Technical Memorandum

Date: November 6, 2014

To: Christina Taylor
Orange County Planning

From: Duong Do, PE

Re: Proposed Onsite Wastewater Treatment System (OWTS) for The Preserve at San Juan Development # 9302E

1.0 Introduction and Purpose

The Preserve at San Juan Development is a proposed greenfield development located on the west side of Ortega Highway (HWY 74) at the Riverside and Orange County limits within the Cleveland National Forest. The Project is divided into several phases: Phase I is the southern land parcel and Phase II is the northern land parcel. A third phase, located between Phases I and II, is to be developed in the future, but there is no current plan for the third phase. Both Phases will have a total of approximately 72 estates homes. The development may also include a clubhouse for the residents and a new fire station for the area.

The purpose of this technical memorandum is to provide a summary of the proposed onsite wastewater treatment system (OWTS) for the Preserve at San Juan Development. Due to its location away from urban development, established sewer service is not available, requiring the Development to provide wastewater treatment for the proposed homes. In addition, the natural pristine condition of the area requires that the OWTS produce high quality effluent that will not adversely impact the surrounding environment.

Wastewater generated from each home within the development will be treated using an Anua Puraflo® Peat Fiber Biofilter OWTS located on individual lots. The Puraflo OWTS will utilize a traditional septic tank system followed by a biological peat filtration system. The septic tank provides primary treatment through biological anaerobic treatment of the wastewater and to settle out solids. The biological peat filtration system provides secondary treatment through aerobic attached growth prior to subsurface irrigation reuse.

The proposed Puraflo OWTS was selected for the following benefits:

- Primary treatment will be through a traditional septic system, which is an accepted treatment process that most residential home owners are familiar with and has an established service industry that can assist home owners with maintenance and repair.
- The Puraflo peat fiber biofilter is a stand-alone modular system that has been certified under the provisions of NSF/ ANSI Standard 40 to meet the classification for Class I residential wastewater treatment systems and can produce high quality effluent that will meet USEPA and California Title 22 for non-disinfected secondary water quality standards. Effluent can be reused for subsurface irrigation, reducing potable water demand.
- Both the septic system and the peat fiber biofilter are designed for continuous operation even during periods of low loading or no-flow dormant stages.

2.0 Wastewater Generation

Phase 1 of the Preserve will consist of 43 estate style homes and Phase 2 will be comprised of 29 estate style homes. Each home will have a minimum of 5 bedrooms and is estimated to be approximately 5,000

ft^2. Due to its location away from more urban development, it is anticipated the occupancy will be based on secondary or vacation residency, and not primary residency. The homes will be equipped with water conserving fixtures and appliances to minimize water use and wastewater generation.

Wastewater generation rate will not be typical due to the frequency of occupancy and the use of water-conserving fixtures. Based on an EPA report, wastewater generation rate for households with water conserving fixtures is approximately 50 gpd per person (EPA, 2008). However, to be conservative, the OWTS will be designed based on a typical wastewater generation rate of 100 gpd per person with an average of 3.2 people per household (EPA, 2008) or 320 gallons per day per household.

3.0 OWTS Treatment Process

Wastewater generated from each residential unit will be treated by an Anua Puraflo® Peat Fiber Biofilter OWTS located on each lot. The Puraflo OWTS will consist of three components: (1) a 1500-gallon septic tank, (2) modular peat fiber biofilters, and (3) an Effluent Pump Station (EPS) with emergency storage. Effluent from the Puraflo OWTS will be used to irrigate portions of the adjacent fuel modification Zone B, which is a 150-ft vegetation management area used for fire protection. Figure 1 shows a typical Puraflo OWTS layout for a typical lot within the Preserve Development.

Septic Tank

The primary purpose of the septic tank is to provide primary treatment, especially to reduce the organic matter and total suspended solids to levels that will not foul the secondary treatment, which in a traditional setting would be leach fields but in this project it will be the peat fiber biofilters. In the septic tank, organic matter is broken down through anaerobic digestion using microorganisms, such bacteria, fungi, and protozoa. Typical septic tank anaerobic process can reduce biological oxygen demand (BOD) loading by 50 – 60% and total suspended solids (TSS) loading by of 60 – 80% (average removal rates are shown in Table 1). Unlike the aerobic process, the anaerobic process does not require oxygen and as a result does not require any aeration equipment, such as mixers and blowers. This reduces maintenance and operating cost for the home owner. The anaerobic process is also a slow-growth process where the microbes multiply slowly, allowing the process to sustain frequencies of low-load or dormant periods. Therefore, septic systems are suitable for secondary or vacation homes or occupancies that may have extended periods of low or no use.

Table 1: Average Removal of BOD, TSS and Grease in Septic Tank[1]

Parameter	Average Raw Sewage Influent	Average Septic Tank Effluent	% Removal
BOD mg/L	308	122	60
Total Suspended Solids mg/L	316	72	77
Grease mg/L	102	21	79

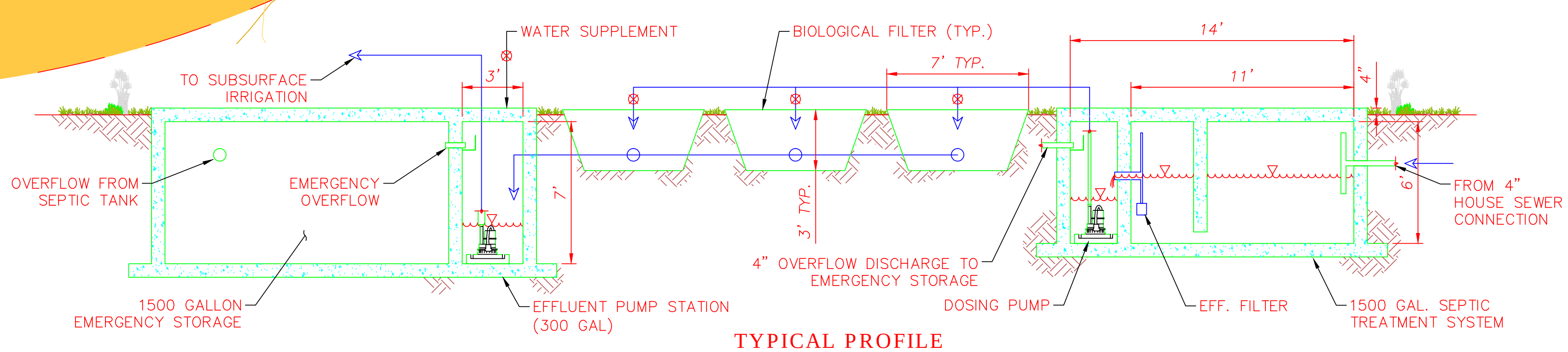
[1]Average of results from the following sources: Crites and Tchobanoglous, (1997); Otis et al. (1973); Seabloom et al. (1982); Bounds, (1997).

Residential septic tank size is based on the number of bedrooms serve per the California Plumbing Code. As a result, a 5-bedroom home will require a septic tank with a minimum volume capacity of 1,500 gallons (See Table 2 for Septic Tank Size Criteria). Specifically for the Preserve Development, the septic tank will include a separate compartment to serve as a dosing tank that will be equipped with a dosing pump. The septic tank will also be equipped with an effluent filter to prevent any solids spill over into the dosing tank and water tight risers (to grade) for filter and tank maintenance. An emergency overflow pipe will also be installed in the dosing tank to allow for emergency overflow to an emergency storage compartment located at the EPS. High water level alarm will be provided to alert the home owner of potential overflow conditions.

PLAN VIEW

FUEL MODIFICATION LEGEND

- ZONE A – 20'
- ZONE B – 150'
- ZONE C – 50'



TYPICAL PROFILE

SCALE: 1/4"=1'-0"

NO | BY | DATE | REVISIONS | DATE | APP.

PRELIMINARY NOT FOR CONSTRUCTION

PREPARED BY DUONG T. DO, PROJECT ENGINEER, R.C.E. NO. #62802, EXP. 06/30/16

DRAWN D.S. | DESIGNED | CHECKED | SCALE | DATE

TITLE: ONSITE WASTEWATER TREATMENT SYSTEM TYPICAL LAYOUT

JOB: THE PRESERVE AT SAN JUAN, ORANGE COUNTY CA

PACE Advanced Water Engineering
17520 Newhope Street, Suite 200 | Fountain Valley, CA 92708
P: (714) 481-7300 | www.pacewater.com

FIGURE 1 OF xx SHEETS

JOB NO. 9302-E

Table 2: Septic Tank Sizing Criteria[1]

Single family dwellings - number of bedrooms	Multiple dwelling units or apartments - one bedroom each	Other Uses: Maximum Fixture Units Served Per Table 4-1	Minimum septic tank capacity in gallons (liters)
1 or 2		15	750 (2839)
3		20	1000 (3785)
4	2 units	25	1200 (4542)
5 or 6	3	33	1500 (5678)
	4	45	2000 (7571)
	5	55	2250 (8518)
	6	60	2500 (9464)
	7	70	2750 (10410)
	8	80	3000 (11356)
	9	90	3250 (12303)
	10	100	3500 (13249)

[1]Source: Orange County Public Works On-Site Sewage Guidelines (2010) adaptation of the California Plumbing Code.

Puroflo Peat Fiber Biofilter
From the septic tank, effluent is then discharged to the dosing tank, where the effluent is pumped to the Puroflo peat fiber biofilters. The biofilters provide secondary treatment where the partially treated septic effluent is fully treated through an aerobic attached growth process. As the water trickles down through the filtering beds, the contaminants are physically absorbed onto the peat fiber. The microbes naturally attached onto the peat media to metabolize the contaminants. Aerobic condition is maintained through the structure porosity of the peat.

The peat fiber structure and quantity provide a high ratio of surface area to volume so the filter can support a relatively large diverse microbial population within a small footprint. This robust microbial population provides the biological oxidation required to produce high quality effluent, and it helps sustain the treatment process during periods of low or no flow to the system. When wastewater supply to system stops, the microbial population changes. Many of the bacteria and fungi will form spores during periods of nutrient depletion. These spores will remain dormant until a new supply of wastewater is added to the biofilter. Other non-sporing microorganisms will remain in a dormant inactive state until nutrients are provided. Some microorganisms and higher life forms will persist in the peat media feeding on the residual biomass, helping to turn over the microbial population in the peat.

The Puraflo peat biofilters use peat fiber media imported from Ireland, which has a greater resistance to decay and degradation than other peat media due to its fibrous structure and high lignin content. It has been tested and certified by the National Sanitation Foundation (NSF) International to meet Class I effluent standards. In multiple case studies, the Puraflo peat biofilters has consistently produce effluent that is less than 10 mg/L BOD and TSS and fecal coliform of less than 1,000 coliform forming units (CFU) per 100 ml. The high effluent quality from the Puraflo peat biofilters exceeds water quality from gray water and exceeds USEPA and California Title 22 Non-Disinfected Secondary Effluent Standards as shown in Table 3. The high quality effluent will be reclaimed for subsurface irrigation of adjacent fuel modification zones, thus reducing potable water demand within the Development. The NSF Certification Testing and independent case studies on the Puraflo peat biofilter treatment system performance can be found in Appendix A.

Table 3: Effluent Quality Comparison.

	Effluent Quality		
	Gray Water System[1]	CA and USEPA Secondary Treatment Standards	Puraflow Peat Effluent Results
BOD (mg/L)	26-130	25 for 30-d ave	<10
TSS (mg/L)	7-240	30 for 30-d ave	<10
Fecal Coliform (CFU/100 ml)	1.8×10^4 - 8×10^6	-	<1000

[1] Eriksson (2003) and Casanova et al. (2001) based on Residential gray water without kitchen sink.

The Puraflo peat biofilter is a modular system with each module rated for 150 gpd. At a design flow of 320 gpd, three modules will be required per residential unit at the Preserve. Typical design criteria of the Puraflo peat biofilter are listed in Table 4 below.

Table 4: Puraflo Peat Biofilter Design Criteria.

Item	Puraflo Peat
Primary treatment (septic tank)	Yes
Effluent screening	Effluent filter 1/32" filtration
Timed-dosing (doses per day)	12
Air ventilation	Surface access (holes in side of module lid)
Area	26.93 ft^2
Hydraulic loading	5.57 gpd/ft^2
Organic loading	0.0140 lbs BOD_5/ft^2/d
Media depth	24"
Media void space	90 - 95%
Water holding capacity, % volume	50 - 55%
Media size	1 - 10mm
Media surface area	52,000 ft^2/ft^3
Media replacement	~15 years
Effluent BOD_5, typical	<10 mg/l
Effluent TSS, typical	<10 mg/l
Effluent fecal coliform range, geo mean	<1,000 - <10,000 per 100 ml

The modules will be installed in-ground to minimize surface obstruction for the home owner. The access lid and aeration vents will be slightly above grade to allow for maintenance and proper air flow. The modules will be piped together to allow the treated effluent to drain to the EPS (Type B configuration) as shown in Figure 2 below. The peat media has an effective life of 15 years. Appendix B contains additional Anua Puraflo equipment information, design details and specifications.

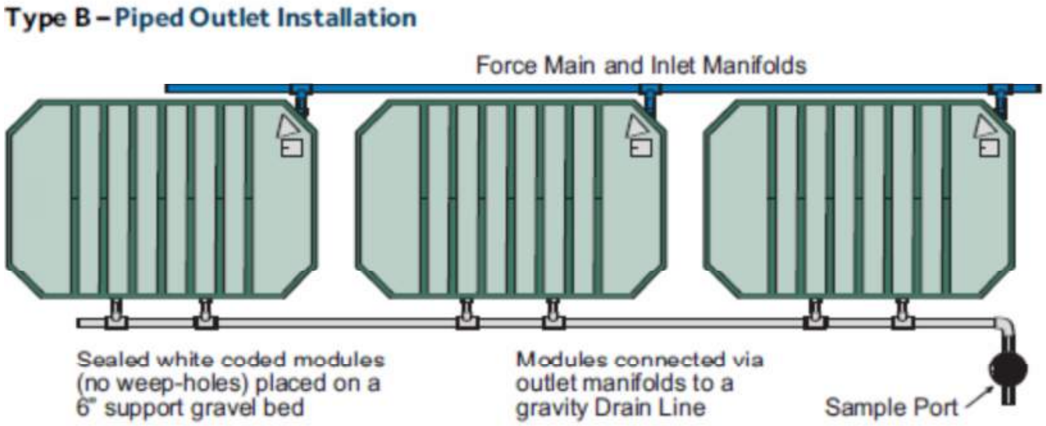


Figure 2: Piped Outlet Configuration for Puraflo Peat Biofilters.

Effluent Pump Station (EPS)

Once treated through the Puraflo OWTS, the effluent flows by gravity to the EPS to be reclaimed for subsurface irrigation of the Zone B fuel modification area adjacent to the homes (see also Figure 1). The EPS will be sized to provide 300 gallons of storage to maximize effluent storage based on the design wastewater generation rate. The pump station will also be equipped with an overflow weir to allow for emergency overflow to the adjacent storage compartment. The pump station will be designed with both level control and timer, as well as high level alarm to notify of a high water level condition. The EPS pump will be sized accordingly based on the irrigation area and subsurface irrigation equipment to be used. Subsurface irrigation lines will be designed and installed per California Plumbing Code and per the manufacturer's recommendations. For additional information on the subsurface irrigation system design and irrigation demand, see The Water Reuse Study (Robert Mitchell & Associates, November 2014) in Appendix C.

In the event of an emergency overflow due to pump issues at EPS or at the septic tank, overflow pipes will allow excess flow to overflow to the emergency storage, located in an adjacent compartment within the EPS structure. The emergency storage compartment will provide 1,500 gallons of storage (equivalent to 5-day storage of effluent). The emergency storage is for emergency overflow conditions only and not intended for daily effluent disposal. High water alarms will alert home owners of high water level conditions prior to an overflow event at either the EPS or at the septic tank. The alarm system will also alert the Development's Home Owners Association to ensure that corrective actions are taken.

Reference:

Bounds, T.R. (1997). *"Design and Performance of Septic Tanks,"* Site Characterization and Design of On-Site Septic Systems, ASTM STP 1324, M.S. Bedinger, J.S. Fleming, and A.I. Johnson, Eds., American Society for Testing and Materials.

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Advanced Water Engineering

Appendix A – NSF Certification

WASTEWATER TECHNOLOGY

NSF/ANSI Standard 40 - *Residential Wastewater Treatment Systems*

Final Report:
Bord Na Mona Environmental Products US, Inc.
Puraflo P150N*3B Wastewater Treatment System
05/09/2015/060

NSF International
789 N. Dixboro Road
PO Box 130140
Ann Arbor, Michigan 48113-0140 USA

Evaluation Report:
Bord na Mona Environmental Products US Inc.
Puraflo P150N*3B Wastewater Treatment System

Under the provisions of NSF/ANSI Standard 40
Residential Wastewater Treatment Systems

June 2006

EXECUTIVE SUMMARY

Testing of the Bord na Mona Model P150N*3B was conducted under the provisions of NSF/ANSI Standard 40 for Residential Wastewater Treatment Systems (August 2005 revision). NSF/ANSI Standard 40 was developed by the NSF Joint Committee on Wastewater Technology.

The performance evaluation was conducted at the NSF Wastewater Technology Test Facility located in Waco, Texas using wastewater diverted from the Waco municipal wastewater collection system, which serves predominantly residential development. The evaluation consisted of sixteen weeks of dosing at design flow, seven and one half weeks of stress testing and two and one half weeks of dosing at design flow. Dosing was initiated on September 2, 2005. After a three-week start up period, sample and data collection for the test was officially started on September 26, 2005. Sampling started in the fall and continued into the spring, covering a range of operating temperatures.

Over the course of the evaluation, the average effluent $CBOD_5$ was 2 mg/L, ranging between <2 and 9 mg/L, and the average effluent total suspended solids was 2 mg/L, ranging between <2 mg/L and 6 mg/L.

The Bord na Mona Model P150N*3B produced an effluent that successfully met the performance requirements established by NSF/ANSI Standard 40 for Class I effluent:

> The maximum 7-day arithmetic mean was 4 mg/L for $CBOD_5$ and 4 mg/L for total suspended solids, both below the allowed maximums of 40 and 45 mg/L respectively. The maximum 30-day arithmetic mean was 3 mg/L for $CBOD_5$ and 2 mg/L for total suspended solids, both below the allowed maximums of 25 mg/L and 30 mg/L respectively.

The effluent pH during the entire evaluation ranged between, 6.4 and 7.4, within the required range of 6.0 to 9.0. The Bord na Mona Model P150N*3B met the requirements for noise levels (less than 60 dbA at a distance of 20 feet), color, threshold odor, oily film and foam.

PREFACE

Performance evaluation of residential wastewater treatment systems is achieved within the provisions of NSF/ANSI Standard 40: Residential Wastewater Treatment Systems (revised August 2005), prepared by the NSF Joint Committee on Wastewater Technology and adopted by the NSF Board of Trustees.

Conformance with the Standard is recognized by issuance of the NSF Mark. This is not to be construed as an approval of the equipment, but a certification of the data provided by the test and an indication of compliance with the requirements expressed in the Standard.

Systems conforming to Standard 40 are classified as Class I or Class II systems according to the quality of effluent produced by the system during the performance evaluation. Class I systems must meet the requirements of EPA Secondary Treatment Guidelines[1] for five day carbonaceous biochemical oxygen demand ($CBOD_5$), total suspended solids (TSS) and pH. Class I systems must also demonstrate performance consistent with the effluent color, odor, oily film and foam requirements of the Standard. Class II system effluent must have no more than 10% of samples exceeding 60 mg/L $CBOD_5$ and 100 mg/L TSS.

Permission to use the NSF Mark is granted only after the equipment has been tested and found to perform satisfactorily, and all other requirements of the Standard have been satisfied. Continued use of the Mark is dependent upon evidence of compliance with the Standard and NSF General and Program Specific Policies, as determined by periodic reinspection of the equipment at the factory, distributors and reports from the field.

NSF Standard 40 requires the testing laboratory to provide the manufacturer of a residential wastewater treatment system, a report including significant data and appropriate commentary relative to the performance evaluation of the system. NSF policy specifies provision of performance evaluation reports to appropriate state regulatory agencies at publication. Subsequent direct distribution of the report by NSF is made only at the specific request of or by permission of the manufacturer.

The following report contains results of the entire testing program, a description of the system, its operation and key process control equipment, and a narrative summary of the test program, including test location, procedures and significant occurrences. The system represented herein reflects the equipment authorized to bear the NSF Mark.

CERTIFICATION

NSF International has determined by performance evaluation under the provisions of NSF/ANSI Standard 40 (revised August 2005) that the Bord na Mona Model **P150N*3B** manufactured by Bord na Mona Environmental Products U.S., Inc. has fulfilled the requirements of NSF/ANSI Standard 40. The Model **P150N*3B** has therefore been authorized to bear the NSF Mark so long as Bord na Mona continues to meet the requirements of Standard 40 and the NSF General and Program Specific Policies.

General performance evaluation and stress tests were performed at the NSF Wastewater Technology Test Facility located in Waco, Texas. The raw wastewater used in the test was municipal wastewater. The characteristics of the wastewater during the test are included in the tabulated data of this report.

The observations and analyses included in this report are certified to be correct and true copies of the data secured during the performance tests conducted by NSF on the wastewater treatment system described herein. The manufacturer has agreed to present the data in this certification in its entirety whenever it is used in advertising, prospectuses, bids or similar uses.

Thomas J. Bruursema
General Manager
Wastewater Treatment Unit Certification

Thomas Stevens
Technical Manager
Federal Programs

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1.0 PROCESS DESCRIPTION

The Bord na Mona Model P150N*3B wastewater treatment system is an attached growth packed bed filter, which uses organic peat fiber as filtering media. The Puraflo filter utilizes a natural process where physical, bio-chemical and microbiological reactions take place to purify septic tank effluent. As the wastewater trickles down through the filtering bed, the contaminants, particulates or soluble forms, are physically filtered or adsorbed by the fibers. The microorganisms naturally attached on the media degrade the contaminants through their metabolic reactions. The numerous fibers in the Puraflo media provide a high ratio of surface area to volume so the filter can support a relatively large amount of microbiological activity for a relatively small imprint. Moreover, the high porosity of the media combined with the design features of the module allows a sufficient oxygenation rate in the filter.

2.0 PERFORMANCE EVALUATION

2.1 Description of System Evaluated

The P150N*3B tested in this evaluation has a rated capacity of 450 gallons per day (gpd). Specifications and drawings are included in Appendix A.

Raw sewage enters a one compartment septic tank (500 gallon volume) that provides about 26.7 hours of retention at the rated capacity. This compartment provides primary treatment; settleable solids accumulate on the bottom and floatable solids accumulate on the surface. Effluent from the clear layer flows through an effluent filter that is located in the outlet tee. The effluent from the septic tank is transferred by gravity to a 500-gallon pump/siphon tank. A time dosing system is activated by a programmable timer, which pumps the effluent through a flow splitting inlet manifold located at the base of the treatment modules. An orifice plate is located inside the top of each inlet manifold, which allows the flows to be split equally and fed simultaneously to each biofilter module. The inlet manifold is connected to the base of the biofilter and is fed upwards to a rectangular distribution grid located 6 inches below the top of each module. Effluent percolates down through the media and is collected at the bottom of the filter module. The treated effluent flows out through a pipe in the bottom of the module.

2.2 Test Protocol

Section 8 of NSF/ANSI Standard 40 protocol, "Performance Testing and Evaluation", is included in Appendix B. Start up of the system was accomplished by filling the system with 2/3 water and 1/3 raw sewage. The system was then dosed at the design loading rate of 450 gpd as follows:

6 a.m. to 9 a.m. - 35 percent of daily rated capacity (157.5 gallons)
11 a.m. to 2 p.m. - 25 percent of daily rated capacity (112.5 gallons)
5 p.m. to 8 p.m. - 40 percent of daily rated capacity (180 gallons)

Dosing was accomplished by opening an electrically actuated valve to feed wastewater to the test system. Four and a half gallon doses were spread uniformly over each dosing period to comprise the total dose volume for the period.

After a start up period (up to three weeks at the manufacturer's discretion), the system is subjected to the following loading sequence:

Design loading	-	16 weeks
Stress loading	-	7.5 weeks
Design loading	-	2.5 weeks

During the design loading periods, flow proportioned 24-hour composite influent and effluent samples are collected five days per week. The influent samples are analyzed for five-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS) concentrations. The effluent samples are analyzed for carbonaceous five-day biochemical oxygen demand ($CBOD_5$), and total suspended solids (TSS) concentrations. On-site determinations of the effluent temperature and pH are made five days per week.

Stress testing is designed to evaluate how the system performs under non-ideal conditions, including varied hydraulic loadings and electrical or system failure. The test sequence includes (1) Wash Day stress, (2) Working Parent stress, (3) Power/Equipment Failure stress, and (4) Vacation stress. Detailed descriptions of the stress sequences are shown in Appendix B.

During the stress test sequences, 24-hour composite samples are collected before and after each stress dosing pattern. The analyses and on-site determinations completed on the samples are the same as described for the design load testing. Each stress is followed by seven consecutive days of dosing at design rated capacity before beginning the next stress test. Sample collection is initiated twenty-four hours after completion of Wash Day, Working Parent, and Vacation stresses, and beginning 48 hours after completion of the Power/Equipment Failure stress.

In order for the system to achieve Class I effluent it is required to produce an effluent, which meets the EPA guidelines for secondary effluent discharge[1]:

(1) $CBOD_5$: The 30-day average of effluent samples shall not exceed 25 mg/L and each 7-day average of effluent samples shall not exceed 40 mg/L.

(2) TSS: Each 30-day average of effluent samples shall not exceed 30 mg/L and each 7-day average of effluent samples shall not exceed 45 mg/L.

(3) pH: Individual effluent values remain between 6.0 and 9.0.

Requirements are also specified for effluent color, odor, oily film and foam, as well as maximum noise levels allowed from the system.

2.3 Test Chronology

The system was installed under the direction of the manufacturer on September 1, 2005. The infiltration/exfiltration test, during which the entire system was tested for leaks, was completed on September 1, 2005. The unit was filled with 2/3 fresh water and 1/3 raw sewage and dosing was initiated at the rate of 450 gallons per day beginning September 9, 2005. Sampling was initiated on September 26, 2005. The stress test sequence was started on January 16, 2006 and ended on March 8, 2006. Testing was completed on March 24, 2006.

3.0 ANALYTICAL RESULTS

3.1 Summary

Chemical analyses of samples collected during the evaluation were completed using the procedures in *Standard Methods for the Examination of Water and Wastewater*[2] and USEPA methods. Copies of the data generated during the evaluation are included in Appendix C. Results of the chemical analyses and on-site observations and measurements made during the evaluation are summarized in Table I.

TABLE I. Summary of Analytical Results

	Average	Std. Dev.	Minimum	Maximum	Median	Interquartile Range
Biochemical Oxygen Demand (mg/L)						
Influent (BOD_5)	240	81	74	530	230	190 - 270
Effluent ($CBOD_5$)	2	0.8	<2	9	2	2 - 2
Total Suspended Solids (mg/L)						
Influent	260	130	22	880	240	180 - 290
Effluent	2	0.6	<2	6	2	2 - 2
Volatile Suspended Solids (mg/L)						
Influent	220	100	42	700	210	160 – 240
Effluent	2	0.4	<2	5	2	2 – 2
pH						
Influent	-	-	6.3	7.3	6.8	6.6 – 7.0
Effluent	-	-	6.4	7.4	6.9	6.7 – 7.0
Temperature (°C)						
Influent	24	3	20	30	22	22 - 26
Effluent	22	4	15	32	20	18 – 24
Dissolved Oxygen (mg/L)						
Effluent	3.0	1.0	1.0	4.7	3.0	2.1 – 4.0

Notes: The median is the point where half of the values are greater and half are less.
The interquartile range is the range of values about the median between the upper and lower 25 percent of all values.

Criteria for evaluating the analytical results from the testing are described in Section 8.5 of NSF/ANSI Standard 40. In completing the pass/fail determination for the data, an allowance is made for effluent TSS and $CBOD_5$ during the first month of testing. The 30 and 7-day averages during this time may equal or exceed 1.4 times the effluent limits required for the rest of the test. This provision recognizes that an immature culture of microorganisms within the system may require additional time to achieve adequate treatment efficiency. Effluent $CBOD_5$ and TSS concentrations from the Bord na Mona Model P150N*3B during the first calendar month of testing were within the normal limits and did not need to use this provision.

Section 8.5.1.1 of the Standard provides guidance addressing the impact of unusual testing conditions, including sampling, dosing, or influent characteristics, on operation of a system under test. Specific data points may be excluded from 7- and 30 - day average calculations where determined to have an adverse impact on performance of the system, with rationale for the exclusion to be documented in the final report. There were no such conditions during this test.

Sections 3.6 and 8.2.1 of the Standard define influent wastewater characteristics as they apply to testing under the Standard. Typical domestic wastewater is defined as having a 30-day average BOD_5 concentration between 100 and 300 mg/L and a 30-day average TSS concentration between 100 and 350 mg/L. The 30-day average influent remained inside this specified range for the duration of the test.

3.2 Biochemical Oxygen Demand

The five-day biochemical oxygen demand (BOD_5) and carbonaceous five-day biochemical oxygen demand ($CBOD_5$) analyses were completed using the EPA Method 405.1. The results of the analyses completed on the samples collected during the testing are shown in Figure 1.

Influent BOD_5:

The influent BOD_5 ranged from 74 to 530 mg/L during the evaluation, with an average concentration of 240 mg/L and a median concentration of 230 mg/L.

Effluent $CBOD_5$:

The effluent $CBOD_5$ concentrations ranged from <2 to 9 mg/L over the course of the evaluation, with an average concentration of 2 mg/L. The median effluent $CBOD_5$ concentration was 2 mg/L.

The Standard requires that the effluent $CBOD_5$ not exceed 40 mg/L on a 7-day average or 25 mg/L on a 30-day average. Table II shows the 7 and 30-day average effluent $CBOD_5$ concentrations and the 30-day average influent BOD_5 concentrations.

The 7-day average effluent $CBOD_5$ ranged from 2 to 4 mg/L. The 30-day average ranged from 2 to 3 mg/L throughout the test. As shown in Table II, the Bord na Mona Model P150N*3B met the requirements of Standard 40 for effluent $CBOD_5$.

BOD_5 Loading:

Over the course of the evaluation the influent BOD_5 loading averaged 0.9 lb/day. The Bord na Mona Model P150N*3B achieved an average reduction of 0.89 lbs/day.

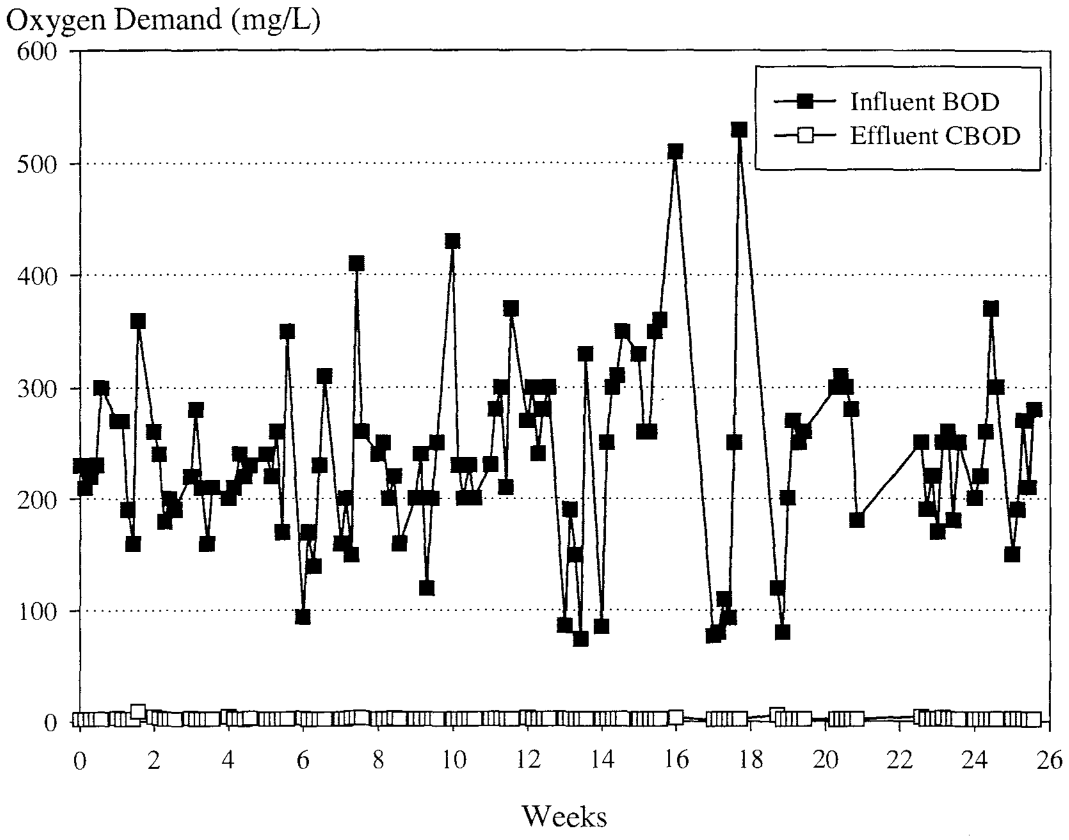

Figure 1. Biochemical Oxygen Demand.

3.3 Total Suspended Solids

TSS and volatile suspended solids (VSS) analyses were completed using Methods 209C and 209D of *Standard Methods*. The TSS results over the entire evaluation are shown in Figure 2. Data from both analyses are summarized in Table I.

Influent TSS:

The influent TSS ranged from 22 to 880 mg/L during the evaluation, with an average concentration of 260 mg/L and a median concentration of 240 mg/L.

Effluent TSS:

The effluent TSS concentration ranged from <2 to 6 mg/L during the evaluation, with an average concentration of 2 mg/L and a median concentration of 2 mg/L.

Over the course of the evaluation, NSF/ANSI Standard 40 requires that the effluent TSS not exceed 45 mg/L on a 7-day average or 30 mg/L on a 30-day average. Table III shows the 7- and 30-day total suspended solids averages.

The 7-day average effluent TSS ranged from 2 to 4 mg/L and the 30-day average was consistently 2 mg/L during the test. As shown in Table III, the Bord na Mona Model P150N*3B met the requirements of NSF/ANSI Standard 40 for effluent TSS.

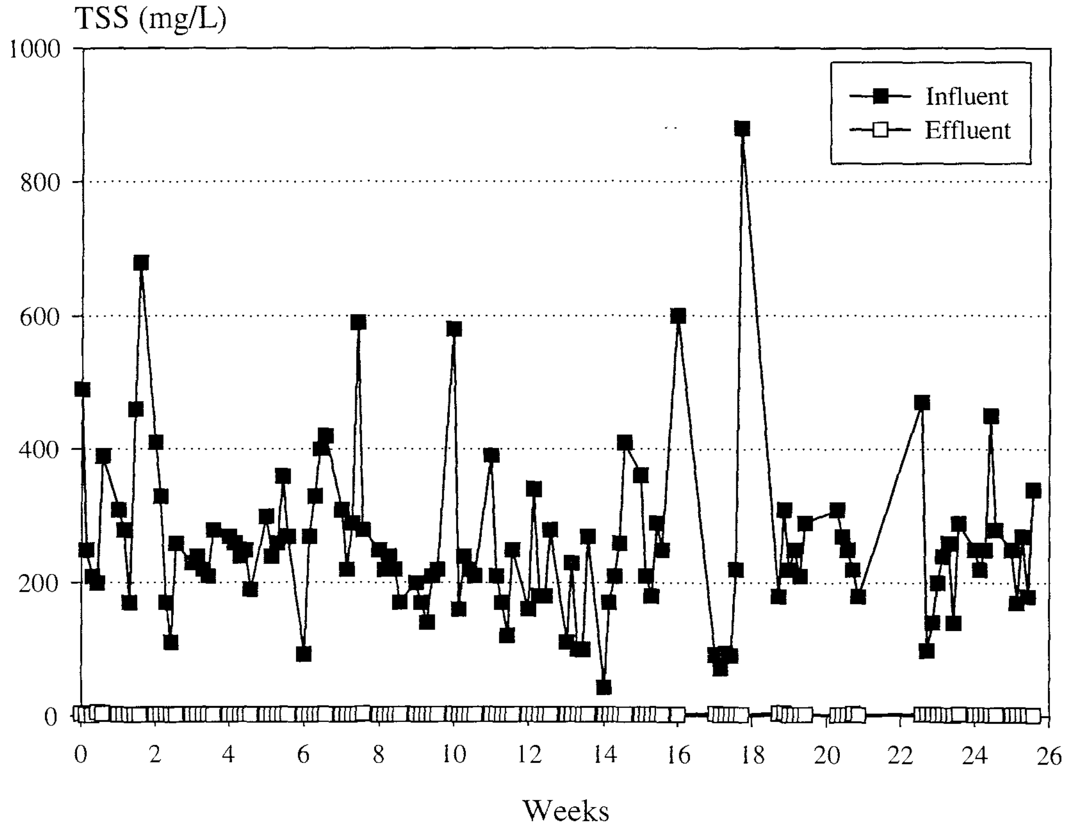

Figure 2. Total Suspended Solids.

Table II. 7- and 30-day Average Effluent $CBOD_5$ and 30-day Average Influent BOD_5

Month	Week	7-day Average Effluent $CBOD_5$ (mg/L)	30-day Average Effluent $CBOD_5$ (mg/L)	30-day Average Influent BOD_5 (mg/L)
1	1	2	3	230
	2	4		
	3	3		
	4	2		
2	5	3	2	220
	6	2		
	7	2		
	8	3		
3	9	2	2	250
	10	2		
	11	2		
	12	2		
	13	2		
4	14	2	2	250
	15	2		
	16	2		
	17	2		
5	18	2	2	220
	19	3		
	20	2		
	21	2		
	22	2		
6	23	3	2	230
	24	2		
	25	2		
	26	2		

Table III. 7- and 30-day Total Suspended Solids

Month	Week	7-day Average Effluent TSS (mg/L)	30-day Average Effluent TSS (mg/L)	30-day Average Influent TSS (mg/L)
1	1	4	2	290
	2	2		
	3	2		
	4	2		
2	5	2	2	280
	6	2		
	7	2		
	8	2		
3	9	2	2	230
	10	2		
	11	2		
	12	2		
	13	2		
4	14	2	2	230
	15	2		
	16	2		
	17	2		
5	18	2	2	250
	19	3		
	20	3		
	21	2		
	22	3		
6	23	3	2	250
	24	2		
	25	2		
	26	2		

3.4 pH

Over the entire evaluation period, the influent pH ranged from 6.3 to 7.3 (median of 6.8). The effluent pH ranged from 6.4 to 7.4 during the evaluation (median of 6.9), within the 6 to 9 range required by NSF/ANSI Standard 40. The pH data for the evaluation are shown in Appendix C.

3.5 Temperature

Influent temperatures over the evaluation period ranged from 20 to 30°C (median of 22°C). The temperature data are shown in Appendix C.

3.6 Dissolved Oxygen

Dissolved Oxygen (DO) was measured in the effluent during the evaluation. The effluent DO ranged between 1.0 to 4.7 mg/L (median of 3.0 mg/L). All dissolved oxygen data are shown in Appendix C.

3.7 Color, Threshold Odor, Oily Film, Foam

Three samples of the effluent were analyzed for color, odor, oily film and foam as prescribed in NSF Standard 40. The effluent was acceptable according to the requirements in NSF Standard 40, with color less than 15 units, non-offensive threshold odor, no visible evidence of oily film and no foam.

3.8 Noise

A reading of the noise level at a distance of 20 feet from the system was taken while the system was in operation, using a hand-held decibel meter. The reading was below the 60 dbA required by ANSI/NSF Standard 40.

4.0 REFERENCES

1. "Environmental Protection Agency Guidelines for Secondary Treatment", Federal Register, Volume 28, No. 159, 1973.

2. APHA, AWWA, WPCF, Standard Methods for the Examination of Water and Wastewater, 20th Edition, American Public Health Association, Washington, D.C.

3. U.S. EPA, Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, Washington, D.C.

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APPENDIX A

SYSTEM SPECIFICATIONS

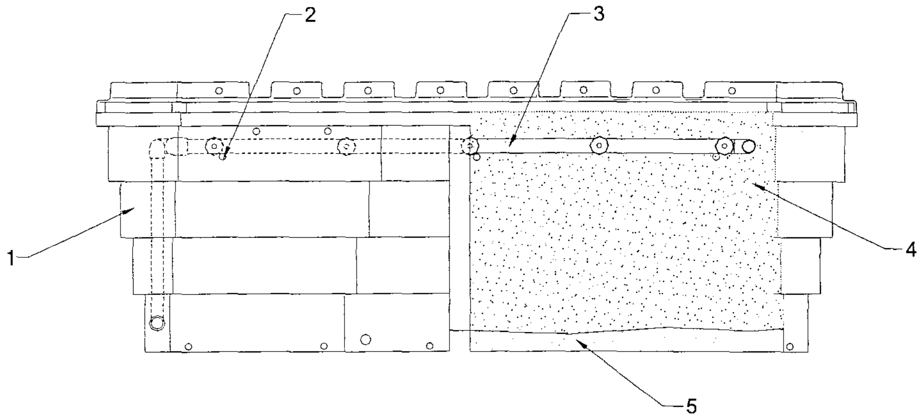
SYSTEM SPECIFICATIONS

Bord na Mona Environmental Products U.S., Inc.
Model P150N*3B

<u>System Capacity</u>

Design Flow	450 gpd
System Hydraulic Capacity	
Pretreatment Tank	500 gallons
Pump/Siphon Tank	500 gallons
Average Hydraulic Retention Time (at Design Flow)	
Pretreatment Tank	26.7 hours
Pump/Siphon tank	26.7 hours
Total Hydraulic Retention Time	53.4 hours

Effluent Filter	Zabel A-300-8"x18" VC
Dosing Pump	Zoeller Model 98 Cast Iron
Control Panel	FCP Phazer TDP – Simplex Time Dose Panel Model P-230-TDP
Peat Biofilter Module	



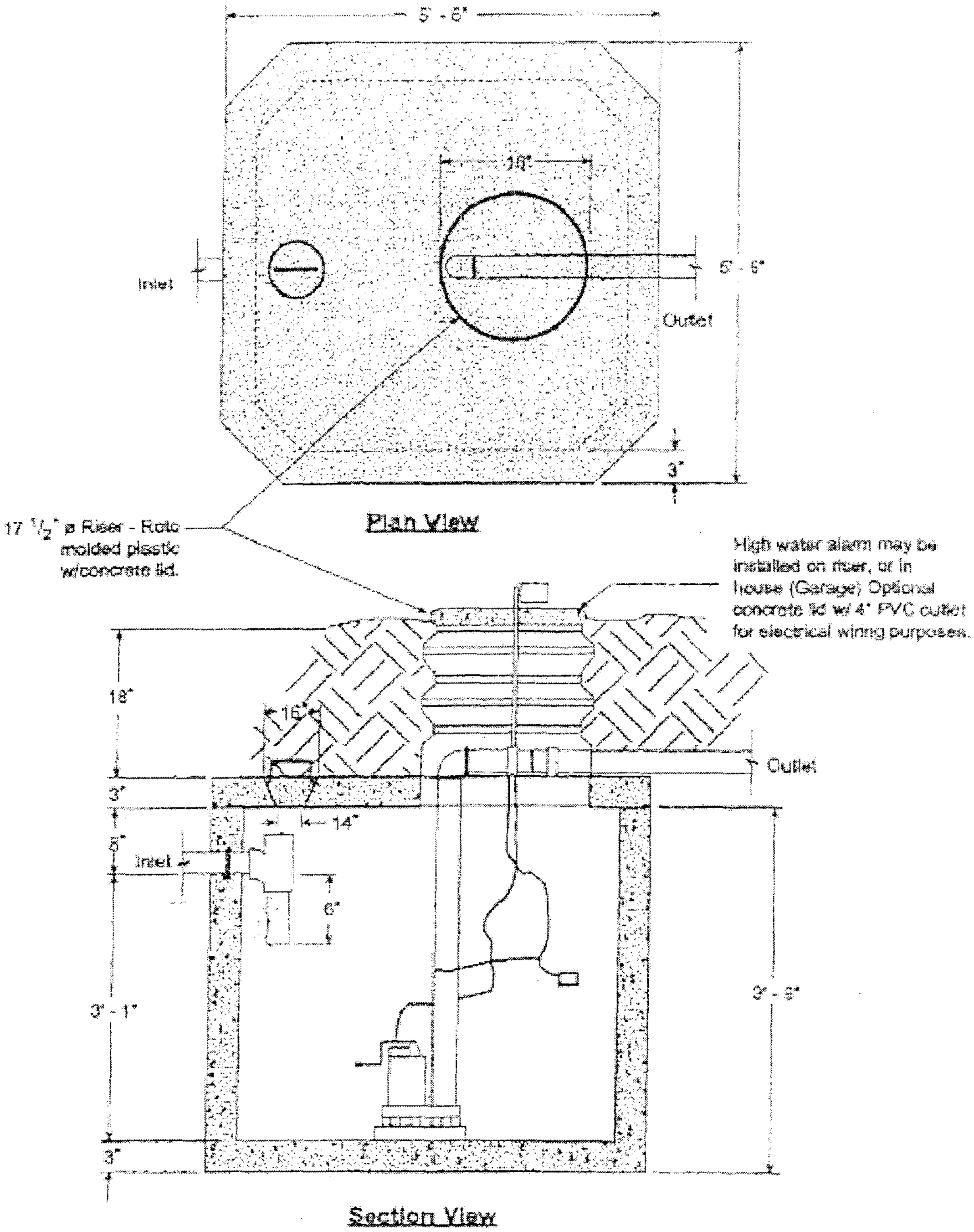
Typical Peat Fibre Characteristics.

Peat fibre consists of root residues of eriophorum (cottongrass) plants extracted from raised bog peats.
Fines content, particle size up to 5mm typically less than 30%
Minimum organic content on anhydrous basis is 95%
Large surface area (50–100 square meters / gramme)
Typical loose density @ 50% mc between 110–140 kg/m3

Approx module dimensions 7' * 4.5' * 2.5' high

ITEM No.	DESCRIPTION	QTY.	MATERIAL/DRG.No./SPEC	OTHER
5	STONE	1	# 5 STONE (3/4 TO 1")	> 3 ft^3
4	MEDIA	1	PEAT FIBRE	80 ft^3
3	DISTRIBUTION GRID	1	PVC PIPING & FITTINGS	
2	STABILIZER BAR	3	STEEL NIPPLE	
1	MODULE	1	HDPE	

Drawn J.P.
Checked
SCALE : NTS
PURAFLO MODULE
REVISION
USED ON
BORD na MONA
ENVIRONMENTAL PRODUCTS
U.S., INC., GREENSBORO, N.C. 27407
Sheet Of
DRG No.



Materials & Features

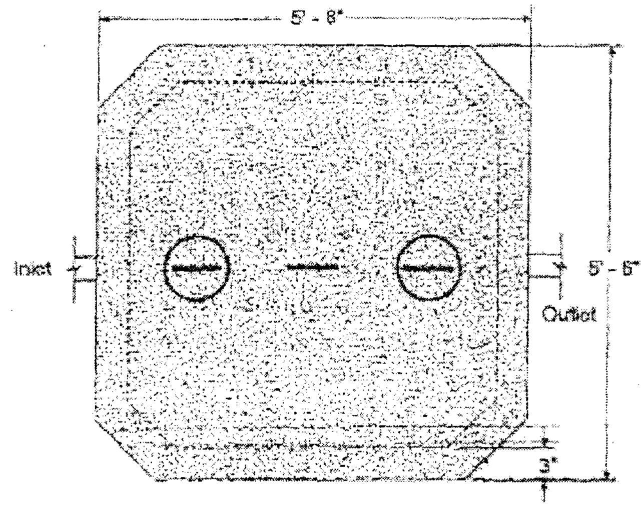
CONCRETE: 5,000 PSI

REINFORCING: 6 x 6 x W1.5 in all surfaces and cover.
#3 bar continuous from side walls to end.
#3 bar 8" O.C. in cover.
(All bar Grade 60.)

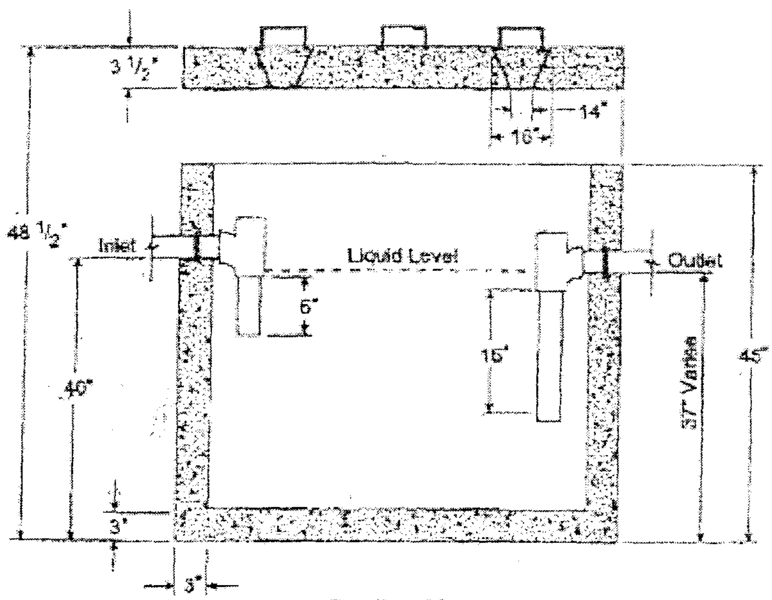
INLET: Sanitary Tee - Sch. 40 stub
Watertight seal at all pipe connections.

-No Scale-
All dimensions subject to allowable specification tolerances.

TITLE	SECTION - PAGE	DATE	
500 Gallon Pump Tank	1.6	5-01-05	Hanson



Plan View



Section View

Materials & Features

CONCRETE: 5,000 PSI

REINFORCING: 6 x 6 x W1.5 in all surfaces and cover.
#3 bar continuous from side walls to end.
(All bar Grade 60.)

INLET: Sanitary Tee - Sch. 40 stub

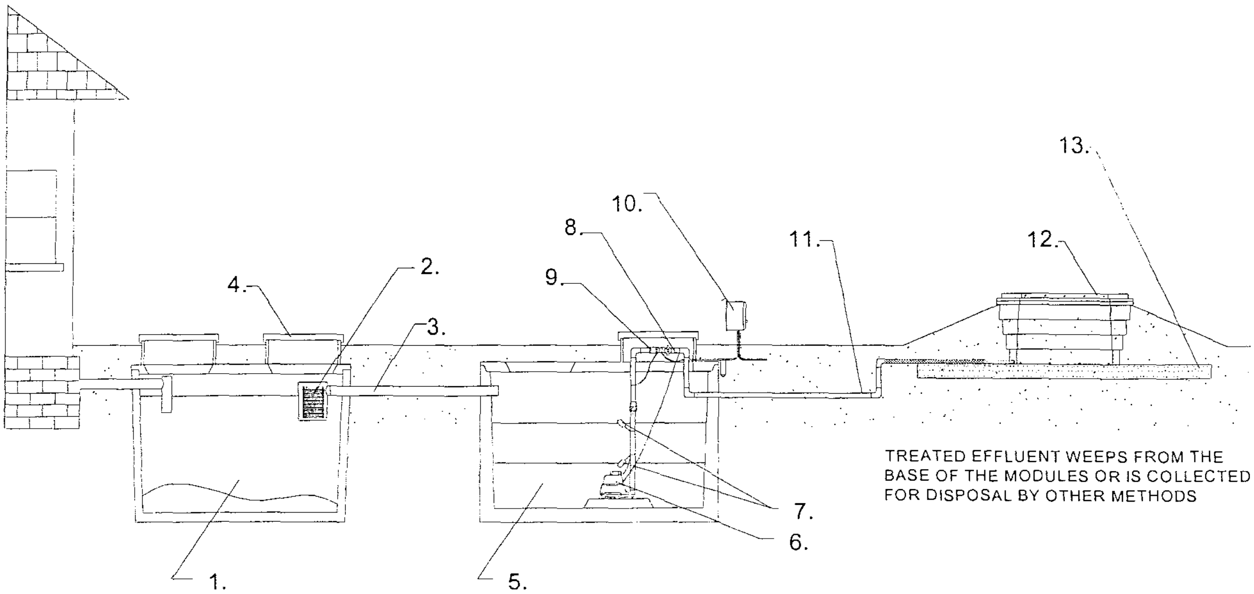
OUTLET: Regular Tee - Sdr. 35 stub
Watertight seal at all pipe connections.

WEIGHT: 5,000 lbs. (approx.) w/Cover
Cover weight = 1,135 lbs. (approx.)

-No Scale-
All dimensions subject to allowable specification tolerances.

TITLE	SECTION/PAGE	DATE	
500 Gallon Septic Tank	1.1	5-01-05	Hanson

Part No.	Description	Part No.	Description
1	Septic Tank	8	Ball Valve
2	Effluent Filter	9	Union Disconnect
3	Sewer Line	10	Time Dose Control Panel
4	Riser and Lid	11	Force Main
5	Pump Tank	12	Puraflo® Module(s)
6	Pump	13	Stone Pad
7	Floats		

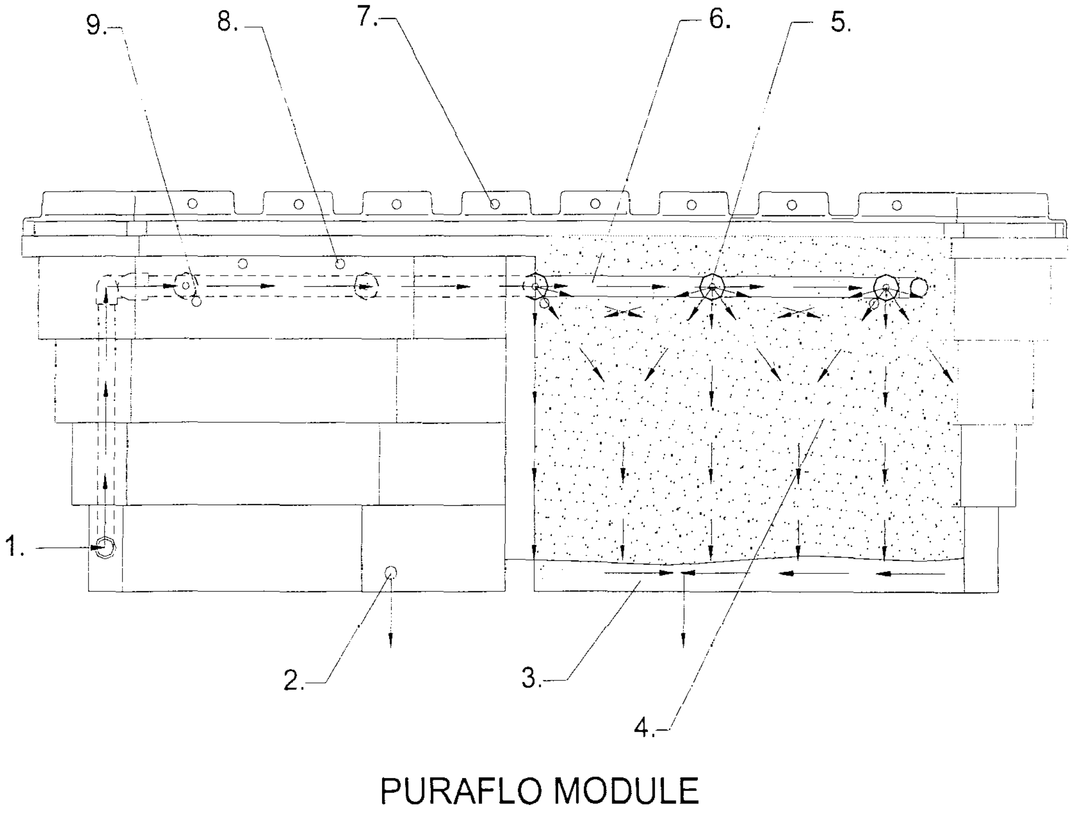


LIST OF PURAFLO SYSTEM COMPONENTS

Specification of Puraflo® Module

Max Treatment Capacity per Module	**150 G.P.D.**
Module Length	**7' 1"**
Module Height	**2' 6"**
Module Width	**4' 6"**
Module Weight	**~1800 lbs**

Part No.	Description	Part No.	Description
1	Inlet	6	Distribution Grid
2	Drain Hole Outlet	7	Vent Holes
3	#5 Stone	8	Rope Handle Holes
4	Peat Fibre Media	9	Stabilizer Bars
5	Distribution Orifice		



PURAFLO MODULE

APPENDIX B

NSF STANDARD 40 PERFORMANCE EVALUATION METHOD AND REQUIREMENTS

8 Performance testing and evaluation

This section describes the methods used to evaluate the performance of residential wastewater treatment systems. Systems shall be designated as Class I or Class II. The performance classification shall be based upon the evaluation of effluent samples collected from the system over a six-month period.

8.1 Preparations for testing and evaluation

8.1.1 The system shall be assembled, installed, and filled in accordance with the manufacturer's instructions.

8.1.2 The manufacturer shall inspect the system for proper installation. If no defects are detected and the system is judged to be structurally sound, it shall be placed into operation in accordance with the manufacturer's start-up procedures. If the manufacturer does not provide a filling procedure, ⅔ of the system's capacity shall be filled with water and the remaining ⅓ shall be filled with residential wastewater.

8.1.3 The system shall undergo design loading (see 8.2.2.1) until testing and evaluations are initiated. Sample collection and analysis shall be initiated within 3 weeks of filling the system and, except as specified in 8.5.1.2, shall continue without interruption until the end of the evaluation period.

8.1.4 If conditions at the testing site preclude installation of the system at its normally prescribed depth, the manufacturer shall be permitted to cover the system with soil to achieve normal installation depth.

8.1.5 Performance testing and evaluation of systems shall not be restricted to specific seasons.

8.1.6 When possible, electrical or mechanical defects shall be repaired to prevent evaluation delays. All repairs made during the performance testing and evaluation shall be documented in the final report.

8.1.7 The system shall be operated in accordance with the manufacturer's instructions. However, routine service and maintenance of the system shall not be permitted during the performance testing and evaluation period.

NOTE – The manufacturer may recommend or offer more frequent service and maintenance of the system but for the purpose of performance testing and evaluation, service and maintenance shall not be performed beyond what is specified in this Standard.

8.2 Testing and evaluation conditions, hydraulic loading, and schedules

8.2.1 Influent wastewater characteristics

The 30-d average BOD_5 concentration of the wastewater delivered to the system shall be between 100 mg/L and 300 mg/L.

The 30-d average TSS concentration of the wastewater delivered to the system shall be between 100 mg/L and 350 mg/L.

8.2.2 Hydraulic loading and schedules

The performance of the system shall be evaluated for 26 consecutive weeks. During the testing and evaluation period, the system shall be subjected to 16 weeks of design loading, followed by 7.5 weeks (52 days) of stress loading, and then an additional 2.5 weeks (18 days) of design loading.

8.2.2.1 Design loading

The system shall be dosed 7 days a week with a wastewater volume equivalent to the daily hydraulic capacity of the system. The following schedule shall be adhered to for dosing:

Time frame	% rated daily hydraulic capacity
6:00 a.m. to 9:00 a.m.	approximately 35
11:00 a.m. to 2:00 p.m.	approximately 25
5:00 p.m. to 8:00 p.m.	approximately 40

8.2.2.2 Stress loading

Stress loading is designed to evaluate a system's performance under four non-ideal conditions. Systems shall be subjected to each stress condition once during the 6-month testing and evaluation period, and each of the four stress conditions shall be separated by 7 days of design loading (see 8.2.2.1).

8.2.2.2.1 Wash-day stress

The wash day stress shall consist of 3 wash days in a 5-day period. Each wash day shall be separated by a 24-h period. During a wash-day, the system shall be loaded at times and capacities similar to those delivered during design loading (see 8.2.2.1), however during the first two dosing periods per day, the design loading shall include 3 wash loads (3 wash cycles and 6 rinse cycles).

8.2.2.2.2 Working-parent stress

For 5 consecutive days, the system shall be subjected to a working-parent stress. During this stress, the system shall be dosed with 40% of its daily hydraulic capacity between 6:00 a.m. and 9:00 a.m. Between 5:00 p.m. and 8:00 p.m., the system shall be dosed with the remaining 60% of its daily hydraulic capacity, which shall include 1 wash load (1 wash cycle and 2 rinse cycles).

8.2.2.2.3 Power/equipment failure stress

The system shall be dosed with 40% of its daily hydraulic capacity between 5:00 p.m. and 8:00 p.m. on the day the power/equipment failure stress is initiated. Power to the system shall then be turned off at 9:00 p.m. and dosing shall be discontinued for 48 hours. After 48 hours, power shall be restored and the system shall be dosed over a 3- h period with 60% of its daily hydraulic capacity, which shall include 1 wash load (1 wash cycle and 2 rinse cycles).

8.2.2.2.4 Vacation stress

On the day that the vacation stress is initiated, the system shall be dosed at 35% of its daily hydraulic capacity between 6:00 a.m. and 9:00 a.m. and at 25% between 11:00 a.m. and 2:00 p.m. Dosing shall then be discontinued for 8 consecutive days (power shall continue to be supplied to the system). Between 5:00 p.m. and 8:00 p.m. of the ninth day, the system shall be dosed with 60% of its daily hydraulic capacity, which shall include 3 wash loads (3 wash cycles and 6 rinse cycles).

8.2.3 Dosing volumes

The 30-d average volume of the wastewater delivered to the system shall be within 100% ± 10% of the system's rated hydraulic capacity.

NOTE – All dosing days, except those with dosing requirements less than the daily hydraulic capacity, shall be included in the 30-d average calculation.

8.2.4 Color, odor, foam, and oily film assessments

During the 6-month testing and evaluation, a total of 3 effluent samples shall be assessed for color, odor, foam, and oily film. The assessments shall be conducted on effluent composite samples selected randomly during the first phase of design loading (weeks 1 – 16), the period of stress loading (weeks 17 – 23.5), and the second phase of design loading (weeks 23.5 – 26).

8.3 Sample collection

8.3.1 General

8.3.1.1 A minimum of 96 data days shall be required during system performance testing and evaluation. No routine service or maintenance shall be performed on the system whether the time period to achieve the 96 data days falls within or exceeds 6 months.

8.3.1.2 All sample collection methods shall be in accordance with APHA's *Standard Methods for the Examination of Water and Wastewater* unless otherwise specified.

8.3.1.3 Influent wastewater samples shall be flow-proportional, 24-h composites obtained during periods of system dosing. Effluent samples shall be flow-proportional, 24-h composites obtained during periods of system discharge.

8.3.2 Design loading

During periods of design loading, daily composite effluent samples shall be collected and analyzed 5 days a week.

8.3.3 Stress loading

During stress loading, influent and effluent 24-h composite samples shall be collected on the day each stress condition is initiated. Twenty-four hours after the completion of washday, working-parent, and vacation stresses, influent and effluent 24-h composite samples shall be collected for 6 consecutive days. Forty-eight hours after the completion of the power/equipment failure stress, influent and effluent 24-h composite samples shall be collected for 5 consecutive days.

8.4 Analytical descriptions

8.4.1 pH, TSS, BOD_5, and $CBOD_5$

The pH, TSS, and BOD_5 of the collected influent and the pH, TSS and $CBOD_5$ of the collected effluent 24-h composite samples shall be determined with the appropriate methods in APHA's *Standard Methods for the Examination of Water and Wastewater.*

8.4.2 Color, odor, oily film, and foam

8.4.2.1 General

The effluent composite samples shall be diluted 1:1000 with distilled water. Three composite effluent samples shall be tested during the 6-month evaluation period.

8.4.2.2 Color

The apparent color of the diluted effluent samples shall be determined with the visual comparison method described in APHA's *Standard Methods for the Examination of Water and Wastewater.*

8.4.2.3 Odor

A panel consisting of at least 5 evaluators shall qualitatively rate 200 mL aliquots of the diluted effluent samples as offensive or non offensive when compared to odor-free water prepared in accordance with APHA's *Standard Methods for the Examination of Water and Wastewater.*

8.4.2.4 Oily film and foam

Diluted effluent sample aliquots shall be visually evaluated for the presence of an oily film or foaming.

8.5 Criteria

8.5.1 General

8.5.1.1 If conditions during the testing and evaluation period result in system upset, improper sampling, improper dosing, or influent characteristics outside of the ranges specified in 8.2.1, an assessment shall be conducted to determine the extent to which these conditions adversely affected the performance of the system. Based on this assessment, specific data points may be excluded from the 7-d and 30-d averages of effluent measurements. Rationale for all data exclusions shall be documented in the final report.

8.5.1.2 In the event that a catastrophic site problem not described in this Standard including, but not limited to, influent characteristics, malfunctions of test apparatus, and acts of God, jeopardizes the validity of the performance testing and evaluation, manufacturers shall be given the choice to:

1) Perform maintenance on the system, reinitiate system start-up procedures, and restart the performance testing and evaluation; or

2) With no routine maintenance performed, have the system brought back to pre-existing conditions and resume testing within 3 weeks after the site problem has been identified and corrected. Data collected during the system recovery period shall be excluded from 7-d and 30-d averages of effluent measurements.

NOTE – Pre-existing conditions shall be defined as the point when the results of 3 consecutive data days are within 15% of the previous 30-d average(s).

8.5.1.3 A 7-d average discharge value shall consist of a minimum of 3 data days. If a calendar week contains less than 3 data days, sufficient data days may be transferred from the preceding calendar week to constitute a 7-d average discharge value. If there are not sufficient data days available in the preceding calendar week, the transfer of data days may take place from the following calendar week to constitute a 7-d average discharge value. No data day shall be included in more than one 7-d average discharge value.

8.5.1.4 A 30-d average discharge value shall consist of a minimum of 50% of the regularly scheduled sampling days per month. If a calendar month contains less than the required number of data days, sufficient data days may be transferred from the preceding calendar month to constitute a 30-d average discharge value. If there are not sufficient data days available in the preceding calendar month, the transfer of data days may take place from the following calendar month to constitute a 30-d average discharge value. No data day shall be included in more than one 30-d average discharge value.

8.5.1.5 During the stress loading sequence, consisting of wash-day, working-parent, power/equipment failure, and vacation stress loading periods, data shall be collected from a minimum of ⅔ of the total scheduled sampling days and from at least 2 of the scheduled sampling days during any single stress loading period.

8.5.2 Class I systems

The following criteria shall be met in order for a system to be classified as a Class I residential wastewater treatment system.

All requirements for each parameter shall be achieved except as provided for in 8.5.2.2.

8.5.2.1 EPA secondary treatment guideline parameters

8.5.2.1.1 $CBOD_5$

The 30-d average of $CBOD_5$ concentrations of effluent samples shall not exceed 25 mg/L.

The 7-d average of $CBOD_5$ concentrations of effluent samples shall not exceed 40 mg/L.

8.5.2.1.2 TSS

The 30-d average of TSS concentrations of effluent samples shall not exceed 30 mg/L.

The 7-d average of TSS concentrations of effluent samples shall not exceed 45 mg/L.

8.5.2.1.3 pH

The pH of individual effluent samples shall be between 6.0 and 9.0.

8.5.2.2 Effluent concentration excursions

System performance shall not be considered outside the limits established for Class I systems if, during the first calendar month of performance testing and evaluation, 7-d average and 30-d average effluent $CBOD_5$ and TSS concentrations do not equal or exceed 1.4 times the effluent limits specified in 8.5.2.1.

NOTE – The technology utilized in many residential wastewater treatment systems is biologically based. The allowance of excursions from the effluent limits established in this Standard during the first calendar month of performance testing and evaluation reflects the fact that an immature culture of microorganisms within the system may require additional time to achieve adequate treatment efficiency.

The value of 1.4 is based on the USEPA Technical Review Criteria for Group I Pollutants, including $CBOD_5$ and TSS.

8.5.2.3 Color, odor, oily film, and foam

8.5.2.3.1 Color

The color rating of each of the 3 diluted composite effluent samples shall not exceed 15 units.

8.5.2.3.2 Odor

The overall rating of each of the three diluted composite effluent samples shall be non offensive.

8.5.2.3.3 Oily film and foam

Oily films and foaming shall not be visually detected in any of the diluted composite effluent samples.

8.5.3 Class II systems

The following criteria shall be met in order for a system to be classified as a Class II residential wastewater treatment system.

8.5.3.1 $CBOD_5$

Not more than 10% of the effluent $CBOD_5$ values shall exceed 60 mg/L.

TSS
Not more than 10% of the effluent TSS values shall exceed 100 mg/L.

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APPENDIX C

ANALYTICAL RESULTS

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: September 25, 2005 Plant Code: Site #3

Weeks Into Test: 1

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	3.9	3.9	4.2	3.8	4.2
Temperature (C)	influent	30	30	30	29	29
	aeration chamber					
	effluent	31	31	32	31	30
pH	influent	6.8	7.0	7.0	7.0	7.1
	aeration chamber					
	effluent	6.8	6.5	6.7	6.7	6.7
Biochemical Oxygen Demand (mg/L)	influent	230	210	220	230	300
	effluent	<2	<2	<2	2	<2
Total Suspended Solids (mg/L)	influent	490	250	210	200	390
	aeration chamber					
	effluent	4	<2	<2	6	4
Volatile Suspended Solids (mg/L)	influent	430	220	180	170	330
	aeration chamber					
	effluent	4	<2	<2	5	4
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: October 2, 2005 Plant Code: Site #3

Weeks Into Test: 2

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	4.5	4.4	4.0	4.2	4.7
Temperature (C)	influent	29	29	29	29	28
	aeration chamber					
	effluent	30	30	30	29	28
pH	influent	6.7	7.1	7.1	6.9	7.2
	aeration chamber					
	effluent	6.5	6.5	6.6	6.8	6.8
Biochemical Oxygen Demand (mg/L)	influent	360	270	190	160	360
	effluent	3	<2	2	<2	9
Total Suspended Solids (mg/L)	influent	310	280	170	460	680
	aeration chamber					
	effluent	<2	<2	<2	<2	2
Volatile Suspended Solids (mg/L)	influent	270	230	150	320	500
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: October 9, 2005 Plant Code: Site #3

Weeks Into Test: 3

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	4.3	4.0	4.1	4.1	4.2
Temperature (C)	influent	28	28	28	28	28
	aeration chamber					
	effluent	25	27	27	27	27
pH	influent	6.9	7.0	7.0	7.0	7.0
	aeration chamber					
	effluent	6.9	6.4	6.4	6.8	6.4
Biochemical Oxygen Demand (mg/L)	influent	260	240	180	200	190
	effluent	4	3	2	<2	2
Total Suspended Solids (mg/L)	influent	410	330	170	110	260
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	330	280	150	94	240
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: October 16, 2005 Plant Code: Site #3

Weeks Into Test: 4

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	4.4	4.2	4.4	4.2	4.1
Temperature (C)	influent	28	28	28	28	28
	aeration chamber					
	effluent	27	28	27	27	27
pH	influent	7.0	7.0	7.0	6.6	6.8
	aeration chamber					
	effluent	6.7	6.6	6.8	6.7	6.6
Biochemical Oxygen Demand (mg/L)	influent	220	280	210	160	210
	effluent	3	2	2	2	<2
Total Suspended Solids (mg/L)	influent	230	240	220	210	280
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	200	210	180	170	220
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: October 23, 2005 Plant Code: Site #3

Weeks Into Test: 5

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	2.4	3.5	4.7	3.5	3.4
Temperature (C)	influent	27	27	26	27	26
	aeration chamber					
	effluent	27	24	24	25	24
pH	influent	7.1	7.1	7.3	7.1	7.2
	aeration chamber					
	effluent	7.0	6.8	6.5	6.9	6.7
Biochemical Oxygen Demand (mg/L)	influent	200	210	240	220	230
	effluent	4	2	2	2	3
Total Suspended Solids (mg/L)	influent	270	260	240	250	190
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	230	220	210	210	160
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: October 30, 2005 Plant Code: Site #3

Weeks Into Test: 6

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	pump tank					
	effluent	4.2	4.3	4.2	3.9	4.6
Temperature (C)	influent	26	26	26	26	26
	pump tank					
	effluent	24	24	24	24	23
pH	influent	7.0	7.0	6.6	6.9	6.9
	pump tank					
	effluent	6.7	6.7	6.7	6.7	6.7
Biochemical Oxygen Demand (mg/L)	influent	240	220	260	170	350
	effluent	<2	<2	<2	<2	<2
Total Suspended Solids (mg/L)	influent	300	240	260	360	270
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	260	220	230	300	230
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: November 6, 2005   Plant Code: Site #3

Weeks Into Test: 7

Weekend Dosing: Sunday 450 gallons   Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	2.8	3.6	3.6	3.1	4.2
Temperature (C)	influent	26	26	26	26	26
	aeration chamber					
	effluent	25	26	26	26	24
pH	influent	6.5	7.0	7.3	6.3	6.9
	aeration chamber					
	effluent	6.4	6.8	6.9	6.7	7.0
Biochemical Oxygen Demand (mg/L)	influent	94	170	140	230	310
	effluent	3	<2	<2	<2	<2
Total Suspended Solids (mg/L)	influent	92	270	330	400	420
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	81	230	230	300	360
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: November 13, 2005   Plant Code: Site #3

Weeks Into Test: 8

Weekend Dosing: Sunday 450 gallons   Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	3.4	4.2	3.2	4.6	3.9
Temperature (C)	influent	26	26	25	25	25
	aeration chamber					
	effluent	26	26	25	24	22
pH	influent	7.1	7.1	7.0	7.2	7.0
	aeration chamber					
	effluent	6.7	6.8	6.7	6.9	6.5
Biochemical Oxygen Demand (mg/L)	influent	160	200	150	410	260
	effluent	<2	<2	3	3	3
Total Suspended Solids (mg/L)	influent	310	220	290	590	280
	aeration chamber					
	effluent	<2	<2	<2	<2	3
Volatile Suspended Solids (mg/L)	influent	270	210	240	470	220
	aeration chamber					
	effluent	<2	<2	<2	<2	2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: November 20, 2005 Plant Code: Site #3

Weeks Into Test: 9

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	3.3	2.4	2.6	2.4	2.8
Temperature (C)	influent	24	24	24	24	24
	aeration chamber					
	effluent	22	22	22	22	22
pH	influent	7.0	7.1	7.0	7.6	7.2
	aeration chamber					
	effluent	6.6	7.0	7.0	7.1	7.0
Biochemical Oxygen Demand (mg/L)	influent	240	250	200	220	160
	effluent	2	<2	<2	3	<2
Total Suspended Solids (mg/L)	influent	250	220	240	220	170
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	220	200	210	190	150
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: November 27, 2005 Plant Code: Site #3

Weeks Into Test: 10

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	3.4	3.4	4.4	3.9	3.7
Temperature (C)	influent	24	24	24	24	24
	aeration chamber					
	effluent	22	22	21	20	20
pH	influent	6.5	6.6	6.8	6.6	6.6
	aeration chamber					
	effluent	7.0	7.1	6.8	7.0	7.0
Biochemical Oxygen Demand (mg/L)	influent	200	240	120	200	250
	effluent	<2	<2	<2	<2	<2
Total Suspended Solids (mg/L)	influent	200	170	140	210	220
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	180	140	120	190	200
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: December 4, 2005 Plant Code: Site #3

Weeks Into Test: 11

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	3.5	4.0	4.3	3.6	4.4
Temperature (C)	influent	23	23	23	22	22
	aeration chamber					
	effluent	20	20	16	15	17
pH	influent	6.8	6.5	6.6	7.0	7.0
	aeration chamber					
	effluent	7.1	7.1	7.4	7.2	7.1
Biochemical Oxygen Demand (mg/L)	influent	430	230	200	230	200
	effluent	2	2	<2	<2	<2
Total Suspended Solids (mg/L)	influent	580	160	240	220	210
	aeration chamber					
	effluent	<2	2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	510	140	210	180	180
	aeration chamber					
	effluent	<2	2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: December 11, 2005 Plant Code: Site #3

Weeks Into Test: 12

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	3.7	3.8	4.1	3.8	2.6
Temperature (C)	influent	22	22	22	22	22
	aeration chamber					
	effluent	18	18	18	17	18
pH	influent	6.8	6.7	6.7	6.7	6.6
	aeration chamber					
	effluent	7.2	7.0	6.9	7.1	7.0
Biochemical Oxygen Demand (mg/L)	influent	230	280	300	210	370
	effluent	<2	<2	<2	<2	<2
Total Suspended Solids (mg/L)	influent	390	210	170	120	250
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	300	200	150	100	220
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: December 18, 2005 Plant Code: Site #3

Weeks Into Test: 13

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	3.1	3.2	3.3	3.8	3.2
Temperature (C)	influent	21	21	21	21	21
	aeration chamber					
	effluent	17	18	18	18	18
pH	influent	6.8	6.6	6.7	6.8	6.6
	aeration chamber					
	effluent	7.2	7.2	7.2	7.0	7.0
Biochemical Oxygen Demand (mg/L)	influent	270	300	240	280	300
	effluent	3	<2	<2	<2	<2
Total Suspended Solids (mg/L)	influent	160	340	180	180	280
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	140	310	160	160	240
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

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Plant Effluent

Week Beginning: December 25, 2005 Plant Code: Site #3

Weeks Into Test: 14

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	3.0	3.0	2.0	2.8	2.8
Temperature (C)	influent	21	21	21	21	21
	aeration chamber					
	effluent	18	18	19	19	19
pH	influent	6.8	6.7	6.6	6.8	6.7
	aeration chamber					
	effluent	6.9	7.0	7.0	7.0	7.0
Biochemical Oxygen Demand (mg/L)	influent	86	190	150	74	330
	effluent	<2	<2	<2	<2	<2
Total Suspended Solids (mg/L)	influent	110	230	100	99	270
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	94	200	92	90	240
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: January 1, 2006 Plant Code: Site #3

Weeks Into Test: 15

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	2.4	2.5	2.8	2.8	2.2
Temperature (C)	influent	21	21	22	22	22
	aeration chamber					
	effluent	20	20	19	19	19
pH	influent	6.8	6.6	6.7	6.3	6.5
	aeration chamber					
	effluent	7.0	7.0	7.0	6.7	6.9
Biochemical Oxygen Demand (mg/L)	influent	85	250	300	310	350
	effluent	2	<2	<2	<2	<2
Total Suspended Solids (mg/L)	influent	42	170	210	260	410
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	42	150	180	240	360
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: January 8, 2006 Plant Code: Site #3

Weeks Into Test: 16

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber					
	effluent	2.1	2.1	2.1	2.0	2.5
Temperature (C)	influent	22	22	22	22	22
	aeration chamber					
	effluent	20	20	20	20	19
pH	influent	6.5	6.9	6.5	6.7	7.0
	aeration chamber					
	effluent	7.0	6.9	6.6	6.6	7.1
Biochemical Oxygen Demand (mg/L)	influent	330	260	260	350	360
	effluent	<2	<2	<2	<2	<2
Total Suspended Solids (mg/L)	influent	360	210	180	290	250
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	320	180	170	250	200
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: January 15, 2006 Plant Code: Site #3

Weeks Into Test: 17

		Sun	Mon	Tue	Wed	Thur	Fri	Sat
Dosed Volume (gallons)		450	450	450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber		1.6					
	effluent		2.5					
Temperature (C)	influent		21					
	aeration chamber		19					
	effluent		19					
pH	influent		6.7					
	aeration chamber		6.9					
	effluent		7.0					
Biochemical Oxygen Demand (mg/L)	influent		510					
	effluent		3					
Total Suspended Solids (mg/L)	influent		600					
	aeration chamber							
	effluent		<2					
Volatile Suspended Solids (mg/L)	influent		530					
	aeration chamber							
	effluent		<2					
45 Minute Settleable Solids (mL/L)	aeration chamber							

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes: Wash day stress 1/16 through 1/20.

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Plant Effluent

Week Beginning: January 22, 2006 Plant Code: Site #3

Weeks Into Test: 18

		Sun	Mon	Tue	Wed	Thur	Fri	Sat
Dosed Volume (gallons)		450	450	450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber		2.1	2.3	1.0	1.2	1.0	1.8
	effluent		2.5	1.8	1.6	1.2	2.0	2.8
Temperature (C)	influent		21	22	22	22	22	20
	aeration chamber		19	18	18	19	19	19
	effluent		18	18	18	18	18	18
pH	influent		7.0	7.0	6.9	7.0	6.8	6.8
	aeration chamber		7.0	7.0	6.9	6.9	6.9	6.8
	effluent		7.0	7.0	6.9	6.8	6.8	6.8
Biochemical Oxygen Demand (mg/L)	influent		77	80	110	93	250	530
	effluent		2	<2	<2	<2	<2	<2
Total Suspended Solids (mg/L)	influent		92	72	94	90	220	880
	aeration chamber							
	effluent		4	2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent		78	63	81	80	190	700
	aeration chamber							
	effluent		2	2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber							

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes: Working Parent Stress started on 1/28.

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Plant Effluent

Week Beginning: January 29, 2006 Plant Code: Site #3

Weeks Into Test: 19

		Sun	Mon	Tue	Wed	Thur	Fri	Sat
Dosed Volume (gallons)		450	450	450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber							1.2
	effluent							1.4
Temperature (C)	influent							21
	aeration chamber							19
	effluent							18
pH	influent							6.6
	acration chamber							7.0
	effluent							7.0
Biochemical Oxygen Demand (mg/L)	influent							120
	effluent							6
Total Suspended Solids (mg/L)	influent							180
	aeration chamber							
	effluent							4
Volatile Suspended Solids (mg/L)	influent							150
	aeration chamber							
	effluent							4
45 Minute Settleable Solids (mL/L)	aeration chamber							

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes: Working Parent Stress completed on 2/1.

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Plant Effluent

Week Beginning: February 5, 2006 Plant Code: Site #3

Weeks Into Test: 20

		Sun	Mon	Tue	Wed	Thur	Fri	Sat
Dosed Volume (gallons)		450	450	450	450	450	0	270
Dissolved Oxygen (mg/L)	aeration chamber	1.1	1.2	1.7	0.8	2.4		
	effluent	1.4	1.5	1.7	1.6	2.3		
Temperature (C)	influent	22	22	21	22	22		
	aeration chamber	19	18	18	18	18		
	effluent	18	18	18	18	17		
pH	influent	6.7	6.6	6.7	6.6	6.7		
	aeration chamber	7.0	7.0	7.0	7.0	7.0		
	effluent	7.0	6.9	6.9	6.9	6.9		
Biochemical Oxygen Demand (mg/L)	influent	80	200	270	250	260		
	effluent	<2	2	2	<2	<2		
Total Suspended Solids (mg/L)	influent	310	220	250	210	290		
	aeration chamber							
	effluent	5	<2	2	<2	<2		
Volatile Suspended Solids (mg/L)	influent	250	190	210	180	240		
	aeration chamber							
	effluent	<2	<2	2	<2	<2		
45 Minute Settleable Solids (mL/L)	aeration chamber							

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes: Power/Equipment Failure Stress 2/9 through 2/11.

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Plant Effluent

Week Beginning: February 12, 2006 Plant Code: Site #3

Weeks Into Test: 21

		Sun	Mon	Tue	Wed	Thur	Fri	Sat
Dosed Volume (gallons)		450	450	450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber				1.2	2.0	1.5	1.3
	effluent				1.2	1.9	1.2	1.0
Temperature (C)	influent				22	21	22	20
	aeration chamber				18	18	18	16
	effluent				17	18	18	17
pH	influent				6.7	6.6	6.6	6.6
	aeration chamber				6.9	6.8	6.9	6.9
	effluent				6.9	6.9	6.9	6.9
Biochemical Oxygen Demand (mg/L)	influent				300	310	300	280
	effluent				<2	<2	2	2
Total Suspended Solids (mg/L)	influent				310	270	250	220
	aeration chamber							
	effluent				<2	<2	<2	4
Volatile Suspended Solids (mg/L)	influent				240	220	210	180
	aeration chamber							
	effluent				<2	<2	<2	4
45 Minute Settleable Solids (mL/L)	aeration chamber							

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

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Plant Effluent

Week Beginning: February 19, 2006 Plant Code: Site #3

Weeks Into Test: 22

		Sun	Mon	Tue	Wed	Thur	Fri	Sat
Dosed Volume (gallons)		270	0	0	0	0	0	0
Dissolved Oxygen (mg/L)	aeration chamber	1.2						
	effluent	1.2						
Temperature (C)	influent	20						
	aeration chamber	16						
	effluent	16						
pH	influent	6.6						
	aeration chamber	6.9						
	effluent	6.9						
Biochemical Oxygen Demand (mg/L)	influent	180						
	effluent	<2						
Total Suspended Solids (mg/L)	influent	180						
	aeration chamber							
	effluent	<2						
Volatile Suspended Solids (mg/L)	influent	150						
	aeration chamber							
	effluent	<2						
45 Minute Settleable Solids (mL/L)	aeration chamber							

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes: Vacation Stress started on 2/19.

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Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: February 26, 2006 Plant Code: Site #3

Weeks Into Test: 23

		Sun	Mon	Tue	Wed	Thur	Fri	Sat
Dosed Volume (gallons)		0	0	270	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber						1.2	1.2
	effluent						1.2	1.2
Temperature (C)	influent						22	22
	aeration chamber						18	18
	effluent						18	17
pH	influent						6.4	6.5
	aeration chamber						6.9	6.9
	effluent						6.8	6.9
Biochemical Oxygen Demand (mg/L)	influent						250	190
	effluent						4	<2
Total Suspended Solids (mg/L)	influent						470	98
	aeration chamber							
	effluent						3	3
Volatile Suspended Solids (mg/L)	influent						430	94
	aeration chamber							
	effluent						2	2
45 Minute Settleable Solids (mL/L)	aeration chamber							

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes: Vacation Stress completed on 2/28.

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: March 5, 2006 Plant Code: Site #3

Weeks Into Test: 24

		Sun	Mon	Tue	Wed	Thur	Fri	Sat
Dosed Volume (gallons)		450	450	450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber	1.2	1.8	1.6	1.0	1.4	1.3	
	effluent	1.3	2.4	2.1	1.7	1.8	2.0	
Temperature (C)	influent	22	22	22	23	22	22	
	aeration chamber	18	20	20	21	21	21	
	effluent	17	20	20	21	21	21	
pH	influent	6.5	6.5	6.5	6.5	6.6	6.6	
	aeration chamber	6.9	6.7	6.8	6.7	6.7	6.7	
	effluent	6.8	6.7	6.8	6.7	6.8	6.8	
Biochemical Oxygen Demand (mg/L)	influent	220	170	250	260	180	250	
	effluent	<2	<2	3	<2	<2	<2	
Total Suspended Solids (mg/L)	influent	140	200	240	260	140	290	
	aeration chamber							
	effluent	3	2	<2	<2	2	3	
Volatile Suspended Solids (mg/L)	influent	120	170	220	230	120	250	
	aeration chamber							
	effluent	2	<2	<2	<2	<2	2	
45 Minute Settleable Solids (mL/L)	aeration chamber							

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: March 12, 2006 Plant Code: Site #3

Weeks Into Test: 25

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber	1.7	1.9	2.4	1.2	1.0
	effluent	1.9	2.3	2.5	1.9	2.1
Temperature (C)	influent	22	22	23	23	23
	aeration chamber	21	21	21	21	21
	effluent	21	22	21	21	21
pH	influent	6.6	6.6	6.6	6.6	6.7
	aeration chamber	6.9	6.9	6.8	6.8	6.8
	effluent	6.9	6.9	6.9	6.8	6.8
Biochemical Oxygen Demand (mg/L)	influent	200	220	260	370	300
	effluent	<2	<2	<2	<2	<2
Total Suspended Solids (mg/L)	influent	250	220	250	450	280
	aeration chamber					
	effluent	2	2	<2	2	<2
Volatile Suspended Solids (mg/L)	influent	210	180	210	370	240
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

NSF International
Standard 40 - Residential Wastewater Treatment Systems
Plant Effluent

Week Beginning: March 19, 2006 Plant Code: Site #3

Weeks Into Test: 26

Weekend Dosing: Sunday 450 gallons Saturday 450 gallons

		Monday	Tuesday	Wednesday	Thursday	Friday
Dosed Volume (gallons)		450	450	450	450	450
Dissolved Oxygen (mg/L)	aeration chamber	2.1	2.1	2.0	1.0	1.8
	effluent	2.4	2.9	2.1	2.0	1.7
Temperature (C)	influent	22	22	22	22	22
	aeration chamber	20	20	20	20	20
	effluent	20	20	20	19	19
pH	influent	6.8	6.8	6.8	6.9	6.9
	aeration chamber	6.8	6.8	6.8	6.8	6.8
	effluent	6.9	6.9	6.9	6.8	6.9
Biochemical Oxygen Demand (mg/L)	influent	150	190	270	210	280
	effluent	<2	<2	<2	<2	<2
Total Suspended Solids (mg/L)	influent	250	170	270	180	340
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
Volatile Suspended Solids (mg/L)	influent	200	150	240	160	290
	aeration chamber					
	effluent	<2	<2	<2	<2	<2
45 Minute Settleable Solids (mL/L)	aeration chamber					

(a) Site problem
(b) Malfunction of system under test
(c) Weather problem
(d) Other

Notes:

APPENDIX G

OWNER"S MANUAL

Puraflo

WASTEWATER TREATMENT SYSTEMS

NSF®

CLASS 1
NSF/ANSI 40

OWNER'S MANUAL

Model No	Model No	Rated Capacity
P150N*3A	P150N*3B	450 G.P.D
P150N*4A	P150N*4B	600 G.P.D
P150N*5A	P150N*5B	750 G.P.D
P150N*6A	P150N*6B	900 G.P.D
P150N*7A	P150N*7B	1050 G.P.D
P150N*8A	P150N*8B	1200 G.P.D
P150N*9A	P150N*9B	1350 G.P.D
P150N*10A	P150N*10B	1500 G.P.D

Bord na Mona Environmental Products US Inc.
P.O. Box 77457, Greensboro, NC 27417
☎: 800 787 2356 Fax 336 547 8559
www.bnm-us.com

Rev. Date 042406

Contents

1.0 CLASSIFICATION STATEMENT

The Puraflo® Peat Bioflter System for wastewater treatment has been tested, certified and listed by NSF International as meeting the requirements of ANSI / NSF Standard 40, Class 1.

2.0 GENERAL DESCRIPTION OF SYSTEM

The Puraflo® Peat Biofilter is an advanced secondary treatment system that purifies septic tank effluent to an extremely high degree before final disposal.

A typical Puraflo® Peat Biofilter system consists of:

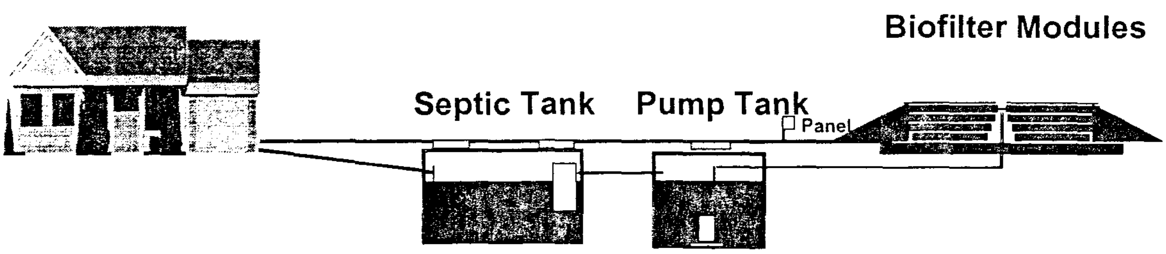
1. A septic tank fitted with an effluent filter on the outlet pipe.
2. A dosing tank and effluent pump or siphon to accommodate dosing of the septic tank effluent onto the peat fibre media.
3. Biofilter modules where advanced treatment occurs due to the physical, chemical and microbial processes that are optimized in the peat fibre media.
4. The site specific final effluent disposal system.

The filtered septic tank effluent is collected under gravity in the pump / siphon tank. A time dosing system is activated by a programmable timer, which pumps the effluent through a flow splitting inlet manifold located at the base of the treatment modules. An orifice plate is located inside the top of each inlet manifold which allows the flows to be split equally and fed simultaneously to each biofilter module. The inlet manifold is connected to the base of the biofilter and is fed upwards to a rectangular distribution grid located 6 inches below the top of each module. The effluent percolates laterally and vertically through the depth of the peat fibre treatment media and emerges as a clear innocuous liquid from the base of the system, for collection or dispersal.

Due to the high quality of the peat biofilter effluent, the siting and sizing requirements for final effluent disposal are typically less stringent than for conventional systems or systems that do not provide the same degree of treatment.

The Puraflo is a modular system with each module rated for 150 gpd. The range and rated capacity of the system is therefore a multiple of the standard unit based on the 150 gpd module. Model P150N*3B incorporating 3 modules and rated at 450 gpd was the treatment plant tested to the NSF/ANSI Standard 40.

Puraflo ® Peat Biofilter



Bord na Móna

3.0 INTRODUCING SUBSTANCES TO THE SYSTEM

The Puraflo® Peat Biofilter is designed for the treatment of domestic strength wastewater from residences or other waste flows with similar wastewater strength characteristics. While the Puraflo® Peat Biofilter will process most waste produced by the average household, in order to prevent malfunctions, and to ensure optimum performance of the system, the following guidelines should be followed:-

DO

- Conserve water to reduce the amount of wastewater that must be treated and disposed
- Repair any leaking faucets and toilets (very important)

DO NOT

- Overload the system by introducing wastewater flows greater than the design flow
- Flush excessive amounts of grease, oil or fat into your septic system
- Dump excessive amounts of disinfectants, cleaners or detergents (normal amounts will not harm the system)
- Allow storm water into your septic system (storm water drains should not be connected to the septic tank and landscaping should divert storm water away from the modules)
- Use additives (septic tank additives should not be introduced into the septic tank for grease reduction, stimulation of biological activity or other purposes)
- Dispose of large quantities of organic material through a garbage grinder as this may organically overload the system and cause more frequent pumping of the septic tank
- Flush cigarettes, tea bags, sanitary napkins, tampons, diapers, condoms and other non-biodegradable products capable of blocking pipes or filters into your system
- Dump solvents, oils, paints, thinners, pesticides or poisons down the drain which can disrupt the treatment process and contaminate the groundwater
- Dispose of water softener waste directly into the septic system (where practical design a separate disposal system or balance flows into the septic system)

4.0 HOMEOWNERS DO'S and DO NOT'S

To ensure optimum performance of the **Puraflo®** Peat Biofilter system, the following Do's and Do Not's should be followed:

DO

- Maintain a stabilized / grassed landscaped area around the modules in order to prevent soil erosion (plants and suitable shrubs can also be used to enhance the appearance of the system)
- Keep ant nests and other pests out of the treatment modules by dosing externally with suitable insecticides and pest controls as necessary
- Divert down spouts and other surface water away from the system and drainfield
- Keep your septic tank cover accessible for tank inspections and pumping
- Have your septic tank pumped regularly and checked for leaks and cracks
- Have the effluent filter cleaned annually
- Test the pump alarm occasionally (as applicable) by briefly activating the test switch on the alarm
- In the event of the alarm sounding after electrical storms or power failure, check if the electrical circuit-breakers tripped off by first turning them off and then turning them back on again
- Call your Authorized Service Provider when you have problems

DO NOT

- Dig in your drainfield or build anything permanent over it
- Plant anything over your drainfield except grass
- Drive over your drainfield or compact the soil in any way
- Attempt any homeowner maintenance to the septic tank, pump tank, electrical controls or treatment modules – **do not remove caps or covers as potentially hazardous gases and waste matter are contained in the treatment tanks which may result in death or bodily injury.**
- Place heavy objects on or drive across your treatment system
- Bury or cover the modules with soil as the Puraflo® treatment is an aerobic process that requires free passage of air through the module lids

5.0 OPERATION AND MAINTENANCE

The Puraflo® peat biofilter is a passive biological treatment system and as such there are no mechanical parts with the exception of the pump and controls which dose the treatment modules. To assure the efficient operation of the Puraflo® system, it is important that the septic tank is well maintained and sludge carryover is avoided. The measures recommended for a standard septic tank treatment system also apply to the Puraflo® system which works on the same basic principles. To ensure optimum performance of the Puraflo® system, the following practices are recommended:

5.1 Septic Tank

A well maintained septic tank is essential for most onsite treatment systems as the septic tank provides the first treatment step in wastewater purification. During a tank retention time of a day or more, the heavier wastewater solids settle to the bottom forming a sludge layer while the lighter solids, greases and oils float to the top to form a scum layer. The anaerobic conditions created in the septic tank by the scum layer allow anaerobic and facultative micro-organisms to break down (feed on) and reduce the sludge and scum volume. In this manner approximately 40 percent of sludge and scum volume can be reduced; however, the remaining solids accumulate in the tank and must be pumped out on a regular basis.

The septic tank should be inspected annually and desludged in accordance with State and EPA guidelines. Depending on use, a typical home will produce sufficient sludge requiring the tank to be desludged during a two to three year period. The importance of desludging can not be over-emphasized since the Puraflo® system is designed to treat effluent from a well functioning septic tank where a significant portion of insoluble solids have been allowed to settle out. The effluent filter installed with the Puraflo® system should be cleaned annually or at the time of system inspection. The inspection / desludging should be carried out by a certified septic pumper and should not be attempted by the homeowner.

A filter is installed on the septic tank outlet pipe to prevent the carryover of solids to the treatment system. If septic tank maintenance recommendations and practices are not followed and in particular, if large objects are disposed into the septic tank, the filter will clog causing wastewater to backup into the house.

5.2 Pump Alarm

The pump alarm should be checked on a regular basis by briefly pushing the test switch on the alarm. This activates the audio alarm buzzer and visual alarm light for a short period before it reverts to its automatic position.

Refer to the Homeowner Troubleshootong Checklist in the event that the control panel alarm is activated.

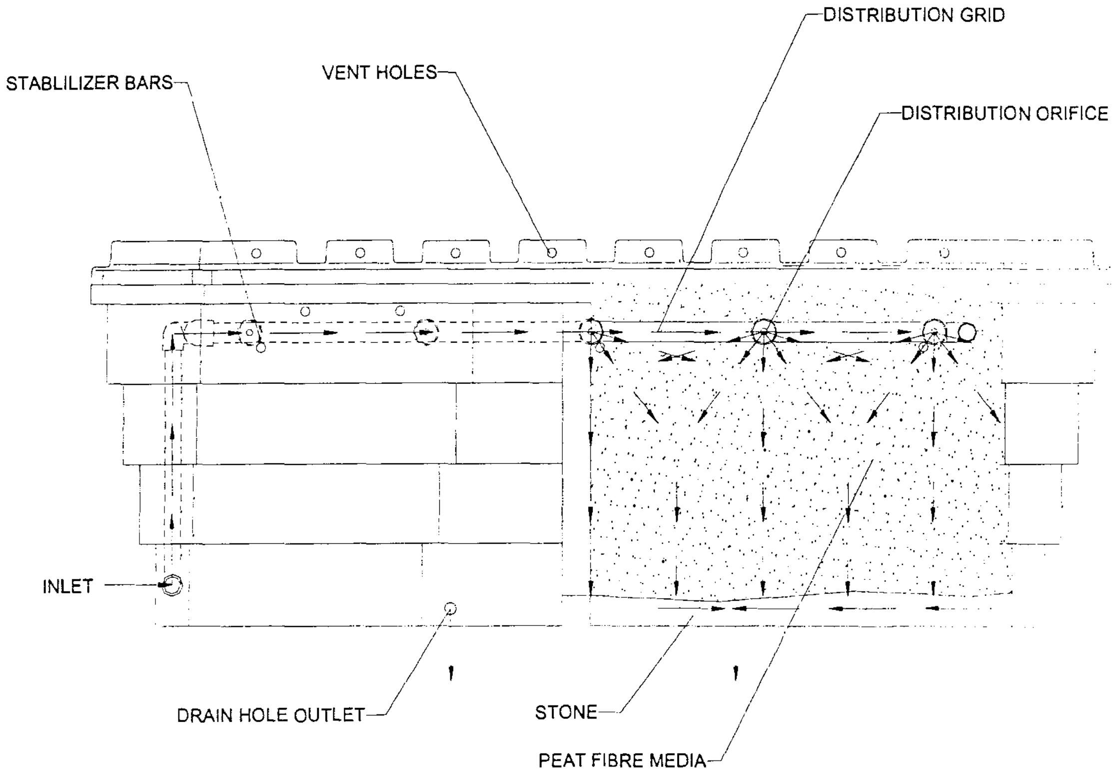
5.3 Electrical Control Panel

In the event of an electrical storm or power failure, the circuit-breaker switches on the electrical lines feeding the Puraflo® pump and alarm should be checked to see if they tripped to the "off" position. If a circuit breaker switch is tripped, the power supply to the alarm/pump should be restored by resetting the breaker. If the Puraflo® system still fails to operate, please call the Authorized Service Provider or Bord na Mona.

5.4 Puraflo® Modules

No heavy objects should be placed on top of the system modules as imposed loads can adversely effect the distribution and hence the performance of the system. The modules can be camouflaged with plants and small root ball type shrubs placed no closer than 2 feet from the modules, however, no soil or other obstruction should be placed within four inches from the top of the module where air is naturally circulated through the system.

It is essential that the treated effluent is allowed to drain freely from the modules and that the final disposal system is kept in good condition. Failure of the final disposal system may cause backing up of effluent in the Puraflo® modules which could damage the treatment capability of the system and the peat fibre. The Authorized Service Provider should be notified if there are any indications of ponding on the final disposal system and either standing water in or overflow from the modules or sampling chamber.



PURAFLO MODULE FLOW DIAGRAM

6.0 VACATION, SEASONAL AND INTERMITTENT USE

The Puraflo® treatment system will function normally when used for vacation, seasonal or intermittent applications.

During normal operation of the Puraflo® Peat Biofilter a stable ecosystem exists in the peat media consisting of a diverse population of microorganisms and also higher life forms. During a period of reduced wastewater flow to the Puraflo® biofilter the microbial population correspondingly decreases in the media. The degree of 'feeding' of the system dictates to a certain degree the microbial numbers in the media, however, the system will continue to treat the wastewater. The reason for this can be explained as follows:-

Upon complete cessation of wastewater supply to the bed a number of changes occur to the resident microbial population. Many types of bacteria and fungi will form spores during periods of nutrient depletion. These spores will remain dormant until a fresh supply of wastewater is added to the biofilter. Other non-sporing microorganisms will remain in a dormant inactive state until fresh nutrients are provided. Some microorganisms and higher life forms will persist in the peat media feeding on the residual biomass present, thus turning over the microbial population in the peat.

Upon start up, when wastewater is once again supplied to the system, the dormant microorganisms and spores quickly resuscitate and become metabolically active. Additional beneficial bacteria will be provided by the wastewater itself. The Puraflo® Peat Biofilter very quickly reactivates to become fully efficient.

7.0 HOMEOWNER TROUBLESHOOTING CHECKLIST

DETECTION	POSSIBLE CAUSE	ACTION
Experience slow flush but electrics are in good working order	1. Unacceptable level of solids in septic tank 2. Effluent filter blocked	1. Pump out septic tank and clean effluent filter 2. Clean effluent filter
Alarm sounds continuously and effluent level rises steadily in the pump tank - this can eventually lead to slow flush caused by sewage backing up and could eventually cause effluent to pond at the septic or pump tank	1. Pump failure due to circuit breaker switch being tripped to the off position by an electrical storm or power surge 2. Pump fails due to faulty system electrics or pump itself is faulty	1. Conserve water usage, reset circuit breaker and test the alarm - if the problem recurs call your Authorized Service Provider 2. Conserve water usage and call your Authorized Service Provider
Alarm sounds periodically but resets itself (indicating that the pump is still operating) Some states require alarms that are latched (continue to alarm after the alarm event has been corrected) and will not auto-reset themselves in which case it will be necessary to reset the alarm manually	1. High water usage above design capacity activates the alarm float switch 2. Leaking plumbing fixtures 3. Leaking pump or septic tank 4. Broken timer or incorrect timer settings. 5. Latched alarm	1. Reduce water usage to range within the design capacity - 2. Repair leaking plumbing fixtures 3. Repair leaks in septic or pump tank 4. Conserve water usage and call your Authorized Service Provider. 5. Reset manually
No alarm warning - effluent level rises continuously in the pump tank potentially leading to slow flush and/or effluent ponding around septic or pump tank	1. Pump and alarm failure due to circuit breaker switches being tripped to the off position by an electrical storm, power surge or power failure 2. Pump and alarm fail concurrently due to faulty system electrics	1. Reset circuit breaker and test the alarm - if the problem recurs call for maintenance 2. Conserve water usage and call your Authorized Service Provider
Ponding of effluent on peat fibre media	1. Failed drainfield 2. Media at end of useful life	1. Consult with your Authorized Service Provider 2. Replace peat fibre media

8.0 SERVICE AGREEMENT

8.1 Initial Service Agreement

All Puraflo® NSF Standard 40, Class I certified wastewater treatment systems have an initial service agreement for two years (two visits per year) included with the system's initial purchase price.

At each Puraflo® inspection the Authorized Service Provider shall, at a minimum:

Observe and Monitor

A wastewater level in the tanks,
B the septic tank outlet filter or screened pump vault for clogging,
C watertightness of tanks, risers and pipe connections at tanks,
D operation of pumps, floats valves, electrical controls and alarms,
E pumping frequency from impulse counters and elapsed run time meters,
F the peat modules for any structural damage, accessibility, adequate ventilation, excess odors, insect or other pest infestations,
G vegetative growth over the drainfield,
H the drainfield area for surfacing of the effluent,
I a sample of peat biofilter effluent collected form the sampling point to check for effluent clarity and odor (note: peat biofilter effluent may have a brackish to straw color from the humic and fulvic acids naturally present in the peat media)

Measure and Report

A Sludge and scum levels in the septic tank,
B Sludge level and grease presence in the pump tank,
C pump delivery rate (drawdown test), and
D dosing volume and measure or calculate average pump run time

Notification of Service/Repair Requirements

The Authorized Service Provider shall alert the system owner in a timely fashion of needed maintenance or repair activities including, but not limited to, landscaping, tank sealing, tank pumping, pipe or control system repairs, media replacement, and adjustments to any other component.

8.2 Extended Service Agreement

An Extended Service Policy is available and may be purchased through your local Puraflo® Distributor. The Extended Service Policy should provide the same service checks as the initial NSF service policy and perform any additional service required by local regulation.

TWO YEAR INITIAL SERVICE POLICY

Date ____________________

Our firm ____, will inspect and service your Puraflo® wastewater treatment system for the first two years from the date of installation. There will be ____ inspections made each year for this initial two year period. Effluent quality inspection will include a visual inspection for color, turbidity, sludge build up, scum overflow and odor. Physical and electrical inspection service include inspection of the pump tank, control and alarm panel, pump and pump tank floats and replacing, cleaning or repairing any component not found to be functioning correctly. The Puraflo® units and sample chamber will be inspected to ensure correct functioning of the system.

The owner shall be notified in writing of improper system operations that cannot be corrected at the time of inspection.

Upon expiration of this policy, our firm will offer a continuing service policy on a yearly basis to cover labor and for normal maintenance and repairs on a year by year basis.

Violations of warranty include: shutting off electric current to the system for more than 24 hours, disconnecting the alarm system, changing the control panel time settings from the approved design settings, restricting natural air flow to the peat fibre modules, overloading the system above its rated capacity or introducing excessive amounts of harmful matter into the system, or any other form of unusual abuse.

THIS POLICY DOES NOT INCLUDE PUMPING
SLUDGE FROM THE SYSTEM IF REQUIRED

Authorized Service Provider:

____

____

____

Owner:

____

____

____

9.0 EMERGENCY CONTACT DETAILS

In the unlikely event that you experience a problem with your Puraflo® Peat Biofilter system or if service is required, you should contact your Authorized Service Provider. The contact details for your Authorized Service Provider can be found on the Service Data Label that is attached to the control panel. You should reference the serial number of the Puraflo® Peat Biofilter found on the System Data Label attached to the Puraflo® modules when you contact the Authorized Service Provider or manufacturer.

9.1 Manufacturer Contact Details

Name	Bord na Mona Environmental Products US Inc.
Address	P.O. Box 77457
	Greensboro
	North Carolina 27417
Office No.	336 547 9338
Toll Free No.	1-800-PURAFLO
Fax No.	336 547 8559
Email Address	info@bnm-us.com
Website Address	www.bnm-us.com

9.2 Authorized Service Provider Contact Details

To identify the initial service provider for your system, check the labels on the control panel and fill in the table below.

Name	
Address	
Office No.	
Mobile No.	
Fax No.	
Email Address	

10.0 LIMITED WARRANTY

Bord na Mona Environmental Products U.S. Inc. (herinafter called BnMEP Inc.) warrants each Puraflo® peat fibre wastewater treatment system to function properly and to be free from defects in material and workmanship for a period of two (2) years from the date of sale to the original documented retail consumer. BnMEP Inc. sole obligation under this warranty is as follows: BnMEP Inc. shall fulfill this warranty by repairing or exchanging any component part, F.O.B Factory, that shows evidence of defects, provided the said component part has been paid for, warrantee has notified BnMEP Inc. of the defect complained of and the component is returned through the Authorized Service Provider, transportation prepaid. This warranty does not cover any costs to ship the defective parts to the factory, nor any labor costs and / or other costs to remove or replace defective parts. There is no informal dispute settlement available under this LIMITED WARRANTY.

BnMEP Inc. warrants the satisfactory operation of the Puraflo® peat fibre wastewater treatment system provided the treatment system is installed and operated in accordance with the design, treatment parameters and BnMEP Inc. recommendations.

This LIMITED WARRANTY applies only to the treatment process parts supplied by BnMEP Inc. and does not include any portion of the residential plumbing, drainage, disposal system, or installation of the systems. In no event shall BnMEP Inc. be responsible for delay or damages of any kind or character resulting from, or caused directly or indirectly by, defective components or materials manufactured by others or to any failure due to accidental or malicious damage, plant abuse, fair wear and tear or frost or storm damage, or use or installation contrary to zoning, regulation, or other legal mandate or ordinance.

Liability does not extend to cover damage, failure repairs and replacements due to third party causes including uncertified installation or incorrect or non regulatory compliant system design or as a result of connection to the a failed dispersal field or if the system is not used in accordance with the instructions for use contained in the owner manual.

Recommendations for special applications will be based on the best available expertise of BnMEP Inc. and published industry information. Such recommendations do not constitute a warranty of satisfactory performance.

This LIMITED WARRANTY extends to the original retail customer of the product. As herein, "original retail customer" is defined as the purchaser who first has the plant installed or in the case of a system designed for non-permanent installation, the purchaser who first uses the system. It is the purchaser's, or any sub-vendors obligation to make known to any other the terms and conditions of this warranty.

This warranty is a LIMITED WARRANTY and no claim of any nature shall be made against BnMEP Inc. unless and until the original retail customer, or his legal representative, notifies BnMEP Inc. in writing of the defect complained of and delivers the product and /or defective part(s), freight prepaid, to BnMEP Inc. or an authorized service station.

BnMEP Inc. reserves the right to revise, change, or modify the construction and/or design of the Puraflo® wastewater treatment systems, or any component part or parts thereof, without incurring any obligation to make such changes or modifications in equipment previously sold. BnMEP Inc. also reserves the right, in making replacements of component parts under this warranty, to furnish a component which, in its judgment is equivalent to the part replaced.

To the extent that the LIMITED WARRANTY statements herein are inconsistent with the locality where the Purchaser uses the Puraflo® Wastewater Treatment System, the warranty shall be deemed to be modified consistent with such local law. Under such local law, certain limitations may not apply. For example, some states in the United States and some jurisdictions outside the United States may (i) preclude the disclaimers and limitations of these warranties from limiting the rights of a consumer (ii) otherwise restrict the ability of a manufacturer to make such disclaimers or to impose such limitations; or (iii) grant the consumer additional legal rights, specify the duration of implied warranties which a manufacturer cannot disclaim, or prohibit limitations on how long an implied warranty lasts.

In no event and under no legal theory, including without limitation, tort, contract, or strict product liability, shall BnMEP Inc. or any of its suppliers be liable to the other party for any indirect, special, incidental, or consequential damages of any kind, including without limitation damages for loss of goodwill, or any kind of commercial damage, even if the other party has advised BnMEP Inc. of the possibility of such damages.

RECORD OF SYSTEM

Owner *Name*		*Phone*	
Street	*City*	*State*	*Zip Code*

Model #	Serial # (on module)	Control panel model #
Pump(s) model #	Float(s) model #	Startup date
Design flow	Pump design specification (gpm)	Tank(s) Size(s)
Recirc ratio (when applicable)	Pump tank timer settings	Dispersal method
Dealer name / phone	Engineer name / phone	Installer name / phone
Service provider name / phone	Regulatory Authority	Permit # (if applicable)

Notice of Transfer

I the undersigned ___________________ hereby declare that I have acquired the property located at
Name

Street *City* *State* *Zip Code*

Telephone

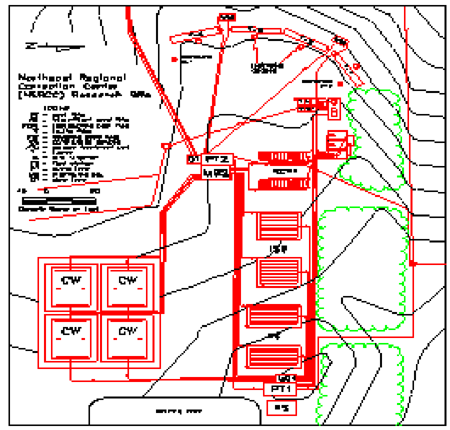
I have taken cognizance of the warranty provided by Bord na Mona for the Puraflo® Peat Biofilter for wastewater treatment. I wish to avail myself of this warranty for the remaining period of its coverage; I accept all of its clauses, undertakings and conditions; I have had the opportunity to examine the Puraflo Peat Biofilter and declare myself satisfied with it at the time of the transfer.
I request that Bord na Mona take note of the change of ownership.

Signature *Date*

Appendix B – Anua Paraflo Case Study & Info

NERCC* Individual Alternative Wastewater Treatment Systems: Pollutant Removal in 2003 and Long-term Performance

[*]Northeast Regional Correctional Center, St. Louis County, Duluth, Minnesota



Richard Axler
Barbara McCarthy[1]
Jerald Henneck

November 2004

Natural Resources Research Institute
University of Minnesota-Duluth
5013 Miller Trunk Highway, Duluth, MN 55811

[1] Current address: Minnesota Pollution Control Agency
525 Lake Avenue South, Suite 400 Duluth, MN 55802

NRRI Technical Report
NRRI/TR-2004/28

Primary funding: **Minnesota Department of Natural Resources**
Minnesota's Lake Superior Coastal Program
MLSCP Project No. 310-01 Contract Number:A41638
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

In-kind match: **Natural Resources Research Institute**
at the University of Minnesota-Duluth
Western Lake Superior Sanitary District

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NERCC Individual Alternative Wastewater Treatment Systems: Pollutant Removal in 2003 and Long-term Performance

Abstract

Near 500,000 Minnesota residences, commercial establishments and resorts rely on the use of onsite wastewater treatment systems to treat generated wastewater from these facilities. The need for effective onsite wastewater treatment systems in the state is growing to service new developments and to upgrade outdated on site sewage treatment systems (a.k.a. septic systems) with modern individual, shared, cluster or small community wastewater treatment systems. In 1995, a research site was established in northern Minnesota at the Northeast Regional Correction Center (NERCC) near Duluth, Minnesota, to design, construct, operate and monitor the performance of a variety of onsite wastewater treatment systems for use in the cold climate of Minnesota. The purpose of the research facility was to test the effectiveness of several onsite wastewater treatment technologies in removing organic matter, solids, pathogens, and nutrients at the same location using the same wastewater under identical climatic conditions. This phase of the study reports upon system performance during the 8th year of operating the facility (2003) after a 1 year monitoring hiatus due to a funding shortfall. Performance results were obtained throughout the year for: replicated, in-ground single pass peat filters, modular peat filters using both Irish and a Minnesota peat, replicated, in-ground single pass sand filters, replicated subsurface flow constructed wetlands, and a recirculating textile filter with shallow infiltration trenches. Results for 2003 were tabulated in comparison to results from previous years. In addition, all of the data for these systems from all years of operation is summarized and tabulated. Additional discussion regarding operation and maintenance issues is also included.

Keywords:
alternative technologies, performance-based systems, cold-climate, constructed wetlands, sand filters, peat filters, textile filters, pathogens, wastewater treatment, on-site septic systems, individual sewage treatment systems (ISTS)

I. Introduction

An estimated half million households in Minnesota are not connected to public sewer systems. Along with the growing use and expansion of lakeshore homes, cabins and resorts, many have the potential to degrade surface and groundwater resources, as they depend primarily on individual sewage treatment systems (ISTS) for treatment and dispersal of domestic wastewater. Many onsite wastewater systems are not in compliance with the state's prescriptive code or are hydraulically failing to the surface. Effective treatment options are needed for the thousands of locations with restrictive soil and site conditions, where many of these conditions occur in sensitive lake and stream environments, creating a potential health hazard to swimmers and others using surface water for drinking water and recreation, leading to increased algal blooms, aesthetic nuisances, and degraded fish habitat.

The Northeast Regional Correction Center (NERCC) Septics Demonstration/Research Facility near Duluth, Minnesota began in October 1995. The facility was designed and operated by scientists at the Natural Resources Research Institute of the University of Minnesota-Duluth in collaboration with the St. Louis County Environmental Health Department and the Western Lake Superior Sanitary District (WLSSD). NERCC's main objective was to establish a research/demonstration facility for directly comparing the year-round performance, operation and maintenance of various alternative on-site treatment systems. Replication, a single source of septic tank effluent, and a common set of performance based design criteria for concentrations of total suspended solids (TSS), biochemical oxygen demand (BOD_5) and fecal coliforms were central to the project's goals. The first set of systems included single pass sand and peat filters, subsurface flow constructed wetlands (with a second cell to enhance nitrogen removal) and a conventional trench system. These systems were operated nearly continuously through 2001 after which the facility was closed due to a funding shortfall. The modular peat filters were added in 1998 and the textile filter was added in 1999.

After a hiatus in 2002, funding from the Lake Superior Coastal Program allowed a more limited monitoring effort to be conducted in 2003 which is reported here. Because of funding limitations, this report serves mostly as a data report with relatively little detailed analysis of the 2003 data. The focus of the study was to revive the monitoring program at NERCC for an additional year, to determine how well the major treatment systems would perform after a year with minimal wastewater inputs (essentially a "wet" hibernation), and how they would perform in relation to their previous history and during a winter that turned out to have much more snow than in recent years. However, this also provided the opportunity to combine the 2003 seasonal data with the historical data to report summary tables of seasonal performance for all years of operation.

More than 25 performance-based, or alternative on-site wastewater treatment systems have been evaluated for varying time periods at NERCC Demonstration/Research Facility or as part of a series of resort-based Iron Range Resources and Rehabilitation Agency (IRRRA) demonstration projects, since 1995. These include:

- in-ground, single-pass sand filters (McCarthy et al., 1997, 1998, 1999; Anderson et al., 1998; McCarthy and Monson-Geerts, 2003a);

- in-ground single-pass peat filters (McCarthy et al., 1997, 1998; Monson Geerts et al., 2000, 2001a, Anderson et al., 1998);

- pre-engineered modular peat filters using both Irish and Minnesota peat (Monson Geerts et al., 2001b);

- granular peat filters (McCarthy et al., 1997, 1998);

- subsurface flow constructed wetlands (Axler et al., 1999, 2000, 2001; Henneck et al., 1999, 2001; Kadlec et al. 2003; McCarthy et al., 2002);

- a textile filter coupled with polishing sand filter and shallow dispersal trenches (McCarthy et al., 2001a);

- a drip irrigation system that discharges to soil depths of 0.5, 1, 1.5 and 2 feet below ground (McCarthy et al. 1997; McCarthy and Monson Geerts 1998**;**

- an aerobic treatment unit coupled with drip distribution (McCarthy et al., 2001b);

- standard infiltrative trenches, a recirculating gravel filter and drip distribution (McCarthy et al., 1997, 1998; McCarthy and Monson Geerts 1998); and

- a recirculating sand filter with shallow infiltration trenches (McCarthy and Monson Geerts 2003b).

Additional detailed studies of the efficiency of pathogenic bacteria (*Salmonella)* and model virus (MS-2) removal were performed on the in-ground peat and sand filters and the constructed wetlands (Pundsack 2001; Pundsack et al. 2001, 2004; Olson 2004; Olson et al. 2004a,b). The University of Minnesota Extension Service's Onsite Wastewater Treatment web site ***http://septic.coafes.umn.edu/Research/index.html*** provides a compilation of these and other publications from the project and many of the technical reports are also downloadable. Additional on-site wastewater treatment related information relevant to the region can be found at the Duluthstreams.org website (***http://duluthstreams.org/stormwater/on_site.html***) and from St. Louis County at ***http://www.co.st-louis.mn.us/publichealth/Environmental/envir_pro_septic.htm*** .

II. General Operation and Performance Monitoring

Detailed descriptions of system designs, operating specifications, monitoring program designs and field and laboratory methodology are reported in the journal manuscripts and technical reports listed above. Briefly, septic tank effluent is pumped from a lift station, located near the NERCC main building complex, and into a 2,500 gallon concrete septic tank installed at the research site, where effluent is time-dosed to the treatment systems at the test site (Figure 1). Once the effluent has passed through the in-ground, single-pass sand and peat filters, the constructed wetlands and the modular peat filters, it flows by gravity to a lower monitoring box, where flows are measured using tipper-buckets and samples are collected. Effluent then drains either to conventional trenches with monitoring piezometers located at 1, 2 and 3 feet below the trench or drains to an adjacent 2,000 gallon collection tank. From here, the effluent is pumped to the NERCC facility drainfield for final dispersal. Effluent from the modular textile filter flows by gravity to a small pump station and is dosed to a separate set of shallow trenches. Funding was only available to monitor inflow and outflow water chemistry for the treatment systems, and not the lysimeters placed under the research trench systems.

Figure 1 presents a plan view of the NERCC demonstration/research facility. Figures 2-6 show schematics of the individual systems and Figures 7 -11 are photographs of the various systems.

The NERCC systems were reactivated on November 19, 2002 and were sampled 10-16 times between January and December 2003 at approximately three week intervals. Septic tank effluent samples were collected using a peristaltic pump from the main head tank. Effluent samples from the constructed wetlands, sand filters, in-ground peat filters and modular peat filters were collected where they drain into tipper buckets located in the lower monitoring box. Textile filter effluent was sampled where it returns into the recirculation tank and the 'mixed effluent samples' were collected from the forcemain dosing the effluent to the textile filter.

Both peat filters were re-activated in November 2002 after a 1-year shut down. Before being re-activated, the modular peat filters were opened up and each module inspected. At that time, the Irish peat subsided about 10% by volume and was wet but not saturated. However, the Minnesota peat subsided significantly more than the Irish peat, losing ~30% of its original volume, exposing the distribution network in all 3 modules. Furthermore, the peat was saturated with water. A pick-up truckload (~4 yds) of coarse peat screenings was added to the modules containing Minnesota peat to once again fill each of the three modules. Additional maintenance information is available directly from the *Bord na Mona Puraflow* website at ***http://www.bnm.ie/environmental/small_scale_wastewater_treatment/puraflo.htm.***. Similarly one can find operation and maintenance information for the textile filter at ***http://www.orenco.com/ots/ots_index.asp.*** Inflow monitoring meters and screens were cleaned for all of the systems and wastewater was applied for about 2 months prior to beginning the monitoring program in order to reestablish their microbial communities.

All wastewater samples were analyzed for total suspended solids (TSS), biochemical oxygen demand (BOD_5), fecal coliform bacteria (fecal coliforms), and total phosphorus (TP) at the Western Lake Superior Sanitary District (WLSSD) Laboratory according to standard methods following APHA (1998). Nitrogen analyses (total-N [TN], ammonium-N and nitrate/nitrite-N) were analyzed by the NRRI Central Analytical Laboratory (methods following APHA, 1998 and Ameel et al. 1998). Both laboratories were certified by the Minnesota Department of Health.

In the field, temperature, specific electrical conductivity (EC25), and dissolved oxygen of the effluent were measured using a YSI 85 multi-sensor meter. Inflows were determined using individual water meters at the inflows for the sand filters, in-ground peat filters and constructed wetlands. Timers and event counters were used for the textile filter and modular peat filters. Outflows may be assumed to equal inflows for all systems except the constructed wetlands (CWs) where evapotranspiration can reduce outflows to zero during warm summer days. Because we were not able to monitor the rates of outflow from the CWs, their reduction efficiencies were calculated by comparing effluent to influent concentrations instead of by mass reduction as was done for previous years and as is appropriate for CWs. This difference would be insignificant for most fall, winter and spring samplings but would likely tend to underestimate performance in the summer when nutrients and other water quality parameters may be in relatively high concentrations but only in a small trickle of effluent. Therefore, the CW performance data are conservative. Temperatures within each system were determined using an Omega hand-held digital thermometer. Climate data were taken from the National Weather Service site located at the Duluth International Airport, approximately 15 km south of NERCC.

III. Performance Results

This section summarizes effluent water quality data and removal efficiencies, and compares the operation and performance of the peat, modular peat, sand and textile filters and the constructed wetlands in 2003 in relation to historical data.

A. Septic tank influent

During the 2003 monitoring period, incoming septic tank effluent from the correctional facility was comparable to residential strength septic tank effluent although at the high end of the range for many constituents (Table 1). Typical residential strength effluent is reported to range from 50-100mgTSS/L (NERCC was a bit low and averaged 47 mg/L), 140-200 $mgBOD_5/L$ (NERCC was relatively high strength and averaged 229 mg/L), 10^6-10^8 cfu/100mL fecal coliform bacteria (NERCC was lower at 10^4-10^5 cfu/100mL in 2003 and a long-term average of ~ 4x 10^5 cfu/100mL), 5-15 mgTP/L (NERCC averaged ~ 14 mgP/L), and 40-100 mgTN/L (NERCC averaged ~ 80-85 mgN/L; Crites and Tchobanoglaus, 1998; EPA, 2002). Effluent "strength" in 2003 was similar to that measured from 1996-2001 (see McCarthy et al. 2003, Axler et al. 2001, Monson-Geerts et al. 2001).

B. Treatment system effluents - 2003

Effluent quality data for 2003 for the 9 monitored systems are tabulated in Tables 2-10 and average annual removal rates for 2003 in Table 11. Tables 12-16 summarize seasonal effluent concentrations and removal efficiencies for all years of operation. The systems had been "rested" from November 2001 to November 2002 due to insufficient funding, but otherwise were used near continuously from 4 to 7 years, depending upon the year of construction or installation.

1. <u>Sand filters</u>:

During this 6^{th} year of operation at ~195 gal/day (0.6 $gal/ft^2/day$), the replicated single-pass sand filters required only routine maintenance, limited to flushing the pressure distribution network which was done in October 2003. Overall, the sand filters provided the best performance in removing BOD (99%), TSS (96-99%), phosphorus (48-50%), and fecal coliform bacteria (>99.8%), followed closely by the modular peat filter containing standard Irish peat. The sand filters removed the most phosphorus, 48-50%, presumably due to the iron content of the media since it was removed from a minepit on the 'Iron Range' (a.k.a. "Iron Ridge") north of Virginia, MN. Other advanced treatment systems tested in 2003 removed relatively little phosphorus, 6-13%. Overall nitrogen removal was minimal (4%) by both sand filters but nitrification was nearly complete at >95% and ammonium levels averaged <3 mgN/L). This result is consistent with the relatively high dissolved oxygen levels in the sand filter effluents (annually means ~ 5 mgO_2/L). Both filters consistently exceeded secondary treatment standards for TSS and BOD_5, with TSS always < 6 mg/L (mean <2) and BOD_5 always <7 mg/L (mean ~ 2 mg/L) with no seasonal difference in removal rates. Pathogen reduction (i.e. fecal coliform bacteria) was fairly consistent between the seasons, with effluent fecal concentrations ranging from <10 cfu/100 mL to 2,760 cfu/100 mL (99.7% removal) with annual geometric means of 387 and 166 cfu/100mL. Overall the sand filters achieved levels of 200 cfu/100 mL fecal coliforms 81% of the time (26 of 32 sampling events) and 1,000 cfu/100 mL fecal coliforms 91% of the time (29 of 32 events). These were the best systems for 2003 in terms of fecal coliform removal and were somewhat better than their long-term performance (7 years and 254 effluent samples). Since 1996, their effluent fecal concentrations have been <200 cfus/100 mL for 74% of the time in summer and 40% in winter; 84% of the time they were <1000 cfu/100 mL in summer and 66% of time in winter (Table17). The 200 and 1000 cfu/100 mL are not actual effluent standards but rather are commonly accepted recreational bathing standards for freshwater and saltwater, respectively, and are only used here for illustrative reasons since the effluents are discharged into subsurface trenches, not public water bodies.

2. Peat filters: in-ground

The peat filters also produced better than "secondary" effluent quality, with ~ 95% BOD removal to 8-13 mgBOD/L and ~ 91% TSS removal to <5 mgTSS/L. Mean (geometric) annual effluent fecal coliform concentrations were 190 and 1246 cfus/100 mL, respectively for the two filters. Phosphorus removal was low at ~ 12% but total-N removal was the highest of any of the NERCC systems in 2003 at 55% for each of the filters. Ironically, this N-removal was probably due to the gradual hydraulic failure and saturation of the filters. Effluent DO levels averaged 2-3 mgO_2/L and values were often <2 mgO_2/L at the tipper bucket outlet where some oxygen diffusion is unavoidable. The peat filters historically were good nitrification reactors with high conversion of ammonium to nitrate and moderate N-removal (~20 %, Monson Geerts et al. 2000, 2001a). However, as the peat ages and subsides, the filters become increasingly saturated and less aerobic. Presumably, they then act as a mixed aerobic/anaerobic reactor with significant coupled nitrification-denitrification within the filter and improved total-N removal, although effluent ammonium concentrations would tend to be higher than in the fully aerobic state. In fact, decreasing DO and increasing ammonium-N were evident after early April 2003 and the west unit (#2) flow rate was reduced to about half the design rate for the period April - December. Another problem that occurred for the West filter (Replicate #2) in August 2003 was a failed timer that took about a month to repair.

Neither peat filter failed hydraulically to the surface although reduced performance was quite apparent.at any time. Based on our experiences with these systems since 1996, the best single indicator of potentially imminent hydraulic failure is low DO - values less than about 3 mgO_2/L. This is an easy to perform field measurement if the system has an appropriate place to monitor effluent DO without introducing air into the system, but requires routine monitoring to be most effective.

A more obvious indicator of hydraulic failure, but one requiring an analytical lab and trained sample collector, was the relatively poor fecal coliform bacteria removal during failure. Historically, properly functioning peat filters removed fecals to the routine detection limit of <5 cfu/100 mL with log removal rates >4 (>99.99%) for fecals, spiked *Salmonella,* and spiked MS-2 bacteriophage virus (Monson Geerts et al. 2001a; Pundsack et al. 2001, 2004; Olson et al. 2004a). However, although pathogen removal was lower than expected, it was still ~ 99% over the entire year (Table 11). The performance decline was evident in May 2003 for the East filter (Table 2) and from the beginning in the West filter. Effluent fecals for both filters combined were 50% for the 1000 cfu/100 mL "criterion" and 30% for the 200 cfu/100 mL "criterion." However, over the longer-term since 1995 (7+ years and 224 effluent samples), the peat filters have outperformed all other systems in terms of fecal coliform disinfection with removal to <200 cfus/ mL more than 81% of the time and to <1000 cfus/100 mL for more than 88% of the time, irrespective of season (Table 17). Little variation was seen between winter and summer months. The poorer performance in 2003 was presumably associated with its year-long period of activity prior to the 2003 study.

3. <u>Modular peat filters</u>
The Irish Peat modular peat filter at a mean flow of 246 gal/day, performed similarly to the sand filters (which were operated at similar mean flows of 226-246 gal/day) in removing organic matter (99% BOD), solids (99% TSS), and pathogens (99.9% fecal coliform bacteria). Effluent concentrations were more than an order of magnitude below secondary wastewater treatment levels with mean annual concentrations of 3 mg BOD/L, <1 mgTSS/L, and 20 fecal cfu/100 mL. However, the system removed substantially less phosphorus (6% TP,) than the sand filters. The overall rate of nitrogen removal was ~31% for the year and the remaining nitrogen was almost entirely in the form of nitrate with ammonium levels reduced to ~ 0.1 mgN/L on average. This high rate of nitrification was consistent with the relatively high levels of oxygen in the effluent (3~7 mg/L) and indicates that the system is aerobic when functioning properly. This filter reduced fecals to <1000 cfu/100mL 100% of the time and <200 for 81% of the samplings in 2003 which was the best disinfection performance of any system in 2003.

The data set for modular peat filters only extends through parts of three years but suggests excellent disinfection spanning a number of years (Tables 15A, 15B, 17). This system disinfected better than all of the other systems in 2003 with removal 81% of the time to <200 cfu/mL and 100% of the time to<1000 cfu/mL over the entire year. Combining these data with our three previous years, the removal to <200 cfu/mL was 90% in summer and 35% in winter; for removal to <1000 cfu/mL the values were 97% and 61% for summer and winter, respectively.

The Minnesota Peat modular peat filter, at a similar average flow of 226 gal/day, was less effective in treatment efficiency than its Irish counterpart, likely due to the significant subsidence/loss of peat (~30% by volume) and near saturation in all 3 modules, observed in September 2003. The peat had "subsided" several inches below the distribution network, and evidently wastewater intermittently was ponding at the peat surface to form an observed biomat. This would likely reduce treatment performance by "short circuiting." However, the filter still performed at a high level by removing 97% BOD, 95% TSS and >98% fecals to produce a mean annual effluent with 6 mgBOD/L, 2 mgTSS/L, and 438 fecal cfus/100 mL.

Total-P removal was also low (~7%) and overall N performance was somewhat lower than for the Irish Peat filled filter. Mean effluent oxygen was still aerobic (3.7 mg/L) but many samples had <2 mgO_2/L as a result the mean annual effluent ammonium concentration was much higher, 12 mgN/L) than for the other modular peat filter.

The Minnesota Peat filter reduced fecals to <1000 cfu/100mL 67% of the time and <200 for 40% of the samplings which was poorer than its long-term performance. Since 1998 (54 samples from 4 different years), the filters removed fecals to <200 cfu/mL for 42% of the summer samplings, but only 7% of the winter samplings. Corresponding summer and winter values for removal to <1000 cfu/mL were 69% and 41% respectively (Table 17). Clearly the Irish peat outperformed the Minnesota peat although the latter still removed >99.9% of the influent fecals over the 4 year period.

4. Constructed wetlands

The subsurface flow wetlands froze over the first winter period in 2003 and data was only available after May. It is not clear to what extent their lack of maintenance in late 2001 and all of 2002 contributed to their freezing. Freezing problems in previous winters with low snowfall (Reed et al. 2001) as in 2002/2003 led to our adding a six inch layer of peat in 2001 but this should be checked annually and augmented periodically, especially if flows are low or intermittent in early winter as was the case in 2002.

At flows of 157-172 gal/day from June-Dec 2003, the CWs removed 83% BOD, 93-95% TSS, 9-13% TP, 15-20% TN and 96-99.1% fecal coliform bacteria. The lower than anticipated annual flows were caused by a timer malfunction in October 2003. Effluent quality was nearly at secondary levels with mean annual values of ~35 mg BOD/L, 4 mg TSS/L and 1677/1183 fecal cfu/100 mL. Unlike the other systems, effluent dissolved oxygen indicated anaerobic conditions during most samplings and this was consistent with the absence of nitrate in the effluent (<0.01 mg N/L). It must also be noted that the removal data for 2003 are based on concentrations and therefore, underestimate the true performance of the wetland during summer when outflows are substantially reduced (on occasion to zero for much of day) due to plant evapotranspiration. This effect concentrates pollutants in the effluent and greatly underestimates their actual mass removal due to the greatly reduced flow. Despite being frozen for nearly half of the 2003 study year, the constructed wetlands reduced fecals to <5000 cfu/mL for all samplings, <1000 cfu/100mL for 60% of the samplings and <200 cfu/100 mL for 40% of the samplings.

Over the long-term, since 1996 (7 years and 198 effluent samples), the CWs performed much better than in 2003 with summer removals to <200 cfu/100 mL 45% of the time and to <1000 cfu/100 mL 70% of the time. Their winter performance dropped substantially however, with removal to <200 cfu/100 mL only 7% of the time and to <1000 cfu/100 mL ~ 20% of the time (Table 17). The stronger seasonal disinfection pattern for the CWs suggests that the removal mechanism may be dominated by biological processes. This is consistent with seasonality of BOD_5 and nitrogen removal. However, there were also freeze-up or partial freezing problems in at least 3 winters that would have reduced bed volume, thus decreasing retention time and decreasing removal efficiencies for various pollutants. Overall, the CWs have removed~99.8% of their fecal coliform bacteria load since 1996.

Additional microbial removal information for the sand, in-ground peat and CWs may be found in Pundsack et al. (2001, 2004) for *Salmonella* and fecals removal and Olson et al. (2004a,b) for virus and fecal coliform removal.

5.Textile filter (modular, recirculating):
The textile filter performed reasonably well in removing organic matter (97% BOD) and pathogens (99.98% removal fecal coliform bacteria) at a flow of 248 gal/day. Secondary level effluent quality was produced consistently throughout the year with means of 6 mgBOD/L, 7 mgTSS/L and a geometric mean of 101 fecal cfus/100 mL. As expected phosphorus removal was low (7%) because there was no adsorbent. N-removal was also relatively low at 21% but the filter nearly entirely removed ammonium after May by nitrifying it to nitrate. The filter remained aerobic throughout the year with DO levels always $\geq$ 3 mgO_2/L. This filter reduced fecals to <1000 cfu/100mL for 92% of the samplings and <200 for 64% which was generally similar to its two previous years of operation (Tables 16 and 17). Overall, its summer removal to <200 cfu/mL was 56% in summer and 13% in winter. Removal to <1000 cfu/mL increased to 73% in both summer and winter. The textile filter typically removed >99.5% of the influent fecal coliform bacteria for the entire period of record since 1999. A polishing sand filter further improved the system's efficiency to >99.9% for fecals in 1999-2000 but eventually failed (i.e. it ponded) due to undersizing.

IV. Treatment system effluents - comparison to previous years
The in-ground sand and peat filters and the constructed wetlands had been operated for 6 years previous to the 2002 shutdown and the modular peat and textile filters had also been operated for 3-4 years prior to 2003. Tables 11-16 summarize the entire record for the in-ground sand and peat filters, the modular peat filters, the textile filter and the constructed wetlands. Pollutant removal efficiencies are also shown as time series for the longer -lived systems, the sand and peat filters and the CWs in Figures 12-14. It is important to note that these summaries might be considered conservative from a design or risk assessment perspective since they include periods of data when system problems were occurring, such as when the original peat filters began to fail hydraulically after their first year (associated with their gravity distribution system that was changed to a pressure system; Monson Geerts et al., 2000, 2001a), when the sand filters were loaded at higher flow rates and one failed in Spring/Summer 2000 (after March 2000 when loading rates were increased by 33-100%, McCarthy and Monson Geerts, 2003) and when the constructed wetlands were impacted by freezing and rainstorm-related flushing, both of which reduce their retention time (Henneck et al., 1999, 2001; Axler et al. 2001; Kadlec et al. 2003).

A major objective of this project was to run the systems for an additional year and to then combine the 2003 data with historical data for ease of use by designers and regulators. Although a detailed analysis of these summary data is beyond the scope of this project, we have summarized the pathogen indicating fecal coliform concentration data in Table 17 and made the following observations regarding system performance in 2003 relative to previous years:

1. Sand filters: in-ground, single-pass

- Performance in 2003 was similar to that over the period 1996-2000 for comparable rates of hydraulic and organic matter loading (higher loading rates were applied in 2001 and the systems were idle in 2002)

2. Peat filters: in-ground, single-pass

- Despite indications that both peat filters were beginning to hydraulically fail, early in 2003, overall performance for TSS, BOD, TP and TN was similar to previous years (although the loading rate was decreased by ~50% for one system to determine if reduced loading would improve treatment performance).

- However, the removal efficiency for fecal coliform indicator bacteria was 1-2 orders of magnitude lower in 2003 than in previous years, although still ~ 99%. This was likely due to possible shortcutting ("channeling") associated with consolidation of the peat after 5 previous years of loading.

3. In-ground, modular peat filters:

- Performance in 2003 for both the Minnesota Peat and Irish Peat systems was similar to that during the initial testing periods of June 1999-Jun 2001 and September 1999 - June 2001, respectively, for comparable rates of hydraulic and organic matter loading. Although the systems were idle in 2002, the mean fecal coliform levels in their effluents were lower than for previous years.

4. Constructed wetlands:

- Overall performance was generally similar to that measured in previous years for BOD, TSS, TP and fecal coliforms. Despite an extended period without use, Fall 2001 to Spring 2003, the wetlands continued to function in a largely anaerobic mode, and so N removal remained lower than originally anticipated. For 2003, N removal was actually lower than either the sand or peat filters. The wetlands also froze over the winter indicating that the 6 inch layer of insulating peat added for winter 2000/2001 was insufficient for long-term insulation. However, the systems were fallow until late November 2002 and so the lack of heat input from continuous wastewater inflow may have contributed to the freezing that occurred mid-winter.

5. Recirculating modular textile filter:

- Performance in 2003 was generally similar to that measured previously for the period November 2000 - April 2001 (McCarthy et al. 2001a). Performance was also notably improved during the summer months in 2003 but there is not comparable data from previous summers. There were no apparent negative effects from the year without operation.

V. Operation and Maintenance

A limited number of problems are expected over the life of onsite treatment systems, ranging from outside influences, such as simple power outages and lightening strikes, homeowner abuse to the system, climate related problems from floods and cold snaps, to design and construction flaws. Because of the accessibility of the NERCC Demonstration Site to the NRRI building (11 miles), the systems were checked or monitored regularly (typically weekly). When problems occurred, they were usually discovered in a timely fashion and corrected within a few days, limiting reduced treatment performance of the systems. There were no major problems during this study other than the previously mentioned wetlands freezing (Table 18) and the indications that the in-ground peat filters, were beginning to fail hydraulically and would likely require partial to full peat replacement before operating them for another year. The research now seems to indicate that the peat in an in-ground filter, using Minnesota peat, would need to be replaced every 4-5 years.

Specific recommendations for system maintenance are included in previous NRRI technical reports. Journal manuscripts describing the NERCC treatment systems for previous years were cited previously in this report and many are downloadable from the following website:

University of Minnesota

http://septic.coafes.umn.edu/Research/index.html
(also linked from ***http://duluthstreams.org*** and

http://www.co.st-louis.mn.us/publichealth/Environmental/envir_pro_septic.htm).

Operation and maintenance (O/M) procedures are essential to maintain optimal performance of any onsite wastewater treatment system. Like a car, the system needs to be operated properly and periodically maintained by qualified personnel, to ensure that the system will work to treat wastewater generated in the home and recycle it back into the environment. Although maintenance requirements are fairly simple, it needs to be done on a routine basis. With proper operation by the homeowner and ongoing maintenance by a qualified service provider, the onsite sewage treatment system should last a long time. Without it, the system will break, much like a car if not properly maintained. An O/M manual should be supplied, and adhered to, with any pre-engineered or designed system.

The following are some basic maintenance and monitoring requirements that need to be considered for single-pass filter systems, grouped by system component: septic and pump tanks, control panel, pump and associated controls, and the filter. Additional recommendations for constructed wetlands may be found in Henneck et al., 1999, Henneck et al., 2001 and Wallace et al., 2001.

1. Septic Tank and Pump Tank

- Flow to the system (water meter in the house)
- Wastewater levels in the tanks
- Water tightness of tanks, risers, and pipe connections at tanks
- Septic tank outlet screen or screened pump vault for clogging
- Condition of tank baffles
- Sludge and scum levels in the septic tanks
- Sludge and grease presence in the pump tank

2. Control Panel and Controls

- Pumping frequency from pump counters and elapsed run time meters
- Operation of pumps, floats, valves, electrical controls and alarms
- Pump delivery rate (draw down test)
- Dosing volume and measure or calculate average pump run time

3. Sand, Peat, Textile Filters

- Inspect for ponding on the surface
- Check for biomat
- Peat - check for and track consolidation; should be somewhat "fluffy", retaining its original characteristics and not be overly wet
- Verification of equal spray/squirt height of orifices on each lateral
- Distribution lateral flushing if necessary
- Unusual odor
- Insect infestations
- Sample of filter effluent to check for clarity and odor or analyzed as specified in an Operating Permit (i.e. dissolved oxygen and/or BOD_5)

- Appropriate measures must be taken to protect the systems from freezing (Table 18). Information should be available from a certified contractor as well as from the National Small Flows Clearing House (URL above), the St. Louis County Onsites website (given previously) , and the Minnesota Extension Service Onsite Septic Systems Website (also given previously). Recent winters with relatively small amounts of snow cover have created conditions extremely favorable to freeze-up of many components of septic systems and additional insulation is a prudent recommendation for all systems.

- Go to the Bord-na-Mona website for more detailed information for maintaining modular peat filters: ***http://www.bnm.ie/environmental/small_scale_wastewater_treatment/puraflo.htm***

- Go to the OSI (Orenco) website at ***http://www.orenco.com/ots/ots_index.asp*** for more detailed information for maintaining modular textile filters and sand filters.

- The University of Minnesota Extension Service, the National Small Flows Clearinghouse (NSFC) and the EPA websites offer additional valuable information. Specific URLs are:

  - U. of Minnesota Extension Service: ***http://septic.coafes.umn.edu/index.html***

  - NSFC- ***http://www.nesc.wvu.edu/nsfc/nsfc_index.htm***

  - EPA- Septics: ***http://cfpub.epa.gov/owm/septic/home.cfm***

National Small Flows Clearinghouse

U.S. Environmental Protection Agency

4. <u>Constructed wetlands (horizontal subsurface flow)</u>

- As above regarding ponding, odors, and appropriate monitoring of the dosing pump, and inlet and outlet structures, and other conditions specified in the Operating Permit.

- Appropriate measures must be taken to protect the CWs from freezing (see Table 18). Information should be available from a certified contractor as well as from the National Small Flows Clearing House (URL above), the St. Louis County Onsites website (given previously) , and the Minnesota Extension Service Onsite Septic Systems Website (also given previously).

- Establishment of vegetation is important and may require multiple plantings and a mixture of plants should be considered; limited harvesting of plants may be desirable for aesthetic reasons and the vegetation may be used for additional insulation..

- Sizing and substrate size are very important and decreased winter performance should be considered.

- Although horizontal subsurface flow systems are the simplest of CWs to operate and except for freezing, the easiest of the alternative systems to maintain, more complex engineered systems such as vertical flow or forced bed aeration (e.g. the NAWE system at ***www.nawe-pa.com/tech/***), or coupled CW-Sand/peat filter systems, should be considered where wastewater strength is higher than average or increased nitrogen removal is required. However, these would require considerably more management.

This list is not meant to be all inclusive of required operation, maintenance and monitoring of a filter or constructed wetland system. The most up-to-date literature should be consulted in preparing operating permits for individual systems for both residential and commercial applications.

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Table 1. NERCC septic tank influent to alternative treatment systems, Nov 2002-Dec 2003, n=16 sample events. NO3-N = [NO3-N]+ [NO2-N].

	Flow (gal/day)	T (ºC)	EC25 (uS/cm)	D.O. (mg/L)	BOD_5 (mg/L)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	NH4-N (mg/L)	NO3-N (mg/L)	Fecals (cfu/100 mL)
22-Nov-02											
13-Dec-02											
10-Jan-03											
24-Jan-03											
29-Jan-03		12.4	1219	0.20	224	31	16.5	72.5	71.73	0.03	126000
19-Feb-03		12.4	1285	0.16	274	34	16.0	74.8	71.2	0.07	245000
12-Mar-03		11.6	1197	0.25	212	32	10.9	-	-	-	104500
02-Apr-03		12.1	1155	0.18	225	34	16.0	-	-	-	74000
23-Apr-03		12.1	1202	0.28	213	50	12.2	-	-	-	155500
14-May-03		13.8	1240	0.23	304	36	11.9	78.6	76.7	0.04	195000
04-Jun-03		14.7	1337	0.04	253	53	12.8	90.3	82.3	0.88	245000
25-Jun-03		17.5	1172	0.01	135	67	15.1	73.7	67.5	0.04	295000
16-Jul-03		19.9	1288	0.02	221	94	12.9	89.5	82.5	0.05	240000
06-Aug-03		19.8	1227	0.08	188	44	12.1	88.2	74.0	4.49	86000
27-Aug-03		21.2	1287	0.04	-	36	14.0	84.5	82.4	0.04	55000
17-Sep-03		20	1330	0.05	258	35	13.0	87.0	85.8	0.03	51000
08-Oct-03		18	1266	0.44	180	40	12.6	79.2	77.3	0.04	95500
30-Oct-03		17.1	1302	0.41	233	50	14.8	81.0	79.0		180250
19-Nov-03		16.2	1338	0.38	287	60	16.9	82.8	80.8	0.10	265000
10-Dec-03		14.3	1248	0.67	237	49	15.1	76.3	74.6	0.05	44000
Range		11.6-21.2	1155-1338	0.01-0.67	135-304	31-94	10.9-16.9	72.5-90.3	67.5-85.8	0.03-4.49	44000-295000
Median		15.5	1257	0.19	225	42	13.5	81.0	77.3	0.04	140750
Mean		15.8	1256	0.22	229	47	13.9	81.4	77.4	0.49	146842

Table 2. In-ground single-pass peat filter (Replicate #1 – East) effluent water quality. Nov 2002-Dec 2003, n=16 sample events. Total gallons treated Nov 22, 2002 – Dec 10, 2003 = 75,848 gallons septic tank effluent and total gallons treated from Jan 12, 1996 – Dec 10, 2003 = 430,278 gallons septic tank effluent. NOTE- TN = combined sample from both replicate filters (East+West). NO3-N = [NO3-N]+ [NO2-N].

	Flow (gal/day)	T (°C)	EC25 (uS/cm)	D.O. (mg/L)	BOD_5 (mg/L)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	NH4-N (mg/L)	NO3-N (mg/L)	Fecals (cfu/100 mL)
22-Nov-02	364										
13-Dec-02	288										
10-Jan-03	282										
24-Jan-03	217										
29-Jan-03	236	5.1	665	5.4	3	0.4	6.6	45	11	40	5
19-Feb-03	220	3.5	589	6.5	2	0.5	7.5	40	12	30	5
12-Mar-03	226	3.5	549	5.3	2	1.2	7.8	-	-	-	5
02-Apr-03	222	4.5	616	5.9	2	0.5	8.6	-	-	-	50
23-Apr-03	208	7.5	643	3.2	2	1.0	8.6	-	-	-	5
14-May-03	206	8.6	670	2.7	3	0.5	8.4	50	13	37	80
04-Jun-03	203	13.9	633	1.6	5	2.0	8.8	43	14	23	1120
25-Jun-03	198	15.1	675	1.7	7	5.6	10.7	41	19	14	2400
16-Jul-03	202	16.2	743	3.6	8	2.0	17.4	32	24	0.09	1830
06-Aug-03	28	19.8	685	0.9	26	5.0	32.4	22	16	0.14	20
27-Aug-03	147	18.9	677	2.2	-	2.8	12.4	28	16	7.7	2500
17-Sep-03	186	18.0	736	0.9	14	5.8	11.8	31	21	5.6	1500
08-Oct-03	216	15.0	706	2.1	14	2.4	11.2	39	24	5.6	1900
30-Oct-03	167	10.0	669	2.0	10	4.8	11.7	33	26	3.6	150
19-Nov-03	180	8.6	763	2.2	16	4.8	11.2	35	32	0.57	6800
10-Dec-03	145	6.6	759	3.9	16	8.8	15.6	32	32	0.04	1560
Range	28-364	3.5-19.8	589-763	0.9-6.5	2-26	<1-8.8	6.6-32.4	22-50	11-32	0.09-40	5-6800
Median	205	9.3	673	2.5	7.0	2.2	11.0	35	21	5.6	635
Mean	207	10.9	674	3.1	8.5	3.0	11.9	36	21	13	190

Table 3. In-ground, single-pass peat filter (Replicate #2 – West) effluent water quality, Nov 2002-Dec 2003, n=14 sample events. Total gallons treated Nov 22, 2002 – Dec 10, 2003 = 49,582 gallons septic tank effluent and total gallons treated from Jan 12, 1996 – Dec 10, 2003 = 429,703 gallons septic tank effluent. NOTE- TN = combined sample from both replicate filters (East+West). NO3-N = [NO3-N]+ [NO2-N].

	Flow (gal/day)	T (ºC)	EC25 (uS/cm)	D.O. (mg/L)	BOD_5 (mg/L)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	NH4-N (mg/L)	NO3-N (mg/L)	Fecals (cfu/100 mL)
22-Nov-02	260										
13-Dec-02	136										
10-Jan-03	310										
24-Jan-03	256										
29-Jan-03	258	5.2	744	2.8	10	7.2	8.4	45	30	5.4	3000
19-Feb-03	246	4.4	794	3.0	18	6.4	9.6	40	37	0.80	12500
12-Mar-03	190	3.0	864	4.3	21	8.4	11.0	-	-	-	1800
02-Apr-03	114	3.5	859	3.7	16	1.2	10.2	-	-	-	740
23-Apr-03	115	5.9	816	1.3	19	7.0	10.6	-	-	-	2700
14-May-03	114	8.4	838	1.8	3	4.4	15.2	50	36	9.8	900
04-Jun-03	111	15.3	864	1.6	17	6.8	10.7	43	39	5.6	5600
25-Jun-03	112	14.8	891	1.4	15	6.0	11.2	41	38	3.9	1900
16-Jul-03	113	15.8	822	3.7	20	3.0	16.4	32	31	0.06	1040
06-Aug-03	18	21.4	892	0.3	24	7.0	24.8	38	16	0.15	190
27-Aug-03	0	-	-	-	-	-	-	28	-	-	-
17-Sep-03	0	-	-	-	-	-	-	31	-	-	-
08-Oct-03	117	15.2	817	0.6	8	2.8	8.2	39	11	33	790
30-Oct-03	105	11.0	719	1.0	6	2.8	10.1	33	10	20	270
19-Nov-03	114	8.6	723	1.8	5	2.8	7.8	35	11	17	570
10-Dec-03	109	6.2	731	3.6	5	2.4	8.9	32	15	13	700
Range	0-310	3.0-21.4	719-892	0.3-4.3	5-21	1.2-8.4	8.2-24.8	31-50	11-39	0.06-33	190-12,500
Median	114	8.5	820	1.9	15.5	5.2	10.4	35	31	5.6	970
Mean	140	9.9	812	2.2	13.4	4.9	11.7	36	27	9.8	1246

Table 4. Modular peat filter (using Minnesota Peat) effluent water quality, Nov 2002-Dec 2003, n=16 sample events. Total gallons treated Nov 22, 2002 – Dec 10, 2003 = 85,273 gallons septic tank effluent and total gallons treated from Aug 6, 1998 – Dec 10, 2003 = 381,833 gallons septic tank effluent NO3-N = [NO3-N]+ [NO2-N].

	Flow (gal/day)	T (ºC)	EC25 (uS/cm)	D.O. (mg/L)	BOD_5 (mg/L)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	NH4-N (mg/L)	NO3-N (mg/L)	Fecals (cfu/100 mL)
22-Nov-02	256										
13-Dec-02	240										
29-Jan-03	234	1.1	883	7.2	5	2.2	10.4	56	16	40	12700
19-Feb-03	247	0.7	871	6.1	9	2.4	12.5	51	22	30	8400
12-Mar-03	247	0.3	960	6.4	5	1.6	11.9	-	-	-	300
02-Apr-03	247	1.4	925	6.2	3	0.5	12.3	-	-	-	100
23-Apr-03	245	6.7	898	4.8	2	2.0	11.7	-	-	-	350
14-May-03	227	8.9	1032	4.6	12	0.5	13.5	81	19	58	160
04-Jun-03	200	14.1	947	2.1	7	3.2	14.7	80	8.4	59	2000
25-Jun-03	197	16.5	874	1.9	5	2.4	14.0	74	4.3	63	780
16-Jul-03	196	17.4	863	1.8	3	1.0	14.2	66	2.7	53	70
06-Aug-03	204	18.3	809	1.7	4	1.2	13.0	69	1.6	59	60
27-Aug-03	216	19.6	832	2.0	-	0.5	12.9	58	1.7	61	5
17-Sep-03	237	17.6	817	1.7	4	1.6	12.3	58	4.9	54	1180
08-Oct-03	247	13.4	842	2.4	4	3.2	12.0	63	6.5	57	-
30-Oct-03	125	10.1	941	2.0	27	8.8	13.0	75	21	52	10000
19-Nov-03	262	6.5	920	4.3	3	1.6	12.0	63	21	40	100
10-Dec-03	247	5.7	955	4.4	4	2.4	12.1	67	28	37	610
Range	125-262	0.7-19.6	809-1032	1.7-7.2	3-27	0.5-8.8	10.4-14.7	51-81	1.6-28	30-63	5-12700
Median	239	9.5	891	3.4	4.0	1.8	12.4	66	8.4	54	350
Mean	226	9.9	898	3.7	6.4	2.2	12.7	66	12	51	438

Table 5. Modular peat filter (using standard Irish peat) effluent water quality, Nov 2002-Dec 2003, n=16 sample events. Total gallons treated Nov 22, 2002 – Dec 10, 2003 = 94,390 gallons septic tank effluent and total gallons treated from Aug 6, 1998 – Dec 10, 2003 = 402,853 gallons septic tank effluent. NO3-N = [NO3-N]+ [NO2-N].

	Flow (gal/day)	T (ºC)	EC25 (uS/cm)	D.O. (mg/L)	BOD_5 (mg/L)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	NH4-N (mg/L)	NO3-N (mg/L)	Fecals (cfu/100 mL)
22-Nov-02	255										
13-Dec-02	250										
29-Jan-03	252	0.8	868	6.8	2	<1	10.8	49	4.5	45	670
19-Feb-03	250	0.5	883	6.6	2	<1	12.4	49	7.2	42	460
12-Mar-03	250	0.3	881	6.3	2	<1	11.4	-	-	-	250
02-Apr-03	252	1.6	869	6.5	2	1.2	12.0	-	-	-	160
23-Apr-03	251	5.6	828	4.7	2	1	11.9	-	-	-	10
14-May-03	252	9.8	866	6.6	2	<1	13.2	62	1.8	56	5
04-Jun-03	254	15.2	814	3.3	2	<1	13.6	61	0.10	54	5
25-Jun-03	252	16.6	846	3.1	2	<1	14.2	64	0.10	60	5
16-Jul-03	251	17.4	727	3.3	2	<1	14.4	57	0.10	52	5
06-Aug-03	250	19.0	751	3.9	2	<1	14.8	57	0.10	52	10
27-Aug-03	252	20.1	758	5.0	-	<1	12.2	49	0.10	52	5
17-Sep-03	252	18.1	783	3.5	2	<1	12.8	51	0.10	52	5
08-Oct-03	254	14.5	710	5.1	2	<1	12.5	51	0.35	53	5
30-Oct-03	127	9.9	902	6.0	2	<1	13.2	65	0.10	65	80
19-Nov-03	265	8.0	631	5.6	2	<1	12.0	54	0.65	56	5
10-Dec-03	251	5.9	858	5.4	2	<1	12.9		0.99	54	10
Range	127-265	0.5-20.1	631-902	3.1-6.8	2	<1-1.2	10.8-14.8	49-65	0.10-7.2	42-65	5-670
Median	252	9.9	837	5.2	2	0.5	12.7	54	0.12	53	10
Mean	246	10.2	811	5.1	2	0.6	12.8	56	0.12	53	20

Table 6. Sand filter (Rep # 1 –East) and treatment performance, Nov 2002-Dec 2003, n=16 sample events. Total gallons treated Nov 22, 2002 – Dec 10, 2003 = 71,925 gallons septic tank effluent and total gallons treated from Sept 27, 1996 – Dec 10, 2003 = 500,786 gallons septic tank effluent. NOTE- TN = combined sample from both replicate filters (East+West). NO3-N = [NO3-N]+ [NO2-N].

	Flow (g/day)	T (°C)	EC25 (uS/cm)	D.O. (mg/L)	BOD_5 (mg/L)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	NH4-N (mg/L)	NO3-N (mg/L)	Fecals (cfu/100 mL)
22-Nov-02	293										
13-Dec-02	273										
10-Jan-03	283										
24-Jan-03	307										
29-Jan-03	273	3.0	878	5.8	3	<1	7.4	67	6.8	65	230
19-Feb-03	254	2.5	972	5.5	2	<1	9.1	71	5.6	72	5
12-Mar-03	240	2.1	1008	7.9	2	<1	10.0	-	-	-	10
02-Apr-03	211	2.0	978	6.2	2	<1	9.5	-	-	-	80
23-Apr-03	171	4.6	955	4.3	6	2	9.1	-	-	-	2760
14-May-03	160	7.7	1051	4.7	3	<1	9.0	92	4.6	90	5
04-Jun-03	168	12.9	985	3.2	5	2	8.0	85	0.82	83	2400
25-Jun-03	159	15.1	901	3.4	3	5	7.2	80	5.9	74	340
16-Jul-03	188	16.0	909	5.1	4	2	6.9	79	6.8	74	110
06-Aug-03	28	19.8	1150	8.9	2	4	4.3	103	0.34	106	220
27-Aug-03	153	18.5	1126	5.1	-	4	4.2	100	0.28	99	5
17-Sep-03	147	17.2	869	3.5	2	<1	4.8	72	0.10	72	5
08-Oct-03	180	14.4	840	6.2	2	<1	5.3	69	0.10	65	5
30-Oct-03	158	11.9	839	5.0	2	5	5.8	67	0.14	64	5
19-Nov-03	169	8.6	800	4.8	2	<1	5.4	64	2.2	57	5
10-Dec-03	160	6.2	904	7.1	2	<1	6.1	66	2.0	69	5
Range	28-307	2.0-19.8	800-1150	3.2-7.1	2-6	<1-5	4.2-10.0	64-103	0.10-6.8	64-106	5-2760
Median	171	10.3	932	5.1	2	<1	7.1	72	2.0	72	7.5
Mean	193	10.2	948	5.4	2.5	1.8	7.0	78	2.7	76	34

Table 7. Sand filter (Rep # 2 –West) effluent water quality, Nov 2002-Dec 2003, n=16 sample events. Total gallons treated Nov 22, 2002 – Dec 10, 2003 = 74,110 gallons septic tank effluent and total gallons treated from Sept 27, 1996 – Dec 10, 2003 = 579,753 gallons septic tank effluent. NOTE- TN = combined sample from both replicate filters (East+West). NO3-N = [NO3-N]+ [NO2-N].

	Flow (gal/day)	T (°C)	EC25 (uS/cm)	D.O. (mg/L)	BOD_5 (mg/L)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	NH4-N (mg/L)	NO3-N (mg/L)	Fecals (cfu/100 mL)
22-Nov-02	265										
13-Dec-02	263										
10-Jan-03	250										
24-Jan-03	227										
29-Jan-03	231	2.7	809	7.1	3	<1	6.0	67	0.88	61	90
19-Feb-03	211	2.3	871	5.7	2	<1	7.2	71	3.4	60	2100
12-Mar-03	201	2.0	850	7.7	2	<1	7.3	-	-	-	20
02-Apr-03	196	3.2	825	6.5	4	<1	7.7	-	-	-	5
23-Apr-03	186	5.4	927	4.8	2	1	8.1	-	-	-	20
14-May-03	190	8.6	943	3.6	2	<1	8.4	92	2.2	81	5
04-Jun-03	186	14.9	981	2.9	2	<1	7.7	85	0.50	83	100
25-Jun-03	182	15.0	882	2.7	2	1.2	7.2	80	2.8	73	150
16-Jul-03	189	16.4	863	5.8	2	<1	7.2	79	3.4	71	30
06-Aug-03	26	19.6	1008	6.5	2	<1	4.3	103	0.11	91	10
27-Aug-03	190	18.7	1048	5.9	-	<1	5.4	100	0.20	93	10
17-Sep-03	188	17.5	867	3.7	2	<1	5.5	72	0.10	71	5
08-Oct-03	221	14.2	919	4.3	2	<1	6.0	69	0.40	77	5
30-Oct-03	193	12.1	927	4.5	2	<1	6.9	67	0.11	74	5
19-Nov-03	215	8.6	900	5.5	2	<1	7.2	64	0.66	69	20
10-Dec-03	203	6.7	874	7.6	2	<1	7.5	66	0.92	64	90
Range	26-265	2.0-19.6	809-1048	2.7-7.7	2-4	<1-1.2	4.3-8.4	64-103	0.1-3.4	60-93	5-2100
Median	196	10.4	891	5.6	2	<1	7.2	72	0.66	73	20
Mean	196	10.5	906	5.3	2	<1	6.9	78	1.2	74	25

Table 8. Subsurface flow constructed wetland (Rep # 1, both cells) effluent water quality, Nov 2002-Dec 2003, n= 10 sample events. NO3-N = [NO3-N]+ [NO2-N].

	Flow (gal/day)	T (ºC)	EC25 (uS/cm)	D.O. (mg/L)	BOD_5 (mg/L)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	NH4-N (mg/L)	NO3-N (mg/L)	Fecals (cfu/100 mL)
22-Nov-02											
13-Dec-02											
10-Jan-03											
24-Jan-03											
29-Jan-03	Frozen										
19-Feb-03	Frozen										
12-Mar-03	Frozen										
02-Apr-03	Frozen										
23-Apr-03	Frozen										
14-May-03	Thawed										
04-Jun-03	236	6.7	1197	0.03	106	2.4	11.4	59	61	<0.01	4000
25-Jun-03	179	14.5	1331	0.06	76	4.4	14.8	72	68	<0.01	4900
16-Jul-03	216	14.3	1210	2.35	N/S	N/S	14.8	76	70	<0.01	210
06-Aug-03	201	16.9	1241	1.16	16	1.6	11.9	80	73	<0.01	180
27-Aug-03	219	17.8	1291	0.09	N/S	<1	11.5	75	76	<0.01	260
17-Sep-03	182	14.0	1241	0.38	16	1.6	11.6	73	72	<0.01	810
08-Oct-03	0*	17.3	1077	0.32	14	<1	10.3	63	63	<0.01	<10
30-Oct-03	93	8.8	1181	0.36	16	1.2	10	65	65	<0.01	330
19-Nov-03	204	5.6	1168	0.46	27	10	10.4	-	64	<0.01	3600
10-Dec-03	190	3.2	1307	0.81	20	4.4	13.6	72	75	<0.01	800
Range	93-236	0-17.8	1077-1331	0.03-2.3	14-106	<1-10	10-15	59-80	61-76	<0.01	<10-4900
Median	196	14.2	1226	0.37	18	2.4	11.6	72	69	<0.01	800
Mean	172	11.9	1224	0.6	36.4	3.7	12.0	71	69	<0.01	1677

* 10/08/03 No flow-timers/pumps off

Table 9. Subsurface flow constructed wetland (Rep # 2, both cells) effluent water quality, Nov 2002-Dec 2003, n= 10 sample events. NO3-N = [NO3-N]+ [NO2-N].

	Flow (gal/day)	T (ºC)	EC25 (uS/cm)	D.O. (mg/L)	BOD_5 (mg/L)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	NH4-N (mg/L)	NO3-N (mg/L)	Fecals (cfu/100 mL)
22-Nov-02											
13-Dec-02											
10-Jan-03											
24-Jan-03											
29-Jan-03	Frozen										
19-Feb-03	Frozen										
12-Mar-03	Frozen										
02-Apr-03	Frozen										
23-Apr-03	Frozen										
14-May-03	Thawed										
04-Jun-03	209	9.1	1079	0.06	106	4	11.4	48	47	<0.01	1200
25-Jun-03	212	14.0	1296	0.04	78	8.8	16.8	67	64	<0.01	1500
16-Jul-03	194	13.9	1234	2.32	26	2	15.5	76	70	<0.01	140
06-Aug-03	179	N/D	1242	1.20	16	1.6	12.4	77	70	<0.01	130
27-Aug-03	179	18.0	1274	0.07	N/S	1.2	12.2	69	69	<0.01	120
17-Sep-03	151	14.8	1258	0.35	14	2.2	11.6	69	72	<0.01	170
08-Oct-03	0*	15.0	1079	0.20	12	<1	10.8	61	62	<0.01	<10
30-Oct-03	102	9.0	1169	0.35	16	2	9.9	65	64	0.03	2000
19-Nov-03	185	5.7	1173	0.43	29	11.8	10.8	65	65	<0.01	3100
10-Dec-03	161	3.3	1288	0.74	18	3.8	14	73	73	0.04	2290
Range	102-212	3.3-18.0	1079-1296	0.04-2.3	12-106	0.5-12	10-17	48-77	47-73	<0.01-0.04	5-3100
Median	179	13.9	1238	0.35	18	2	11.9	68	67	<0.01	1200
Mean	157	11.4	1210	0.58	35	4	12.5	67	66	<0.01	1183

*10/08/03 No flow-timers/pumps off

Table 10. Textile filter (single unit) effluent water quality, Nov 2002 -Dec 2003, N=14 sample events. Total gallons treated Nov 22, 2002 – Dec 10, 2003 = 70,000 gallons septic tank effluent and total gallons treated from June 29, 1999 – Dec 10, 2003 = 263,356 gallons septic tank effluent. NO3-N = [NO3-N]+ [NO2-N].

	Flow (gal/day)	Temp (°C)	EC25 (uS/cm)	D.O. (mg/L)	BOD_5 (mg/L)	TSS (mg/L)	TP (mg/L)	TN (mg/L)	NH4-N (mg/L)	NO3-N (mg/L)	Fecal s (cfu/100 mL)
22-Nov-02	346										
13-Dec-02	278										
10-Jan-03	366										
24-Jan-03	227										
29-Jan-03	212	3.7	1153	7.6	24	27	10.7	69	70	0.55	160
19-Feb-03	221	3.5	1167	6.2	16	10	11.3	66	66	0.66	610
12-Mar-03	82	3.9	1144	7.6	5	1	10.2	-	-	-	740
14-May-03	264	10.2	988	6.5	9	9	14.2	70	42	28	830
04-Jun-03	244	17.0	886	4.4	5	2	15.4	78	0.97	71	1450
25-Jun-03	268	18.4	874	2.9	2	<1	15.4	66	1.2	60	170
16-Jul-03	255	18.9	855	3.6	2	<1	13.0	73	1.8	65	150
06-Aug-03	277	20.4	787	3.6	2	<1	11.6	72	0.47	62	10
27-Aug-03	234	20.5	785	3.3	-	<1	12.0	59	0.12	56	50
17-Sep-03	272	18.9	838	3.9	3	<1	13.0	60	0.27	57	10
08-Oct-03	201	15.5	816	4.4	2	<1	12.2	63	0.10	57	20
30-Oct-03	250	10.0	855	4.6	2	<1	14.6	63	0.10	57	5
19-Nov-03	218	8.0	774	6.5	12	47	12.0	42	0.23	41	500
10-Dec-03	346	5.0	902	7.1	2	<1	13.0	65	0.26	59	20
Range	82-366	3.5-20.5	774-1167	2.9-7.6	2-24	<1-47	10.2-15.4	42-78	0.10-70	0.55-71	5-1450
Median	250	12.9	865	4.5	3.0	<1	12.6	66	0.47	57	155
Mean	248	12.4	916	5.2	6.4	7.1	12.8	65	14	47	101

Table 11. Average annual % removal rates for 9 onsite wastewater treatment systems tested in 2003 at the Northeast Regional Correction Center. N =16 sampling events Jan-Dec 2003; except N = 10 for the constructed wetlands which froze at the end of January 2003 and thawed in May 2003. Average percent removal based on: ((inflow conc.- outflow conc.)/inflow conc.) x 100 = % removed. ( ) indicates number of systems tested.

Onsite System	Flow (gal/day)	BOD_5	TSS	TP	TN	Fecal Coliform Bacteria
Sand Filters (2) (single pass, in-ground)	193 196	99 99	96 99	48 50	41 41	99.8 99.9
Peat Filters (2) (single-pass, in-ground)	207 140	96 94	94 88	12 13	55 55	98.9 98.8
Peat Filters (single-pass, modular) (1) *Irish peat* (1) *Minnesota peat*	246 226	99 97	99 95	6 7	31 19	99.9 98.4
Constructed wetlands (2) (subsurface flow, 2-cells)	172 157	83 83	95 93	13 9	15 20	96.0 99.1
Textile Filter (1 unit) (recirculating RX-30)	248	97	84	7	21	99.8

Table 12. Performance (all years) of NERCC in-ground, single-pass peat filters, 3/96-9/01 and 1/03-12/03.

NERCC Peat Filters

	WINTER (Nov. - Apr.)			SUMMER (May - Oct)		
Parameter	Inflow[1]	Outflow[2]	% - Removal[3]	Inflow[1]	Outflow[2]	% - Removal[3]
Q (gal/d)	185			191		
BOD_5 (mg/L)	269 (64)	10.5 (14.1)	96	221 (84.4)	7.5 (11.4)	96
TSS (mg/L)	43 (13)	2.6 (2.9)	93	48 (17.2)	2.3 (2.2)	94
TP (mg/L)	13.4 (2.9)	8.8 (3.9)	32	13.0 (3.7)	9.6 (4.8)	22
TN (mg/L)	84.1 (18)	48.2 (27.8)	43	77.1 (19.7)	51.7 (22.0)	33.6
NH_4-N (mg/L)	75.8 (14.8)	14.1 (7.8)	80	69.3 (18.2)	19.5 (11.6)	70
NO_3-N (mg/L)	0.03 (0.02)	34.8 (34.1)	Nitrification	0.15 (0.69)	32.1 (27.4)	Nitrification
fecal coliforms[3]	$3.7x10^5$	522	99.86	$2.0x10^5$	194	99.90

N=57 winter, N=50 summer;
[1]average during the seasonal period (Standard Deviation);
[2] mean percent removal based on: ((inflow-outflow)/inflow) x 100 = %
[3]geometric mean colony-forming units (cfu) per 100mL

Table 13. Performance (all years) of NERCC in-ground, single-pass sand filters, 3/96-9/01 and 1/03-12/03.

	NERCC Sand filters (East and West)					
	WINTER (Nov. - Apr.)			SUMMER (May - Oct.)		
Parameter	Inflow[1]	Outflow2	% - Removal[3]	Inflow[1]	Outflow[2]	% - Removal[3]
Q (gal/d)	262			246		
BOD_5 (mg/L)	261 (57)	11.7 (20.9)	96	243 (77.6)	7.5 (13.6)	97
TSS (mg/L)	44 (13)	5.0 (7.9)	88	48 (18.5)	3.7 (5.5)	92
TP (mg/L)	13.7 (2.6)	7.8 (2.6)	42	13.3 (3.3)	6.6 (3.0)	48
TN (mg/L)	83.9 (16.5)	69.6 (18.7)	16	82.1 (15.3)	69.1 (22.4)	13
NH_4-N (mg/L)	76.1 (13.9)	13.4 (13.9)	82	73.8 (14.0)	7.5 (13.2)	90
NO_3-N (mg/L)	0.03 (0.03)	56.5 (27.6)	Nitrification	0.14 (0.68)	63.0 (24.3)	Nitrification
fecal coliforms[3]	$2.8x10^5$	217	99.92	$2.5x10^5$	68	99.97

N=50 winter, N=46 summer

[1]average during the seasonal period (Standard Deviation)

[2] mean percent removal based on: ([inflow-outflow]/inflow) x 100 = % removed

[3]geometric mean colony-forming units (cfu) per 100mL

Table 14. Performance (all years) of NERCC constructed wetlands, 3/96-9/01 and 6/03-12/03.

NERCC constructed wetlands (cells 1 and 2)

	WINTER (Nov. - Apr.)			SUMMER (May - Oct.)		
Parameter	Inflow[1]	Outflow[1]	% - Removal[2]	Inflow[1]	Outflow[1]	% - Removal[2]
Q (gal/d)	207			216		
BOD_5 (mg/L)	268 (57)	55.2 (41.9)	79	230 (91)	22.8 (18.1)	88.2
TSS (mg/L)	44 (13)	9.1 (4.6)	76	48 (19)	7.7 (6.3)	81.7
TP (mg/L)	13.7 (2.6)	9.9 (3.3)	25	13.4 (3.3)	8.8 (5.0)	36
TN (mg/L)	86 (13)	64.2 (16.1)	24	81.4 (14.3)	52.4 (21.3)	34
NH_4-N (mg/L)	77.1 (12)	59.9 (16.4)	22	74(14)	53.2 (21.2)	29
NO_3-N (mg/L)	0.03 (0.02)	0.48 (2.1)	nitrification	0.13 (0.63)	0.22 (0.33)	nitrification
fecal coliforms[3]	4.0×10^5	6487	98.3	2.3×10^5	369	99.8

N=50 winter, N=46 summer

[1]average during the seasonal period (" Standard Deviation)

[2] mean percent removal based on: ((inflow-outflow)/inflow) x 100 = % removed

[3]geometric mean colony-forming units (cfu) per 100mL

Table 15A. Performance (all years) of modular peat filter (using Minnesota Peat), 7/98-5/01 and 1/03-12/03. There was no flow from 6/99-8/99 due to ponding.

NERCC modular peat filter using Minnesota Peat (MSI)

	Winter (Nov. - Apr.)			Summer (May - Oct.)		
Parameter	Inflow[1]	Outflow[1]	% - Removal[2]	Inflow[1]	Outflow[1]	% - Removal[2]
Q (gal/d)	289			211		
BOD_5 (mg/L)	265 (75.1)	11.8 (13.4)	90	225 (76.1)	11.7 (22.9)	92
TSS (mg/L)	44.1 (15.2)	4.4 (3.5)	84	52.1 (17.8)	3.4 (2.5)	92
TP (mg/L)	14.0 (3.4)	11.9 (3.0)	13	14.3 (3.4)	12.4 (2.5)	5
TN (mg/L)	80.9 (24.8)	54.8 (20.7)	32	75.1 (27.9)	48.2 (27.4)	25
NH_4-N (mg/L)	74.2 (21.1)	20.5 (26.9)	76	65.9 (28.0)	10.7 (21.3)	84
NO_3-N (mg/L)	0.03 (0.03)	36.4 (17.9)	nitrification	0.18 (0.76)	36.1 (23.5)	nitrification
fecal coliforms[3]	$3.5x10^5$	2468	99.3	$2.4x10^5$	396	99.8
EC25 (umhos)	1128 (322)	749 (285)		1136 (299)	662 (309)	
Temp. (°C)	12.5 (1.6)	3.9 (2.6)		17.3 (4.3)	13.4 (6.0)	
pH	7.3 (0.1)	6.4 (0.7)		7.2 (0.1)	4.1 (2.9)	
DO (mg/L)	0.4 (0.4)	4.6 (3.1)		0.3 (0.5)	2.6 (2.5)	

N=30 winter, N=28 summer
[1]average during the seasonal period (Standard Deviation);
[2] mean percent removal based on: ((inflow-outflow)/inflow) x 100 = % removed;
[3]geometric mean colony-forming units (cfu) per 100mL.

Table 15B. Performance (all years) of NERCC modular peat filter (using Irish Peat), 7/98-5/01 and 1/03-12/03.

	NERCC modular peat filter using Irish Peat					
	Winter (Nov. - Apr.)			Summer (May - Oct.)		
Parameter	Inflow[1]	Outflow[1]	% - Removal[2]	Inflow[1]	Outflow[1]	% - Removal[2]
Q (gal/d)	287			223		
BOD_5 (mg/L)	265 (75.1)	6.6 (7.7)	94	225 (76.1)	6.1 (11.1)	94
TSS (mg/L)	44.1 (15.2)	3.7 (4.6)	88	52.1 (17.8)	2.1 (2.7)	96
TP (mg/L)	14.0 (3.4)	12.4 (3.2)	10	14.3 (3.4)	14.0 (3.7)	0
TN (mg/L)	80.9 (24.8)	52.6 (16.4)	34	75.1 (27.9)	55.9 (17.8)	28
NH_4-N (mg/L)	74.2 (21.1)	15.8 (17.5)	79	65.9 (28.0)	2.6 (5.2)	96
NO_3-N (mg/L)	0.03 (0.03)	37.2 (16.8)	nitrification	0.18 (0.76)	52.9 (17.8)	nitrification
fecal coliforms[3]	$3.5x10^5$	531	99.8	$2.4x10^5$	28	99.99
EC25 (umhos)	1128 (322)	748 (216)		1136 (299)	759 (170)	
Temp. (°C)	12.5 (1.6)	4.1 (2.6)		17.3 (4.3)	16.1 (3.6)	
pH	7.3 (0.1)	6.4 (0.4)		7.2 (0.1)	5.9 (0.6)	
DO (mg/L)	0.4 (0.4)	4.8 (3.0)		0.3 (0.5)	3.1 (2.6)	

N=30 winter, N=34 summer
[1]average during the seasonal period (Standard Deviation);
[2] mean percent removal based on: ((inflow-outflow)/inflow) x 100 = % removed;
[3]geometric mean colony-forming units (cfu) per 100mL.

Table 16. Performance (all years) of NERCC textile filter, 7/99-5/01 and 1/03-12/0. The system was inactive from 12/22/99-5/17/00. Note- there is data for the performance of this system coupled to a polishing sand filter that received its effluent but there were problems with the sand filter. Therefore, we did not include those data here. A polishing sand filter would be expected to further improve BOD5, TSS and fecal coliform removal, and further convert effluent NH4-N to NO3-N via nitrification as long as the filter remains aerobic. Additional removal of TN and TP would occur but the improve would be relatively small.

NERCC textile filter

	Winter (Nov. - Apr.)			Summer (May - Oct.)		
Parameter	Inflow[1]	Outflow[1]	% - Removal[2]	Inflow[1]	Outflow[1]	% - Removal[2]
Q (gal/d)	234			254		
BOD_5 (mg/L)	239 (41.8)	7.5 (6.7)	97	212 (67.1)	6.6 (8.9)	98
TSS (mg/L)	39.6 (9.8)	7.5 (12.9)	82	49 (18.4)	4.3 (5.1)	92
TP (mg/L)	14.2 (2.5)	11.6 (1.6)	16	13.4 (3.3)	12.0 (3.0)	3
TN (mg/L)	65.2 (23.3)	51.1 (23.7)	20	69.9 (25.3)	57.9 (18.6)	21
NH_4-N (mg/L)	67.1 (11.6)	14.7 (22.2)	78	63.8 (23.3)	6.2 (9.6)	92
NO_3-N (mg/L)	0.04 (0.03)	28.7 (20)	nitrification	0.26 (0.92)	50.4 (16.3)	nitrification
fecal coliforms[3]	1.9×10^5	568	99.7	1.9×10^5	170	99.91
EC25 (umhos)	1108 (163)	783 (315)		1117 (241)	752 (127)	
Temp. (°C)	12.4 (1.8)	5.4 (3.2)		17.2 (3.2)	16.4 (3.7)	
pH						
DO (mg/L)	0.5 (0.4)	5.7 (2.5)		0.3 (0.6)	3.5 (1.8)	

N= 15 winter, N=24 summer
[1]average during the seasonal period (Standard Deviation);
[2] mean percent removal based on: ((inflow-outflow)/inflow) x 100 = % removed;
[3]geometric mean colony-forming units (cfu) per 100mL.

Table 17 . Summary of Fecal coliform concentrations in NERCC alternative system effluents from all years. Mean annual flows (averaged from winter and summer means, in gal/d): Peat (in-ground) = 188; Sand (in-ground) = 254; Constructed Wetlands = 211 ; Peat (modular-Irish) = 255 ; Peat (modular-MN) = 250; Textile = 244. Note that there is no regulatory standard for fecal coliform concentrations because effluents are dispersed subsurface, not into surface waters (see text). No systems were operated in 2002. In-ground peat filters converted from gravity dosing to pressure dosing in November 1997.

		SUMMER				WINTER			
SYSTEM	YEARS (not 2002)	#	<2500 cfus	<1000 cfus	<200 cfus	#	<2500 cfus	<1000 cfus	<200 cfus
Peat Filter (in-ground)	1995-2003	108	97%	90%	84%	96	92%	88%	81%
Sand Filter (in-ground)	1996-2003	133	88%	84%	74%	121	78%	66%	40%
Textile Filter (re-circ)	1999-2003	23	95%	73%	56%	15	89%	82%	13%
Peat Filters (modular) - Irish	1998-2003	29	100%	97%	90%	31	71%	61%	35%
Peat Filters (modular) -MN	1998-2003	26	80%	69%	42%	29	48%	41%	7%
Constructed Wetlands	1996-2003	116	84%	70%	45%	82	35%	20%	7%

Table 18. Summary of freezing problems, frost protection methods, and snowfall at NERCC during 8 winters of operation from 1995-2004.

Winter	**Snowfall (Inches)**	**Peat (in-ground)**	**Peat (modular)**	**Sand (single pass)**	**Textile (recirculating)**	**Wetland**	**Drip (4 depths)**
1995-96		No problems *Straw used*	Not constructed	Not constructed	Not constructed	No problems *Straw used*	Not constructed
1996-97	135 >12" early snow	No problems *Straw used*	Not constructed	No problems *Straw used*	Not constructed	No problems *Straw used*	No problems *Straw used*
1997-98	130 >12" early snow	No problems	Not constructed	Freezing (human error) *Ends exposed, not covered*	Not constructed	No problems *Straw used*	No problems *Tall grass no straw added*
1998-99	80 0-7" snow cover	No problems *But supply line froze*	Near freezing *Uninsulated lids*	No problems *Wood chips added*	Not constructed	No problems *Straw used*	Freezing *6" drip froze No straw Mowed grass*
1999-00	90 0-6" snow cover	No problems	No problems *Insulated lid & straw*	No problems *Wood chips from 1998*	No problems, *but… drain line froze trenches froze*	Freezing *No straw used*	Freezing *6" drip froze No straw Mowed grass*
2000-01	58 6-34" snow cover	No problems	No problems *Insulated lids*	No problems *Wood chips from1998*	No problems *Straw on shallow trenches*	No problems *6" peat added*	No problems *New hydraulic unit tall grass*
2001-02	86	All systems off ~12 months					
2002-03	56 0-2" snow cover	No problems *Dense grass*	No problems *Insulated lids*	No problems *Wood chips from 1998*	No problems *but.. drain line froze trenches froze*	Freezing *Started up late Nov 2002*	Not operated
2003-04 through Dec '03	32 2-6" snow cover	*Dense grass*	*Insulated lids*	*Wood chips from1998*	No problems	No problems	Not operated

Figure 1. Plan view of the NERCC Alternative Septics Demonstration/Research Facility.

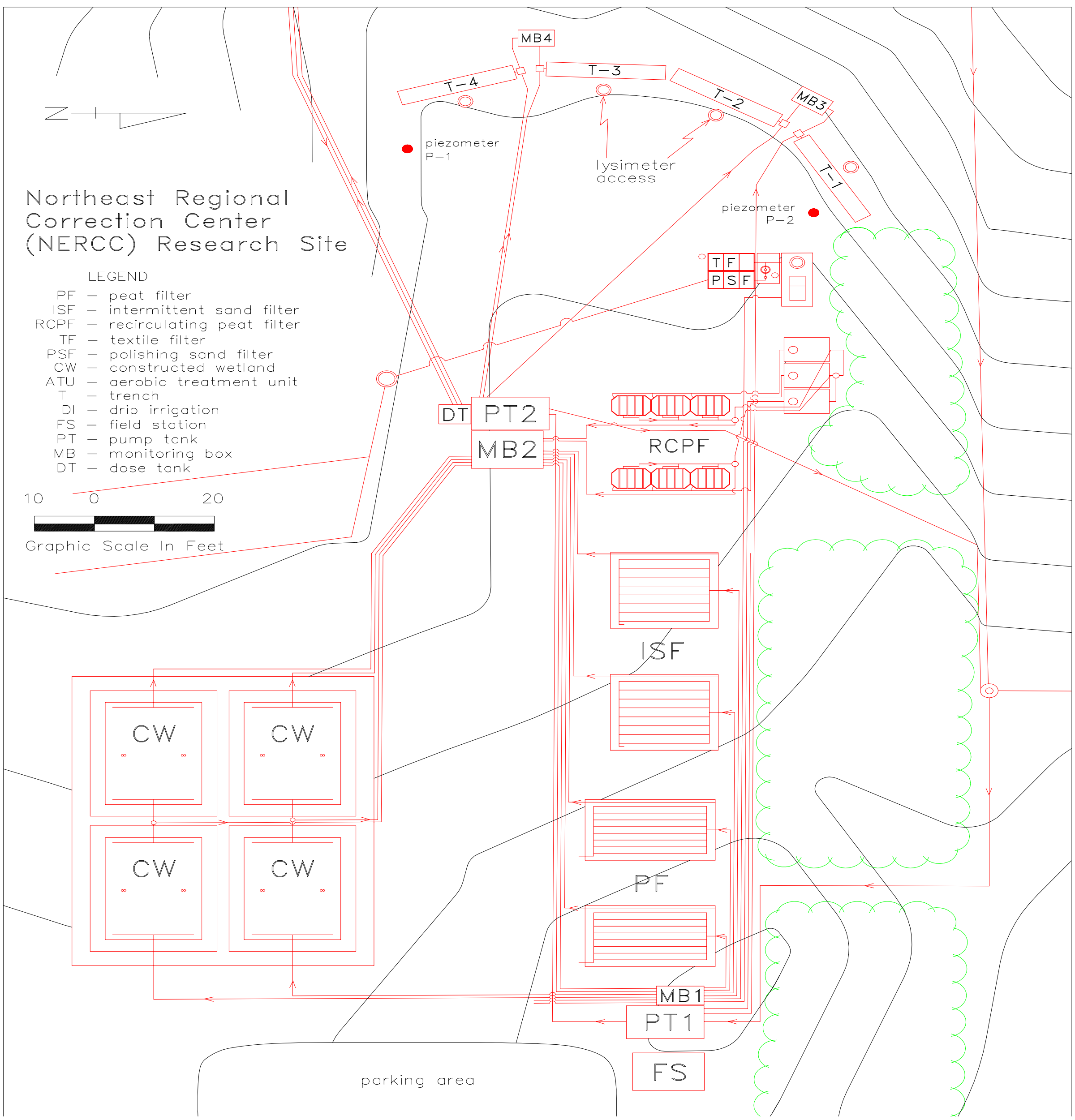


Figure 2. Schematic of the in-ground, single pass peat filters.

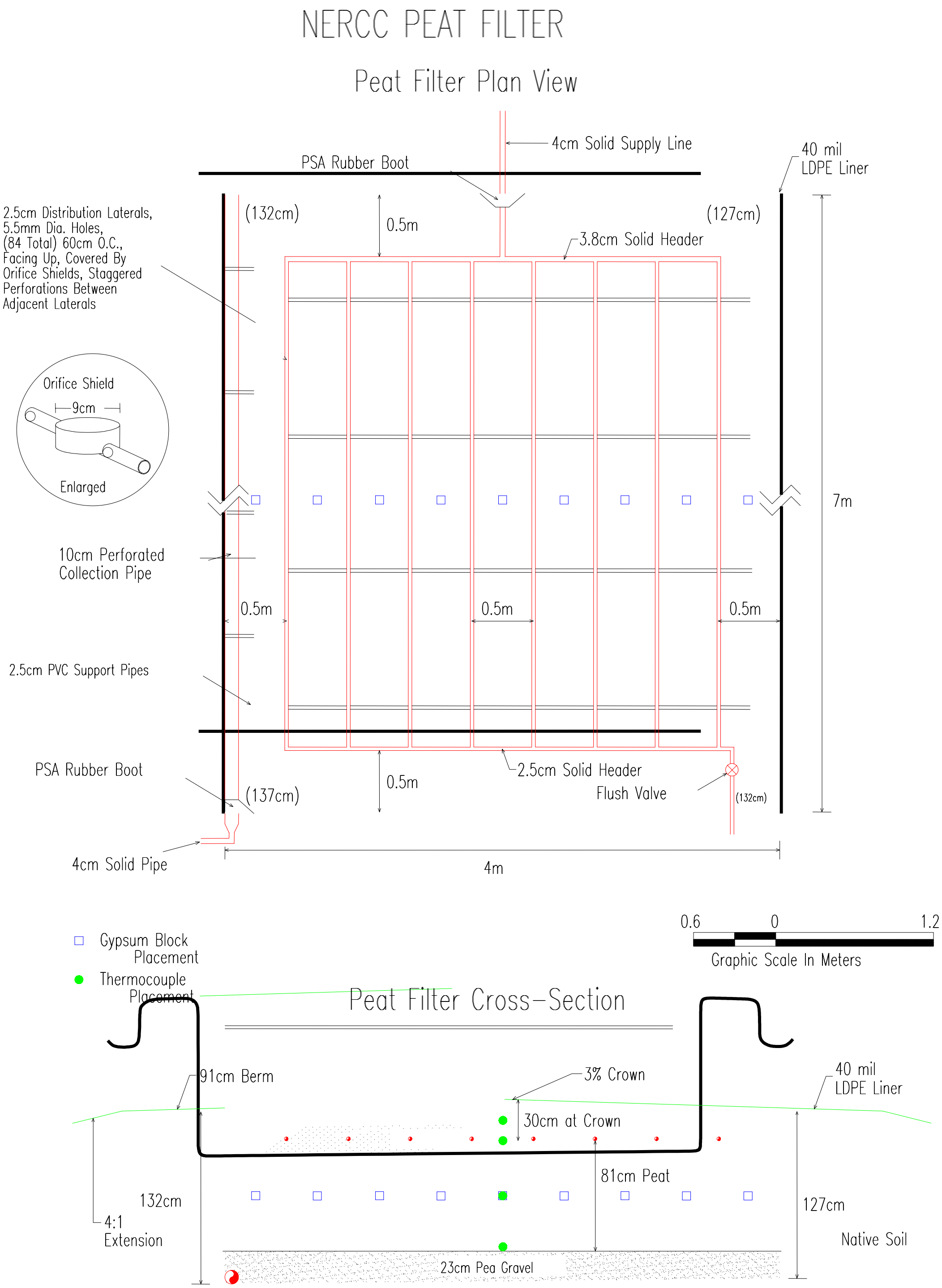


Figure 3. Schematic of the modular peat filters.

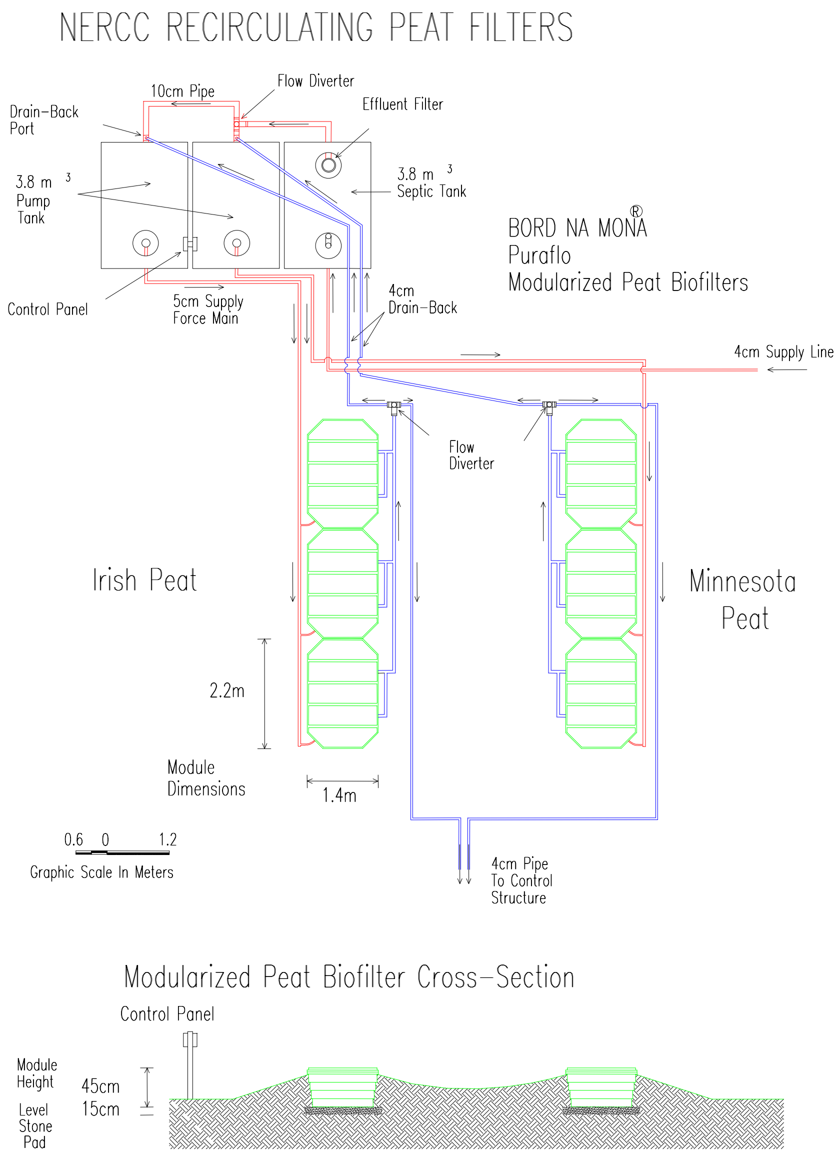


Figure 4. Schematic of the in-ground single pass sand filters.

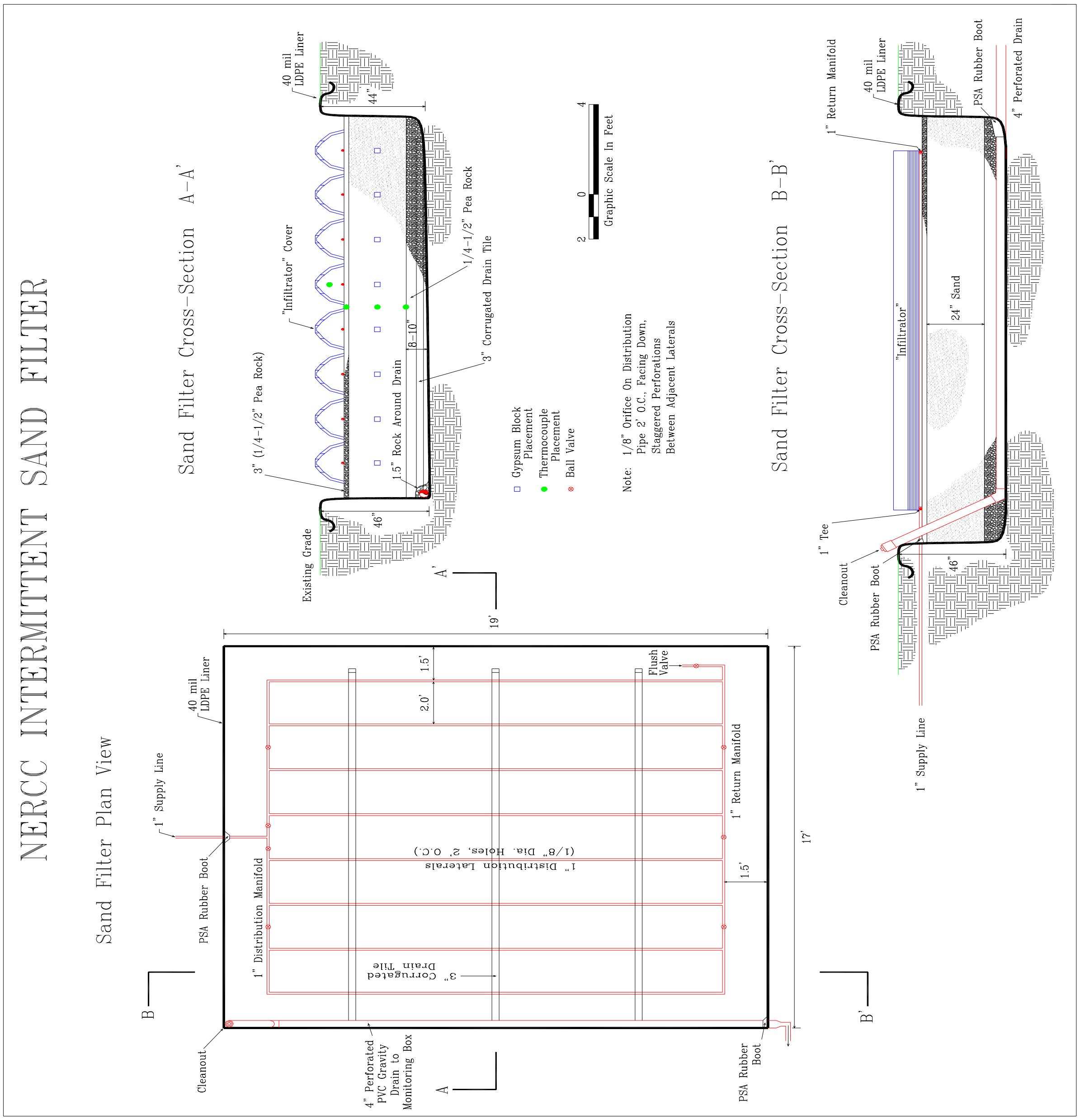


Figure 5. Schematic of the subsurface flow constructed wetlands.

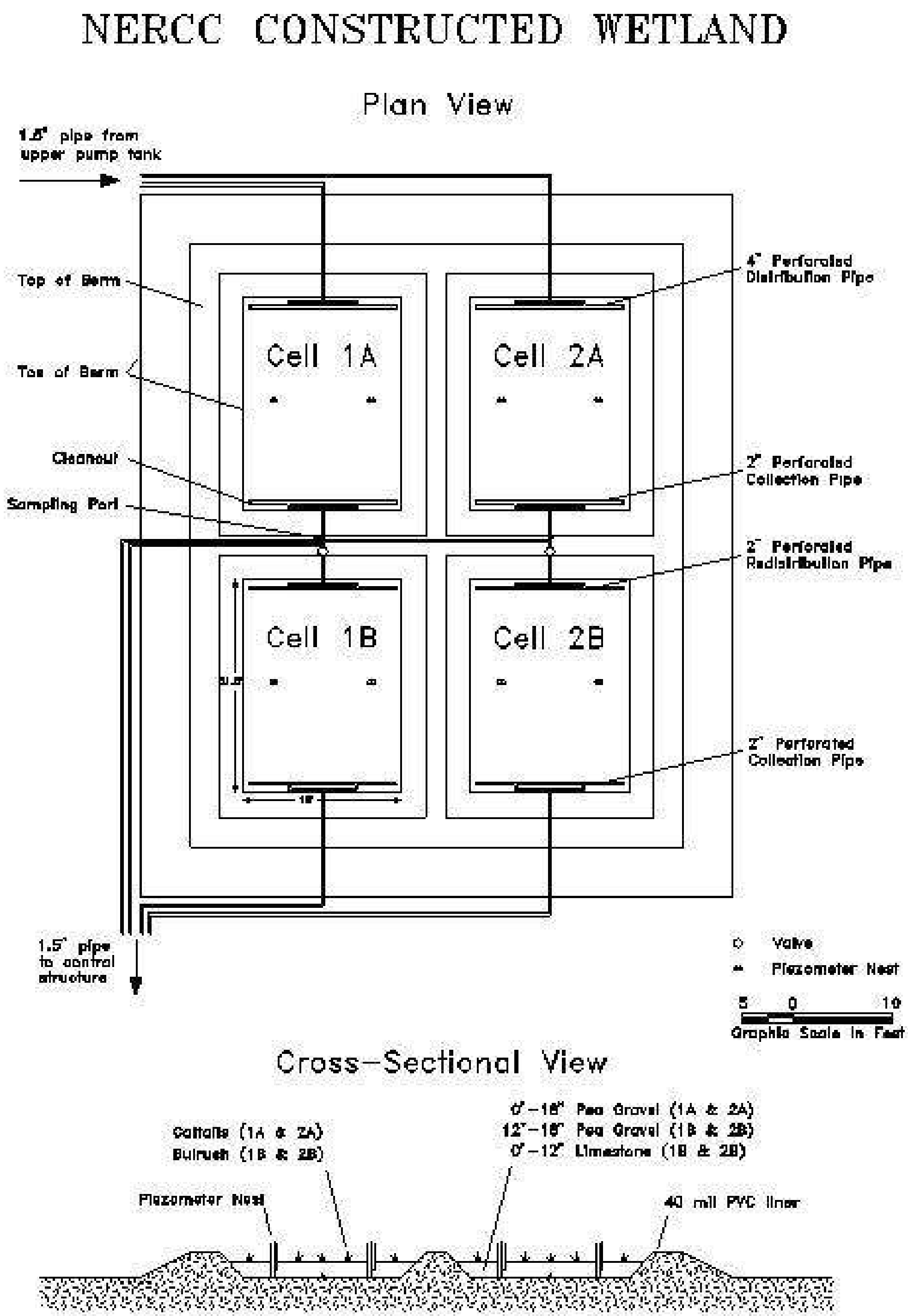


Figure 6. Schematic of the recirculating textile filter system.

Figure 7. Image of in-ground peat filter with an exposed pressure distribution network.

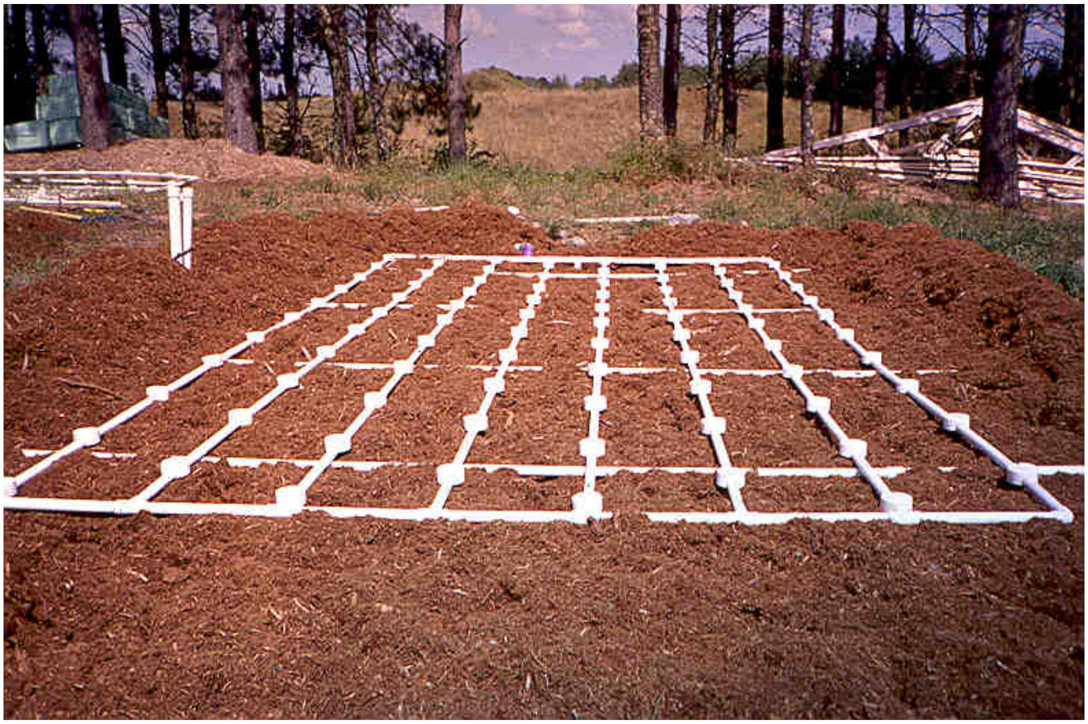


Figure 8. Image of the completed in-ground peat filters.

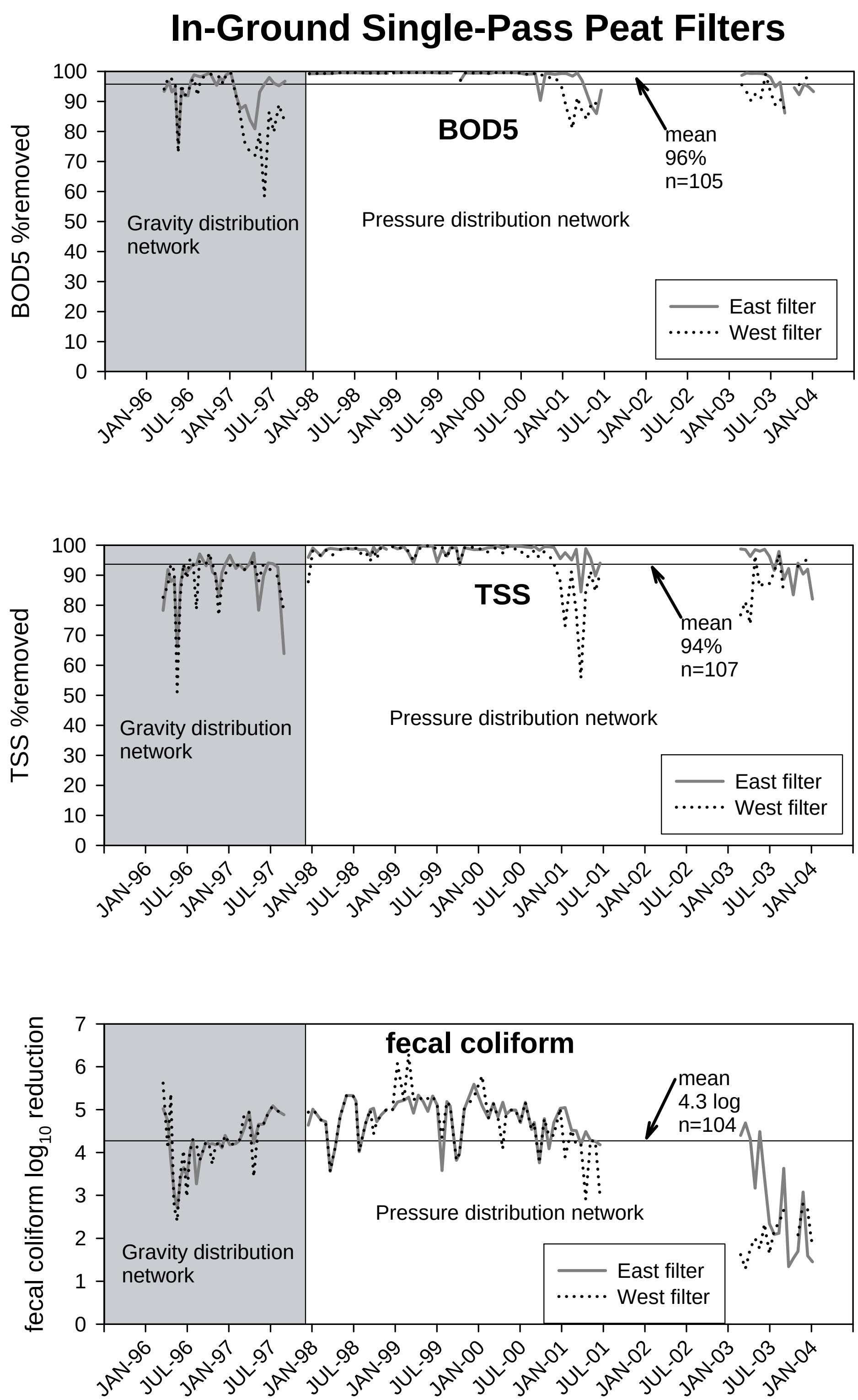
Figure 9. Image of the sand filter showing the pressure distribution network.

Figure 10. Image of the sand filter chamber covers over the distribution network.

Figure 11. Image of the finished sand filters with the wood chip layer.

Figure 12. In-ground, single pass peat filter removal efficiency, 1996-2003

A. BOD5, TSS and fecal coliform bacteria



B. TP, TN, and NH4-N

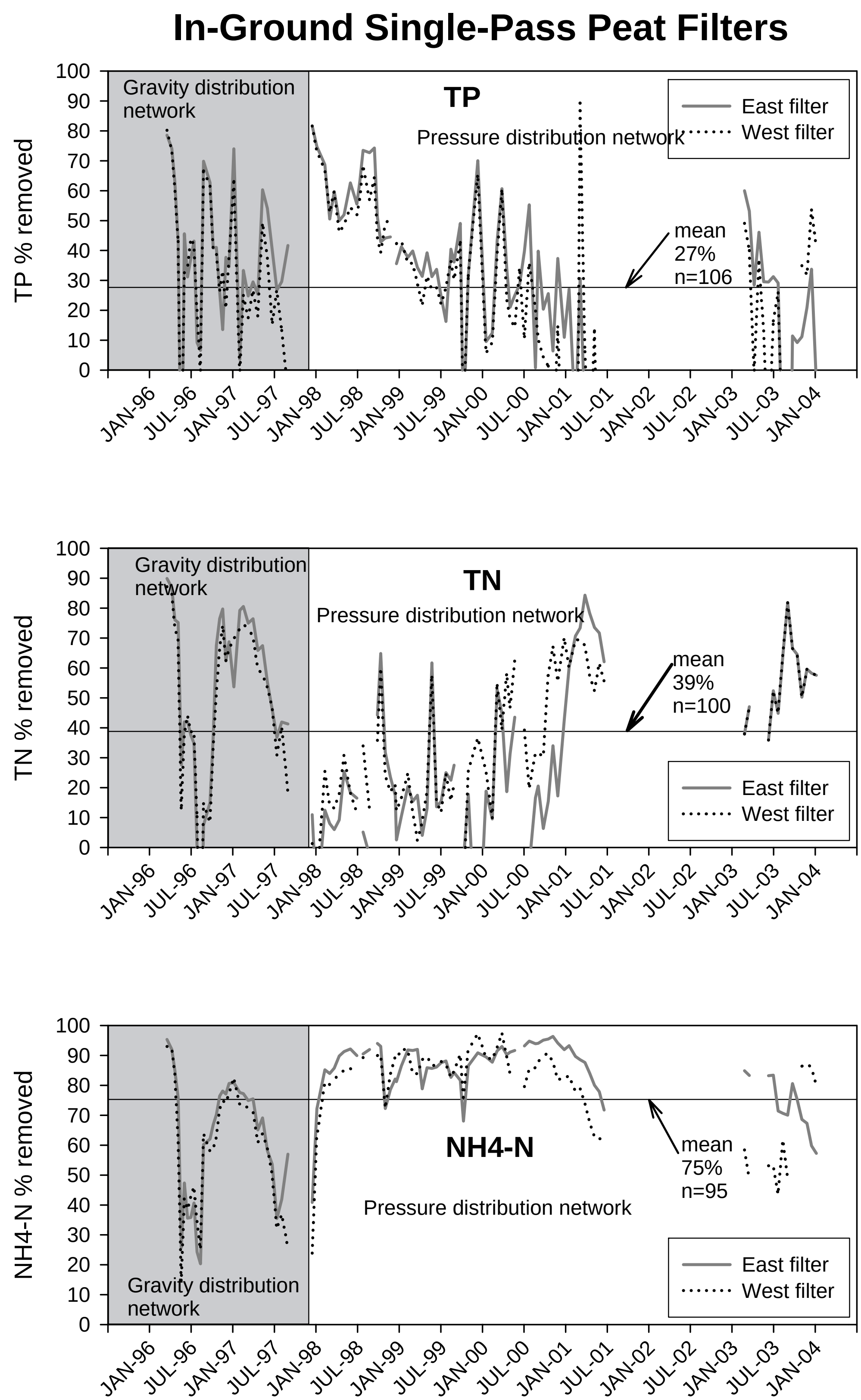
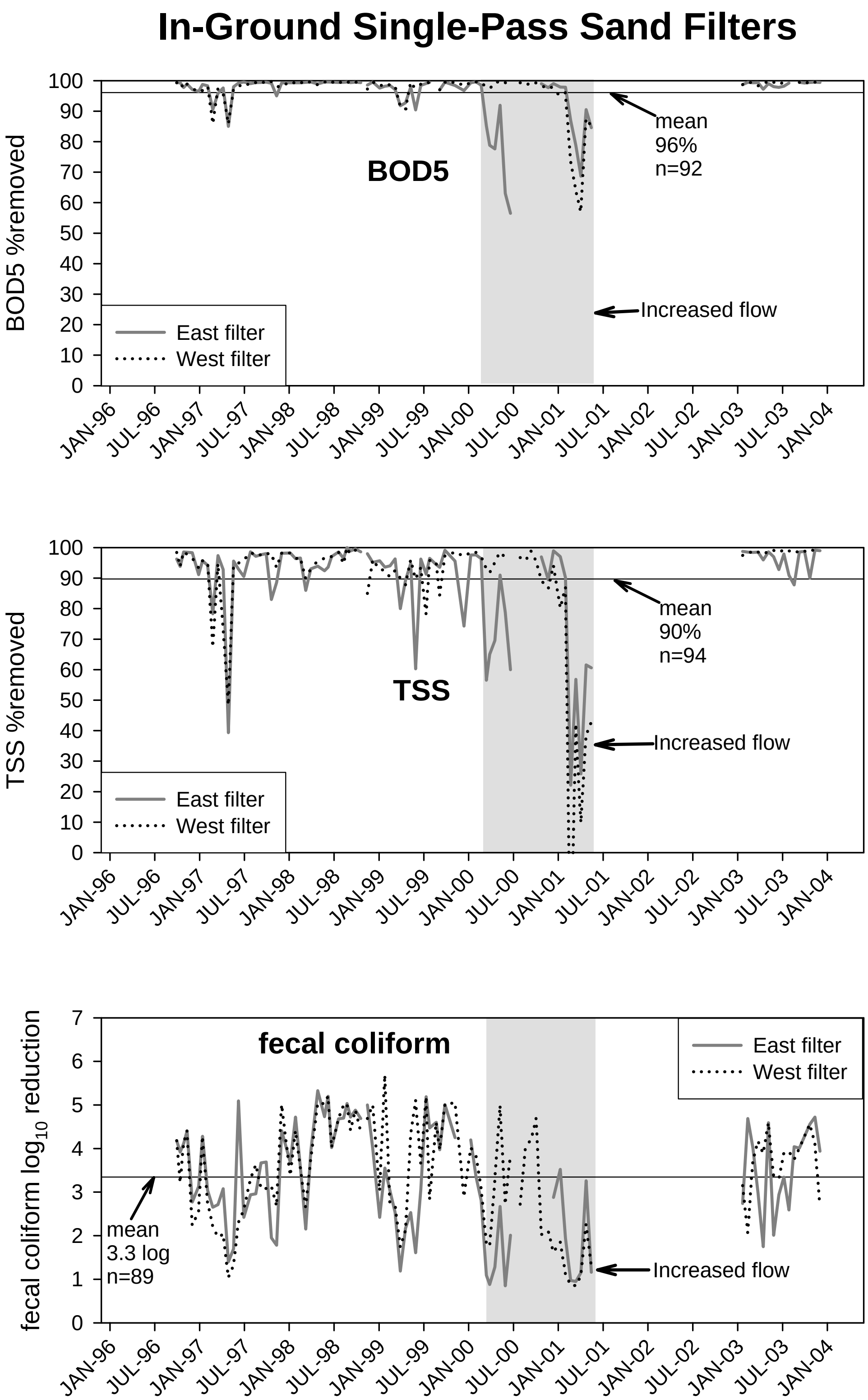


Figure 13. In-ground, single pass sand filter removal efficiency, 1996-2003

A. BOD5, TSS, and fecal coliform bacteria.



B. TP, TN, and NH4-N

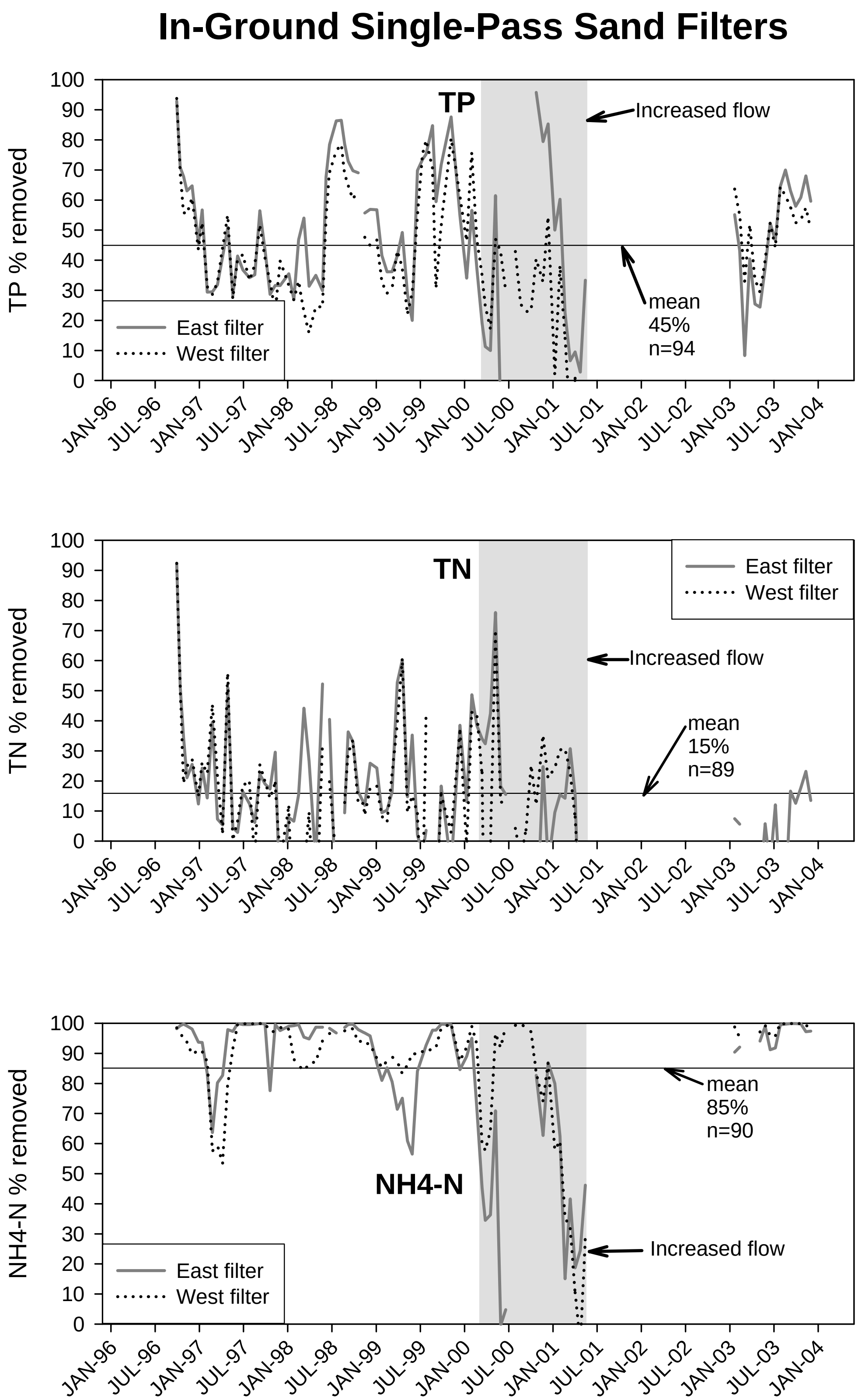
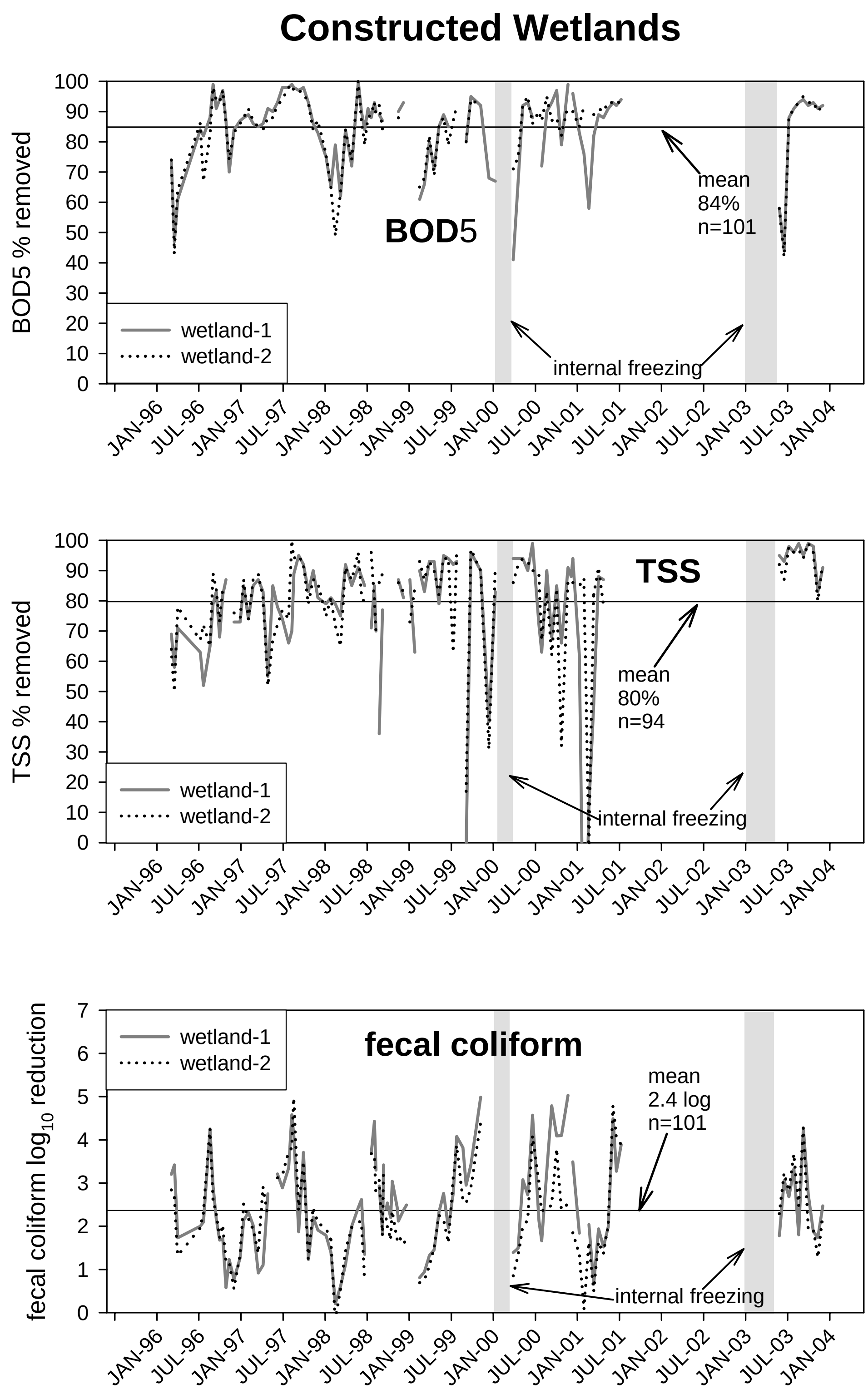
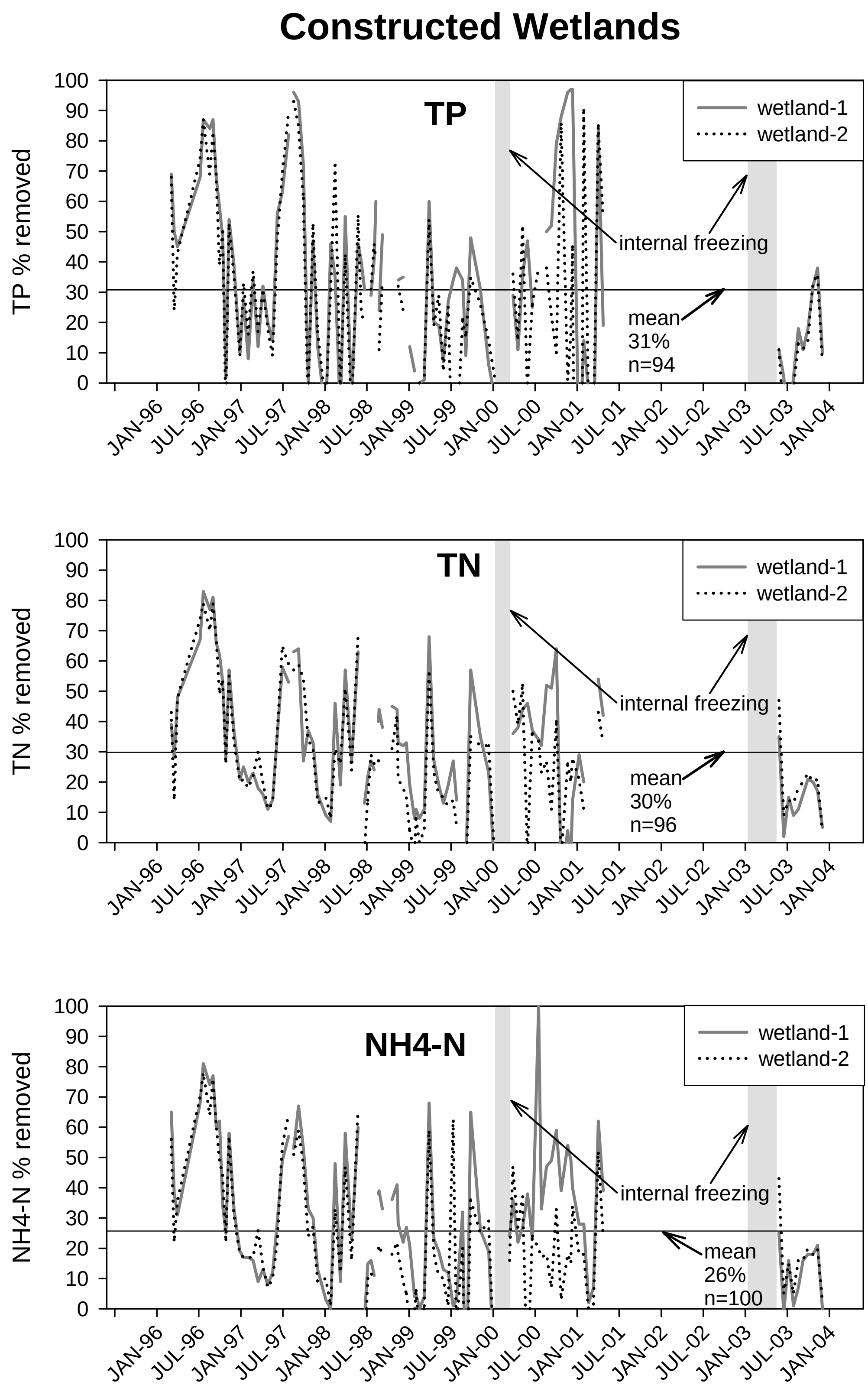


Figure 14. Subsurface flow 2-cell constructed wetland removal efficiency, 1996-2003.

A. BOD5, TSS, and fecal coliform bacteria



B. TP, TN, and NH4-N



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EVALUATION OF A PEAT BIOFILTER TREATMENT SYSTEM

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ABSTRACT

Soil and landscape conditions of the North Carolina lower coastal plain combine to hinder the use of conventional on-site systems. This can be of particular concern wben an existing system fails to work on a site that by today's standards is considered unsuitable. To avoid the condemnation of a residence, alternative systems are utilized to reduce space requirements and treat the wastewater prior to subsurface disposal. Researcb evaluated a peat biofilter system installed at several sites on the lower coastal plain. All sites had existing bouses with failing septic systems that were replaced with a peat bio-filter treatment system followed by subsurface disposal of the treated effluent. Site 1 is located on a clayey soil with a seasonal high water table between 15 and 45 cm. Sites 2 and 3 are located on small lots with high water tables and deep sandy soils. Site 4 is located on a small lot with a high water table and fill over organic soil. Systems at sites 2, 3, and 4 have been performing with a 93 to 99% reduction in fecal coliform, biocbemical oxygen demand (BOD_5), and total suspended solids (TSS). Ammonium (NH_4-N) was nearly totally converted to nitrate (NO_3-N) in the filter. Nitrate was detected in the nitrification trencbes as well as directly below the trencbes. In general the nitrate levels down gradient of the system were similar to those observed in background wells. The system at site 1 functioned similarly for over two years but in the fall of its third year of operation the filter saturated, became anaerobic, and ceased to treat the septic tank effluent effectively. The cause of the failure was linked to excessive ground water infiltration into the septic and pump tanks and poor soil conditions. The excessive amounts of groundwater overloaded the filter thus causing its ultimate demise.

KEYWORDS. Pre-treatment, Peat filter, Effluent, Septic system.

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INTRODUCTION

Recent increases in the population of North Carolina have resulted in greater developmental pressure on land resources. This is particularly noticeable in regards to on-site wastewater treatment and disposal since approximately 50% of North Carolina's population relies on septic systems for treating their wastewater (Angoli, 1998). The NCDENR rules and regulation regarding locating septic systems rate the soils as to their suitability to treat and dispose of waste effectively. In the lower coastal plain of North Carolina soil and landscape combine to rate a large number of sites unsuitable for new construction. These conditions generally consist of high water tables, organic soils, ortstein associated with sandy soils, flat landscapes and/or close proximity to surface water. Many sites that have soils presently rated as unsuitable already have been built upon. If and wben these systems fail to operate it is difficult if not impossible to design a conventional septic system that will adequately treat and dispose of the wastewater.

Given this situation alternative systems need to be used to assure that risk of contamination to surface and groundwater is minimized or eliminated.

Subsurface disposal of wastewater under the adverse conditions mentioned above is prohlematic at best. Systems installed under these conditions eventually fail to operate and allow untreated effluent to contaminate surface and ground water. These system failures and the difficulty of using conventional systems in marginal areas have prompted investigations into treating wastewater prior to suhsurface disposal. Such research has focused on the use of sand filters (Ball, 1991; Cagle and Johnson, 1994; Piluk and Peters, 1994), aerohic treatment units (Converse and Tyler, 1994; Jacquez et al., 1991), and peat hio-filters (Brooks et al., 1984, Winkler and Veneman, 1991; Brooks and McKee, 1992; Couillard, 1994; McKee and Brooks, 1994; Talhot et. al, 1996; 1998; O'Driscoll, et al., 1998). This paper focuses on the use of a peat bio-filter as an alternative to conventional repairs of failing septic systems.

The physiochemical properties of peat make it an effective treatment media. Peat consists mainly of lignin and cellulose. These components contain polar functional groups, which result in a high exchange capacity and adsorptive properties (Coupal and Lalancette, 1976). Peat also has a high surface area, whicb improves adsorption and influences bydraulic conductivity (Rock et al., 1984). These properties make peat an effective filter for wastewater treatment. Peat has heen shown in numerous laboratory settings to effectively reduce several key components of wastewater. A laboratory study of peat columns was used to determine loading rates, allowahle compaction, and nutrient removal parameters (Rock et al., 1984). A reduction of 96% BOD_5, 80% chemical oxygen demand (COD), and 93% TSS was observed in a peat column of 30 cm with a bulk density of 0.12 Mg m^{-3}. Little phosphorous (P) reduction was observed and the authors concluded that NO_3 reduction was likely if anaerohic conditions persisted in the peat. Similar column and hatch reactor studies indicated that as the thickness of peat increased treatment efficiency also increased (Rana and Viraraghaven, 1987; Viraraghaven and Rana, 1991). A study of varying peat/sand filter comhinations designed to enhance N removal concluded that under the proper conditions denitrification should occur (Winkler and Veneman, 1991). All the previously mentioned studies were performed in a laboratory, whicb were used to complement field scale studies and estahlisb design parameters. Overall these studies all indicated the effectiveness of peat in reducing wastewater strength.

Full-scale treatment systems utilizing peat have been used successfully to treat secondary effluent for many years (Farnham and Brown, 1972, Tilton and Kadlec, 1972; Guntenspergen et al., 1981; Nichols and Boelter, 1982). These studies used either natural wetlands or constructed peat beds. A system designed to treat an individual residence was constructed and evaluated hy Brooks (1980) and Brooks et al. (1984). The system varied in design and can be described as peat filled beds lined with an impermeable memhrane and an under drain to remove the filter effluent. Various methods of adding wastewater to the peat heds were investigated as well. These studies confirmed the laboratory studies and showed a high removal percent for fecal coliform (99% reduction), BOD_5, (90% reduction), COD (80% reduction), and total P (58-96% reduction). Nitrate-nitrogen (NO_3-N) was measured at 4.5 mg l^{-1} which is below the EPA drinking water standard of 10 mg l^{-1}. Brooks et al. (1984) concluded their study by suggesting that peat filters could be used in those areas where conventional systems would not function well. They further suggested that peat filters could be used in pollution sensitive areas to reduce contamination risks. These studies all illustrate the high efficiency of peat filters in reducing septic tank effluent strength. More recent studies have summarized the use and effectiveness of peat filters in treatment wastewater (Brooks and McKee, 1994; Couillard, 1994) concluding that higb treatment efficiencies are expected.

The systems evaluated by Brooks et al. (1984) were engineered on-site. Such custom fabrication may not be appropriate for all locations. Recently, a second generation of peat bio-filters has been developed. These filters place the peat in modules that are periodically dosed with wastewater. The result is a high degree of treatment effectiveness (Talbot et. al, 1996; 1998; O'Driscoll, et al., 1998). A second advantage to these systems is their ease of installation and small size making them appropriate for areas that are difficult to work on or on small lots. Despite high treatment efficiencies, 100% of contaminants are not removed thus the soil is still utilized as the final step in the treatment of the wastewater.

The overall objective of this research is to determine the effectiveness of a peat bio-filter on the treatment of domestic wastewater. The specific objectives were to determine: (i) the treatment efficiency of the peat bio-filter for fecal coliform, BOD, NH_4-N, NO_3-N, total kjeldahl nitrogen (TKN), total phosphate-phosphorus (PO_4-P), and ortho- phosphate-phosphorus (PO_4-P); (ii) how the peat bio-filter effluent was treated within the soil adsorption system; and (iii) if there was ground or surface water contamination from the overall system.

METHODS AND MATERIALS

Site Locations and Descriptions

Four (4) sites located on the lower Coastal Plain of North Carolina were chosen to install and monitor peat bio-filters (Table 1). The sites all had failing systems that were difficult or impossible to repair with a convention gravity flow system (Table 1). Although other alternative systems could have been utilized the peat bio-filter was chosen because it required less space, therefore less disturbance of the lot and improved wastewater treatment prior to subsurface disposal. The peat bio-filter (Puraflo™) evaluated by this study is manufactured by Bord na Mona, Greensboro, NC.

The systems were designed and installed basically following the rules set forth by the On-Site Wastewater Section, of the North Carolina Department of Environment and Natural Resources, Division of Environmental Health. Two basic system designs are commonly utilized. The Type A system allows the effluent from the biofilter to drain directly into a gravel pad below the filters; the Type B system collects some of the biofilter effluent and redirects it to standard nitrification trenches (fig. 1).

Table 1. Site Locations and Characteristics

	County	Design Flow	Peat Filter Type	Soil Series, Drainage Class[a]	ESHW[b]	Other Site Restrictions
Site 1	Gates	480 gpd	B	Bladen, PD	15-30 cm (6-12 in.)	Group 4 soil, Massive structure
Site 2	New Hanover	360 gpd	A	Lynn Haven, PD	22-45 cm (9-18 in.)	Limited space
Site 3	New Hanover	360 gpd	A	Lynn Haven, PD	22-45 cm (9-18 in.)	Limited space
Site 4	Dare	360 gpd	A	Fill over Icaria, VPD	0-30 cm (0-12 in.)	Limited space, Organic soil

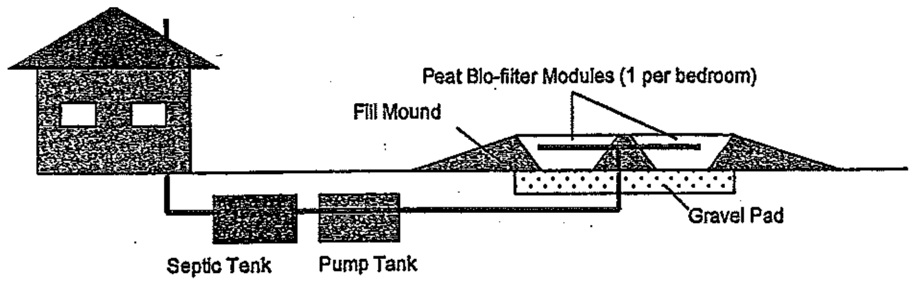
[a] PD = Poorly Drained, VPD = very poorly drained
[b] ESHW = Estimated seasonal high water table

Field and Laboratory Methods

Piezometer construction, placement, and installation followed procedures outlined by Hinson et al. (1994). Piezometers were located both up and down gradient from the bio-filter and drainfield. Additional background piezometers were located on the site if possible. At site 1 a drainage ditch at the property line was also sampled. Samples were collected from each piezometer bimonthly during winter and spring (high water table months) and every other month during the rest of the year. Each piezometer was purged and allowed to recharge with fresh groundwater and then sampled with a peristaltic pump or vacuum pump. Approximately 1000 to 2000 ml of water was collected. In addition to samples from piezometers, wastewater samples were also collected from the pump tank and peat bio-filter sample chamber (O'Driscoll et al., 1994). Water samples were transported to the lab in an ice-filled cooler.

Laboratory analysis included fecal coliform, BOD_5, TSS, NH_4-N, NO_3-N, TKN, total PO_4-P, ortho PO_4-P, and chloride (Cl^-). Analysis followed standard procedures (APHA, 1994). The sample was split with the majority (500 to 2000 ml) being used for fecal coliform, BOD_5, and TSS, analysis. Fecal coliform, and BOD_5 analysis was done within 6 hours of sampling and TSS was done within 12 hours of sampling. The remaining sample (100-200 ml) was stabilized with sulfuric acid and analyzed for nutrients and Cl^-.

Type A System: Peat bio-filters drain directly into gravel pad beneath them.



Type B System: One Peat bio-filter drain directly into gravel pad beneath it; effluent from the remaining peat biofilters is collected and distributed to convention nitrification trenches.

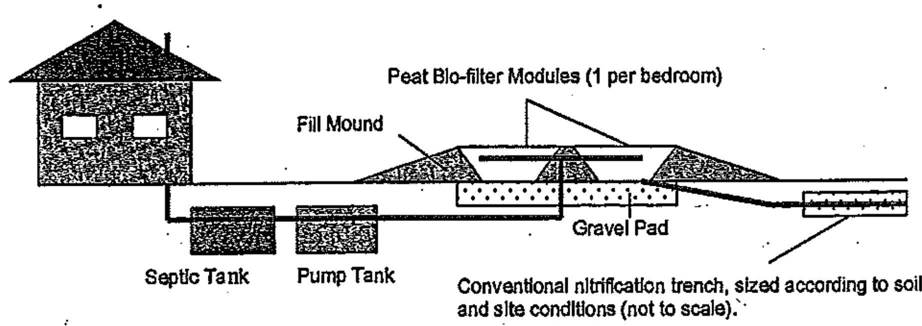


Figure 1. Schematic of Type A and Type B Peat Bio-filter System in North Carolina (not to scale). Details of septic tank and pump tanks omitted for clarity. A two compartment septic tank with an effluent filter is standard. Risers on the septic tank are used when the septic tank is more than 15 cm (6 in.) from surface. The pump tank is a single compartment with exposed access riser. Control panel, alarm etc. are generally located next to the pump tank.

RESULTS

The peat bio-filters have for the most part effectively reduced the wastewater strength (Tables 2 and 3). Fecal coliform was reduced on average by 99%. Initial samples (approximately 6 months) did not exhibit this high level of treatment due to a period of acclimation. The TSS and BOD_5 were reduced by between 93 and 97%. The TSS in the sample chamber was higher in the first 6 months. Small peat fragments were often observed in these early samples but after the initial 6 months the peat bio-filter effluent had only a slight golden brown color with no visible peat fragments. The BOD_5 followed a similar pattern. Conversion of NH_4-N to NO_3-N was nearly 100%. This was evidence that the peat bio-filters were consistently aerobic. Total kjeldahl nitrogen was greatly reduced by the peat bio-filter primarily due to the conversion of NH_4 to NO_3. Phosphorus and chloride were basically unaffected by the peat bio-filter. The results shown in this study were similar to those reported in the literature (Brooks et al., 1984, Brooks and McKee, 1992; McKee and Brooks, 1994; Talbot et. al, 1996; 1998; O'Driscoll, et al., 1998).

Water samples for the trench (or pad) receiving peat bio-filter effluent had slightly elevated NO3-N levels. The NO3-N levels decreased in ground water samples below the trench (pad) and in samples outside the drain field area (up and down gradient, background and ditch). Ammonium and TKN were slightly elevated in some samples but for the most part showed similar trends. The overall decrease in N species away from the drain field may be due to dilution of the effluent in groundwater, denitrification, assimilation, or simply missing the effluent plume or a combination of all. Assuming that the effluent plume was indeed sampled, the low N content associated with the bio-filter should be considered as evidence of water quality improvement.

Table 2. Geometric Mean for Fecal Coliform, and Average BOD_5 and Total Suspended Solids Data.

	Pump Tank Bffluent	Sample Chamber	Trench	Below Trench	Up Gradient	Down Gradient	Background or Ditch
				Type A System (Site 2)			
Fecal Coliform (cfu/100 ml)	1.5×10^2	2.9×10^2	$<2 \times 10^2$	$<2 \times 10^2$	$<2 \times 10^2$	$<2 \times 10^2$	$<2 \times 10^2$
BOD_5 (mg l^{-1})	114	3	1	1	1	1	1
TSS (mg l^{-1})	143	7					
				Type B System (Site 1)[a]			
Fecal Coliform (cfu/100 ml)	2.5×10^5	1.6×10^3	$<2 \times 10^2$	$<2 \times 10^2$	$<2 \times 10^2$	$<2 \times 10^2$	1.1×10^3
BOD_5 (mg l^{-1})	172	6	2	2	1	1	8
TSS (mg l^{-1})	80	6					

[a] Data for the Type B system (Site 1) represents values for the first 25 months of operation prior to its failure due to hydraulic overloading of the soil.

Despite the overall high level of treatment observed from the data (Tables 2 and 3) one system did have major problems that ultimately lead to its failure. The pump tank and septic tank at Site 1 had significant groundwater infiltration almost from the day they were installed. Numerous attempts were made to seal the tank but these proved to be unsuccessful. The result of the infiltration was an average of 25 to 50% increase in monthly flow (daily flow may have been higher) over the design flow. The system operated well for 25 months under these conditions. Finally, heavy rains, and saturated soils resulted in a hydraulic overload in the soil. The soil type at this site is a group 4 soil with a high clay content (<60 %) and a low hydraulic conductivity. Since the soil was unable to absorb the excess effluent it backed up into the peat biofilter causing the biofilter to become anaerobic.

Table 3.: Average Nutrient and Chloride Data from the 4 Sites.

	Pump Tank Effluent	Sample Chamber	Trench	Below Trench	Up Gradient	Down Gradient	Background or Ditch
	mg l^{-1}						
			Type A Systems (Sites 2, 3, 4)				
TKN	28.8	1.0	1.1	3.3	0.6	3.4	1.5
NH_4-N	24.3	0.4	0.3	3.9	0.2	0.5	0.3
NO_3-N	0.4	22.1	5.9	0.8	2.1	0.3	0.2
Total PO_4-P	4.4	4.0	0.5	0.5	0.3	0.5	0.7
Ortho PO_4-P	3.7	3.8	0.5	0.4	0.3	0.4	0.5
Cl^-	50.9	45.3	70.8	48.9	30.6	76.9	74.4
			Type B System (Site 1)[a]				
TKN	27.0	4.1	1.3	1.7	0.6	0.9	1.2
NH_4-N	18.7	1.5	1.0	0.6	0.3	0.4	0.6
NO_3-N	0.4	18.0	4.8	0.8	0.3	0.3	0.3
Total PO_4-P	1.9	1.9	0.4	0.5	0.1	0.2	0.1
Ortho PO_4-P	1.5	1.9	0.4	0.5	0.1	0.2	0.1
Cl^-	70.1	71.1	41.6	61.2	37.1	15.4	26.7

[a] Data for the Type B system (Site 1) represents values for the first 25 months of operation prior to its failure due to hydraulic overloading of the soil.

Conclusions

The overall performance of the peat bio-filter was well within the expectations. The bio-filter effectively reduced fecal coliform (99% reduction), BOD5 (93% reduction), and TSS (97% reduction). Ammonium was almost completely converted to NO3-N due to the highly aerobic nature of the bio-filter. Phosphorus was little affected by the bio-filter, but was effectively removed in the soil. The bio-filter effluent was finally treated in the soil and with little impact of the effluent on the local groundwater quality. The observed failure of one system occurred due to external problems, namely water infiltration into the system and subsequent hydraulic overload of the soil. Every effort must be taken to ensure systems are water tight.

ACKNOWLEDGEMENTS

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Reduction of Nonpoint Source Pollution from On-Site Sewage Systems in Clermont County Ohio

Ohio EPA 319 Project #98(h) E-10

Final Technical Report

Project Sponsor: Clermont County General Health District

Project Time Frame: April 1, 1998 - March 31 2001

Submitted To: Ohio Environmental Protection Agency

Submitted: August 17, 2001

I. Project Summary

A. **Project Name:** Reduction of Nonpoint Source Pollution from On-Site Sewage Systems in Clermont County Ohio- Project # 98(h) E-10

B. **Project Sponsor**: Clermont County General Health District

C. **Project Time Frame**:
Originally Proposed: January 1, 1998 - December 31, 2000
Actual: April 1, 1998 - March 31, 2001

D. **Project Cost:**
Federal (319) $ 119,022 State $ 0 Local $ 136,869
Total Project Cost $ 255,891

E. **Description of Project Area:** The project focused on all of Clermont County with two general areas were targeted as critical in this effort. The first and most critical area related to new onsite systems that were yet to be installed in the county. The focus was on those portions of the county with the more severe Avonburg, Blanchester and Clermont soils in areas that were not sewered.

The second area related to existing systems. In the northwest corner of the county, Miami Township is the location of five high density subdivisions that contain approximately 1,000 aerobic systems. Similar subdivisions can be found in Wayne Township, Tate Township, Union Township and Ohio Township.

Land Use: The land use in Clermont County is primarily residential with light industrial in urbanized areas. The eastern portion of the county has a strong agricultural component. About 35% of Clermont county land is used for agriculture.

Water Quality Problems Prior to Implementation:

Known causes of impairment for the hydrologic units affected by this project include: siltation, nutrients, organic enrichment, habitat alteration, metals, flow alteration, suspended solids, and ammonia.

The surface water quality in the county's watersheds range from attaining use in some stream segments to NPS impaired in others (*Ohio Nonpoint Source Assessment, Hydrologic Unit Water Quality Reports*). In over 60% of the stream segment miles that are actually in Clermont County, onsite wastewater treatment systems are listed as a source of known or suspected impact.

In the 1995 OEPA Biological and Water Quality Study of the Little Miami River and Selected Tributaries, the East Fork of the Little Miami River was reported as marginally deteriorated since the 1982 results. The conclusions indicated that the principal cause of the observed partial and non-attainment designations were organic and nutrient enrichment. Although the report attributed these pollutants to point sources, the county had generated other data which suggested that nonpoint sources, such as onsite septic systems may have been contributing significantly to this pollutant loading.

A comprehensive wastewater study sponsored by the Board of County Commissioners (*Clermont County Wastewater Master Plan*, Harza Environmental Services, Inc., 1994) estimated that 56% of the onsite systems discharged off lot either by design (aerobics and sand filters), through intentional alteration of on-lot systems, or as a result of system failure. Using known point source data, review of existing water quality and flow data, and by updating predictive modeling efforts undertaken by the Ohio-Kentucky-Indiana Regional Council of Governments in 1977, this same report estimated total pollutant loading in the county with rather startling results for onsite systems. While the total suspended solids contributed by onsite systems was less than 0.2%, the $CBOD_5$ was estimated at 18% of the total loading, total nitrogen was estimated at 14% of the total loading, and total phosphorus was estimated at 26% of the total loading.

Map of Project Area: A map of the project area (the entire county) can be seen on the following page. Since the primary emphasis was onsite systems in Clermont's severe soils, this soil association map provides an overview of the extent of the most severe (the Avonburg, Blanchester, and Clermont) soils throughout the county.

F. Project Goals and Specific Objectives:

Project Goal: The goal of this project was to reduce the non-point source impact from onsite sewage disposal system in Clermont County through improved management of existing systems and by increasing the number of options available for effective, non-discharging systems.

Objective No. 1: Implement the use of proven alternative treatment technologies consisting of two alternative secondary treatment options and two alternative dissipation/subsurrface drainage options and various combinations thereof, that are not currently approved for use in Ohio, at 30 Clermont County sites to increase the viable options for on-lot disposal. System selection for all sites will be based on in-depth site assessment including soil probes. Design and consultation to installers will be provided in-house.

Associated Activities:

- Obtain ODH approval for alternative systems
- Continuous investigation of technical information on alternative system designs.
- Design 30 systems of proven alternative treatment technologies consisting of two alternative secondary treatment options and two alternative dissipation/subsurface drainage options and various combinations thereof, that are not currently approved for use in Ohio.
- Install 30 systems of proven alternative treatment technologies consisting of two alternative secondary treatment options and two alternative dissipation/subsurface drainage options and various combinations thereof, that are not currently approved for use in Ohio.

Objective No. 2: Develop and implement field demonstration project on two non-proven, innovative on-lot disposal options designed for specific problems associated with clay soils and seasonal high water table. Two systems of each design to be installed. System selection for all sites will be based on in-depth site assessment including soil probes. Design and consultation to installers will be provided in-house.

Associated Activities:

- Continuous investigation of technical information on innovative system designs
- Develop and advertise "Call for Proposals" for innovative systems
- Select 2 non-proven, innovative on-lot disposal options designed for specific problems associated with clay soils and seasonal hgih water table. Two systems of each design to be installed as demonstration project.
- Design overall study for demonstration project.
- Select 4 sites for demonstration project
- Design 4 systems (2 each of 2 innovative systems) for demonstration project
- Identify installer(s) for installation of 4 innovative system installation
- Install 4 innovative systems

Objective No. 3: Evaluate performance of all systems utilizing alternative technology through semi-annual sampling and annual routine operation inspections, and performance of innovative systems through monthly sampling and system monitoring.

Associated Activities:

- Performance evaluation on 30 alternative systems (240 samples)
- Performance evaluation on 4 innovative systems (120 samples)

Revised Activities: (Approval attached dated 5/19/1999 - Appendix A)
Activity Added

- Development of Quality Assurance Project Plan

Objective No. 4: Conduct sampling program of outfall from 5 high density sand filter and aerobic subdivisions.

Associated Activities:

- Identify 5 subdivisions for outfall sampling. Office of Environmental Quality conducts sampling program
- 50 monthly samples analyzed for metals. Conduct sampling program of outfall from 5 high density sand filter and aerobic subdivisions.
- 100 samples analyzed for fecal coliforms, CBOD, TSS, ammonia, total phosphorus, nitrates, nitrites, hardness, conductivity, pH, TKN, TVSS, DO

Revised Activities: (Approval attached dated 5/19/1999 - Appendix A)
Activity Deleted

- ~~50 monthly samples analyzed. (Metals) Conduct sampling program of outfall from 5 high density sand filter and aerobic subdivisions~~.

Activity Revised:

- 100 samples from outfall areas and 75 SAMPLES FROM EXISTING SYSTEMS will be analyzed for fecal coliforms, CBOD, TSS, ammonia, total phosphorus, nitrates, nitrites, hardness, conductivity, pH, TKN, TVSS, DO.

Objective No. 5: Increase the number of systems in the renewable Operation Permit Inspection Program from the current level of 22% to at least 40% of all systems. 100% of all new and repaired systems from 1998 on will be in the inspection program.

Associated Activities:

- Increase the number of systems in the renewable Operation Permit Inspection Program from the current level of 22.5% (4,200 of 19,400 systems) to at least 40% (8,200 of 20,500). 100% of all new and repaired systems from 1998 on will be added to the inspection program (about 350 per year)
- 150 (estimated) early mound systems added and begin inspection program
- 2,600 early sandfilters added and begin inspection program

Objective No. 6: Provide presentations and education to Township Trustees, Planning

Commission, Zoning, Township Officials, Village Mayors, Board of County Commissioners, and homeowners on the 319 project as soon as the grant approval notification is received, with emphasis on the project's relationship to the County's Wastewater Master Plan and Project XLC. Provide homeowner education to reduce discharge impacts in targeted high density discharge areas.

Associated Activities:

- Hold 11 meetings for officials.
- Hold 15 meetings for homeowners.

Objective No. 7: Conduct focused public relations effort on the 319 project objective and creatively market the alternative on-lot treatment and disposal options in order to promote use of these systems.

Associated Activities:

- Prepare 6 press releases
- 3 newspaper articles on 319 efforts
- 3 Health District newsletter articles
- 3 Soil & Water newsletter articles
- 2,000 landscaping/planning brochures for onsite systems developed with Soil and Water Conservation District & OSU Extension.
- Hold 8 professional education efforts
- Public outreach at the Clermont County fair and with fliers
- Prepare journal article for publication of year 1 results

Revised Activities: (Approval attached dated 5/19/1999 - Appendix A)
Activity Deleted

- 1,000 fliers on 319 project printed, 1,000 mailed

Activity Added

- Alternative Systems Information Package developed and made available to homeowners.

Activity Revised:

- ~~2,000 landscaping/planning brochures~~ 1,200 BOOKLETS ENTITLED <u>THE HOMEOWNERS CONSERVATION GUIDE</u> WITH GOOD INFORMATION ABOUT ~~for~~ onsite systems ~~developed~~ PRINTED IN CONJUNCTION with Soil and Water Conservation District ~~& OSU Extension~~.

Objective No. 8: Provide equivalent of 0.15 FTE per year of management personnel to implement and oversee all aspects of the project. Perform all technical and fiscal reporting.

Associated Activities:

- 12 quarterly fiscal reports
- 5 semi-annual technical reports
- 1 final project report

II. Project Accomplishments

All of the critical components of this project were completed within the timeframe and bounds of this 319 project. Several of the minor components were not completed either to the degree or in the manner originally envisioned as the following discussions will indicate.

All efforts were guided by a local Advisory Committee which was comprised of the following individuals:

Ralph Benson, Sanitarian, Clermont County General Health District
Paul Barringer, Director, Clermont County Soil and Water Conservation District
Paul Braasch, Director, Clermont County Office of Environmental Quality
Brian Bramble, Member, Clermont Homebuilders Association
George Cummings, District Conservationist, NRCS
Alfred Fangman, President, Clermont County Board of Health
Joseph Glassmeyer, Board of Supervisors, Clermont County Soil & Water Conservation District
Carlos Hamilton, Member, Clermont County Board of Health
Marty Lambert, Assistant Health Commissioner, Clermont County General Health District
Jim McDonough, Dean, University of Cincinnati/Clermont College
Kevin Miller, Private Consultant, Miller Designs
Steve Olmsted, Director, Clermont County Department of Planning and Development
Janet Rickabaugh, Health Commissioner, Clermont County General Health District
April Robbins, Member, Clermont Zoning Association
Ray Sebastian, Chief Building Official, Clermont County Building Department
David Spinney, Assistant County Administrator, Clermont County
John Trautmann, Member, Clermont County Board of Realtors
Hugh Trimble, Area Assistance Team Member, Division of Surface Water, Ohio EPA
Glenn Welling, Chair, Ohio State University Extension
Robert Wildey, Director, Water & Waste Division, Clermont County General Health District

Major Accomplishment #1: Four alternative treatment technologies followed by one alternative dissipation/subsurface drainage option were introduced and are available for use in Clermont County.

As the Clermont County General Health District was in the process of developing and submitting the 319 proposal in May 1997, the Health District was also in the midst of a minor onsite system crisis. Health District staff were actively searching for alternatives to the Wisconsin Mound that would be acceptable for use in the county's worst soils. The timing of the 319 project provided a mechanism for a more in-depth look at the systems that were identified. The four systems that were identified and evaluated as a part of this project were the Nibbler Jr. to a modified mound (a fixed-film aerobic technology, FF-ATU), a suspended growth aerobic treatment unit followed by a modified mound (SG-ATU), an Orenco intermittent sand filter to a modified mound (ISF), and Puraflo peat biofilters followed by a modified mound (PEAT). In March 1998 the Clermont County General Health District received approval from the Ohio Department of Health to install these systems under experimental status.

In order to evaluate the systems in the most difficult conditions, it was decided that only systems installed on Clermont soils would be a part of the 319 evaluation. These four system types were installed over the next three years. The first 30 systems installed on Clermont soils where homeowners intended to assume immediate occupancy were assigned to the evaluation. Since homeowners were able to choose among the systems for the system type that suited them the best, there was no attempt to limit the number of systems of any particular type to a fixed and equal number.

The number of systems installed as part of the 319 project was consistent with the total number of these same systems installed throughout the county on all soils during this same time period. It also reflects the relative number of applications for alternative systems received during this same time period.

Alternative Systems in Clermont County 1/1/1998 - 12/31/2000

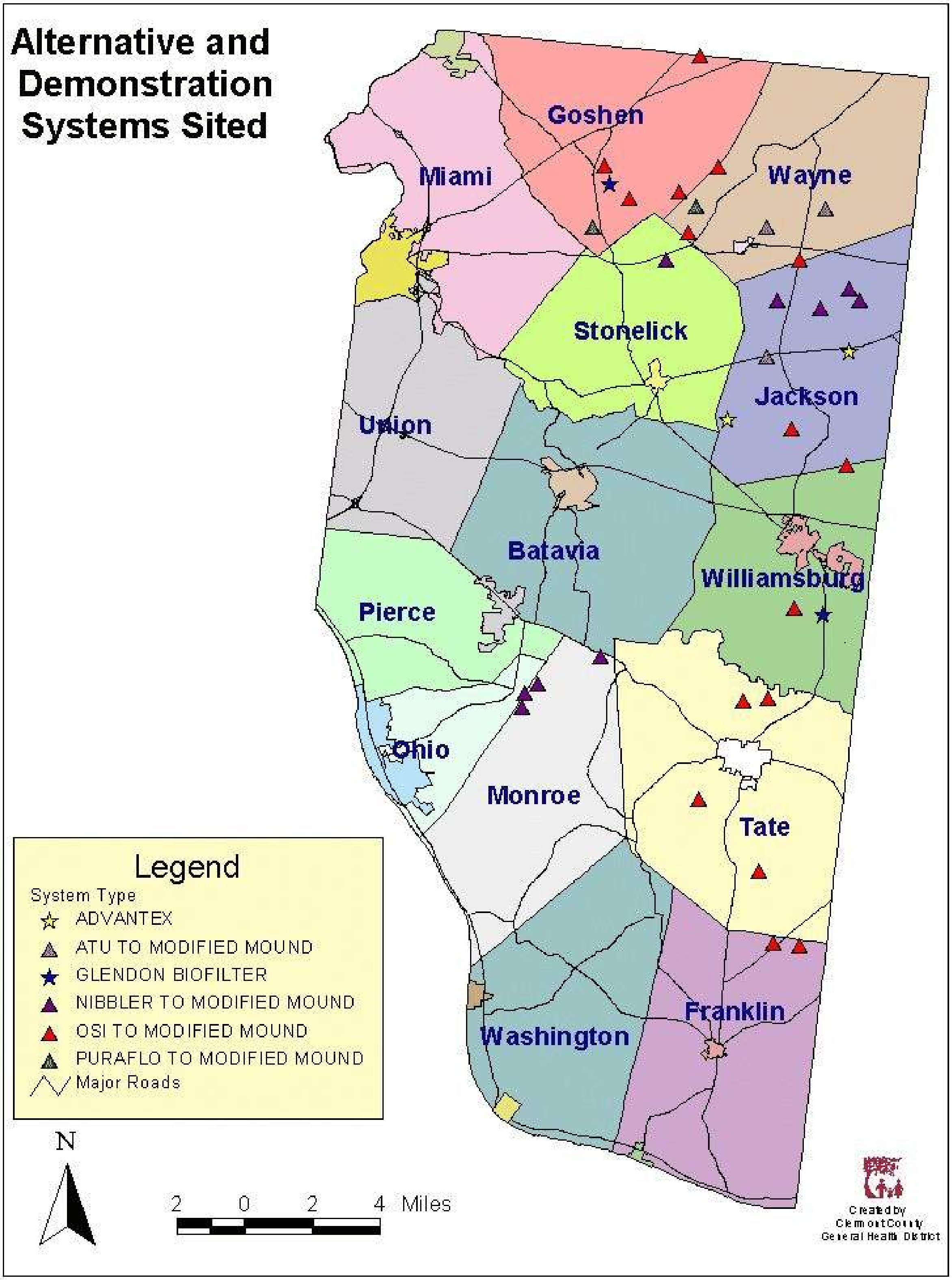
System Type (Abbreviation Used)	Number of Systems Installed as Part of 319 Project	Total Number of Systems Completed	Total Number of Applications
SG-ATU to Modified Mound	3 (10%)	4 (3%)	11 (4%)
FF-ATU to Modified Mound	9 (30%)	29 (24%)	58 (23%)
ISF to a Modified Mound	16 (53%)	62 (51%)	133 (53%)
PEAT to a Modified Mound	2 (7%)	8 (7%)	16 (6%)
Other alternative systems	0 (0%)	18 (15%)	33 (13%)
TOTAL SYSTEMS INSTALLED	**30 (100%)**	**121 (100%)**	**251 (100%)**

It is clear that the ISF to a modified mound was the system of choice. There are several possible reasons for this. Homeowners on Clermont soils were offered a choice of five different systems types; the four systems included in the 319 evaluation and the traditional Wisconsin Mound. At the time the project started, Clermont homeowners had developed such a resistance to using the Wisconsin Mound that few people were voluntarily choosing that option. FF-ATU's and SG-

ATU's were less expensive to install initially but more expensive to run and lifetime maintenance contracts are required for both systems. Although the PEAT was probably the least expensive to maintain, it was the most expensive to install which may have kept homeowners from giving this system serious consideration. When either installers or sanitarians were asked for information it's likely that both tended to encourage the ISF sand filter option. Although they are more expensive to install than SG-ATU's and FF-ATU's they require less maintenance, have lower operating costs, and lifetime service contracts were not mandatory.

Although the original proposal indicated that 10 systems would be installed each project year it was realized early on that this was not a controllable factor. Since the Health District limited the project to Clermont soils only, systems were simply added to the project as they were available and completed. A map indicating the location of all systems installed under this project can be seen on the next page. The systems were installed as follows:

YEAR **System Type**	**Number of Systems Installed as Part of 319 Project**
1998	**7**
SG-ATU	0
FF-ATU	1
ISF	6
PEAT	0
1999	**11**
SG-ATU	3
FF-ATU	1
ISF	6
PEAT	1
2000	**12**
SG-ATU	0
FF-ATU	7
ISF	4
PEAT	1
TOTAL SYSTEMS	**30**


Alternative and Demonstration Systems Sited
Goshen
Miami
Wayne
Stonelick
Jackson
Union
Batavia
Williamsburg
Pierce
Ohio
Monroe
Tate
Franklin
Washington
Legend
System Type
ADVANTEX
ATU TO MODIFIED MOUND
GLENDON BIOFILTER
NIBBLER TO MODIFIED MOUND
OSI TO MODIFIED MOUND
PURAFLO TO MODIFIED MOUND
Major Roads
N
2 0 2 4 Miles
Created by Clermont County General Health District

Lessons Learned

A tremendous amount of design and installation information has been learned as the result of this project. The Health District has developed and updated an alternative technology design document for use in Clermont County. This document is included as Appendix B.

As the installers warmed to the idea of the alternative systems, more and more were interested in installing the new designs. Unfortunately, this included both the conscientious installers that took the time to attend trainings and learn how to install the systems correctly and the less scrupulous installers that simply saw it as a means to make additional revenue. This put an extremely heavy burden on the sanitarians who inspected the alternative technology systems. In many cases, they were essentially teaching the installers on the job. This in itself would not have been a huge problem but it seemed that they needed to show the same installers the same corrections time and time again. After three years of struggling with some installers, the Board of Health approved an "Advanced Technology" registration for any installer wishing to install any systems other than leach lines, Wisconsin Mounds and subsurface sand filters. Installers that continue to have repeated failed inspections for the same issues will have their advanced technology registrations revoked.

Maintenance contracts MUST be required for all of the higher tech systems. As the onsite systems become more and more complex, it is less likely that homeowners are going to have the knowledge or the willingness to learn about the routine preventive maintenance required to keep their systems in proper working order. In some cases, incorrect problem resolution can be as big of a problem as not correcting the problem at all. The simplest way to be sure systems are being maintained properly would be to require lifetime service contracts on all alternative technology systems. While the Health District is moving in this direction, the current lack of qualified preventive maintenance vendors is an obstacle that has not yet been overcome.

The final lesson learned is that introduction of new onsite technologies requires a strong commitment and active cooperation from the equipment vendors. The vendors cannot simply be interested in selling product to installers. They must be willing to play a leading role in introducing the new technology to the area, providing quality assurance oversight, providing support to installers and regulators, and they need to provide well-developed training programs. They must also work with regulators to identify sources of watertight septic tanks and basic materials that meet their design specifications. Without this level of support from the equipment vendor the responsibility falls inappropriately to the regulator. This particular hard learned lesson was presented as a challenge to the National Onsite Wastewater Recycling Association at the fall 2000 annual conference. A copy of the paper presented can be seen in Appendix C.

Major Accomplishment #2: A field demonstration project on two non-proven, innovative on-lot disposal options was implemented. Two systems of each design were installed and evaluations were initiated.

To obtain proposals for system technologies that were new and untried, a nationally advertised call for proposals was published in the National Small Flows Clearinghouse publication, *Small Flows Journal* and in the National Onsite Wastewater Recycling Association Newsletter. A total of twenty-three requests for the call for proposals were received. A total of eight actual proposals were received for consideration.

In order to assist Health District personnel in making the selection of the two innovative technologies, a Technical Committee which was separate from the Advisory Committee was formed. This included the following individuals:

Ralph Benson: Clermont County General Health District, Staff Sanitarian
Hugh Trimble: Ohio EPA , Area Assistance Team Member, Division of Surface Water
Jim Kriessl: US EPA, Office of Research and Development
Al Fangman: Clermont County Board of Health, President
Kevin Miller: Miller Designs, System Designer
Ron Ware: Ohio EPA, Division of Surface Water
Jesse Shaw: Henderson & Bodwell LLP, Professional Engineer

The Technical committee reviewed the proposals and the recommendations made by Health District staff. The group was searching for technology that was likely to work in the difficult Clermont soils and that offered some identifiable advantage over currently used systems. Two systems were selected for the demonstration. The first was Orenco's textile recirculating trickle filter system. This was a pretreatment component using a manufactured media which would be followed by a modified mound. A more detailed overview of the system can be found in Appendix D. A significant advantage of this system was the elimination of problems associated with locally-sourced media.

The second system selected was Glendon BioFilter Technologies' Glendon BioFilter. This system was selected because of the simplicity of the concept and the low energy use. The system consists of a septic tank, pump tank, the BioFilter Modules, and the native soil absorption areas. The system uses a standard concrete two compartment septic tank with an effluent filter. The dosing tank is a 1,000 gallon tank with a pump and controls. The BioFilters were constructed on site using septic tanks without tops as the basins which were filled with a proprietary mixture and arrangement of sand and gravel. Influent from the septic tank flows by gravity to the pump tank which is then pumped on a specific schedule to the BioFilters. Once inside the basin, the effluent flows upward through the media until it migrates out of the basin using capillary rise and wick -siphon-like action. The treated effluent then flows to an absorption area contiguous to the biofilter basin. An overview of the Glendon BioFilter can be seen in Appendix E.

Clermont County homeowners were solicited for participation through advertisements in the local Soil & Water Conservation District newsletter, the Health District's newsletter and through the local paper. Only sites that met the following criteria were only considered:

- An existing home with a failing system or no system at all
- Located in Clermont County on Clermont Silt Loam soil
- Lot must be adequately sized and acceptable topography to enable installation
- Homeowner occupied and be willing to participate in the study for five years
- Home with 3 or 4 bedrooms with at least 4 residents in the home
- Willing to share information about water usage, laundry and cleaning products and other products used in the home

In addition, since homeowners were not asked to pay for these demonstration systems, participants had to be willing to sign a five year forgivable mortgage as well as a participation contract with the Health District in order protect the Health District's interest in the systems.

A total of 26 homeowners contacted the Health District concerning participation in the project. Clearly, none of the four homeowners selected had any idea what they were getting involved with although all continue to be cooperative.

Installers were selected differently for each system type. Since the Glendon BioFilter is a proprietary design, only a franchised installer can install the system. After the Glendon proposal was accepted, the vendor visited Clermont County to identify a local partner to install the systems. Since only one local installer was able to do the installation, installer selection for the Glendon system was straightforward. Rob Trace, of Trace Excavating was the Glendon installer in both 1999 and 2000.

Health District Sanitarians invited one the county's meticulous installers, Steve Meador, to install the Orenco trickle filter system. This was done in hopes of eliminating installation problems that could be confused with system performance problems. Mr Meador was not available at the time of installation of the second year's system so Conall Stapleton was invited to install the 2000 version of the trickle filter.

The Glendon Biofilter Experience

The first Glendon BioFilter was installed in October 1999. Mr. Glen Helm of Glendon Biolfilter Technologies traveled from Washington state to consult on the actual building of the filters. Prior to this demonstration project in Ohio, Mr. Helm had worked extensively in the Pacific northwest and Canada with his biofilter design. The distance and the proprietary nature of the cell construction may have contributed to some confusion and communication issues on this first installation which ultimately may have led to problems that were later encountered.

The design called for use of three single compartment concrete septic tanks without tops to be used as the basin in which the biofilters would be built. The tanks that arrived at the site were actually two compartment tanks that had a U shaped section of the inner wall removed. Each tank still retained a significant portion of the inner compartment wall. The tanks apparently had been constructed to "function" as single compartment septic tanks but retained the outer section of the wall to maintain tank integrity. Mr. Helm was anticipating actual single compartment tanks that could easily be lined with PVC so the Glendon Biofilter faced an immediate dilemma during installation. In retrospect it appears that this was simply a breakdown in communication and it's not entirely clear why something so apparently simple was a problem. However, this resulted in problems that were both expensive and took a long time to identify and correct.

During the installation there were essentially two alternatives considered for addressing the liner/tank dilemma. The first was to remove the remaining portion of the wall in the tanks so that the tanks would be as anticipated. Both Mr. Helm and the tank manufacturer had concerns about the structural integrity of the tanks if this was attempted which led to Mr. Helm's decision to simply place the liner on the outside of each biofilter cell.

The remainder of the installation was completed without issue and the cells were covered with sand. The homeowner had indicated a desire to landscape the mounds with low growing perennial vines rather than the clover which traditionally would have been seeded. A seeding of annual rye grass was made with straw mulch to protect the structures until the homeowners could complete their planting.

Based on design flows and water usage it was anticipated that the system would begin to generate effluent in about seven to ten days. The system was checked frequently in anticipation and almost immediately the system began to experience problems. Initially, there was no effluent and this condition continued for several weeks. By the fifth week effluent was observed in the apron sampling point which was designed to collect the effluent after completing treatment in the biofilter. This effluent was dark and cloudy with a distinct odor. Preliminary fecal coliform analyses indicated very high levels of coliforms in this effluent.

After discussions with Mr. Helm it was decided that it was most likely that there was a leak in the biofilter supply line such that the untreated sewage was finding its way to the sample collection area. To test this theory the installer pressure tested the system with air. Pressure was maintained throughout the test which led to the conclusion that there were no pipe leaks. However, the untreated effluent continued to be collected. Clearly the systems was not treating the sewage, but no one could provide a theory on what might be happening. Mr. Helm had never seen a Glendon Biofilter perform in this manner and had no suggestion but to dismantle and rebuild the biofilters.

In May 2000 Mr. Helm returned to Clermont County to assist the installer in dismantling and rebuilding the biofilters. When the cells were originally filled, the PCV liner had been wrapped around the outside of the tanks with the edges tucked back into the tank and down the inside walls of the tank about one third of the way. The cells were then filled with the sand and gravel mixture which held the liner in place. When the cells were emptied it was determined that the effluent was following the inside of the liner up and out of the cell without moving through the majority of the biofilter. Untreated effluent was collecting between the liner and the outside of the tank basin. Leaks in the liner would have accounted for the problems, but leaks could not be confirmed as the sole source of effluent.

To eliminate this problem, the PVC liner needed to be placed on the inside of the septic tanks but the original issue of the remaining inner wall was still a concern. In the end, the remaining wall was cut out so that the liner could be installed. The structural integrity of the tank did not pose a major hurtle at this point and it was assumed the PVC liner would ensure the watertightness that might be compromised by the removal of the wall. The 30 mil PVC liner did not fit snugly in the corners of the tank but it was folded as tightly as possible and the biofilters were rebuilt. The edges of the liner were folded over the lip and out of the septic tank into the sand covering each cell.

The system began to produce effluent in the time expected which was clear and odorless. The system continued to produce similar effluent for about a month at which time it was assumed that the repair was a success The homeowner was told to proceed with planting the special vegetative cover that they had chosen for the system.

Within a few months the effluent in the apron sampling point was again dark and cloudy with a strong odor. Fecal coliform results were in the range of 10^4 units per 100 ml. It appeared that the same problem had happened again although this seemed highly unlikely. Everyone, particularly Mr. Helm, was completely dumbfounded. There were no new theories and no explanation so the only recourse was to dismantle and rebuild the cells again.

In March 2001 Mr. Helm returned to Clermont to assist the installer in the second dismantling and rebuilding of the biofilters. A black biomass buildup was observed in the sand at each of the corners outside of the tanks but particularly on the far end of the third cell. Apparently the folded liner created channels which acted like straws through which the effluent could flow unobstructed and untreated to the sand outside of the biofilters. This "piping" phenomenon would have accounted for the original problems with the first set of liners. In addition, the third cell was found to be two inches lower at the far end and this contributed to a greater volume of untreated effluent in proximity to the sampling point.

To address the difference in levels the installer built up the back and side edges of the tank to create a lip that was level. The PVC liner was then cut below the lip on the inside of all the cells to prevent any piping up and out of the tank without moving through the sand. If any sewage pipes from the bottom of the tank to the top of the liner it will continue to move as designed through the treatment area of the sand rather than out of the tank without treatment.

After completing the repair the systems produced effluent of less than 100 fecal coliform units per 100 ml for several weeks until the very warm weather in April 2001 began evaporating the effluent before it reached the sampling point. The system continues under observation.

The second Glendon installed in October/November 2000, addressed the issues encountered in the first installation and repairs. In order to address the liner/tank issue the septic tanks were coated with a liquid rubber which eliminated the need for the PVC liner altogether and yet still ensured watertightness of the tank. This installation was uneventful and to date the system appears to be functioning as designed.

Lessons Learned on the Glendon

The primary problem was clearly the use of the PVC liner. This approach as attempted led to many problems as previously discussed. The use of the liner in the original system is still a concern and warrants long-term observation to be sure the effluent has not found yet another way to short circuit treatment. Any future Glendons installed would use the coated septic tank design rather than a PVC liner or an unlined concrete tank constructed to Glendon specifications. However, additional observation and testing of both Glendon systems is necessary before any additional systems will be installed. Unfortunately, sampling of the second Glendon did not begin during this 319 project period so the actual performance of the coated tanks is not documented in this report.

Another problem identified involves the sand cover. The second Glendon was completed late in the fall past the time when a good erosion control clover cover could be established. After some months, the straw placed over the cells to protect the seeding was thinning and the sand cover was beginning to show signs of erosion. The original Glendon had been built and rebuilt such that by March 2001 it was also without an adequate cover and subject to the same erosion concerns. In order to address this the Health District and the installer will be covering the cells with a coconut fiber erosion control blanket after reseeding with a suitable perennial mixture. This should provide sufficient erosion control until the cover can become well established. The loose mesh construction of the blanket also provides the ability to reseed if necessary without actually removing the blanket. Finally, homeowners wishing to landscape their cells can easily cut through the mesh to plant while still benefitting from the erosion control while their plantings become established. The erosion control blanket will become a mandatory component of the system design in any future Clermont County installations.

One concern with the system is the long-term integrity of the concrete septic tanks which serve as the basins for the biofilters. Insufficient data exists to determine the likelihood of cracks and leaks however, this reason alone is unlikely to exclude the system from consideration. At the present time Mr. Glen Helm is working to address this issue through the use of a preformed plastic tank or a concrete tank constructed to Glendon specifications.

As a result of the work under this 319 project the Glendon Biofilter is currently considered a future possible option for repairs on severe soils in Clermont County. Although more data needs to be collected on these demonstration systems before full-scale utilization, staff are optimistic about the potential of this simple system. Each biofilter has a relatively small footprint but because the system sits primarily above ground it is not a particularly attractive system. It is ideally suited for wooded lots where the biofilters can be installed out of the way and out of sight. However, the small footprint also makes the system a viable option on small lots where space constraints prevent installation of a more conventional system.

The Orenco Textile Recirculating Trickle Filter Experience

The first of Orenco's textile recirculating trickle filters, the AdvanTexRX-30 was installed in October 1999. The system was easily installed with no major installation issues noted. Several months after installation the homeowner began reporting a recurring alarm condition on their system. The alarm was a high water alarm but the reason for the high water condition was not easily identified. The homeowners simply disconnected the alarm which had become a nuisance to them but the high water conditions were continuing.

Sanitarians from the Health District investigated the situation and determined that all components appeared to be functioning yet the high water situation continued. Finally after many months and discussions with Orenco it was determined that the system was not pumping as designed although it apparently was pumping as programmed. Inconsistent volumes were being pumped such that the tank volume was never really emptied sufficiently to accommodate even normal flow. Orenco eventually indicated that they were replacing the program chip in the controller and that did resolve the problem. Since that time the original AdvanTex installed has been functioning without problem.

The second of Orenco's textile recirculating trickle filters, the AdvanTex AX-10 was installed in October 2000. The AX-10 would have undoubtedly been used in the first installation as well had it been available at the time but when the original selection was made only the RX-30 model was available. The decision to change models was based on two factors. Although both systems are marketed as residential systems, the AX-10 is a slightly smaller system designed to handle daily flows of up to 450 gpd versus the RX-30 design flows of up 600 gpd. The smaller system is adequately sized to handle most residential installations in Clermont County and it was hoped that the smaller system might realize some cost savings to homeowners. The second factor dealt with the media used in the AX-10 versus the RX-30. The media used in both models is made of the same synthetic fiber with the RX-30 the media in the form of random chips while in the AX-10 the media hangs in aligned sheets. According to Orenco, the media in both should last indefinitely. The hanging media is easily cleaned with a hose or pressure washer when excessive build up of solids occurs. The random chip style of the media is not conducive to cleaning so removal and replacement of some of the media on top may be required making the RX-30 maintenance somewhat more expensive and difficult.

There were no significant installation issues with the second Orenco textile recirculating trickle filter installed. Although the programming for the controller was different than the RX-30 there were no problems encountered with dosing volumes or high water alarms.

Lessons Learned about the AdvanTex

The AX-10 appears to be the more appropriate system for residential use and in fact, Orenco seems to be encouraging this as well. Both the RX-30 and the AX-10 were installed without issues and both systems performed as expected once programming issues were resolved. As a result of this project Clermont County is prepared to begin using the AdvanTex AX-10 under Ohio Department of Health experimental status for replacement installations at the present time.

Major Accomplishment #3: Sampling program initiated to evaluate 30 systems utilizing alternative technology and 4 systems utilizing innovative technology in order to order to obtain a snapshot of system performance in Clermont's most difficult soil type.

Alternative Systems

The sampling program established in the original project proposal required semi-annual sampling for the 30 alternative technology systems. This would have resulted in 10 systems sampled 6 times each, 10 systems sampled 4 times each, and 10 systems sampled 2 times each for a total of 120 samples. In actuality, over the course of the project the 30 alternative technology systems were sampled approximately 4 times for each system with a number of duplicate samples taken per the QAPP. Each system was sampled from the septic tank to determine influent strength, at the pump basin to determine effluent quality immediately following secondary treatment, and at the gradient drain to determine the quality of the effluent after lateral movement through the soil. During the second year of the project Clermont County experienced very low rainfall during most of the spring, summer and autumn making it impossible to obtain gradient drain samples. After many months of no sampling at all it was decided to take the samples that could be obtained even though gradient drain samples would not be obtained. As a result, a total of 127 influent samples, 124 pump basin samples and 98 gradient drain samples were obtained and analyzed. These 349 samples were analyzed for fecal coliforms, total phosphorus, ammonia, total suspended solids and BOD_5. A copy of all of the data generated is included in Appendix F.

Sampling Procedures

Per the terms of the 319 contract with Ohio EPA, a Quality Assurance Project Plan (QAPP) was developed and submitted covering all approaches and considerations connected to sampling and data generation. Although there was no input or comment from OEPA on the proposed project approach, every attempt was made to adhere to the plan as originally developed. A description of exactly how samples were obtained and handled is explained in detail in the QAPP. A copy of the original QAPP can be found in Appendix G.

Each alternative sewage system was sampled from three locations. In order to decrease the variability from site to site, sampling locations were chosen for their commonality with all other systems in the 319 study.

The first sample location was in the first compartment of the septic tank or ATU. This sample was intended to provide information on the influent to each system. A sub-surface grab sampler was used to obtain a liquid sample without contamination from the scum layer.

The second sample location was in the pump basin for dosing the modified mound, which immediately follows each system's secondary treatment device. Three of the technologies, the

SG-ATU, the FF-ATU Jr, and the PEAT filters were sampled at the inlet pipe into the dosing tank or the pump basin. These samples clearly reflected the effluent quality directly after secondary treatment. By design, the intermittent sand filter had to be sampled directly out of the pooling effluent in the pump basin.

Gradient drains were installed just outside the perimeter of each modified mound bed at least 24 inches below the original grade. Final samples were obtained from the gradient drains to determine if poorly treated effluent was reaching the ground water. Gradient drain samples were only obtained when gradient drain water was actually flowing.

Data Quality Issues

System failure in Clermont County is predominantly determined through observation. If all components of the treatment system are in place, the components are operating as designed, and there is no odor or visible sewage being discharged or surfacing in the yard, the system is considered to be operating as designed. If not, the system is considered to be failing. Actual sampling of system effluent is rarely done simply because there are neither sufficient funds nor personnel for ongoing sampling programs. The sampling program designed for this project was intended to support the observations that were made about each system. That is, if there was no obvious failure of a particular system did the data support the failing or not failing conclusion? Was treatment actually occurring or was the effluent simply being distributed and disposed? Last of all, the data provided a glimpse of the relative strength of the waste after secondary treatment to assist system designers in sizing of the modified mounds used after each secondary treatment unit.

There has been no attempt to compile the data into summary statistics such as mean or median concentrations for any systems or sample types nor would it be meaningful to do so. At best these sample results are "ballpark estimates." Data is good enough to see that there are differences between septic tank waste strength and gradient drain water and that there appears to be some differences between the ISF, FF-ATU, SG-ATU and PEAT.

All samples were obtained as grab samples. These samples do not necessarily represent the quality of the effluent at all times nor do they necessarily represent the entire septic tank, pump basin or gradient drain contents at the specific time of sampling. These results should not be used to evaluate treatment efficiencies of the four system types evaluated. However, the grab samples do provide a snapshot view of system performance and are useful in supporting basic design alterations.

The primary problem encountered during sampling was the lack of gradient drain samples on many of the sampling days. In fact, two systems had no flow in the gradient drains during any of the sampling events. At other times samples were obtained but problems in the drain were noted. This included obvious solids, grass clippings, animal nests, etc. These types of problems frequently accompanied spikes in gradient drain sample concentrations. Occasionally, sample analyses simply were not completed either because of an oversight by the lab or because there was insufficient sample to complete all analyses. In spite of the problems encountered the data do present a general overview of how the systems were performing.

Results

Summary graphs of the alterative system sampling can be seen on the following pages. The data was primarily used in two ways. First, as data was generated it became clear that the strength of effluent sampled from the pump basin after secondary treatment but prior to dosing to the modified mound was consistently higher strength from the SG-ATU and FF-ATU than from the ISF and PEAT systems. It was clear that the modified mound being used, which had originally been designed for the effluent anticipated from the ISF and PEAT systems, was marginally acceptable for use with the higher strength effluent. As a result, the modified mound used with the SG-ATU and FF-ATU systems was redesigned to increase the residence time prior to dispersal in the native soil.

The second way the data was used was to determine whether insufficiently treated sewage was reaching the gradient drain or if the systems were successfully treating the sewage and dispersing the effluent into the native soil. The data on the following pages compares the three sample locations analyzed for all alternative system types for fecal coliforms, total suspended solids, ammonia, biochemical oxygen demand, and total phosphorus. Ohio EPA's discharge limits identified in the proposed residential NPDES general permit is indicated on the gradient drain graph as a point of reference. A gross summary of the number of samples analyzed that met this standard for the pump basin samples and the gradient drain samples gives an quick snapshot of general system performance.

Percentage of Samples Analyzed Meeting OEPA General Permit Discharge Limit

System Type **Sample Location**	**Total *** **Samples**	**Fecal Coliforms**	**Total Suspended Solids**	**Ammonia**	**Biochemical Oxygen Demand**

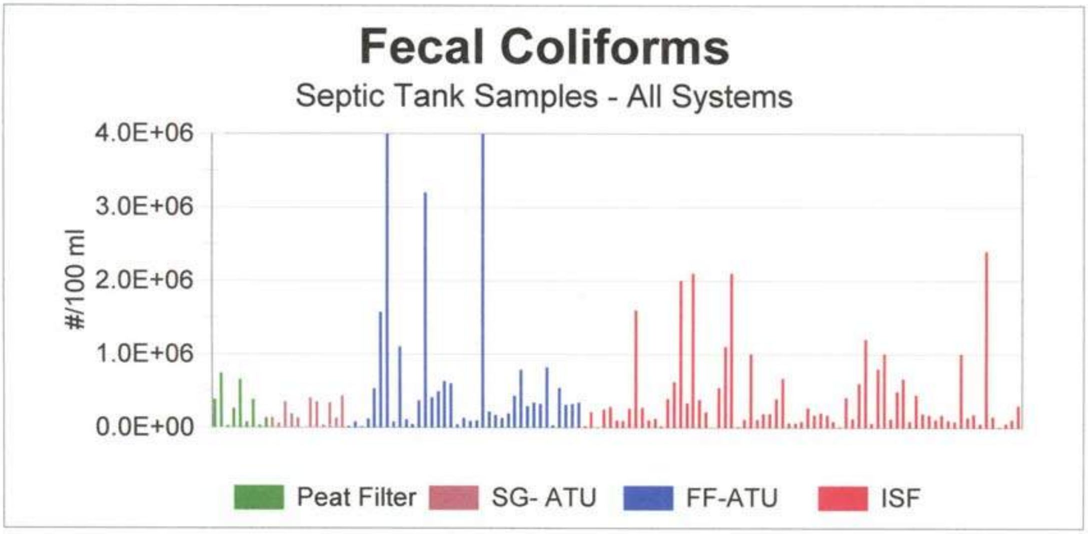
ISF Gradient Drain Pump Basin	46/47 68/69	96% 88%	96% 90%	98% 90%	100% 93%
FF-ATU Gradient Drain Pump Basin	24 37	100% 14%	79% 24%	100% 0%	100% 11%
SG-ATU Gradient Drain Pump Basin	8 10	100% 70%	100% 30%	100% 0%	100% 10%
PEAT Gradient Drain Pump Basin	8/7 9/8	88% 100%	71% 100%	100% 100%	100% 100%

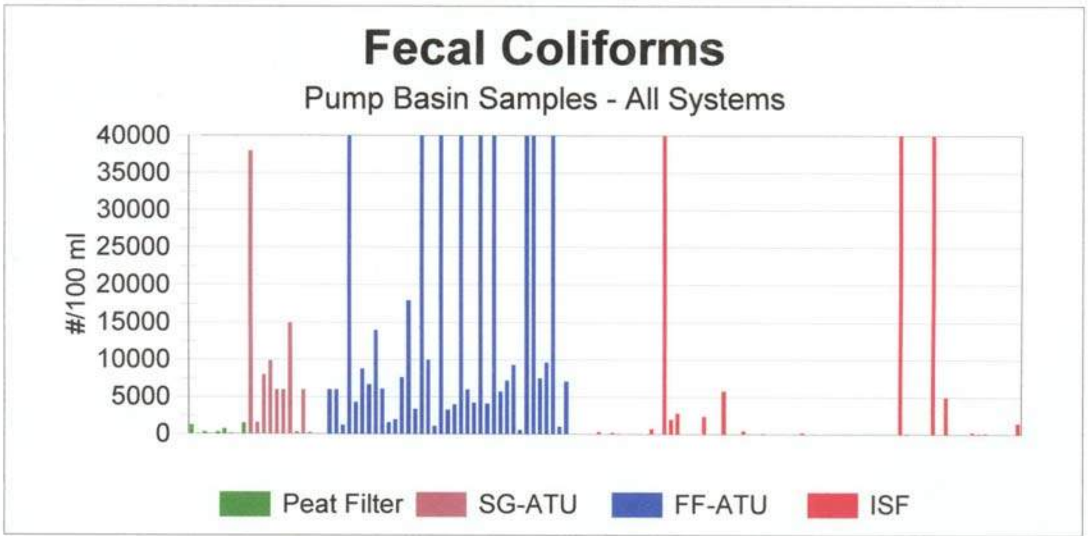
* Total number of samples may differ for fecal coliforms and all other analyses. These differences are designated as 46/47 where there were 46 samples analyzed for fecal coliforms and 47 samples analyzed for all other parameters.

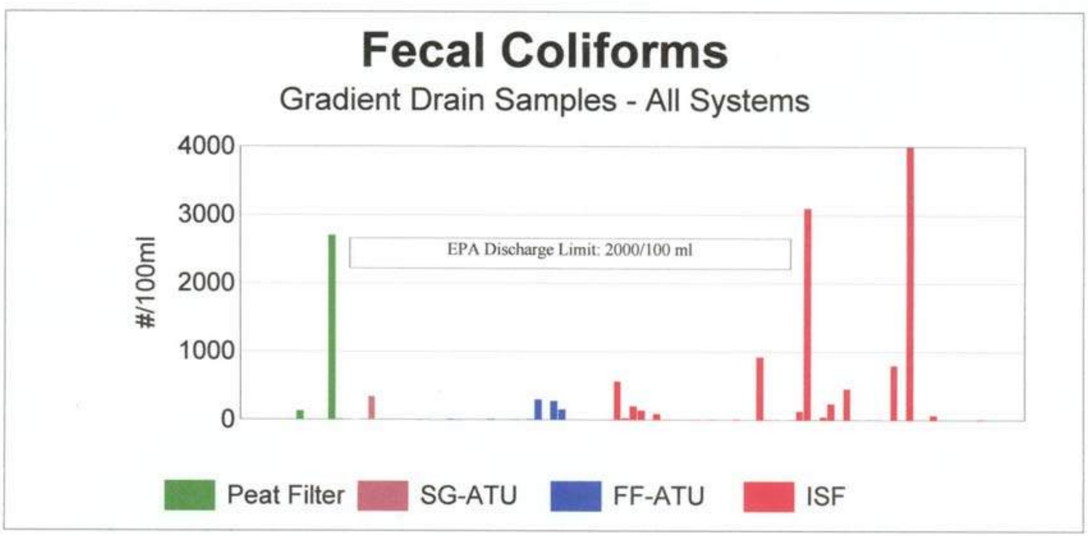
The pump basin samples represent the relative strength of the waste prior to being pumped to the modified mound. Clearly most samples from the FF-ATU and SG-ATU have higher concentrations of all parameters in the effluent from those treatment units. In the ISF systems 88% to 93% of the samples from the treatment unit would meet the OEPA discharge limit and in the PEAT 100% of the samples analyzed met the limits.

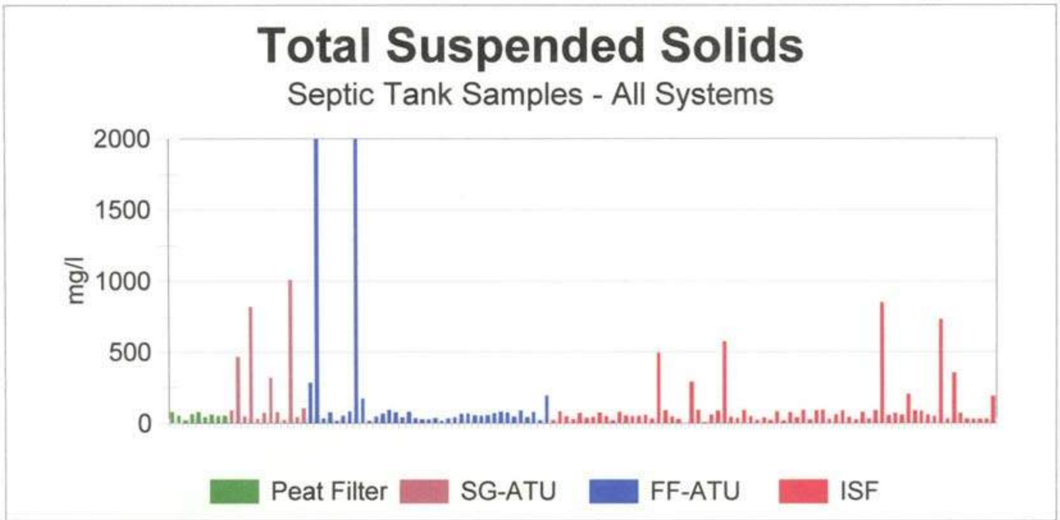
The gradient drain samples should represent the impact the effluent from the modified mound has on the groundwater. Since gradient drain samples are only obtained under saturated conditions, the effluent should always represent some component of this groundwater sample. What is unknown is the relative contribution from other sources such as animals, birds, gardens, etc. For the ISF and particularly for the FF-ATU and SG-ATU systems there is a significant increase in the number of samples that meet the OEPA limits for all parameters tested. It should be noted that the relatively small sample size for the FF-ATU systems and even more so for the SG-ATU's may be positively influencing these results. That is, if 60 or 70 samples had been analyzed it is likely that some percentage would not meet the limits simply from some non-system related influence like animals. This would certainly hold true for the PEAT samples as well but in an inverse way. That is, the percentage of PEAT gradient drain samples that meet the limits would probably increase if the sample size were greater. The fact that a lower percentage of fecal coliform and total suspended solids samples met the limit from gradient drain samples than from pump basin samples is probably indicative of non-system related contributions to the gradient drain.

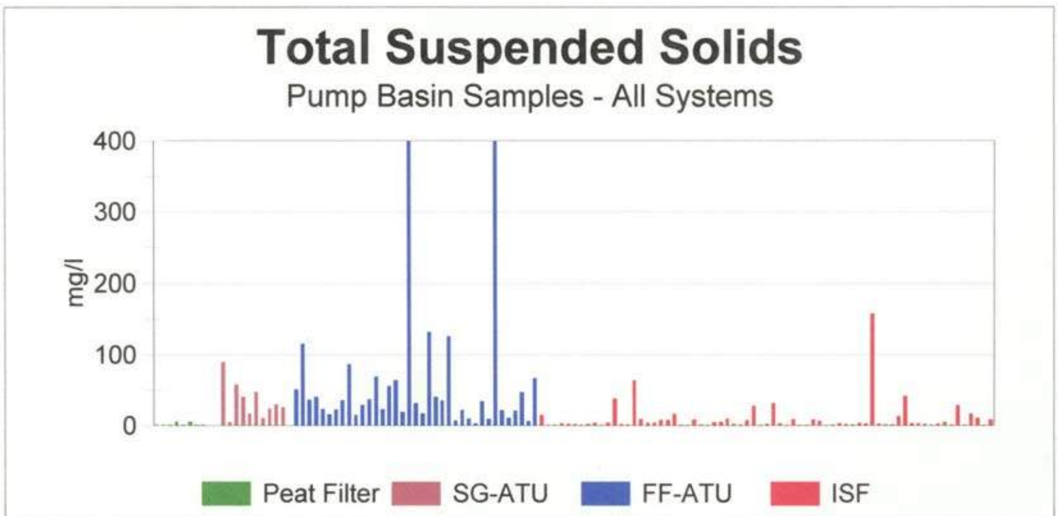
The observations that these systems were functioning as designed was confirmed by the data that was generated. All of this data used together provides sufficient assurance that these four system types perform adequately in the Clermont soils such that they will continue to be viable options for the most challenging lots.

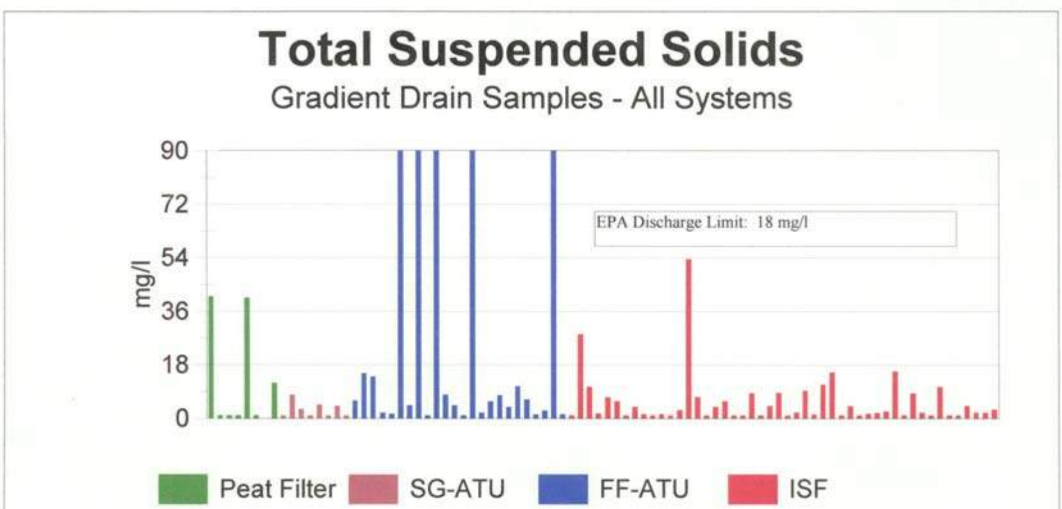

Fecal Coliforms
Septic Tank Samples - All Systems
#/100 ml
4.0E+06
3.0E+06
2.0E+06
1.0E+06
0.0E+00
Peat Filter
SG- ATU
FF-ATU
ISF

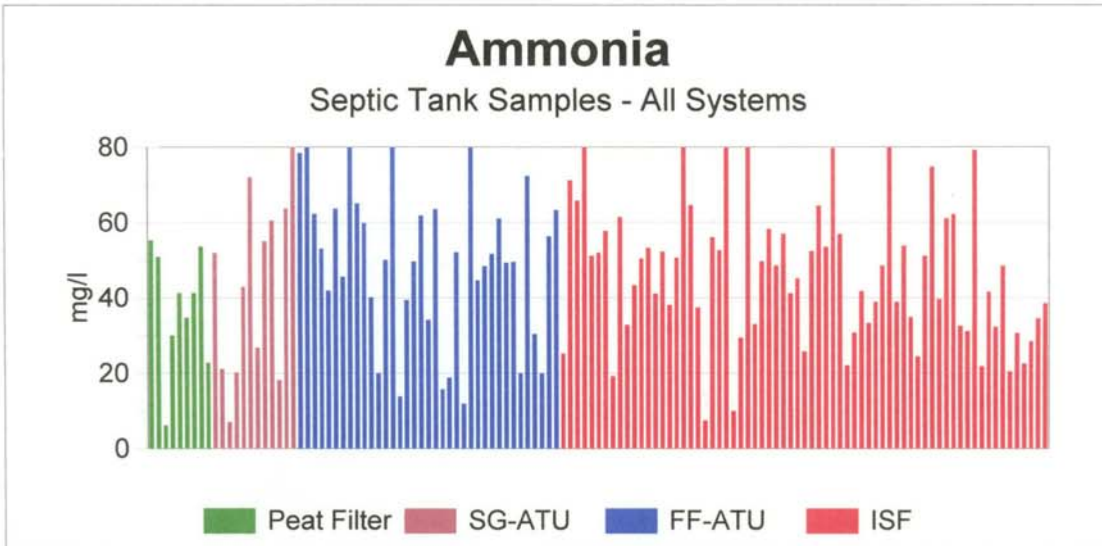

Fecal Coliforms
Pump Basin Samples - All Systems
#/100 ml
40000
35000
30000
25000
20000
15000
10000
5000
0
Peat Filter
SG-ATU
FF-ATU
ISF

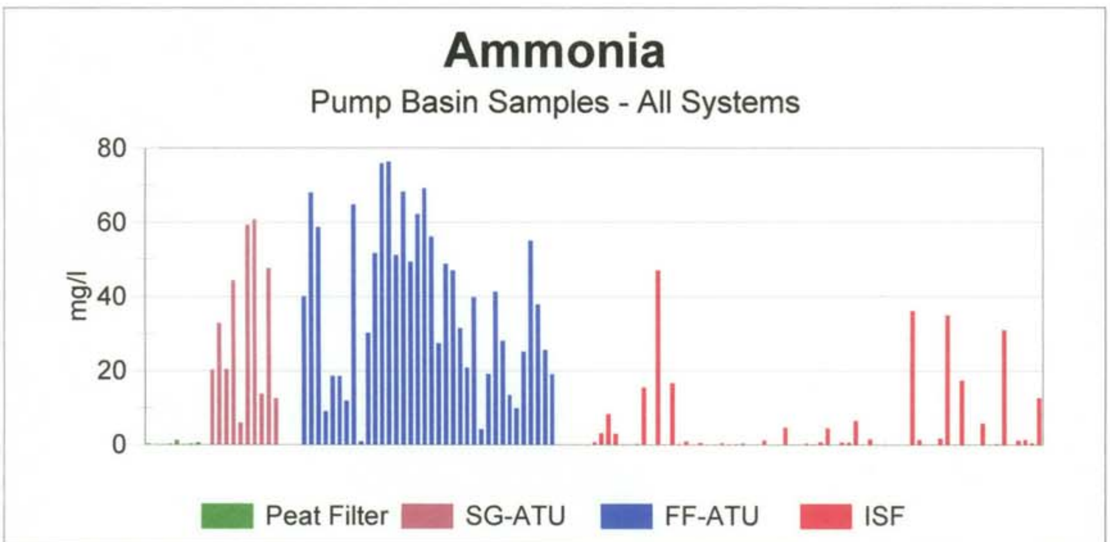

Fecal Coliforms
Gradient Drain Samples - All Systems
#/100ml
4000
3000
2000
1000
0
EPA Discharge Limit: 2000/100 ml
Peat Filter
SG-ATU
FF-ATU
ISF

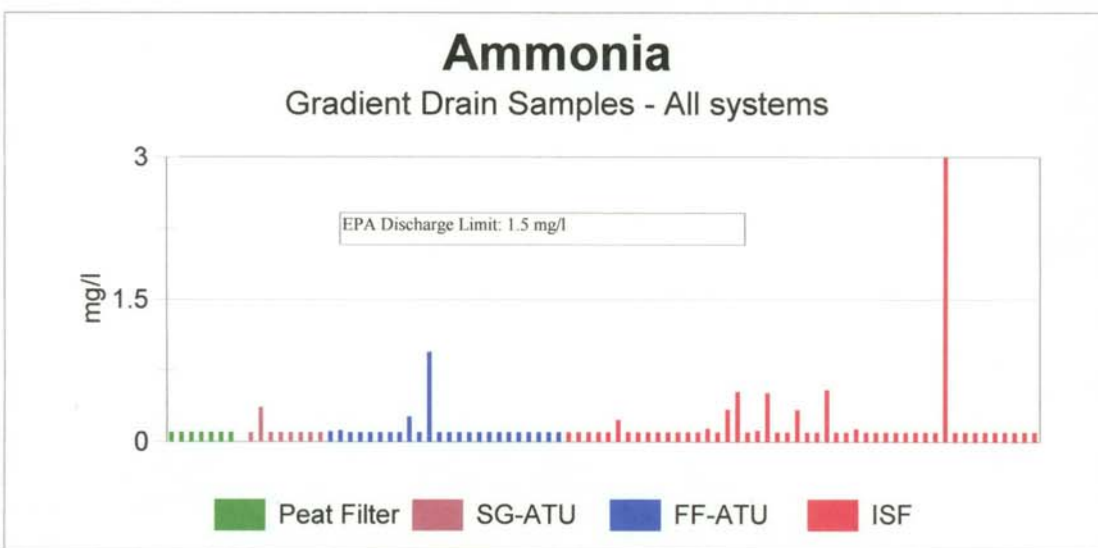

Total Suspended Solids
Septic Tank Samples - All Systems
2000
1500
1000
500
0
mg/l
Peat Filter
SG-ATU
FF-ATU
ISF

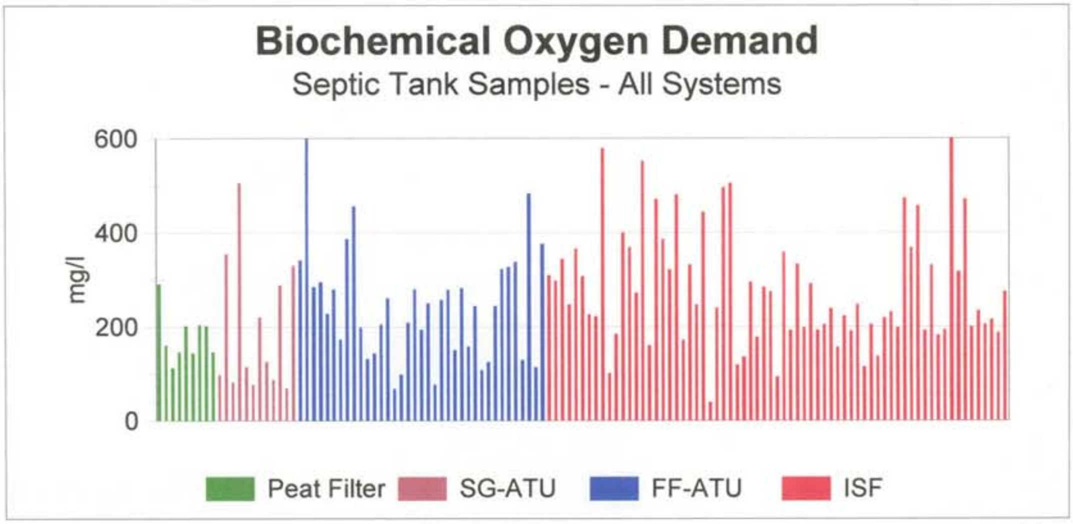

Total Suspended Solids
Pump Basin Samples - All Systems
400
300
200
100
0
mg/l
Peat Filter
SG-ATU
FF-ATU
ISF

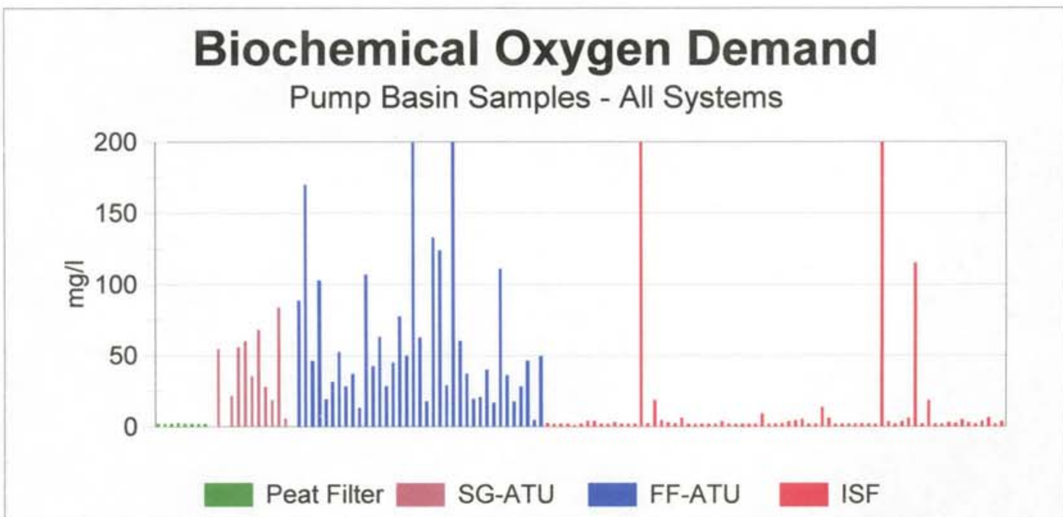

Total Suspended Solids
Gradient Drain Samples - All Systems
90
72
54
36
18
0
mg/l
EPA Discharge Limit: 18 mg/l
Peat Filter
SG-ATU
FF-ATU
ISF

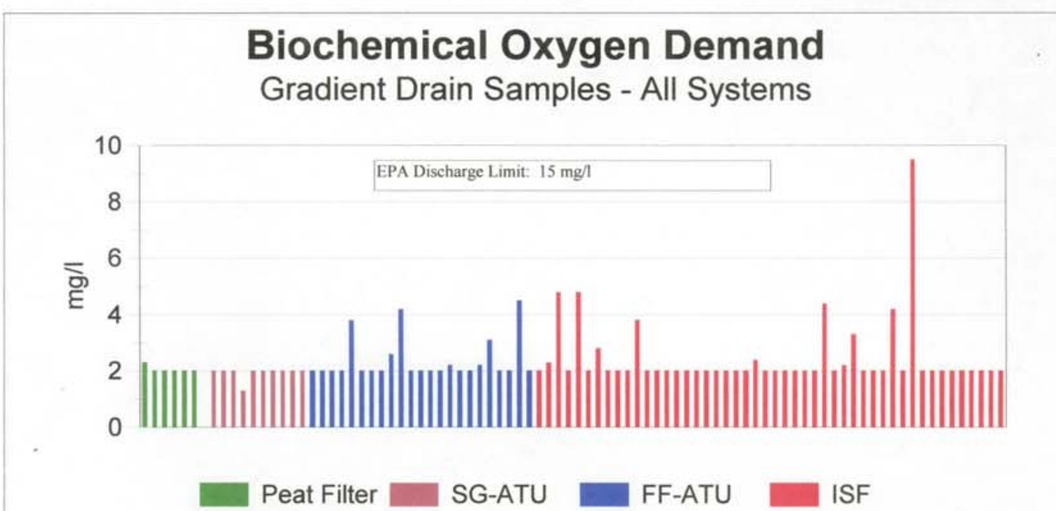

Ammonia
Septic Tank Samples - All Systems
80
60
40
20
0
mg/l
Peat Filter
SG-ATU
FF-ATU
ISF

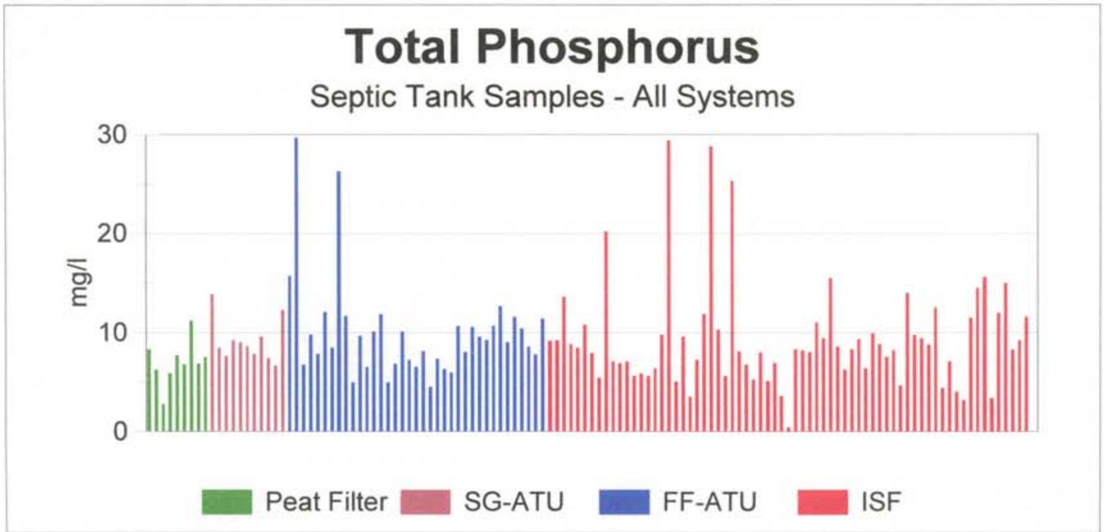

Ammonia
Pump Basin Samples - All Systems
80
60
40
20
0
mg/l
Peat Filter
SG-ATU
FF-ATU
ISF


Ammonia
Gradient Drain Samples - All systems
3
1.5
0
mg/l
EPA Discharge Limit: 1.5 mg/l
Peat Filter
SG-ATU
FF-ATU
ISF

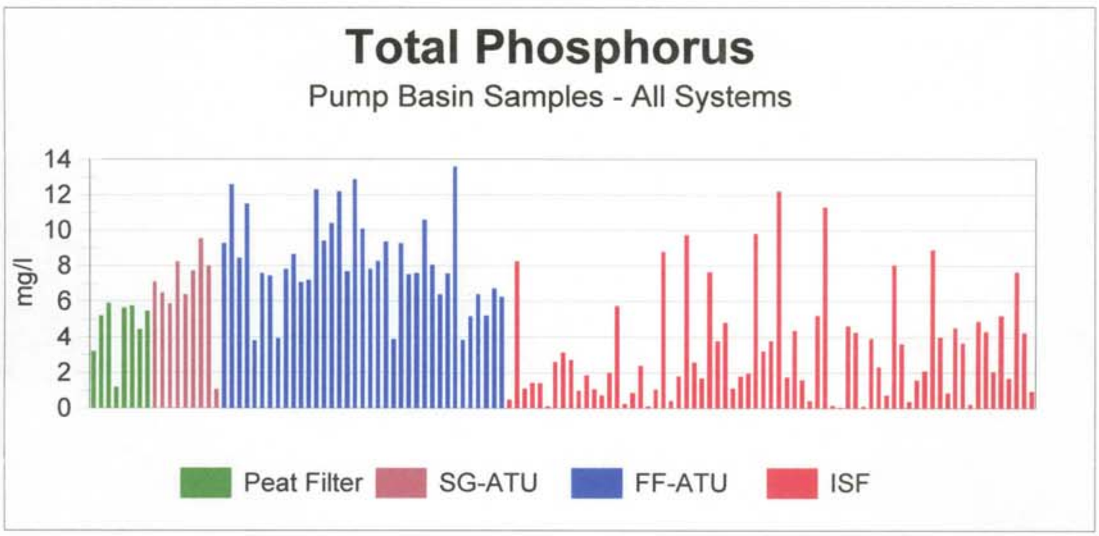

Biochemical Oxygen Demand
Septic Tank Samples - All Systems
600
400
200
0
mg/l
Peat Filter
SG-ATU
FF-ATU
ISF


Biochemical Oxygen Demand
Pump Basin Samples - All Systems
200
150
100
50
0
mg/l
Peat Filter
SG-ATU
FF-ATU
ISF

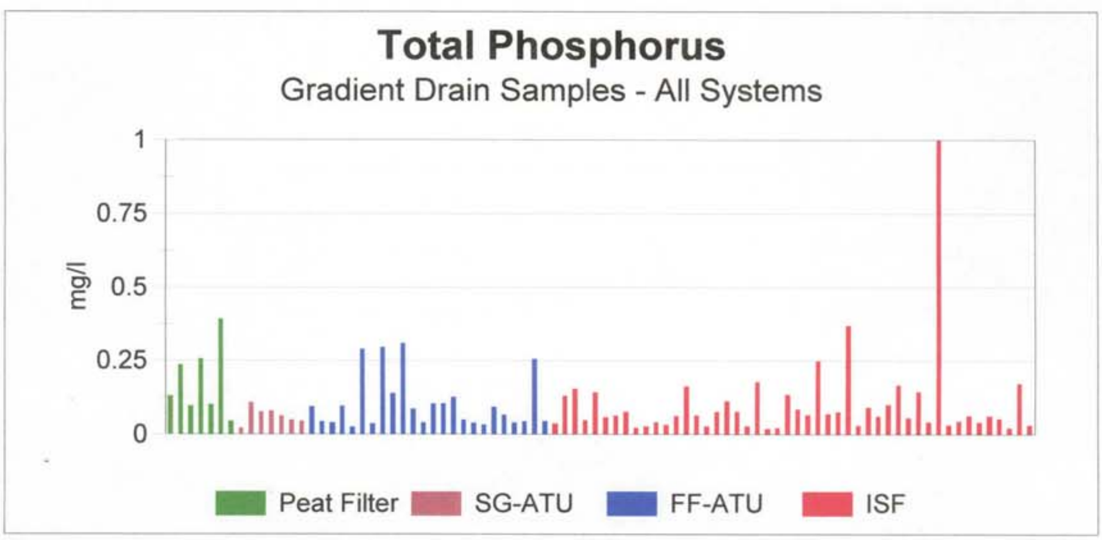

Biochemical Oxygen Demand
Gradient Drain Samples - All Systems
10
8
6
4
2
0
mg/l
EPA Discharge Limit: 15 mg/l
Peat Filter
SG-ATU
FF-ATU
ISF



Total Phosphorus
Septic Tank Samples - All Systems
mg/l
0
10
20
30
Peat Filter
SG-ATU
FF-ATU
ISF



Total Phosphorus
Pump Basin Samples - All Systems
mg/l
0
2
4
6
8
10
12
14
Peat Filter
SG-ATU
FF-ATU
ISF



Total Phosphorus
Gradient Drain Samples - All Systems
mg/l
0
0.25
0.5
0.75
1
Peat Filter
SG-ATU
FF-ATU
ISF

Demonstration Systems

The original sampling program established a monthly sampling schedule for the innovative technology systems. After the first Glendon Biofilter and the ISF sand filter were installed in 1999 there were immediate problems with the systems so sampling startup was postponed until the issues could be resolved. Although the issues with both systems were resolved in 2000, sampling didn't really begin until late 2000 after the second Glendon Biofilter and the second sand filter systems were installed. As a result, only the two recirculating trickle filters and the first Glendon installed were actually sampled during this project. A total of 79 samples were analyzed primarily obtained during the last three months of this project.

Sampling Procedures

The Glendon Biofilter system was sampled in four locations. Grab samples were obtained from the septic tank in order to provide information on the relative strength of the sewage being treated in the systems. The third filter for each system was designed to collect all effluent from that cell as it drains to an apron area of the system. This grab sample provided a snapshot of the effluent quality immediately after being treated by the biofilters. A third sample was obtained from the drop box of the gradient drain surrounding the system. This sample provided an idea of the quality of the effluent as it migrated through the soil. Finally, a fourth sample was obtained from a duplicate gradient drain which was installed next to but above the drainage area for the system. This sample was intended to provide background data on the groundwater quality at the site.

AdvanTex systems were each sampled slightly differently because the treatment flow varied between the two models. In the first AdvanTex, the RX-30, samples were obtained from the septic tank, the gradient drain and duplicate gradient drain in the same manner as the Glendon's to gauge influent strength, final effluent impact on the groundwater, and background groundwater quality. At the Health District's request , Orenco modified the treatment process somewhat in the RX-30 in order to use a single pump in the system. All of the effluent from the filter is diverted back to the septic tank where it receives further treatment. A secondary recirc/blend chamber blends the treated effluent with the raw influent. This blended effluent is then split with most of the blended effluent flowing back to the filter for additional treatment and the remainder pumped to the modified mound. A fourth sample was obtained of the blended effluent which represents both the strength of the effluent as it enters the filter and the strength of the effluent being pumped to the modified mound.

The AX-10 had a more conventional flow and the four sampling locations essentially match those of the advanced technology systems. Effluent from the filter was either recirculated to the second compartment of the septic tank or flowed directly to the modified mound. The septic tank was sampled to gauge influent strength, the pump basin immediately following the filter was sampled to measure the quality of the effluent flowing to the modified mound, the gradient drain was sampled to determine the system's impact on the groundwater, and a background gradient drain was sampled to determine background groundwater quality.

Data Quality Issues

There are several data quality issues with the demonstration system samples that should be noted and considered when reviewing the results obtained. The first is that sampling was initiated very late in the course of the project such that the eight to nine sampling dates represent only a three month period in early 2001. In addition, no background samples were ever obtained on the RX-30 system nor are they ever likely to be obtainable. Unfortunately, the duplicate gradient drain was installed such that it is directly next to and down grade from both the system and the primary gradient drain. Groundwater flows to the primary gradient drain before it ever reaches the duplicate drain making background estimates impossible to obtain.

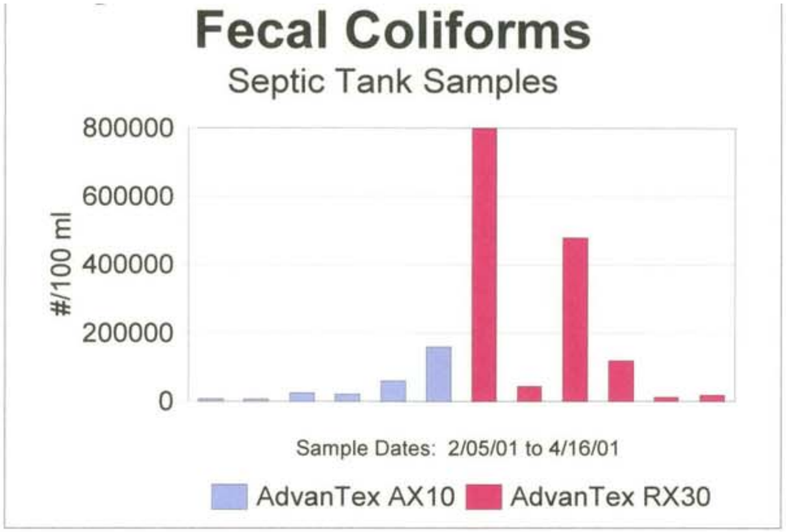
As with the alternative systems and for the same reasons there has been no attempt to compile the data into summary statistics such as mean or median concentrations for any systems or sample types nor would it be meaningful to do so. Data is good enough to see that there are differences between septic tank waste strength and gradient drain sample strength and where spikes in background sample strength are similar to gradient drain samples.

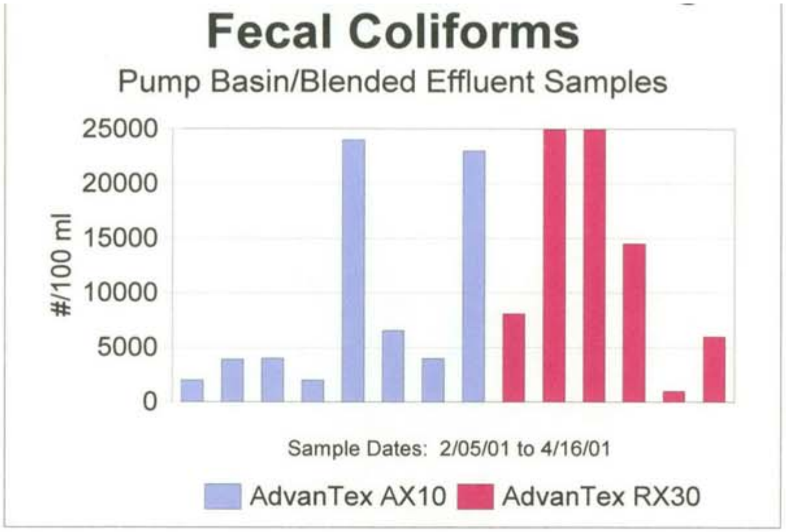
As mentioned earlier, all samples were obtained as grab samples. These samples do not necessarily represent the quality of the effluent at all times nor do they necessarily represent the entire septic tank, pump basin or curtain drain contents at the specific time of sampling. These results should not be used to evaluate treatment efficiencies of the two system types evaluated. However, the grab samples do provide a snapshot view of system performance and are useful in supporting basic design alterations.

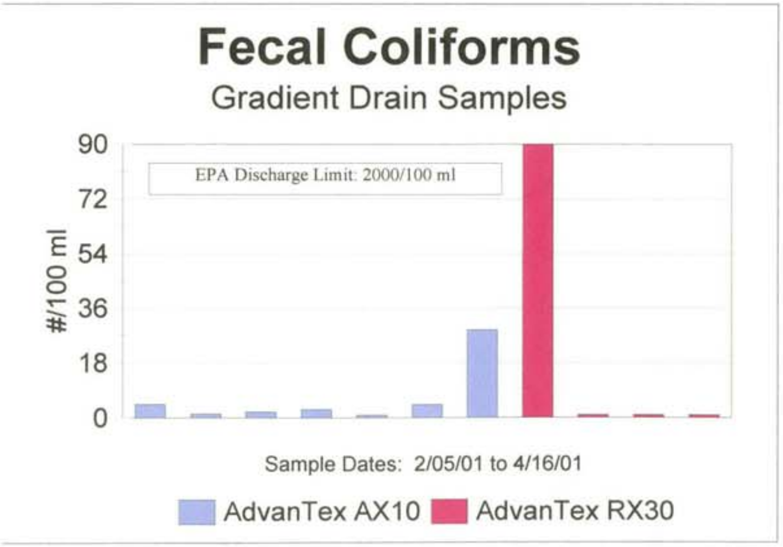
Results

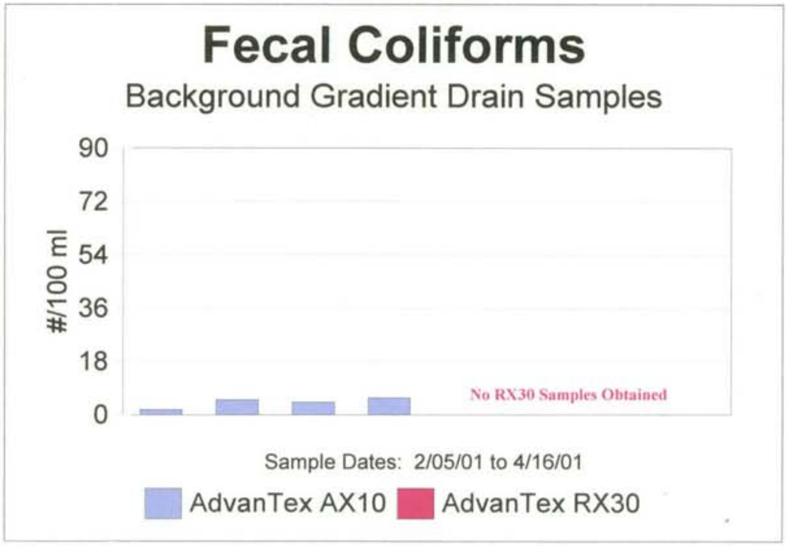
Summary graphs of the data generated to date can be seen on the following pages. The actual data results are attached in Appendix F. The most striking result is the failure of the AX-10 to successfully remove ammonia as indicated in the gradient drain samples. This is likely the result of the choice to recirculate filter effluent to the second compartment rather than to the first compartment where conditions would promote increased nitrogen removal. In the RX-30 where filter effluent was recirculated to the first compartment the ammonia levels were below the detectable limits in all samples that were obtained. For the remaining parameters, background and gradient drain samples were not significantly different and all were below OEPA limits.

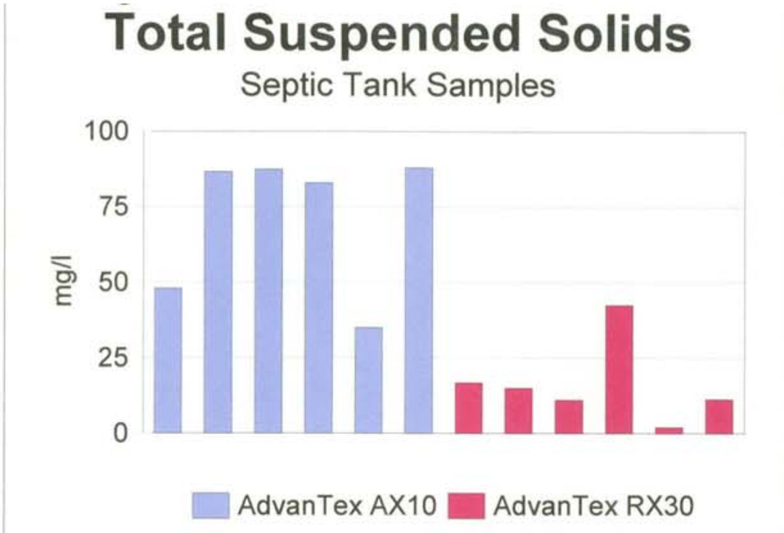
Neither the Glendon systems or the AdvanTex systems have been sampled sufficiently to provide a strong assurance of adequate system performance over time. All systems will continue to be sampled and reviewed over the course of the next several years.

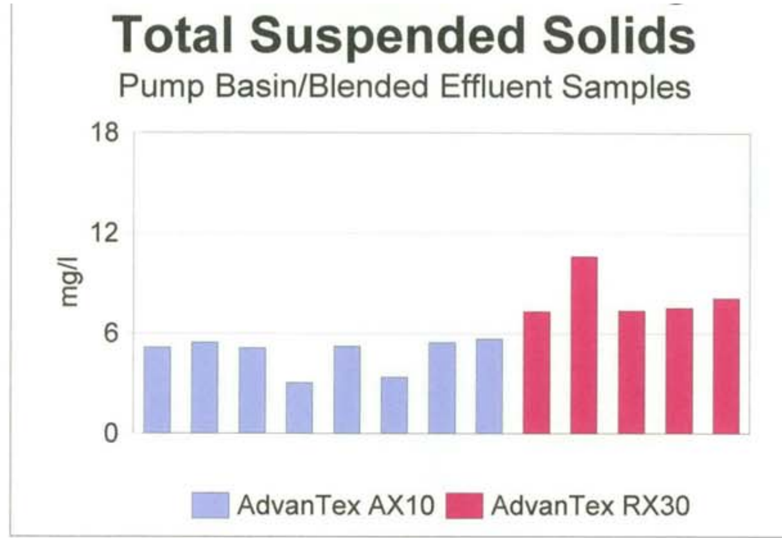

Fecal Coliforms
Septic Tank Samples
800000
600000
400000
200000
0
#/100 ml
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

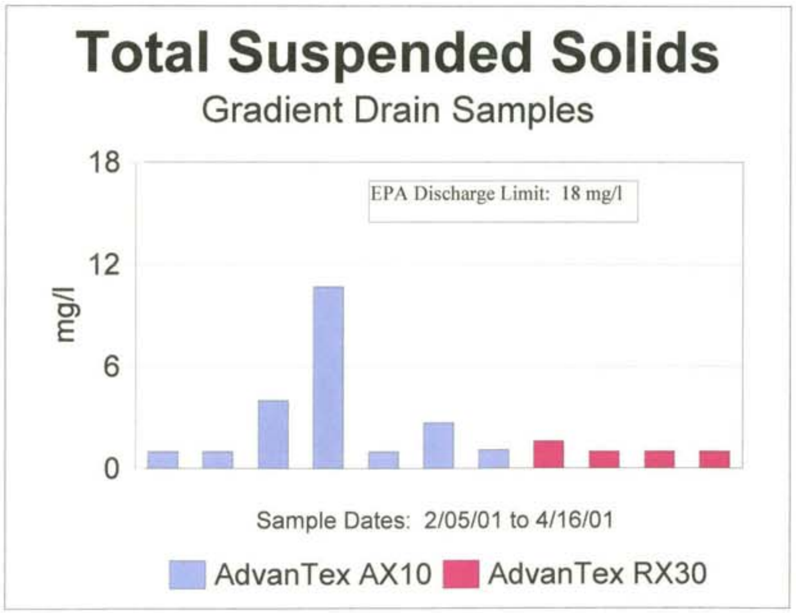

Fecal Coliforms
Pump Basin/Blended Effluent Samples
25000
20000
15000
10000
5000
0
#/100 ml
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

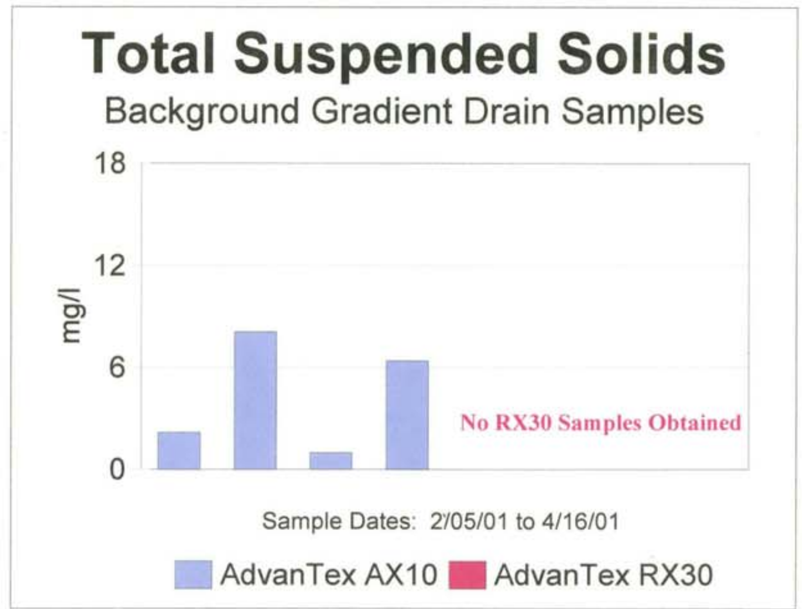

Fecal Coliforms
Gradient Drain Samples
90
72
54
36
18
0
#/100 ml
EPA Discharge Limit: 2000/100 ml
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

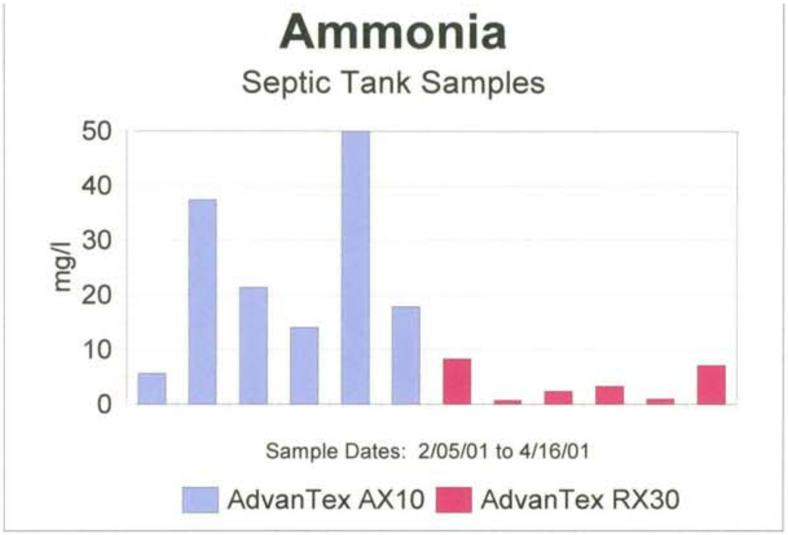

Fecal Coliforms
Background Gradient Drain Samples
90
72
54
36
18
0
#/100 ml
No RX30 Samples Obtained
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

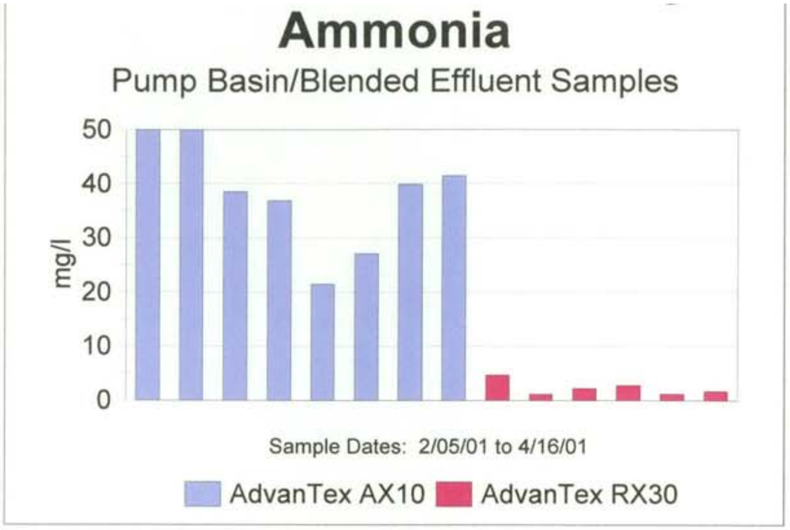

Total Suspended Solids
Septic Tank Samples
100
75
50
25
0
mg/l
AdvanTex AX10
AdvanTex RX30

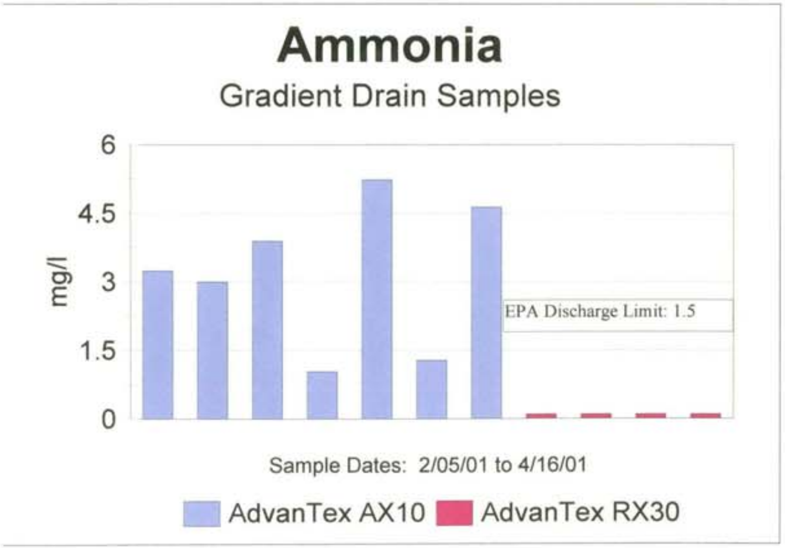

Total Suspended Solids
Pump Basin/Blended Effluent Samples
18
12
6
0
mg/l
AdvanTex AX10
AdvanTex RX30

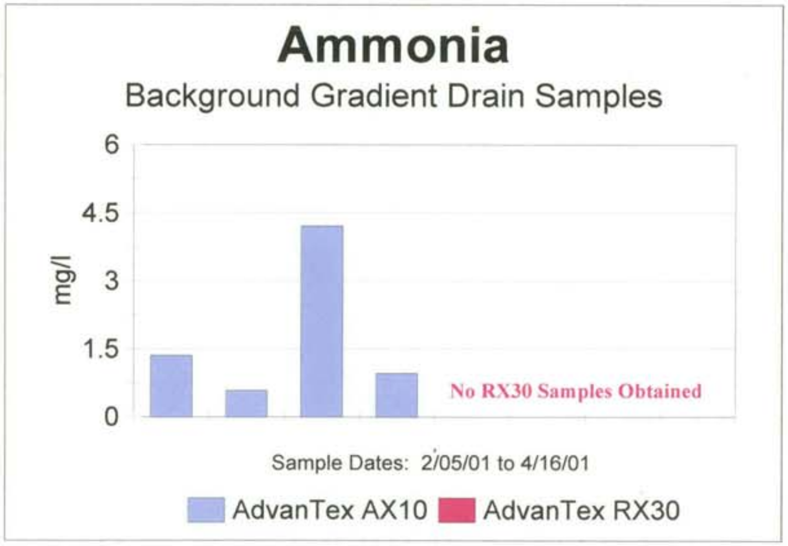

Total Suspended Solids
Gradient Drain Samples
18
12
6
0
mg/l
EPA Discharge Limit: 18 mg/l
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

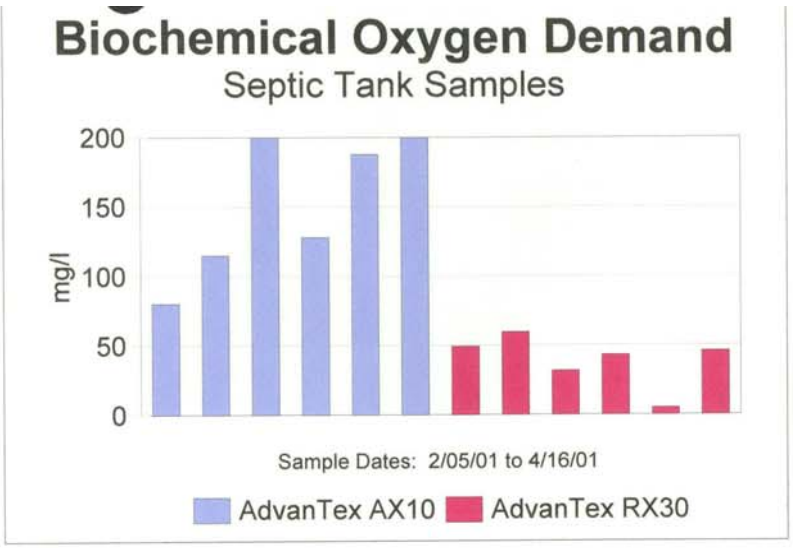

Total Suspended Solids
Background Gradient Drain Samples
18
12
6
0
mg/l
No RX30 Samples Obtained
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

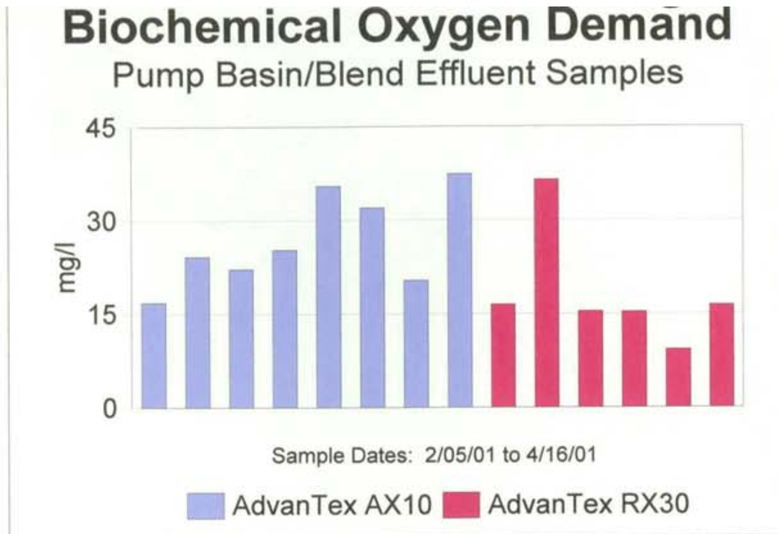

Ammonia
Septic Tank Samples
50
40
30
20
10
0
mg/l
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

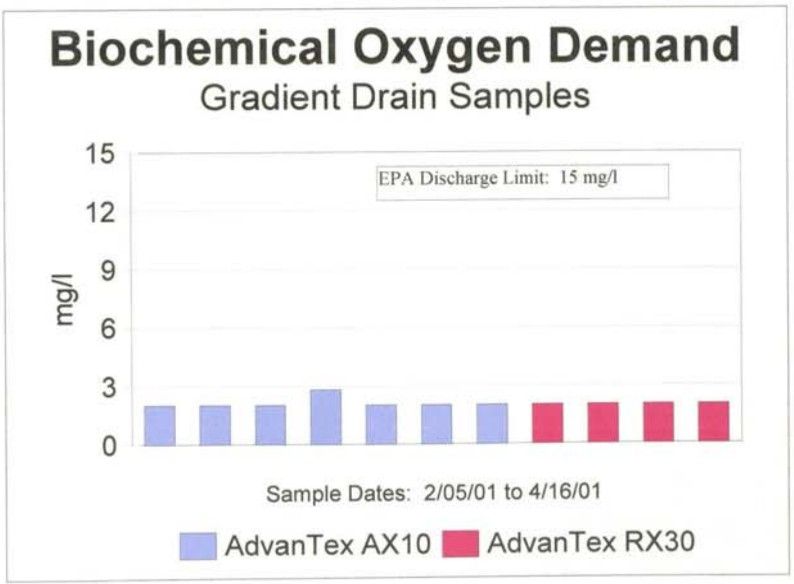

Ammonia
Pump Basin/Blended Effluent Samples
50
40
30
20
10
0
mg/l
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

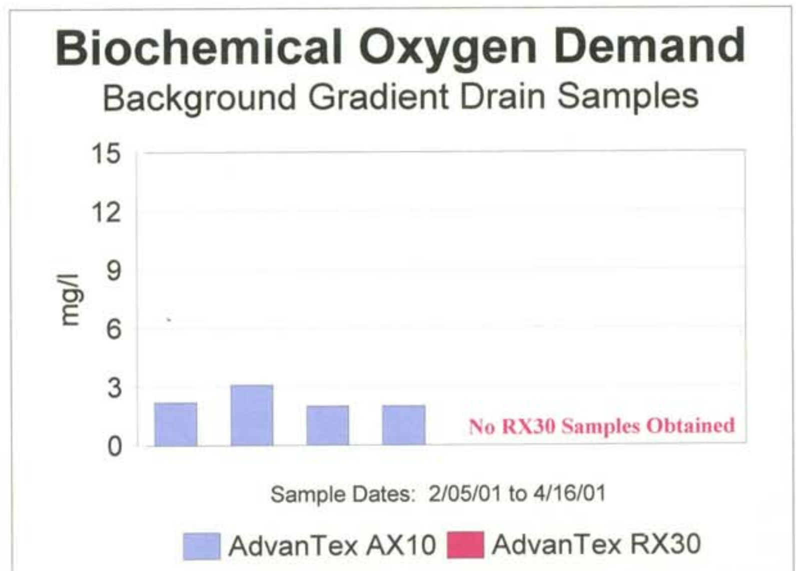

Ammonia
Gradient Drain Samples
6
4.5
3
1.5
0
mg/l
EPA Discharge Limit: 1.5
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

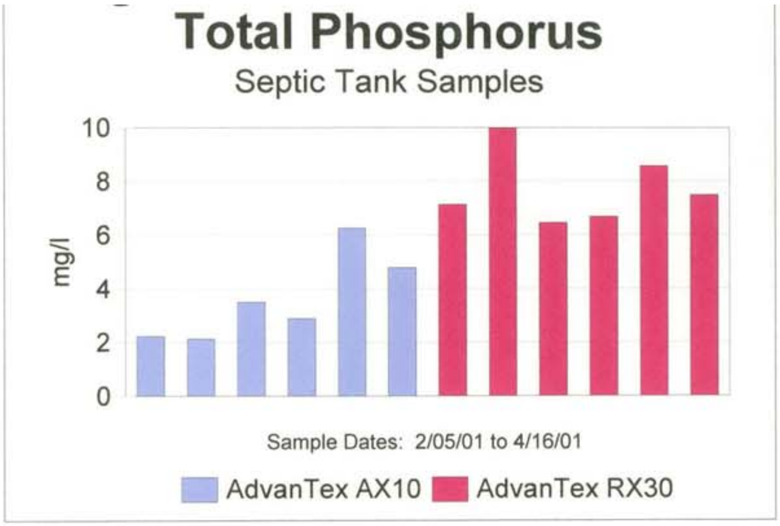

Ammonia
Background Gradient Drain Samples
6
4.5
3
1.5
0
mg/l
No RX30 Samples Obtained
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

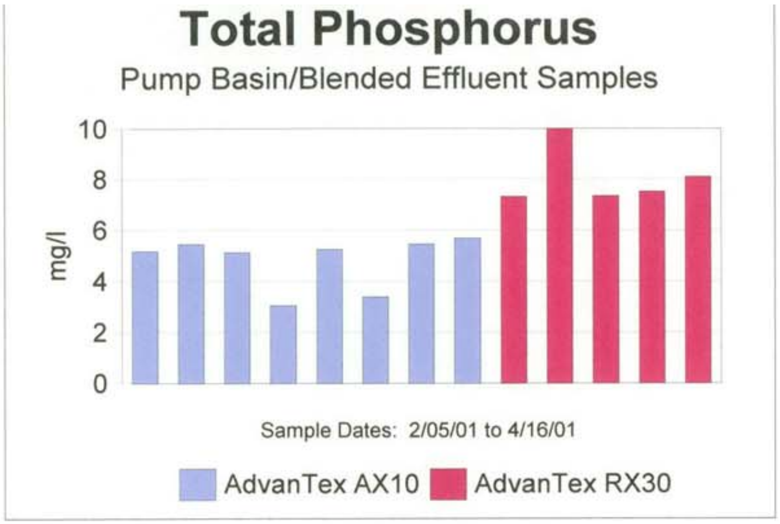

Biochemical Oxygen Demand
Septic Tank Samples
200
150
100
50
0
mg/l
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

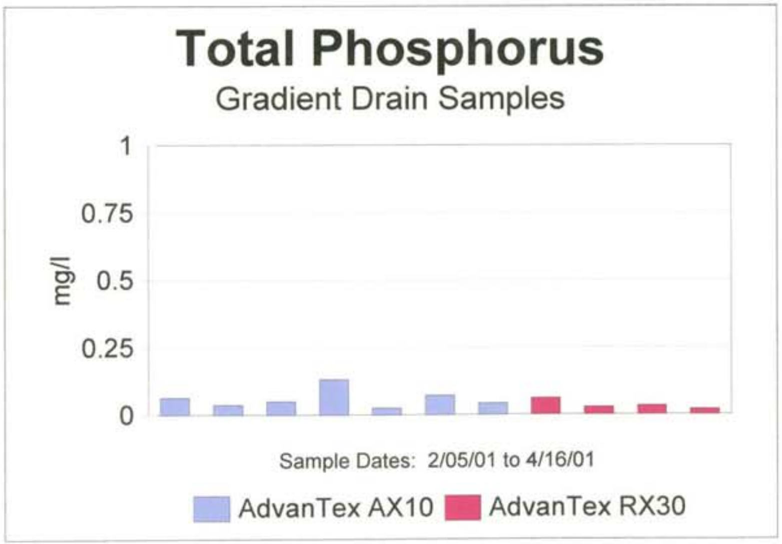

Biochemical Oxygen Demand
Pump Basin/Blend Effluent Samples
45
30
15
0
mg/l
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

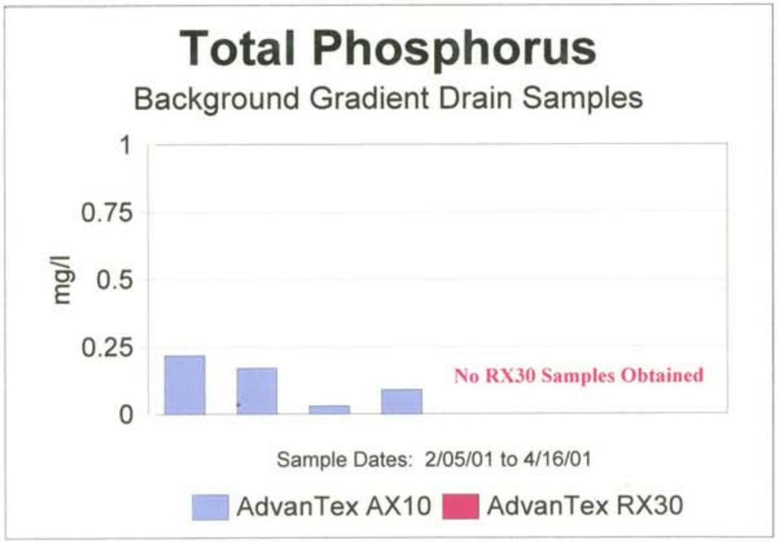

Biochemical Oxygen Demand
Gradient Drain Samples
15
12
9
6
3
0
mg/l
EPA Discharge Limit: 15 mg/l
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

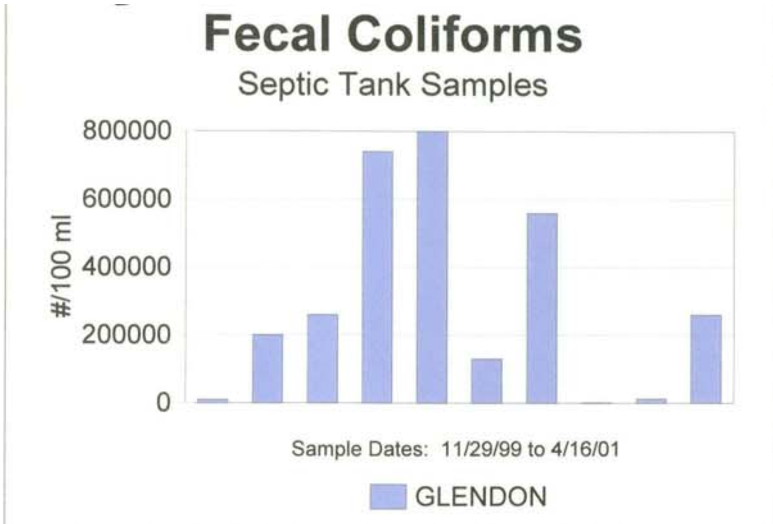

Biochemical Oxygen Demand
Background Gradient Drain Samples
15
12
9
6
3
0
mg/l
No RX30 Samples Obtained
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

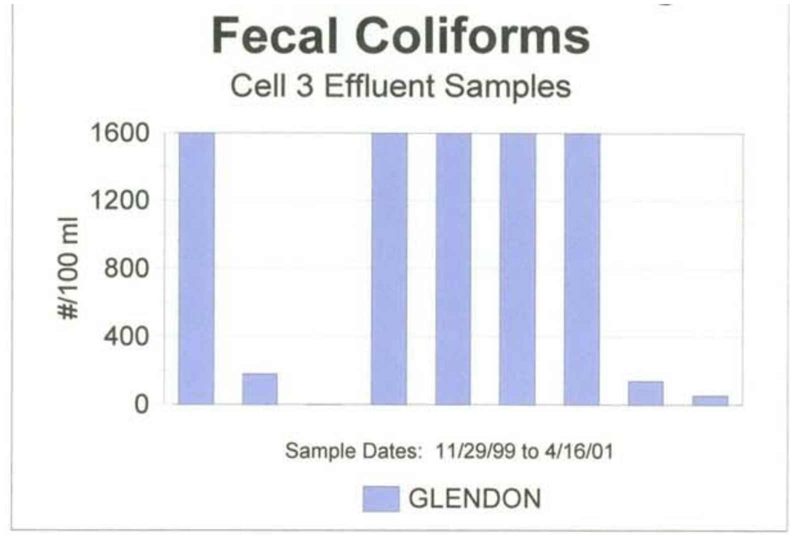

Total Phosphorus
Septic Tank Samples
10
8
6
4
2
0
mg/l
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

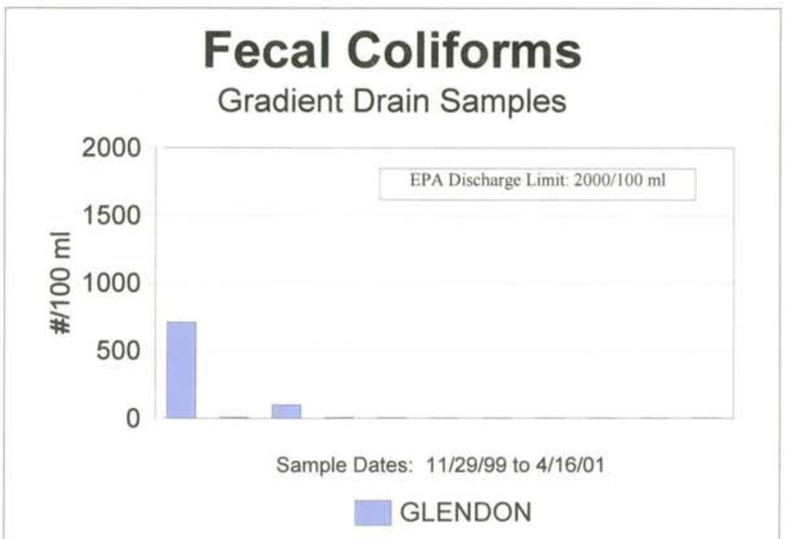

Total Phosphorus
Pump Basin/Blended Effluent Samples
10
8
6
4
2
0
mg/l
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

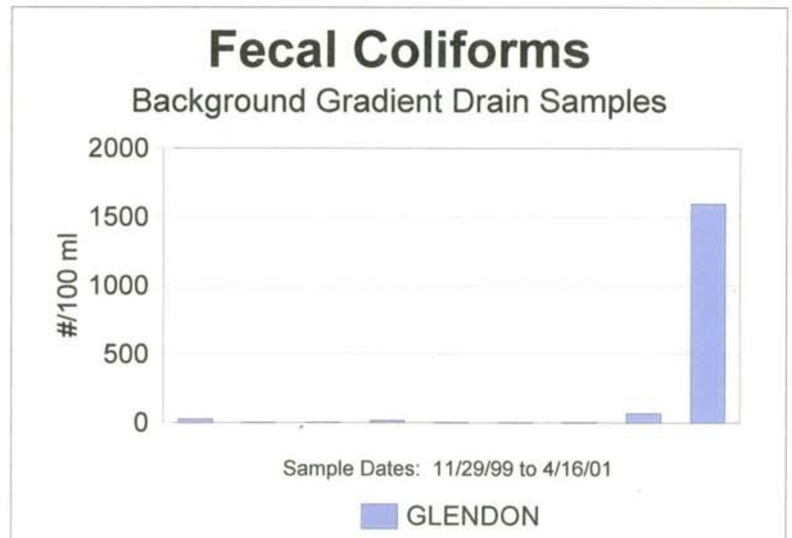

Total Phosphorus
Gradient Drain Samples
1
0.75
0.5
0.25
0
mg/l
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

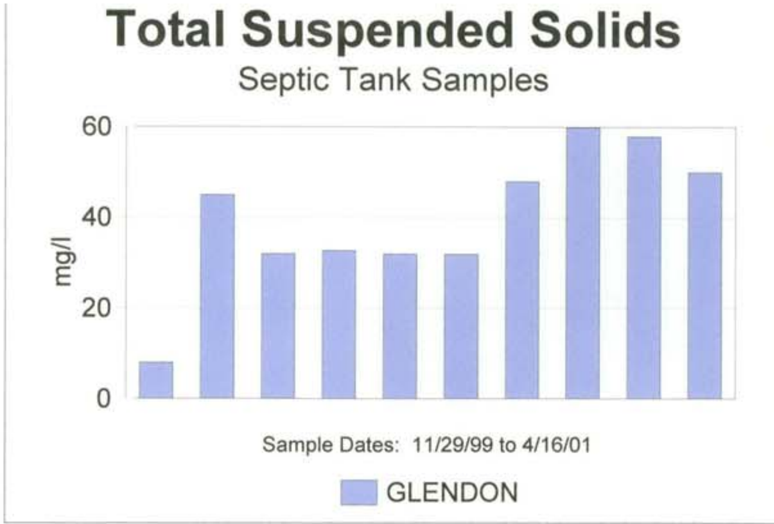

Total Phosphorus
Background Gradient Drain Samples
1
0.75
0.5
0.25
0
mg/l
No RX30 Samples Obtained
Sample Dates: 2/05/01 to 4/16/01
AdvanTex AX10
AdvanTex RX30

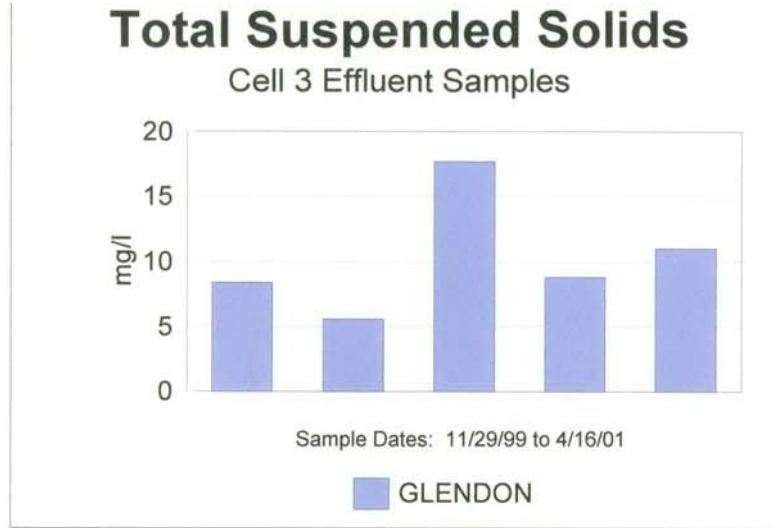

Fecal Coliforms
Septic Tank Samples
#/100 ml
800000
600000
400000
200000
0
Sample Dates: 11/29/99 to 4/16/01
GLENDON

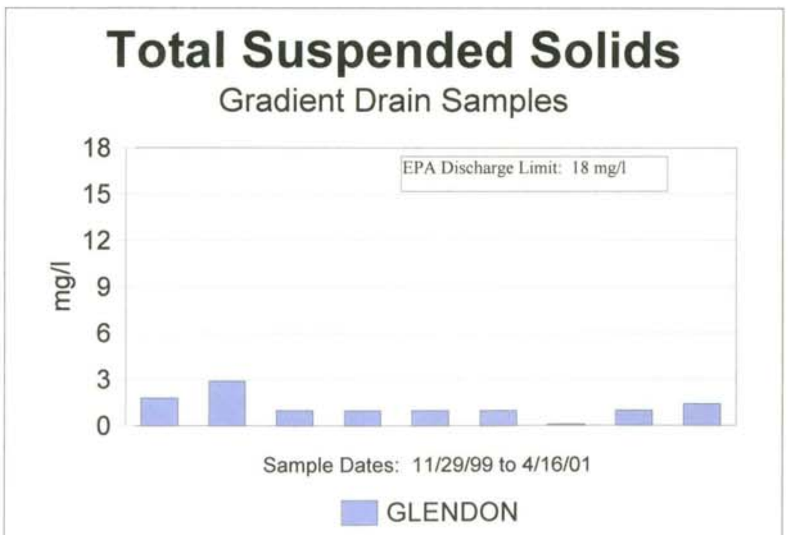

Fecal Coliforms
Cell 3 Effluent Samples
#/100 ml
1600
1200
800
400
0
Sample Dates: 11/29/99 to 4/16/01
GLENDON

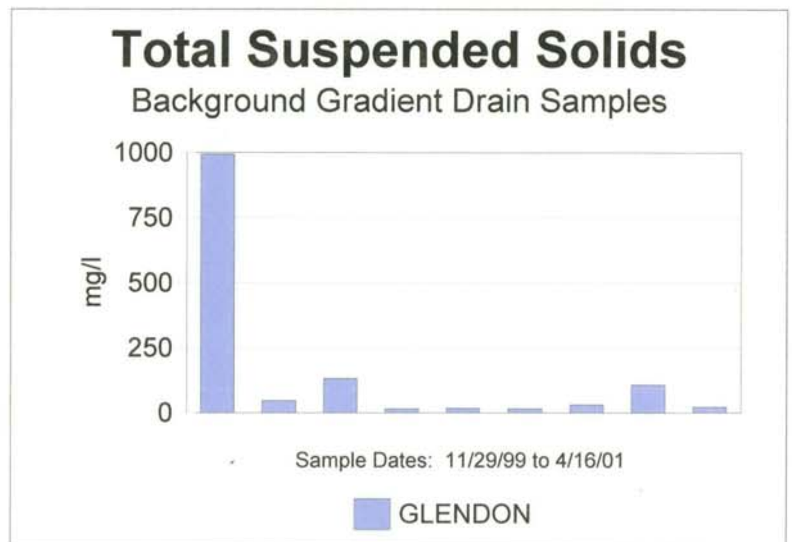

Fecal Coliforms
Gradient Drain Samples
#/100 ml
2000
1500
1000
500
0
EPA Discharge Limit: 2000/100 ml
Sample Dates: 11/29/99 to 4/16/01
GLENDON

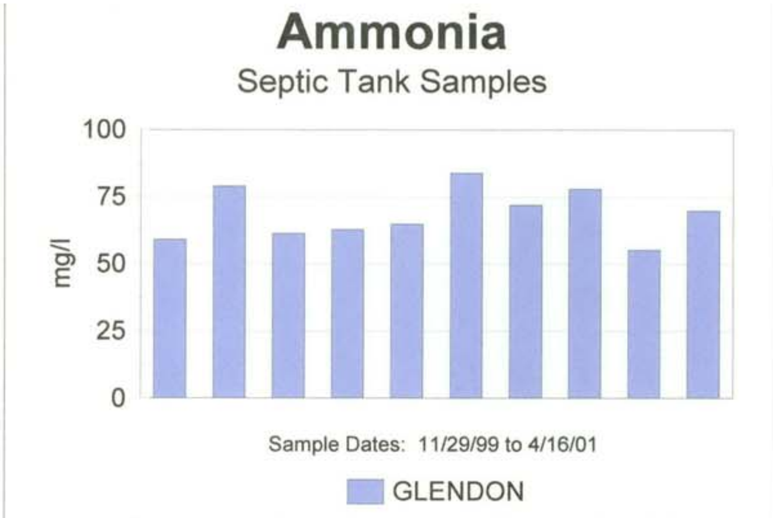

Fecal Coliforms
Background Gradient Drain Samples
#/100 ml
2000
1500
1000
500
0
Sample Dates: 11/29/99 to 4/16/01
GLENDON


Total Suspended Solids
Septic Tank Samples
60
40
20
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON

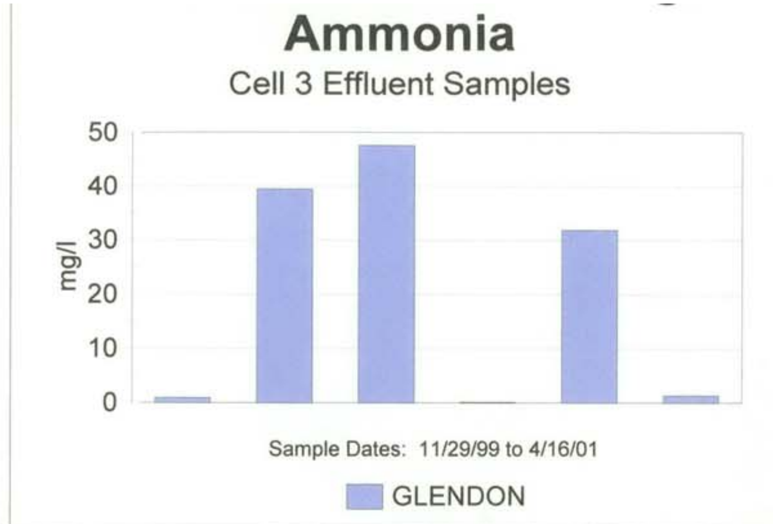

Total Suspended Solids
Cell 3 Effluent Samples
20
15
10
5
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON


Total Suspended Solids
Gradient Drain Samples
EPA Discharge Limit: 18 mg/l
18
15
12
9
6
3
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON

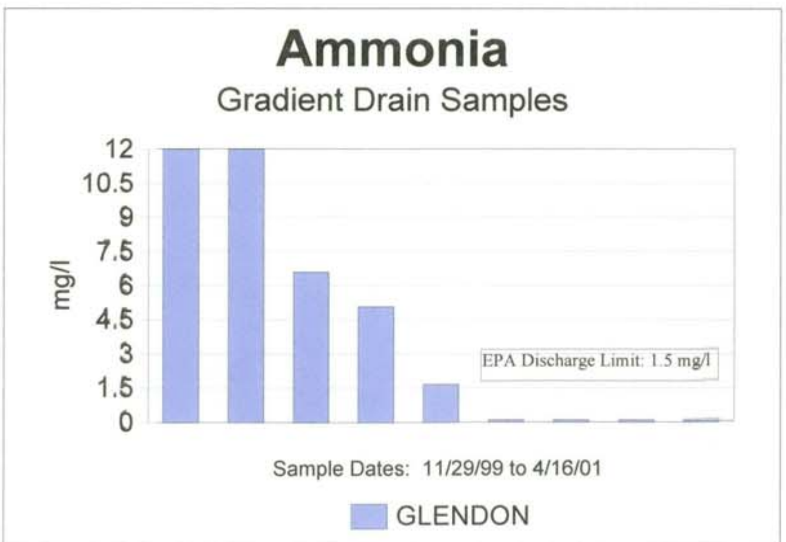

Total Suspended Solids
Background Gradient Drain Samples
1000
750
500
250
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON



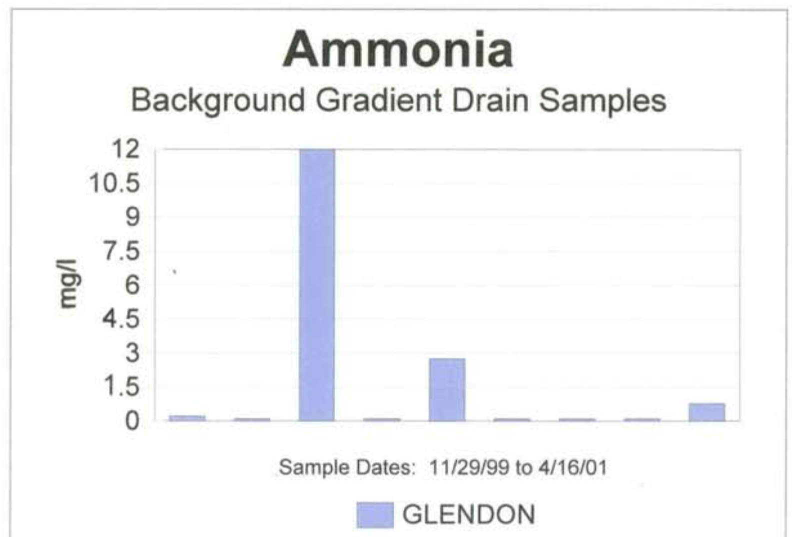
Ammonia
Septic Tank Samples
100
75
50
25
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON



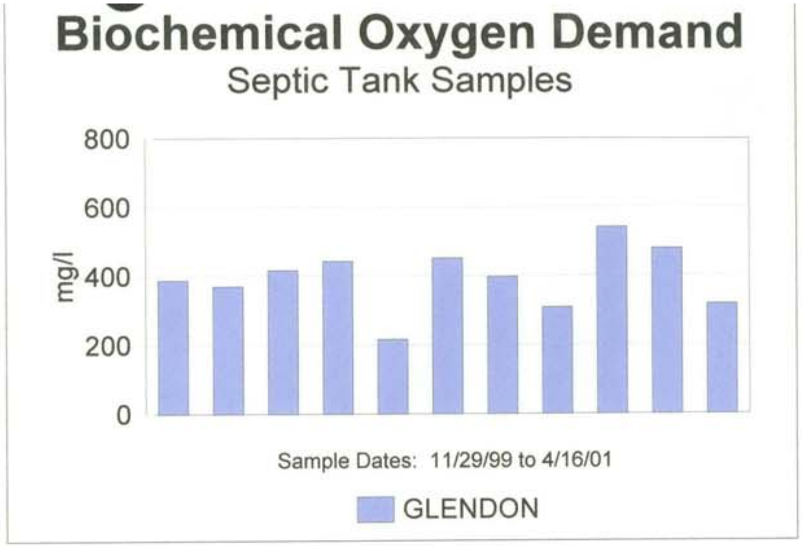
Ammonia
Cell 3 Effluent Samples
50
40
30
20
10
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON

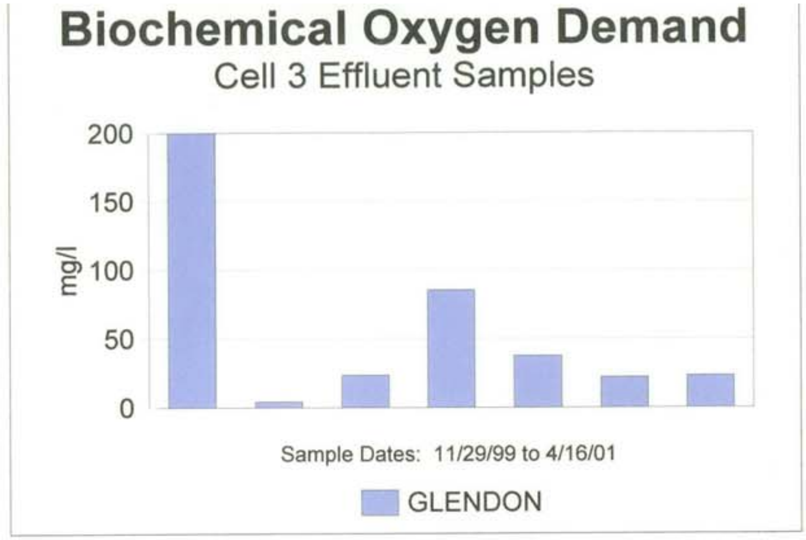


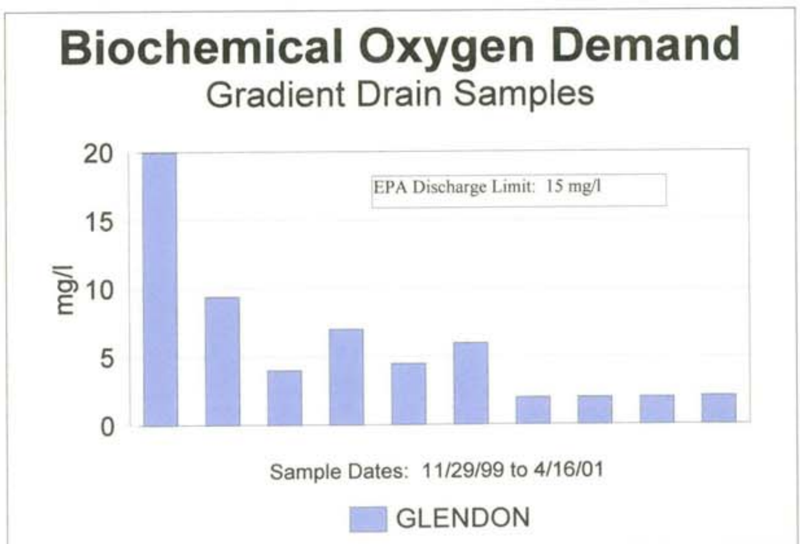
Ammonia
Gradient Drain Samples
12
10.5
9
7.5
6
4.5
3
1.5
0
mg/l
EPA Discharge Limit: 1.5 mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON

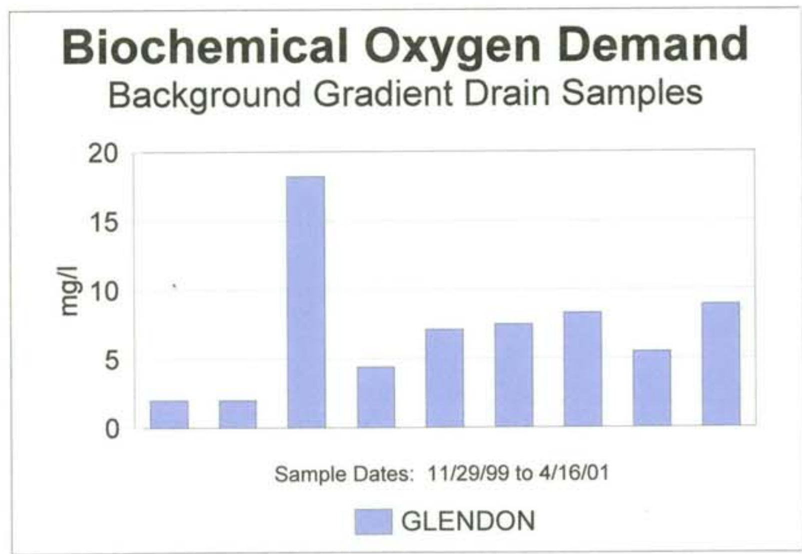


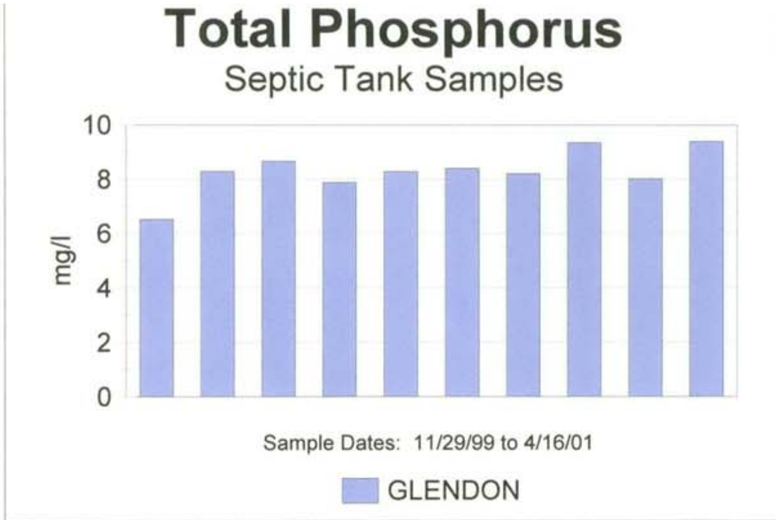
Ammonia
Background Gradient Drain Samples
12
10.5
9
7.5
6
4.5
3
1.5
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON

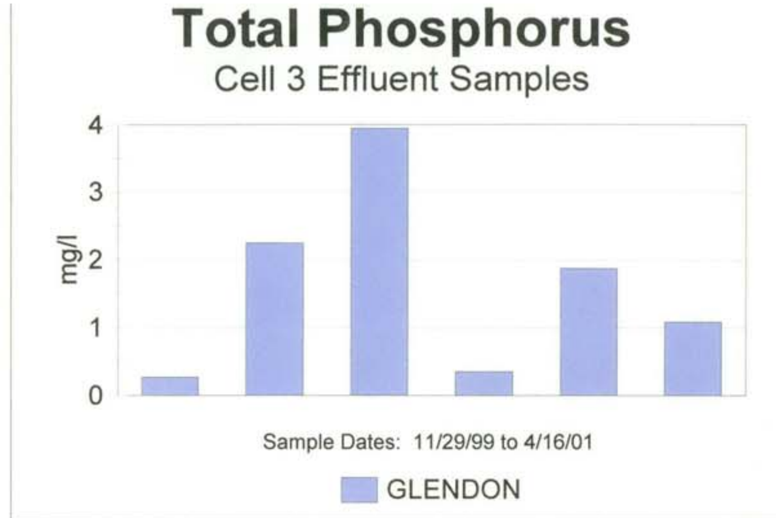

Biochemical Oxygen Demand
Septic Tank Samples
800
600
400
200
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON

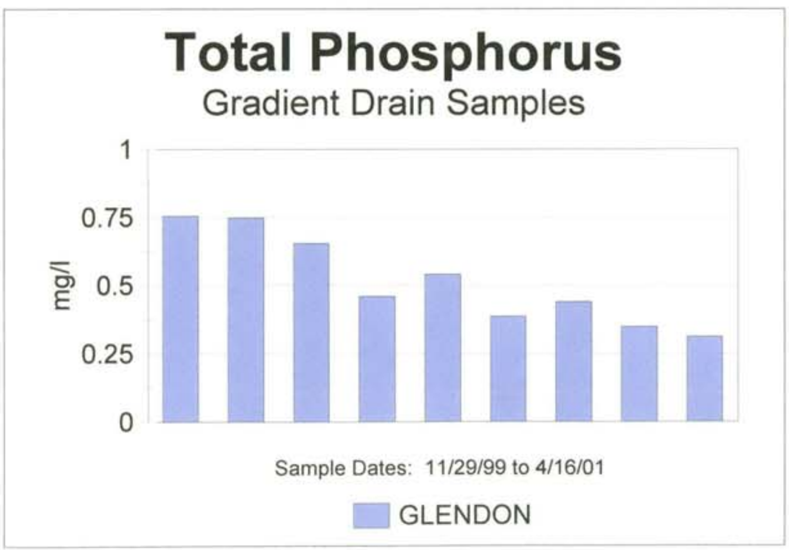

Biochemical Oxygen Demand
Cell 3 Effluent Samples
200
150
100
50
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON

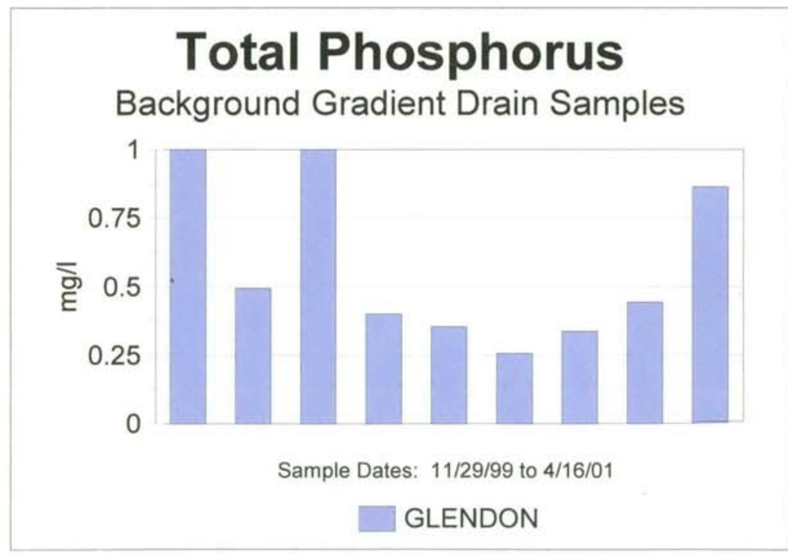

Biochemical Oxygen Demand
Gradient Drain Samples
EPA Discharge Limit: 15 mg/l
20
15
10
5
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON


Biochemical Oxygen Demand
Background Gradient Drain Samples
20
15
10
5
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON


Total Phosphorus
Septic Tank Samples
10
8
6
4
2
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON


Total Phosphorus
Cell 3 Effluent Samples
4
3
2
1
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON


Total Phosphorus
Gradient Drain Samples
1
0.75
0.5
0.25
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON


Total Phosphorus
Background Gradient Drain Samples
1
0.75
0.5
0.25
0
mg/l
Sample Dates: 11/29/99 to 4/16/01
GLENDON

Major Accomplishment #4: Clermont County Office of Environmental Quality implemented sampling program of outfall from 3 high density sand filter and aerobic subdivisions in order to determine loading rates of discharging systems on various watersheds.

The Office of Environmental Quality (OEQ) has been involved in an ambitious program to monitor the water quality of the Eastfork of the Little Miami River and the watershed associated with this river over the past five years. To that end an in-depth sampling program has been on-going with corresponding annual reports. All of the reports are available on-line at the OEQ website: http\\www.oeq.net. A copy of the Executive Summary of each of the available reports can be seen in Appendix H.

Work to finalize a watershed model that will provide a tool for estimating the impact of various nonpoint sources is in progress. Data generated to date will be used to test and calibrate the model. More information about the model can also be found on OEQ's website.

Major Accomplishment #5: Concentrated sampling program of 20 aerobic systems and 4 collector lines performed in order to assess the performance and evaluate loading to watershed.

Over a period of about 30 days during April and May 1998, Health District staff sampled 20 separate aerobic treatment units on three separate occasions. In addition, four samples from four different collector lines were also sampled. The purpose of the sampling was to quantify the effluent quality coming from discharging systems that had just passed the Health District's visual operation permit inspection. The results from these samples can be seen in Appendix I and are summarized on the following page.

	Fecal Coliforms		BOD_5		Total Suspended Solids		Ammonia	
OEPA Proposed Discharge Limit	***Daily*** ***2000 per 100 ml***	***30 Day*** ***1000 per 100 ml***	***Daily*** ***15 mg/l***	***30 Day*** ***10 mg/l***	***Daily*** ***18 mg/l***	***30 Day*** ***12 mg/l***	***Daily Summer 1.5 mg/l Winter 4.5 mg/l***	***30 Day Summer 1.0 mg/l Winter 3.0 mg/l***
Total: Systems: 20 Collector Lines: 4 Samples: 72								
In compliance: Systems: Collector Lines: Samples:	 2 (10%) 0 (0%) 18 (25%)	 4 (20%) 1 (25%) n/a	 2 (10%) 2 (50%) 16 (22%)	 2 (10%) 2 (50%) n/a	 3 (15%) 2 (50%) 29(40%)	 4 (20%) 3 (75%) n/a	 3 (15%) 0 (0%) 11 (15%)	 3 (15%) 0 (0%) n/a
Non compliance: Systems: Collector Lines: Samples:	 11 (55%) 2 (50%) 52 (72%)	 16 (80%) 3 (75%) n/a	 18 (90%) 0 (0%) 56 (78%)	 18 (90%) 2 (50%) n/a	 10 (17%) 0 (10%) 41 (68%)	 16 (10%) 1 (25%) n/a	 17 (85%) 2 (50%) 61 (85%)	 17 (85%) 4 (100%) n/a

Systems and collector lines were logged as in compliance under daily standards if all three samples were less than the established limit. Systems and collector lines were logged as non compliance if all three samples were greater than the established limit. Systems and collector lines with some samples that were in compliance and some that were not in compliance were not counted in daily system/collector line totals.

Using OEPA's proposed NPDES general permit discharge limits as a point of comparison, only two of the 20 systems passed for all parameters. This information confirms that aerobic systems are significant contributors to the nonpoint source pollution loading in Clermont County. It also points out that the Health District's visual inspection program does not identify systems that are failing as a result of inherent system design limitations. That is, each of the aerobic systems in this sampling program had passed a routine operation inspection immediately prior to sampling. Pumps were functioning, filters were not clogged, and no significant odors were noted. All systems appeared to be functioning as designed.

Lessons Learned: Gathering data such as this is truly a double edged sword. After data collection, much more is known about the systems yet there is little immediate action that can be taken. By the standards used in Clermont County to define system failure, these aerobic systems were not failing. However, by all practical standards, 90% of the systems were failing. This may be one clear picture of the changing mind set for onsite sewage. Until recently, onsite systems were largely thought of as "disposal" systems. Sewage was disposed of and therefore no longer an issue. More recently there has been a huge push to recognize and embrace the concept that onsite systems must be “treatment” systems not just disposal systems. If adequate treatment is not achieved at the point of generation, the problem is simply passed downstream. One of the best outcomes that can be hoped for is to use this information to encourage expansion of conventional sewers into areas such as these. This is never a quick answer but for small, densely populated lots such as these it is the best answer. Fortunately, the Clermont County Sewer District and the Office of Environmental Quality are working with the Health District to try to address possible sewer expansions.

Major Accomplishment #5: The number of systems in the renewable Operation Permit Inspection Program increased from a 1998 level of 22% to over 40%. In addition, the first steps to bring all systems into the program have been initiated with the submittal and approval of a new 319 grant.

When the idea for the 319 project was first conceived the Health District was actively inspecting all aerobic systems and all systems installed after 1991 that had any electrical components such as pumps. With a long term vision of having all onsite systems become part of the routine inspection program, several expansion phases were established. The first such expansion occurred in 1996 when all Wisconsin Mounds installed prior to 1991, all sand filters with chlorinators, all experimental systems as described in OAC 3701-29-20, and all new systems in the Special Sanitary District surrounding Harsha Lake at East Fork State Park were added to the program. A second phase expansion included all new systems permitted after 1/1/1998.

With the second phase expansion of the Operation Permit Inspection Program in1998 the inspection frequency was modified to reflect the risk of failure and resulting public health affects from the various system types. All aerobic systems, experimental systems, and all systems with electrical components were maintained on an annual inspection schedule. Sand filters were placed on an every two year inspection schedule, and gravity onsite absorption systems were placed on an every three year inspection schedule.

At the start of the 319 project the Health District had 4,200 systems or approximately 22% of the estimated 19,400 existing onsite systems in the county as part of the operation inspection program. At the completion of the 319 project the Health District had increased the number of systems in the inspection program to 8,100 systems or 39% of the approximately 20,724 onsite systems in the county. Because of the staggered inspection schedules this results in approximately 5,500 inspections per year or roughly 450 per month.

One of the main problems with any inspection program is the number of staff required to maintain the established schedule. All inspections must be as efficiently organized as possible to minimize travel time. When this project was initiated, systems were added to the program as they were finaled with their routine one, two or three year inspection schedule based on the date of the final system approval. In order to provide the inspections as scheduled without the need for significant additional staff it was necessary to change both the manner in which systems were added to the schedule and the inspection frequency.

Clermont County has 14 townships with onsite systems found in each township. It was decided that it would be much more efficient to inspect the systems township by township on a 15 month revolving schedule. The sequence was established so that adjoining townships would follow one after another to minimize driving time when performing reinspections on the previous month's failed systems. The 15 month schedule allows inspectors to view each system at different seasons of the year. This is of particular concern in Clermont County where a high seasonal water table during the wet seasons results in seasonal system failure. Those same systems viewed in the summertime appear to be functioning fine. Systems that were on a 2 year inspection schedule are now on a 30 month schedule and systems that were on a 3 year inspection schedule are now on a 45 month schedule. Although the systems on the 30 month frequency are only viewed in two seasons they are seen in alternating typically dry and typically wet seasons.

The final frontier for the expansion of the inspection program is finding and adding the remaining 12,000 plus onsite systems. Although the location of some systems is known through the Health District's other programs such as the loan inspection program or the complaint program, this only represents knowledge of approximately 1,500 additional systems. The location and type of the remaining onsite systems is unknown. To that end, the Health District has embarked on a second 319 project intended to identify all of the onsite systems in the East Fork Special Sanitary District and to assist homeowners in addressing any failing systems found. This represents approximately 1,800 additional systems in 3 townships. Future directions may include adding systems once identified through the loan inspection program rather than parcel to parcel surveying .

Major Accomplishment #7: Support and awareness of non-point source wastewater issues promoted to homeowners and county/township officials. New partnerships between the Health District and the Clermont County Sewer District emerged to team resources in addressing onsite wastewater issues.

Homeowners

Homeowners embraced the new alternative technology wholeheartedly. There was little need to market the systems to obtain acceptance even though the systems were typically more expensive than the Wisconsin Mound. Homeowners had grown to hate the Mound so much that any systems that could promise to be a smaller and less obvious hump in their yards was considered a good thing. Health District newsletter and local newspaper articles were published to educate the public about the new options and homeowner information packets were developed to assist homeowners in choosing their new system. The most recent version of the homeowner information packet can be seen in Appendix J. Staff continue to revise the packet in order to provide the information to the homeowners in a manner that is easily understood and that addresses the questions considered most crucial by homeowners.

A survey of homeowners that had selected alternative systems was completed during May 2000. A total of 54 surveys were returned out of 90 that were originally distributed. The purpose of the survey was to identify issues important to the homeowner that may not have been readily apparent to Health District staff. The survey itself was created by Health District staff with direction from New Richmond resident, Paul Zimmerman. Mr. Zimmerman is a marketing professional with significant experience in survey development. He provided guidance on the best ways to phrase the questions in order to be clear on what was being asked and maintain objectivity.

A copy of the survey and the results obtained can be seen in Appendix K. In order to obtain a good response rate all surveys were completely anonymous and homeowners were given an incentive to respond. Each respondent received a waived fee on the next annual operation inspection which had a $20 value. This seemed to work well in terms of obtaining responses, however, there was no way to determine which response went with which system types.

An attempt was made to determine which factors were most important to homeowners as well as how well their particular systems would be rated for those specific factors. The following summarizes the responses in terms of relative importance to respondents.

Reliability: Clearly the most important factor to respondents was reliability. All respondents rated reliability as either very important or somewhat important. Only 80% of the respondents rated their particular system as excellent or very good. Another 16% rated their system's performance as good with the remaining 4% rating their system's performance as fair. No respondents felt their system was providing poor reliability.

Ease of Routine Maintenance: The next most important factor was the ease of performing routine maintenance. Over 91% of respondents rated ease of maintenance as either very important or somewhat important. Interestingly, only 52% of the respondents rated their own systems as either excellent or very good in terms of routine maintenance. An additional 35% rated the ease of maintenance of their system as good.

Noise: Noise was considered the third most important factor to homeowners. Nearly 90% of respondents rated noise as very important or somewhat important. Only 65% of the respondents rated their own system as excellent or very good in terms of overall noise. Another 24% of the respondents rated the noise level of their alternative system as good.

Appearance: Appearance of the system on the homeowner's property was the fourth most important factor to homeowners. This was something of a surprise given the known history and aversion to Wisconsin Mounds because of the "big hump" in the yard. Approximately 87% of the respondents rated this as very important or somewhat important. Only 33% of the respondents felt the appearance of their current system was excellent or very good. More respondents (43%) felt the appearance was fair or poor. The remaining respondents rated the appearance on their property as good. When an open ended question was asked later in the survey about what homeowners liked least about their systems the most common answers dealt with appearance. About 20% of respondents made some negative comment concerning the appearance of their system. A similar open ended question concerning what homeowners liked best about their system received 13% of respondents mentioning they liked the appearance of their systems.

Training: The quality of the training received on system operation after the system was installed was considered of equal importance to appearance. Again, 87% of the respondents rated training as very important or somewhat important. Only 35% of the respondents felt the training they received from their installer was excellent or very good. 26% felt the training was good and 39% felt the training they received was fair or poor.

Location of Control Panel: The least important factor to homeowners was the location of the control panel. While 87% of respondents considered this very important or somewhat important only 59% rated it as very important compared to 65% rating appearance and training as very important. About 76% of the respondents felt the accessibility of the control panel for their system was excellent or very good, 20% felt it was good, and 4% felt the location was poor.

One interesting result of the survey was that 26% of the respondents indicated that they were not sure what type of system they had. Another 18% did not answer that question which can probably be reasonably translated to they did not know. That means nearly half of the respondents were not able to identify the type of household sewage treatment system they were using. This fact alone, but certainly coupled with the responses concerning training, indicates the need for additional homeowner training/education by the system installers.

New Directions with Partner Agencies

The Clermont County General Health District has worked hard to cooperate with local and state and even national efforts to address onsite wastewater issues. This has ranged from active participation in state-wide committees, to having staff members serve on boards of both state and national onsite associations. Two important partnering efforts were initiated during this project that links the agency with other entities working to solve the issues facing onsite wastewater treatment. The first partnership links the Health District with the Clermont County Commissioners, Ohio EPA and USEPA in Clermont County's Project XLC. This project provides an opportunity for Clermont County to propose more effective and efficient ways of protecting the environment through regulatory flexibility. Three of the project's problem areas address onsite systems so this partnership provides opportunity to develop a comprehensive approach to non-point source pollution far beyond what the Health District alone could achieve.

Another innovative approach being investigated in Clermont involves public ownership and management of onsite systems. The second partnering effort explores this option in a pilot subdivision in which the developer, the County, and the Health District created new homes with onsite systems that would be owned and maintained by the Clermont County Sewer District. This presented a number of challenges since the homeowners actually built the systems but then turned them over to the Sewer District to maintain. The Health District designed the systems and oversaw installation. Once the systems were finaled they were turned over the Sewer District. To date there is no agreement on which state agency has primary oversight of these systems; Ohio EPA or Ohio Department of Health. Although the agencies have never been asked to provide an official response, informal conversations suggest that the two agencies may not agree on the issue. Rather than enter into a debate on the issue, the Health District and the Sewer District agreed to utilize a system in which the state agency oversight issue was moot. The approach adopted provides a manner in which both Health District and the Sewer District are able to meet all regulatory requirements while still giving the Sewer District the flexibility to operate and manage the systems as they see fit.

In order to do this the Board of Health established an onsite system Management District Operation permit with a ten year inspection schedule. This permit differs significantly from the routine 15, 30 or 45 month permits routinely issued. This type of permit and the corresponding special conditions applied to the Sewer District's specific permit enables the Clermont County Sewer District to operate and manage the system with little to no Health District involvement. The Management District (i.e. the Sewer District) actually replaces the homeowner in terms of overall responsibilities not the Health District. However, because the Sewer District is a known and knowledgeable entity, the Health District can minimize involvement by utilizing the Sewer District's inspection data when desired. More information on the Health District's Management District Operation Permits can be seen in Appendix L.

B. Pollutant Load Reductions:

The pollutant load reductions achieved as a result of this effort are difficult to completely quantify because much of the work involved effort peripheral to non-point discharges. A good example is the increased inspection and maintenance program. Clearly identifying and repairing failing systems is reducing the loading. However, no actual data was generated to measure this improvement and any such conjecture would be based completely on assumptions. Another critical but unmeasurable result of this effort is the number of additional paths that have opened up to address non-point source pollution in the county. This would include joint efforts with the County Commissioners and the Office of Environmental Quality as well as internal opportunities that have been embraced such as the new Eastfork 319 project. All of these efforts contribute to the overall load reduction in the county and all are attributable to this effort. For simplicity's sake the pollutant load reductions calculated are based only on the alternative and demonstration systems installed during this effort.

Quantify each BMP implemented in the project area

- A total of 30 alternative systems were installed and evaluated directly as a part of this project. A total of 121 alternative systems have been installed throughout the county since the initiation of this project all of which can be directly attributed to the push and emphasis of this effort. In the past, traditional leach line systems would have installed on these sites.

- A total of 4 innovative systems have been installed and evaluated directly as a part of this project. All 4 systems replaced failing leach line systems on sites where there were no real alternatives prior to introduction of the innovative technology.

Quantify the estimated pollutant loads kept from reaching the water of concern.

Depending on lot size, design, isolation distance and other factors, failing leach line systems deliver an estimated 5% to 30% of the total septic tank effluent flow to the county's surface streams. The following assumptions have been made in estimating pollutant loads. Most assumptions have been based on information in the County's Wastewater Master Plan.

- November through April represent the wet months and the systems fail to treat sewage adequately only during these months of the year (181 days)
- Each home with a failing system generates 210 gallons of sewage per day
- 25% of the flow reaches the receiving stream for that watershed during the wet months
- The systems installed under this project contribute no measurable load to the watershed
- Sewage effluent characteristics from failing leach lines would have averaged the following:

- Total Phosphorus: 10 mg/L
- Total Ammonia: 30 mg/L
- Total Suspended Solids: 60 mg/L
- BOD_5: 75 mg/L

Estimated Pollutant Loads Kept out of Clermont Watersheds
(Calculated loading assumes failing leach lines)

	Total lbs/yr **For Each Unit**	**Total lbs/yr** **All Units on Study**	**Total lbs/yr All Alt Tech Systems in County**
Total Suspended Solids	4.7	160	569
Total Ammonia	2.4	82	290
Total Phosphorus	0.8	27	95
BOD_5	5.9	201	714

Positive and/or negative water quality impacts that resulted from the project

Clearly the results of this effort resulted in new system types that adequately treat residential sewage even on Clermont's most difficult soil type. The end result is that pollutants do not reach waters of the county.

C. Immediate and Future Implication of Project Implementation

Effects or changes on the local environment and local attitudes of citizens.

As discussed previously, citizens have embraced the new systems wholeheartedly. Homeowners have been given more responsibility and options in selecting their onsite systems and have been able to deal with that challenge successfully. Unfortunately, the prevailing attitude remains out of sight out of mind and these more technical systems being introduced are not compatible with this mind set. The need for ongoing preventive maintenance is critical to the long-term success of these systems no matter how effective the technology.

Describe the benefits/activities that will continue after the project ends

A considerable amount of information has been collected on design, installation, problem solving, and even troubleshooting with these six new system types. Although the two demonstration system types are not quite ready for wide spread use throughout the county, the remaining four systems are offered freely as choices to homeowners. Under the current onsite regulations in Ohio, these options along with several others (i.e. drip) developed outside the scope of this project, allow landowners to develop almost any site in this county with little to no nonpoint source pollution contribution. This is of critical importance to both landowners and officials alike. These options will continue to be offered until such time that revised sewage regulations alter the manner in which systems are sited.

In addition to the increase in the number of system types available for use in Clermont County, the number of existing systems in the Operation and Maintenance program continues to increase. Existing systems continue to be added each year and this process will continue until all onsite systems in the county are part of an Operation and Maintenance program.

The knowledge and experience gained in Clermont County is being shared and disseminated throughout the state and nationally in some cases. Both what went right and what went wrong is openly shared with anyone interested. There are preliminary plans for the future to become involved with state or regional training efforts on advanced technologies for other Health District's and perhaps installers.

III. Project Recommendations

A. Nonpoint sources that still need further attention

In spite of the identification and utilization of improved treatment systems on Clermont's difficult soils, onsite systems continue to be a part of the overall nonpoint problem in the county. Although the impact that newly installed systems have on nonpoint pollution is being addressed, there are thousands of existing systems in place that continue to fail or that discharge inadequately treated sewage. Although failing systems are addressed as they are located, in some instances there is no answer. The lots may be too small to accommodate even the smallest of the alternative technologies or more often, there are simply no funding sources to help homeowners pay for these costly repairs. An approach is also needed for older discharging systems that perform as designed but that generate an effluent of unacceptable quality. Significant work remains in addressing these existing systems.

B. Project modifications that might have made the project more successful

See item D.

C. Particularly efficient approaches that could be used in similar projects in other geographical areas.

No comment.

D. Approaches that were not effective

This project was a huge effort for a General Health District. The concept, while comprehensive, simply tried to cover too much area. It would have been much more effective to really focus on a particular area e.g. alternative and innovative system evaluation, or the operation and maintenance program expansion, or the evaluation of outfall from high density subdivisions. Doing all as a part of this single effort meant no single component was done as efficiently and effectively as it might have been done.

E. Modifications to the Ohio Nonpoint Source Program that would make initiation, implementation, and administration of projects more effective

The project was a very labor intensive effort that was essentially spread between five primary staff members. It would have been a more coordinated and successful effort if a single individual had been designated and paid by the grant as the primary responsible individual.

OEPA's reluctance to pay directly for personnel when this project was initiated led to the approach taken. Although the result is good there were many problems, shortcomings, and oversights that might have been avoided which would have resulted in a more complete and solid effort.

F. Modification to other state and federal conservation programs that would make the Ohio Nonpoint Source Program more effective

No comment at this time.

IV. Cumulative project accomplishments

Obj #	Major activities/products for project (a)	Quantity actually accomplished by end project (c)	Overall Project % Accomplished (cx100/a)	Ref #
1	Obtain ODH approval for alternative systems.	Approval for 395 experimental systems	100%	
	Continuous investigation of technical information on alternative system designs.	---------------	100%	
	Design 30 systems of proven alternative treatment technologies consisting of two alternative secondary treatment options and two alternative dissipation/subsurface drainage options and various combinations thereof, that are not currently approved for use in Ohio	250 systems designed	100+%	
	Install 30 systems of proven alternative treatment technologies consisting of two alternative secondary treatment options and two alternative dissipation/subsurface drainage options and various combinations thereof, that are not currently approved for use in Ohio	30 systems finaled and on 319 project	100%	

Obj #	Major activities/products for project (a)	Quantity actually accomplished by end project (c)	Overall Project % Accomplished (cx100/a)	Ref #
2	Continuous investigation of technical information on innovative system designs	-------	100%	
	Develop and advertise Call for Proposals for innovative systems.	Call for proposals nationally advertised	100%	
	Select 2 non-proven, innovative on-lot disposal options designed for specific problems associated with clay soils and seasonal high water table. Two systems of each design to be installed as demonstration project.	2 systems selected	100%	
	Design overall study for demonstration project.	1 protocol established	100%	
	Select 4 sites for demonstration project.	4 sites selected	100%	
	Design 4 systems (2 each of 2 innovative systems) for demonstration project	4 systems designed	100%	
	Identify installer(s) for installation of 4 innovative system installation	4 installers identified	100%	
	Install 4 innovative systems	4 systems installed	100%	

Obj #	Major activities/products for project (a)	Quantity actually accomplished by end project (c)	Overall Project % Accomplished (cx100/a)	Ref #
3	Complete QAPP.	1 QAPP submitted	100%	
	Performance evaluation on 30 alternative systems (240 samples)	341 samples analyzed from 30 septic tanks, 30 pretreatment units and 30 curtain drain discharges	100+%	
	Performance evaluation on 4 innovative systems (120 samples)	70 samples analyzed	58%	a
4	Identify 5 subdivisions for outfall sampling. OEQ conducts sampling program.	4 outfall areas sampled, 2 aerobic subdivisions targeted 58 outfall samples analyzed ;	100+% 79%	b
	100 samples analyzed for fecal coliforms, CBOD, TSS, ammonia, total phosphorus, nitrates, nitrites, hardness, conductivity, pH, TKN, TVSS, DO. 75 aerobic systems sampled	75 aerobic system samples analyzed	100%	

Obj #	Major activities/products for project (a)	Quantity actually accomplished by end project (c)	Overall Project % Accomplished (cx100/a)	Ref #
5	Increase the number of systems in the renewable Operation Permit Inspection Program from the current level of 22% (4,200 of 19,500 systems) to at least 40% (8,200 of 20,500). 100% of all new and repaired systems from 1998 on will be added to the inspection program (about 350 per year)	822 new and repair systems added	100%	
	150 (estimated) early mound systems added and begin inspection program.	145 mounds inspected	100%	
	2600 early sand filters added and begin inspection program	1690 early sand filters added, 979 sand filters inspected	100% 58%	c
6	Hold 11 meetings for officials. Provide presentations and education to Township Trustees, Planning Commission, Zoning, Township officials, Village Mayors, Board of County Commissioners, and homeowners on the 319 Project as soon as the grant approval notification is received, with emphasis on the project's relationship to the County's Wastewater Master Plan and Project XL.	17 officials meetings	100+%	
	Hold 6 meetings of 319 Advisory Group.	6 Advisory meetings 3 Technical committee meetings	100%	
	Hold 15 meetings for homeowners. Provide homeowner education to reduce discharge impacts in targeted high density discharge areas.	6 homeowner education events	33%	d

Obj #	Major activities/products for project (a)	Quantity actually accomplished by end project (c)	Overall Project % Accomplished (cx100/a)	Ref #
7	Conduct focused public relations effort on the 319 project objectives and creatively market the alternative on-lot treatment and disposal options in order to promote use of these systems			
	Prepare 6 press releases.	2 press releases	33%	e
	3 newspaper articles on 319 efforts.	5 news articles	100+%	
	3 Health District newsletter article.	4 newsletter articles	100+%	
	3 Soil & Water newsletter articles	1 newsletter article,1 OEHA article	66%	f
	Alternative Systems Information Package developed and made available to homeowners.	Package developed	100%	
	1,200 booklets entitled <u>The Homeowners Conservation Guide</u> with good information about onsite systems printed in conjunction with Soil and Water Conservation District OSU Extension	1200 Booklets	100+%	
	Hold 8 professional education programs.	12 Professional Ed programs	100+%	
	Public outreach at County Fair and/or Soil and Water District (3 years)	Outreach at 1999 and 2000 Fair	66%	g
	Journal Article	Paper presented at ASAE - 3/12/2001, published in conf. proceedings	100%	

Obj #	Major activities/products for project (a)	Quantity actually accomplished by end project (c)	Overall Project % Accomplished (cx100/a)	Ref #
8	Provide equivalent of .15 FTE per year of management personnel to implement and oversee all aspects of the project. 12 Quarterly Fiscal Reports 5 Semi-annual Technical Reports 1 Final Project Report	 12 Quarterly Fiscal Reports 5 Semi-annual Technical Reports 1 Final Reports	 100% 100% 100%	

Referencing activities that were not 100% accomplished for the project.

a. See in depth data discussion on the Demonstration Systems.

b. Yearly sampling period was shortened by Clermont County Office of Environmental Quality.

c. After revising inspection program to a township basis no further effort was made to inspect just the sand filters. Remaining sand filters were scheduled in first year of township by township inspection effort.

d. Homeowner education through meetings was de-emphasized after easy acceptance of alternative technologies. Emphasis was placed on increasing individual homeowner awareness and sophistication concerning onsite systems as the homeowners proceeded through the selection and installation process. Most homeowners received one-on-one education and assistance rather than attempting to gather homeowners for group meetings.

e. There was little need to do press releases to promote the new systems since they were so readily accepted.

f. A third newsletter article was not accomplished. Emphasis instead was placed on conference presentations.

g. During the first year of the 319 project the Health District did not include information about the effort at the county fair. It was too early in the program to have much of interest to share with fair goers.

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VERIFYING PERFORMANCE OF A PROPRIETARY TECHNOLOGY FOR ONSITE TREATMENT AND DISPERSAL OF RESIDENTIAL WASTEWATER – VIRGINIA'S EXPERIENCE

D. J. Alexander, A. R. Jantrania[1]

ABSTRACT

As we enter the new century and the new millenium, the onsite industry is growing rapidly to meet the increasing demands for alternatives to the conventional septic tank drainfield system. Just a few years ago, Wisconsin mounds, low-pressure pipe, and recirculating sand filters were considered to be the state-of-the-art alternative systems. Today, there are dozens of companies offering pre-engineered treatment systems sucb as peat filters, foam filters, and textile filters, along with a wide range of aerobic treatment units for onsite treatment. Verifying the performance claims and design standards for alternative onsite systems has always been a challenge to any state regulatory program. Virginia Department of Health is not an exception. The Department has developed and implemented several protocols to carefully verify performance claims and design standards for pre-engineered onsite systems. One such protocol was recently completed after a three year evaluation of the Bord-na-Mona peat filter system whicb entailed collecting and analyzing bundreds of samples from 24 sites that were selected out of more than 200 sites, representing four pbysiographic provinces in the state. Hundreds of samples were collected over a period of 18 months to determine the treatment efficiency of the peat filter and to evaluate migration of pollutants below the dispersal system. The data obtained from this study indicated a very high level of treatment by the filter and no major hydraulic problems with the effluent dispersal beds that were sized according to the company's sizing criteria. This paper presents details on how the Department developed the evaluation protocol with the company's input, allowed the company to market its system during the evaluation period, and evaluated the results using the information to develop new regulations for onsite systems that use pre-treatment devices. The cballenges faced by the Department for making regulatory decisions based on the field evaluation data that were collected in the real world from homes occupied by real people are also presented in this paper.

Keywords: Performance evaluation, pretreated effluent, biofilter, regulatory process

INTRODUCTION

In December 1994, the Virginia Department of Health received an application from Bord na Mona U.S., Inc., requesting permission to test a peat biofilter under the experimental provisions of the *Sewage Handling and Disposal Regulations* (the *Regulations*). This application was received as a result of previous meetings and a preliminary review of the Puraflo™ system. Initially Bord na Mona proposed to test six to ten systems in Virginia on sites with 15 cm (6 incbes) of soil above a water table and a 30 cm (12 inch) offset to rock using less absorption area than is required for conventional gravel trench systems. Systems were to be monitored quarterly for three years at two locations within eacb system. Table 1 shows the constituents proposed to be monitored, the location and acceptable limits for the results. The stated goal was to gain general approval for use within the Commonwealth.

The Department evaluated the proposal from numerous perspectives. Theoretically the underlying assumption that a biofilter could provide treatment on sites wbere the naturally occurring soils were considered inadequate to receive septic effluent and that

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the treated effluent could be dispersed into a smaller receiving environment appeared reasonable. From a policy perspective the goal of collecting data on the application of treated effluent in native Virginia soils was attractive and would be exceptionally useful in making future policy and regulatory decisions regarding this and similar systems. Using pretreated effluent to overcome limiting site conditions appeared to provide citizens with additional options for using properties that did not "perc" when limited to systems using septic tank effluent. Public acceptance of new technology needs to include local environmental health specialists (EHS) from the start and a study such as the one proposed offered an opportunity to introduce a new tool into environmental health specialists tool box.

One foot down-gradient of absorption area		Fifty feet down-gradient of absorption area	
Constituent	Proposed limit	Constituent	Proposed limit
BOD_5	≤25 mg/l	BOD_5	n/a
Fecal Coliforms	≤1000 cfu/100ml	Fecal Coliforms	≤3 cfu/100ml
Nitrates	≤25 mg/l	Nitrates	≤10 mg/l

Table 1. Initial Proposal for Performance Monitoring.

Limiting the scope of the project to six to ten systems appeared inadequate to provide meaningful information on the range of soils that may be encountered in Virginia and on the robustness of the system in actual use. Virginia has four physiographic provinces (Coastal Plain, Piedmont, Ridge and Valley, and the Cumberland Plateau). The soils in each area vary substantially in terms of parent material, soil texture, structure, and depth to perched water tables and restrictive features. In short, ten carefully placed systems could not adequately cover the range of site conditions that occur in Virginia. In addition to this natural site diversity the range of residential wastewater characteristics that should be expected also vary greatly. It became clear that ten systems could not provide a data set sufficient to render a meaningful decision at the conclusion of the study. During the course of discussing the proposal with the applicant it became apparent that in order to collect sufficient data and to make the process economically more viable to the applicant, more than ten systems needed to be installed and monitored. Ultimately that applicant requested permission to install 50 systems.

The regulatory requirements for issuing an experimental protocol contained two obstacles that had to be dealt with before starting the experimental process. First, the regulations limited the number of installations to 16 and required that the systems be spread out across the state by placing no more than 4 systems in each physiographic province. This obstacle was overcome by granting a variance to Bord na Mona. The variance initially allowed up to 100 systems and was later revised to allow 500 systems, with an incremental release of permits. By establishing an over-all limit on the number of permits and releasing them in blocks of 100-200, the Department limited health risks and financial liability in the event the experiment failed. In addition, by allowing up to 500 systems the Department could get homeowner feedback should problems occur and could assure that most local EHSs would become familiar with the use and operation of the system.

A condition of the variance that allowed 500 systems instead of 16 was that Bord na Mona would conduct monthly testing on 24 systems as opposed to quarterly for the six to ten initially proposed. The systems tested would be such that six systems would be placed in each of the four soil texture groups recognized in the regulations. Additionally, the testing would be more extensive than initially proposed but the test period was reduced from 36 to 18 months, the minimum allowed by the regulations.

The second obstacle in the regulations that severely restricted the use of the Puraflo system (and all other experimental systems) was a requirement that there be an approved backup system available in the event the Puraflo system failed. This regulation has been in place since November 1,1982 and was implemented to limit the risk to the public from failing experimental systems. The unintended result was that very few experimental systems were installed. Prospective homeowners and builders were not inclined to spend three to five times the cost of a conventional system when it wasn't necessary in order to build the home. Consequently, only landowners without a backup up site were motivated to use an experimental system, and these were the very people that were prohibited from having an experimental system. It was a genuine "Catch-22" situation.

The solution to the problem, as most solutions are, turned out to be a compromise. The solution redefined the requirement that the site and soil conditions be suitable for a conventional system. A second variance was granted that allowed sites to be permitted when a reserve area with site and soil conditions suitable for a second Puraflo system was held in reserve. In short, a 100% reserve area continued to be required but the site conditions of the area were redefined. The Department was sufficiently confident in the outcome of the treatment aspects of the experiment, based on qualitative and quantitative data from across the nation and in Virginia, that our principle concern was with establishing sizing criteria that would prevent effluent from breaking out on the ground surface near the system.

METHODS AND PROCEDURES

On June 9, 1995, the Virginia Department of Health issued a policy (GMP #69) allowing Bord na Mona to install up to 100 systems in Virginia (with the potential to install up to 500 systems) and requiring testing on 24 systems. The policy contained a detailed description of the Puraflo system and components, siting criteria, design criteria, the testing and evaluation protocol, operation and maintenance requirements, and procedural details and responsibilities. The Department considered this document central to success or failure of the experiment. It established precisely what constituted a Puraflo system and provided for amendments to the protocol should there be revisions to any component. It described what site conditions were necessary to permit a system and allowed VDH and private sector consultants a concise reference for permitting decisions. The experimental protocol defined what wonld be monitored and established the pass-fail criteria. The protocol called for third-party testing. The Environmental Engineering Department at Old Dominion University was suggested by Bord na Mona and agreed to by the Health Department to administer the sampling and testing portions of the protocol. The policy also established a process whereby site evaluations would be conducted by local health departments and construction permits would be issued locally. Finally, it established the responsibilities of each party, provided reporting time frames, and established the scope of the experiment.

In addition to the testing established in the protocol, the Department conducted an annual evaluation for a period of three years, which consisted of field visits to 12-15 sites over a 2-3 day period during the springtime to visually inspect the condition of the systems. These systems were selected randomly and included a mix of systems from across the state in all pbysiographic provinces, soil texture groups, and age groups of systems. Individual systems selected varied from year to year and wben possible, the bomeowners were interviewed to determine their perception and understanding of the system.

Siting Criteria

Bord na Mona proposed to use sites with a six-incb standoff to rock and watertable. The Department agreed to permit sites with pereolation rates ranging from 5 to 120 minutes per incb and with a sliding scale stand-off to water table ranging from 15 to 30 cm depending on the percolation rate of the soil. Figure 1 illustrates the relationship between stand-off distances and percolation rates. This table reflects the Department's best effort to incorporate the anticipated benefits of the system with both existing and proposed regulations. The current regulations (then proposed) require a45 cm separation distance for all soil types and percolation rates for septic tank effluent and 30 cm for treated effluent.

The Department also approved the system for use on any site fully complying with the regulations and for repairs wbere the site conditions did not meet the regulations because it appeared reasonable to assume the system would "enhance wastewater treatment and potentially enhance wastewater disposal." When used to repair a failing system, the installation was not counted against the total number of systems approved for installation. While the Puraflo system was used to replace failing systems, the principle use was for new home construction on lots without a site for a conventional onsite system.

Design Criteria

The design goal was to provide wastewater treatment and disposal equal or superior to that obtained with a conventional gravity drainfield system. This design concept was carried through to the standards adopted to review the success or failure of the performance of the Puraflo systems.

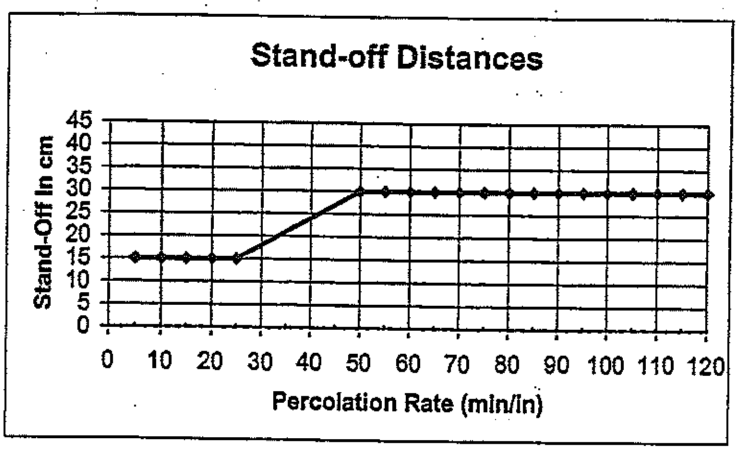

Figure 1. Stand-off Distance and Percolation Rate Relationship

The Puraflo system utilized a 4.8 x 6 meter pad area with 15 cm of gravel beneath the treatment modules for dispersal. This absorption bed was installed so that the bottom area was level within a tolerance of two inches. When additional area was necessary, gravel absorption trenches, or a combination of both pad area and trenches were used. The siting criteria required the minimum stand-off to water table, or other limiting factor, be achieved over the entire absorption area. When trenches were used, they were required to be installed on contour and parallel distribution was utilized.

Either gravity or pressure distribution was allowed. Essentially all installations had pressure dosing to the peat modules and gravity flow of the treated effluent into the dispersal area. No minimum installation depth was specified, however, fill material was not permitted beneath any part of the absorption area. The maximum allowable slope was 50%. Installers were required to undergo training by Bord na Mona Environmental Products US, Inc., and be certified as having passed their minimum training qualifications prior to installing any systems in Virginia.

Testing and evaluation procedures

Each system selected for monitoring and testing had two sampling ports installed for the purpose of collecting effluent. Effluent samples were collected at a depth of 30 cm below the bottom of the absorption area. When a port was located beneath an absorption field trench, the sampling port was located within the first ten feet of the trench to assure it was in an area receiving effluent. Sampling wells consisted of a 4-inch PVC pipe that was slotted, gravel packed and sealed with bentonite clay below the absorption area. The well was brought above grade and capped. The sampling ports were designed to preclude the entrance of untreated effluent; however, wells were frequently damaged (apparently inadvertently) by lawn mowers and other residential uses, and it is questionable whether this goal was achieved.

Effluent samples were collected from beneath the trenches and analyzed for fecal coliform bacteria, pH, and chlorides on a monthly basis. Initially tests were also conducted on septic tank effluent and effluent from the Puraflo treatment unit for BOD_5 on a monthly basis. After more than half the data was collected this sampling frequency was reduced to semi-annually. The samples were also analyzed for NO_3-N to demonstrate nitrate removal efficiency. This analysis, while of interest to the Department and Bord na Mona, was not required and was not part of the criteria used to determine product approval.

Standards

Fecal Coliforms: The average of samples collected from unsaturated soil horizons was required to average less than 10 cfu/100mls and no single sample could have in excess of 200 cfu/100mls. The Department reserved the exclusive right to discard sample results obtained during the first six months of operation. The Department's intention was to allow the Puraflo system a start up period to establish a viable community of treatment organisms. No samples were discarded and no initial start up period with less than average treatment was observed.

Nitrates: No performance standard was established for nitrates; however, testing was encouraged to demonstrated nitrate-nitrogen reduction.

Chlorides: No pass/fail standard was established. Chloride concentrations were measured to confirm that the samples collected contained treated effluent.

BOD_5: Five day biochemical oxygen demand was measured in septic tank effluent samples to assure that the wastewater collect was typical of residential wastewater. The protocol required the effluent to have a BOD_5 between 100 and 300 mg/l for any individual samples and an average greater than 150mg/l. Effluent from the Puraflo unit was tested to demonstrate treatment effectiveness but no pass/fail limit was established for BOD_5. Samples were collected and the results used to qualify the Puraflo system for use under the NPDES program.

Surfacing and ponding

Any system that showed surfacing of effluent was considered a failure. Ponding depth within the absorption area was monitored on a monthly basis in each system. Two monitoring ports were installed in eacb system for this purpose.

RESULTS AND DISCUSSION

During the course of the study, only two reports of systems with surfacing of effluent were received. The first report occurred in a system on the Eastern Shore of Virginia in coarse sandy soils (texture group I soils). The contractor that installed this system had not completed final grading around the system because of excessively wet soil conditions due to a prolonged period of high rainfall. An evaluation revealed standing water in a low area within ten feet of the Puraflo system and over the area where absorption trencbes were installed. Soil borings indicated that there was a 30-45 cm deep unsaturated soil horizon immediately below the ponded water. It was concluded that the ponded water was strictly surface water and not connected with the sewage disposal system. After grading was completed, no further incidents were reported with this system. The second reported failure occurred during winter when the homeowners were away on vacation. The failure was observed by the Department and Bord na Mona. The failure stopped almost immediately upon the return of the homeowners from vacation. While it could not be verified, the Department attributed the failure to a leaking plumbing fixture, such as a leaking commode, that hydraulically overloaded the system.

Data collected on the Puraflo treatment system indicated that the units were capable of treating residential wastewater to a very high degree with notable consistency. For the purposes of this study, residential wastewater was defined as septic tank effluent having an average BOD_5 between 100 and 300 mg/l with an average not less than 150 mg/l. The Department did not want to base an approval on testing conducted on low-strength wastewater. The average BOD_5 of the systems monitored was 270 mg/l with only one system having an average BOD_5 less than 200 mg/l. The average effluent BOD_5 from the Puraflo modules was 6.6 mg/l, a 97.6% reduction, with only two systems baving an average effluent above 10 mg/l. Of these, one system had an average BOD_5 of 12mg/l and the other 14 mg/l. System performance was notably consistent with only four isolated samples collected from different systems exceeded the secondary standard of 30 mg/l. Three of the four samples were collected during one sampling event, suggesting that collection or laboratory error may have occurred.

Samples were collected for fecal coliform analysis from the pump tank (located between the septic tank and the Puraflo modules), a sample chamber located after the Puraflo modules, and from a well penetrating to a depth of 30 cm beneath the pad or trencb absorption area. Additionally a background well was installed at each site to establish base conditions without the introduction of treated wastewater. The average fecal coliform count from the pump chamber was $1.26X10^6$ FC/100ml. After passing through the Puraflo modules the average count had been reduced to 263 FC/100ml. It was anticipated that additional treatment would be necessary and would be provided by the soil beneath and around the absorption area. Thirty centemeters below the absorption area (trench or pad) the average fecal coliform count was 154 FC/100ml.

At face value, the data failed to meet the criteria established for approving the Puraflo system. Arguably the standard established at the start of the study may have been too stringent. Nonetheless, this was the standard of measure establisbed, and the Department was not inclined to revise the standard without a substantive reason. Unfortunately, there were few relevant standards that could be applied to determine the epidemiological significance of the results of this study. The standard established was almost certainly safe in terms of public health protection and the Department believed achievable with existing technology. The Department was also concerned that the standard should have been evaluated on its own merits only in terms of public health and environmental considerations. Re-evaluating the standard in light of the Puraflo data would bave been inappropriate because it could easily compromise the impartiality of the standard. Therefore the standard was not reconsidered.

Nonetheless, the Department did consider the results of this study within the context of our understanding of the science and practice of onsite systems and the existing regulatory framework in the Commonwealth. Whatever decision was made needed to make scientific sense and be consistent with the safeguards in place in other regulatory programs. In exercising this judgement to arrive at a conclusion, there were three areas of consideration. These were: (1) the methodologies employed in the study, (2) results of other research evaluating the treatment potential of soils, and (3) the application of Puraflo technology within the existing regulatory framework and future direction of the Department.

Methodologies

In hindsight the methodology employed to evaluate effluent quality beneath the infiltrative surface *may* have been flawed. At this time no definitive proof exists to show that the study was flawed but several concerns are difficult to dismiss. As designed, the sampling wells were constructed of PVC (polyvinyl chloride) plastic pipe installed through the absorption portion of the system gravel packed and then grouted with bentonite clay. By design these wells are subject to leakage around the annular space and only yield results during saturated soil conditions. While the initial installation of these wells may be adequate, the residential environment where they were used may have subjected them to inadvertent misuse.

Even though great care was taken during the construction of the wells, the report submitted summarizing the data collection indicates that homeowner abuse occurred. Wells were observed with missing well caps, broken casings, occasionally tilted casings, and some contained water in and around the annular space. It was suspected that some homeowners may have inadvertently damaged their wells while performing yard maintenance (i.e., striking the well with a lawn mower) or during other recreational pursuits. Maintaining the watertight integrity of these wells may have been compromised. If so, wbere there was effluent ponded in the absorption area, little or no effect would be noted as a result of soil treatment. This is consistent with field observations (i.e., damaged wells) and test data (i.e., no significant soil treatment). These observations and speculations suggest, but do not prove, that leakage occurred around the annular space.

Although not initially considered, the fact that these wells can only be sampled during periods of saturation will skew the data in comparison to more rigorous controlled studies. Much of the data that the Department is familiar with was collected using suction lysimeters. The suction lysimeter can collect samples under unsaturated condition and as a result, comparison of data collected by the different methodologies may not be possible for the purpose intended in this study. There are several reasons for making this statement. In the Puraflo experiment, when unsaturated conditions occurred beneath the absorption area, no sample could be collected. More than half of the sampling events yielded no sample. One would normally expect to be able to collect a sample under similar conditions using a suction lysimeter. In these instances, the suction lysimeter would yield a result when no bacterial movement would be expected and more results would be obtained when there was little or no potential for fecal contamination. In short, the sampling well methodology employed assured that samples would only be collected when bacterial movement was possible and assured no sample could be collected when bacterial movement was least likely to occur. This error, while impossible to quantify, is almost certain to be adverse to the outcome of the study.

Other Research

Other research, in particular work conducted by Dr. Raymond B. Reneau at Virginia Tech, Crop and Soil Environmental Sciences Department, has demonstrated satisfactory soil treatment in as little as six inches of soil using highly pretreated effluent similar to the effluent from the Puraflo modules (Reneau et al., 2000). There are many reasons for the differences between the Puraflo demonstration and the results of Dr. Reneau and other researchers. As noted, different methodologies may account for some of these differences. Additionally, the controlled conditions in a true research project were not present in this experimental protocol. The ground water quality at the sites where some of the test systems were installed was not pristine. Background readings in many of the up-gradient wells exceeded the pass/fail limits established in the protocol. In fairness, the background water quality may have been better than was reported since by design they were subject to surface water influence in a manner similar to the pad wells. Given the sample size and variability of the results, in some cases it was not possible to determine if the biological impact beneath the pad area was due to the addition of effluent from the Puraflo system or naturally occurring fecal organisms from endemic species and/or domestic animals.

The Department also informally discussed the results of this demonstration project with other researchers in government, research and industry. These individuals, respected in their field, in general agreed that significant additional soil treatment is reasonable to expect under the conditions defined in the protocol, even though not observed. Whether or not the additional treatment that these individuals expect should occur would be enough to make a difference in the outcome of the protocol (i.e. pass the test), is impossible to establish. Nonetheless, it is assuring to note the consistent support across the breadth of the industry for the concept of additional soil treatment. It lends weight to the possibility that aspects of the methodology employed may have been flawed and that there are problems associated with this type of data collection.

Regulatory Framework

Finally, in evaluating whether or not to grant the waiver of the experimental process it is important to consider it in light of the regulatory framework in existence in the Commonwealth. The Department should take a consistent and rational approach when evaluating health risks and system applications. The ten-page limits of this paper prevent a detailed explanation of the regulatory inconsistencies that would result from failing to approve the system. However, had this action been taken, there would have been instances, albeit not widespread, where septic tank effluent would have been permitted for a given set of site conditions while treated effluent would not have been allowed or encouraged. One final regulatory thought is that the fecal coliform standard for recreational waters is 200 fcu/100ml. Effluent from the Puraflo modules nearly met that standard and effluent in the soil below the absorption area did meet this standard. This comparison, while interesting from a regulatory and "popular science" perspective does not stand up to close scrutiny. While it might appear that if the Department failed to grant the waiver, we are saying that effluent that is clean enough to swim in isn't suitable for subsurface disposal. This is not entirely accurate. The sampling regimes and assumptions are different. With the Puraflo effluent, one can be certain that the fecal source is human and the associated pathogens are more likely to infect a human than recreational waters where significant portions of the fecal contamination would be from animals which pose a significantly less concern to humans. Nonetheless, the reduction in coliforms from 1.3 million to a few hundred organisms is significant. Placed in the context of the recreational water standard one can see that the risks associated with the effluent have been greatly reduced but not necessarily entirely eliminated. Furthermore, by utilizing subsurface disposal the risks appear to be reduced even further.

Consequently, even though Puraflo failed to meet the fecal coliform criteria established in the protocol, the performance results were sufficient to reasonably conclude that the system had demonstrated operation competence in full scale testing. Specifically, the health risks associated with the continued use of this system are minimal at best. On January 21, 2000, the Department granted a waiver of the experimental requirements for the Puraflo system. The Department is also in the process of developing new sets of regulations that will allow the use of pre-treatment systems with reduced stand-off distances and area requirements compared to the requirements for conventional septic drainfield systems.

REFERENCES

Reneau, R. B., C. Hagedorn, and M. Saluta. July 2000. Annual Progress Report to the Virginia Department of Health – Onsite Waste Treatment and Disposal by Recirculating Medial Filter—Low Pressure Distribution System. Kentland Research Farm Experimental Site, Virginia Tech.

ANUA

Puraflo®

Peat Fiber Biofilter

Design Guide

and

Installation Manual

Only modules bearing the NSF® logo
and designated P150N*XX
are certified to
NSF/ANSI Standard 40

Peat Fiber Biofilter Design Guide and Installation Manual

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1.0 General Description of System

The Puraflo peat biofilter is an advanced secondary treatment system that purifies septic tank effluent to an extremely high degree before final dispersal.

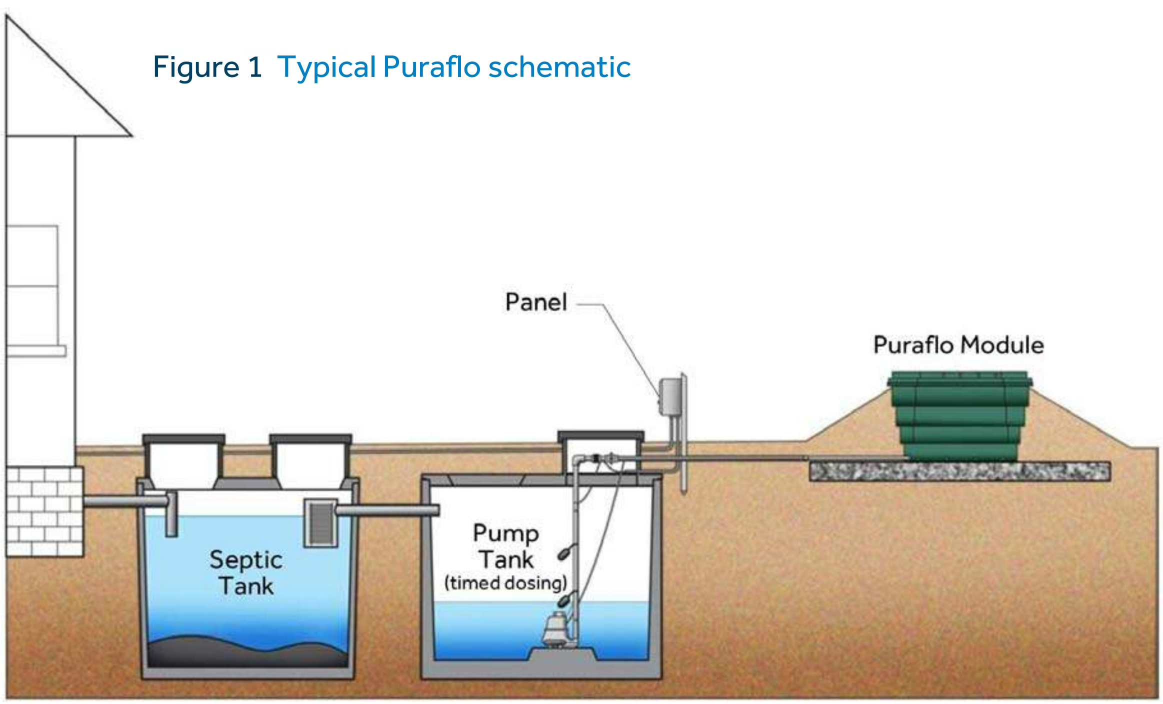
A typical Puraflo peat biofilter system consists of:

- Septic tank with a commercially-rated effluent filter, with 1/32" filtration, connected to the tank outlet pipe
- Dosing tank and effluent pump, or siphon, to accommodate dosing of the septic tank effluent onto the peat fiber media
- Biofilter modules where advanced treatment occurs due to the physical, chemical and biological processes that are optimized in the peat fiber media.
- Site specific, final effluent dispersal system

The filtered septic tank effluent is collected under gravity in the pump tank. A timed dosing system is activated by a programmable timer or a siphon-dose system triggers, which pumps the effluent through a flow splitting inlet manifold located at the base of the treatment modules. An orifice plate is located inside the top of each inlet manifold which allows the flows to be split equally and fed simultaneously to each biofilter module. The inlet manifold is connected to the base of the biofilter module and is fed upwards to a rectangular distribution grid located 6 inches below the top of lid. The effluent percolates laterally and vertically through the depth of the peat fiber treatment media and emerges as a clear, innocuous liquid from the base of the system. The treated effluent is then collected and dispersed.

The Puraflo peat biofilter system has been tested, certified and listed by the National Sanitation Foundation, International as meeting the requirements of NSF/ANSI Standard 40, Class 1. Puraflo is a modular system with each module rated for 150 gallons per day (gpd). The range and rated capacity of the system is therefore a multiple of the standard unit based on the 150 gpd per module. Model P150N*3B, incorporating 3 modules and rated at 450 gpd, was the treatment plant tested to NSF/ANSI Standard 40.

Figure 1 Typical Puraflo schematic



2.0 Process Fundamentals

2.1 Treatment Mechanisms

The Puraflo peat biofilter treatment technology is based on simple, passive biofiltration principles. The treatment of the effluent within the system is achieved by a combination of unique physical, chemical, and biological interactions between the effluent and the fibrous peat media. The residence period or contact time in the media at the design loading rate has been calculated and demonstrated to be somewhere between 36 and 48 hours by using tracer organisms.

Extensive scientific examination of the peat fiber media has revealed a complex structure which permits a number of separate treatment and attenuation processes to occur simultaneously. The treatment mechanisms within the fixed film media are summarized in **Table 1** below.

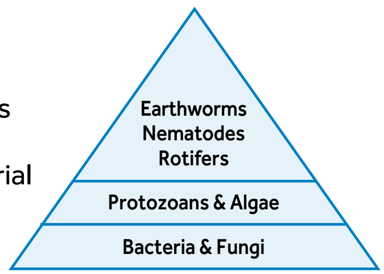
Table 1

Treatment	Characteristics	Significance
Physical	Surface Area	Greater the surface area, greater the contact between effluent, air and media
	Void Space	Open fibrous structure and large pore volume results in efficient transfer of air and effluent throughout the biofilter
	Bulk Density	Low bulk density media – light open material resulting in large surface area and void spaces, characteristics attractive in respect to wastewater treatment.
Chemical	ph	Pathogenic bacteria in wastewater undergo significant die-off in peat due to the acidic conditions prevailing and the predation/competition from naturally occurring pH tolerant microfauna.
	Cation Exchange Capacity (CEC)	Peat particles tend to be negatively charged. This gives peat a great ability to absorb positively charged molecules. A high CEC means the peat can effectively hold positively charged molecules including ammonium, metals, pesticides, some organic molecules and possibly viruses.
	High Adsorptive Surface Area	The larger the surface area the greater the number of adsorption reactions taking place
Biological	Buffering Capacity	The ability of the system to withstand shock loadings
	Resistance to Degradation	Due to a high lignin content, peat fiber is resistant to breakdown or decay thus prolonging the life span of the media
	Beneficial organism growth	Biological treatment achieved by complex and diverse microflora which adhere to peat fiber media. Microflora largely composed of aerobic and facultative aerobic heterotrophic bacteria from different genera. Supports higher life forms : protozoans, rotifers, algae, insects, nematode and annelid worms.

2.2 Microbiology of the System

In a mature peat fiber unit the biological processes are known to be crucial in maintaining the treatment efficiency observed. The bulk of the treatment and assimilation processes are achieved by diverse microflora which adhere to the surface of the peat media. This microflora is largely composed of aerobic and facultative aerobic heterotrophic bacteria from a large number of genera. The most important bacteria genera represented include:

- Pseudomonas
- Aeromononas
- Bacillius
- Micrococcus
- Flavobacteria
- Alcaligenes
- Streptococcus



The total bacterial population recorded per gram of peat has been measured at $1x10^9$ cfu. Similarly, high numbers (up to $1x10^7$ cfu/g) of fungal organisms have been isolated from the Puraflo units. A wide variety of "higher life" forms have also been recorded within the media matrix (ranging from protozoans, rotifers, and algae to nematode and annelid worms, insects and their larvae). These organisms play an important role in keeping the bacterial population "in check" thereby maintaining balanced microflora and ultimately a stable ecosystem.

The larger numbers of heterotrophic bacteria are found in the upper portions of the filter media with nitrifiers becoming more prevalent at depths of 12" or greater. Therefore, the degradation and assimilation of the carbonaceous elements of the waste is affected within the upper portions of the filter bed with nitrification occurring at greater depths.

The peat fiber system is also very effective at eliminating enteric bacteria contained in the waste. The antimicrobial properties of the system can be classified under two broad headings:

Aggressive nature of the peaty media

The anti-microbial properties of the acidic peaty soils are developed through the low pH which directly affects the cell walls of the organisms in addition to limiting the amounts of nutrients available for uptake. Also, the trace amounts of phenols, bitumes and other complex hydrocarbons which are associated with peaty materials are directly toxic to certain bacteria, in particular enteric organisms which find themselves in a hostile environment (low temperature, high competition, etc.) and are already in a stressed condition. Finally, certain peaty soils have been demonstrated to contain a significant fungal species population (in addition to certain actinomycetes) which produce antibiotics and thus can adversely affect bacterial species in the zone of influence. It is important to note that the natural anti-microbial properties of the peat fiber media are only effective on the "stressed" enteric organisms contained in the primary wastewater. The indigenous microflora associated with the treatment media are largely unaffected by the properties described.

Microbial antagonism

The second means by which the enteric organisms are extinguished in the Puraflo system is by microbial antagonism. This simply means that the stressed micro-organisms within the primary wastewater are out competed by the indigenous microflora. The low temperature, low pH and production of certain microbial toxins within the peat fiber media adversely affects the "foreign" organisms. As such, they are largely ineffective in assimilating nutrients and other constituents, which are necessary for their survival. The large retention time in the peat fiber media ensures maximum lethality.

2.3 Treated Effluent Quality

When treating domestic strength wastewater (300 mg/l BOD_5 or less) up to the design flows and loads, a properly maintained Puraflo peat fiber biofilter system will exceed the performance requirements of NSF Standard 40 Class 1. Actual NSF test results established through analytical methods described in NSF/ANSI Standard 40 averaged 2mg/l $CBOD_5$ and 2 mg/l TSS.

Table 2

Parameter	NSF Std 40 Avg, 30-day	Puraflo Effluent Avg
$CBOD_5$ (mg/l)	25	2
TSS (mg/l)	30	2
pH (pH units) range	6 - 9	6 - 7.5

The pH, $CBOD_5$ and suspended solids (TSS) concentrations demonstrated in this table will be attained within a few weeks of commissioning and will be consistently achieved over the lifetime of the peat fiber media.

Also, the treatment efficiency in the peat fiber media is not subject to significant variation with ambient air temperature fluctuations.

3.0 Media Filters

3.1 System Features

The Puraflo peat fiber biofilter system has been part of numerous field studies and observations. Keys aspects of single pass media filters are:

- Primary treatment (septic tank)
- Septic tank effluent screening (effluent filter or screened pump vault)
- Timed-dosing in small, even increments
- Hydraulic loading
- Organic loading
- Air ventilation
- Media properties
- Media depth
- Media replacement or adjustment

Using the criteria listed above, the following table gives a technology summary. The Puraflo peat fiber biofilter (1 module) loading is 150 gpd and 300 mg/l BOD_5 (NSF Standard 40 maximum loading).

Table 4

Item	Puraflo Peat
Primary treatment (septic tank)	Yes
Effluent screening	Effluent filter 1/32" filtration
Timed-dosing (doses per day)	12
Air ventilation	Surface access (holes in side of module lid)
Area	26.93 ft^2
Hydraulic loading	5.57 gpd/ft^2
Organic loading	0.0140 lbs $BOD_5/ft^2/d$
Media depth	24"
Media void space	90 - 95%
Water holding capacity, % volume	50 - 55%
Media size	1 - 10mm
Media surface area	52,000 ft^2/ft^3
Media replacement	~15 years
Effluent BOD_5, typical	<10 mg/l
Effluent TSS, typical	<10 mg/l
Effluent fecal coliform range, geo mean	<1,000 - <10,000 per 100 ml

Some Table 4 values derived from:

1. Loudon, T.L., T.R. Bounds, J.R. Buchanan and J. C. Converse. "Media Filters Text." in (M.A. Gross and N.E. Deal, eds.) University Curriculum Development for Decentralized Wastewater Management. National Decentralized Water Resources Capacity Development Project. University of Arkansas, Fayetteville, AR. 2005.

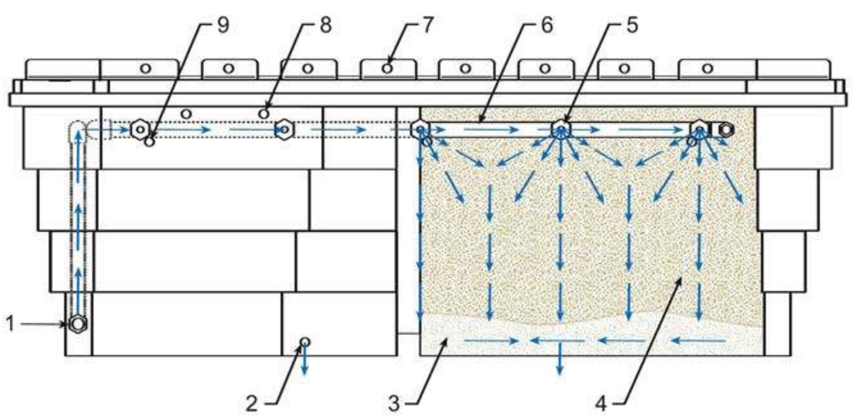
3.2 Comparison of Puraflo & Single Pass Sand Filter Treatment

To review, the Puraflo Peat Fiber Biofilter and the Single Pass Sand Filter, employ three main treatment mechanisms:

- Biological
- Chemical
- Physical

The media properties dictate the level of treatment expected under each mechanism. Within a mature media filter (all types), biological treatment predominates, confirmed by the following statements:

- The effluent from this sand filter during the experiments was purer than many drinking-water supplies, and the last published analysis. after the tank has been in operation 14 years, indicate that the sewage that was applied to it in 1901 was freed from 89 per cent. of its organic impurities. At first thought, this purification might be attributed to the fact that the sewage is strained through the sand. Such is not the case, however. Most of the organic impurities have been absolutely destroyed or transformed into other and inoffensive combinations, mainly through the action of bacteria (International Library of Technology 440, 1926).
- Treatment filters using sand or peat as media make effective attached growth systems. They can be designed as either single-pass or recirculating filters, meaning that the wastewater is run across the media more than one time. Regardless of the media, the process is generally the same–wastewater from the septic tank is allowed to run through a bed of media and collected from underneath. Treatment occurs as the bacteria grows on the media (NESC, 2004).
- As the wastewater passes through the sand filter, treatment is accomplished through physical and chemical means, but mainly by microorganisms attached to the filter media (NFSC, 1998).
- A biologically active film of organisms forms on the surface of the media. Microorganisms play an essential role in treating the waste-water as it flows over media surfaces. Certain bacteria known as primary colonizers attach (via adsorption) to the surfaces and dif-ferentiate to form a complex, multi-cellular structure known as a biofilm (Loudon, Bounds, Buchanan and Converse, 2005).
- The bulk of the treatment and assimilation processes are achieved by a diverse microflora which adhere to the surface of the peat media (Walsh and Henry, 1998).



Item	Description
1	Inlet
2	Outlet Port
3	#5 Stone
4	Peat Fiber Media
5	Distribution Orifice
6	Distribution Grid
7	Vent Holes
8	Rope Handle Holes
9	Stabilizer Bars

As shown, the Puraflo Peat Fiber Biofilter and the Single Pass Sand Filter have similar performance characteristics. The media employed within the Puraflo Peat Fiber Biofilter has some unique properties that enhance treatment and that are worth noting:

- Surface area: 52,000 ft^2/ft^3
- Void space: 90-95%
- Water holding capacity: 50-55%
- Retention time: 36-48 hours
- Cation Exchange Capacity (CEC): 125 mg/g

Patterson (2004) outlines the roles identified above in the treatment process:

- **Physical properties - filtration:** the small particulate matter (usually high in BOD_5) that passes through the septic tank treatment is captured within the interstices of the peat fiber, and does not percolate through the peat with the drainage water. Thus, the loading of BOD_5 and TSS at the top of the peat can be significantly higher than the quality from average septic tanks.

- **Biological properties – microbial decomposition:** the peat fibers support a significant population of microbes which consume organic matter in the incoming primary treated effluent in much the same way as the zoogleal film in a trickling filter consume the organic loading in a conventional sewage treatment works. In the peat system, the actual surface area of the peat fibres is many thousand times that of the trickling filter. This fact is borne out by the very high CEC of the peat that is a direct relationship with surface area. The 99.2% removal of fecal coliform without any external disinfecting agent indicates the efficacy of the peat as a disinfecting medium. The naturally high acidic properties of the peat also play a role in the disinfection process.

- **Biological properties – aerobic environment:** similar to an aerated wastewater treatment system, a highly developed population of aerobic bacteria is maintained within this environment. Laboratory results show that the peat can hold up to 300% of its own weight in water and maintain an air-filled capacity of more than 30% (about that of a soil at field capacity). This high aeration is confirmed by the ability of the peat to oxidize up to 96% of the ammonia-N in the STE.

- **Chemical properties:** the high CEC of the peat and its mineral content resulted in the changes to the cation ratios from the start of the trial to the end, reflected in the reduction in sodium adsorption ratio of the effluent in its transit through the peat. The loss of 74.6% of TP by adsorption is a highly significant reduction without further chemical additions. The reduction in salinity by 38% and the loss of 81.5% of alkalinity are further chemical changes induced by the peat environment. These losses are statistically significant.

Headley (2006) describes some aspects of chemical and physical treatment:

- Peat can be described as partially fossilized plant matter which accumulates in wet areas (wetlands) where there is a lack of oxygen and the accumulation of the plant material is more rapid than its decomposition (Couillard, 1994; Viraraghaven, 1993). Peat is a porous, complex material containing lignin and cellulose as major constituents. These constituents contain polar functional groups, such as alcohols, aldehydes, ketones, acids, phenolic hydroxides, and ethers than can be involved in chemical bonding (Viraraghaven, 1993). This polar nature gives peat a high specific adsorption capacity for suspended and dissolved solids, such as transition metals and polar organic molecules. The particulate and highly porous nature of peat also makes it an effective physical filter (Perez et al. 2005). Studies have shown that partially decomposed peat has a relatively high porosity of approximately 95% and a specific surface area of 200 m^2 per gram.

Kennedy and Van Geel (2000) make the following observation:

- Peat is an alternative filter medium for the treatment of various waste streams including septic tank effluent. The water holding capacity and adsorption capacity of peat make it a favorable filter medium over sand or gravel which are commonly used as the filter medium for the drainage field of septic systems.

4.0 SUMMARY

From the long history and wealth of studies done on peat biofilters it can be concluded that the treatment capability and performance is equivalent, or better, to a single pass sand filter.

Headley (2006) offered the following comments and comparisons:

- Peat filters offer significant potential as a relatively passive, low-maintenance and robust secondary treatment device for on-site systems in the Gisborne region. Experience with peat filters internationally indicates that they are highly effective at removing TSS and BOD, and are more effective at removing pathogen indicators than similar fixed-bed filters using other media, such as sand or gravel. Peat filters have also been shown to be highly effective at nitrifying domestic wastewater, and in many cases are capable of removing 30-50% of the total nitrogen load.

- Field evaluations of peat filters used in on-site systems indicate that they are relatively robust under the typically variable loadings experienced in domestic situations (Patterson. 1999). They also represent a relatively low maintenance and passive treatment system, especially compared to package aerated wastewater treatment systems which generally require at least quarterly servicing by a trained technician. For example, Patterson (1999) reported that a domestic peat filter required only two hours of active maintenance in over 13 years of successful operation (1986-1999).

5.0 SYSTEM DESIGN & SPECIFICATION

The Puraflo Peat Fiber Biofilter is a pre-engineered treatment system contained in factory pre-assembled molded polyethylene modules. It is a highly efficient system for the treatment of domestic strength waste-water and is designed to minimize site construction. Domestic quality primary effluent is evenly distributed over the specialized fibrous peat fiber media. One biofilter module (approx. 7.1 ft. long x 4.5 ft. wide x 2.5 ft. high) is designed to treat the wastewater from one bedroom, 2 people or a design flow of up to 150 gallons per day of domestic strength wastewater. Guideline hydraulic and organic loading rates per module are as follows:

- Maximum design organic loading per module 0.3755 lbs/d
- Maximum design hydraulic loading per module 150 gpd

5.1 System Configuration

The designer of a Puraflo system will be responsible for proper configuration and sizing of the components of the system, pump and other peripheral component specifications, timer settings, and construction details.

5.2 Design Flow & Number of Modules

Applicable regulations usually define the daily flow based on the number of bedrooms or the number of occupants with a defined flow per person per day. Anua research has determined that one module per bedroom or one module per 150 gallons is required to treat domestic strength wastewater.

5.3 System Configuration

The size and configuration of the septic tank shall be in accordance with the NSF listing (as applicable) or State or Local requirements. The septic tank shall have a usable volumetric capacity of at least 24 hours retention. The septic tank, risers and lids must be watertight.

A commercial effluent filter with 1/32 inch filtration must be specified. Acceptable commercial effluent filters are the Bear Onsite ML3-932, Zabel A300, BEST GF10-32 and Polylok PL-625 (alternatively, the Sim/Tech Pressure Filter STF-100 may be used where it is not possible to install a gravity effluent filter). The effluent filter is installed on the septic tank outlet pipe to prevent grease and solids carryover into the pump tank.

5.4 Timed Dose Pump Tank

Dosing is typically regulated by a control panel with programmable timer, low water cut-off float and high water alarm float. The low water cut-off should ensure that the pump remains covered at all times. Storage capacity above the high water alarm float equal to or greater than one quarter of the daily design flow must be provided. The flow equalization zone (between the low water cut-off and high water alarm floats) should be approximately half the daily flow to avoid nuisance alarms. **An override float or override capability must not be used.** A 750 to 1,000 gallon pump tank is usually adequate for a 3 to 4 bedroom residential home. A 500 gallon pump tank is the minimum (e.g., single room cabin or one bedroom home). The size and configuration of the pump tank shall be based on design flow and occupancy and per the NSF listing (as applicable) or State or Local requirements. The pump tank, risers and lids must be watertight.

The dosing *rate* should be between 7 to 12 gallons per minute per module. The dosing *volume* should be approximately 5 to 15 gallons per module per dose. For example, a 2 hour dosing interval for a 450 gpd, three module system would result in 12 doses at 37.5 gallons per dose. This equates to 12.5 gallons per module per dose. If the force main is set up to drain back, the drain back volume should be factored into the dosing calculations. A sample pump tank drawdown test calculation is outlined in the table at right.

The diameter of the force main piping is typically 2 to 4 inches. The Puraflo inlet piping manifold diameter is typically 2 inches where 1 and 5 modules are installed or 4 inches where 6 to 10 modules are installed. The outlet piping manifold (were applicable) is typically the same diameter as the inlet piping manifold.

Buoyancy calculations for the septic tank and pump tank should be performed when necessary.

Table 5 Sample Drawdown Test Calculation

Tank	
Gallons per inch	20.00
Design flow (gpd)	450
Drainback volume (gals)	25
# Puraflo modules	3
# doses per day	12
Drawdown in tank (inches)	1.25
Time (seconds)	60
"ON" timer setting, secs	95
"ON" timer setting, mins	1.58
Dose volume per module	12.5

5.5 Biofilter Modules

Effluent from the force main is distributed to the modules via a flow splitting manifold with pressure equalizing orifice plates. Effluent is distributed over the peat fiber media by a pre-installed rectangular grid with large diameter openings that prevent clogging. The effluent charges the grid using the velocity generated by the orifice plates. It is not a pressurized distribution grid.

The site specific design will detail the final effluent dispersal method. Effluent may be either discharged directly to a pad installation or may have a piped outlet for discharge to trench, pressure system, point discharge system or other effluent dispersal method, as applicable.

Modules are pre-assembled depending on the final effluent dispersal method and can have:

Pad system:

- Weep-holes at the base for drainage to a pad system (Blue Module color code)
- Partial weep-holes with a piped outlet on the sealed end diverting effluent to a sample chamber (Green Module color code)

Other effluent dispersal methods:

- Piped outlet for connection to another dispersal system (White Module color code)

It is important to specify which modules are needed for a particular design. The type of module is designated by a painted circle on the module lid.

Green module(s) adjacent to a sample chamber have half of their effluent piped from one end of the base of the module through the sample chamber; therefore, there are no weep holes on the end of the module feeding the sample chamber. The chamber essentially provides access to the sample pipes for performance testing purposes. Any uncollected effluent exits the sample chamber through holes in the base or side of the sample chamber.

Models:

- "A" denotes modules with weep holes around the base for discharge directly into a dispersal pad or trench. "B" denotes modules with a set of two, 1" threaded-ports at the base for connection to collection piping that can be routed to a drainfield or to a pump tank/chamber.
- Each module is painted on one corner of the lid with a color-coded triangle. Coding table and diagrams provided below and at right.

TREATMENT UNIT MODEL NUMBER	
Model Number	**Rated Capacity** (Gallons/Day)
Puraflo Series	
P150*1A	150
P150*1B	150
P150*2A	300
P150*2B	300
P150*3A	450
P150*3B	450
P150*4A	600
P150*4B	600
P150*5A	750
P150*5B	750
P150*6A	900
P150*6B	900
P150*7A	1050
P150*7B	1050
P150*8A	1200
P150*8B	1200
P150*9A	1350
P150*9B	1350
P150*10A	1500
P150*10B	1500

Modules bearing the NSF® logo & designated P150N*XX are certified to NSF/ANSI Standard 40

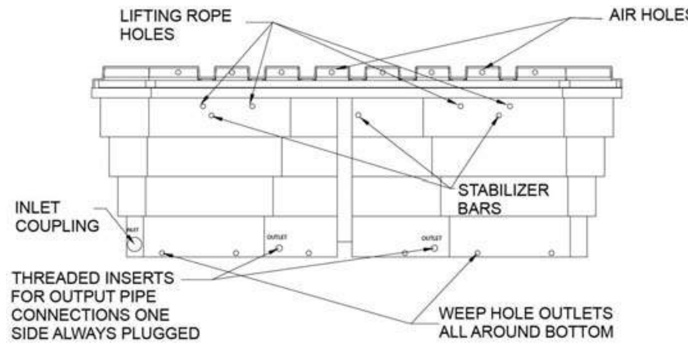
Module Color Coding

- Blue Coded Module: (20) 7/8" dia. holes around bottom area of module
- Green Coded Module: (16) 7/8" dia. holes around half of module for sampling requirements
- White Coded Module: Closed bottom area, no holes in module

3 Module Types

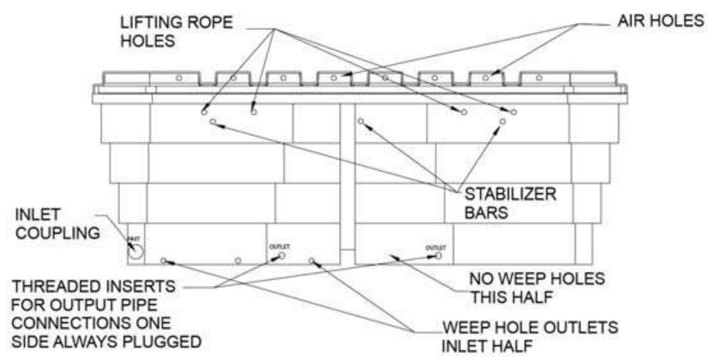
Blue Coded Module

Type A: Pad System



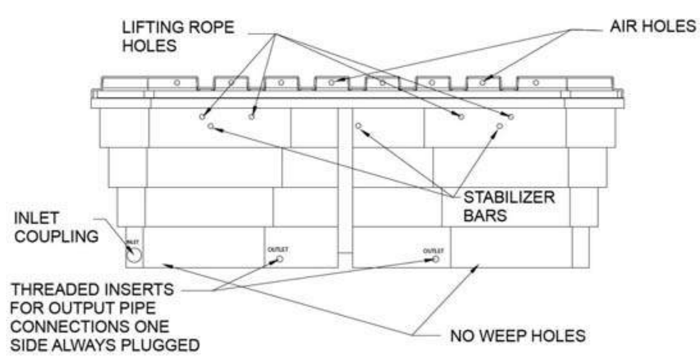
Green Coded Module

Type A: Pad System (for Sample Chamber)



White Coded Module

Type B: Trench System



5.6 Cold Weather Conditions

Certain precautions should be taken in extreme cold weather conditions. In particular, the force main should be designed to drain back after each cycle. Also, the module lids will come with foam insulation on the under-side of the module lid. All systems must be verified for force main drain back and module lid insulation. Any other accepted standard practice for cold weather conditions should be used per State or Local requirements.

5.7 Life of the Peat Fiber Media

The effective life of the Puraflo peat fiber media is estimated to be 15 years under the following conditions:

- System has been operated at or under design flow and loadings
- System has been designed and installed in accordance with Anua guidelines
- System has been maintained in accordance with Anua guidelines, been operated under and ongoing service contract and is in compliance with all Administrative Authority permit conditions

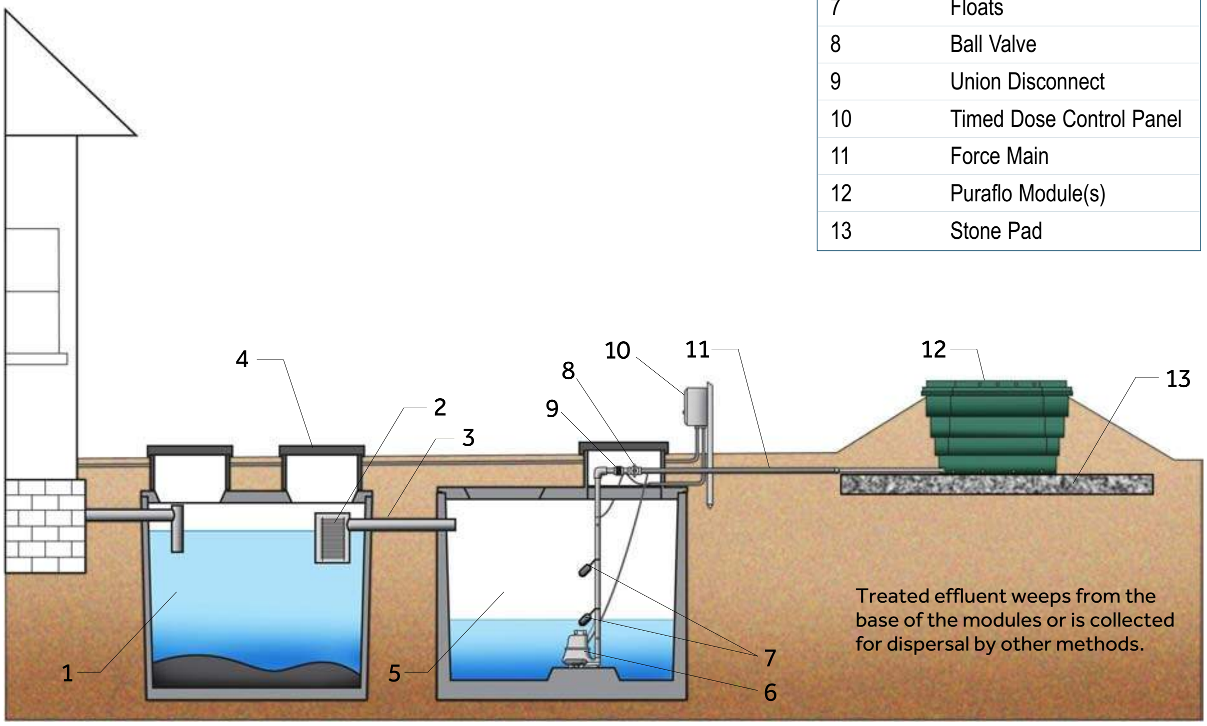
5.8 Final Dispersal System

The final dispersal system must be designed in accordance with State or Local regulations and Anua guidelines.

6.0 System Layout & Components

6.1 Schematic of Puraflo System Components

Part No.	Description
1	Septic Tank
2	Effluent Filter
3	Sewer Line
4	Riser and Lid
5	Pump Tank
6	Pump
7	Floats
8	Ball Valve
9	Union Disconnect
10	Timed Dose Control Panel
11	Force Main
12	Puraflo Module(s)
13	Stone Pad



6.2 Specification of Puraflo Module

Max Treatment Capacity per Module: 150 gpd
Module Length: 7' 1"
Module Height: 2' 6"
Module Width: 4' 6"
Module Weight: ~1800 lbs

7.0 Installation Requirements

Installation of the Puraflo system is straight forward and can usually be completed in less than a day.

- **Warning:**
- Use recognized, safe lifting techniques to off-load and set modules.
- Ensure all lifting equipment is clear of overhead obstructions such a power lines, trees, rooftops or any other construction.
- Place the lifting equipment on solid, stable ground.
- Use a four-point sling or equivalent (see Fig.2).

The contractor/installer is required to provide the following:

- Mechanical excavator (backhoe) with operator.
- An electrician or person qualified to undertake the work in accordance with State or Local regulations (the electrician will be required to connect the pump and alarm to the control panel, set timer as required, and connect the control panel/junction box with the main power supply). Provide and supervise the installation of the underground cable from the control panel/junction box to the main circuit board.
- Provide gravity and force main piping and fittings per design. Piping under pressure must be PVC Schedule 40 or equivalent.
- Clean stone (3/4 to 1-inch) as required.
- Additional/imported fill material (typically not sand) and topsoil as required.
- Labor as necessary to install the system.
- Necessary supervision to ensure the system is installed per design.

8.0 Electrical Requirements

An independent electrical circuit to power the control panel (115/230 volts and 20 amps typical) must be provided. These requirements may change by State or Local code or when a duplex panel, a larger pump or a high head pump is required per design. Please refer to site specific design to verify electrical requirements noting the requirement for 115 or 230 volts and the amps rating required for the controls and the pump.

Figure 2 Module Off-loading

9.0 Sequential Installation Procedure

9.1 Site Clearance

- Clear site vegetation as required (minimize site disturbance).
- Provide sufficient access to proposed system.

9.2 Septic Tank

- Supply and install septic tank and sewer pipe from the dwelling in accordance with applicable State or Local regulations. The septic tank must be watertight against ground and/or surface water infiltration and exfiltration.
- Install septic tank on stable, compacted ground and backfill with suitable material as recommended by the manufacturer.
- Fit an effluent filter (1/32" specification) on the outlet pipe.
- Install water tight risers over inlet and outlet access ports to provide access for filter maintenance, septage removal, etc.
- Backfill and grade around the septic tank to prevent infiltration of surface water.
- See Appendix 1: *Typical Septic Tank Detail.*

9.3 Pump Tank Installation

- Supply and install the pump tank in accordance with applicable State or Local regulations. The pump tank must be watertight against ground or surface water infiltration and/or exfiltration.
- Install pump tank on stable, compacted ground and backfill with suitable material as recommended by the manufacturer.
- Install gravity main from the septic tank to the pump tank in accordance with applicable State or Local regulations.
- Excavate a trench, typically 18 inches deep, from the pump tank to the location of the modules. In colder climates the force main may be buried deeper (below frost line).
- Place sufficient risers on top of the pump tank to reach slightly above grade level. It is extremely important to ensure a water-tight seal between the pump tank and the first riser and between individual risers.
- All connections/seals should be made water tight in accordance with manufacturer's recommendations.
- Backfill, compact and landscape around the pump tank inlet/outlet pipes and electrical cable points of entry. Ensure suitable backfill material is used in accordance with manufacturers instructions.

9.4 Pump Fittings and Piping

- Place the base of the pump 4 to 6 inches above the base of the pump tank.
- Glue required length of PVC force main into the fitting at the outlet of the pump. Install the required fittings (check valve, union, ball valve, etc. as required by the design). Note: in most cases a 2 inch forced main is specified so a bushing (11/2 inch x 2 inch) may be required to connect the internal pump tank piping to the pump. In some cases, the force main may be designed to drain back and a drain back hole will be required above the check valve. Install an air vent hole when required and an anti-siphon hole if the module grid is lower than the liquid level in the pump tank.
- Floats are generally used however other suitable level devices may be installed. Install on/off float typically at pump level (to ensure that the pump is kept submerged). Install alarm float with 1/2 day storage above the on/off float. Strap floats to force main or separate stand pipe or hang from bracket.
- Install the force main in the trench from the pump tank to the modules. Backfill trench once the line is correctly installed and connected. Be careful not to damage the installed force main line with heavy vehicle activity.
- See Appendix 1: *Typical Septic Tank Detail.*

9.5 Puraflo Installation

The site specific design will detail the final effluent dispersal method. Effluent may be either discharged directly to a pad installation or may have a piped outlet for discharge to trench, pressure systems, point discharge systems or other effluent dispersal methods, as applicable. The model numbers are identified as A for a pad installation and B for a piped outlet installation.

Type A – In-Ground Pad Installation
See Appendix 2:
Type A: In-Ground Pad Configuration

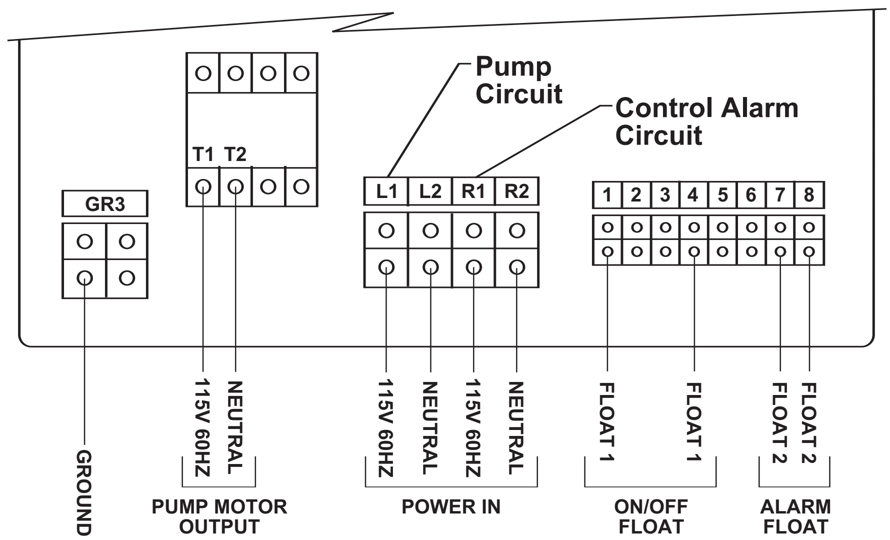
- Excavate a pad area (as specified in the design), making sure to maintain the required vertical separation distance between the bottom of the pad and any vertical restrictions such as seasonal high water table. The pad bottom must be level.
- Fill and level the excavated area with clean stone (3/4 to 1 inch, see Appendix 8) in accordance with the design, to a minimum depth of 6 inches.
- Position the modules on the stone pad area. Connect the force main to the module inlet coupling (incorporating a flexible pipe).
- Fit the sample chamber pipe to the outlet from the side of the green color coded module that does not have weep holes in the base. Insert the sample chamber pipe so that it extends 3 inches into the sample chamber and at least 5 inches off the base of the sample chamber. The sample chamber is pre-drilled with 3/4 inch holes in the base/side of the sample chamber to allow effluent to enter the pad foot-print area when samples are not being collected. The top of the sample chamber should be positioned at approximately the same level as the top of the modules.
- Backfill with stone around the modules to a height of 6 inches above the weep holes around the base of the modules when applicable.
- Cover the remaining exposed stone surface around the outside of modules with a suitable filter fabric. This prevents smaller soil particles from being washed into and subsequently clogging the foot-print area.
- Reinstate with suitable backfill and topsoil to finished design level.
- Ensure that the Puraflo lids are securely fastened.

Type B – Piped Outlet Installation
See Appendix 2: *Type B: Final Dispersal Separate from Module Configuration*

- For piped outlet installations the pad area's primary function is to level and support the modules.
- Excavate a pad area (as specified in the design). The pad bottom must be level.
- Fill and level the excavated area with clean stone (3/4 to 1 inch) in accordance with the design, to a minimum depth of 6 inches.
- Position the modules on the stone pad area. Connect the force main to the module inlet coupling (incorporating a flexible pipe). Construct the outlet pipework to the sampling chamber and to the final dispersal system in accordance with the design.
- Backfill with stone around the modules to a height of 6 inches above the drain holes on the side of the modules.
- Reinstate with suitable backfill and topsoil to finished design level.
- Ensure that the Puraflo lids are securely fastened.

9.6 Electrical Connections

- Select a location for the electrical control panel near the pump tank or home.
- Install the cable between the power source and the control panel in accordance with State or Local regulations.
- Place the electrical power cable(s) in the trench/conduit (do not stretch cable). Connect each cable coming from the equipment in the pump tank in accordance with the wiring diagram located on the door of the control panel (a typical wiring schematic is detailed below). The cable between the pump tank and the control panel is to be installed in conduit and include the appropriate conduit seal. Reinstate area.
- Connect the electrical power cable(s) to an independent electrical power supply of the specified voltage (usually 115 volts), terminating in a socket or junction box protected by an M.C.B. as required (usually 20 amps). If a duplex control panel or high head pump is required the voltage and amperage requirements may increase.
- Input timer settings in accordance with design.
- Test and commission pump operation, start/stop conditions and alarms.
- All electrical work shall be done in accordance with State or Local regulations and/or building codes.



Typical Wiring Schematic for a simplex pump system. Please refer to the inside of the Control Panel for the actual wiring diagram and specifications.

9.7 Spare Parts

Spare or replacement parts can be obtained from the manufacturer of the component or Anua if they need to be replaced.

9.8 Site Restoration

- The modules must be installed at grade or above grade with the ground landscaped to divert storm water away from the modules.

- Backfill around modules to a height just under the lid of the modules.

  Grade the backfill back to the existing ground level on a slope no steeper than 2:1.

  Backfill should be suitable, loose, workable material.

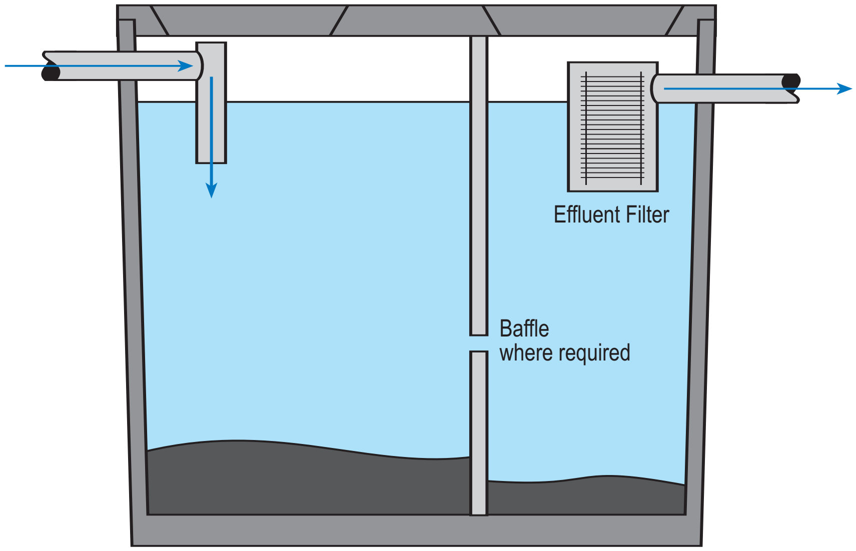
  Compact backfill sufficiently to counteract settlement.

  Ensure a 6 inch minimum cover over drainfield stone where applicable.
  The final layer (6 inches) of fill material should be suitable topsoil capable of supporting vegetative growth.

- Grass seed and straw the sloped backfill area and any trench excavation lines with a suitable indigenous seed variety. In some cases, sodding for immediate stabilization may be specified.

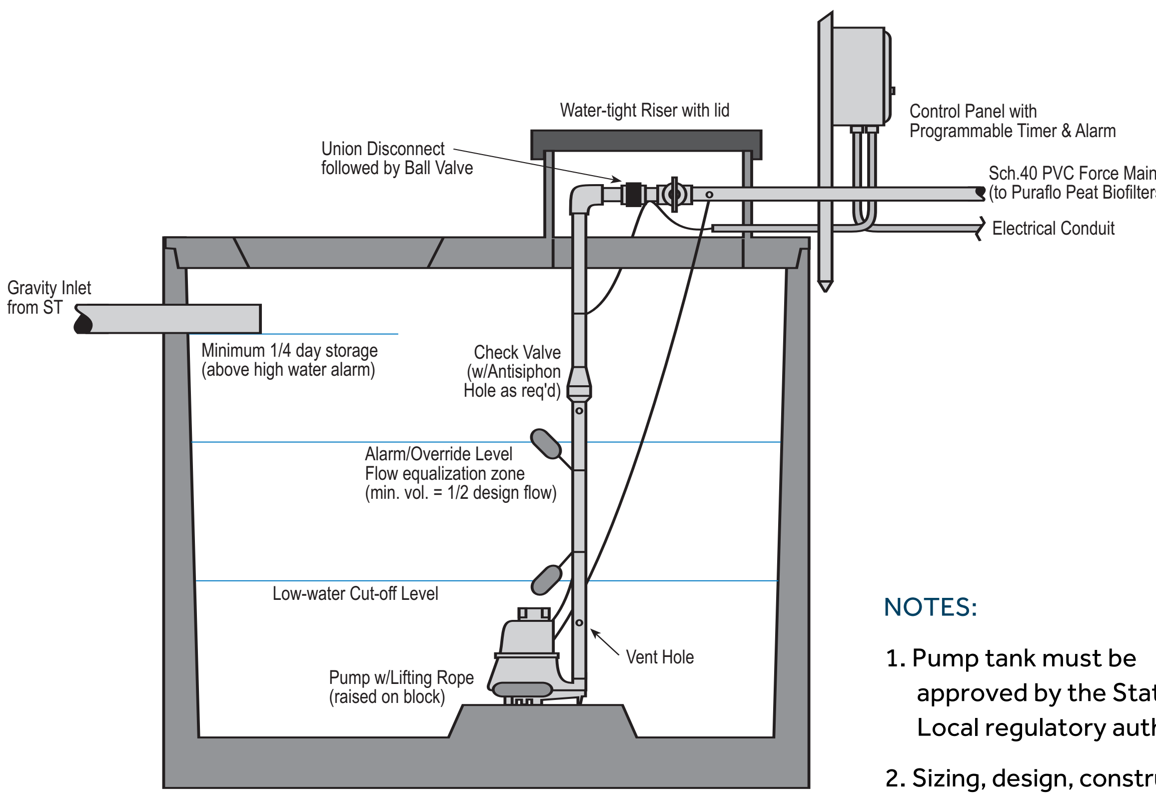
- PROVIDE EROSION PROTECTION AS REQUIRED PER DESIGN PLAN.

Appendix 1 Typical Septic Tank & Pump Detail



NOTES:

1. Septic tank must be approved by the State or Local regulatory authority.
2. Sizing, design, construction and installation must conform to applicable regulations.

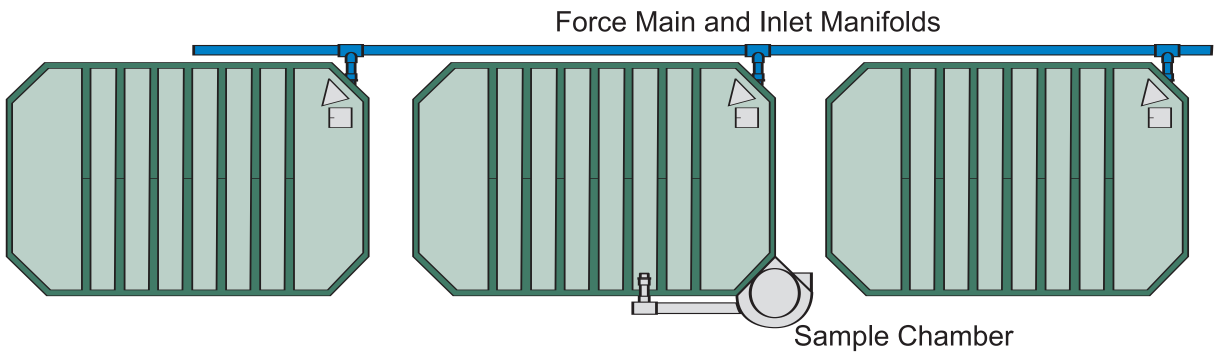


NOTES:

1. Pump tank must be approved by the State or Local regulatory authority.
2. Sizing, design, construction and installation must conform to applicable regulations.

Appendix 2 Type A & Type B Installation

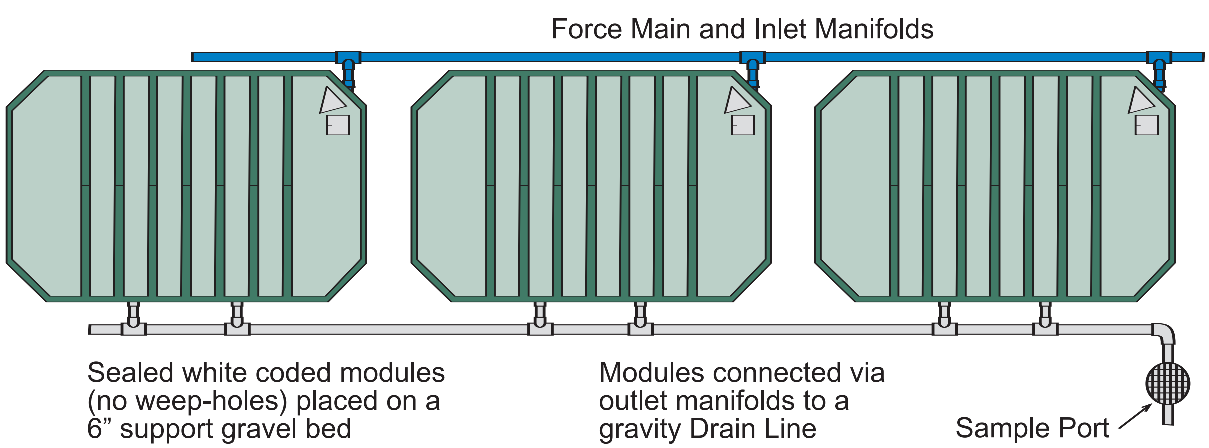
Type A – Pad Installation



Blue coded modules with weep holes and one green coded module with sampling chamber, drain into a stone pad for final treated effluent disposal.

Pad dimensions can be selected to match site conditions and modules can be installed side-by-side as well as end-to-end (as shown above)

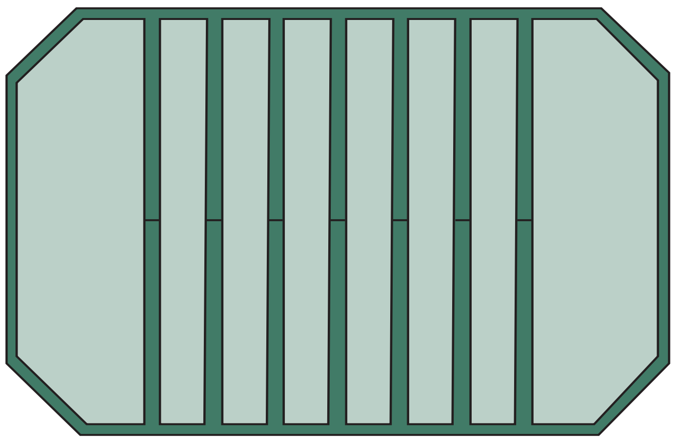
Type B – Piped Outlet Installation



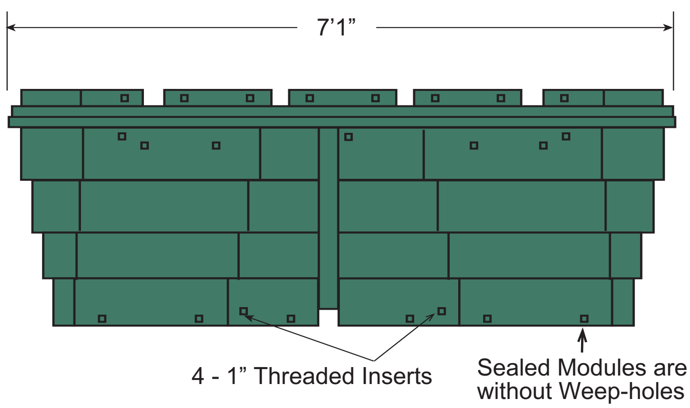
Sealed white coded modules (no weep-holes) placed on a 6” support gravel bed

Modules connected via outlet manifolds to a gravity Drain Line

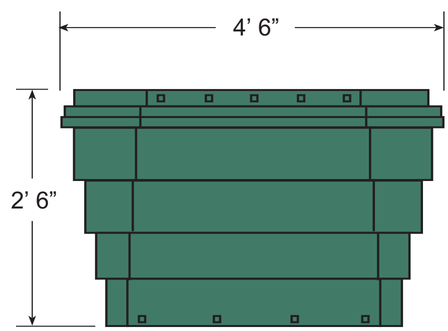
Appendix 3 Assembled Module Detail



Plan View



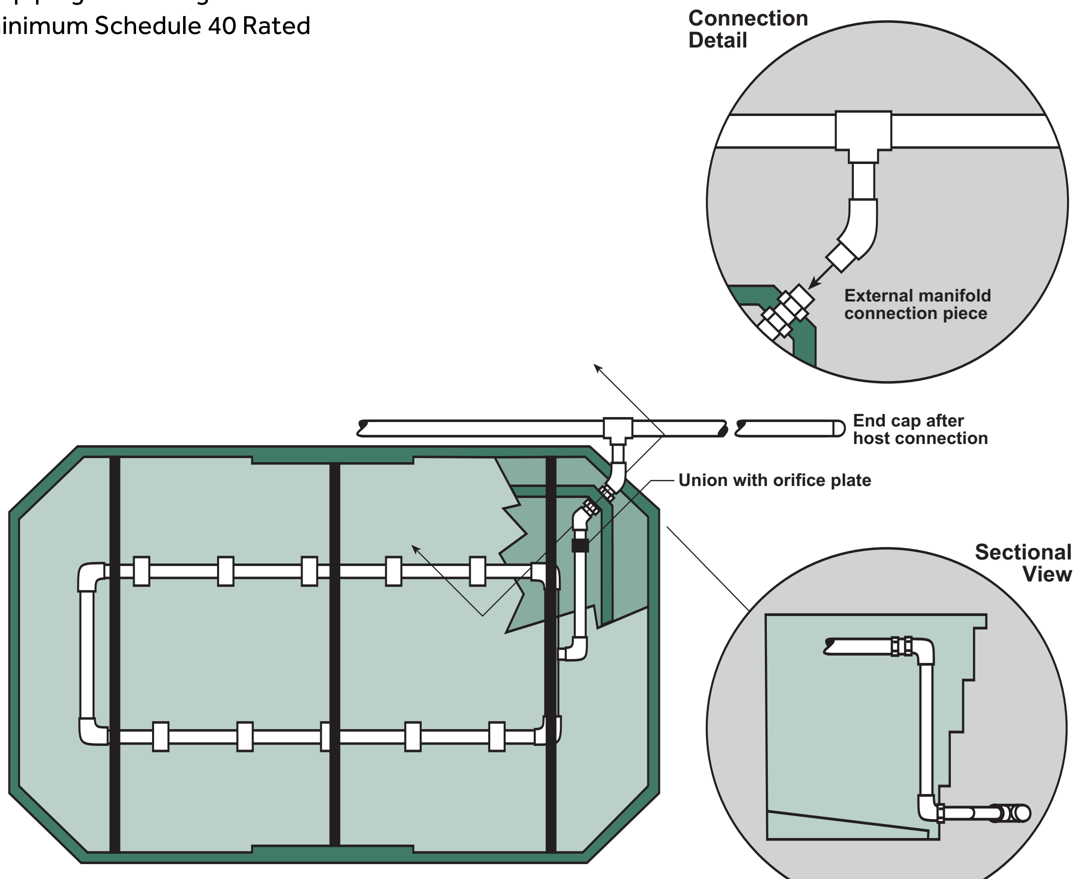
Elevation View



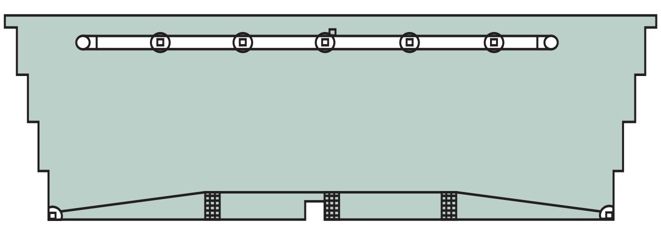
End View

Appendix 4 Module Grid Detail

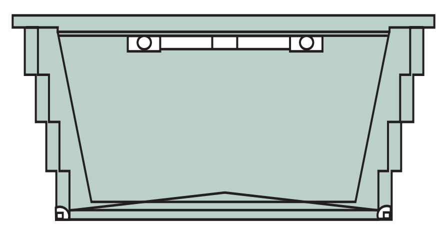
NOTE:
All piping and fittings must be a minimum Schedule 40 Rated



Plan View

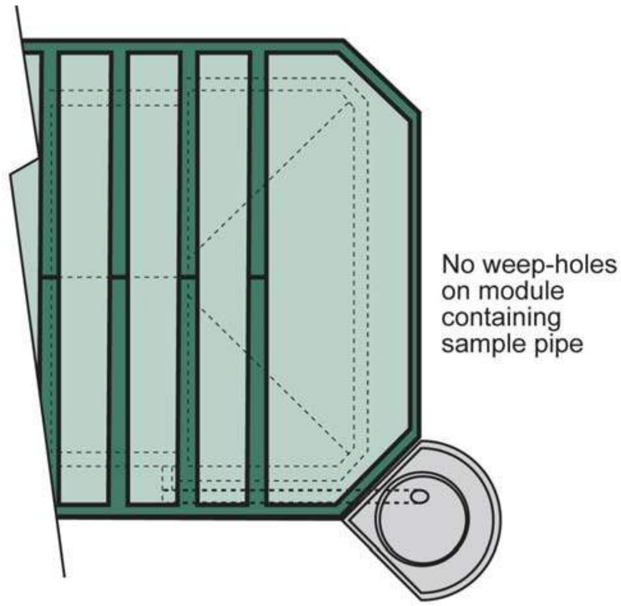


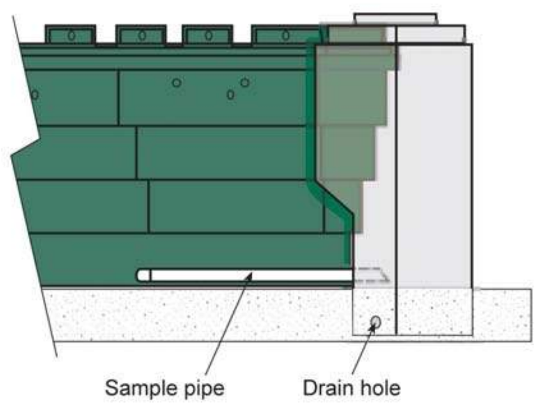
Sectional Elevation View

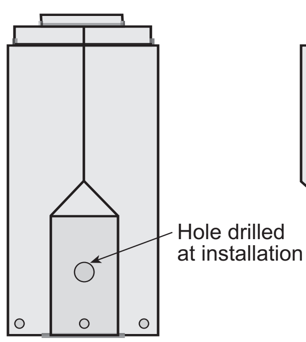


Sectional End View

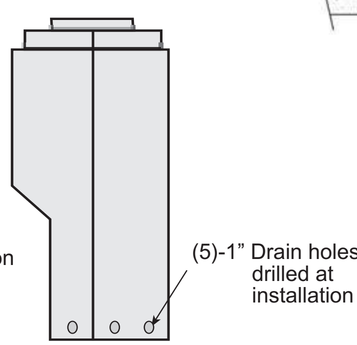
Appendix 5
Sample Chamber Detail



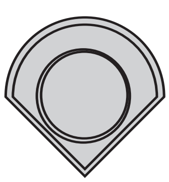




Elevation View



End View



Plan View

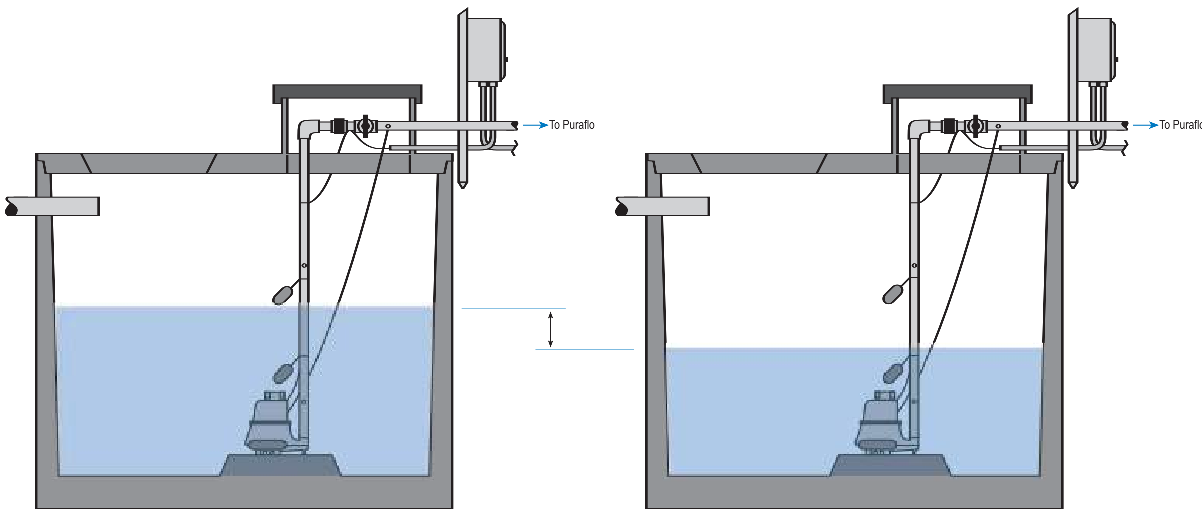
Appendix 6 Module Pictures

NOTE: Pipe is colored for emphasis

Appendix 7 Information Needed for the Drawdown Test

- Pump tank gallons per inch
- Design flow (gallons per day)
- Drainback volume (gallons), if applicable for cold weather situations
- # of Puraflo modules
- # of doses per day (typically 12)

Drawdown Test Procedures



STEP 1
1. Record water level
2. Record time
3. Turn pump "on"

STEP 2
1. Turn pump "off"
2. Record water level
3. Record time
4. Record water level difference and elapsed time

Timer Setting & Module Dose Volume Based on Drawdown Test

Example Parameters

Pump tank gallons per inch:	20 gallons
Design flow:	450 gpd (3 bedroom home)
Drainback volume, per dose:	5 gallons
# of Puraflo modules:	3 modules
# of doses per day:	12 doses
Water level difference:	2 inches
Elapsed time:	1 minute

Example Timer Setting Step 1

Multiple Drainback volume, per dose by # of doses per day — 5 gallons x 12 doses = **60**

Example Timer Setting Step 2

Add Design flow & Total from Step 1 — 450 gallons + 60 gallons = **510**

Example Timer Setting Step 3

Divide the Total from Step 2 by # of doses per day — 510 ÷ 12 doses = **42.5**

Example Timer Setting Step 4

Multiply the Total from Step 3 by Elapsed time — 42.5 x 1 minute = **42.5**

Example Timer Setting Step 5

Multiply the Pump tank gallons per inch by the Water level difference — 20 gallons per inch x 2 inches = **40**

Example Timer Setting Step 6

Divide the Total from Step 4 by the Total from Step 5 — 42.5 ÷ 40 = **1.06 minutes**

1.06 minutes for "on" timer setting or

1.06 minutes x 60 seconds/minute = **63.6 seconds (round-up to 64 seconds)**

Example Timer Setting Step 7

Divide the Hours in a day by the # of doses per day — 24 hours ÷ 12 doses = **2 hours for "off" timer setting**

Example Module Dose Volume Step 1

Divide the Design flow by the # of doses per day — 450 ÷ 12 = **37.5**

Example Module Dose Volume Step 2

Divide the Total from Step 1 by the # of Puraflo modules — **37.5 ÷ 3 = 12.5 gallons/dose per Puraflo module**

Appendix 8 Additional Effluent Dispersal Criteria

Type A System: Puraflo Modules Combined with IN-GROUND PAD Dispersal

- Refer to section 5 and 9 of this manual.
- All components used in conjunction with the Puraflo Peat Fiber Biofilter must comply with all applicable State or Local rules and codes.
- The septic tank shall be sized according to State or Local code.
- An effluent filter/screen shall be placed on the outlet of the septic tank that meets the requirements of Section 5.3 of this manual.
- The pump tank shall be sized according to State or Local code.
- Calculations can be done with the Microsoft Excel Design Sheet.
- The in-ground pad dispersal area shall be sized according to the soil texture hydraulic loading (BOD=30) in Table 4-3 of the USEPA 2002 Onsite Wastewater Treatment Systems Manual.
- The length and width can be sized using the Kaplan (1991) water mounding equations or linear loading rates in the Tyler (2001) Table ≤30 mg/l BOD_5.
- The bottom of the rock dispersal area shall maintain a minimum vertical separation distance from limiting conditions per State or Local code or 1 foot. In situ soil must be a minimum of 6 inches.
- The dispersal aggregate shall be clean stone (3/4 to 1 inch). The stone shall be washed with not more than 5% passing the No. 200 (75 Ìm) sieve as determined by ASTM C117, "Test Method for Material Finer than 75-Ìm (No. 200) Sieve in Mineral Aggregates by Washing" and shall be durable with a hardness of 3 or greater on the Moh's Scale of Hardness.
- The dispersal material shall be leveled to a depth of 6 inches.
- The Puraflo modules shall be placed on the dispersal material so that they are evenly spaced from the sides of the distribution bed and end of the distribution bed with even spaces between each module and the ends of the dispersal area. The minimum spacing from the end of the dispersal material to module end is 1 foot. For spacing calculation, see example below. The modules shall consist of one green coded module and the remainder blue coded (modules may be shipped from the factory as white coded that can be field modified to blue or green by drilling the appropriate number of 7/8" holes on predetermined spots on the modules). If modules are field modified it is the responsibility of the installer to change the color code on the lid of the module.

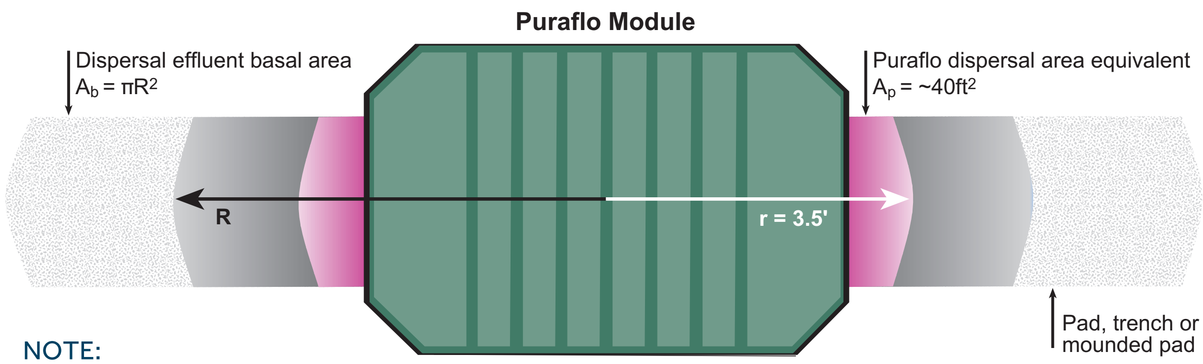
Sample spacing calculation

3 modules, each module is 4.58'W x 7.08'L
Dispersal pad is 10'W x 96'L
Total module L = 3 x 7.08' = 21.24'
Spacing between modules & ends = 96' - 21.24' = 74.76'
=74.76' / 2 (in-between modules) + 2 (ends) = 74.76' / 4
= 18.69' between modules & from ends

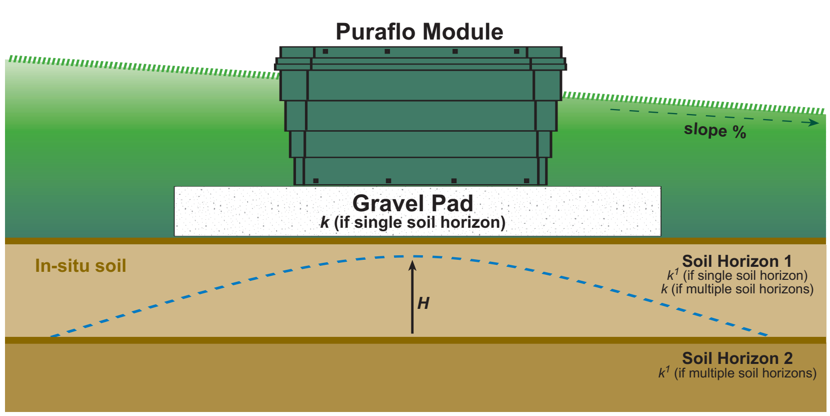
- The Puraflo modules shall be level from side-to-side and end-to-end.
- Connect the force main to the module inlet coupling (incorporating a flexible pipe). Note sizing requirements in Section 5.3 of this guide. The manifold connection shall be configured like the illustration in Appendix 2 and 4 of this guide and shall pass the last module by a minimum of six Inches and be capped. It is recommended that a clean-out be brought to finished grade.
- Distribution media shall be placed at a level to completely cover the distribution holes on the side bottom of the Puraflo modules.
- An Anua specified sample chamber shall be placed on one of the outlet connections of a green color coded module for sampling of effluent.
- Once the Puraflo modules are installed and all connections have been made, the distribution media shall be covered with a geotextile fabric.
- The system shall be backfilled with sandy to loamy soil material and topsoil to the bottom lip of the Puraflo modules.
- Additional design considerations:

  For slowly permeable soils, designers must use professional judgment to ensure effluent absorption into the soil and that other potential issues are mitigated, such as water mounding. For most soils, absorption and water mounding are not issues, even with as little as 1 foot of minimum vertical separation. Also, Converse and Tyler (2000) note, "The design loading rates are based on 150 gpd/bedroom resulting in 450 gpd for a 3 bedroom home. If the mound, as well as other soil based units, is loaded at 450 gpd on a regular basis, it will likely fail. The daily average flow is expected to be no more than about 60% of design or 270 gpd."

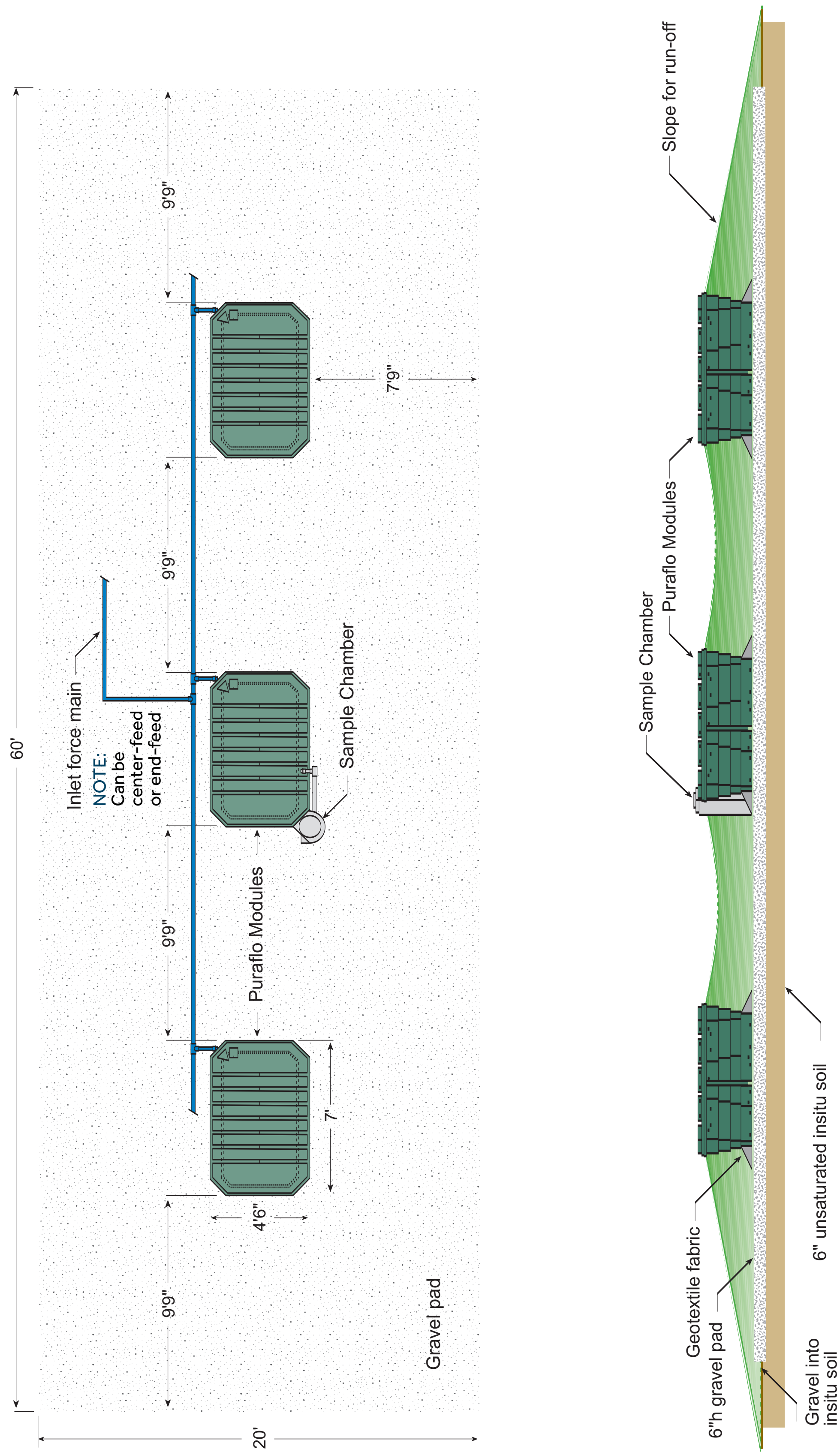
The effluent spread, as depicted in the diagram below, and water mounding height can be calculated using the Kaplan (1991) equations below:



NOTE:
In-ground effluent movement will occur within gravel layer.
For mounded applications, movement will occur through gravel and sand along contour.



In-ground Pad System Diagram (typical)



Type A System: Puraflo Modules Combined with MOUNDED PAD Dispersal

Conditions

- Refer to section 5 and 9 of this manual.
- All components used in conjunction with the Puraflo Peat Fiber Biofilter must comply with all applicable State or Local rules and codes.
- The septic tank shall be sized according to State or Local codes.
- An effluent filter/screen shall be placed on the outlet of the septic tank that meets the requirements of Section 5.3 of this manual.
- The pump tank shall be sized according to State or Local codes.
- Calculations can be done with the Microsoft Excel Design Sheet.
- The bottom of the rock dispersal area shall maintain a minimum vertical separation distance from limiting conditions per State or Local code or 1 foot. In situ soil must be a minimum of 6 inches.

Site limitations and Modifications

- Mounded pads shall be oriented parallel to natural surface contours and shall be sited to avoid natural drainage features and depressions that may hold surface water. A design plan shall address surface water diversion as needed.
- An interceptor drain may be used upslope of a mounded pad soil absorption component to intercept the horizontal flow of subsurface water to reduce its impact on the down gradient mounded pad component.
- A mounded pad soil absorption component shall not be sited on a slope greater than 25 percent unless the design plan includes special installation criteria.
- Sites with boulders or numerous trees are less desirable for a mounded pad soil absorption component. Such conditions shall be avoided or the design plan shall increase the basal area to compensate for losses due to boulders or flush cut trees and shall include special instructions for the basal area preparation under such conditions.

Site and Soil Information

- Site information shall include a description of landscape position, slope, vegetation, drainage features, rock outcrops, erosion and other natural features; and documentation of any relevant surface hydrology, geologic and hydrogeologic risk factors for the specific site or in the surrounding area that may indicate vulnerability for surface water and ground water contamination.
- Soil Information shall include identification of depth to limiting conditions including but not limited to water table and rock strata, and a description of soil texture, consistence, and structure, including shape and grade.

Design Criteria

- The mounded pad basal area shall be sized according to the soil texture hydraulic loading (BOD=30) in Table 4-3 of the USEPA 2002 Onsite Wastewater Treatment Systems Manual.
- The length and width can be sized using the Kaplan (1991) water mounding equations or linear loading rates in the Tyler Table ≤30 mg/l BOD_5 Tyler (2001) Table.
- Location must be comply with State of Local codes.

Sand Fill

- The mounded pad sand fill depth shall be determined based on the depth to the limiting conditions. The sand fill depth shall not exceed two feet and shall not be less than four inches. The loading rate for the sand fill material shall not exceed 2.0 gpd/ft².
- Natural sand is defined as naturally deposited silica based sand not manufactured by mechanical processing such as the crushing of rock or coarse aggregates.
- Sand fill for the mounded pad must be concrete sand meeting the gradation requirements of ASTM C33 provided not more than 5% passes the No. 100 sieve and not more than 5% passes the No. 200 sieve as determined by ASTM C117, "Test Method for Material Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing".
- A comparison of sand application rates from various regulatory authorities is in the table below.

Regulatory Authority	Gradation	Additional Gradation Requirements	Effective Size	Uniformity Coefficient	Sand Application Rate Gpd/ft² (≤30mg/l BOD_5)
Iowa	ASTM C33 or IDOT No.1	Sand fill must not have more than 20% (by weight) material that is greater than 2mm in diameter (coarse fragments), which includes stone, cobbles and gravel. Also, there must not be more than 3% silt and clay (< 0.53 mm, 270 mesh sieve) in the fill.	0.15 – 0.3mm	4 – 6	2.0
Minnesota	ASTM C33	No spec for No. 100 sieve. No. 200 sieve 0-5% passing. Clean sand must also contain less than three percent deleterious substances and be free of organic impurities.	None Specified	None Specified	1.6
Washington	ASTM C33	No. 100 sieve prefer <4% passing. No. 200 sieve 0-3% passing.	None Specified	None Specified	2.0
Wisconsin	ASTM C33	None Specified	None Specified	None Specified	2.0
British Columbia	ASTM C33	No. 100 sieve 0-4% passing. No. 200 sieve 0-1% passing.	None Specified	None Specified	1.6 – 3.15
Manitoba	CSA A23.1 (ASTM C33)	No. 200 sieve 0-5% passing.	None Specified	None Specified	1.6 – 3.75

Distribution of Area Over Sand Fill

- The dispersal aggregate shall be clean stone (3/4 to 1 inch). The stone shall be washed with not more than 5% passing the No. 200 (75 μm) sieve as determined by ASTM C117, "Test Method for Material Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing" and shall be durable with a hardness of 3 or greater on the Moh's Scale of Hardness. Plans may specify the use of other distribution area products or material such as gravelless and chamber products.

- The dispersal material shall be leveled to a depth of 6 inches.

- The Puraflo modules shall be placed on the dispersal material so that they are evenly spaced from the sides of the distribution bed and end of the distribution bed with even spaces between each module and the ends of the dispersal area. The minimum spacing from the end of the dispersal material to module end is 1 foot. For spacing calculation, see "Mounded Pad Design Example".

- The Puraflo modules shall be level from end-to-end.

- Connect the force main to the module inlet coupling (incorporating a flexible pipe). Note sizing requirements in Section 5.3 of this guide. The manifold connection shall be configured like the illustration in Appendix 2 and 4 of this guide and shall pass the last module by a minimum of six inches and be capped. It is recommended that a clean-out be brought to finished grade.

Distribution Network (if applicable)

Modules are typically Type A with weep holes; however, Type B modules with distribution network may be used as required by regulatory authority.

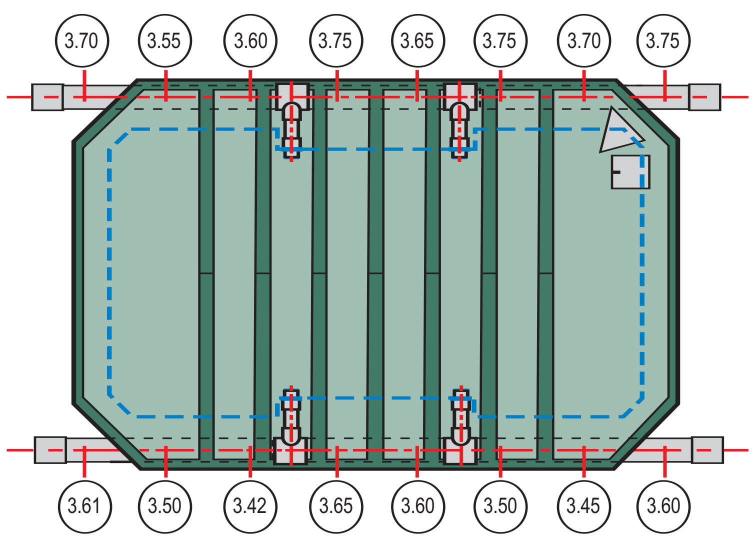
- The distribution network must be 2 inch PVC pipe with 3/8 inch orifices spaced between one to three feet. The orifices should be oriented in the 9 o'clock position.

- Each module must have an isolated lateral with clean-out brought to finished grade on each distal end.

- Each individual distribution lateral must be level within 1/4 inch +/- from module drain hole to lateral end.

- Testing was conducted by Anua to demonstrate the ability of the network to reasonably provided uniform distribution. Test results conducted on the network are shown in the diagram below (Each circle represents a collection bucket below a 3/8-inch orifice.)

Dose Volume = 60 Liters



Monitoring Components

- At least three inspection ports shall be spaced at intervals adequate for observation of the absorption area and any ponding at the sand fill surface. The ports shall be anchored and be accessible with at least a four inch opening and a removable watertight cap.

- Each module must have an isolated lateral with clean-out brought to finished grade on each distal end for flushing-out any materials, such as peat particles migrating to the lateral during initial operation of the system.

Mound Cover

- Once the Puraflo modules are installed and all connections have been made, the distribution media shall be covered with a geotextile fabric used to prevent introduction of soil fines and allow for free movement of air and water.

- The soil cover shall be applied to allow for an approximate depth of six inches after settling, and the mounded pad shall be crowned to promote runoff.

- Soil cover shall be of a quality to allow for oxygen transfer and growth of vegetation.

Installation

- **Pre-Installation:** The full soil absorption area shall be free of any site disturbances. If any disturbance or damage has occurred, installation shall not proceed and the registered installer shall contact the owner and the board of health. Prior to installation the registered installer shall check all elevations in the design plan relative to the established benchmark including the surface contour and the flow line elevation of other components to assure proper flow through the system and freeze protection as applicable. Soil moisture conditions shall be evaluated and basal area preparation shall not proceed when there is risk of smearing or compaction.

- **Site Preparation & Installation:** The mound shall be installed according to the design manual and any referenced resource and shall comply with the following:

  (1) All vegetation shall be cut close to the ground and removed from the site. Stumps, roots, sod, topsoil, and boulders shall not be removed.
  (2) The force main should be installed from the upslope side. All vehicle traffic on the basal area and downslope area of the mounded pad should be avoided with installation work being conducted from the upslope side or end of the mounded pad basal area.
  (3) The basal area of the mounded pad shall be prepared to provide a sand/soil interface and to improve infiltration if needed. The basal area preparation shall not reduce the infiltrative capacity of the soil surface. The degree of basal area preparation shall be determined on a site by site basis depending on soil conditions. Any basal scarification or other basal area preparation shall be conducted working along the contour. Sand may be incorporated into the basal area during the preparation process. Following basal preparation, a layer of sand fill shall be placed on the entire basal area to prevent damage from precipitation and foot traffic.
  (4) The specified depth and sufficient amount of sand fill shall be placed to cover the basal area, form the absorption area, and shall not be steeper than 3 to 1 side slopes. The distribution area shall be formed to the specified dimensions and the sand surface of the distribution area shall be level.
  (5) Construct and install all components, including the distribution laterals and observation ports.
  (6) Once the Puraflo modules are installed and all connections have been made, the distribution media shall be covered with a geotextile fabric.
  (7) Field test the sand to verify quality with one of the methods outlined below.

Minnesota Method

(from 1995 University of Minnesota "Onsite Sewage Treatment Manual")

Jar Test for Clean Sand for Mounds

Use a 1 quart Mason jar

If the fines that settle out in 1 hour is greater than **1/8 inch**, then the percentage of fines is too great and the sand **SHOULD NOT** be used for mound construction.

Manitoba Method

(from OWMS Jar Test revised April, 2010)

OWMS – Field Reference Guide Jar Test

Under some circumstances, it may be beneficial to perform a jar test for fines (silt or clay) on the sand when it is received or before it is purchased to determine if the sand supplied meets the specification of the sand ordered.

An <u>8 hour jar test</u> must be conducted for best results.

The jar test is a "quick" method to determine if the sand contains too many fines. The jar test is not to be used as a replacement for sieve analysis; however the test can be used as a field method to determine that the sand meets CSA A23.1-04 (ASTM C33) specifications.

After settling for several hours, if the layer of fines that settle on top of the sand is thicker than 3.2mm (1/8 inch), the sand contains too many fines and is not suitable for use in a treatment mound. When in doubt the aggregate supplier should provide an aggregate analysis report to confirm that the product meets the sieve specification.

When a "check" in the sand is required, it is recommended that a sample of the sand be obtained prior to construction and the 8 hour jar test be conducted.

Jar test procedure is as follows:

- Place approximately 2 inches of sand in a glass quart jar.
- Fill the jar with water.
- Shake the jar vigorously to mix the sand and water.
- Set the jar on a level platform and allow to settle for 4–8 hours.
- Upon settling, after 4–8 hours, the layer of fines that settle on top of the sand layer should not be thicker than 3.2mm (1/8 inch).

Tips:

- Take a sample from the middle of the pile.
- It may be necessary to jar test a composite sample.
- It may be necessary to conduct two jar tests.
- When in doubt, obtain the sieve analysis report from the aggregate supplier or send a sample to the laboratory. Be sure to ask the laboratory to include the No. 200 sieve size.

Completion

(1) The area around the mound system shall be protected from erosion through upslope surface water diversion and provision of suitable vegetative cover, mulching, or other specified means of protection.
(2) Installer documentation shall include the drawdown test, as specified in Appendix 7, as baseline measure for future O&M and monitoring. Documentation shall be provided to the local health district to be included in the permit record.
(3) The system shall be backfilled with sandy to loamy soil material and topsoil to the bottom lip of the Puraflo modules.

Mounded Pad Operation and Maintenance

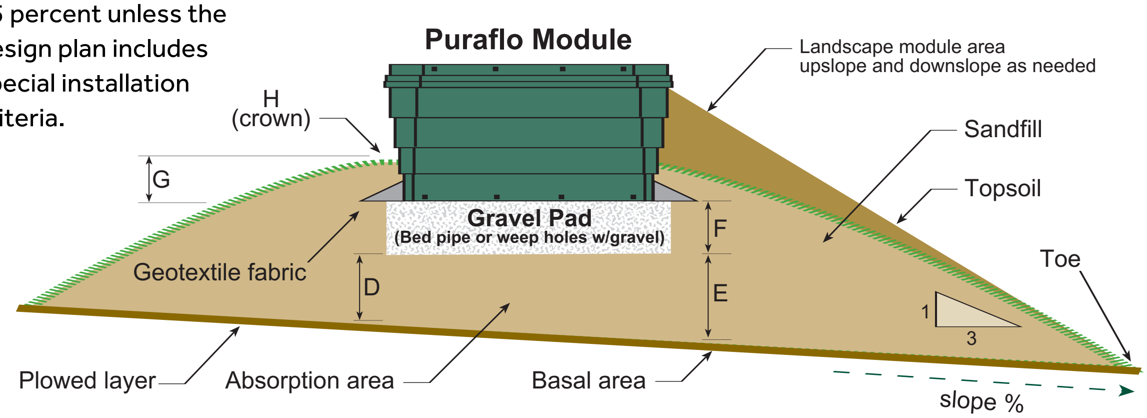
- The mounded pad system shall be operated, maintained, and monitored as outlined in the "Operation and Maintenance Manual" and per requirements of the regulatory authority.

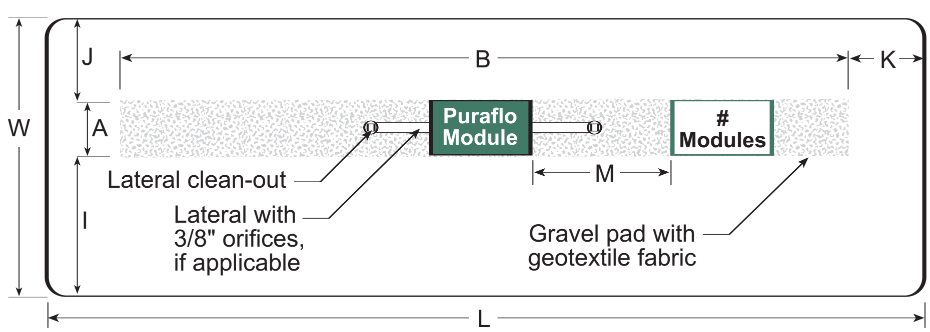
- The O&M of a mound soil absorption system shall include but is not limited to:

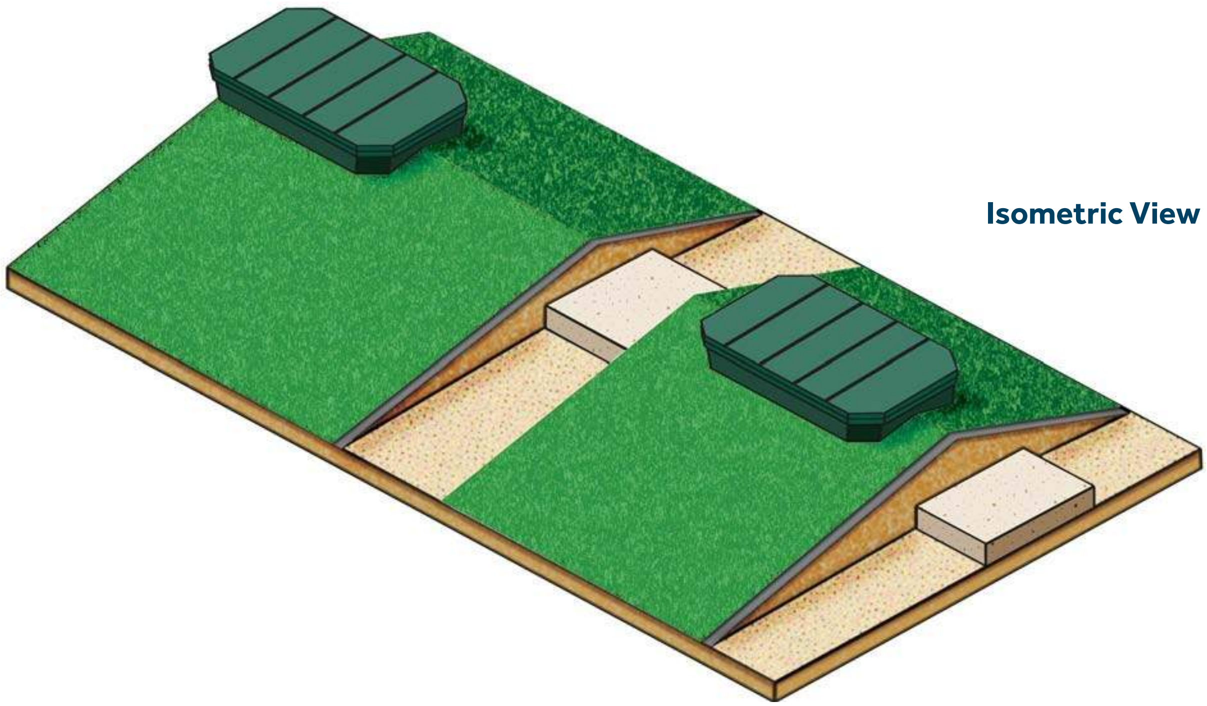
  (1) Checking the mounded pad vegetative cover for erosion or settling and any evidence of seepage on the sides or toes of the mounded pad.
  (2) Flushing of distribution laterals.
  (3) Checking for ponding in the distribution area.
  (4) Monitoring the dose volume to the Puraflo modules and performing the drawdown test as outlined in Appendix 7.
  (5) Checking for any surface water infiltration or clear water flows from the dwelling or structures into the system components or around the mounded pad soil absorption area.

Mounded Pad System Diagram (typical)

NOTE:
A mounded pad soil absorption component shall not be sited on a slope greater than 25 percent unless the design plan includes special installation criteria.







Isometric View

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Type B System: Puraflo Modules Combined with SEPARATE Dispersal

- Refer to section 5 and 9 of this manual.
- All components used in conjunction with the Puraflo Peat Fiber Biofilter must comply with all applicable State or Local rules and codes.
- The septic tank shall be sized according to State or Local codes.
- An effluent filter/screen shall be placed on the outlet of the septic tank that meets the requirements of Section 5.3 of this manual.
- The pump tank shall be sized according to State or Local codes.
- Calculations can be done with the Microsoft Excel Design Sheet.
- The bottom of the rock dispersal area shall maintain a minimum vertical separation distance from limiting conditions per State or Local code or 1 foot. In situ soil must be a minimum of 6 inches.

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Puraflo Peat Fiber Biofilter

Fecal Coliform Reduction Summary for 3rd Party Field Tested Systems

Study	System Location	Year(s)	Mode[1]	No. Systems	Sample Location[2]	Fecal Coliform Geo Mean (per 100 ml)
Anne Arundel County National	Maryland	1995-97	SP	1	SC	23.6
Anne Arundel County National	Maryland	1995-97	MP	1	SC	23.6
Old Dominion University	Virginia	1997-99	SP	23	SC	263
Old Dominion University	Virginia	1997-99	SP	23	PW: 12in below	154
Old Dominion University	Virginia	1997-99	MP	1	SC	41
Bernalillo County Environmental Health Dept New Mexico Environment Department	New Mexico	1997-98	SP	1	SC	<200[3]
North Carolina State University	North Carolina	1997-99	SP	1	SC	290
North Carolina State University	North Carolina	1997-99	SP	1	PW	<200
Natural Resources Research Institute University of Minnesota-Duluth	Minnesota	1998-2003	SP	1	SC	Summer: 28 Winter: 531 All data: 113
Clermont County General Health District Ohio EPA 319 Project #98(h) E-1	Ohio	1998-2000	SP	2	SC	100% met discharge standards <2,000 daily <1,000 monthly avg
La Pine National Demonstration Project	Oregon	2001-04	MP	3	SC	267

[1] *SP=Single Pass; MP=Multiple Pass (Recirc)*

[2] *SC=Post Puraflo Sample Chamber; PW=Pad Well (Drainfield)*

[3] *Study did additional fecal coliform sampling beyond initial study*

Think Green

Puraflo®

Peat Fiber Biofilter

It's Time for a New Contract with Nature

- Low operation and maintenance costs
- Suitable for LEED certification
- Odor-free natural system
- Pre-assembled modules for compact installation on size restrictive sites
- Best solution for extreme sites with difficult soils or shallow water tables
- Alternative to NPDES discharging systems
- Suitable for environmentally sensitive sites, such as waterfront properties
- Ideal for homes, schools, offices, parks, churches and communities
- Excellent for vacation homes and sites subject to intermittent use

ANUA

Community Systems

Residential Systems

The Difference is the Fiber – It Lasts Twice as Long as our Competitors

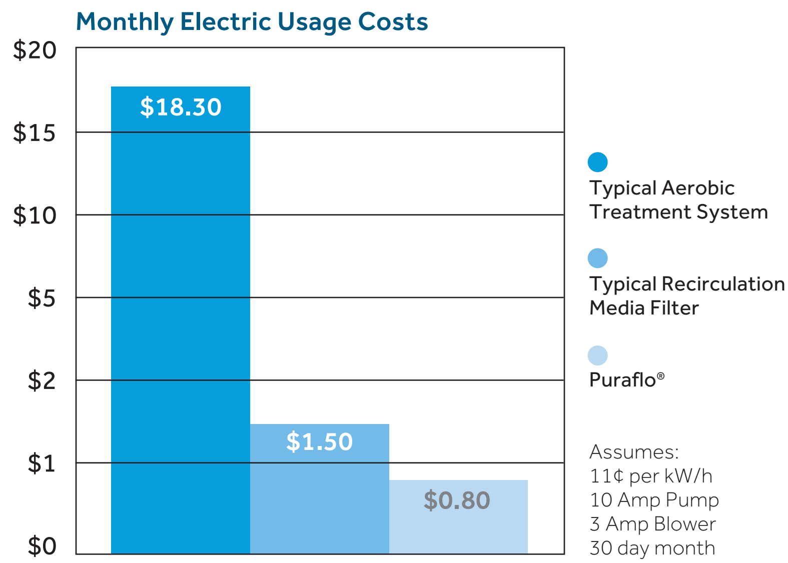
Puraflo peat fiber media is imported from the Republic of Ireland and has a greater resistance to decay and degradation than other peat media. This is due to its extremely fibrous structure and high lignin content.

Low Power + Low Maintenance = Big Savings

Reducing costs to the owner, Puraflo requires significantly less power than many other treatment systems such as aerobic treatment units or recirculating media filters. Blowers or maintenance intensive effluent filters/screened pump vaults not required.

Reduced Complexity Lowers the Cost of Operation and Maintenance

Puraflo can be installed as a combined treatment and effluent dispersal system, which saves energy and space. Treated effluent exits the Puraflo modules via weep holes around the perimeter at the module base and flows into the dispersal system situated directly beneath the modules. Available dispersal system options are in-ground pad or mounded pad.



ANUA

Call: 336-547-9338 or visit: www.anua-us.com

PACE
Advanced Water Engineering

Appendix C – OWTS Water Reuse

Appendix C – OWTS Water Reuse

1.0 Introduction

The Preserve development is located in an area with large amounts of native vegetation with the potential for periodic wildfires. Therefore, the proposed new home lots will be subject to large amounts of fuel modification (fuel mod) vegetation management for fire protection. The fuel mod plan requires a minimum 150-foot "wet zone" (fuel mod zone B) of permanently irrigated planting surrounding the building pads.

No recycled water source is available for irrigating fuel mod areas, so potable water sources must be used. The output from the onsite wastewater treatment systems (OWTS) will be utilized to irrigate portions of the fuel mod planting in zone B, thus reducing the amount of potable water needed for this purpose. Technically, the water generated by the OWTS is not Title 22 recycled or reclaimed water, it is effluent treated to a high standard.

Due to the unique aspects of the development, its location, and the OWTS, the developer, water engineer, and the County have agreed it is acceptable to reuse the treated effluent for irrigation. All irrigation systems connected to OWTS will be marked as non-potable using standard purple-colored components for recycled water irrigation systems. All dispersal field irrigation equipment will be operated and maintained by qualified personnel, not by individual homeowners.

2.0 OWTS Dispersal Irrigation Design

OWTS dispersal systems will be designed and installed to meet the standards of the California State Water Resources Control Board resolution no. 2012-0032 - "OWTS Policy", including setbacks (section 7.5) and burial depth (section 8.1.4).

The output from each treatment system will be connected to a subsurface dripline dispersal system adjacent to the lot. Dispersal irrigation fields will be placed on fill slopes and natural areas. Placement on cut slopes will be avoided. Irrigation fields will primarily be at the same or lower elevations than the lot they serve. OWTS dispersal fields will be sized to provide all the daily needs of water for the plants in fuel mod zone B in the month of January.

The area needed for each lot's irrigation field has been calculated as follows: County of Orange Ordinance No. 09-010 *Landscape Irrigation Code* sets forth formulas to use to calculate the Maximum Applied Water Allowance (MAWA) and the Estimated Applied Water Use (EAWU) for all new landscape and irrigation installations within the unincorporated areas of the County. The County formula for Estimated Applied Water Use (EAWU) is:

EAWU = (ETo) x (KL) x (LA) x (0.62) ÷ (IE) = Gallons per year

where:

ETo	=	Reference Evapotranspiration (inches per year)
KL	=	Landscape Coefficient
LA	=	Landscaped Area (square feet)
0.62	=	Conversion factor (to gallons per square foot)
IE	=	Irrigation Efficiency

ETo is an estimate of the amount of moisture needed to be replaced in plants due to the action of evapotranspiration, and is primarily influenced by solar exposure and prevailing temperatures. Historically in Orange County, January is the month with the lowest ETo rate, that is, the month in which plants need the least amount of water lost to evapotranspiration to be replaced. Appendix C in the Landscape Irrigation Code dictates a Reference ETo of 2.20" for all areas in Orange County for January. Placing this value in the EAWU formula results in the following:

*EAWU = **(2.20 ÷ 31)** x (KL) x (LA) x (0.62) ÷ (IE) = Gallons per **day (in January)***
*EAWU = **(0.071)** x (KL) x (LA) x (0.62) ÷ (IE) = Gallons per day (in January)*

Landscape Coefficient (KL) values are derived from WUCOLS, the *Water Use Classification of Landscape Species*, a publication produced by the California Department of Water Resources. Within WUCOLS, landscape plants are assigned a Landscape Coefficient by plant species and region of California. Generally speaking, the major classifications of landscape plants are high, moderate, and low water use, and they are given the following KL values:

High water use plant species	0.7 - 0.9
Moderate water use plant species	0.4 - 0.6
Low water use plant species	0.1 - 0.3

Within the irrigation field areas of fuel mod zone B, the planting design will use moderate water use landscape species. This will result in the irrigation fields being significantly smaller than if these areas were planted with low water use species. Our estimate for the KL value of moderate water use species on OCFA's approved list for fuel mod zone B is 0.5.

The OWTS Policy does not allow water to be dispersed through overhead spray equipment, it must be delivered below the soil surface (section 8.1.4). The Landscape Irrigation Code provides an assumed Irrigation Efficiency (IE) value of 90% for subsurface irrigation. (Ord. 09-010 Appendix A 2.5(a)(1)(k)).

Inserting the values detailed above in the EAWU formula results in the following:

*EAWU = (0.071) x **(0.5)** x (LA) x (0.62) ÷ **(0.90)** = Gallons per day (in January)*

Each home is projected to produce up to 320 gallons of reclaimed water per day. We can place this value in the formula:

*EAWU = (0.071) x (0.5) x (LA) x (0.62) ÷ (0.90) = **320** Gallons per day (in January*

And then solve for LA, the amount of landscape area needed to use 320 gallons in one day in January to irrigate fuel mod planting:

*EAWU = (0.071) x (0.5) x (LA) x (0.62) = (320) **x (0.90)***
*EAWU = (**0.022**) x (LA)) = **288***
***LA** = (288) ÷ (0.022) = square feet per day (in January)*
LA = 13,091 square feet per day (in January)

Each lot will need to have 13,100 square feet of moderate water use fuel mod planting adjacent to it, irrigated with a subsurface drip system, in order to disperse 320 gallons per day of OWTS treated effluent, while satisfying the plants' water needs in an average January without supplemental watering.

The irrigation field control valves will be connected to controllers separate from the H.O.A.'s overhead spray system controllers. Both will be managed by qualified personnel, not homeowners. A potable water supplement line to the effluent pump station will insure the availability of 320 gallons per day of water from each OWTS when output is low, or even if a home is vacant.

Using subsurface dripline with 0.5 gallon-per-hour in-line emitters at 18" on center, and installing the driplines 18" apart, a typical irrigation field for each lot will have 3-4 zones running at 13-17 gallons-per-minute and require approximately 18-24 minutes of total run time per day (6 minutes per zone). This equals a precipitation rate of 0.04" of water **per day**. We believe a precipitation rate this low will have no adverse effect on soil saturation conditions, even during times of significant rainfall. Also, generally speaking, most plants will tolerate much more water than their WUCOLS classification might indicate.

The WUCOLS classifications are meant to be a guideline for the minimum percentage of ETo that plants need to survive and be healthy, since WUCOLS has been developed as a water conservation tool.

3.0 Fuel Mod Irrigation Design

In months other than January, or when January is abnormally warm, the irrigation field areas will be supplemented with a separate H.O.A. overhead spray irrigation system. Irrigation zones watering over the irrigation fields will be separated from the zones watering the rest of fuel mod zone B. This will allow these zones to be separately scheduled to compensate for the treated effluent irrigation and the higher water requirement plants used in the dispersal field areas. This separation will also allow for periodic leaching of salts in the irrigation fields, which result from both the use of treated effluent water and subsurface drip irrigation technology.

The fuel mod irrigation systems will be designed to comply with the Landscape Irrigation Code, including the use of controllers which utilize evapotranspiration data for varying schedules. The typical irrigation systems for fuel mod irrigation will consist of a dedicated 2" potable water service, buried PVC main lines, electric control valves, and UV-resistant PVC lateral lines installed on grade. Overhead spray rotor sprinkler heads will be used wherever possible to efficiently and effectively irrigate the fuel mod planting. Irrigation zones will be further divided into south/west and north/east solar exposures to accommodate their differing water needs. A typical irrigation zone will run at 50-60 gallons-per-minute and have a precipitation rate of 0.50"-1.50" of water per hour.

4.0 Fuel Mod Planting Design

Fuel mod zone B extends a minimum of 150 feet from zone A, and shall be cleared of all undesirable plant species, irrigated, and planted with species from the OCFA approved plant list. Fuel mod planting will be designed and installed to comply with the Orange County Fire Authority (OCFA), including the spacing between shrub and tree masses.

Fuel mod zone B will be separated into two planting areas: The upper area adjacent to fuel mod zone A will consist of 'moderate' water use plants, and shall be partially irrigated with treated effluent from the adjoining residential lot. The remaining portion of fuel mod zone B will consist of 'low' water use plant material, and shall be watered with an irrigation system connected to the domestic water system.

5.0 OWTS Policy excerpts *(State Water Resources Control Board resolution no. 2012-0032)*

7.5 Minimum horizontal setbacks from any OWTS treatment component and dispersal systems shall be as follows:

7.5.1 5 feet from parcel property lines and structures.

7.5.2 100 feet from water wells and monitoring wells, unless regulatory or legitimate data requirements necessitate that monitoring wells be located closer.

7.5.3 100 feet from any unstable land mass or any areas subject to earth slides identified by a registered engineer or registered geologist; other setback distance are allowed, if recommended by a geotechnical report prepared by a qualified professional.

7.5.4 100 feet from springs and flowing surface water bodies where the edge of that water body is the natural or levied bank for creeks and rivers, or may be less where site conditions prevent migration of wastewater to the water body.

7.5.5 200 feet from vernal pools, wetlands, lakes, ponds, or other surface water bodies where the edge of that water body is the high water mark for lakes and reservoirs, and the mean high tide line for tidally influenced water bodies.

7.5.6 150 feet from a public water well where the depth of the effluent dispersal system does not exceed 10 feet.

8.1 OWTS Design Requirements

8.1.4 All dispersal systems shall have at least twelve (12) inches of soil cover, except for pressure distribution systems, which must have at least six (6) inches of soil cover.

6.0 OWTS Policy Final Substitute Environmental Document excerpts *(State Water Resources Control Board resolution no. 2012-0032)*

4.5.4.3 Shallow Dispersal

The most biologically active area in a soil column is the aerobic environment at or near the ground surface. An aerobic environment (oxygen rich) is desired for most wastewater treatment and dispersal systems. Aerobic decomposition of wastewater solids is significantly faster and more complete. Maximum delivery of oxygen to the infiltration zone is most likely to occur when dispersal systems are shallow (USEPA 2002).

Shallow dispersal methods, primarily drip distribution, which was derived from drip irrigation technology, is a method of pressure-dosed distribution capable of delivering small, precise volumes of wastewater effluent to the infiltrative surface. It is the most efficient of the distribution methods, and although it requires supplemental treatment, it is well suited for all types of dispersal system applications.

A drip line pressure network consists of several components:

- *dose tank,*
- *pump,*
- *pre-filter,*
- *supply manifold,*
- *pressure regulator (when turbulent, flow emitters are used),*
- *drip line,*
- *emitters,*
- *vacuum release valve,*
- *return manifold,*
- *flush valve, and*
- *controller.*

The drip line is normally a flexible polyethylene tube that is a half-inch in diameter with emitters attached to the inside wall spaced 1–2 feet apart along its length. Because the emitter passageways are small, friction losses are large and the rate of discharge is low (typically from 0.5 to nearly 2 gallons per hour). Usually, the drip line is installed in shallow (less than 1 foot deep), narrow trenches 1–2 feet apart and only as wide as necessary to insert the drip line using a trenching machine or vibratory plow. The trench is backfilled without any porous medium so that the emitter orifices are in direct contact with the soil. The distal ends of each drip line are connected to a return manifold. The return manifold is used to regularly flush the drip line.

Because of the unique construction of drip distribution systems, they cause less site disruption during installation, are adaptable to irregularly shaped lots or other difficult site constraints, and use more of the soil mantle and take advantage of plant uptake (absorption into the roots of plants) for treatment because of their shallow placement in the ground.

Reference:

California Department of Water Resources (August 2000). "*A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California – The Landscape Coefficient Method and WUCOLS III*".

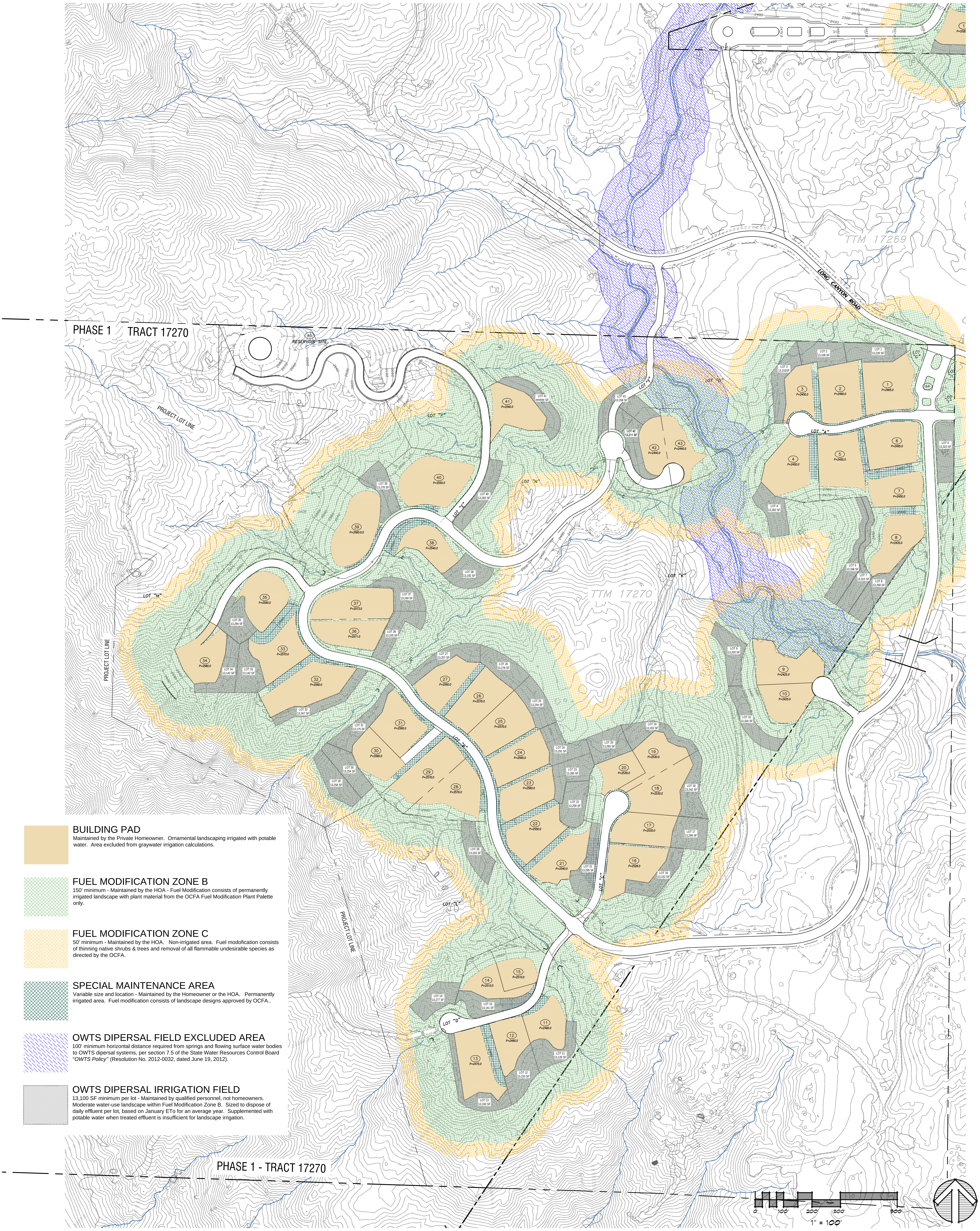
California State Water Resources Control Board (June 19, 2012). Resolution No. 2012-0032 "OWTS Policy – Water Quality Control Policy for Siting, Design, Operation, and Maintenance of Onsite Wastewater Treatment Systems".

California State Water Resources Control Board (June 19, 2012). Resolution No. 2012-0032 "Onsite Wastewater Treatment System Policy Final Substitute Environmental Document".

County of Orange California (December 15, 2009). Ordinance No. 09-010 "*Landscape Irrigation Code*".

Orange County Fire Authority Planning & Development Services Section (January 1, 2008). "*Guidelines for Fuel Management Plans and Maintenance Program*".

Orange County Public Works (November 2009). "*Guidelines (Appendix A) for Implementation of the County of Orange Landscape Irrigation Code*".



BUILDING PAD
Maintained by the Private Homeowner. Ornamental landscaping irrigated with potable water. Area excluded from graywater irrigation calculations.

FUEL MODIFICATION ZONE B
150' minimum - Maintained by the HOA - Fuel Modification consists of permanently irrigated landscape with plant material from the OCFA Fuel Modification Plant Palette only.

FUEL MODIFICATION ZONE C
50' minimum - Maintained by the HOA. Non-irrigated area. Fuel modification consists of thinning native shrubs & trees and removal of all flammable undesirable species as directed by the OCFA.

SPECIAL MAINTENANCE AREA
Variable size and location - Maintained by the Homeowner or the HOA. Permanently irrigated area. Fuel modification consists of landscape designs approved by OCFA..

OWTS DIPERSAL FIELD EXCLUDED AREA
100' minimum horizontal distance required from springs and flowing surface water bodies to OWTS dipersal systems, per section 7.5 of the State Water Resources Control Board "*OWTS Policy*" (Resolution No. 2012-0032, dated June 19, 2012).

OWTS DIPERSAL IRRIGATION FIELD
13,100 SF minimum per lot - Maintained by qualified personnel, not homeowners. Moderate water-use landscape within Fuel Modification Zone B. Sized to dispose of daily effluent per lot, based on January ETo for an average year. Supplemented with potable water when treated effluent is insufficient for landscape irrigation.

THE PRESERVE

WATER REUSE STUDY - PHASE 1

ORANGE & RIVERSIDE COUNTIES, CALIFORNIA

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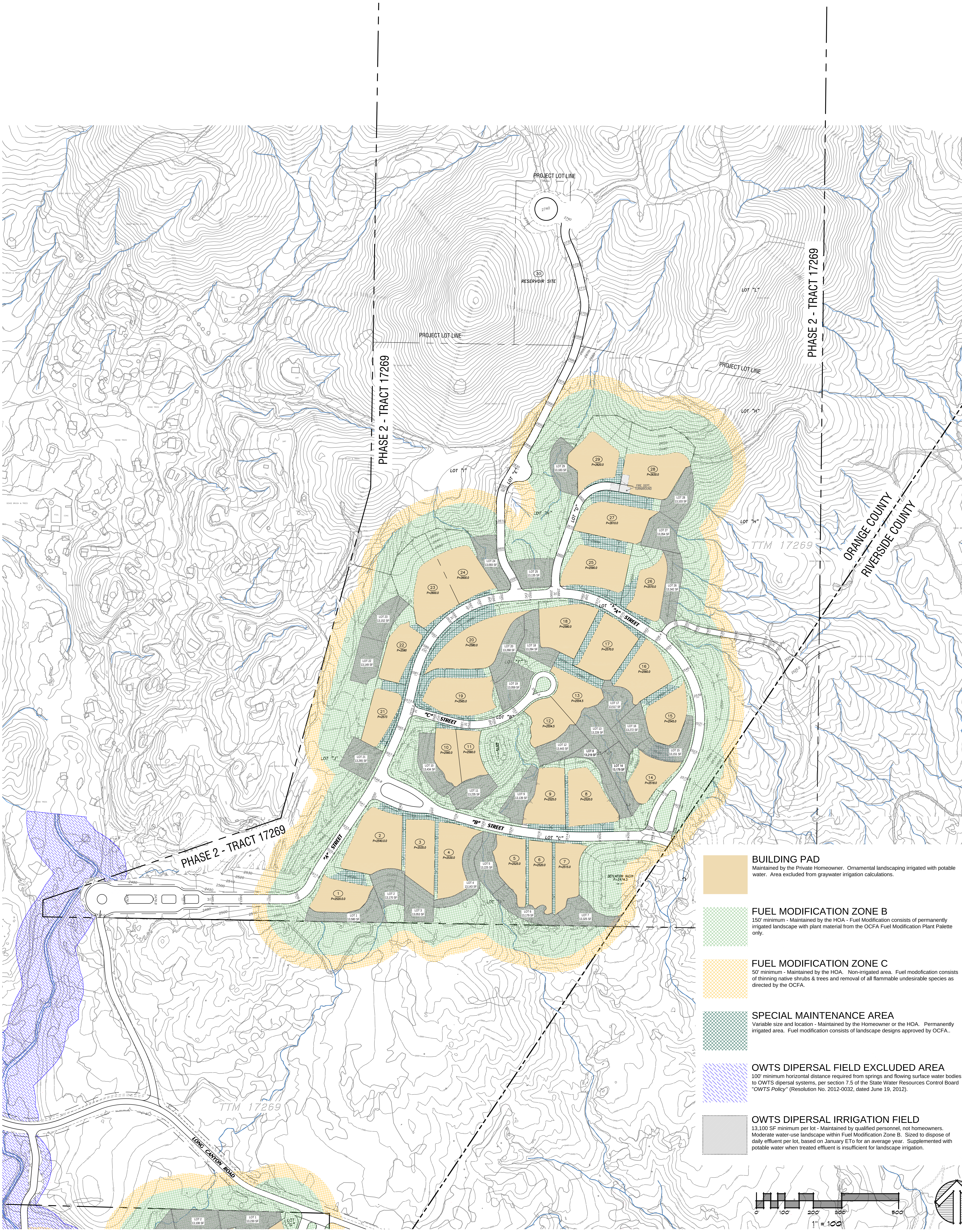

BUILDING PAD
Maintained by the Private Homeowner. Ornamental landscaping irrigated with potable water. Area excluded from graywater irrigation calculations.

FUEL MODIFICATION ZONE B
150' minimum - Maintained by the HOA - Fuel Modification consists of permanently irrigated landscape with plant material from the OCFA Fuel Modification Plant Palette only.

FUEL MODIFICATION ZONE C
50' minimum - Maintained by the HOA. Non-irrigated area. Fuel modofication consists of thinning native shrubs & trees and removal of all flammable undesirable species as directed by the OCFA.

SPECIAL MAINTENANCE AREA
Variable size and location - Maintained by the Homeowner or the HOA. Permanently irrigated area. Fuel modification consists of landscape designs approved by OCFA..

OWTS DIPERSAL FIELD EXCLUDED AREA
100' minimum horizontal distance required from springs and flowing surface water bodies to OWTS dipersal systems, per section 7.5 of the State Water Resources Control Board "*OWTS Policy*" (Resolution No. 2012-0032, dated June 19, 2012).

OWTS DIPERSAL IRRIGATION FIELD
13,100 SF minimum per lot - Maintained by qualified personnel, not homeowners. Moderate water-use landscape within Fuel Modification Zone B. Sized to dispose of daily effluent per lot, based on January ETo for an average year. Supplemented with potable water when treated effluent is insufficient for landscape irrigation.

THE PRESERVE

WATER REUSE STUDY - PHASE 2

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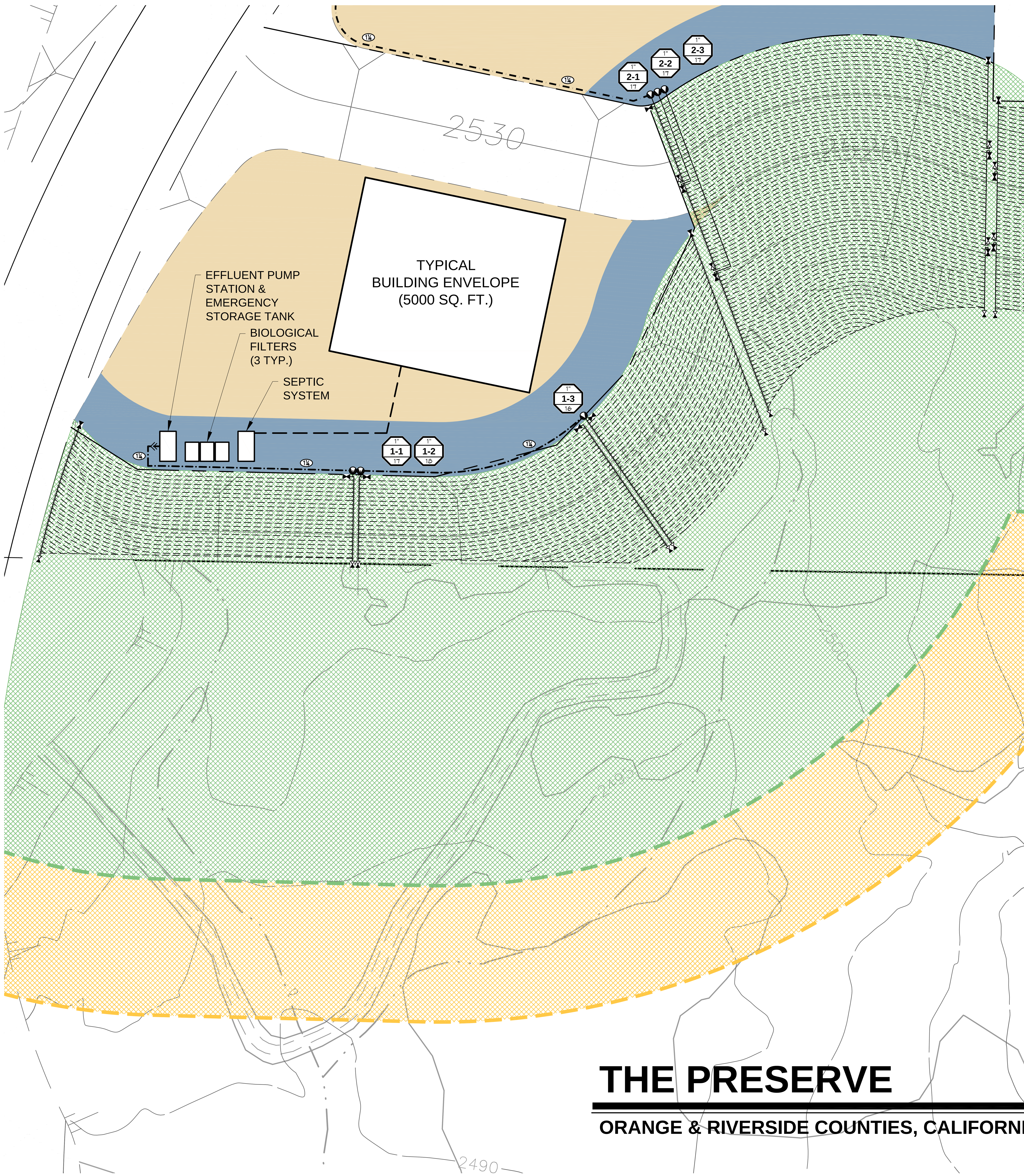

FUEL MODIFICATION LEGEND

- ZONE A - 20'
- ZONE B - 150'
- ZONE C - 50'

LEGEND

- POINT OF CONNECTION TO EFFLUENT PUMP STATION
- PVC LINE TO PUMP STATION (BURIED)
- REMOTE CONTROL VALVE
- PVC SUPPLY & FLUSH MANIFOLDS w/ DRIPLINE ADAPTERS
- 0.5 GPH DRIPLINE w/ EMITTERS @ 18" O.C. & LINES @ 18" O.C.
- DRIPLINE AIR VACUUM BREAKER AT HIGH POINTS
- PVC BALL VALVE FOR FLUSHING & DRAINING AT LOW POINTS

NOTES

- OWTS DISPERSAL FIELDS WILL BE DESIGNED AND INSTALLED TO MEET THE STANDARDS OF THE CALIFORNIA STATE WATER RESOURCES CONTROL BOARD RESOLUTION NO. 2012-0032 - "OWTS POLICY", INCLUDING SETBACKS (SECTION 7.5) AND BURIAL DEPTH (SECTION 8.1.4).
- EACH HOME IS PROJECTED TO PRODUCE UP TO 320 GALLONS OF TREATED EFFLUENT PER DAY. THE EFFLUENT WILL BE REUSED FOR IRRIGATING PLANTING WITHIN FUEL MODIFICATION ZONE B.
- A POTABLE WATER SUPPLEMENT LINE TO THE EFFLUENT PUMP STATION WILL INSURE THE AVAILABILITY OF 320 GALLONS PER DAY OF WATER OUTPUT FROM EACH RESIDENTIAL ONSITE TREATMENT SYSTEM (OWTS).
- THE OUTPUT OF EACH TREATMENT SYSTEM WILL BE CONNECTED TO A SUBSURFACE DRIPLINE DISPERSAL SYSTEM ADJACENT TO THE LOT.
- DISPERSAL IRRIGATION FIELDS WILL BE PLACED ON FILL SLOPES AND NATURAL AREAS. PLACEMENT ON CUT SLOPES WILL BE AVOIDED.
- IRRIGATION FIELDS WILL PRIMARILY BE AT THE SAME OR LOWER ELEVATIONS THAN THE LOT THEY SERVE.
- OWTS DISPERSAL FIELDS ARE SIZED (13,100 SQ. FT. MINIMUM) TO PROVIDE ALL THE DAILY NEEDS OF WATER FOR THE PLANTS IN FUEL MODIFICATION ZONE B IN THE MONTH OF JANUARY (1.10" PER MONTH ON AVERAGE).
- IN ALL OTHER MONTHS, THE DISPERSAL SYSTEM WILL BE SUPPLEMENTED WITH A SEPARATE H.O.A. OVERHEAD SPRAY IRRIGATION SYSTEM. REFER TO THE "TYPICAL FUEL MOD. IRRIGATION" PLAN.
- IRRIGATION FIELD CONTROL VALVES WILL BE CONNECTED TO CONTROLLERS SEPARATE FROM THE H.O.A.'S OVERHEAD IRRIGATION SPRAY SYSTEM CONTROLLERS. BOTH WILL BE MANAGED BY QUALIFIED PERSONNEL, NOT HOMEOWNERS.
- A TYPICAL DISPERSAL IRRIGATION FIELD FOR EACH LOT WILL HAVE 3-4 ZONES RUNNING AT 13-17 GALLONS-PER-MINUTE AND REQUIRE APPROXIMATELY 18-24 MINUTES OF TOTAL RUN TIME PER DAY (6 MINUTES PER ZONE). THIS EQUALS A PRECIPITATION RATE OF 0.04" OF WATER PER DAY.

TYPICAL DISPERSAL FIELDS

0' 20' 40' 60' 100'

1" = 20'

THE PRESERVE

WATER REUSE STUDY

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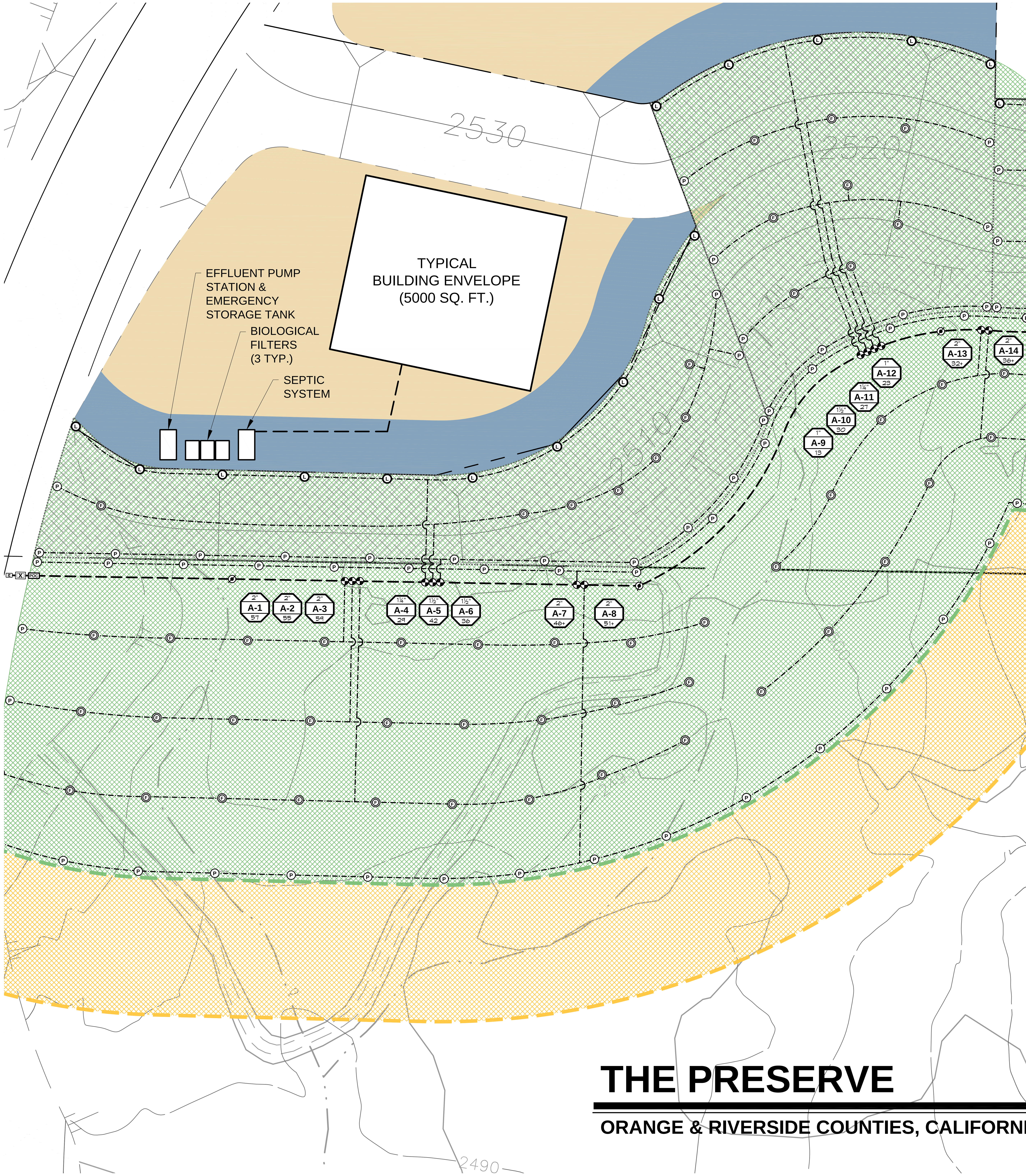

FUEL MODIFICATION LEGEND
ZONE A – 20'
ZONE B – 150'
ZONE C – 50'

LEGEND

M	WATER METER DEDICATED TO IRRIGATION
X	BACKFLOW PREVENTER IN VANDAL-RESISTANT ENCLOSURE
POC	POINT OF CONNECTION EQUIPMENT IN PLASTIC VAULT
— —	PVC MAIN LINE (BURIED)
	REMOTE CONTROL VALVE
—·—	UV-RESISTANT PVC LATERAL LINE (ON GRADE)
L	LOW-ANGLE ROTOR SPRINKLER HEAD
P	PART-CIRCLE ROTOR SPRINKLER HEAD
F	FULL-CIRCLE ROTOR SPRINKLER HEAD
	QUICK-COUPLING VALVE FOR SUPPLEMENTAL WATERING

NOTES

- FUEL MOD. IRRIGATION WILL BE DESIGNED AND INSTALLED TO COMPLY WITH COUNTY OF ORANGE ORDINANCE NO. 09-010 - "LANDSCAPE IRRIGATION CODE".
- FUEL MODIFICATION ZONE B EXTENDS A MINIMUM OF 150 FT.FROM ZONE A, AND SHALL BE CLEARED OF ALL UNDESIRABLE PLANT SPECIES, IRRIGATED, AND PLANTED WITH SPECIES FROM THE OCFA APPROVED PLANT LIST.
- A TYPICAL IRRIGATION SYSTEM FOR FUEL MOD. ZONE B WILL CONSIST OF A DEDICATED 2" POTABLE WATER SERVICE, BURIED PVC MAIN LINES, ELECTRIC CONTROL VALVES, AND UV-RESISTANT PVC LATERAL LINES INSTALLED ON GRADE.
- OVERHEAD SPRAY ROTOR SPRINKLER HEADS WILL BE USED WHEREVER POSSIBLE TO EFFICIENTLY AND EFFECTIVELY IRRIGATE THE FUEL MOD. PLANTING.
- IRRIGATION ZONES WATERING OVER THE IRRIGATION FIELDS WILL BE SEPARATED FROM THE ZONES WATERING THE REST OF FUEL MOD. ZONE B. THIS WILL ALLOW THESE ZONES TO BE SEPARATELY SCHEDULED TO COMPENSATE FOR THE TREATED EFFLUENT IRRIGATION AND THE HIGHER WATER REQUIREMENT PLANTS USED IN THE DISPERSAL FIELD AREAS. THIS SEPARATION WILL ALSO ALLOW FOR PERIODIC LEACHING OF SALTS IN THE IRRIGATION FIELDS, WHICH RESULT FROM BOTH THE USE OF TREATED EFFLUENT WATER AND SUBSURFACE DRIP IRRIGATION TECHNOLOGY.
- IRRIGATION ZONES WILL BE FURTHER DIVIDED INTO SOUTH/WEST AND NORTH/EAST SOLAR EXPOSURES TO ACCOMMODATE THEIR DIFFERING WATER NEEDS.
- THE OVERHEAD SPRAY SYSTEM VALVES WILL BE CONNECTED TO A CONTROLLER SEPARATE FROM THE DIPERSAL FIELD CONTROLLERS. THE OVERHEAD SPRAY SYSTEM CONTROLLER WILL BE MANAGED BY THE H.O.A'S LANDSCAPE MAINTENANCE CONTRACTOR.
- A TYPICAL IRRIGATION ZONE WILL RUN AT 50-60 GALLONS-PER-MINUTE AND HAVE A PRECIPITATION RATE OF 0.50"-1.50" OF WATER PER HOUR.

TYPICAL FUEL MOD. IRRIGATION

0' 20' 40' 60' 100'

1" = 20'

THE PRESERVE

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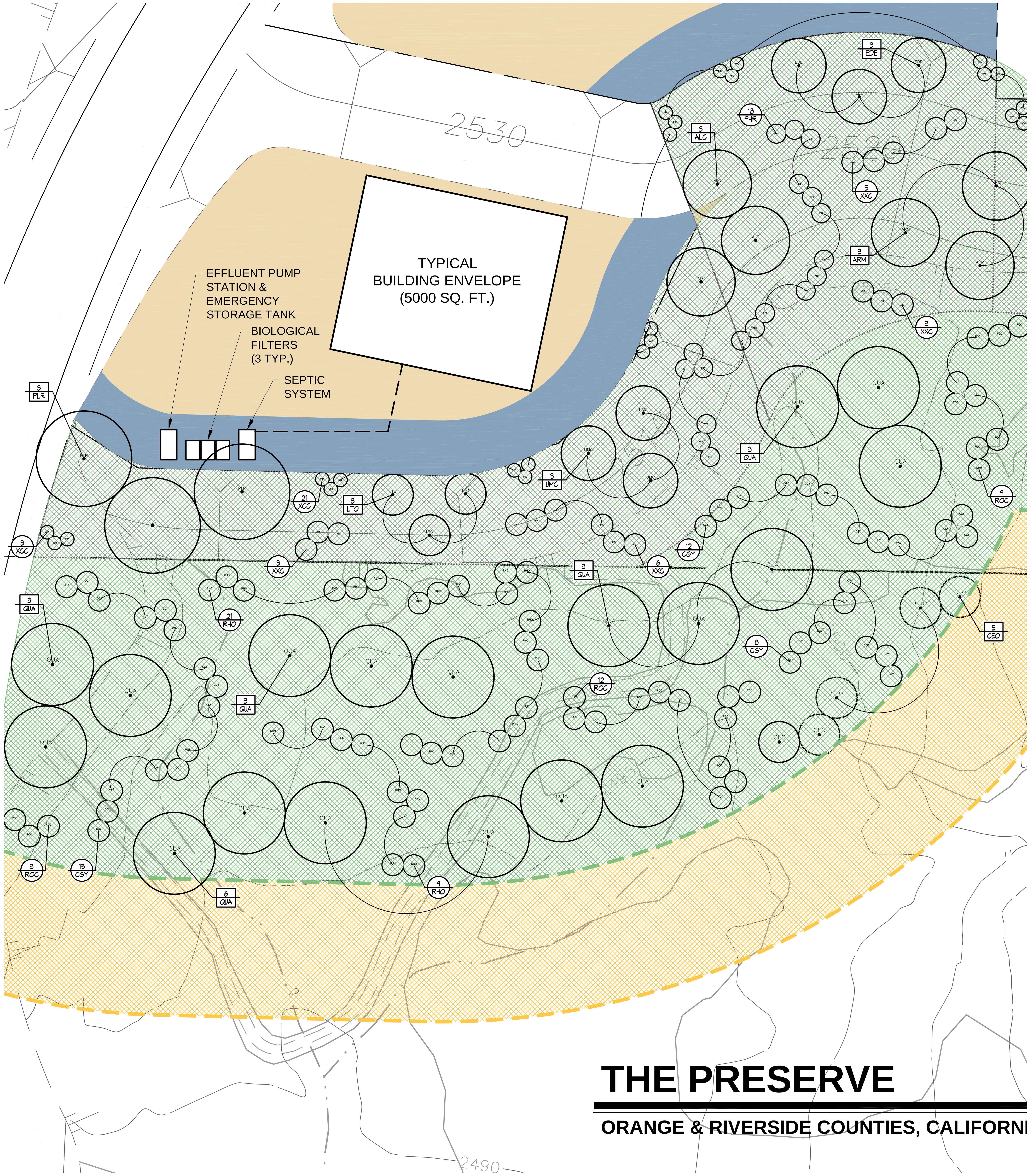


FUEL MODIFICATION LEGEND

- ZONE A – 20'
- ZONE B – 150'
- ZONE C – 50'

OWTS DISPERSAL FIELD PLANT PALETTE

TREES

KEY	BOTANICAL NAME	COMMON NAME	WUCOLS ZONE 4	FIRE RATING	HT. (FT.)	SPRD. (FT.)	DEC. / EVRG.	MIN. O.C. SPACING (FT.)
ALC	ALNUS CORDATA	ITALIAN ALDER	MOD	W	40	25	DEC	6 OR 5 WRB
ARM	ARBUTUS 'MARINA'	MARINA MADRONE	MOD	W	30	30	EVRG	8
ERC	ERIOBOTRYA 'COPPERTONE'	COPPERTONE LOQUAT	MOD	N	40	6	EVRG	8
EDE	ERIOBOTRYA DEFLEXA	BRONZE LOQUAT	MOD	N	15	10	EVRG	4 OR 3 WRB
ERJ	ERIOBOTRYA JAPONICA	JAPANESE LOQUAT	MOD	N	22	22	EVRG	4 OR 3 WRB
FES	FEIJOA SELLOWIANA	PINEAPPLE GUAVA	MOD	N	25	22	EVRG	5 OR 4 WRB
LIM	LAGERSTROEMIA INDICA 'MUSKOGEE'	MUSKOGEE CRAPE MYRTLE	MOD	W	25	12	DEC	8
LIN	LAGERSTROEMIA INDICA 'NATCHEZ'	NATCHEZ CRAPE MYRTLE	MOD	W	25	12	DEC	8
LTO	LAGERSTROEMIA INDICA 'TUSCARORA'	TUSCARORA CRAPE MYRTLE	MOD	W	22	12	DEC	8
MAB	MAYTENUS BOARIA	MAYTEN TREE	MOD	W	40	30	EVRG	5 OR 4 WRB
PLR	PLATANUS RACEMOSA	CALIFORNIA SYCAMORE	MOD	W	55	30	DEC	8 OR 5 WRB
UMC	UMBELLULARIA CALIFORNICA	CALIFORNIA LAUREL	MOD	o	75	100	EVRG	6 OR 5 WRB

WRB = WITH ROOT BARRIER

SHRUBS

KEY	BOTANICAL NAME	COMMON NAME	WUCOLS ZONE 4	FIRE RATING	HT. (FT.)	SPRD. (FT.)	DEC. / EVRG.
AGE	ABELIA GRANDIFLORA 'EDWARD GOUCHER'	EDWARD GOUCHER ABELIA	MOD	W	8	6	EVRG
ESF	ESCALLONIA FRADESII	ESCALLONIA	MOD	N	6	6	EVRG
EJS	EUONYMOUS JAPONICUS 'SILVER KING'	SILVER KING EUONYMUS	MOD	N	6	8	EVRG
GRC	GREWIA OCCIDENTALIS	LAVENDER STAR FLOWER	MOD	W	8	8	EVRG
LJT	LIGUSTRUM JAPONICUM 'TEXANUM'	TEXAS PRIVET	MOD	N	8	5	EVRG
MLA	MYOPORUM LAETUM	MYOPORUM	MOD	W	30	22	EVRG
MYP	MYOPORUM PACIFICUM	PACIFIC MYOPORUM	MOD	W	2	30	EVRG
PFR	PHOTINIA FRASERI	FRASER'S PHOTINIA	MOD	W	12	12	EVRG
PLC	PLUMBAGO CAPENSIS	CAPE PLUMBAGO	MOD	W	6	8	EVRG
PUG	PUNICA GRANATUM	POMEGRANATE	MOD	N	8	8	EVRG
PRC	PYRACANTHA COCCINEA	FIRETHORN	MOD	W	6	8	EVRG
PYF	PYRACANTHA 'FORTUNEANA'	FIRETHORN	MOD	W	6	8	EVRG
PSC	PYRACANTHA KOIDZUMII 'SANTA CRUZ'	SANTA CRUZ FIRETHORN	MOD	W	4.5	10	EVRG
RIC	RHAPHIOLEPIS INDICA 'CLARA'	CLARA INDIA HAWTHORN	MOD	N	8	8	EVRG
RIM	RHAPHIOLEPIS INDICA 'MAJESTIC BEAUTY'	MAJESTIC BEAUTY INDIA HAWTHORN	MOD	N	25	8	EVRG
RIS	RHAPHIOLEPIS INDICA 'SPRINGTIME'	SPRINGTIME INDIA HAWTHORN	MOD	N	5	5	EVRG
XYC	XYLOSMA CONGESTUM	SHINY XYLOSMA	MOD	W	8	8	EVRG
XCC	XYLOSMA CONGESTUM 'COMPACTA'	COMPACT XYLOSMA	MOD	W	5	6	EVRG

GROUND COVERS

KEY	BOTANICAL NAME	COMMON NAME	WUCOLS ZONE 4	FIRE RATING	DEC. / EVRG.	MIN. O.C. SPACING (FT.)	SZ 18
MYP	MYOPORUM PACIFICUM	PACIFIC MYOPORUM	MOD	W	EVRG	6	X
COG	COTONEASTER CONGESTUS	PYRENEES COTONEASTER	MOD	W	EVRG	8	X
PYF	PYRACANTHA 'FORTUNEANA'	FIRETHORN	MOD	W	EVRG	8	X

FIRE RATING LEGEND	
Plant species prohibited in wet and dry fuel modification zones adjacent to reserve lands. Acceptable on all other fuel modification locations and zones.	X
Plant species appropriate for use in wet fuel modification zones adjacent to reserve lands. Acceptable in all other wet and irrigated dry (manufactured slopes) fuel modification locations and zones.	W
Acceptable in all fuel modification wet and dry zones in all locations.	o
Plant species acceptable on a limited basis (maximum 30% of the area at the time of planting) in wet fuel modification zones adjacent to reserve lands. Acceptable on all other fuel modification	N
If locally collected.	*
Not native but can be used in all zones.	**
Plant species acceptable on a limited use basis. Refer to qualification requirements below.	n

NOTES

- FUEL MODIFICATION PLANTING WILL BE DESIGNED AND INSTALLED TO COMPLY WITH THE ORANGE COUNTY FIRE AUTHORITY (OCFA).
- FUEL MOD. ZONE B EXTENDS A MINIMUM OF 150 FT.FROM ZONE A, AND SHALL BE CLEARED OF ALL UNDESIRABLE PLANT SPECIES, IRRIGATED, AND PLANTED WITH SPECIES FROM THE OCFA APPROVED PLANT LIST. SEE PLANT PALETTES ABOVE.
- FUEL MOD. ZONE B WILL BE SEPARATED INTO TWO PLANTING AREAS. THE UPPER AREA ADJACENT TO FUEL MOD. ZONE A WILL CONSIST OF 'MODERATE' WATER USE PLANTS, AND SHALL BE PARTIALLY IRRIGATED WITH TREATED EFFLUENT FROM THE ADJOINING RESIDENTIAL LOT. THE REMAINING PORTION OF FUEL MOD. ZONE B WILL CONSIST OF 'LOW' WATER USE PLANT MATERIAL, AND SHALL BE WATERED FROM THE POTABLE WATER SYSTEM.
- ALL PLANT MATERIAL SHALL BE APPROVED BY THE ORANGE COUNTY FIRE AUTHORITY, AS WELL AS THE SPACING BETWEEN SHRUB AND TREE MASSES.
- REFER TO THE FUEL MODIFICATION PLANS FOR PLANT SPACINGS WITHIN FUEL MODIFICATION ZONE B AREAS.

TYPICAL FUEL MOD. PLANTING

0' 20' 40' 60' 100'

1" = 20'

THE PRESERVE

WATER REUSE STUDY

ORANGE & RIVERSIDE COUNTIES, CALIFORNIA

THE RESERVE, LLC
SUITE 345
100 PACIFICA
IRVINE, CALIFORNIA 92618

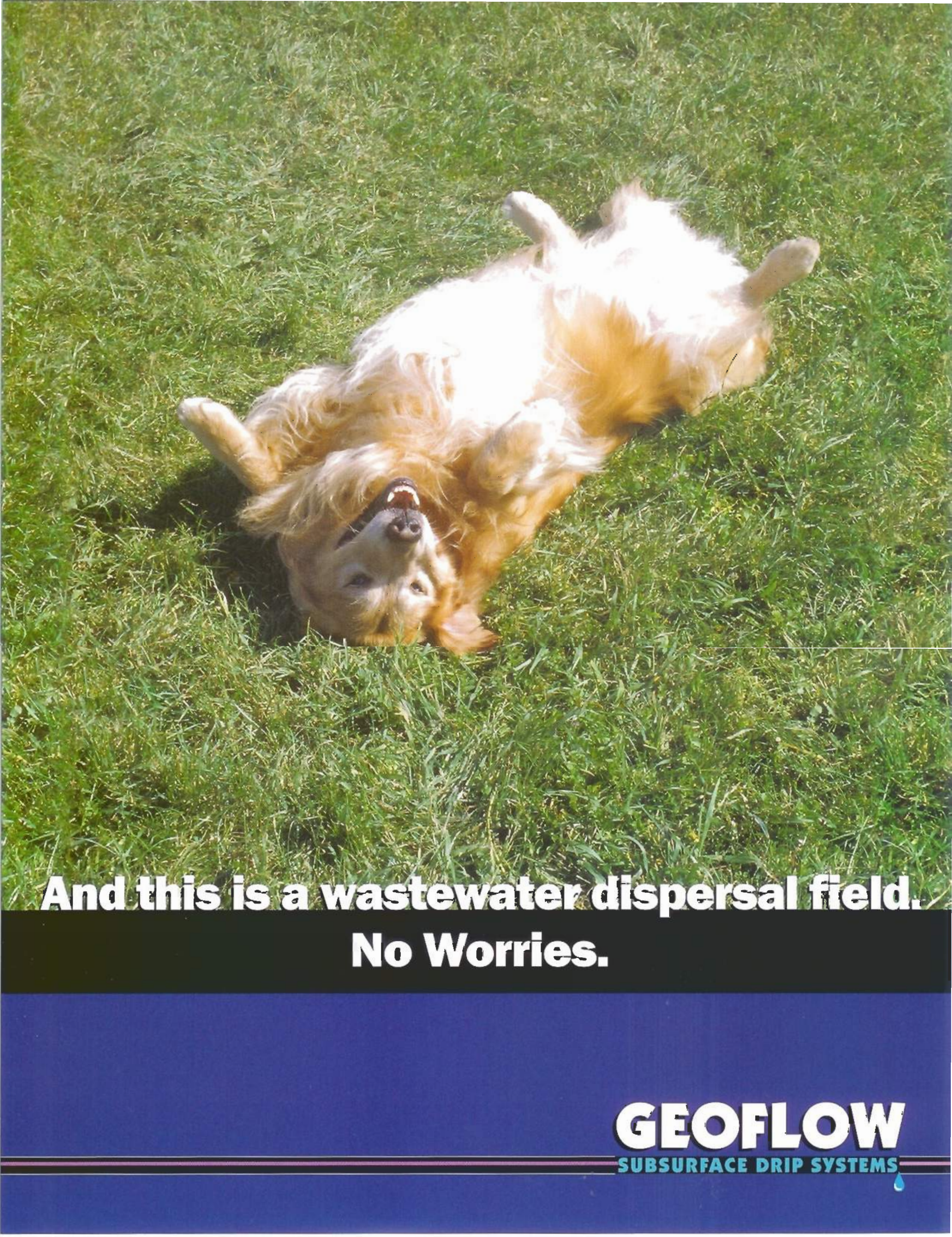
ROBERT MITCHELL & ASSOCIATES
LAND SOLUTIONS
22982 El TORO ROAD LAKE FOREST, CA. 92630
(949) 581-2112 FAX (949) 581-5809 rmalandsolutions.com (rmals.com)

PLANNING • DESIGN • LANDSCAPE ARCHITECTURE

DRAWN: RAM DATE: NOVEMBER 7, 2014 JOB: 1127 PC

PACE
Advanced Water Engineering

Appendix D – Subsurface Drip Product Information


And this is a wastewater dispersal field.
No Worries.
GEOFLOW
SUBSURFACE DRIP SYSTEMS

Geoflow WASTEFLOW®

Geoflow's subsurface drip systems solve many of the problems that plague traditional methods of wastewater dispersal. Since the effluent is dispersed underground where it is absorbed in the biologically active soil layer, there is no surface contamination, no ponding, no run-off problems, no bad smells.

Issues such as overspray and aerosol drift are eliminated, dose scheduling is unaffected by land use or weather, and it is a politically and environmentally favorable means of dispersing wastewater.

With subsurface drip, secondary reclaimed wastewater can be used, eliminating the ongoing cost of additional effluent treatment.

Geoflow drip dispersal is recommended for commercial, municipal, industrial, residential and agricultural applications.

Subdivision in Minnesota.

How It Works

The WASTEFLOW dripline has factory-installed emitters evenly spaced along the tubing. The dripline is usually installed six to ten inches below the surface, directly into the biologically active soil horizon where the treated effluent can be absorbed by the plants, animal life, and soil.

Wastewater is pumped to the dripfield on a time-activated dose cycle. The slow, even application of effluent with resting periods is key to the drip system's success.

Easy To Install — New or Retrofit

Geoflow subsurface systems are simple to install. The tubing can be laid on a graded parcel then covered with topsoil or installed using a tubing plow or trencher.

Subsurface drip also solves the problem of small or odd-shaped areas, such as property edges and around buildings and other structures. The flexible tubing can easily be fit to uneven spaces. Since the wetted area is within close proximity of each emitter, run-off problems are easily eliminated.

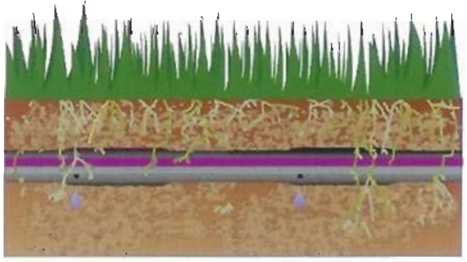
Plow single or multiple driplines at a time.

But What About...?

Clogging — Geoflow drip systems are installed with self-cleaning filters to keep large particles from entering the drip field.

WASTEFLOW emitters are also self-cleaning and have been used for over 15 years in actual onsite applications. They are made with large orifices, raised entry ports, and turbulent flow paths to keep smaller particles from collecting in the emitters.

Root intrusion — Each emitter features ROOTGUARD®, patented protection against roots entering the emitters. The non-toxic active ingredient, Treflan®, directs root growth away from the emitters. Treflan is impregnated into the emitters during the molding process.



Rootguard keeps roots from penetrating and clogging the emitters.

Bacterial growth — Geoflow's WASTEFLOW dripline is coated inside with the anti-bacterial, *Ultra-Fresh®* to inhibit bacterial growth on the walls of the tube and in the emitters. *Ultra-Fresh* has been found to be effective in preventing slime build-up inside the tube, even with effluent that has very high BOD.

Look for the anti-bacterial turquoise lining.

This eliminates the need to scour the dripline with high flush velocities.

There is virtually no discharge into the environment because the active ingredient, TBT-maleate, does not migrate readily through plastic (Note: Ultra-Fresh does not treat the water flowing through the tube.)

Freezing climates – Geoflow systems can be used year round, even in freezing conditions. The polyethylene dripline is flexible enough so as not to crack when it freezes. The dripline self-drains through the emitters every time the system is turned off, and will not hold water. Sound design, including drainback of the system, air vacuum breakers and insulation of the more rigid parts of the system keep the system working even in the coldest climates.

Difficult sites – Geoflow systems can be effective in areas with
- tight soils,
- rocky terrains,
- steep slopes,
- high water tables.

Design guidelines are available directly from Geoflow and at www.geoflow.com.


A steep slope installation in California – 65% slope.

Testimonials

Higgins Corner Retail Development
Nevada County, California

"The Geoflow dripline system proved to be successful in four areas: Foremost, there was a tremendous cost saving in installing the Geoflow system. Secondly, the time and effort saved in installing Geoflow as compared to the construction of deep absorption trenches was also a benefit. Thirdly, one and a half acres of land could be used for other monetary-inducing projects; and fourth, the final disposal site looks like the original untouched property. Neighbors are pleasantly surprised at the final effluent disposal field."

Mark Kahl, Design Engineer
7H Technical Services Group Inc.


Higgins Corner, Nevada County, CA.

Ocala Airport
Ocala, Florida

"The [44-acre] site has operated successfully at an average of 500,000 gpd over a three-year period. Monitoring data reveals that groundwater quality has not been adversely effected despite high loading rates... The cost to operate and maintain a subsurface reuse system is much less than a conventional irrigation system..."

Ed T. Earnest, P.E. Utility Engineer.
City of Ocala Engineering Dept.


Ocala Airport.

Omaha Beach Golf Course
Matakana, New Zealand

"As part of the construction of the new 9-holes the developer installed a new subsurface drip irrigation system on some of the new fairways to act as part of the overall community treated effluent disposal system... We are extremely pleased with the system, which gives a very even deep green appearance to the fairways where it was been installed. The fairways that are irrigated with the subsurface drip system are in better condition than those that do not yet have the system."

Allan Anderson,
Head Greenkeeper

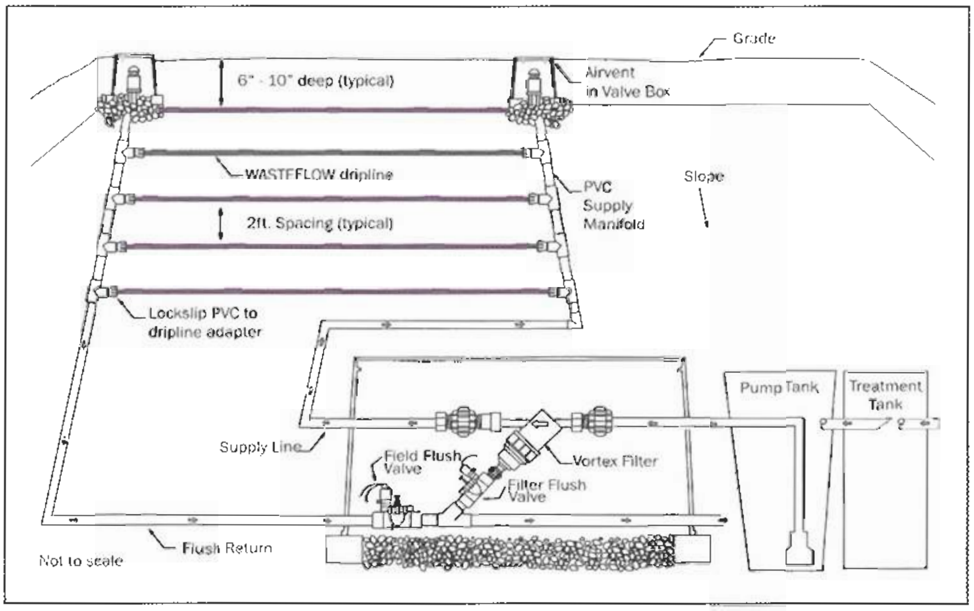

Omaha Beach Golf Course, N.Z.

Typical Layout

WASTEFLOW dripline is made of flexible ½" polyethylene tubing coated on the inside with an anti-bacterial lining to inhibit bacterial growth. The factory-installed emitters are spaced evenly along the tubing.

The dripline is placed six to ten inches below the surface, directly into the biologically active soil horizon. Effluent is pumped on a time-activated dose cycle through a self-cleaning filter out to the dripfield, providing slow, even application of effluent.

The system returns back to the pump tank or treatment tank in a closed loop, and is kept clean with regular flushing.



Typical disposal field elements and layout

The Drip Emitters

Geoflow offers two different emitters, the Classic and the PC.

WASTEFLOW Classic

WASTEFLOW PC

Each dripper has a filter built in at the entry port to to keep particles out.

Turbulent flow path

Effluent travels through a turbulent flow path that helps keep any fine particles from settling inside the dripper.

CUTAWAY OF THE PC EMITTER

Dose mode – When pressurized, the rubber diaphragm flexes across the compensating chamber to regulate flow across 7 to 60 psi.

Flushing mode – As the pump is powered on and off again, the rubber diaphragm relaxes across the exit hole enabling the dripper to self-flush every cycle.

Geoflow Team

The people at Geoflow are the subsurface drip *experts*. We offer training, answers to your questions, and support every step of the way from concept through design and installation.

Geoflow dripline comes with an unprecedented 10-year limited warranty for root intrusion, workmanship and materials.

GEOFLOW, INC.
506 Tamal Plaza
Corte Madera, CA 94925
www.geoflow.com

Tel: (800) 828-3388
Fax: (415) 927-0120

GEOFLOW SUBSURFACE DRIP SYSTEMS

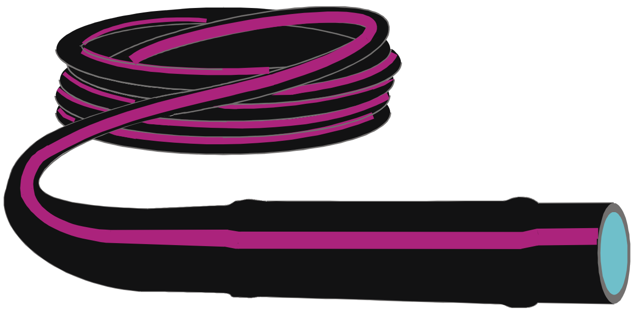
Look for the purple stripe on the tubing to be sure you are getting Geoflow!

GEOFLOW SUBSURFACE DRIP

WASTEFLOW DRIPLINE

Description

The flexible 1/2" polyethylene dripline has large emitters regularly spaced in the line. With the dripline hidden about six inches below ground, effluent is distributed slowly and uniformly, reducing ponding, even in difficult soils and hilly terrain.



WASTEFLOW is built to last. It is guaranteed to be trouble-free from root intrusion with built-in nano-ROOTGUARD® protection, and the dripline wall is protected from organic growth with the *Geoshield* lining. WASTEFLOW provides uniform distribution. The emitters have a Coefficient of variation of less than .05.

Different flow rates, dripline diameters and emitter spacings can be special ordered.

Use 600 series compression adapters or lockslip fittings to connect the dripline to PVC pipe.

nano-ROOTGUARD® Protection

WASTEFLOW dripline features patented nano-ROOTGUARD technology to prevent roots from clogging the emission points. The pre-emergent, Treflan®, is bound into WASTEFLOW emitters when they are molded to divert roots from growing into the emitter outlet. The system is guaranteed against root intrusion for 15 years.

ANTI BACTERIAL Protection

Geoshield® is incorporated into the inner lining and emitters of WASTEFLOW dripline to prevent bacteria from growing on the walls of the tubing and emitters. It eliminates the need to scour the tubing. It is a tin based formula that defeats the energy system of microbial cells. This means smaller pumps or larger zones can be used with WASTEFLOW dripline than unprotected dripline.

PC vs. CLASSIC

Geoflow, Inc. offers WASTEFLOW dripline in both pressure compensating (WASTEFLOW PC) and non-compensating (WASTEFLOW Classic) models.

We recommend that WASTEFLOW PC be used when the advantages are of substantial economic value.

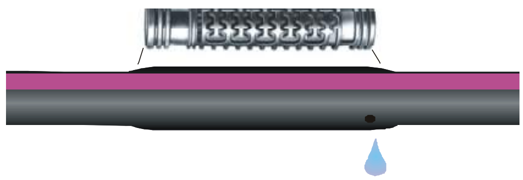
a) Very long runs.
b) Steep slopes. Systems should be designed for the dripline lateral to follow the contour. If this is possible, the extra cost of pressure regulators required for WASTEFLOW Classic would likely be less than the incremental cost of WASTEFLOW PC.
c) Rolling terrain. If the difference in height from trough to peak exceeds six feet then WASTEFLOW PC should be used. Vacuum relief valves must be placed at the top of each rise.

WASTEFLOW PC and WASTEFLOW Classic can be interchanged to meet filter and zone flow requirements.

- WASTEFLOW is manufactured under US Patents 5332160,5116414 and Foreign equivalents.
- **Geoshield**® is a registered trademark of A.I.Innovations
- WASTEFLOW is a registered trademark of A.I.Innovation
- TREFLAN is a registered trademark of Dow Agro Chemicals.

Look for the **Genuine Geoflow** stamp of quality

WASTEFLOW CLASSIC



Available in 2 standard models

WF16-4-24 WASTEFLOW Classic 24"/1.3gph
WF16-4-12 WASTEFLOW Classic 12"/1.3gph
Alternate flow rates, diameters and spacing available upon request.

Flow Rate vs. Pressure

Pressure psi	Head ft.	ALL WASTEFLOW Classic Dripline
10 psi	23.10 ft.	.81 gph
15 psi	34.65 ft.	1.00 gph
20 psi	46.20 ft.	1.16 gph
25 psi	57.75 ft.	1.31 gph
30 psi	69.30 ft.	1.44 gph
35 psi	80.85 ft.	1.57 gph
40 psi	92.40 ft.	1.68 gph
45 psi	103.95	1.80 gph

Maximum Length of Run vs. Pressure

Flow variation +/- 5%

Pressure psi	Head ft.	Emitter Spacing		
		24"	18"	12"
10 psi	23.10 ft.	170'	165'	100'
15 psi	34.65 ft.	170'	165'	100'
20 psi	46.20 ft.	170'	165'	100'
25 psi	57.75 ft.	170'	165'	100'
30 psi	69.30 ft.	170'	165'	100'
35 psi	80.85 ft.	170'	165'	100'
40 psi	92.40 ft.	170'	165'	100'
45 psi	103.95 ft.	170'	165'	100'

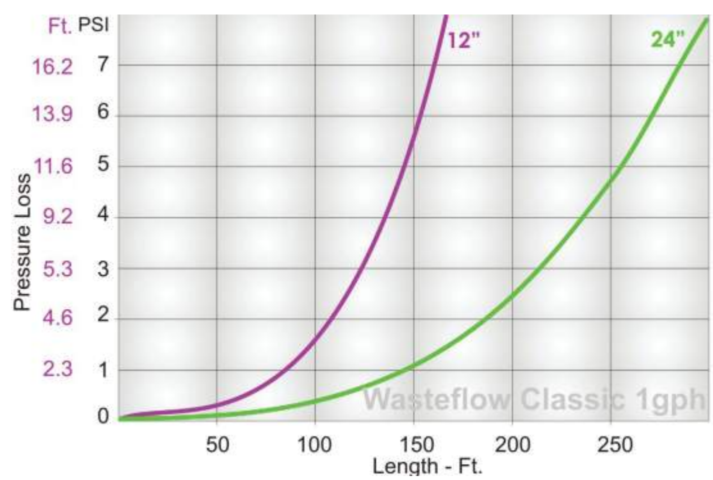
Kd=0.9 Cv < .05

NOTE:
For rolling terrain use Geoflow's WASTEFLOW PC-SD, our slow drain anti-siphon dripline

WASTEFLOW Classic Specification

The dripline shall consist of nominal sized one-half inch linear low density polyethylene tubing, with turbulent flow drip emitters bonded to the inside wall. The drip emitter flow passage shall be 0.053" x 0.053" square. The tubing shall have an outside diameter (O.D.) of approximately .64-inches and an inside diameter (I.D.) of approximately .55-inches. The tubing shall consist of three layers; the inside layer shall be *Geoshield*® protection, the middle layer shall be black and the outside layer shall be purple striped for easy identification. The dripline shall have emitters regularly spaced 24" (or 12") apart. The turbulent flow emitters shall be molded from virgin polyethylene resin. The turbulent flow emitters shall have nominal discharge rates of 1.16 gallons per hour at 20 psi. The emitters shall be impregnated with Treflan® to inhibit root intrusion for a minimum period of fifteen years and shall be guaranteed by the manufacturer to inhibit root intrusion for this period. WASTEFLOW Classic dripline shall be Geoflow model number WF16-4-24 (or WF16-4-12).

Pressure Loss vs. Length of Run



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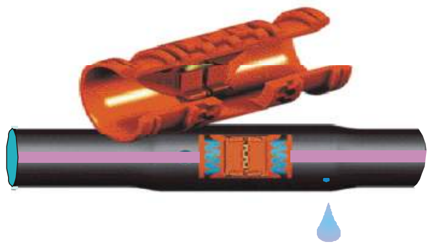
WASTEFLOW PC 1/2 gph



Standard products:

WFPC16-2-24 WASTEFLOW PC 24"/.53gph or 2lph
WFPC16-2-18 WASTEFLOW PC 18"/.53gph or 2lph
WFPC16-2-12 WASTEFLOW PC 12"/.53gph or 2lph
Alternative spacing, flow rates and diameters available upon request.

Flow Rate vs. Pressure

Pressure	Head	ALL WASTEFLOW PC 1/2 gph dripline
7-60 psi	16-139 ft.	0.53 gph

Maximum Length of Run vs. Pressure

Allows a minimum of 10 psi in the line.
Recommended operating pressure 10-45 psi.

Pressure psi	Pressure ft.	Emitter Spacing 6"	12"	18"	24"
10 psi	23.10 ft.				
15 psi	34.65 ft.		174'	260'	321'
20 psi	46.20 ft.	120'	229'	330'	424'
25 psi	57.75 ft.		260'	377'	478'
30 psi	69.30 ft.	150'	288'	415'	535'
35 psi	80.85 ft.		313'	448'	576'
40 psi	92.40 ft.	172'	330'	475'	612'
45 psi	103.95 ft.		354'	501'	651'
50 psi	115.5 ft.		363'	523'	675'
55 psi	127.05 ft.		377'	544'	700'
60 psi	138.6 ft.		403'	563'	727'

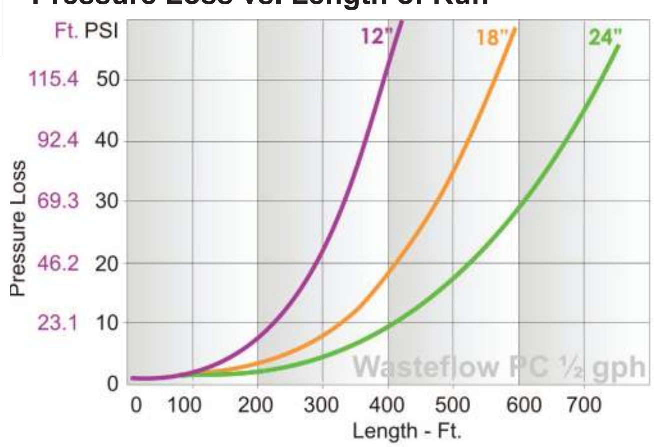
Kd = 2.070

NOTE:
For rolling terrain use Geoflow's WASTEFLOW PC-SD, our slow drain anti-siphon dripline

WASTEFLOW PC ½ gph PC Specification

The dripline shall consist of nominal sized one-half inch linear low density polyethylene tubing, with turbulent flow drip emitters bonded to the inside wall. The drip emitter flow passage shall be 0.032" x 0.045" square. The tubing shall have an outside diameter (O.D.) of approximately .64-inches and an inside diameter (I.D.) of approximately .55-inches. The tubing shall consist of three layers; the inside layer shall be a *Geoshield*® protection, the middle layer shall be black and the outside layer shall be purple striped for easy identification. The dripline shall have emitters regularly spaced 24" (or 18" or 12") apart. The pressure compensating emitters shall be molded from virgin polyethylene resin with a silicone rubber diaphragm. The pressure compensating emitters shall have nominal discharge rates of 0.53 gallons per hour. The emitters shall be impregnated with Treflan® to inhibit root intrusion for a minimum period of fifteen years and shall be guaranteed by the manufacturer to inhibit root intrusion for this period. 0.53 gph WASTEFLOW PC pressure compensating dripline shall be Geoflow model no. WFPC16-2-24 or WFPC16-2-18 or WFPC16-2-12.

Pressure Loss vs. Length of Run



WASTEFLOW PC 1 gph

Standard Products:

WFPC16-4-24 WASTEFLOW PC 24"/1.02 gph or 4lph
WFPC16-4-18 WASTEFLOW PC 18"/1.02 gph or 4lph
WFPC16-4-12 WASTEFLOW PC 12"/1.02 gph or 4lph
Alternative spacing, flow rates and diameters available upon request.

Flow Rate vs. Pressure

Pressure	Head	ALL WASTEFLOW PC 1 gph dripline
7-60 psi	16-139 ft.	1.02 gph

Maximum Length of Run vs. Pressure

Allows a minimum of 10 psi in the line.
Recommended operating pressure 10-45 psi.

Pressure		Emitter Spacing		
psi	ft.	12"	18"	24"
10 psi	23.10 ft.	95'	140'	175'
15 psi	34.65 ft.	115'	172'	211'
20 psi	46.20 ft.	146'	210'	265'
25 psi	57.75 ft.	171'	242'	315'
30 psi	69.30 ft.	180'	266'	335'
35 psi	80.85 ft.	199'	287'	379'
40 psi	92.40 ft.	211'	305'	385'
45 psi	103.95 ft.	222'	321'	429'
50 psi	115.5 ft.	232'	334'	431'
55 psi	127.05 ft.	240'	347'	449'
60 psi	138.6 ft.	249'	360'	465'

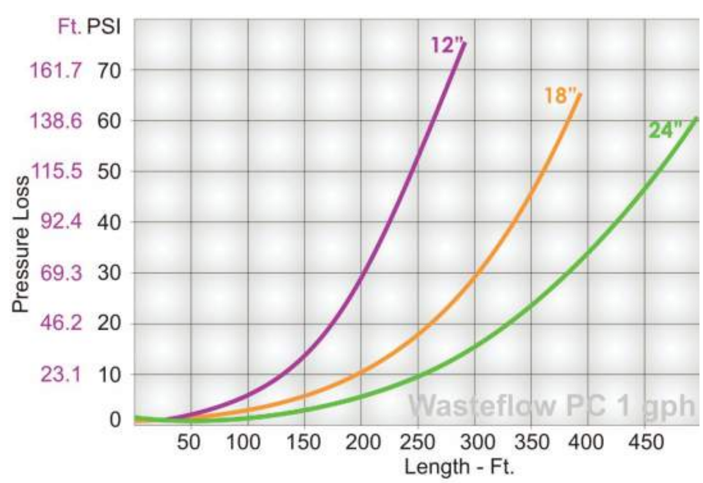
Kd = 2.070

NOTE:
For rolling terrain use Geoflow's WASTEFLOW PC-SD, our slow drain anti-siphon dripline

WASTEFLOW PC 1 gph PC Specification

The dripline shall consist of nominal sized one-half inch linear low density polyethylene tubing, with turbulent flow drip emitters bonded to the inside wall. The drip emitter flow passage shall be 0.032" x 0.045" square. The tubing shall have an outside diameter (O.D.) of approximately .64-inches and an inside diameter (I.D.) of approximately .55-inches. The tubing shall consist of three layers; the inside layer shall be *Geoshield*® protection, the middle layer shall be black and the outside layer shall be purple striped for easy identification. The dripline shall have emitters regularly spaced 24" (or 18" or 12") apart. The pressure compensating emitters shall be molded from virgin polyethylene resin with a silicone rubber diaphragm. The pressure compensating emitters shall have nominal discharge rates of 1.02 gallons per hour. The emitters shall be impregnated with Treflan® to inhibit root intrusion for a minimum period of fifteen years and shall be guaranteed by the manufacturer to inhibit root intrusion for this period. 1.02 gph WASTEFLOW PC pressure compensating dripline shall be Geoflow model number WFPC16-4-24 (or WFPC16-4-18 or WFPC16-4-12) .

Pressure Loss vs. Length of Run



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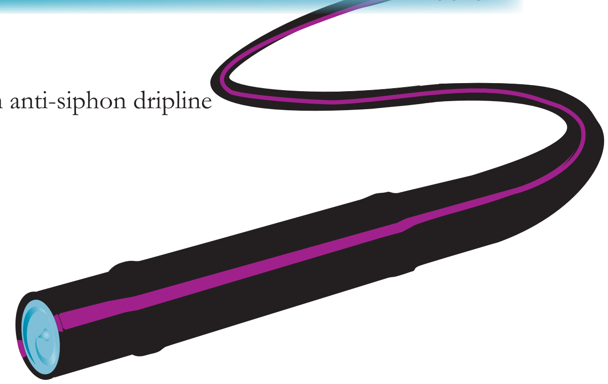
GEOFLOW SUBSURFACE DRIP

WASTEFLOW PC SD 1/2 gph

24-in. 60-cm.



SD = slow drain anti-siphon dripline

Features

Ideal for undulating terrain where vacuum relief is tricky, Geoflow's slow drain anti-siphon dripline features a slow drain dripper. Slow to release water when not pressurized, WASTEFLOW PC SD reduces suction of soil into the dripline. We carefully selected the slow drain rather than the non drain option for wastewater applications for 2 reasons: reduction of biological growth and freezing. Emptying the dripline slowly will avoid pipes from bursting in freezing zones, or plugging from biological growth that may occur when wastewater sits in dripline for long periods of time. Ultimately WASTEFLOW PC SD reduces suction of soil into the drippers without compromising freezing or internal clogging.

Kd = 2.070

Flow Rate vs. Pressure

Pressure	Head	ALL WASTEFLOW PC 1/2 gph dripline
7-60 psi	16-139 ft.	0.55 gph / 2.1 lph

WASTEFLOW PC SD ½ gph Specification

The dripline shall consist of nominal sized one-half inch linear low density polyethylene tubing, with turbulent flow slow draining anti siphon drip emitters bonded to the inside wall. The drip emitter flow passage shall be 0.032" x 0.045" square. The tubing shall have an outside diameter (O.D.) of approximately .64-inches and an inside diameter (I.D.) of approximately .55-inches. The tubing shall consist of three layers; the inside layer shall be a *Geoshield*® protection, the middle layer shall be black and the outside layer shall be purple striped for easy identification. The pressure compensating emitters shall be molded from virgin polyethylene resin with a silicone rubber diaphragm. The pressure compensating emitters shall have nominal discharge rates of 0.53 gallons per hour. The emitters shall be impregnated with Treflan® to inhibit root intrusion for a minimum period of fifteen years and shall be guaranteed by the manufacturer to inhibit root intrusion for this period. Dripline shall be Geoflow model number WFPCSD16-2-12 or WFPCSD16-2-24

Maximum Length of Run vs. Pressure

Allows a minimum of 10 psi in the line.
Recommended operating pressure 10-45 psi.

Pressure psi	Pressure ft.	Emitter Spacing 24"
15 psi	34.65 ft.	321'
20 psi	46.20 ft.	424'
25 psi	57.75 ft.	478'
30 psi	69.30 ft.	535'
35 psi	80.85 ft.	576'
40 psi	92.40 ft.	612'
45 psi	103.95 ft.	651'
50 psi	115.5 ft.	675'

Note: For typical wastewater applications maximum lengths of run should not exceed 300 ft. This is to maintain uniformity in the dripfield with short run cycles typical of onsite wastewater dispersal.

Pressure Loss vs. Length of Run

- WASTEFLOW is manufactured under US Patents 5332160,5116414 and Foreign equivalents.
- **Geoshield**® and WASTEFLOW® are registered trademark of A.I.Innovations

Product sheets - 2014 WASTEFLOWPCsd halfgph24in 14G10

Look for the Genuine Geoflow stamp of quality

Single family home WASTEFLOW®references:

Steve Braband	Biosolutions	(818) 991-9997 ext 203
Kevin Pfoffinger	EPD	(310) 241-6565
Kevin Green	Enviroseptic	(949) 305-0651
Rod Myers	Accredited Septic	(707) 664-8875
Richard McCauley	Superior On-Site Solutions	(877) 888-4688

Steve Braband told me has two single family home systems in Orange County

Larger Geoflow WASTEFLOW systems in California

Reference
Mark Kahl
All Inclusive Water/Wastewater Solutions, Inc.,
Tel: 530 878 8148
e-mail: aussie@allinclusiveinc.net

Sysco Warehouse
Pleasant Grove
3 acre field

City of Yreka
Yreka
1,300,000 gpd on 31 acre field

Dark Horse Golf Course
105,000' on the edge of the golf course.

Reference	
Nick Bergera	Scott Miller
Nick's Backhoe Service	Mendocino County Health Dept
1450 Road D	
Redwood Valley, CA 95470	
707-462-9451	707-463-4172

Deerwind Country Club
3,000 gpd on 5,000 sq. ft. field

Reference
Jack Niblett (former engineer at Tenaya Lodge)
Biotech
29959 Yosemite Springs Road, Suite B
Coarsegold, CA 93614
559-642-0490

Tenaya Lodge, see http://geoflow.com/Kahl%20final%20paper%20as%20published.pdf
Yosemite
25,000 gpd on a steep slope

Reference
Norm Hantzsche, P.E.
Questa Engineering
1220 Brickyard Cove Rd, Suite 206
Richmond, CA 94807
510-236-6114

Bernadus Lodge, Carmel Valley
20,000 gpd on major landscaping reuse – pictures available.

Reference
Bonadiman Construction,
Tel: 909 382 3490
w.bonadiman@verizon.net

Calusa Casino
Approx 70,000 gpd on 8 acre field

Malibu – 16 single family home systems
See; http://www.geoflow.com/wastewater/w_pdfs/Malibu%20Beach%20project.pdf

Angel Island
See: http://www.geoflow.com/wastewater/w_pdfs/Wastewater%20on%20an%20Island%20Park.pdf

West Yosemite and Tenaya Lodge
See: http://geoflow.com/Kahl%20final%20paper%20as%20published.pdf

For a general overview of Geoflow systems please see:
http://www.geoflow.com/projects_w.html

This is a rather old paper but the concepts are unchanged
SUBSURFACE DRIP SYSTEMSAS APPLIED TO ONSITE EFFLUENT DISPOSAL OF WASTEWATER IN CALIFORNIA
http://www.geoflow.com/waste_p7.html

Graywater Pilot Project by the City of Los Angeles (1992)
www.geoflow.com/.../L.A.%20Graywater%20Project%201992.pdf

Home on Ocean – see attached
This single family home is in Carmel.

This is the largest **reuse** project we have on record:
Large municipal reuse system in New Zealand
http://geoflow.com/wastewater/w_pdfs/Pauanui%20Project.pdf
I will be delivering a paper on this project at NOWRA on Nov 11.

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Appendix E

Appendix E – Wastewater Reuse Educational Article

Pipeline

Winter 1999
Vol. 10, No. 1

National Small Flows Clearinghouse

Small Community Wastewater Issues Explained to the Public

SPRAY AND DRIP IRRIGATION FOR WASTEWATER REUSE, DISPOSAL

Did you ever wonder how golf courses keep their large fairways looking so lush, healthy, and green all season long? The answer may surprise you.

In many communities in the U.S. and around the world, treated wastewater is reused to irrigate golf courses, lawns, landscaping, forests, and even crops. Because water is such a precious commodity, recycling wastewater can have both economic and environmental benefits for communities. Irrigation also can be the most practical and environmentally-friendly way communities can dispose of treated effluent from wastewater treatment plants and individual home systems.

Better for the Environment

Currently, the most common way community treatment plants dispose of wastewater after treatment is to discharge it to surface waters. However, as populations grow, the burden to local streams and rivers is increasing. Reusing wastewater to irrigate land can help protect precious surface water resources by preventing pollution and by conserving potable water for other uses.

Another benefit of applying wastewater to land is that the soil provides additional treatment through naturally occuring physical, biological, and chemical processes. Irrigating with wastewater also adds nutrients and minerals to soil that are good for plants, and it helps to recharge valuable groundwater resources.

A Solution for "Problem" Sites

Irrigation systems often can be used in place of soil absorption fields (drainfields) to provide final treatment and disposal of wastewater from individual onsite systems, such as septic systems and home aerobic treatment units. As the demand for land in rural areas is increasing, more sites are being developed in places previously considered unsuitable for onsite systems. Irrigation sometimes is permitted as an alternative wastewater disposal method for difficult sites, such as areas with slowly permeable soils, shallow soils, or complex topographies.

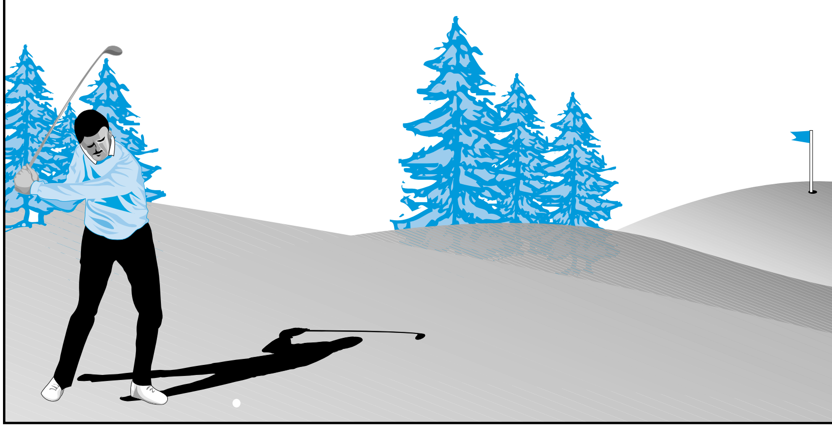
This *Pipeline* issue provides a brief overview of two types of wastewater irrigation systems—spray systems and subsurface drip systems—how they work, their advantages and disadvantages, and when they may be a good option for homes, businesses, and communities. Operation and maintenance issues also are discussed.

Readers are encouraged to reprint *Pipeline* articles in local newspapers or include them in flyers, newsletters, or educational presentations. Please include the name and phone number of the National Small Flows Clearinghouse (NSFC) on the reprinted information and send us a copy for our files.

If you have any questions about reprinting articles or about any of the topics discussed in this newsletter, please contact the NSFC at (800) 624-8301 or (304) 293-4191.

Treated wastewater can be reused to irrigate . . .

- lawns;
- parks;
- landscaped areas around offices and industrial developments;
- landscaped areas around residences;
- pasture grass;
- highway medians;
- golf courses;
- cemeteries;
- forests;
- trees, corn, alfalfa, and other feed, fodder, and fiber crops; and
- food crops.



Is irrigating with wastewater a good option for your home or community?

If you live in an area where water must be conserved or is expensive, or where other options for disposing of wastewater are restricted, then reusing wastewater for irrigation may be a good option for your home, farm, business, or community. It also can be a good choice simply because it is an efficient use of local resources.

In arid climates, such as in Arizona, New Mexico, and parts of California, for example, or where the demand for water threatens to exceed the supply, as it does in parts of Florida, many homes and businesses could not afford to maintain grass lawns or landscaped areas without reusing wastewater. In Hawaii, treated wastewater is used to irrigate pineapples and sugar cane to save money and conserve fresh water for other uses.

Irrigation also can serve as an alternative onsite disposal method for lots deemed unsuitable for conventional septic tank/soil absorption systems. Because irrigation systems are designed to deliver wastewater slowly at rates beneficial to vegetation, and because the wastewater is applied either to the ground surface or at shallow depths, irrigation may be permitted on certain sites with high bedrock, high groundwater, or slowly permeable soils. Irrigation systems also can be designed to accommodate sites with complex terrains.

Local governments sometimes choose to reuse wastewater from community treatment plants for irrigation, rather than discharging all of it to local surface waters. Irrigation can help communities to save money or avoid exceeding surface discharge permit limits, while preserving the quality of local water resources for drinking water, aquatic life, and recreation. Some communities even have two separate distribution systems—one for potable water and another for reclaimed water for watering lawns and other irrigation needs.

Is it safe?

Irrigating with wastewater is safe when all federal, state, and local regulations regarding its treatment and use are strictly followed. When regulatory requirements are met, the wastewater returned to the environment after irrigation usually is higher quality than the wastewater discharged from treatment plants due to the additional treatment provided in the soil.

Regulations protect public health and the environment by requiring that wastewater always be pretreated prior to irrigation and by restricting its quality, use, and the manner and location of its application. Cumulative levels of nutrients, salts, heavy metals, and disease-causing organisms also must be monitored in the soil at some sites.

Regulations Vary

Wastewater reuse is not permitted everywhere. Regulations vary from state to state and sometimes from community to community. State and local governments may have additional or more stringent requirements than the federal regulations.

Community residents can contact local health agency officials to find out about regulations in their area. The National Small Flows Clearinghouse (NSFC) also offers information about federal and state regulations. *(Refer to the contacts list on page 7 and the products information on page 8.)*

Pretreatment Is Required

After wastewater receives primary and sometimes secondary treatment in a community treatment plant or individual onsite treatment system, additional treatment steps often are required prior to irrigation to reduce the amount of suspended solids and organisms in the wastewater. Both can pose a threat to public health and clog systems. Microorganisms, such as bacteria, can collect or multiply and create slime that clogs systems. Pretreatment also minimizes odors in wastewater, so there is less potential for creating a public nuisance and attracting animals that can spread diseases.

Different degrees of pretreatment are required for the wastewater depending on how it will be used and the intended method of irrigation. For example, standards are more rigorous for surface irrigation methods, such as spray irrigation, and when irrigating food or feed crops or land intended for public use. Biological pretreatment to remove organic matter from the wastewater is followed by filtration, to remove small particles from the wastewater, and disinfection.

Subsurface drip irrigation systems also employ filters mainly to protect against system clogging. Additional treatment may be necessary to protect the receiving environment and may include secondary treatment plus disinfection. This adds to the cost of building, operating, and maintaining systems, which should be considered when determining whether irrigation is a practical wastewater disposal option.

Site Conditions Are Important

Not all sites are appropriate for wastewater application. Communities wishing to dispose of wastewater from treatment plants through irrigation sometimes must purchase or lease suitable land for disposal or enter into cooperative arrangements with local farmers or landowners. Sites near surface water or high groundwater often are restricted, especially when these are used as drinking water sources. Regulations typically require minimum separation distances or buffer zones from ground and surface water resources and public areas to minimize contact with wastewater.

Other important site selection criteria include the type of soil, soil wetness, slope, drainage patterns, and local climate, including rainfall amounts and evaporation rates. In areas that have cold or wet weather part of the year, wastewater often must be stored in lagoons or holding tanks until irrigation is needed. Some irrigation equipment also can freeze in very cold weather.

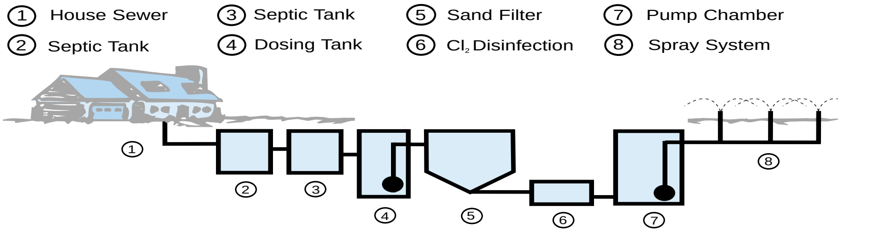
Maintenance Is Necessary

All systems, including irrigation systems, have operation and maintenance requirements. These include periodic checking and cleaning of filters, checking valves, pumps, and timers, and, in some cases, monitoring wastewater quality and its impact on soils. Large systems serving farms, businesses, or communities often have operators, but most systems are at least partially automated.

Although spray and subsurface drip irrigation systems serving individual homes may only need maintenance about once or twice per year, homeowners should consider that these systems will require more attention than conventional onsite systems.

Spray Systems Irrigate Lawns, Parks, Crops

Example residential spray system schematic



Spray irrigation is an efficient way to nourish plants and apply reclaimed wastewater to land. Some spray systems are very similar to potable-water sprinkler systems used to irrigate lawns. Others are specifically designed for agricultural applications.

While there are many possible spray system designs, they all work by distributing treated wastewater across the soil surface. Systems should be designed by qualified professionals who have specific experience working with irrigation systems.

System Design

Because spray systems apply effluent above-ground, the wastewater must be treated to a high enough level to protect public health and reduce odors. In general, regulations require that effluent used for surface irrigation at least meet secondary treatment standards plus disinfection.

With spray systems, therefore, after primary treatment in a septic tank or community treatment plant, the wastewater usually goes to a home aerobic treatment unit, sand filter, recirculating sand filter, or other filter, and then to a dosing tank or pump chamber. The wastewater is then disinfected with chlorine, ozone, or ultraviolet light before it is stored in a lagoon or holding tank for later use or just prior to its application to land. In some community systems, aerated or facultative lagoons provide treatment as well as additional storage area for the wastewater.

After treatment, filtration, and disinfection, a pump equipped with timers sends the wastewater under pressure through the mains and lines of the spray distribution system at preset times and rates as needed for irrigation. The area to be irrigated (the spray field) can be sloped up to 30 percent, depending on local regulatory requirements, but must be vegetated and landscaped to minimize runoff and erosion.

Chlorination is the most common disinfection method used with spray irrigation. One common chlorinator design accepts chlorine tablets or powder; another doses liquid chlorine into the wastewater. With chlorination, adequate contact time is necessary to allow the chlorine time to kill harmful bacteria and other pathogens.

A holding tank or lagoon is another necessary component in most spray systems, because storage space allows operators to adjust application rates, if needed. In some onsite systems that employ a recirculating sand filter, the recirculation tank serves as the storage tank. However, spray systems in cold or wet climates may need to store 130 days of design flow or more. Systems may be permitted to apply wastewater only certain months of the year, or they may be required to include subsurface drainage to help prevent runoff and erosion during wet weather.

Large community systems sometimes reduce the amount of storage area they need by obtaining controlled discharge permits, which allow them to release wastewater to surface water in winter or during times of high stream flows.

Spray Equipment

There is an impressive array of high-tech spray equipment available for irrigating crops. Some consist of series of sprinkler heads mounted to elevated distribution pipes, which move across fields either laterally, by means of drive units at both ends of the pipe (called linear move), or in a circular motion from one fixed end (called pivot move). The height and amount of pressure with which the spray nozzles emit wastewater can be adjusted. Systems even can be programmed to adjust application rates for different parts of the field and to shut off automatically during rain or high winds. And some can be operated remotely.

Another design used to irrigate row crops, called a portable irrigation reel, is a little less high-tech. It consists of a hard plastic hose wound to a drum reel. One end of the hose is attached to a portable sprinkler cart, which is pulled away from the reel during setup, and the other end of the hose is attached to a hydrant. A motor or turbine rewinds the reel and crops are irrigated as the sprinkler cart moves along the uncultivated irrigation paths, which must be kept clear for this purpose.

There also is a variety of sprinkler designs for irrigating smaller field crops, lawns, and landscaping, which are similar to potable-water lawn sprinkler systems. The sprinklers can be fixed (called solid-set) or moveable, buried or above-ground, and some designs are telescoping to adjust the height of application to fit the height of the plants. Other variations exist in the amount of pressure and manner in which the wastewater is released from the sprinklers—examples include full circle, partial circle, gun, and microspray. Different pressure amounts are appropriate for irrigating different plant types. Individual home systems use low trajectory sprinklers to minimize aerosol production.

Fixed, buried sprinkler systems usually are among the most expensive designs to purchase and install, but they have certain advantages. They are less likely to be vandalized or accidently damaged and they make maneuvering farm equipment and lawn mowers easier. However, some moveable system components can be stored indoors in the winter. Most spray system designs include valves and controls that allow operators or homeowners to adjust the flow to certain areas of the spray field. Some larger systems have both automated and manual controls.

continued on page 4

Some Advantages of Spray Systems Include . . .

- When properly designed, installed, and operated, most spray systems provide uniform distribution of wastewater to plants and eliminate discharge to streams.
- Above-ground irrigation is needed for some germinating plants.
- Spray irrigation increases levels of nitrogen, phosphorus, and minerals in the soil.
- Above-ground spray system components are easier to inspect, control, and service than subsurface drip irrigation components.
- When performed during the heat of the day it has a cooling effect on some crops and decorative landscape plants.
- Evaporation contributes to the rate of wastewater disposal.

Some Disadvantages of Spray Systems Include . . .

- Spray systems generate aerosols, which can pose a threat to public health. Therefore, regulations typically require large minimum setback distances, buffers, and other restrictions that make spray systems inappropriate for small lots.
- Wet soil surface promotes weed growth, making some crops and landscaping difficult to maintain.
- Wet soil surface makes weeding, harvesting, and operating lawn mowers and farm equipment more difficult.
- Applications of insecticides and fungicides to crops must be scheduled carefully between spray irrigation applications to allow maximum contact/ exposure times.
- Above-ground spray equipment is exposed to the elements and can be accidentally damaged or vandalized.
- Bacteria tends to survive better in wet, cool soil conditions.

Spray Systems Irrigate Lawns, Parks, Crops

continued from page 3

Setbacks and Buffer Zones

To guard against the possibility that drifting aerosols and runoff created by spray irrigation systems will reach and contaminate nearby public areas and water resources, regulations typically require considerable minimum setback distances or buffer zones to nearby residences, property lines, public areas, wells, streams, rivers, lakes, and wetlands. Minimum setbacks of as much as 150 to 500 feet from neighboring residences and water sources are not unusual, depending on local regulations. Buffers also may be required from water lines, embankments, drains, drainage ditches, and public rights of way. A minimum vertical separation distance to the water table also applies.

Because of these setback requirements, spray systems tend to be mainly practical for irrigating crops, fields, and larger land areas or home lots.

Operation and Scheduling

Unlike traditional irrigation systems whose sole purpose is to deliver water to plants, several additional factors must be considered when managing wastewater irrigation systems. The timing and rate of wastewater application must be designed so that plants benefit as much as possible from the nutrients and other constituents in the wastewater without being overwhelmed by them. In addition, there is the potential that certain wastewater constituents may accumulate in the soil and plants over time and become toxic to the plants, clog the soil, or alter the soil structure.

For example, too much nitrogen can result in nitrate accumulation in crops, but too little can result in reduced yields. If evaporation regularly exceeds precipitation, too much salt may remain in the soil, which can damage roots. The particular characteristics of the wastewater must be considered in relation to such factors as climate and the individual nutrient requirements of the crops, grass, or landscape plants selected.

In addition, the need to dispose of the wastewater has to be balanced with the needs of the plants during various stages of growth and the hydraulic capacity of the soil and its ability to effectively provide treatment.

Farmers must schedule irrigation times and rates carefully, always adjusting for different rainfall and evaporation amounts. Some use devices, such as tensiometers, to measure soil wetness, and rain gauges and pan evaporation tests to keep track of irrigation needs. Spray irrigation of crops also needs to be scheduled around applications of pesticides and fungicides to plants.

Scheduling the irrigation of other types of spray fields is usually less complicated. Unrestricted public access sites, such as the lawns of homes or businesses, landscaping, parks, highway medians, and golf courses, often are irrigated only at night or during off-hours to minimize the potential for public contact with the wastewater. Small systems and systems serving individual homes often are designed to apply a set amount of wastewater twice a week or so at predetermined rates and times. The system designer estimates the amount needed based on records showing average precipitation and evaporation rates in the area. Homeowners usually can adjust or override the pump settings if needed.

If a system is designed and sized primarily for wastewater disposal, the loading rates permitted for the wastewater may be below the irrigation needs of the plants. Therefore, additional water may be required for irrigation with some systems.

Monitoring and Maintenance

The pump, disinfection system, and spray heads in spray irrigation systems require regular maintenance. For example, the chlorine tablets in chlorinators need to be replenished regularly—approximately once per month for home systems. Open pipes and spray heads can become damaged, plugged, or frozen. Any changes in pressure in the system can alter the spray patterns in the field, so spray patterns should be tested to ensure that the system still complies with all setback requirements.

Other monitoring requirements vary depending on state and local regulations, public access to the site, and system size. In some systems, regular daily or weekly monitoring is needed to check influent and effluent quality, system storage capacity, wind speed and direction, signs of ponding or runoff in the spray field, and depth to water table. Cumulative levels of nutrients, heavy metals, fecal coliforms, and other wastewater constituents must be monitored in the soils (and groundwater) at some sites once or twice per year.

Subsurface Drip Irrigation Systems Have Many Advantages

Drip irrigation systems (also known as "trickle" systems) are another efficient and proven technology many small communities can chose to recycle and dispose of wastewater. Drip irrigation technology using treated wastewater is used in Israel and throughout the world as a way to conserve water resources. These systems require less water than spray systems to irrigate plants, and the technology has been used for more than 30 years for various agricultural and landscape applications.

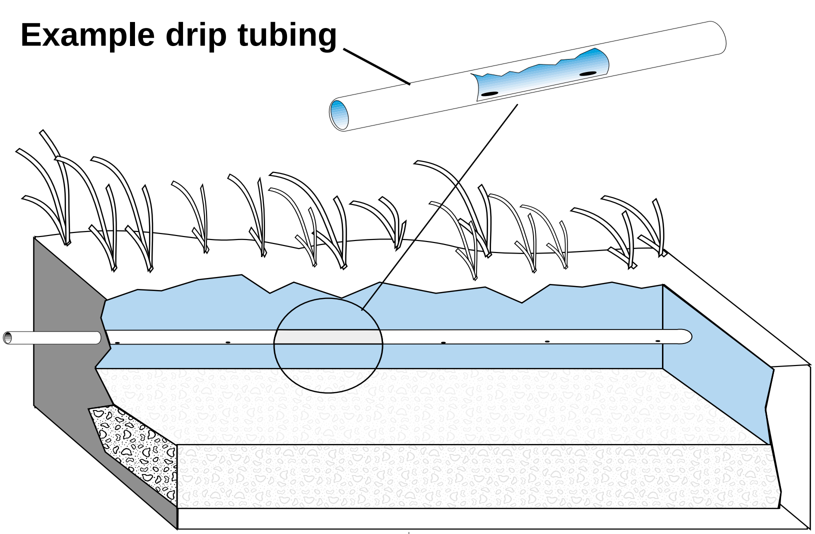
Subsurface Drip Systems Deliver Effluent to Plant Roots

With drip systems, treated wastewater is applied to soil slowly and uniformly from a network of narrow tubing (0.5- to 0.75-inch diameter), usually plastic or polyethylene, placed either on the ground surface or below ground at shallow depths of 6 to 12 inches in the plant root zone. The wastewater is pumped through the tubes under pressure, but drips out slowly from a series of evenly-spaced openings. The openings may be simple holes or, as is the case in most subsurface systems, they may be fitted with turbulent flow or pressure-compensating emitter devices. These emitter designs are proprietary and vary depending on the manufacturer of the system. *(The graphic below is meant to illustrate a generic subsurface drip tube design.)*

Drip system emitters are designed to ensure that the wastewater is always released at the same slow rate at atmospheric pressure, even though the water pressure inside the tubes can range from 5 to 70 pounds per square inch (psi) during a dosing cycle. However, most systems are engineered to maintain relatively consistent pressure inside the tubes, usually about 20 psi. The pressure-compensating feature of emitters allows drip irrigation lines to be installed at different elevations at a site while maintaining uniform flow.

Because subsurface drip systems release wastewater below-ground directly to plant roots, they irrigate more efficiently and have advantages different from those of surface irrigation systems. For example, the soil surface tends to stay dry, which means there is less water lost to evaporation and there is almost no opportunity for the wastewater to come in contact with plant foliage, humans, or animals. Also, percolation losses are reduced because the wastewater is applied to a wide area of soil at a slow rate directly to plant roots.

In addition, in drip systems the wastewater is delivered to the most biologically active part of the soil, which enhances treatment and minimizes the possibility of groundwater contamination. The constant moisture in the root zone also may increase the availability of nutrients to plants, reducing the delivery of nitrogen to groundwater. *(Refer to page 6 for a list of some advantages and disadvantages of subsurface drip systems.)*



Other System Design Elements

As with spray irrigation systems, wastewater must be pretreated prior to drip irrigation to protect public health and the environment and to prevent systems from clogging. Settleable and floatable solids are removed by primary treatment, which may take place in a community treatment plant or lagoon or on individual home lots in a septic tank or home aerobic treatment unit. Primary treatment always is followed by filtration in a particle-size filter to protect the tubing from clogging.

In most systems, effluent flows to a tank or pump chamber equipped with controls, where it is stored until a predetermined dosing volume is reached. All drip systems are equipped with a filtration system before the distribution system, such as a series of disc filters or mesh screen filter membranes, to remove small suspended solid materials from the wastewater that can clog tubes and emitters. Some systems also include a disinfection step to protect public health.

The U.S. Environmental Protection Agency approves the use of the chemical trifluralin to prevent root intrusion into emitters, although some states may not permit it. One manufacturer of drip system tubing incorporates a chemical barrier to root intrusion directly into the tubing material itself. However, the consistently wet conditions in the soil and the pressure compensating emitter design discourages root growth into the distribution lines.

The distribution system in subsurface drip systems usually includes a mainline, submain, and narrow drip laterals with emitters. The total length of drip tubing will depend on the restrictiveness of the site, the area needing irrigation, and the amount of storage space available. The laterals normally are installed in narrow trenches (approximately 10 centimeters wide) dug with a vibratory plow. Because of the flexibility of the laterals and their shallow placement, drip lines can be laid around trees and other topographic features with little disturbance to the site.

continued on page 6

Advantages of Subsurface Drip Systems Include . . .

- Water and nutrients are delivered directly to plant roots.
- Less water is required when irrigating with drip systems than with spray systems and other suface irrigation methods.
- Wastewater is distributed more evenly with drip systems than spray systems and open irrigation trenches.
- Evaporation losses and weed growth are reduced because the soil surface remains dry.
- Operating lawnmowers and farm equipment is easier because system components are buried and the soil surface stays dry.
- There is no aerosol generation and no wastewater contact with plant foliage.
- Crops irrigated with drip systems can be harvested sooner than when irrigated with spray systems.
- Fewer problems exist with odors, ponding, and runoff.
- There is less chance of wastewater carrying additional chemicals, such as pesticides and fungicides, from the ground surface to groundwater.
- Studies suggest nitrogen in wastewater may be better absorbed by plants and less likely to pollute groundwater when applied directly to plant roots.
- In some cases, fewer pretreatment steps are required for wastewater with drip systems.
- It is less likely that subsurface drip components can be accidently or intentionally damaged.
- Flexible tubing can accommodate sites with complex topographies.
- There are generally fewer operation and maintenance requirements than with spray systems.

Disadvantages of Subsurface Drip Systems Include . . .

- Emitters can potentially clog, affecting the uniformity of application.
- Temporary use of sprinklers or other surface irrigation may be necessary during plant germination period.
- It is difficult to monitor and correct potential emitter clogging.
- Effects of freezing temperatures on drip systems and applying wastewater to frozen ground is still the subject of study and debate.

Subsurface Drip Systems Have Many Advantages

continued from page 5

The submains supply the amount of water required by the individual laterals it feeds, and valves are located between the main and the submains to control the flow of water to different parts of the system.

Clogging

Drip system emitter clogging was more of a problem in the past than it is today. Root intrusion into the drip tubing and internal clogging from the buildup of sediment, suspended solids, algae, and bacterial slime have been diminished greatly by better pretreatment, filtration, disinfection, and new tubing and emitter designs. Most systems allow weekly or biweekly forward flushing of the tubes to scouring velocity to remove slime and sediment buildup.

The size of the emitter orifices also is important to prevent clogging and should range from four to six times the maximum size of the particles that can pass through the mesh of the filter screen preceding the distribution system. For example, a system using a filter screen size of 115 microns (140 mesh) should have emitters approximately 800 microns in diameter to achieve about a six-to-one ratio.

When even a few emitters do clog, it can affect the pressure inside the tubes and the uniformity of wastewater distribution in the field. It also may be difficult to identify and service buried emitters that clog. And like traditional soil absorption systems used with septic systems, saturation of the soil around the emitters of a drip system can eventually lead to the formation of a biological clogging mat, which can cause system failure. However, in general, subsurface drip systems are considered to be a manageable and reliable technology.

Filters on all drip systems need to be checked and periodically backflushed or cleaned. Backflushing reverses the water flow through the lines and the filters to release trapped sediments. Some systems can be set up to backwash automatically at preset intervals, or operators can do it manually as needed. The wastewater flow needs to checked periodically to determine if any emitters are plugging. If a scale buildup develops on emitters, an acid treatment may be necessary.

Setbacks and Buffer Zones

As with spray irrigation systems, regulations typically require that drip systems be installed at minimum distances from nearby residences, property lines, public areas, wells, surface water resources, and groundwater. However, because drip systems deliver wastewater below ground and do not produce aerosols, buffer zones of 25 to 50 feet are generally required to neighboring residences—considerably less than is required for spray systems, making drip disposal more practical for smaller home lots.

Operation, Maintenance, and Scheduling

As with spray systems, drip irrigation must be scheduled so that plants benefit from the nutrients and other constituents in the wastewater without being overwhelmed by them, and the needs of the plants must be balanced with the capacity of the soil to treat the most restrictive components in the wastewater. These concerns must be balanced in turn with climate and other site factors.

Less labor usually is required for operating and maintaining fixed subsurface drip system components as compared to spray systems and surface drip systems with moveable components. For small and individual home systems, the pattern of flow may be fixed or adjusted manually or automatically by the homeowner or operator, depending on the system design and sophistication. In general, the best care for subsurface drip systems is provided by following the individual manufacturer recommendations.

Some communities may require homeowners and small system owners to maintain a service contract with an authorized manufacturer's representative to ensure appropriate monitoring and maintenance. Larger systems often have full-time operators to maintain and service systems and to control the pattern of wastewater flow to irrigate different crops or fields. Some systems can be operated and monitored remotely through telemetry.

Refer to the list of NSFC documents on page 8 and the list of contacts on page 7 for more detailed information on subsurface drip systems.

Wisconsin Drip System Is an "Educational Opportunity"

If you were to pinpoint the center of Wisconsin on a map, you just might find Nasonville Elementary School. Located in the rural Marshfield School District, in the middle of dairy country, Nasonville has plans to consolidate with another local school adding 67 students to the 95 currently enrolled. But before health officials would approve the additional students, the school needed to upgrade its old wastewater system.

"In our part of Wood County, we have some of the densest clay soils ever seen," explained Paul Rodenbeck, the school district's building and grounds director. "For years, the school's wastewater system consisted of a septic tank that discharged across an open field. Because of the difficult local site conditions (heavy silt loam over massive clays), our options for upgrading were somewhat limited."

Holding tanks are the only new onsite wastewater systems being permitted in the area. But Rodenbeck, a former municipal wastewater treatment plant operator, was inspired to research possible onsite wastewater treatment alternatives for the school.

One option that may have been appropriate for Nasonville was a mound system, but the school was not keen on the way it might look on the school grounds, the earthwork involved, or the prospect of having to mow it. Repair costs were another concern. "Even if only one part of the system needs to be repaired, the mound has to be dug up," Rodenbeck said.

Rodenbeck's inquiries led him to work with Duane Grueul of the Wood County Planning and Zoning Department. Grueul suggested several area design firms that have experience with onsite systems. He also introduced Rodenbeck to Dr. James Converse of the University of Wisconsin's Small Scale Waste Management Project, one of the first research programs in the country to study onsite systems.

The firm the school chose for the project, Ayres and Associates of Madison, worked together with Dr. Converse, Grueul, and Rodenbeck to design a solution for the site—namely, a subsurface drip system. The system was installed in August 1998 and is part of the University of Wisconsin's research project.

"Because we are working with the university, we were able to get an experimental permit for a drip system," Rodenbeck said. "Graduate students from the university regularly monitor the system's performance, which is good for us and an educational opportunity for them."

Nasonville's new system is sized to handle 2,500 gallons of wastewater flows per day, which is enough to accommodate approximately 350 students. Rodenbeck estimated the system size needed by checking daily water use at other area schools. The system consists of a 3,000-gallon septic tank equiped with a Zabel™ filter at the outlet. From the septic tank the wastewater flows to a recirculation tank where the wastewater is pumped to a recirculating gravel filter. After treatment in the gravel filter, the wastewater returns to the recirculation tank and then flows to an intermediate settling tank equipped with another Zabel™ filter at the outlet. Next, the wastewater flows to a dosing tank where it is sent to the drip distribution system.

"The system is designed to dose over a 24-hour period," explained Rodenbeck. The drip system itself has four zones or cells and takes up about one acre of the 10-acre school lot.

Rodenbeck said that the system has been working well. "Due to mechanical problems, the gravel filter was taken out of service during the winter, and we had to bypass the filter all together," he said. "The university requested that we not fix this problem, but, instead, operate the system with just the septic tank effluent going through the drip system filters and then to the drip lines. The system has been working fine this way. None of the emitters have plugged and I haven't even had to clean the filters. The gravel filter will be modified and be online for the start of school."

The university students continually monitor the performance of the system and levels of bacteria in the soil as well as investigate the effect of temperature on the levels of bacteria in the soil.

To learn more about Nasonville's system and the University of Wisconsin study, contact Dr. Converse at (608) 262-1106.

CONTACTS

The National Small Flows Clearinghouse (NSFC)

The NSFC offers technical assistance and free and low-cost information about onsite and small community wastewater technologies and issues, including spray and drip irrigation, wastewater reuse, and state and federal regulations. Only a few of the NSFC's many resources and services are mentioned in this issue. Visit the NSFC's Web site at www.nsfc.wvu.edu, or call (800) 624-8301 or (304) 293-4191 for assistance or to request a free catalog.

Local and State Health Agencies

For more information about spray and drip irrigation, local regulations, or permit requirements, community residents should contact their local or county health department officials. Community leaders who wish to evaluate irrigation as an alternative to direct discharge should contact their state health agency. State and local agencies usually are listed in the government section or blue pages of local phone directories.

Extension Service Offices

Many universities have U.S. Department of Agriculture Extension Service offices on campus and in other locations, which provide a variety of services and assistance to individuals and small communities. For the number of the Extension Service office in your area, check the government pages of your local phone directory, call the NSFC, or call the U.S. Department of Agriculture directly at (202) 720-3377.

The Irrigation Association (IA)

The IA is the irrigation industry's trade organization and has members who can provide professional assistance in all aspects of irrigation. IA members include researchers, technicians, manufacturers, distributors, dealers, system designers, consultants, installers, and contractors. Visit its Web site at www.irrigation.org to conduct a search of IA's membership or for consumer information, including how to hire an irrigation contractor. Or, contact IA headquarters in Fairfax, Virginia, at (703) 573-3551 for assistance.

RESOURCES AVAILABLE FROM NSFC

To order any of the following products, call the National Small Flows Clearinghouse (NSFC) at (800) 624-8301 or (304) 293-4191, fax (304) 293-3161, e-mail nsfc_orders@estd.wvu.edu, or write NSFC, West Virginia University, P.O. Box 6064, Morgantown, WV 26506-6064. Be sure to request each item by number and title. ***A shipping and handling charge will apply.***

Spray and Drip Irrigation Technology Package

A selection of useful articles about spray and drip irrigation with wastewater is presented in this publication. The articles are chosen from the NSFC's Bibliographic Database. Onsite irrigation systems and the application of wastewater to forest lands and parks are among the topics discussed. Case studies also are included. The price is $16.25. Request Item #WWBKGN53.

Guidelines for Water Reuse

This EPA manual presents federal guidelines for implementing a water reuse system and how to evaluate water reclamation and reuse opportunities. Chapters are devoted to each of the technical, financial, legal, institutional, and public involvement considerations that a reuse planner might examine.The price is $30.00. Request Item #WWBKDM72.

Computer Search: Drip Irrigation

This booklet is a compilation of article abstracts on drip irrigation compiled from a search of the NSFC's Bibliographic Database. Complete copies of the articles can be ordered from the NSFC. The price is $2.75. Request Item #WWBLCM18.

Computer Search: Spray Systems

Spray systems as an alternative to conventional methods of wastewater disposal is the topic of this NSFC Bibliographic Database search. Abstracts of spray system articles are included. The price is $6.75. Request Item #WWBLCM19.

Manufacturers and Consultants Database

Customized searches of the NSFC's Manufacturers and Consultants Database are available upon request. Contact the NSFC and ask to speak with a technical assistance specialist to request a search of irrigation system manufacturers, dealers, designers, consultants, and operators in your area. The price varies. Request Item #WWPCCM16.

Guide to State Level Onsite Regulations

This guide provides information about state regulations regarding onsite wastewater systems. Contacts, keywords, and definitions are included. The price is $12.50. Request Item #WWBKRG01.

Free Brochure: Water Reuse Via Dual Distribution Systems

This free brochure examines the benefits of a wastewater reuse system and includes information on system operation, design, cost, and public acceptance issues. Request Item #WWBRGN15.

PIPELINE

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