenable to replacement with a different type of technology if necessary.

In performance studies of peat biofilters in other areas of the country, ponded peat filters have often recovered if they were rested, aerated, and allowed to dry (Monson Geerts et al., 2001; Ebeling et al., 2003). Thus, in many cases, failure of one or more peat biofilter modules may not result in a need to replace the modules with a different type of pretreatment system, particularly if the original cause of the component's failure is identified and corrected. Additionally, in Nags Head's sandy soils, most OWTS failures occur in the system (due to root intrusion, lack of maintenance, or other issues) and not in the soil (Rob Crawford, pers. comm., 2005). In some instances, it may be preferable to repair only the failed portion of the system instead of replacing the entire system with a different technology.

5. INNOVATIVE/ALTERNATIVE SYSTEMS IN NAGS HEAD

The innovative and alternative systems currently operating in Nags Head are predominantly peat biofilter systems and low-pressure pipe (LPP) distribution systems, with a few trickling filter systems. Section 5.1 briefly describes the data sources that were used to analyze the condition and performance of I/A systems in Nags Head. A general summary of available I/A system information is provided in Section 5.2. Additional information about the performance of alternative systems in Nags Head, as well as information from discussions with Dare County Health Department regulators and from permit/file reviews, is presented in the following sections for peat biofilter systems, trickling filter systems, and LPP systems.

5.1. Data Sources and Analysis Methods

Parcel records were obtained from the Dare County Information Technology Department Web site, http://www.co.dare.nc.us/, in April of 2004. The database includes parcel address, ownership, land use, and structure information for all the parcels in Nags Head. This dataset formed the foundation of the database developed for analysis of water quality and OWTS data; the same database was used to analyze information about peat filters and other I/A systems for this report. This dataset also contains information about parcel use (residential or non-residential, and seasonal or year-round use) and design characteristics (numbers of bedrooms/bathrooms).

Data related to the conditions of I/A systems were collected from several sources, including the Septic Health Database developed by the Town of Nags Head Planning Department, a Permits Database maintained by the Dare County Health Department, a Peat Filter Compliance Tracking spreadsheet developed by Dare County Health Department staff, an I/A Systems Inventory developed by the Town of Nags Head Planning Department, and supplementary information collected from paper files at the Dare County Health Department offices. These data were evaluated to extract information on system type and location, components of systems, system inspections, permits on systems, system maintenance, and compliance with permit conditions and performance standards.

Municipal water use records were extracted from the Town of Nags Head databases by Town of Nags Head Planning Department staff. The raw data, collected approximately every two months, contained the water meter reading date and amount of water consumed for all the water accounts in the Town database from August 1999 through June 2004. For each water consumption record, the appropriate land use PIN value was determined. In addition, in order to calculate water use rates, the number of days between meter readings was required. The water consumption information that was imported to the database included the water account number, PIN, reading date, water use, and days since the last reading. Water use information was then compared to design flows to assess water use as a percentage of the design flow of each system. The magnitude of water use relative to design flows was assessed to identify the degree to which specific properties are exceeding the design flows of their onsite systems. Rather than take the water use from the single worst 2-month period during the last 5 years, the water use rate during the highest period in each of the past 5 years was averaged. This average annual maximum water use rate was then represented as a percentage of the property's onsite system design flow.

5.2. I/A Systems in Nags Head: General Findings

The innovative and alternative systems currently operating in Nags Head are predominantly peat biofilter systems and low-pressure pipe (LPP) distribution systems, with a few trickling filter systems. A summary of the alternative system types installed in Nags Head by year is shown in Table 8. Prior to 2000, LPP systems were the only alternative treatment technology used for onsite wastewater treatment. The first Bioclere® systems and Puraflo® peat biofilter systems were installed in Nags Head in 2000, and the first Ecoflo® peat systems and AdvanTex™ trickling filter systems were installed in 2002. At the end of 2004, there were at least 64 LPP systems, 64 peat biofilter systems, four Bioclere® systems, and one AdvanTex system installed in Nags Head.

Alternative systems in Nags Head are used on commercial and residential properties with both seasonal and year-round occupancy (Table 9). Low-pressure pipe distribution systems are used on both commercial and residential properties. Interestingly, for commercial uses LPP systems are predominantly used at businesses with year-round occupancy, while residences with LPP systems are primarily seasonally occupied. Peat biofilter systems are only used on residential properties, and the majority of these systems (50 of 64) are used on seasonally occupied residences. The Bioclere® systems are evenly split between year-round commercial and seasonal residential properties, and the AdvanTex™ system is installed on a seasonal residential property.

Water use that exceeds the design flow of any OWTS can lead to poor effluent treatment and ultimately to system failure. Some alternative wastewater treatment systems are especially sensitive to excessive water use. The magnitude of water use relative to design flows was assessed to explore whether excessive water use was likely to affect the performance of alternative systems in Nags Head (as in Section 4.5.2.3 of the Final Technical Report, Stone, 2005). The variability in water use rates by alternative system type and by property use is shown in Table 10. Interestingly, commercial LPP systems with year-round use were most likely to have peak water use rates that exceed their systems' design flows. Eighty percent of year-round commercial properties with LPP systems have peak use rates above 100% of design flows, while only 15% of all peat biofilter systems with water use records available have peak use rates above 100% of design flow.

5.3. Peat Biofilter Systems

5.3.1. Peat Biofilter Performance

As noted in Section 3.4, the TS-I treatment performance standard for peat filters is < 15 mg/L BOD_5 and TSS, plus reductions in ammonia-N and fecal coliform densities (Table 6). Peat filter systems are sampled once during the months of June or July, the months that systems in coastal communities generally receive the highest flows. Permit compliance for systems in Nags Head during the 2004 monitoring season is summarized in Table 11. Overall, the peat biofilter systems were approximately evenly divided between systems in compliance with treatment performance standards (36%), systems not in compliance (33%), and systems that could not be sampled (31%). Many of the systems that were not sampled were installed during spring or summer of 2004. Systems that are installed after September of any given year are not required to be sampled the following summer; thus, systems that were installed in early 2004 are not required to be sampled until the summer of 2005. Other reasons that systems were not sampled included insufficient flow into the sample chamber and difficult access to the sample chamber (Rob Crawford, pers. comm., 2005).

Although it appears that the Ecoflo® systems were more likely to comply with treatment performance standards than the Puraflo® filters, there are many more Puraflo® filters installed in Nags Head. If percentages of systems that were sampled are compared, about 25% of the Ecoflo® systems exceeded one or more treatment performance standards, while 53% of Puraflo® systems exceeded one or more performance standards. Most of the Puraflo® systems that exceeded performance standards (15 of 19 noncompliant systems) are seasonal residences.

The types of treatment performance standard violations observed for peat filter systems during the 2004 monitoring season are summarized in Table 12. Most of the violations observed were violations of the TSS and fecal coliform performance standards (total of 14 violations for each parameter), followed by BOD_5 (total of 8 violations). Only two systems had violations of the NH_4-N performance standard. The pattern of violations indicates that effluent may be traveling too quickly through the peat media for complete filtration and treatment to occur, resulting in elevated fecal coliform and TSS concentrations. However, the low number of NH_4-N violations indicates that the peat filters are not consistently saturated during the peak usage season and that adequate nitrification is generally occurring in the peat filter media.

For peat biofilter systems where both performance standard compliance data and water use data were available, there was not a strong correlation between potential excessive water use and performance standard violation. There were five peat biofilter systems (of 41 systems with both permit compliance and water use data available) with peak water use rates above 100% of design flow. Of these five, three systems were in compliance and two systems were non-compliant. Both of these systems had fecal coliform violations, while one system also had violations for BOD_5 and TSS. While the pattern of violations for the systems with excessive water use is similar to that noted above, it is interesting that most of the violations occurred on systems that, according to water use records, were operating within design flows. Water use information collected before and during the sampling period will allow a greater understanding of the correlation between water use and performance standard violation for peat biofilter systems.

Studies in North Carolina and in other parts of the country have shown that peat filter systems can take anywhere from two months to almost a year to mature after they are installed (Sections 2.1.4 and 4.3). After the maturation period, the peat filters studied in the literature generally produce effluent that is within North Carolina's performance standards. The current permit compliance effluent monitoring protocols acknowledge this maturation period by not requiring effluent monitoring for systems installed after September of each year as described above. There is no information in the literature regarding start-up issues with seasonally occupied properties. However, it is plausible that peat filter systems serving properties that are only occupied during the summer months would undergo a "start-up" and maturation period every summer that could conceivably last through the 2-3 peak months of peak occupancy. The Town is currently monitoring groundwater quality near a seasonally occupied residence that is served by a peat filter system. Collecting water use and occupancy data concurrently with water quality samples at this site would greatly aid in answering questions about seasonal start-up periods and their potential for impacts on effluent quality and water quality.

The peat biofilter effluent sampling protocol for the upcoming monitoring season has been modified by NC DENR in an attempt to better understand the reasons for noncompliance. The modified program will include septic tank effluent sampling and flow monitoring immediately before, during, and after the sampling event.

A number of design issues and other related problems with the peat biofilter units were noted by Dare County Health Department staff and/or were observed by Stone staff during a visit to Nags Head in May 2005. Bulging around the lid edges of the Puraflo® peat filter modules can allow sand into the unit, and warping of the units during backfill can make it difficult to remove the lids later for access. Additionally, the grooves in the lids of these modules slope towards the center of the unit, creating mosquito breeding habitat during rainy periods. For both Puraflo® and Ecoflo® peat filter systems, the distribution systems from the pump tank to the individual modules presumably dose all modules equally during each pump cycle. However, there is no simple way to assure that all modules are dosed equally, and there is some evidence that modules are not always dosed equally. Ants and vegetative growth around the units are also known issues with these systems. Some new installations in Nags Head are being landscaped with bark mulch around the modules to control plant growth.

5.3.2. Peat Biofilter Operation and Maintenance

Inspection, operation, and maintenance requirements for peat biofilter systems in Nags Head are the same as those mandated in approval documents and individual permits (Section 4.2). These requirements include two operator visits per year and peat filter effluent sampling once a year during the peak use season. This schedule is more rigorous than that recommended by the manufacturer (Section 2.1.3), and appears to be adequate from the perspective of Dare County regulators (Rob Crawford, pers. comm., 2005). Peat systems seem more sensitive to over-occupancy than LPP or conventional systems; in reality, if operator visits due to alarm conditions are included, peat systems are likely to have 4-5 operator visits per year (Crawford 2005 pers. comm.).

In Dare County, inspections, maintenance activities, and compliance sampling are generally being completed as required. County regulators estimate that 98% of systems are being sampled (or attempts are made to sample) during the peak usage season each year (Rob Crawford, pers. comm., 2005). During 2004, all the systems were inspected, and attempts were made to sample effluent from the peat biofilters at all but 5 of the systems. While regular inspections are occurring, the inspection results are often not reported to the County or to towns on a regular basis. Only two of 21 operators currently practicing in Dare County are completely compliant on reporting requirements (Rob Crawford, pers. comm., 2005). Enforcing the reporting requirements for operators is difficult, as the County is not the licensing agent for operators. The licensing agency appears to be overwhelmed and may not be adequately staffed to enforce compliance for operators.

5.3.3. Dare County Design Requirements and Perspectives

The largest concern of Dare County regulators is underdesigned systems, particularly peat biofilters, in resort areas. Dare County regulators currently design larger septic tanks and equalization tanks for peat biofilter systems than are specified by the manufacturers or in approval documents. They request 24-hour extra storage in the septic tank and extra storage equal to 2/3 of daily design flow in the equalization tank before emergency storage (Rob Crawford, pers. comm., 2005).

These additional storage volumes in the tanks help to protect the systems against overloading during peak usage periods. Additional actions planned at the County level include ongoing discussions with State regulators and manufacturers regarding the use of peat biofilter systems in resort areas. The County is likely to conduct a survey of water use patterns in these areas within the next 1-2 years in order to better understand how much metered water actually goes through wastewater treatment systems, and how much goes to other uses such as hot tubs, swimming pools, or outdoor showers. County regulators are also considering other system design modifications, such as requiring remote monitoring control panels (similar to the Vericomm™ panels used with AdvanTex™ treatment systems) and increasing required design flows for rental properties.

County regulators are concerned that real estate and rental companies are not enforcing occupancy limits in rental properties (Rob Crawford, pers. comm., 2005). It is currently a major hurdle to get real estate and rental companies to abide by these limits. Capacities of rental properties are often misrepresented, either by the homeowners or by the rental agents. Realtors must do their "due diligence" to verify the maximum number of occupants that a property should sleep, but they often do not. The County's only enforcement options are voluntary compliance and, failing that, formal complaints to the Realtors' Commission. A related issue is that developers are constructing new homes served by peat biofilter systems, and selling these properties to new homeowners without informing the owners about the system's permitting, operation, or maintenance requirements.

A longer-term regulatory concern is that North Carolina may be trending towards requiring nitrogen reduction in some sensitive environments (e.g., the TS-II treatment performance standard). Peat systems are not well suited for N reduction, especially the Type A systems that cannot be retrofitted for recirculation to the septic tank for denitrification.

5.3.4. Dare County Permit and File Review

During a site visit in May 2005, Stone staff reviewed permit files, effluent quality monitoring results, and inspection reports for peat biofilter systems that were not in compliance during the 2004 monitoring season. Generally, the file review confirmed observations of Town of Nags Head and Dare County staff. Over-occupancy was noted several times during inspections, as were problems with vegetation and sand covering the pods. Often, systems that exceeded performance standards in 2004 had a history of previous violations. There was also some evidence that, in a few cases, maintenance that must be initiated by the property owner (such as pumping septic tanks or pump tanks) was not being performed. Other issues included parking in repair areas, problems with alarms and control panels, settling of the peat media and uneven distribution of effluent between modules, and covering of the vent holes in the sides of the modules with sand or mulch.

5.4. Other Innovative/Alternative Systems in Nags Head

5.4.1. Trickling Filter Systems

The Bioclere® trickling filter systems being used at commercial properties in Nags Head and in Dare County are performing within their permitted standards. They generally remove 95-98% of influent BOD_5 and TSS. There are currently a total of eight Bioclere® projects in Dare County with design flows of over 3,000 gpd that are either approved or in pipeline for approval (Rob Crawford, pers. comm., 2005).

Aquapoint, Inc. has voluntarily discontinued the use of Bioclere® systems for residential use in North Carolina until mechanical issues with the systems' return pumps can be resolved (Rob Crawford, pers. comm., 2005). The effluent recycle rate for residential systems was too high initially, so hydraulic overloads were occurring in the septic tank and the Bioclere® treatment unit. The manufacturer is working with regulators to solve the problem before additional installations are permitted.

There is only one AdvanTex™ trickling filter system in Nags Head, and only a handful in Dare County. The system in Nags Head, serving a seasonal residential property, has fully complied with its permit requirements since it was installed in 2002. No problems have been reported with these systems to date, but the first installations are only about two years old. The systems appear to work well even under high flow conditions (Rob Crawford, pers. comm., 2005). One reason for this apparent robustness may be that the manufacturer requires much larger tank volumes (at least three times the daily design flow) than required for peat filters or other alternative systems. The AdvanTex™ systems are also equipped with remote monitoring panels that allow operators to observe flow and operating conditions as needed. Interestingly, the remote monitoring is showing flow spikes, but not the significant hydraulic overloads that other manufacturers have reported.

5.4.2. Low-Pressure Pipe Distribution Systems

Although initially, LPP systems in Dare County experienced some clogging issues, the use of sleeved LPP has eliminated most problems. Neither Dare County regulators nor Town staff expressed much concern about the performance of these systems. At the County level, regulators are seeing permit applications for the replacement of LPP systems with peat biofilter systems when systems are repaired or structures are expanded (Rob Crawford, pers. comm., 2005).

During a site visit in May 2005, Stone staff reviewed permit and inspection files for the two LPP distribution systems that are included in the Town's Water Quality Monitoring Program (Bodie Island Beach Club and Jeannette's Pier). The Jeannette's Pier LPP system appears to generally be operating in accordance with its permit requirements, while the Bodie Island Beach Club system has a history of problems that can generally be attributed to lack of maintenance (such as scum backed up into tank risers in at least two annual inspections in the mid-1990s). A number of annual inspection reports were missing from both files, so it is difficult to accurately assess the performance of these systems over time.

In North Carolina and in many other areas of the country, LPP distribution systems qualify for a reduced separation distance between the bottom of the distribution system and wetness (Table 4). The reduced separation distance is granted because the equal distribution of wastewater effluent over the dispersal area usually results in improved treatment of the effluent (Hoover et al., 1991; Bomblat et al., 1994; Amoozegar et al., 1994). However, improved treatment does not always occur in field situations, especially when the LPP distribution systems are overloaded (Gross, 2002). More than half of the commercial LPP systems that operate year-round in Nags Head show some evidence of being loaded at more than 100% of design flow during at least part of the year (see Section 5 above). The Town may wish to consider encouraging proper use and management of these systems in order to ensure that they do not impact groundwater or surface water quality in the future.

6. CONCLUSIONS AND RECOMMENDATIONS

Alternative wastewater treatment systems are used in many areas of the United States where site conditions, such as shallow water tables, small lot sizes, or nearby sensitive natural resources, preclude the use of conventional onsite wastewater treatment systems (OWTS). The two alternative technologies used most commonly in Nags Head are peat biofilters (on residential, predominantly seasonal properties) and LPP dispersal systems (mostly on year-round commercial and seasonal residential properties). There are also a few trickling filter systems in town serving both commercial and residential properties. Performance studies of these technologies in North Carolina and elsewhere show that when the systems are installed and operated properly, they can provide substantial additional treatment of septic tank effluent before dispersing it.

Prior to 2000, LPP systems were the only alternative treatment technology used in Nags Head for onsite wastewater treatment. Currently, there are a total of 64 LPP systems, 64 peat biofilter systems, four Bioclere® systems, and one AdvanTex system installed in Nags Head. Low-pressure pipe distribution systems in Nags Head are used primarily for year-round commercial and seasonal residential properties, while peat biofilter systems are predominantly used on seasonal residential properties.

Wastewater effluent quality at the bottom of peat filter systems is expected to meet the TS-I tertiary wastewater treatment standards, which are similar to the values generally observed 3-5 feet below the leachfield of a properly functioning standard OWTS. Peat filters and other alternative systems are granted reduction in vertical separation distances between the bottom of the system and groundwater, as well as reductions in horizontal separation distances to surface water and other natural features, on the basis of this improved treatment. These reductions in minimum site conditions mean that if an alternative system fails, there is less possibility for natural attenuation of wastewater effluent before it reaches the groundwater and, ultimately, the waters of the ocean or the sound.

As with all wastewater treatment systems, peat biofilters and other alternative technologies are designed to handle specific design flows and effluent strengths. If these design parameters are exceeded, the systems are more likely to provide incomplete treatment. Exceeding design parameters, coupled with lack of regular maintenance, may result in the premature failure of these systems and may eventually impact nearby groundwater and surface water quality. One of the Town's interests to date has been with the overloading of peat biofilter systems on seasonal residential properties; however, there is some evidence that commercial LPP systems may also be subject to the strain of excessive water use.

The performance of peat biofilter systems in Nags Head during the 2004 monitoring season was almost evenly divided between systems in compliance with treatment performance standards (36%), systems not in compliance (33%), and systems that were not sampled (31%). Most of the systems that were not sampled were installed during spring and summer 2004. Many of the systems that exceeded performance standards are seasonal residences, and the most common violations observed were violations of the TSS and fecal coliform performance standards. The pattern of violations indicates that effluent may be traveling too quickly through the peat media for complete filtration and treatment to occur, resulting in elevated fecal coliform and TSS concentrations. However, the low number of ammonia-N violations indicates that the peat filters are not consistently saturated during the peak usage season and that adequate nitrification is generally occurring in the peat filter media. An analysis of permit compliance and water use data did not discover a strong correlation between excessive water use and performance standard violation; however, water use information collected near the time of effluent sampling would produce a more accurate snapshot of this relationship. Operation, maintenance, inspection, and sampling of peat biofilter units in Nags Head is generally occurring as specified in approval documents and permits, although operator inspection results are not always reported in a timely fashion.

The following recommendations are offered to enhance the long-term sustainability of alternative wastewater treatment systems in Nags Head.

For all Type IV (LPP) and V (peat filter, trickling filter) wastewater treatment systems:

- Continue to track and periodically review operator inspection reports, Dare County Health Department inspection reports, and effluent quality monitoring results (for Type V systems).
- Encourage owners of alternative systems to maintain their systems through targeted outreach (such as annual postcards to all owners) and through the Town's inspection/pumpout program (perhaps by offering water bill credits for pumpouts if either the Town's inspection or a normal operator or County inspection shows that tank(s) need to be pumped).
- Through the Town's Water Quality Monitoring Program, collect water use information during normal sampling events by reading the structure's water meter, particularly on properties with LPP or peat biofilter systems. This information will help both the Town and Dare County regulators to understand water use patterns as they relate to alternative system performance and potential impacts on nearby groundwater quality.
- Conduct a water use survey (perhaps in collaboration with Dare County regulators), including a representative sample of both conventional and alternative wastewater treatment systems, to better understand water use patterns (including what amount of water used on a property actually passes through the property's wastewater treatment system).

For peat biofilter systems:

- The effluent sampling program for peat biofilters has been changed to include septic tank effluent sampling and flow monitoring immediately before, during, and after the sampling event. After the 2005 sampling season, review the inspection reports and monitoring results to determine whether there is a correlation between either organic or hydraulic overloading and non-compliance.

- The pattern of treatment performance standard violations for peat biofilter systems indicates that effluent may be short-circuiting or otherwise traveling too quickly through the peat media for complete filtration and treatment to occur, resulting in elevated fecal coliform and TSS concentrations. Changing the dosing regime of effluent to the peat filter modules to more frequent, smaller doses may help to correct this pattern.
- Encourage careful backfilling practices during installation to ensure that peat module lids can be easily removed for inspection and maintenance.
- Continue efforts to educate real estate and rental companies about the importance of understanding and abiding by occupancy limits on rental properties, particularly those served by peat biofilters.
- Keep abreast of ongoing discussions between County and State regulators and manufacturers regarding the use of peat biofilter systems in resort areas.
- Consider offering assistance, through informal phone calls or other means, to property owners where systems have a history of noncompliance.
- Consider developing outreach materials about peat biofilter systems and providing them to developers and/or prospective home buyers to increase awareness about the systems' permitting, operation, or maintenance requirements.
- Consider requiring landscaping, such as permeable landscape fabric covered with decorative stone, bark mulch, or wood chips, around peat biofilter units to control vegetative growth. Specify that the landscaping media should be large enough that it will not enter the peat modules through the vent holes in the sides of the modules.
- Consider suggesting design changes to manufacturers that would improve accessibility and appearance of the peat biofilter modules, including smooth lids that shed precipitation and lid attachment systems that do not require digging into the soil to access.
- Consider collaborating with Dare County regulators and/or State regulators to determine appropriate design flows, tankage volumes, distribution system improvements (such as dose counters or other means of ensuring equal flows to multiple modules), and other design parameters for peat biofilter systems serving resort properties in coastal communities.
- Consider encouraging system design changes at the County and State level, including requiring remote monitoring panels and increasing required design flows for rental properties.

For LPP distribution systems:

- In addition to the general recommendations above, consider targeting education efforts regarding water conservation to owners of commercial properties, particularly those with LPP distribution systems.

7. REFERENCES

Amoozegar, A., E. W. West, K. C. Martin, and D. F. Weymann. 1994. Performance evaluation of pressurized subsurface wastewater disposal systems. In *On-Site Wastewater Treatment: Proceedings of the Seventh International Symposium on Individual and Small Community Sewage Systems*. Atlanta, Georgia.

Aquapoint, Inc. 2003. Aquapoint Product Manual. New Bedford, Massachusetts.

Belanger, M.C., R.L. Uebler, R. Lacasse, S, Berkowitz, G. Belanger, J. Pearce, B. Withrow, and R. Crawford. 2004. Field evaluation of a single parameter screening method for assessing the performance of peat filters in North Carolina. In *NOWRA 2004 Conference Proceedings, 13th Annual Conference and Exposition*, Albuquerque, New Mexico, November 7-11, 2004.

Bomblat, C., D. C. Wolf, M. A. Gross, and E. M. Rutledge. 1994. Field performance of conventional and low pressure distribution septic systems. *On-Site Wastewater Treatment: Proceedings of the Seventh International Symposium on Individual and Small Community Sewage Systems*. Atlanta, Georgia.

Coupal, B., and J. Lalancette. 1976. The treatment of wastewaters with peat moss. *Water Resources* 10: 1071- .

Ebeling, J., S. Tsukuda, J. Hankins, and C. Solomon. Performance evaluation of a recirculating sand filter and peat filter in West Virginia. *Small Flows Quarterly* 4(1): 27-37.

Gross, M. 2002. Science vs. reality—Case study of system effectiveness. In *Proceedings of the Eighteenth Annual On-Site Wastewater Treatment Conference: Life Cycle Management of On-Site Technologies*. Raleigh, North Carolina.

Hoover, M. T., A. Amoozegar, and D. Weymann. 1991. Performance Assessment of Sand Filter: Low Pressure Pipe Systems in Slowly Permeable Soils of a Triassic Basin. In *On-Site Wastewater Treatment: Proceedings of the Sixth National Symposium on Individual and Small Community Sewage Systems*. Chicago, Illinois.

Jantraina, A.R., K.C. Sheu, A.N. Cooperman, and O.C. Pancorbo. 1998. Performance evaluation of alternative systems—Gloucester, MA, Demonstration Project. In *On-Site Wastewater Treatment* Volume 6, ASAE, St. Joseph, Michigan, pp. 480-489.

Lindbo, D. 2002. Peat Biofilter. In *Proceedings of the 18th Annual On-site Wastewater Conference, Life Cycle Management of On-site Technologies*, October 22-24, 2002, North Carolina State University, Raleigh, North Carolina, pp. 66-74.

Monson Geerts, S.D., B. McCarthy, R. Axler, J. Henneck, S. Heger Christopherson, J. Crosby, and M. Guite. 2001. Performance of peat filters in the treatment of domestic wastewater in Minnesota. In *On-Site Wastewater Treatment* Volume 7, ASAE, St. Joseph, Michigan, pp. 295-304.

NC DENR. 1998. Innovative Wastewater System Approval IWWS-98-1-R3, Puraflo® Peat Biofilter System. Issued May 15, 1998; last amended April 8, 2003. Available online at http://www.deh.enr.state.nc.us/oww/Innovati/IWWS_98_1-R3BordNM040803.pdf.

NC DENR. 2000. Innovative Wastewater System Approval IWWS-2000-3-R3, Ecoflo® Peat Biofilter System. Issued December 4, 2000; last amended September 2, 2003. Available online at http://www.deh.enr.state.nc.us/oww/Innovati/IWWS-2000-3-R3Ecoflo090203.pdf.

NSF International. 2003. Environmental Technology Verification Report: Reduction of Nitrogen in Domestic Wastewater from Individual Residential Homes, Aquapoint, Inc. Bioclere™ Model 16/12. Ann Arbor, Michigan., 02/02/WQPC-SWP. Available online at http://www.nsf.org/business/water_quality_protection_center/pdf/AWT_Bioclere_EPAAcceptedFinalReport.pdf.

O'Driscoll, J.P., K.D. White, D.W. Salter, and L. Garner. Long term performance of peat biofilters for onsite wastewater treatment. In *On-Site Wastewater Treatment* Volume 8, ASAE, St. Joseph, Michigan, pp. 530-537.

Orenco Systems, Inc. 2001. AdvanTex Treatment Systems Design/Engineering Package for Residential Applications. Orenco Systems Inc., Sutherlin, Oregon.

Premier Tech Environment, Inc. 2003. Ecoflo® Biofilters ST-500 and STB-500 Product Information. Accessed online on April 26, 2005 at http://www.premiertech.com/ecoflo/biofilter/new/images/fiche%20promo%20AN.pdf.

Rich, B., D. Halderman, T. Cleveland, J. Johnson, and R. Weick. 2003. Denitrifying systems using packed bed filters in the La Pine National Demonstration Project. In *Leaders for Decentralized Systems—The Changing World of Wastewater Treatment, NOWRA 2003 Conference Proceedings*, National Onsite Wastewater Recycling Association, Edgewater, Maryland, pp. 201-222.

Rich, B. 2005. La Pine National Demonstration Project, Puraflo® System Performance Summary. Accessed online on April 26, 2005 at http://marx.deschutes.org/deq/puraflo.htm.

Rock, C.A., J.L. Brooks, S.A. Braden, and R.A. Struchtemeyer. 1984. Use of peat for on-site wastewater treatment: I. Laboratory evaluation. *J. Environmental Quality* 13: 518-523.

Stone Environmental, Inc. 2005. *Warren, Vermont: A Different Approach For Small Rural Villages, a Demonstration Project Case Study for the US EPA*. In press.

Talbot, P., G. Belanger, M. Pelletier, G. Laliberte, and Y. Arcand. 1996. Development of a biofilter using organic medium for on-site wastewater treatment. *Water Science and Technology* 34: 435-441.

Talbot, P., H. Ouellett, and G. Laliberte. 1998. Development of a new on-site wastewater treatment technology in the evolving context of the last decade. In *On-Site Wastewater Treatment* Volume 6, ASAE, St. Joseph, Michigan, pp. 165-172.

US Environmental Protection Agency. 2000. Wastewater Technology Fact Sheet: Trickling Filters. Accessed on April 27, 2005 at http://www.epa.gov/owm/mtb/trickling_filter.pdf.

White, K.D.; L.A. Byrd, S.C. Robertson, J-P O'Driscoll, and T. King. 1995. Evaluation of Peat Biofilters for Onsite Sewage Management. *Environmental Health* 58 (4): 11-17.

Nags Head Decentralized Wastewater Management Plan
Town of Nags Head, North Carolina
Table 1: States With Peat Biofilter Installations

State	Puraflo® Approved Installers	Ecoflo® Approved Installers
Alabama	X	X
Arizona		X
Arkansas	X	
Delaware	X	
Florida		X
Georgia	X	X
Illinois	X	
Indiana	X	
Iowa	X	X
Kentucky	X	X
Maine		
Massachusetts		
Michigan	X	
Minnesota	X	X
Missouri	X	X
New York	X	
New Mexico		
North Carolina	X	X
Ohio	X	X
Pennsylvania	X	X
Tennessee	X	
Vermont		X
Virginia	X	X

Source: Manufacturers' websites, accessed April 13, 2005. STONE ENVIRONMENTAL, INC
Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\TableXX_PeatFilterInstallations.xls
Date/init: 4/13/05 anm

Nags Head Decentralized Wastewater Management Plan
Town of Nags Head, North Carolina
Table 2: Peat Biofilter Performance as Compared to Performance Standards

System Type	System Purpose and Location	Number of Units	Study Duration (months)	5-day Biochemical Oxygen Demand (BOD_5), mg/L	Total Suspended Solids (TSS), mg/L	Ammonium-nitrogen (NH_4-N), mg/L	Fecal Coliform Bacteria Density (MPN/100 mL)	Reference
Treatment Standard I (TS-I)[a]				15	15	15	10,000	NC DENR approval memo, 2004
Ecoflo	Demonstration units in Quebec (Canada)	4	24	6	5	17.6	6 (1)	Talbot et al., 1996
Ecoflo	Single-family, commercial, and institutional systems	24	12	6	4	n/r	10 (1)	Talbot et al., 1998
Ecoflo	Dare and Brunswick counties, North Carolina	22	2	9	5	10	591 (1)	Belanger et al., 2004
Puraflo	Replacement systems serving single family homes, southern Alabama	10	12	17.6	n/r	1.9	57665 (1) 3200 (2)	White et al., 1995
Puraflo	Subset of 10 S. Alabama systems above	4	5	4	13	11	23769 (1)	O'Driscoll et al., 1998
Puraflo	Single-family systems in central Alabama	3	2		0.3	14.3	595 (1)	O'Driscoll et al., 1998
Puraflo	Demonstration systems receiving STE in northern Minnesota	2	12	3.8	1.9	4.1	272 (3)	Monson Geerts et al., 2001
Puraflo	Single-family replacement systems on difficult sites in North Carolina	4	~25	4.5	6.5	1	945 (3)	Lindbo, 2002
Puraflo	Demonstration system receiving STE in West Virginia	1	12	1.9	6.1	15.2	8955 (3)	Ebeling et al., 2003
Puraflo	Single-family systems in Oregon	3	36	4	4.2	4	10,084(1) 278(3)	LaPine Demonstration Project, 2005
Constructed onsite	Demonstration systems receiving STE in northern Minnesota	2	18	3.7	13.3	21.2	638 (1)	McCarthy et al., 2001

Source: North Carolina Sewage Treatment and Disposal Systems Rules; individual innovative wastewater system approvals; literature reports as cited in table.

STONE ENVIRONMENTAL, INC

Notes: TS-I = Treatment Standard I; n/r = not reported.
[a] Effluent characteristics are determined by arithmetic mean concentrations except for fecal coliform densities, which are determined by geometric mean concentrations
BOD5, TSS, and NH4-N are reported here as average values over all systems reported in each study
Fecal coliform values are reported as averages, medians, or geometric means as follows
(1) = average
(2) = median
(3) = geometric mean
Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\TableXX_PeatBiofilterPerformanceSummary.xls
Date/init: 4/6/05 anm

Nags Head Decentralized Wastewater Management Plan
Town of Nags Head, North Carolina
Table 3: List of Approved Innovative Technologies for North Carolina

Component Category	Technology Name	Product Name	Manufacturer Name	Approval Date (and last revision date)	Approval Number
Alternative Septic Tanks	Fibermesh Reinforced Tanks	Fibermesh Reinforced Tank - Capacity 1000 gal.	Dellinger Septic Tank, Denver, NC	6/1/1998	IWWS-98-2
	Fibermesh Reinforced Tanks	Fibermesh Reinforced Tank - Capacity 1000 gal.	Stroupe Septic Tank Systems, Inc., Morganton, NC	2/1/1999	IWWS-99-1
Filters and Pumps	GAG Sim/Tech Filters	GAG Sim Tech Filters	GAG Sim/Tech filter, Boyne City, MI	6/1/1999	IWWS-99-2
	Flow Equalization System	None	Generic Approval	7/6/2004	IWWS-2004-01
	Non-Mercury Float Pump Control System	Pressure Activated Control Liquid Level Controllers (PAC) and associated RKSP-Series Control Panels	Chandler Systems, Inc.	9/29/2004	IWWS-2004-2
Pretreatment Systems	Norweco Bio-Kinetic® System	Norweco Bio-Kinetic® System	Norweco Inc.	2/12/2000	IWWS-2000-1
	Norweco Singular ATU/Sand Filter System	Singular ATU/Sand Filter System	Norweco Inc.	11/1/1999	IWWS-99-3
	Peat Filter Pretreatment Systems	Puraflo® Peat Biofilter System	Bord Na Mona Environmental Products US, Inc.	4/3/2001 (4/8/2003)	IWWS-98-1-R3*
	Peat Filter Pretreatment Systems	Ecoflo® Peat Biofilter System	Premier Tech Environment Inc.	12/4/2000 (9/2/2003)	IWWS-2000-3R3*
	Pressure Dosed Intermittent Sand Filter Kits		Orenco Systems, Inc.	7/23/1999	IWWS-97-1,attachment1
	Sand Filter Pretreatment Systems	Pressure Dosed Sand Filter Pretreatment Systems	Soil Science Dept., NCSU	5/1/1997	IWWS-97-1
	Trickling Filter System	Bioclere Modified Trickling Filter System	Aquapoint, Inc.	4/18/2002	IWWS-2002-1

Source: North Carolina Innovative Wastewater System Approvals, http://www.deh.enr.state.nc.us/oww/Innovati/innovative.htm

Nags Head Decentralized Wastewater Management Plan
Town of Nags Head, North Carolina
Table 3: List of Approved Innovative Technologies for North Carolina

Component Category	Technology Name	Product Name	Manufacturer Name	Approval Date (and last revision date)	Approval Number
Dispersal Systems	Brunswick Bed/Fill System	"Brunswick" Bed/Fill Wastewater Disposal System	Brunswick County Health Department	8/10/1995	IWWS-95-1
	Chamber Trench System	"Contactor Model 75, 100, 125 and field drain" Chambered Sewage Effluent Disposal System	Cultec, Inc.	4/5/1999	IWWS-95-4R2*
	Chamber Trench System	"Infiltrator" Chambered Sewage Effluent Sub-surface Disposal System	Infiltrator Systems, Inc.	8/25/1994 (9/29/2004)	IWWS-93-2-R9*
	Chamber Trench System	"Hancor EnviroChamber" Sewage Effluent Sub-surface Disposal System	Hancor, Inc.	8/10/1995 (1/13/2005)	IWWS-95-2-R2
	Chamber Trench System	Chambered Sewage Effluent Sub-surface Disposal System	PSA, Inc.	10/5/2001 (4/9/2003)	IWWS-97-2-R5*
	Drip System	"Perc-Rite"Subsurface Wastewater Drip Irrigation System	American Manufacturing Company	3/7/2001 (10/18/2002)	IWWS-93-1-R3*
	Drip System	Geoflow's Subsurface Drip System	Geoflow, Inc.	8/29/2000	IWWS-2000-2
	Drip System	Delta's Subsurface Drip System	Delta Environmental Products, Inc.	8/2/2001	IWWS-2001-1
	Multi-pipe System	PTI Multi-Pipe System, 11-pipe Model	Advanced Drainage Systems	4/18/2002 (8/2/2004)	IWWS-2002-2R
	Polystyrene Aggregate Trench System	EZflow Drainage Systems	Ring Industrial Group	10/10/1995 (4/18/2002)	IWWS-95-3-R3*
	Substitutes for 4" Corrugated Tubing	None	Generic Approval	7/13/2004	IWWS-2003-01
	Tire Chip aggregate	None	Generic Approval	10/1/2002 (7/15/2004)	IWWS-2002-03R

Source: North Carolina Innovative Wastewater System Approvals, http://www.deh.enr.state.nc.us/oww/Innovati/innovative.htm

STONE ENVIRONMENTAL, INC

Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\TableXX_IAApprovalsList.xls

Date/init: 5/2/05 anm

Nags Head Decentralized Wastewater Management Plan
Town of Nags Head, North Carolina
Table 4: Vertical Separation Distances for Standard and Approved Innovative Systems

Treatment System Type	Minimum depth of suitable or provisionally suitable soil (inches)	Minimum vertical separation between bottom of system and wetness (inches)
Conventional Trenches	36	18
LPP Systems	24	12
Type A Peat Filters	18	12
Type B Peat Filters	12	9
Bioclere Trickling Filters	12	12
AdvanTex TS-I	12	9
AdvanTex TS-II	12	6

Source: North Carolina Sewage Treatment and Disposal Systems Rules; individual innovative wastewater system approvals.

STONE ENVIRONMENTAL, INC

Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\Table4_VerticalSeparations.xls

Date/init: 4/1/05 anm

Nags Head Decentralized Wastewater Management Plan

Town of Nags Head, North Carolina

Table 5: Horizontal Separation Distances for Standard and Approved Innovative Systems

Land Feature or Component	Existing Rules [.1950 (a)]	Systems Meeting Class I Criteria: ATUs Meeting NSF Standard 40	Systems Meeting TS-I Criteria: Ecoflo®, Puraflo®, Bioclere, AdvanTex	Systems Meeting TS-II Criteria: Bioclere, AdvanTex
Any private water supply source	100	50	70	50
Any public water supply source	100	100	100	100
Streams classified as WS-I	100	70	70	50
Waters classified as S.A. (from mean high water mark)	100	70	70	50
Other coastal waters (from mean high water mark)	50	35	35	25
Any other stream, canal, marsh or other surface waters	50	35	35	25
Any Class I or Class II reservoir (from normal pool elevation)	100	70	70	50
Any permanent storm water retention pond (from flood pool elevation)	50	35	35	25
Any other lake or pond (from normal pool elevation)	50	35	35	25
Any building foundation	5	5	5	5
Any basement	15	15	15	15
Any property line	10	10	10	10
Top of slope of embankments or cuts of 2 feet or more vertical height	15	15	15	15
Any water line	10	10	10	10
Upslope Interceptor drains	10	10	7	7
Sideslope Interceptor drain	15	15	10	10
Downslope Interceptor drain	25	25	20	15
Groundwater Lowering Ditch	25	25	20	15
Any swimming pool	15	15	15	15
Any other nitrification field (except repair area)	20	20	10	10

Source: North Carolina Sewage Treatment and Disposal Systems Rules; individual innovative wastewater system approvals.

STONE ENVIRONMENTAL, INC

Notes: Class I: NSF Standard 40 effluent quality standard (secondary wastewater treatment)
TS-I: Treatment Standard I (tertiary wastewater treatment without nitrogen reduction)
TS-II: Treatment Standard II (tertiary wastewater treatment with nitrogen reduction)

Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\TableXX_HorizontalSeparations.xls

Date/init: 4/4/05 anm; rev 7/5/05 anm

Nags Head Decentralized Wastewater Management Plan

Town of Nags Head, North Carolina

Table 6: Performance Standards for Alternative Systems

Effluent Characteristic	Septic Tank Effluent[a]	Expected Soil Water Quality 3-5 Feet Below Standard OWTS Disposal Field[b]	NSF Standard 40 Class I Effluent Limits[c]	Treatment Standard I (TS-I)[d]	Treatment Standard II (TS-II)
Biochemical Oxygen Demand, 5-Day (BOD_5)	300	14-20	25	< 15	< 15
Total Suspended Solids (TSS), mg/L	200	5-10	30	< 15	< 15
Ammonium-nitrogen (NH_4-N), mg/L	(included with total N)	0-8	n/a	< 10	< 10
Fecal Coliform Bacteria Density (MPN/100 mL)	n/a	100-10,000	n/a	< 10,000	< 10,000
Total Nitrogen, mg/L	80	32-90	n/a	n/a	50% reduction or Total N < 15 mg/L

Source: North Carolina Sewage Treatment and Disposal Systems Rules;
individual innovative wastewater system approvals.

STONE ENVIRONMENTAL, INC

Notes: TS-I = Treatment Standard I; TS-II = Treatment Standard II; n/a = not applicable.

[a] Specified for peat biofilter systems in innovative approval modifications (NC DENR, 2004).

[b] Values are from Table 3-19 in US EPA, 2000.

[c] Class I effluent characteristics are determined by maximum 30-day average concentrations

[d] For TS-I and TS-II, effluent characteristics are determined by arithmetic mean concentrations except for fecal coliform densities, which are determined by geometric mean concentrations.

Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\TableXX_PerformanceStandards.xls

Date/init: 4/5/05 anm; rev 7/5/05 anm

Nags Head Decentralized Wastewater Management Plan
Town of Nags Head, North Carolina

Table 7: Summary of Maintenance and Management Requirements for Type IV, V, and VI Systems

System Classification	System Description	Health Department Internal Review Frequency	Management Entity Responsibilities: Management Entity	Management Entity Responsibilities: Inspection/Maintenance Frequency	Management Entity Responsibilities: Reporting Frequency
Type IV	a. Any system with LPP distribution b. System with more than 1 pump or siphon	3 yrs.	Public Management Entity with a Certified Operator or a private Certified Operator	2/yr.	12 mos.
Type V	a. Sand filter pretreatment system	12 mos.	Public Management Entity With a Certified Operator or a private Certified Operator	a. 2/yr (0-1500 GPD) 4/yr (1500-3000 GPD) 12/yr (3000-10000 GPD) 1/wk (> 10000 GPD)	6 mos.
	b. Any > 3,000-GPD septic tank system with a nitrification field designed for > 1500 GPD			b. 12/yr (3000-10000 GPD) 1/wk (> 10000 GPD)	
	c. Aerobic Treatment Unit (ATU)			c. 4/yr.	
	d. Other mechanical, biological, or chemical pretreatment plant (< 3000 GPD) including peat biofilters			d. 12/yr.	
Type VI	a. Any > 3,000 GPD system with mechanical, biological, or chemical pretreatment system plant	6 mos.	Public Management Entity With a Certified Operator	a. 1/wk (3000-10000 GPD) 2/wk (10000-25000 GPD) 3/wk (25000-50000 GPD) 5/wk (> 75000 GPD)	3 mos.
	b. Wastewater reuse/recycle			b. 12/yr.	

Source: North Carolina Sewage Treatment and Disposal Systems Rules;
individual innovative wastewater system approvals.

Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\TableXX_MgmtRequirements.xls

Date/init: 4/11/05 anm

STONE ENVIRONMENTAL, INC

Nags Head Decentralized Wastewater Management Plan
Town of Nags Head, North Carolina
Table 8: Alternative Systems Permitted in Nags Head by Type and Year

System Type	Total Systems	1999 and earlier	2000	2001	2002	2003	2004
Bioclere	4		1	1	1	1	
Advantex	1				1		
LPP	64	47	3	9	5		
Ecoflo Peat Filter	13				6	5	2
Puraflo Peat Filter	51		6	4	13	12	16
Unspecified	9	9					

Source: LPP, Advantex, and Bioclere permit dates from Dare County permits database, 2004; peat filter permit dates from tracking spreadsheet provided by Dare County staff, 2005.

STONE ENVIRONMENTAL, INC

Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\TableXX_IASystemsByYear.xls

Date/init: 5/10/05 anm

Nags Head Decentralized Wastewater Management Plan
Town of Nags Head, North Carolina
Table 9: Alternative Systems Permitted in Nags Head by Type and Use

Use Type	Occupancy	Bioclere	Advantex	LPP	Ecoflo	Puraflo	Unspecified
Commercial	Year-round	2		21			4
Commercial	Seasonal			2			
Residential	Year-round			9	1	13	2
Residential	Seasonal	2	1	32	12	38	3

Source: Town of Nags Head staff and Dare County permit data; 2004-2005.
STONE ENVIRONMENTAL, INC
Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\TableXX_IASystemsByUse.xls
Date/init: 5/10/05 anm

Table 10: Peak Average Water Use by Alternative System Type and Property Use

System T ype	Use Type	Occupancy	Total Systems With Water Use Information	Peak Average Water Use as Percentage of Design Flow			
				< 75%	75-100%	101-150%	>150%
Bioclere	Commercial	Year-round	2	2 (100%)			
Bioclere	Residential	Seasonal	1	1 (100%)			
LPP	Commercial	Year-round	20	2 (10%)	2 (10%)	5 (25%)	11 (55%)
LPP	Commercial	Seasonal	2	1 (50%)			1 (50%)
LPP	Residential	Year-round	8	5 (63%)		1 (12%)	2 (25%)
LPP	Residential	Seasonal	30	14 (47%)	11 (37%)	3 (10%)	2 (6%)
Ecoflo	Residential	Year-round	1	1 (100%)			
Ecoflo	Residential	Seasonal	12	9 (75%)	1 (8%)		2 (17%)
Puraflo	Residential	Year-round	9	6 (67%)	1 (11%)	2 (22%)	
Puraflo	Residential	Seasonal	30	16 (53%)	10 (33%)	2 (7%)	2 (7%)
IA-Unspecified	Commercial	Year-round	4	1 (25%)			3 (75%)
IA-Unspecified	Residential	Year-round	2				2 (100%)
IA-Unspecified	Residential	Seasonal	3		1 (33%)	2 (67%)	
TOTALS			124	58 (47%)	26 (21%)	15 (12%)	25 (20%)

Source: Parcel usage and water use data from Town of Nags Head staff, 2004.

STONE ENVIRONMENTAL, INC

Notes: Peak average water use was calculated by determining peak daily water use for each year of available data for a property, then averaging the peak water use values. The peak water use value was then divided by the property's OWTS design flow to determine water use as a percentage of design flow.

Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\TableXX_IASystemsPeakWaterUse.xls

Date/init: 5/11/05 anm

Nags Head Decentralized Wastewater Management Plan

Town of Nags Head, North Carolina

Table 11: Peat Biofilter System Permit Exceedances for 2004 Monitoring

				Permit Compliance		
System T ype	Use Type	Occupancy	Total Systems	Compliant Systems	Noncompliant Systems	Not Sampled
Ecoflo	Residential	Year-round	1		1 (100%)	
Ecoflo	Residential	Seasonal	12	6 (50%)	1 (8%)	5 (42%)
Puraflo	Residential	Year-round	13	4 (31%)	4 (31%)	5 (38%)
Puraflo	Residential	Seasonal	38	13 (34%)	15 (39%)	10 (27%)
TOTALS			64	23 (36%)	21 (33%)	20 (31%)

Source: Parcel usage data from Town of Nags Head staff, 2004;
peat filter system permit compliance data from Dare County Health Department staff, 2005.

STONE ENVIRONMENTAL, INC

Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\TableXX_PeatFilterCompliance.xls

Date/init: 5/11/05 anm

Nags Head Decentralized Wastewater Management Plan

Town of Nags Head, North Carolina

Table 12: Peat Biofilter System Permit Exceedances for 2004 Monitoring Season

				Number of Exceedances for Each Performance Standard			
System T ype	Use Type	Occupancy	Total Noncompliant Systems	BOD_5	TSS	NH_4-N	Fecal Coliform
Ecoflo	Residential	Year-round	1				1
Ecoflo	Residential	Seasonal	1		1		1
Puraflo	Residential	Year-round	4	1	3		3
Puraflo	Residential	Seasonal	15	7	10	2	9
TOTALS			21	8	14	2	14

Source: Parcel usage data from Town of Nags Head staff, 2004;
peat filter system permit compliance data from Dare County Health Department staff, 2005.

Path: O:\Proj-04\1477-W\Reports\IASystems\Tables\TableXX_PeatFilterNonComplianceParams.xls

Date/init: 5/11/05 anm

STONE ENVIRONMENTAL, INC