STATE OF MAINE
DEPARTMENT OF HUMAN SERVICES
11 STATE HOUSE STATION
AUGUSTA, MAINE
04333-0011

ANGUS S. KING, JR.
GOVERNOR

KEVIN W. CONCANNON
COMMISSIONER

October 8, 1998

AWT Environmental, Inc.
Attn.: Mark Lubbers, Vice President
P. O. Box 50120
New Bedford, MA 02745

Subject: Product Registration, AWT Bioclere

Dear Mr. Lubbers:

Thank you for your registration submission regarding your company's product. Please forgive my delay in responding.

Under provisions of Section 1802 of the Maine State Plumbing Code, Subsurface Wastewater Disposal Rules (copy enclosed), any manufacturer or distributor submitting a new product for code registration needs to demonstrate that:

1. The product is designed to protect public health, prevent the creation of any nuisance, and prevent environmental pollution to the same extent as comparable products presently authorized by Department for use in this code, and

2. The product is based on sound engineering principles and can be expected to provide the same level of protection to public health and the environment as offered by the authorized products presently authorized by the Department for use in this code.

Such demonstration may be achieved by submitting a letter to the Division of Health Engineering from: a) a certifying organization, such as the International Association of Plumbing and Mechanical Officials (IAPMO), Building Officials and Code Administrators (BOCA), or other suitable organization stating their approval of the product, or b) the American Society for Testing and Materials (ASTM) indicating the requested product (used as indicated in the request) meets the ASTM standard as specifically listed in the appropriate section of any nationally recognized plumbing code, such as BOCA, IAPMO (same as International Plumbing Code), or equal.

According to the information you provided, AWT Bioclere has received approval from National Sanitation Foundation (NSF) pursuant to Criteria C-9 (similar to NSF Standard 40). Further, the New England Interstate Water Pollution Control Commission's Technical Review Committee issued a favorable Advisory Opinion for the AWT Bioclere. On that basis, the Division has determined that AWT Bioclere is acceptable for use in the State of Maine, provided that it is installed, operated, and maintained in conformance with the manufacturer's directions.

Because installation and owner maintenance has a significant effect on the working order of onsite sewage disposal systems, including their components, the Division makes no representation or guarantee as to the efficiency and/or operation of AWT Bioclere. Further, registration of this product for use in the State of Maine does not represent Division preference or recommendation for this product over similar products.

If you have any questions please feel free to contact me at (207) 287-5695.

Sincerely,

James A. Jacobsen

James A. Jacobsen, Manager
Wastewater and Plumbing Control Program
Division of Health Engineering
e-mail: james.jacobsen@state.me.us

xc: File

Div. of Health Engineering

Div. of Health Engineering
Wastewater and Plumbing
Control Program
10 State House Station
Augusta, ME 04333-0010

Phone: 207-287-5695
FAX: 287-4172
email: james.jacobsen@state.me.us

Memorandum

To: *Fred Michaud, LPI*
From: *James A. Jacobsen*
cc: *File*
Date: *Wednesday, June 24, 1998*
Subject: *AWT Bioclere*

Following up our conversation this morning, it turned out that we have not yet issued a letter for the AWT Bioclere unit. However, two days ago we received NEIWPCC's Technical Review Committee Adivisory Opinion for the product. (A copy is enclosed.) The Advisory opinion was quite favorable for the product.

Since DHE is a member of NEIWPCC, it is our policy to accept products for use in Maine which have obtained favorable reviews by the Technical Review Committee. We will be issuing an acceptance letter for AWT Bio clere as soon as possible.

Finally, I was in error about Bioclere using a sponge medium for the biological reactor. That was in fact the medium used by a competing device.

NEIWPCC

New England Interstate Water Pollution Control Commission

255 Ballardvale Street
2nd floor
Wilmington, MA
01887-1013
Tel: (978) 658-0500
Fax: (978) 658-5509
mail@neiwpcc.org
www.neiwpcc.org

June 16, 1998

JUN 1998
Received
Div. of Health
Engineering

John Lafreniere
AWT Environmental
P.O. Box 50120
241 Duchaine Blvd.
New Bedford, MA 02745

Re: Regional Evaluation of AWT Bioclere

Dear Mr. Lafreniere,

The New England Interstate Water Pollution Control Commission's Technical Review Committee has reviewed your application for the AWT Bioclere as a Category 3 – Advanced Wastewater Treatment System. At this time, the Committee is pleased to present you with the final Advisory Opinion for your product/technology.

Due to the interest in the pilot project and the extension of the EPA funding, NEIWPCC will continue the regional evaluation of innovative/alternative on-site wastewater technologies/products through our next fiscal year. Some of the original applications have required additional time due to the Committee's request for new/additional data or other clarifications. Once the original applications are finished, the Committee will proceed to evaluate technologies/products who are currently on our waiting list. If there is space available for additional applications, NEIWPCC will solicit new requests at that time.

NEIWPCC and EPA are very interested in your next steps towards New England-wide approval of the AWT Bioclere. NEIWPCC or EPA-New England's Center for Environmental Industry and Technology (CEIT) may contact you in the near future in order to determine the benefits, if any, of this regional review process. Hopefully this process has been fruitful for all involved. On behalf of the Technical Review, we wish you the best of luck in your future endeavors.

Thank you again for your participation in this project. If you have any questions, please feel free to contact me at (978) 658-0500.

Sincerely,

Thomas W. Groves
Senior Environmental Engineer

cc: Technical Review Committee
Carol Kilbride, EPA-CEIT

Advisory Opinion
From the
Technical Review Committee
For the
New England Interstate Regulatory Cooperation Project

Product/Technology Name:
Bioclere

Applicants Name & Address:
John Lafreniere
AWT Environmental, Inc.
P.O. Box 50120
241 Duchaine Blvd.
New Bedford, MA 02745
(508) 998-7577

NEI Category:
3 – Advanced Wastewater Treatment

Date of Opinion:
March 25, 1998

Project Background:
The New England Interstate Water Pollution Control Commission (NEIWPCC) in cooperation with the New England Governors Conference (NEGC), EPA Center for Environmental Industry and Technology (CEIT), EPA's National Small Flows Clearinghouse (NSFC), and the New England state environmental/health agencies responsible for the administration of on-site wastewater treatment systems are undertaking a 12-month pilot project for the regional voluntary evaluation of innovative/alternative on-site wastewater products/technologies. The goal of the project is to facilitate the technical evaluation of innovative/alternative (I/A) on-site wastewater products/ technologies on a regional basis. This effort should help expedite the acceptance of innovative/alternative on-site wastewater treatment products/technologies. The work will be carried out by a Technical Review Committee (the Committee) which will conduct independent evaluations of product/technology performance. The Committee, made up of New England state regulators and advisors, will assess each product/technology on its merits, backed by quality data, and render an Advisory Opinion. The benefit of the Committee is to assist regulators in carrying out their responsibilities for evaluating these technologies in a more efficient manner.

The Committee has defined three categories of On-site I/A technologies:

1. **Material Replacement**
2. **System Modification**
3. **Advanced Wastewater Treatment**

Commercial units are designed according to hydraulic and organic influent characteristics and effluent requirements that will achieve the same levels of treatment.

Technical Review Committee's Response to Claims:

The Technical Review Committee's opinion is based on the Committee's evaluation of available information on the product/technology and relates to the specific products, materials, and specifications stated in the Technology Claim(s) of performance.

X The Committee agrees that the product/technology meets the above-stated performance claims. The Committee reached this decision via a unanimous vote.

The applicant should request a determination from the committee for any modifications to the product/technology or to the product/technology claim. The product/technology is also evaluated for the quality of the data, wastewater science, and the technology's apparent merit as an innovative/alternative on-site wastewater treatment technology.

General Observations/Concerns:

After thoroughly evaluating all of the available information, the Technical Review Committee has identified the following concerns which may affect the approval of said technology in a state:

1. *Maintenance is essential to the long-term performance of the system.*
2. *Excessive oil and grease may impact the performance of the trickling filter.*
3. *An operation and maintenance (O & M) manual should be prepared and distributed with each system.*
4. *Care should be taken to properly install the unit per manufacturer's specifications. Of primary concern are the compaction of backfill around the unit and the prevention of unit flotation.*

Recommendations:

Based on the Technical Review Committee's evaluation, the Committee recommends the following items to improve or insure product performance:

1. *The unit should be designed, installed, and operated in accordance with manufacturer's specifications (i.e., waste load, etc.).*
2. *For all mechanical wastewater treatment systems, a licensed treatment plant operator should provide professional maintenance.*
3. *A contract for long-term maintenance should be required for the life of the unit.*
4. *A septic tank effluent filter should be used in any system in which a septic tank is utilized.*

State Regulations:

A positive Advisory Opinion shall in no way be considered a substitute for compliance with individual state regulations. Every states' regulations are designed to reflect the concerns of that state. Information generated in this opinion is intended to alleviate the investigative work required by an individual state for the consideration of said technology for approval as an alternative/innovative technology. Before state approval of the technology, the technology must comply with all pertinent state regulations. The Technical Review Committee also recommends that each state have a control for insuring that the above-listed concerns are met, addressed, or closely monitored and tracked.

"BIOCLERE™"

Self-Contained
200 gpd to 50,000 gpd
Wastewater Treatment Plants

AWT ENVIRONMENTAL, INC.
241 Duchaine Blvd.
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New Bedford, MA 02745

Tel. 508-998-7577
Fax 508-998-7177

BIOCLERE

Wastewater Treatment Systems

Introduction

The Bioclere is a modified trickling filter which was developed in Finland and which is used extensively throughout Europe and the Middle East for the secondary treatment of wastewater and the conversion and reduction of nitrogen. A modified Bioclere for the precipitation of phosphorus is frequently added to the process chain.

Bioclere system serving a housing development. Standard effluent requirements are: 15 mg/l BOD, 25 mg/l TSS, 3 mg/l Ammonia and 1 mg/l Phosphate. The final stage of treatment is U.V. disinfection.

Installations range from 200 gpd to 50,000 gpd. The Bioclere is constructed of insulated and U.V. resistant fiberglass or plastic. Modular in nature they may be installed in parallel to accommodate larger flows or in series to achieve higher levels of treatment. The stability of the process, which is characteristic of its trickling filter heritage, and the simplicity of design minimize the life cycle operating and maintenance costs generally associated with the secondary treatment of wastewater. Typical installations include individual homes, residential clusters, malls, nursing homes, schools, supermarkets, restaurants, gas stations, golf courses, hotels and small communities.

The trickling filter is a fixed film aerobic process in which microorganisms attach themselves to a highly permeable media creating a biological filter or slime layer through which wastewater is trickled allowing organic matter to be absorbed into the slime layer. Designed properly this filter is self-purging and maintenance free.

Unlike traditional trickling filters in the Bioclere the biofilter is enclosed and positioned over a clarifier. Hydraulic dosing and secondary sludge return pump systems are set at pre-determined rates minimizing maintenance and enhancing treatment. The self-purging biological filter is designed by AWT Environmental Inc. to accommodate influent characteristics and achieve effluent requirements . Oxygen is introduced to the system through a fan in the Bioclere housing and is exhausted through a vent typically located in the discharge line.

The Bioclere is a gravity flow treatment system. Installed in line between the primary tank and distribution box, the Bioclere neither intrudes on or adversely affects the flow of a conventional onsite system. Because the treatment process is above the gravity flow of the system electrical outages do not inhibit flow and dilution factors within the system minimize the impact of a short term power failure on effluent quality.

The Bioclere's fixed film process and hydraulic capacity minimize the impact of organic and hydraulic fluctuations on the treatment process and effluent quality. Generally Bioclere installations do not require flow equalization prior to treatment. The ability of the biological film which forms in the filter to self-regulate daily and seasonal variations in hydraulic and organic loading as well as environmental variations such as temperature, pH and process inhibitors is widely acknowledged.

The Bioclere is a designed treatment system. Hydraulic and organic influent characteristics must be determined in designing the Bioclere to meet effluent requirements. A design questionnaire is included for this purpose on page 8.

The National Sanitation Foundation (NSF) has tested and approved the Bioclere under its Criteria C-9 which is essentially equivalent to Standard 40. The test results and Executive Summary are on pages 9 and 10.

BIOCLERE PROCESS

Wastewater flows from the septic tank or primary settling tank into a baffled chamber in the clarifier of the Bioclere. Dosing pumps located in this clarifier intermittently dose the filter media with the wastewater.

In the trickling filter the organic material in the wastewater is reduced by a population of microorganisms which attach to the filter media and form a biological slime layer. In the outer portion of the slime layer treatment is accomplished by aerobic micro-organisms. As the microorganisms multiply the biological film thickens and diffused oxygen and organic substrate are consumed before penetrating the full depth of the slime layer. Consequently the biological film develop aerobic, anoxic and anaerobic zones.

Absent oxygen and a sufficient external organic source for cell carbon the micro-organisms near the media surface lose their ability to cling to the media. The wastewater flowing over the media washes the slime layer off the media and a new slime layer begins to form. This process of losing the slime layer is called "sloughing" and it is primarily a function of the organic and hydraulic loading on the filter. This natural process allows a properly designed media bed to be self-purging and maintenance free.

The sloughed biomass settles to the bottom of the sump as sludge. These secondary sludges are periodically pumped back to the primary tank for storage and eventually removed.

This process is essentially the same for the reduction of BOD_5 and nitrification or the conversion of ammonia nitrogen to nitrate.

NITRIFICATION/DENITRIFICATION

Removing ammonia from wastewater is a well established and quantifiable biological process. Nitrogen exists in the influent primarily in the form of organic nitrogen and ammonia (TKN). The principle part of the organic nitrogen is converted to ammonia by anoxic bacterial activity. Therefore, ammonia is commonly regarded as the starting point in the nitrogen reduction process. Nitrification: the conversion of ammonia nitrogen (NH_3) to nitrate (NO_3) which is rich in oxygen is a biological process accomplished in the presence of oxygen.

Because carbonaceous BOD asserts the primary demand for oxygen in the treatment process, large flow nitrifying Bioclere systems are typically designed as split filters or with two units in series. By placing Biocleres in series each unit may be designed to achieve the effluent required from the influent characteristics. Nitrification is a major consideration for most of the Bioclere installations in Europe. Typical requirements for effluent ammonia are from 1 to 3 mg/l which is reliably accomplished.

Successful nitrification is accomplished with a healthy microorganism population and an environment where pH, temperature, organic loading and supply of oxygen are stable. In a Bioclere system the pH is buffered by the carbonate system associated with the wastewater; the temperature remains consistent because of the insulated environment and the relatively constant temperatures generated by the fixed film biomass; the organic loading is relatively constant because the waste water has been pre-treated in the first stage; and the fan provides an adequate supply of oxygen.

Denitrification utilizing septic tank carbon is widely considered to be the most economical and efficient method for nitrogen removal. Utilizing prescribed recirculation rates this method of returning Bioclere nitrified wastewater to the carbon source in the anoxic zone of the primary tank has achieved reductions of nitrogen between 85% and 90%.

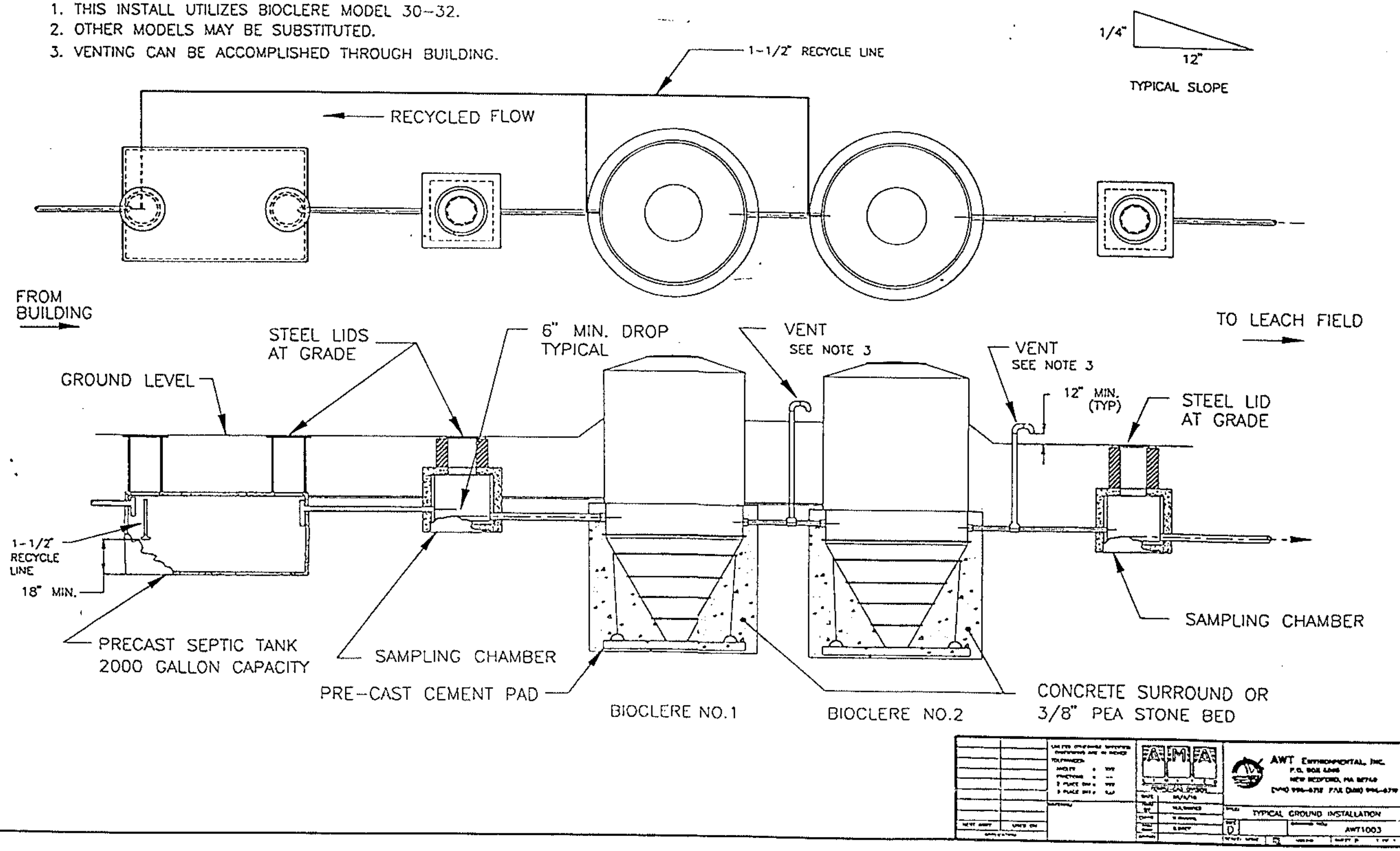
Biological denitrification is accomplished by anaerobic heterotrophic organisms under anoxic conditions. In this process bacteria convert the nitrate to nitrogen gas which is released into the atmosphere.

In the Bioclere system the nitrified mixed liquor in the clarifier of the nitrif[illegible] Bioclere is returned to the anoxic zone in the primary tank for denitrification.

NITROGEN TRANSFORMATIONS AND REMOVAL

Form of Nitrogen	Responsible Micro-organisms	Representative Equations	Control and Removal Process
Organic-N (Protein)	Aerobic Heterotrophs		
Ammonia-N			
NH3	Aerobic Autotrophs Nitrosomonas	2NH3 + 302 => 2NO2 + 2H + 2H20	Biological nitrification for control
Nitrite-N NO2	Nitrobacter	2NO2 + 02 => 2NO3	
Nitrate-N NO3		3NO3 + CH30H => 3NO2 + 2H20 + CO2	Biological denitrification for removal
Nitrite-N NO2	Anaerobic Heterotrophs	2NO2 + CH30H => N2 + H20 + 20H + CO2	
Nitrogen gas N2			

NOTES:
1. THIS INSTALL UTILIZES BIOCLERE MODEL 30–32.
2. OTHER MODELS MAY BE SUBSTITUTED.
3. VENTING CAN BE ACCOMPLISHED THROUGH BUILDING.



PHOSPHORUS PRECIPITATION

The most common and reliable method of achieving phosphorus removal is by chemical precipitation. The Bioclere onsite system incorporates a separate stage chemical precipitation unit which is placed in line after carbonaceous BOD_5 and nitrification have been accomplished, thus minimizing sludge production. These systems have been used for over 20 years in Europe and typically reduce effluent phosphorus concentrations to > 1 mg/l.

Chemical precipitation requires dosing of a coagulant, rapid mixing and flocculation to precipitate insoluble phosphate. Metal salts (aluminum sulfate) are the most efficient and easily managed coagulants. Dosing requires a coagulant storage tank and chemical feed system which are housed in the top portion of a modified Bioclere. The rapid mixing and flocculation devices are fixed in the clarifier located directly beneath the dosing system. Dosing is based upon the stcichiometric metal salt to phosphorus ratio as dictated by the concentration of phosphorus contained in the daily wastewater flow. Sludge produced by the reaction is typically returned to the septic tank for storage and eventual removal.

BIOCLERE COMPONENTS

Major components of the Bioclere are constructed of U.V. resistant insulated fiberglass or plastic.

The *filter shell* and lid are insulated to provide near constant temperature conditions in the biofilter.

The *clarifier* (sump) is of single wall construction and baffled to facilitate settling.

A *central channel* provides ready access to dosing and recirculation pumps.

Random packed *media* which is biologically inert and mechanically durable facilitates oxygen transfer and increases wastewater detention time in the biofilter.

Weir bowl or spray nozzle *distribution systems* uniformly distribute the wastewater over the biofilter.

Pumps are used for both dosing the biofilter, sludge return and recirculation. 1/4 horse, 1/3 horse and 1/2 horse stainless steel Grundfos pumps are used. The size and number of pumps is dependent on model and wastewater characteristics.

A moisture resistant *axial fan* provides a consistent supply of oxygen to the treatment process.

The *control panel* contains the following equipment:

- NEMA IV cabinet
- circuit breakers
- main switch
- pumping timers
- alternators
- audio and visual alarms
- control and regulation electronics
- electrical connection terminal strip
- options for remote control alarm

controls for tertiary treatment components are optional

GENERAL INFORMATION

Existing septic tanks may be adapted to form the primary treatment stage of the Bioclere process. Sizing the primary tank should take into consideration the impact of recirculation on detention time.

Biocleres are constructed with the effluent pipe 180° opposite the influent pipe. However, the influent and effluent pipes may be positioned at different angles. Should this be necessary for a specific project please review your needs with AWT.

The only routine service procedures required by the Bioclere are pump and fan maintenance and cleaning of the distribution system. Tertiary treatment equipment added to the process chain may require additional service. In most states this maintenance must be performed by a licensed wastewater treatment plant operator.

AWT provides operations and maintenance services. Please contact our offices for a service contract proposal.

Biocleres may be easily installed into new or existing facilities. Generally the pre-assembled, self-contained Bioclere is delivered with a lifting harness. Concrete pads with lifting rings are set at appropriate elevations and the Bioclere is set on the pad. The Bioclere is leveled using self-adjusting cables in tripod fashion from the top of the clarifier to the rings on the cement pad. A larger two stage system may be installed in a few hours if site preparation is adequate.

The Bioclere may be pre-tested by filling the clarifiers with fresh water if wastewater is not readily available. Once the Bioclere system is commissioned six to twelve weeks are required to establish a functioning biomass for treatment.

BIOCLERE SYSTEM DESIGN CRITERIA

Date:

Engineer:	Client/Site Address:
Tel.	
Fax.	

a) Application: 1) Residential 2) Commercial 3) Other
Description:

b) Description of proposed treatment components:

c) Permits: Massachusetts, TITLE 5: 1) General 2) Remedial 3) Provisional
Other:

Typical Residential Wastewater Assumptions *(single family homes without home based businesses)*

BOD5 = 250 mg/l
TSS = 250 mg/l
TKN = 45 mg/l

Design Flow = # of bedrooms ( ) * (110 gpd) = gpd

Actual Flow = Pop. Equivalent ( ) * (55 gpd) = gpd

** Please specify effluent requirements under EFFLUENT DATA*

Commercial, Industrial or Other Residential Applications*

**Please obtain composite samples at the septic tank effluent tee for the parameters listed under INFLUENT DATA*
**Please provide AWT Environmental with all applicable Material Safety Data Sheets (MSDS)*

INFLUENT DATA	EFFLUENT DATA
Specify test location:	Please specify location of effluent requirements:
Flow data (gpd): Design Ave. Peak	
Seasonal Flows: Y N when?	
Are low flow devices utilized?: Y N Will they be used?: Y N	
Are garbage grinders utilized?: Y N They should not be used in conjunction with the Bioclere	
pH:	pH:
BOD5:	BOD5:
COD:	COD:
TSS:	TSS:
TKN:	TKN: Ammonia-N:
Ammonia-N:	Nitrate-N: Total nitrogen:
Oil & Grease (omit if traps are included):	Oil & Grease:
Phosphorus:	Phosphorus:
Alkalinity:	Other:

NOTES: **Commercial installations require baffled septic tanks and a gas baffle under the effluent tee*

Signature:

Summary of Analytical Results

		Median[1]	Average	Std. dev	Min	Max	Interquartile range[2]
Temperature (°C)	influent	13	13.2	2.0	10	17	11 - 14
	septic tank effluent	11	10.9	3.0	5	15	8 - 14
	effluent	11	11.4	3.0	5	16	8 - 14
pH	influent	7.5	7.6	0.14	7.3	7.9	7.5 - 7.7
	septic tank effluent	7.5	7.6	0.22	7.1	8.1	7.4 - 7.8
	effluent	8.0	7.9	0.20	7.4	8.5	7.8 - 8.1
Biochemical Oxygen Demand (mg/L)	influent	170	167	49	80	290	130 - 210
	septic tank effluent	73	74	14	44	100	62 - 86
	effluent	11	13	6	5	45	8 - 16
Suspended Solids (mg/L)	influent	120	141	85	54	720	97 - 160
	septic tank effluent	40	47	26	18	200	33 - 52
	effluent	13	17	10	5	50	8 - 24
Volatile Suspended Solids (mg/L)	influent	100	111	58	37	430	77 - 120
	septic tank effluent	32	37	20	13	160	26 - 42
	effluent	10	14	8	5	35	7 - 20
Dissolved Oxygen (mg/L)	effluent	5.6	5.9	1.3	3.4	10.2	4.7 - 6.5

[1] Median: Fifty percent of the values are less than or equal to this value.

[2] Interquartile Range: The range of values about the median between the upper and lower 25 percent of all values

EXECUTIVE SUMMARY

Testing of the Bioclere Model BP3 was conducted under provisions of NSF Criteria C-9. The evaluation protocol was developed by a special Task Committee composed of professionals working in the field of wastewater treatment and public health. The protocol established the procedures to be used in the performance evaluation and criteria to be met for the plant to be listed under the criteria.

The performance evaluation was conducted at the NSF Wastewater Technology Test Facility in Chelsea, Michigan, using wastewater diverted from the Chelsea municipal wastewater collection system. The evaluation consisted of two months of dosing at 200 gallons per day, a stress test sequence and two months of dosing at design loading. The stress test sequence consisted of four separate loading patterns: wash day, working parent, equipment or power failure, and a one week vacation.

The performance evaluation was complete using a 1,000 gallon septic tank ahead of the Bioclere BP3 plant. The septic tank was seeded with septage from a residence that had been in service for at least two years. Sampling of the effluent started after four weeks of dosing to allow for plant start-up. Sampling started in the fall and continued through the winter and into late spring, covering a full range of operating temperatures. At the request of the manufacturer, additional sampling and analysis was completed to evaluate the performance of the Bioclere BP3 for coliform reduction and nitrification.

Over the course of the evaluation, the Bioclere BP3 produced an effluent with carbonaceous BOD_5 ranging from 5 to 45 mg/l, suspended solids ranging from 5 to 50 mg/l and pH ranging from 7.34 to 8.5. During the non-stress dosing period, the effluent BOD_5 averaged 13 mg/l, while the effluent suspended solids averaged 17 mg/l. During the stress testing, the effluent BOD_5 averaged 13 mg/l and the effluent suspended solids averaged 9 mg/l.

The plant produced an effluent that successfully met the performance requirements established in the evaluation protocol.

During the non-stress dosing: The arithmetic mean of seven consecutive sample days ranged from 8 to 24 mg/l for BOD_5 and 6 to 36 mg/l for suspended solids, both well below the requirement of 45 mg/l.

The arithmetic mean of 30 consecutive sample days ranged from 9 to 17 mg/l for BOD_5 and 9 to 23 mg/l for suspended solids, both well below the requirement of 30 mg/l. Removal rates ranged from 91% to 97% for BOD_5 and 86% to 93% for suspended solids.

The pH during the entire evaluation remained in the range of 7.3 to 8.5, within the required range of 6.0 to 9.0.

Effluent BOD_5 concentrations during the stress testing ranged from 5 to 17 mg/l, well below the required 60 mg/l. Likewise, the effluent suspended solids ranged from 5 to 14 mg/l during the stress test, well below the required 100 mg/l.

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CLUSTERED ONSITE WASTEWATER TREATMENT
A DECENTRALIZED APPROACH

Rural and suburban communities are beginning to realize that to maintain the public health, and the integrity of their ground and surface waters they must develop strategies to reduce and remediate nonpoint pollution from wastewater and storm water. They are also beginning to understand that to ignore these issues may have profound economic consequences. While, nationally, a few communities have demonstrated some capacity to address these issues, for the most part local community efforts to develop cost effective and technologically sound solutions are complicated by regulatory protocols which were devised for an earlier time as well as by questions about the social, economic and environmental implications of their decisions.

Nevertheless, there is a growing consensus that a "decentralized approach" to wastewater remediation, which includes the "clustering" of small flows residential and/or commercial sites on one wastewater treatment system is a practical approach whose time has arrived.

The viability of a decentralized and clustered approach has emerged because:

> The original EPA grants to build conventional sewers and centralized treatment plants have not been available since the mid 1980's.
>
> There is a growing public awareness that nonpoint wastewater discharges can have public health as well as environmental and economic consequences when they are not properly managed.
>
> There is an increasing reluctance of smaller communities to accept the high capital and operating costs as well as the growth and development implications of traditional sewers.
>
> Telemetry and digital technologies can provide the regulatory control and operating assurances which were traditionally achieved by large scale collection systems.

Simultaneously, there has been an increasing demand for the secondary and tertiary treatment of nonpoint wastewater because:

> Groundwater and drinking water are strategic resources for economic development as well as the public health and they must be sustained.
>
> Nutrient loading to coastal estuaries and fresh water bodies not only adversely alters the related ecology, it also adversely effects related property values.

Capital cost comparison of individual onsite soil infiltration systems and a clustered Bioclere system for secondary treatment and a 50% reduction in nitrogen:

	A Individual cost w/o <u>Biocleres</u>	B Individual cost with <u>11 Biocleres</u>	C Clustered System cost with <u>shared Biocleres</u>
1500 gal. septic tank	$2000.		
leaching trench	$1200.		
engineering	$1450.		
permitting	$ 200.		
pipe/stone/excavation, etc.	$2684.		
Total	$7534.	$7534.	
Biocleres installed (pro-rated)		$2900.	$2040.
Collection (pro-rated)			$1654.
Clustered disposal system installed (pro-rated)			$2564.
Engineering and misc. (pro-rated)			$ 946.
Average cost per home	$7534.	$10434.	$7204.

While Cape Cod is flat and free of ledge and other variables which typically effect installation costs, this project more than illustrates the capital cost and treatment advantages of clustering. There is a similar advantage in life cycle costs which is illustrated in the following table.

	Individual <u>nitrogen reducing system</u>	Clustered 24 home <u>nitrogen reducing system</u>
Annual electrical costs	$180.	$1200.
Annual maintenance costs	$300.	$1200.
Annual monitoring costs	$500.	$ 500.
Total annual cost per home	$980.	$ 125.

Unlike residential wastewater which is relatively predictable, the nature of commercial wastewater varies dramatically and the ability to treat it effectively requires a careful review of the facilities procedures and sanitary codes. Supermarkets and restaurants typically have BOD and fats, grease and oil (FOG) concentrations which significantly shorten the expected life of a soil infiltration system or sand mound. Established sanitary codes frequently increase the concentrations of the elements which require treatment such as ammonia or prescribed concentrations of chemicals which may inhibit treatment. Flows may be intermittent, with daily or seasonally high peak loading, as well as shock hydraulic and organic loading. For example, a fast food restaurant may have an average BOD concentration of 600 mg/l but on

I have suggested that with respect to effectively reducing nonpoint pollution communities seem frozen in place, frequently lacking the expertise and sometimes the will to create viable options. Correspondingly, there is a very legitimate concern in the regulatory communities that without satisfactory mechanisms for control the common objective of reducing nonpoint pollution may be in jeopardy. Nevertheless, there are clear islands of progress. In some states and municipalities officials are realizing that to transform the current situation and provide for a decentralized and clustered approach to wastewater treatment they will need new administrative approaches and a new set of relationships. The National Forum for Nonpoint Source Pollution clearly endorses such innovations for the economic advantages they represent, and, more importantly, for the environmental urgency of addressing nonpoint source pollution.

Craig Lindell is President of AWT Environmental Inc. in New Bedford, Massachusetts and a member of the Board of Directors of the Coalition for Buzzards Bay.

NITROGEN REMOVAL and TERTIARY TREATMENT with BIOCLERE ONSITE SEWAGE TREATMENT SYSTEMS

For over thirty years the Bioclere™ system has proven effective in removing carbonaceous biochemical oxygen demand ($CBOD_5$), total suspended solids (TSS) and total nitrogen (TKN + NO_2^--N + NO_3^--N) from onsite waste streams throughout the world. The Bioclere, a modified trickling filter which was developed in Finland, is used extensively for the secondary and tertiary treatment of residential, commercial and industrial wastewater with hydraulic flows under 100,000 gpd.

The Bioclere relies on the inherent advantages of the fixed film process, predominantly the ability of the biological film to self-regulate over daily and seasonal variations in organic and hydraulic loadings and its ability to withstand varying environmental conditions. Biofilm mathematical modeling has verified that the substrate removal rate is not decreased as drastically for biofilms under adverse conditions as it is for suspended growth systems. This is due to the dynamics of substrate and oxygen utilization that are dependent upon diffusion and mass flux characteristics (USEPA-*Nitrogen Control* 1993, Williamson *et. al.* 1976). Additionally, the intrinsic weaknesses associated with traditional trickling filters, such as providing consistent seasonal treatment and adequate oxygen transfer are overcome in the Bioclere by insulating the biofilter, utilizing plastic media and supplying forced draft ventilation.

Bioclere Description:

As the wastewater is generated it typically flows by gravity from the septic tank to the baffled chamber in the clarifier under the biofilter (Fig. 1). A dosing pump located in the baffled chamber forces wastewater to the distribution system for uniform dispersion over the surface of PVC media. The pump is controlled by an electronic timer and operates at a specified cycle to maximize oxygen diffusion and mass transfer of pollutants into the biofilm.

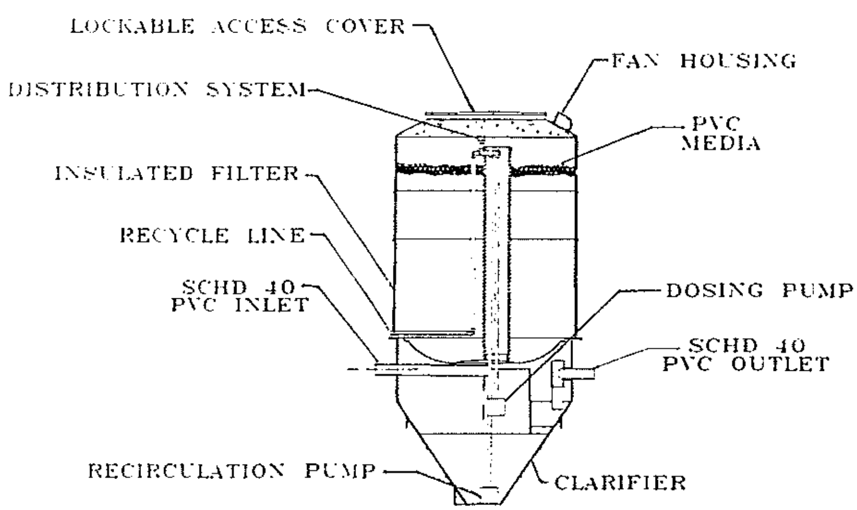

FIG. 1. Sectional View of Bioclere Components

In the Bioclere as in a traditional trickling filter, a biological film forms on the surface of the media. In the outer portion of the biofilm organic matter and ammonium ions are absorbed and oxidized as the wastewater trickles through the filter. As this film increases in thickness, diffused oxygen is consumed by microorganisms in the outer layer resulting in the development of aerobic, anoxic and anaerobic zones within the biofilm (Metcalf & Eddy 1991). Absent cell carbon, the microorganisms near the media surface lose their ability to remain attached and slough through the media bed. The sloughed biomass settles on the bottom of the clarifier as secondary sludge and is periodically pumped to the septic tank, thus eliminating the need for media purging and sludge wasting.

A typical Bioclere treatment system is comprised of a septic tank in series with a Bioclere and a soil absorption field. Together, the septic tank and Bioclere provide a biologically stable environment for the conversion and reduction of nitrogen. Nitrogen in raw wastewater consists of Kjeldahl nitrogen, equivalent to the sum of organic nitrogen and ammonium ions (TKN = Organic-N + NH_4-N). Though septic tanks alone are incapable of substantial nitrogen reduction, the microorganisms present in the anoxic environment perform an essential precursor of nitrification by mineralizing organic-N to NH_4-N.

Nitrification:
Nitrification is the sequential biological oxidation of NH_4-N, first to nitrite (NO_2^--N) by *Nitrosomonas* bacteria then to nitrate (NO_3^--N) by *Nitrobacter* bacteria according to the following overall equation: $\mathbf{2NH_4^+ + 2O_2 \rightarrow NO_3^- + 2H^+ + H_2O}$
Oxidation of 1 mg/l of NH_4-N requires approximately 4.6 mg/l of dissolved oxygen and produces acid resulting in the consumption of approximately (7.1 mg alkalinity as $CaCO_3$/mg NH_4-N oxidized). The autotrophic nitrifying bacteria require a stable environment because of their sensitivity to numerous inhibitory and toxic substances and an array of environmental factors including temperature, pH, dissolved oxygen, and alkalinity.

Because the design of a fixed film reactor is dependent on diffusion and mass flux characteristics, no simple design criteria are available for $CBOD_5$ removal and nitrification (USEPA-*Nitrogen Control* 1993, USEPA-*Assessment* 1991). Historically, the process design of trickling filters has been based on empirical pollutant media loading rates developed and verified by means of monitoring pilot and full scale systems. Similarly, the Bioclere media loading rates to achieve $CBOD_5$ and NH_4-N oxidation have been verified in 7500 plants located throughout Europe and Northeastern United States.

The process design and stable environment provided by the Bioclere satisfy the requirements to sustain aggressive and consistent nitrification. For instance, the high internal dosing rates and recirculation of effluent to the primary tank have been proven to promote the mass transfer rate of NH_4-N into the biofilm (Gullicks and Cleasby 1986.)

Depending on the influent ratio of $CBOD_5$:NH_4-N, nitrification and oxidation of $CBOD_5$ may be accomplished simultaneously in one Bioclere filter (combined oxidation-nitrification (CON)), or subsequently in a separate filter after substantial $CBOD_5$ reduction. In a CON unit, $CBOD_5$ oxidation and nitrification are accomplished without isolation of the heterotrophic ($CBOD_5$ removal) and autotrophic nitrifying bacteria. By utilizing modified loading factors to compensate for contrasting bacterial growth rates, effluent NH_4-N concentrations <5 mg/l may consistently be achieved when treating the equivalent of typical residential wastewater. Conversely, separate stage nitrification is employed when signifigant nitrogen removal is required from a high strength wastewater. It involves the isolation of the autotrophic bacteria in a single Bioclere for oxidation of the remaining NH_4-N contained in the waste stream.

Denitrification:

Dissimilating denitrification, the biological reduction of nitrate (NO_3^--N) to nitrite (NO_2^--N) and ultimately nitrogen gas in an anoxic environment, involves the transfer of electrons from a reduced electron donor (organic substrate) to an oxidized electron acceptor (NO_3^--N). It is an important reaction as it restores approximately (3.57 mg alkalinity/mg of NO_3^--N reduced), and partially offsets the effects of nitrification in a combined nitrification/denitrification process. The microorganisms responsible for completing the reaction are facultative heterotrophic aerobes contained in the wastewater and responsible for $CBOD_5$ oxidation in the Bioclere. Although these microorganisms are less susceptible to varying environmental factors, an absence of molecular oxygen is one condition that must be satisfied since its presence will supress the enzyme system necessary for denitrification (Metcalf & Eddy 1991).

Denitrification in the Bioclere system is accomplished by periodically recirculating secondary sludge and nitrified effluent to the septic tank (Fig. 2). The septic tank provides a stable anoxic environment and the raw wastewater enhanced by secondary sludges an adequate carbon source to complete the reaction. Study of a typical residential waste stream has demonstrated denitrification to occur completely and rapidly in the septic tank (Annunziato 1995). The weight ratios of carbon to nitrate, measured as **TOC:BOD:NO_3-N** averaged **6.9:18.4:1** and were greater than the generally accepted ratio of **2:4:1** to complete the reaction (Kristensen and Jansen 1985). Over the study period between March-June 1995, the effluent total nitrogen concentrations averaged 10.8 mg/l. Additional testing required by the Massachusetts Department of Environmental Protection has demonstrated denitrification to be equally successful at numerous facilities including: several residential sites, elderly housing and nursing homes, supermarkets and fast food restuarants.

Depending upon the influent pollutant concentrations and environmental factors, the Bioclere system (comprised of a primary tank and Bioclere unit(s)) is capable of achieving total nitrogen removals of approximately 75%-85% without the addition of a supplemental carbon source. If higher removals are required, tertiary treatment components may be installed between the Bioclere and the final discharge point to meet the effluent standards.

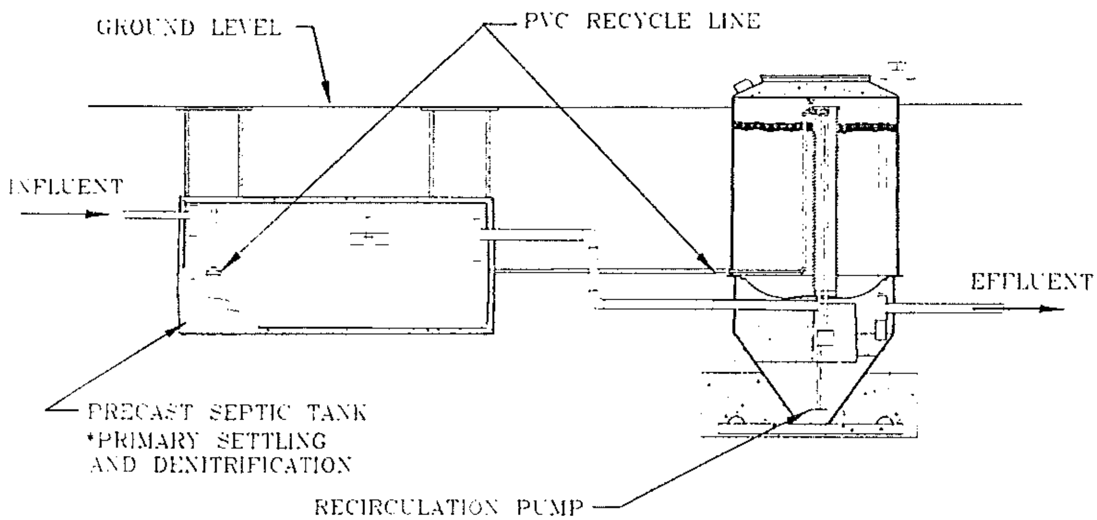

FIG. 2. Denitrification by Recirculation to Septic Tank

TERTIARY TREATMENT

Tertiary treatment involves the advanced treatment of secondary effluent. Depending upon the final disposal or reuse potential, there are several methods of obtaining nearly pure effluent. Below is a description of the processes generally employed by AWT Environmental and the technologies used to achieve the desired effluent quality.

BOD5 and TSS:

Stringent BOD5 and TSS effluent limits (typically < 10 mg/l) are required from sites that reuse or discharge effluent to surface water. In such cases a small diameter rapid gravity sand filter is installed following the Bioclere unit(s). The filter utilizes a dual media composed of sand and anthracite. This media combination is widely recognized to have advantages over single media filters such as accommodating high filtration rates and long filtration runs. The filter process design conforms to well acknowledged design standards for secondary wastewater effluent filtration. Filtration rates of $\leq$ 4 gal./min*ft^2 are standard and have been extensively demonstrated to achieve a high quality effluent (Metcalf & Eddy 1991-*Wastewater Engineering*, EPA 1975-*Suspended Solids Removal*). Additionally, the filter may be equipped to accommodate a fully automated backwash cycle. The standard filter system includes all pumps and controls necessary for operation.

Nitrogen:

Tertiary denitrification is employed when total nitrogen concentrations of less than 10 mg/l are required from sites with elevated influent TKN concentrations. Depending upon the site and flow characteristics, denitrification is accomplished utilizing a supplemental carbon source in either (1) an anoxic zone containing submerged PVC media or (2) a deep bed continuous backwash granular media filter. These methods have proven effective and are recognized as viable processes by the EPA (*Nitrogen Control* 1993).

Ordinarily, the anoxic zone is contained within a precast concrete tank. PVC media which provides a growth medium for the nitrate reducing microorganisms is submerged in the tank. A supplemental carbon source is dosed to the influent wastewater and submersible stainless steel pumps are used for mixing and scouring excess biomass from the PVC media. The effluent from the anoxic tank is passed through a rapid gravity sand filter to eliminate biological solids. The process is based on well acknowledged design standards. The system is comprised of the anoxic zone with all essential components, rapid gravity sand filter and controls necessary for efficient operation.

Denitrification may also be reliably achieved in a continuos backwash deep bed granular media filter. The major benefits of a continuous backwash filter are: (1) simple installation and low energy cost, requiring only a low horsepower air compressor for backwash, (2) uninterrupted filtration cycle. Physically, the water is pumped to the filter as the supplemental carbon is metered into the pipe. Microorganisms responsible for denitrification grow on the granular sand media and reduce the nitrate in the wastewater. The deep bed provides the necessary detention time to complete the reaction and polish the effluent. Operating data is available upon request.

Phosphorus:

Tertiary phosphorus removal to < 1 mg/l may also be accomplished when necessary. Depending upon the site and flow characteristics, removal is achieved using either a modified Bioclere unit or a deep bed continuous backwash sand filter. Both methods follow the well documented and widely practiced principles of chemical precipitation with metal salts. Chemical precipitation requires dosing and rapid mixing of the coagulant (typically polyaluminum chloride) with the wastewater, and flocculation to allow settling of insoluble phosphate. Dosing of coagulant is based on the stoichiometric metal salt to phosphorus ratio dictated by the concentration of phosphorus in the daily wastewater flow.

The Bioclere system incorporates a separate stage chemical precipitation unit that is generally placed in line after carbonaceous BOD_5 removal and nitrification (Fig. 3). The top portion of this unit contains all the essential equipment for coagulation including: coagulant storage tank, chemical feed pump, mixer, heater and ultrasonic flow meter. Dosing of the coagulant is controlled by either an electronic signal from a forward feed pump or an ultrasonic flow meter. Rapid mixing of the coagulant and wastewater is accomplished in the baffled chamber of the clarifier. Flocculation and settling of the insoluble phosphorus also occurs in the clarifier and conforms to widely acknowledged design standards (EPA 1987-*Phosphorus Removal*). The precipitated solids are automatically returned to a sludge holding or primary tank. Bioclere chemical precipitation units have been successfully operated in Europe for over 20 years to achieve a typical effluent standard of < 0.5 mg/l total-P. Data is available upon request.

Phosphorus removal may also be achieved in a deep bed continuous backwash sand filter. In this application wastewater is pumped at a controlled rate of approximately 3 gpm/ft^2 to the sand filter. The coagulant is metered directly into the filter feed pipe to ensure adequate mixing with the wastewater. Flocculation and filtration of the insoluble phosphorus occurs within the deep media bed. Operating data is available upon request.

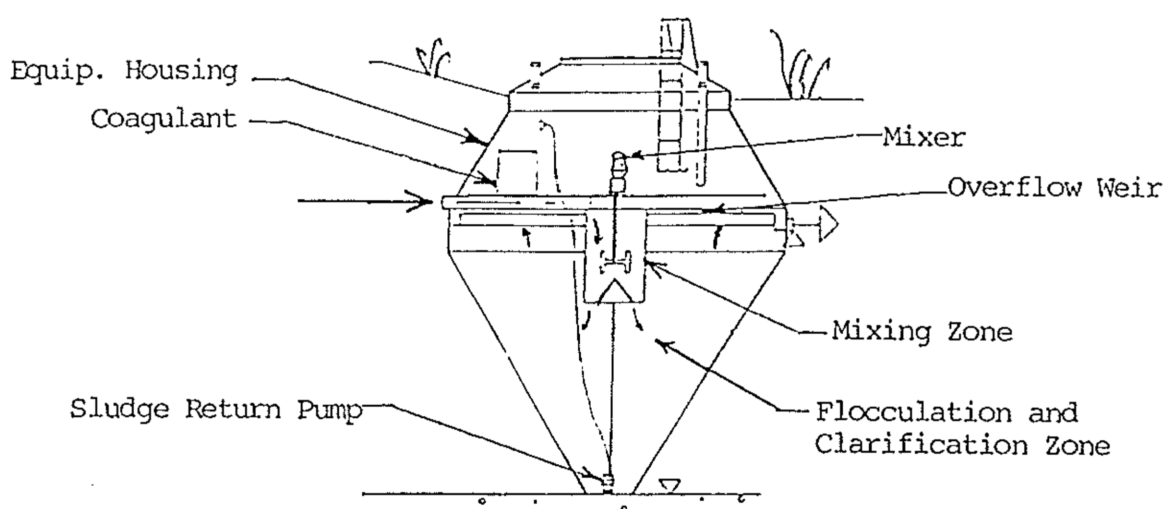

FIG. 3. Sectional View of Phosphorus Removal Unit

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APPENDICES (TEST DATA)

A. National Sanitation Foundation Testing

B. Nursing Home

C. Wendy's Hamburger Restaurant

D. Phosphorus Removal

E. Phosphorus Removal

APPENDIX A

Summary of Analytical Results

		Median[1]	Average	Std. dev	Min	Max	Interquartile range[2]
Temperature (°C)	influent	13	13.2	2.0	10	17	11 - 14
	septic tank effluent	11	10.9	3.0	5	15	8 - 14
	effluent	11	11.4	3.0	5	16	8 - 14
pH	influent	7.5	7.6	0.14	7.3	7.9	7.5 - 7.7
	septic tank effluent	7.5	7.6	0.22	7.1	8.1	7.4 - 7.8
	effluent	8.0	7.9	0.20	7.4	8.5	7.8 - 8.1
Biochemical Oxygen Demand (mg/L)	influent	170	167	49	80	290	130 - 210
	septic tank effluent	73	74	14	44	100	62 - 86
	effluent	11	13	6	5	45	8 - 16
Suspended Solids (mg/L)	influent	120	141	85	54	720	97 - 160
	septic tank effluent	40	47	26	18	200	33 - 52
	effluent	13	17	10	5	50	8 - 24
Volatile Suspended Solids (mg/L)	influent	100	111	58	37	430	77 - 120
	septic tank effluent	32	37	20	13	160	26 - 42
	effluent	10	14	8	5	35	7 - 20
Dissolved Oxygen (mg/L)	effluent	5.6	5.9	1.3	3.4	10.2	4.7 - 6.5

[1] Median: Fifty percent of the values are less than or equal to this value.

[2] Interquartile Range: The range of values about the median between the upper and lower 25 percent of all values

AWT Environmental, Inc.
Sachem Skilled Nursing Facility: East Bridgewater, MA
Bioclere Treatment System - Analytical Results

AVE. WASTEWATER INFLUENT:	Q (Design) = 10,000 gpd				BOD5=275mg/l		TSS=175mg/l		TKN=50 mg/l	
SEPTIC TANK EFFLUENT	DATE	pH	BOD5	COD	CBOD5	TSS(mg/l)	TKN (mg/l)	NH3	NO3	OIL/GREASE
	3/21/96	6.87	142			178				24.20
	4/18/96	6.79	133			57.8				4.96
	5/16/96	6.95	136			122	35.00	24.00		2.64
	6/20/96	6.69	98.7			34.8				4.46
	7/18/96	6.69	127							9.75
	8/15/96	6.8	185			109				10.00
	9/19/96	6.88	103			97				6.04
	10/17/96	6.82	99.2			27				21.30
	11/21/96	6.42	276			149	34.00			1.93
	12/19/96	6.6	506			426				6.96
	1/16/97	6.6	330			66.2				37 10
	2/20/97	6.5	271			45				21.90
	3/20/97	6.9	118			106				15.00
	4/17/97	6.8	96.4			92				17.40
	5/15/97	6.9	76.5	404		13.5				6.06
	6/19/97	6.7	64.2	238		52				1.83
	7/17/97	6.5	152	325		20				13 20
AVE. SEPTIC TANK EFFLUENT			***171.41***	***322.33***		***99.71***	***34.50***	***24.00***		***13.12***
BIOCLERE EFFLUENT DATA:	DATE	pH	BOD5	COD	CBOD5	TSS (mg/l)	TKN (mg/l)	NH3	NO3	OIL/GREASE
	2/15/96	7.63	31.8			12.0				1.32
	3/21/96	7.62			11.1	8 0				2.56
	4/18/96	7.42			22.5	23 0				0 16
	5/16/96	7.57			10.3	24.0	8	6.55	11.6	
	6/20/96	7.44			4.59	4.8				<0.10
	7/18/96	7.24			7.22	9 0				
	8/15/96	7.35			9.27	13.3				<0.10
	9/19/96	7.5			4.8	6.0				<0.10
	10/17/96	7.44			9.12	8.2				3.76
	11/21/96	7.36			18.9	15.0	21			<0.10
	12/19/96	7.4			18.9	16.2				0.8
	1/16/97	7.5			21.4	20.0				<0.10
	2/20/97	7.4			22.1	14.6				<0.10
	3/20/97	7.4			9.9	10.0				<0.10
	4/17/97	7.4			5.2	8.0				<0.10
	5/15/97	7.5		58.7	2.2	6.5				<0.10
	6/19/97	7.3		75.8	4.7	5.6				0.18
	7/17/97	7.1		74.9	10.1	6.0				0.8
AVERAGE BIOCLERE EFFLUENT:				***69.80***	***11.31***	***11.68***	***14.50***	***6.55***	***11.60***	***1.37***

Wendy's Bioclere System

Marshfield, Massachusetts

Samples collected by DeFeo, Wait & Pare
Samples analyzed by Envirotech Laboratories, Inc. Sandwich, MA
* measurement in mg/l unless specified

AVERAGE INFLUENT DATA:
BOD5 = 450-600 mg/l
TSS = 150-200 mg/l
TKN = 55-60 mg/l

Effluent Quality Summary

Sample Date	Ave. Flow (gpd)	pH pH units	Temp. C	BOD5	Total Susp. Solids	NH4-N	TKN	NO3-N+NO2-N	Total-N	Fecal Coliform
9/7/94	1437	7.3	23.7	66.0	35.4	1.2	9.5	0.3	9.8	
10/7/94	1388	7.5	20.0	14.2	12.0	<0.1	3.4	2.7	6.1	8.0
11/18/94	1488	7.2	19.5							
12/29/94	1258	7.0	14.0							
1/10/95	1329	7.0	12.3	34.4	11.5	1.7	5.9	4.2	10.1	820.0
2/27/95	1351	6.9	9.0							
3/30/95	1379	7.0	13.9							
4/25/95	1386	7.5	12.6	15.0	12.0	3.2	8.1	7.1	15.2	<100
5/23/95	1318	6.9	18.9							
6/27/95	1306	7.2	22.5							
7/21/95	1401	7.4	21.4	39.0	23.0	1.2	6.8	0.6	7.4	<1000
8/21/95	1503	7.0	25.4							
9/21/95	1384	7.1	23.5							
10/23/95		7.5	21.2	21.3	14.2	1.8	6.5	2.4	8.9	<10
5/8/96		6.4	13.3	16.0	38.1	<0.1	3.5	4.8	8.3	6000.0
7/18/96	1134	6.5	24.3	10.5	8	0.77	5	2	7.0	ND
1/23/97	1300	7.1	16.2	45	20.7	0.91	7.2	4.6	11.8	LT 5
AVE.				29.0	19.4	1.2	6.2	3.2	9.4	

SITE LOCATION:
Mellanbergavagen, Sweden
Installed by:
Bioclere SVAB, Stockholm

Wastwater Source:
Typical Residential

Average daily flow = 3200 gpd

TYPICAL BIOCLERE PHOSPHORUS REMOVAL DATA

EFFLUENT DATA: All measurements in mg/l except for pH

DATE	pH	CBOD7	TSS	Total-P
12/1/86	6.6	5.0	6.0	0.29
1/13/87	6.5	11.0	5.0	0.21
2/17/87	6.6	11.0	9.0	0.40
3/17/87	5.0	12.0	17.0	0.68
4/15/87	6.4	12.0	8.0	0.25
5/13/87	6.1	7.0	13.0	0.38
6/18/87	6.2	8.0	4.0	0.29
7/3/87	4.3	6.0	5.0	0.29
8/27/87	5.9	5.0	6.0	0.40
9/15/87	5.9	9.0	8.0	0.27
10/25/87	6.3	10.0	7.0	0.49
11/30/87	6.7	12.0	7.0	0.25
8/9/88	5.3	9.0	11.0	0.23
11/25/88	5.7	7.0	18.0	0.52
6/29/89	6.3	3.0	4.0	0.63
1/9/90	6.4	<5	15.0	0.60
5/30/90	6.1	5.0	6.0	0.25
9/13/90	6.3	9.0	14.0	0.49
1/9/91	6.4	<5	15.0	0.60
6/11/91	6.3	<5	<5	0.06
11/13/91	6.0	8.0	11.0	0.35
9/18/92	5.4	6.0	<5	0.33

MULTIPLE INSTALLATIONS
AVLOPPSVATTEN, Sweden
Installed by:
Bioclere SVAB, Stockholm

NS = NOT SAMPLED

INFLUENT

DATE	pH	BOD7	TSS	Total-P
9/21/92	7.2	330	53	5.7
10/13/92	7.5	130	66	5.5
5/26/93	7.5	510	500	28.0
7/8/93	NS	900	NS	23.0
5/9/94	7.7	79	NS	3.4
6/8/95	8.3	320	NS	4.2
2/10/95	8.4	100	NS	8.7
EFFLUENT				
9/21/92	6.4	7.2	<5	0.17
10/13/92	6.9	8.0	20	0.24
5/26/93	7.4	6.9	10	0.39
7/8/93	NS	14.0	NS	0.25
5/9/94	7.5	3.0	NS	0.12
6/8/95	7.8	6.3	NS	0.23
2/10/95	7.0	12.0	NS	0.53

Advisory Opinion
From the
Technical Review Committee
For the
New England Interstate Regulatory Cooperation Project

Product/Technology Name:
Bioclere

Applicants Name & Address:
John Lafreniere
AWT Environmental, Inc.
P.O. Box 50120
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New Bedford, MA 02745
(508) 998-7577

NEI Category:
3 -- Advanced Wastewater Treatment

Date of Opinion:
March 25, 1998

Project Background:
The New England Interstate Water Pollution Control Commission (NEIWPCC) in cooperation with the New England Governors Conference (NEGC), EPA Center for Environmental Industry and Technology (CEIT), EPA's National Small Flows Clearinghouse (NSFC), and the New England state environmental/health agencies responsible for the administration of on-site wastewater treatment systems are undertaking a 12-month pilot project for the regional voluntary evaluation of innovative/alternative on-site wastewater products/technologies. The goal of the project is to facilitate the technical evaluation of innovative/alternative (I/A) on-site wastewater products/ technologies on a regional basis. This effort should help expedite the acceptance of innovative/alternative on-site wastewater treatment products/technologies. The work will be carried out by a Technical Review Committee (the Committee) which will conduct independent evaluations of product/technology performance. The Committee, made up of New England state regulators and advisors, will assess each product/technology on its merits, backed by quality data, and render an Advisory Opinion. The benefit of the Committee is to assist regulators in carrying out their responsibilities for evaluating these technologies in a more efficient manner.

The Committee has defined three categories of On-site I/A technologies:

1. **Material Replacement**
2. **System Modification**
3. **Advanced Wastewater Treatment**

Applicant's Description of Product/Technology:
The Bioclere is a modified trickling filter over a clarifier, which is installed between the primary settling chamber (typically a septic tank) and the distribution box of a traditional on-site system.

Unlike traditional trickling filters, the Bioclere is sealed and insulated to retain the heat generated by the fixed film process. This allows for stable treatment despite dramatic seasonal temperature variations. Oxygen is supplied to the system through a small axial fan creating a force draft ventilation system which is vented through the effluent pipe. The clarifier provides a reservoir from which the media bed may be consistently dosed despite intermittent flows which are typical of on-site systems.

The Bioclere relies on the inherent advantages of the fixed film process, mainly the ability of the biological film to self-regulate over daily and seasonal variations in organic and hydraulic loadings and its ability to withstand varying environmental conditions. Biofilm mathematical modeling has verified that the substrate removal rate is not decreased as drastically for biofilms as it is for suspended growth systems, due to the dynamics of substrate and oxygen utilization that are dependent upon diffusion and mass flux characteristics (US EPA-Nitrogen Control 1993, William et. al 1976).

As the wastewater is generated it typically flows by gravity from the septic tank to the baffled chamber in the clarifier under the biofilter. A dosing pump located in the sump forces wastewater to the distribution system for uniform dispersion over the surface of PVC media. The pump is controlled by an electric timer and operates at a specified cycle to maximize oxygen diffusion and mass transfer of pollutants into the biofilm.

In the Bioclere, as in a traditional trickling filter, a biological film forms on the surface of the media. In the outer portion of the biofilm organic matter and ammonium ions are absorbed and oxidized as the wastewater trickles through the filter. As this film increases in thickness, diffused oxygen is consumed by microorganisms in the outer layer resulting in the development of aerobic, anoxic, and anaerobic zones within the biofilm (Metcalf & Eddy 1991). Absent cell carbon, the microorganisms near the media surface lose their ability to remain attached and slough through the media bed. The sloughed biomass settles on the bottom of the clarifier as secondary sludge and is periodically pumped to the septic tank, thus eliminating the need for media purging and sludge wasting.

The Bioclere is typically installed between the septic tank and the distribution box of a conventional on-site system. Because the treatment process is above the flow, it is generally considered not to intrude on or in any way adversely affect the performance of a conventional on-site system.

Technology Claim(s):
The above-mentioned applicant submitted the following Claims of product performance with the formal submittal. The applicant was seeking the Committee's validation of these claims as part of the product/technology's consideration for regional evaluation in the Advisory Opinion:

Claim: The Bioclere produces the following levels of treatment for residential wastewater:

BOD < 30 mg/l or 90% reduction
TSS < 30 mg/l or 90% reduction
Fecal Coliform - 75% reduction
Oil & Grease < 5 mg/l
NH_3 < 2 mg/l

Commercial units are designed according to hydraulic and organic influent characteristics and effluent requirements that will achieve the same levels of treatment.

Technical Review Committee's Response to Claims:
The Technical Review Committee's opinion is based on the Committee's evaluation of available information on the product/technology and relates to the specific products, materials, and specifications stated in the Technology Claim(s) of performance.

X The Committee agrees that the product/technology meets the above-stated performance claims. The Committee reached this decision via a unanimous vote.

The applicant should request a determination from the committee for any modifications to the product/technology or to the product/technology claim. The product/technology is also evaluated for the quality of the data, wastewater science, and the technology's apparent merit as an innovative/alternative on-site wastewater treatment technology.

General Observations/Concerns:
After thoroughly evaluating all of the available information, the Technical Review Committee has identified the following concerns which may affect the approval of said technology in a state:

1. *Maintenance is essential to the long-term performance of the system.*
2. *Excessive oil and grease may impact the performance of the trickling filter.*
3. *An operation and maintenance (O & M) manual should be prepared and distributed with each system.*
4. *Care should be taken to properly install the unit per manufacturer's specifications. Of primary concern are the compaction of backfill around the unit and the prevention of unit flotation.*

Recommendations:
Based on the Technical Review Committee's evaluation, the Committee recommends the following items to improve or insure product performance:

1. *The unit should be designed, installed, and operated in accordance with manufacturer's specifications (i.e., waste load, etc.).*
2. *For all mechanical wastewater treatment systems, a licensed treatment plant operator should provide professional maintenance.*
3. *A contract for long-term maintenance should be required for the life of the unit.*
4. *A septic tank effluent filter should be used in any system in which a septic tank is utilized.*

State Regulations:
A positive Advisory Opinion shall in no way be considered a substitute for compliance with individual state regulations. Every states' regulations are designed to reflect the concerns of that state. Information generated in this opinion is intended to alleviate the investigative work required by an individual state for the consideration of said technology for approval as an alternative/innovative technology. Before state approval of the technology, the technology must comply with all pertinent state regulations. The Technical Review Committee also recommends that each state have a control for insuring that the above-listed concerns are met, addressed, or closely monitored and tracked.

The NEIWPCC Technical Review Committee has endorsed this Advisory Opinion herewith on this 25th day of March 1998.

Warren Herzig, Connecticut DEP

Frank Schaub, Connecticut DPH

Christos Dimisioris, Massachusetts DEP

Robert Mincucci, P.E., New Hampshire DES

Thomas W. Groves, NEIWPCC

Brian Moore, Rhode Island DEM

Roger Thompson, Jr., Vermont DEC

THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**BIOLOGICAL WASTEWATER TREATMENT – NITRIFICATION AND DENITRIFICATION FOR NITROGEN REDUCTION**
APPLICATION:	**REDUCTION OF NITROGEN IN DOMESTIC WASTEWATER FROM INDIVIDUAL RESIDENTIAL HOMES**
TECHNOLOGY NAME:	**BIOCLERE™ MODEL 16/12**
COMPANY:	**AQUAPOINT, INC.**
ADDRESS:	**241 DUCHAINE BLVD. NEW BEDFORD, MA 02745** **PHONE: (508) 998-7577 FAX: (508) 998-7177**
WEB SITE:	http://www.aquapoint.com
EMAIL:	Aquapoint@aquapoint.com

NSF International (NSF) operates the Water Quality Protection Center (WQPC) under the U.S. Environmental Protection Agency's (EPA) Environmental Technology Verification (ETV) Program. The WQPC evaluated the performance of a fixed film trickling filter biological treatment system for nitrogen removal for residential homes. This verification statement provides a summary of the test results for the Aquapoint, Inc. Bioclere™ Model 16/12 system. The Barnstable County (Massachusetts) Department of Health and the Environment (BCDHE) performed the verification testing.

The EPA created the Environmental Technology Verification (ETV) Program to facilitate deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV program is to further environmental protection by substantially accelerating the acceptance and use of improved and more cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer reviewed data on technology performance to those involved in the design, distribution, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations, stakeholder groups consisting of buyers, vendor organizations, and permitters, and the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and verifiable quality are generated and that the results are defensible.

ABSTRACT

Verification testing of the Aquapoint, Inc. (AQP) Bioclere™ Model 16/12 was conducted over a thirteen month period at the Massachusetts Alternative Septic System Test Center (MASSTC), located at Otis Air National Guard Base in Bourne, Massachusetts. Sanitary sewerage from the base residential housing was used for the testing. An eight-week startup period preceded the verification test to provide time for the development of an acclimated biological growth in the Bioclere™ system. The verification test included monthly sampling of the influent and effluent wastewater, and five test sequences designed to test the unit response to differing load conditions and power failure. The Bioclere™ system proved capable of removing ammonia nitrogen in the aerobic unit and nitrate in the anaerobic/anoxic primary tank. The influent total nitrogen (TN), as measured by the TKN, averaged 37 mg/L with a median of 38 mg/L. The effluent TN average 16 mg/L over the verification period, with a median concentration of 14 mg/L, which included an average TKN concentration of 10 mg/L and a median concentration of 6.3 mg/L. The system operating conditions (pump and timer settings) remained constant during the test. Only routine maintenance and system checks were performed for most of the test, except when a nozzle-plugging problem occurred. The plugged nozzles impacted treatment performance, but performance improved quickly once they were cleared.

TECHNOLOGY DESCRIPTION

The AQP, Inc. Bioclere™ Model 16/12 uses a fixed film trickling filter for wastewater treatment. A complete treatment system has two stages of treatment. The first stage of treatment occurs in the primary tank (a 1,000 gallon single compartment septic tank) in which the solids are settled and partially digested. Septic tank effluent flows by gravity to the Bioclere™ unit, which is a separate system that provides secondary wastewater treatment. Microorganisms present in the wastewater attach to the Bioclere™ proprietary plastic filter media, and use the nutrients and organic materials provided by the constant supply of fresh wastewater to form new cell mass. The open spaces within the media allow air to freely pass through, providing oxygen to support the microorganisms.

The system has a recycle line for pumping of recycled solids from the Bioclere™ clarifier section (located below the plastic media) back to the primary tank. The pump operated for 1.5 minutes every 2.5 hours during the test, controlling the recycle rate to the primary tank. A dosing pump, set to run on a 3 minutes on/5 minute off cycle, circulated treated effluent from the clarifier section back the top of the unit, where the wastewater is sprayed over the media using a manifold and nozzle system. Air (oxygen) is supplied to the Bioclere™ by a fan located on the top of the unit, which runs continuously.

The Bioclere™ system is designed to remove total nitrogen from the wastewater by nitrification and denitrification. Nitrification occurs in the aerobic Bioclere™ unit, where ammonia nitrogen is converted to nitrite and nitrate (predominately nitrate). Denitrification occurs in the anaerobic/anoxic primary tanks, where the nitrite/nitrate is converted to nitrogen. The verification testing was performed using a full scale, commercially available unit, which was received as a self-contained system ready for installation.

VERIFICATION TESTING DESCRIPTION

Test Site

The MASSTC site, initially funded by the State of Massachusetts and operated by BCDHE, is located at the Otis Air National Guard Base in Bourne, Massachusetts. The site uses domestic wastewater from the base residential housing and sanitary wastewater from other military buildings for use in testing. A chamber located in the main sewer line upstream of the base wastewater treatment facility provides a location to obtain untreated wastewater. The raw wastewater, after passing through a one-inch bar screen, is pumped to a dosing channel at the test site. This channel is equipped with four recirculation pumps, which are spaced along the channel length to ensure mixing such that the wastewater is of similar quality at all locations along the channel. Wastewater is dosed to the test unit using a pump submerged in the dosing channel. A programmable logic controller (PLC) is used to control the pumps and the dosing sequence or cycle.

Methods and Procedures

All methods and procedures followed the *ETV Protocol for Verification of Residential Wastewater Treatment Technologies for Nutrient Reduction*, dated November 2000. The Bioclere™ was installed by a contractor, in conjunction with the BCDHE support team in June 1999 as part of an earlier test program. The unit was installed in accordance with the Operations and Maintenance Manual supplied by AQP. In order to prepare for ETV testing, the entire Bioclere™ system was emptied of wastewater and cleaned. Solids were removed from the primary tank and the clarifier section of the Bioclere™ filter unit. All pumps, lines, and associated equipment were cleaned. The filter media was repeatedly flushed and solids removed from the bottom of the unit. Clean water was recirculated to further clean the media and lines. The entire unit was then drained and remained off until the startup period.

In early January 2001, fresh water was added to the unit and the system was cycled for several days to make sure the unit was operating properly, the dosing pumps were calibrated, and the PLC was working properly. An eight-week startup period, following the startup procedures in the AQP Technical Manual, allowed the biological community to become established and allowed the operating conditions to be monitored. Startup of the cleaned Bioclere™ system began on January 15, 2001, when the primary tank was filled approximately two thirds (2/3) full with clean water and one third (1/3) with raw wastewater from the dosing channel. The dosing sequence was then started, with the unit's pumps and timers on the factory default settings.

The system was monitored during the startup period through visual observation, routine calibration of the dosing system, and collection of influent and effluent samples. Six sets of samples were collected for analysis. Influent samples were analyzed for pH, alkalinity, temperature, BOD_5, TKN, NH_3, and TSS. The effluent was analyzed for pH, alkalinity, temperature, $CBOD_5$, TKN, NH_3, TSS, dissolved oxygen, NO_2, and NO_3.

The verification test consisted of a thirteen-month test period, incorporating five sequences with varying stress conditions simulating real household conditions. The five stress sequences were performed at two-month intervals, and included washday, working parent, low loading, power failure and vacation test sequences. Monitoring for nitrogen reduction was accomplished by measurement of nitrogen species (TKN, NH_3, NO_2, NO_3). Biochemical (BOD_5) and carbonaceous biochemical oxygen demand ($CBOD_5$) and other basic parameters (pH, alkalinity, TSS, temperature) were monitored to provide information on overall system treatment performance. Operational characteristics, such as electric use, residuals generation, labor to perform maintenance, maintenance tasks, durability of the hardware, and noise and odor production, were also monitored.

The Bioclere™ system has a design capacity of 400 gallons per day. The verification test was designed to load the system at design capacity (± 10 percent) for the entire thirteen-month test, except during the low load and vacation stress tests. The Bioclere™ system was dosed 15 times per day with approximately 26-27 gallons of wastewater per dose. The unit received five doses in the morning, four doses mid-day, and six doses in the evening. The dosing volume was controlled by adjusting the pump run time for each cycle, based on twice weekly pump calibrations.

the remaining months (monthly sampling). Therefore, impacts of a stress test or an upset condition occurring during concentrated sampling periods can have an impact on the calculation of average values. Both average and median results are presented, as the median values compared to average values can help in analyzing these impacts. In the case of the Bioclere™ results, the median concentrations are lower than the average concentrations due to the upset condition when the nozzles plugged during the working parent stress test.

The TSS and BOD_5/$CBOD_5$ results for the verification test, including all stress test periods, are shown in Table 1. The influent wastewater had an average BOD_5 of 210 mg/L and a median BOD_5 of 200 mg/L. The TSS in the influent averaged 160 mg/L and had a median concentration of 140 mg/L. The Bioclere™ effluent showed an average $CBOD_5$ of 14 mg/L with a median $CBOD_5$ of 10 mg/L. The average TSS in the effluent was 16 mg/L and the median TSS was 10 mg/L. $CBOD_5$ concentrations in the effluent typically ranged from 4 to 20 mg/L, and TSS ranged from 4 to 17 mg/L, except during an apparent upset condition that occurred in July 2001.

Table 1. BOD_5/$CBOD_5$ and TSS Data Summary

	BOD_5 Influent (mg/L)	$CBOD_5$ Effluent (mg/L)	Percent Removal	TSS Influent (mg/L)	TSS Effluent (mg/L)	TSS Percent Removal
Average	210	14	93	160	16	90
Median	200	10	95	140	10	93
Maximum	380	60	98	410	62	98
Minimum	72	3.5	78	40	2	63
Std. Dev.	70	11	5.0	71	16	7.0

Note: The data in Table 1 are based on 53 samples.

The nitrogen results for the verification test, including all stress test periods, are shown in Table 2. The influent wastewater had an average TKN concentration of 37 mg/L, with a median value of 38 mg/L, and an average ammonia nitrogen concentration of 23 mg/L, with a median of 23 mg/L. Average TN concentration in the influent was 37 mg/L (median of 38 mg/L) based on the assumption that the nitrite and nitrate concentrations in the influent were negligible. The Bioclere™ effluent had an average TKN concentration of 10 mg/L and a median concentration of 6.3 mg/L. The average NH_3-N concentration in the effluent was 6.2 mg/L and the median value was 2.8 mg/L. The nitrite concentration in the effluent was low, averaging 0.45 mg/L. Effluent nitrate concentrations averaged 5.3 mg/L with a median of 4.4 mg/L. Total nitrogen was determined by adding the concentrations of the TKN (organic plus ammonia nitrogen), nitrite and nitrate. Average TN in the Bioclere™ effluent was 16 mg/L (median 14 mg/L) for the thirteen month verification period. The Bioclere™ system averaged a 57 percent reduction of TN for the entire test, with a median removal of 64 percent.

Verification Test Discussion

Beginning in late March and early April, temperatures began to increase and the nitrifying population clearly became established, as indicated by the decrease in the TKN and NH_3 concentrations in the effluent. Nitrate concentrations increased somewhat in this same period, but the data show that denitrification was also occurring. The concentration of organic matter in the effluent, as measured by $CBOD_5$ and TSS concentrations, also decreased. During May and June, the TN concentration in the effluent was in the range of 8.8 to 11 mg/L. The Washday stress test in May 2001 showed no negative impact on nitrogen reduction.

Table 2. Nitrogen Data Summary

	TKN (mg/L)		Ammonia (mg/L)		Total Nitrogen (mg/L)		Nitrate (mg/L)	Nitrite (mg/L)	Temperature (°C)
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Effluent	Effluent	Effluent
Average	37	10	23	6.2	37	16	5.2	0.45	15
Median	38	6.3	23	2.8	38	14	4.4	0.34	15
Maximum	46	35	27	22	46	36	14	1.5	23
Minimum	24	1.9	18	0.7	24	6.2	<0.1	0.07	7.4
Std. Dev.	4.4	10	2.1	7.0	4.4	8.4	3.5	0.26	4.9

Note: The data in Table 2 are based on 53 samples, except for Temperature, which is based on 51 samples.

In early July 2001, the data show that there was loss of the nitrifying population in the unit, with total nitrogen levels in the effluent of 25 to 36 mg/L. The effluent concentrations of $CBOD_5$ and TSS also increased during this time, indicating the system was under stress. It was discovered that two of the nozzles in the Bioclere™ unit were clogged. AQP responded to the problem and cleaned the nozzles, and within two to three weeks, the TN concentration decreased to 9.4 mg/L, similar to the period before the problem occurred. The $CBOD_5$ and TSS levels in the effluent also decreased, returning to the levels measured before the nozzle plugging occurred. The loss of nitrogen and $CBOD_5$ removal efficiency during the nozzle-plugging problem makes it unclear whether the Working Parent dose sequence would have had an impact on the system.

Once the nitrifying population was reestablished, the Bioclere™ system continued to reduce the total nitrogen concentration on a consistent basis (7.7 to 11 mg/L) until December. This period included the Low Dose sequence, when the Bioclere™ was dosed with 50 percent of the daily design loading, which appears to have had no impact on the system operation. The temperature of the wastewater began to decrease in October, as would be expected. While the trend was not clear, the late November sample indicated a lower removal of nitrogen was occurring as compared to September and October. The Power Failure stress test (power shut off for 48 hours) was started on December 3, 2001. Sample results for the post stress period showed effluent total nitrogen had increased to 18 mg/L, while subsequent monitoring over the next few weeks showed the total nitrogen concentration to be in the range of 6.2 to 19 mg/L. Most of the concentrations were in the 13 to 19 mg/L range, with influent levels of 35 to 46 mg/L. The lower nitrogen removal efficiencies in the December to February period correspond to lower temperatures in the wastewater. It appears that the Power Failure stress test may have contributed to the change in efficiency by stressing the nitrifying population. The lower temperatures in the wastewater appeared to have slowed the total nitrogen removal and possibly the re-establishment of the nitrifying population.

The Vacation stress test in February had no noticeable impact on the system performance for nitrogen removal. The last scheduled samples for total nitrogen in the first week of March showed that the Bioclere™ system was removing TN in the 60 to 66 percent range, somewhat lower than the efficiencies of the previous summer and fall. The temperature of the wastewater appeared to have an effect on the nitrogen reduction levels based on both the startup data and on the December 2001 to February 2002. The test period was extended one additional month to determine if removal would improve as the wastewater temperature increased. The final sample showed a sharp decrease in TN from 16 mg/L on March 8 to 8 mg/L on April 17. During this period, the temperature of the wastewater increased to 14.3 °C from 9.2 °C.

Operation and Maintenance Results

Noise levels associated with mechanical equipment were measured once during the verification period using a decibel meter. Measurements were made one meter from the unit, and one and a half meters above the ground, at 90° intervals in four (4) directions. The average decibel level was 49.5, with a minimum of 45.5 and maximum of 52.8. The background level was 37.7 decibels.

Odor observations were made monthly for the last eight months of the verification test. The observations were qualitative based on odor strength (intensity) and type (attribute). Observations were made during periods of low wind velocity (<10 knots), at a distance of three feet from the treatment unit, and recorded at 90° intervals in four directions. There were no discernible odors found during any of the observation periods.

Electrical use was monitored by a dedicated electric meter serving the Bioclere™ system. The average electricity use was 4.2 kW/day. The Bioclere™ system does not require or use any chemical addition as part of the normal operation of the unit.

During the test, very few problems were encountered with the operation of the system with the exception of the plugged nozzles after five and half months of operation. The plugging problem was discovered when the effluent's visual characteristic changed and had notably more suspended solids. In addition, during the nozzle plugging, the noise level of the spray hitting the inside of the media containment structure was slightly louder, signaling higher flow through one of the nozzles and overloading of a portion of the media bed. The nozzles were cleaned again in the fall by AQP in accordance with the quarterly maintenance check recommended in their O&M manual. AQP installed a new set of helical nozzles in January 2002. These nozzles required no additional cleaning through the remainder of the test. AQP believes that the nozzle plugging problem was a unique occurrence as this type of unit had been operated at MASSTC and many other locations without a problem. AQP added a statement regarding the nozzle issue at the end of the Verification Report.

Routine quarterly maintenance by a person knowledgeable of the treatment system was recommended in the O&M manual, and was confirmed to be appropriate by the BCDHE staff during the test. The maintenance should involve checking the two pumps (recirculating and recycling), the fan, and cleaning the distribution manifold and nozzles. The maintenance check should also include measurement of the sludge depth in the primary tank, observation of the condition of the media, and a visual inspection of the effluent. Pump cycle times should be verified and alarms checked.

The treatment unit itself proved durable for the duration of the test and appears to generally be a durable fiberglass design. The piping is standard PVC that is appropriate for the applications. Pump and level switch life are always difficult to estimate, but the components used are made for wastewater applications by a reputable and known manufacturer.

Quality Assurance/Quality Control

QA audits of the MASSTC and BCDHE laboratory were completed by NSF International during testing. NSF personnel completed a technical systems audit to assure the testing was in compliance with the test plan, a performance evaluation audit to assure that the measurement systems employed by MASSTC and the BCDHE laboratory were adequate to produce reliable data, and a data quality audit of at least 10 percent of the test data to assure that the reported data represented the data generated during the testing. In addition to quality assurance audits performed by NSF International, EPA QA personnel conducted a quality systems audit of NSF International's QA Management Program, and accompanied NSF during audits of the MASSTC and BCDHE facilities.

Original signed by Hugh W. McKinnon	*5/30/03*	*Original signed by Gordon E. Bellen*	*6/3/03*
Hugh W. McKinnon	Date	Gordon E. Bellen	Date

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NOTICE: Verifications are based on an evaluation of technology performance under specific, predetermined criteria and the appropriate quality assurance procedures. EPA and NSF make no expressed or implied warranties as to the performance of the technology and do not certify that a technology will always operate as verified. The end user is solely responsible for complying with any and all applicable federal, state, and local requirements. Mention of corporate names, trade names, or commercial products does not constitute endorsement or recommendation for use of specific products. This report in no way constitutes an NSF Certification of the specific product mentioned herein.

Availability of Supporting Documents

Copies of the *ETV Protocol for Verification of Residential Wastewater Treatment Technologies for Nutrient Reduction,* dated November 2000, the Verification Statement, and the Verification Report are available from the following sources:

1. ETV Water Quality Protection Center Manager (order hard copy)
   NSF International
   P.O. Box 130140
   Ann Arbor, Michigan 48113-0140
2. NSF web site: http://www.nsf.org/etv (electronic copy)
3. EPA web site: http://www.epa.gov/etv (electronic copy)

(NOTE: Appendices are not included in the Verification Report. Appendices are available from NSF upon request.)

EPA's Office of Wastewater Management has published a number of documents to assist purchasers, community planners and regulators in the proper selection, operation and management of onsite wastewater treatment systems. Two relevant documents and their sources are:

1. *Handbook for Management of Onsite and Clustered Decentralized Wastewater Treatment Systems* http://www.epa.gov/owm/onsite
2. *Onsite Wastewater Treatment Systems Manual*
   http://www.epa/gov/owm/mtb/decent/toolbox.htm

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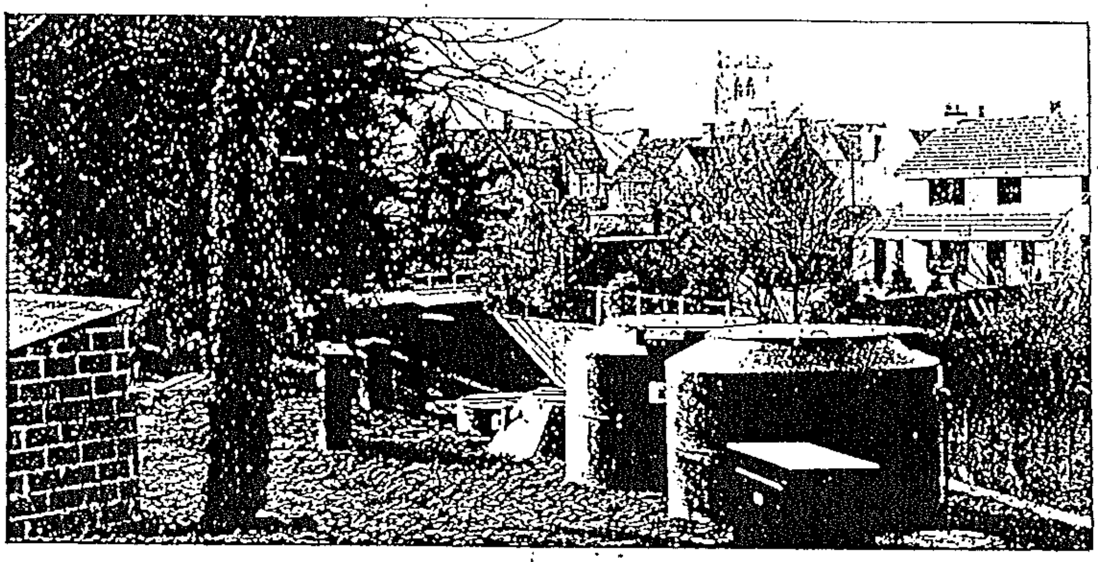
BIOCLERE

Wastewater Treatment Systems

Introduction

The Bioclere is a modified trickling filter which was developed in Finland and which is used extensively throughout Europe and the Middle East for the secondary treatment of wastewater and the conversion and reduction of nitrogen. A modified Bioclere for the precipitation of phosphorus is frequently added to the process chain.



Bioclere system serving a housing development. Standard effluent requirements are: 15 mg/l BOD, 25 mg/l TSS, 3 mg/l Ammonia and 1 mg/l Phosphate. The final stage of treatment is U.V. disinfection.

Installations range from 200 gpd to 50,000 gpd. The Bioclere is constructed of insulated and U.V. resistant fiberglass or plastic. Modular in nature they may be installed in parallel to accommodate larger flows or in series to achieve higher levels of treatment. The stability of the process, which is characteristic of its trickling filter heritage, and the simplicity of design minimize the life cycle operating and maintenance costs generally associated with the secondary treatment of wastewater. Typical installations include individual homes, residential clusters, malls, nursing homes, schools, supermarkets, restaurants, gas stations, golf courses, hotels and small communities.

The trickling filter is a fixed film aerobic process in which microorganisms attach themselves to a highly permeable media creating a biological filter or slime layer through which wastewater is trickled allowing organic matter to be absorbed into the slime layer. Designed properly this filter is self-purging and maintenance free.

Unlike traditional trickling filters in the Bioclere the biofilter is enclosed and positioned over a clarifier. Hydraulic dosing and secondary sludge return pump systems are set at pre-determined rates minimizing maintenance and enhancing treatment. The self-purging biological filter is designed by AWT Environmental Inc. to accommodate influent characteristics and achieve effluent requirements . Oxygen is introduced to the system through a fan in the Bioclere housing and is exhausted through a vent typically located in the discharge line.

The Bioclere is a gravity flow treatment system. Installed in line between the primary tank and distribution box, the Bioclere neither intrudes on or adversely affects the flow of a conventional onsite system. Because the treatment process is above the gravity flow of the system electrical outages do not inhibit flow and dilution factors within the system minimize the impact of a short term power failure on effluent quality.

The Bioclere's fixed film process and hydraulic capacity minimize the impact of organic and hydraulic fluctuations on the treatment process and effluent quality. Generally Bioclere installations do not require flow equalization prior to treatment. The ability of the biological film which forms in the filter to self-regulate daily and seasonal variations in hydraulic and organic loading as well as environmental variations such as temperature, pH and process inhibitors is widely acknowledged.

The Bioclere is a designed treatment system. Hydraulic and organic influent characteristics must be determined in designing the Bioclere to meet effluent requirements. A design questionnaire is included for this purpose on page 8.

The National Sanitation Foundation (NSF) has tested and approved the Bioclere under its Criteria C-9 which is essentially equivalent to Standard 40. The test results and Executive Summary are on pages 9 and 10.

BIOCLERE PROCESS

Wastewater flows from the septic tank or primary settling tank into a baffled chamber in the clarifier of the Bioclere. Dosing pumps located in this clarifier intermittently dose the filter media with the wastewater.

In the trickling filter the organic material in the wastewater is reduced by a population of microorganisms which attach to the filter media and form a biological slime layer. In the outer portion of the slime layer treatment is accomplished by aerobic micro-organisms. As the microorganisms multiply the biological film thickens and diffused oxygen and organic substrate are consumed before penetrating the full depth of the slime layer. Consequently the biological film develop aerobic, anoxic and anaerobic zones.

Absent oxygen and a sufficient external organic source for cell carbon the micro-organisms near the media surface lose their ability to cling to the media. The wastewater flowing over the media washes the slime layer off the media and a new slime layer begins to form. This process of losing the slime layer is called "sloughing" and it is primarily a function of the organic and hydraulic loading on the filter. This natural process allows a properly designed media bed to be self-purging and maintenance free.

The sloughed biomass settles to the bottom of the sump as sludge. These secondary sludges are periodically pumped back to the primary tank for storage and eventually removed.

This process is essentially the same for the reduction of BOD_5 and nitrification or the conversion of ammonia nitrogen to nitrate.

NITRIFICATION/DENITRIFICATION

Removing ammonia from wastewater is a well established and quantifiable biological process. Nitrogen exists in the influent primarily in the form of organic nitrogen and ammonia (TKN). The principle part of the organic nitrogen is converted to ammonia by anoxic bacterial activity. Therefore, ammonia is commonly regarded as the starting point in the nitrogen reduction process. Nitrification: the conversion of ammonia nitrogen (NH_3) to nitrate (NO_3) which is rich in oxygen is a biological process accomplished in the presence of oxygen.

Because carbonaceous BOD asserts the primary demand for oxygen in the treatment process, large flow nitrifying Bioclere systems are typically designed as split filters or with two units in series. By placing Biocleres in series each unit may be designed to achieve the effluent required from the influent characteristics. Nitrification is a major consideration for most of the Bioclere installations. Typical requirements for effluent ammonia are from 1 to 3 mg/l which is reliably accomplished.

Successful nitrification is accomplished with a healthy microorganism population and an environment where pH, temperature, organic loading and supply of oxygen are relatively stable. In a Bioclere system the pH is buffered by the carbonate system associated with the wastewater; the temperature remains consistent because of the insulated environment and the relatively constant temperatures generated by the fixed film biomass; the organic loading is relatively constant because the waste water has been pre-treated in the first stage; and the fan provides an adequate supply of oxygen.

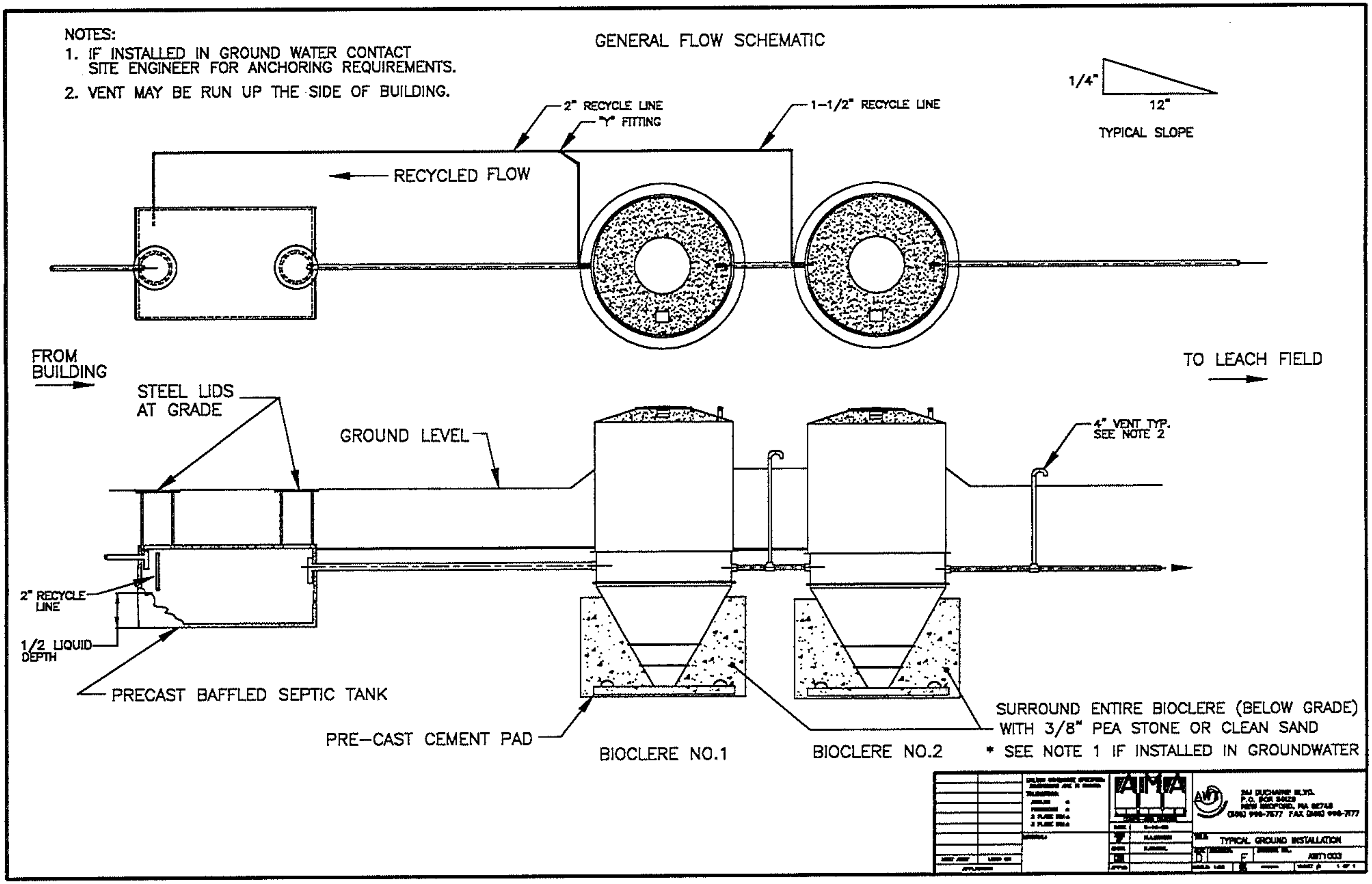
Denitrification utilizing septic tank carbon is widely considered to be the most economical and efficient method for nitrogen removal. Utilizing prescribed recirculation rates this method of returning Bioclere nitrified wastewater to the carbon source in the anoxic zone of the primary tank has achieved reductions of nitrogen between 85% and 90%.

Biological denitrification is accomplished by anaerobic heterotrophic organisms under anoxic conditions. In this process bacteria convert the nitrate to nitrogen gas which is released into the atmosphere.

In the Bioclere system the nitrified mixed liquor in the clarifier of the nitrifying Bioclere is returned to the anoxic zone in the primary tank for denitrification.

NITROGEN TRANSFORMATIONS AND REMOVAL

Form of Nitrogen	Responsible Micro-organisms	Representative Equations	Control and Removal Process
Organic-N (Protein)	Aerobic Heterotrophs		
Ammonia-N NH3	Aerobic Autotrophs Nitrosomonas	2NH3 + 302 => 2NO2 + 2H + 2H20	Biological nitrification for control
Nitrite-N NO2 Nitrate-N NO3	Nitrobacter	2NO2 + 02 => 2NO3	
Nitrite-N NO2	Anaerobic Heterotrophs	3NO3 + CH30H => 3NO2 + 2H20 + CO2 2NO2 + CH30H => N2 + H20 + 20H + CO2	Biological denitrification for removal
Nitrogen gas N2			


NOTES:
1. IF INSTALLED IN GROUND WATER CONTACT SITE ENGINEER FOR ANCHORING REQUIREMENTS.
2. VENT MAY BE RUN UP THE SIDE OF BUILDING.
GENERAL FLOW SCHEMATIC
1/4"
12"
TYPICAL SLOPE
2" RECYCLE LINE
"Y" FITTING
1-1/2" RECYCLE LINE
RECYCLED FLOW
FROM BUILDING
TO LEACH FIELD
STEEL LIDS AT GRADE
GROUND LEVEL
4" VENT TYP. SEE NOTE 2
2" RECYCLE LINE
1/2 LIQUID DEPTH
PRECAST BAFFLED SEPTIC TANK
PRE-CAST CEMENT PAD
BIOCLERE NO.1
BIOCLERE NO.2
SURROUND ENTIRE BIOCLERE (BELOW GRADE) WITH 3/8" PEA STONE OR CLEAN SAND
* SEE NOTE 1 IF INSTALLED IN GROUNDWATER
AWT
TYPICAL GROUND INSTALLATION

PHOSPHORUS PRECIPITATION

The most common and reliable method of achieving phosphorus removal is by chemical precipitation. The Bioclere onsite system incorporates a separate stage chemical precipitation unit which is placed in line after carbonaceous BOD_5 and nitrification have been accomplished, thus minimizing sludge production. These systems have been used for over 20 years in Europe and typically reduce effluent phosphorus concentrations to > 1 mg/l.

Chemical precipitation requires dosing of a coagulant, rapid mixing and flocculation to precipitate insoluble phosphate. Metal salts (aluminum sulfate) are the most efficient and easily managed coagulants. Dosing requires a coagulant storage tank and chemical feed system which are housed in the top portion of a modified Bioclere. The rapid mixing and flocculation devices are fixed in the clarifier located directly beneath the dosing system. Dosing is based upon the stoichiometric metal salt to phosphorus ratio as dictated by the concentration of phosphorus contained in the daily wastewater flow. Sludge produced by the reaction is typically returned to the septic tank for storage and eventual removal.

BIOCLERE COMPONENTS

Major components of the Bioclere are constructed of U.V. resistant insulated fiberglass or plastic.

The *filter shell* and lid are insulated to provide near constant temperature conditions in the biofilter.

The *clarifier* (sump) is of single wall construction and baffled to facilitate settling.

A *central channel* provides ready access to dosing and recirculation pumps.

Random packed *media* which is biologically inert and mechanically durable facilitates oxygen transfer and increases wastewater detention time in the biofilter.

Weir bowl or spray nozzle *distribution systems* uniformly distribute the wastewater over the biofilter.

Pumps are used for dosing the biofilter, sludge return and recirculation. 1/4 horse, 1/3 horse and ½ horse stainless steel Grundfos pumps are used. The size and number of pumps is dependent on model and wastewater characteristics.

A moisture resistant *axial fan* provides a consistent supply of oxygen to the treatment process.

The *control panel* contains the following equipment:

- NEMA IV cabinet
- circuit breakers
- main switch
- pumping timers
- alternators
- audio and visual alarms
- control and regulation electronics
- electrical connection terminal strip
- options for remote control alarm

controls for tertiary treatment components are optional

GENERAL INFORMATION

Existing septic tanks may be adapted to form the primary treatment stage of the Bioclere process. Sizing the primary tank should take into consideration the impact of recirculation on detention time.

Biocleres are constructed with the effluent pipe 180° opposite the influent pipe. However, the influent and effluent pipes may be positioned at different angles. Should this be necessary for a specific project please review your needs with AWT.

The only routine service procedures required by the Bioclere are pump and fan maintenance and cleaning of the distribution system. Tertiary treatment equipment added to the process chain may require additional service. In most states this maintenance must be performed by a licensed wastewater treatment plant operator.

AWT provides operations and maintenance services. Please contact our offices for a service contract proposal.

Biocleres may be easily installed into new or existing facilities. Generally the pre-assembled, self-contained Bioclere is delivered with a lifting harness. Concrete pads with lifting rings are set at appropriate elevations and the Bioclere is set on the pad. The Bioclere is leveled using self-adjusting cables in tripod fashion from the top of the clarifier to the rings on the cement pad. A larger two stage system may be installed in a few hours if site preparation is adequate.

The Bioclere may be pre-tested by filling the clarifiers with fresh water if wastewater is not readily available. Once the Bioclere system is commissioned six to twelve weeks are required to establish a functioning biomass for treatment.

BIOCLERE SYSTEM DESIGN CRITERIA

Date:

Engineer: Client/Site Address:

Tel.

Fax

A) Application: 1) Residential 2) Commercial 3) Other

Description:

B) Description of proposed treatment components:

C) Permits: Massachusetts, TITLE 5: 1) General 2) Remedial 3) Provisional

Rhode Island CLASS 2:

Other:

Typical Residential Wastewater Assumptions *(single family homes without home based businesses)

BOD5 = 250 mg/l

TSS = 250 mg/l

TKN = 45 mg/l

MA Design Flow = # of bedrooms ( ) * (110 gpd) = gpd

RI Design Flow = # of bedrooms ( ) * (150 gpd) = gpd

Actual Flow = Pop. Equivalent ( ) * (55 gpd) = gpd

* *Please specify effluent requirements under EFFLUENT DATA.*

Commercial, Industrial or Other Residential Applications*

* *Please obtain composite samples at the septic tank effluent tee for the parameters listed under INFLUENT DATA*
* *Please provide AWT Environmental with all applicable Material Safety Data Sheets (MSDS)*

INFLUENT DATA	EFFLUENT DATA
Specify test location:	Please specify location of effluent requirements:
Flow data (gpd): Design Ave. Peak	
Seasonal Flows: Y N when?	
Are low flow devices utilized?: Y N Will they be used?: Y N	
Are garbage grinders utilized?: Y N They should not be used in conjunction with the Bioclere.	
pH:	pH:
BOD5:	BOD5:
COD:	COD:
TSS:	TSS:
TKN:	TKN: Ammonia-N
Ammonia-N:	Nitrate-N: Total nitrogen:
Oil & Grease (omit if traps are included):	Oil & Grease:
Phosphorus:	Phosphorus:
Alkalinity:	Other:

NOTES: * *Commercial Installations require baffled septic tanks and a gas baffle under the effluent tee*

Signature:

SUMMARY OF BIOCLERE ANALYTICAL RESULTS
PREVIOUSLY TESTED TO CRITERIA C-9 BY NATIONAL SANITATION FOUNDATION

		Median[1]	Ave.[2]	Std.Dev.	Min	Max	Interquartile Range
Temperature (°C)	influent	13	13.2	2.0	10	17	11-14
	septic tank effluent	11	10.9	3.0	5	15	8-14
	effluent	11	11.4	3.0	5	16	8-14
pH	influent	7.5	7.6	0.14	7.3	7.9	7.5-7.7
	septic tank effluent	7.5	7.6	0.22	7.1	8.1	7.4-7.8
	effluent	8.0	7.9	0.20	7.4	8.5	7.8-8.1
Biochemical Oxygen Demand (mg/l)	influent	170	167	49	80	290	130-210
	septic tank effluent	73	74	14	44	100	62-86
	effluent	11	13	6	5	45	8-16
Supended Solids (mg/l)	influent	120	141	85	54	720	97-160
	septic tank effluent	40	47	26	18	200	33-52
	effluent	13	17	10	5	50	8-24
Volatile Suspended Solids (mg/l)	influent	100	111	58	37	430	77-120
	septic tank effluent	32	37	20	13	160	26-42
	effluent	10	14	8	5	35	7-20
Dissolved Oxygen (mg/l)	effluent	5.6	5.9	1.3	3.4	10.2	4.7-6.5

[1]Median: Fifty percent of the values are less than or equal to this value.
[2]Interquartile Range: The range of values about the media between the upper and lower 25 percent of all values.

EXECUTIVE SUMMARY

Testing of the Bioclere Model BP3 was conducted under provisions of NSF Criteria C-9. The evaluation protocol was developed by a special Task Committee composed of professionals working in the field of wastewater treatment and public health. The protocol established the procedures to be used in the performance evaluation and criteria to be met for the plant to be listed under the criteria.

The performance evaluation was conducted at the NSF Wastewater Technology Test Facility in Chelsea, Michigan, using wastewater diverted from the Chelsea municipal wastewater collection system. The evaluation consisted of two months of dosing at 200 gallons per day, a stress test sequence and two months of dosing at design loading. The stress test sequence consisted of four separate loading patterns: wash day, working parent, equipment or power failure, and a one week vacation.

The performance evaluation was complete using a 1,000 gallon septic tank ahead of the Bioclere BP3 plant. The septic tank was seeded with septage from a residence that had been in service for at least two years. Sampling of the effluent started after four weeks of dosing to allow for plant start-up. Sampling started in the fall and continued through the winter and into late spring, covering a full range of operating temperatures. At the request of the manufacturer, additional sampling and analysis was completed to evaluate the performance of the Bioclere BP3 for coliform reduction and nitrification.

Over the course of the evaluation, the Bioclere BP3 produced an effluent with carbonaceous BOD_5 ranging from 5 to 45 mg/l, suspended solids ranging from 5 to 50 mg/l and pH ranging from 7.34 to 8.5. During the non-stress dosing period, the effluent BOD_5 averaged 13 mg/l, while the effluent suspended solids averaged 17 mg/l. During the stress testing, the effluent BOD_5 averaged 13 mg/l and the effluent suspended solids averaged 9 mg/l.

The plant produced an effluent that successfully met the performance requirements established in the evaluation protocol.

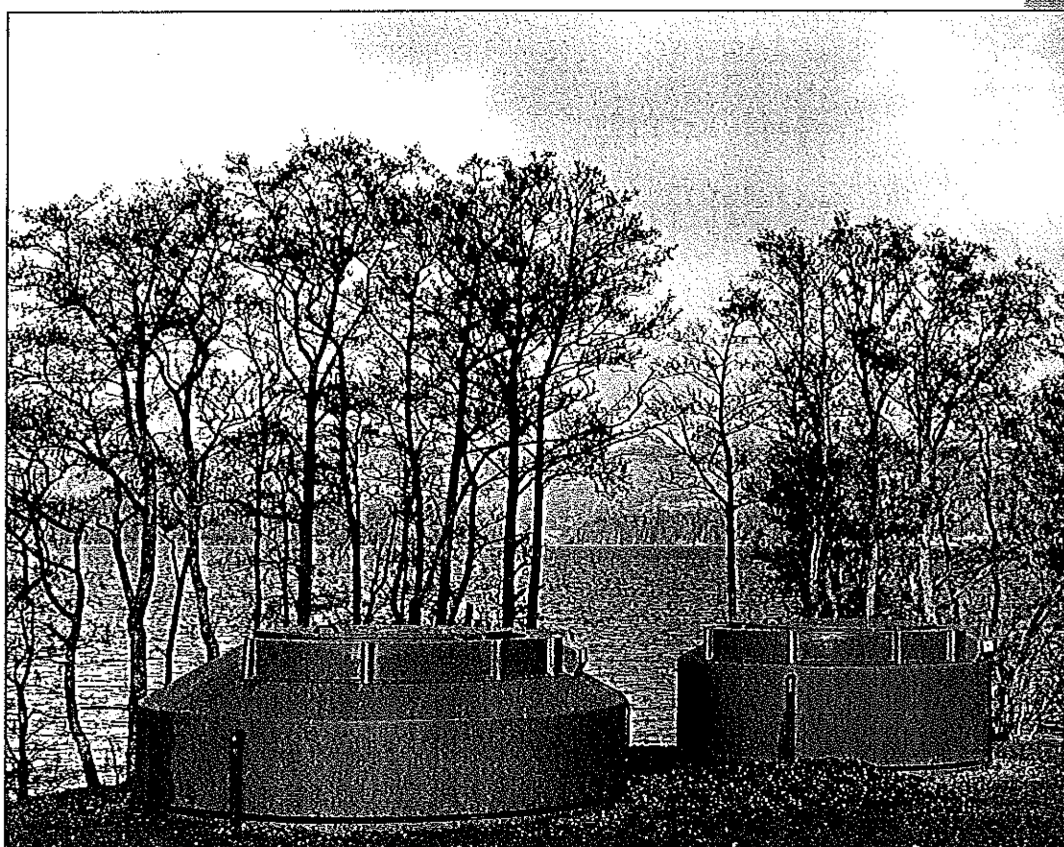
During the non-stress dosing: The arithmetic mean of seven consecutive sample days ranged from 8 to 24 mg/l for BOD_5 and 6 to 36 mg/l for suspended solids, both well below the requirement of 45 mg/l.

The arithmetic mean of 30 consecutive sample days ranged from 9 to 17 mg/l for BOD_5 and 9 to 23 mg/l for suspended solids, both well below the requirement of 30 mg/l. Removal rates ranged from 91% to 97% for BOD_5 and 86% to 93% for suspended solids.

The pH during the entire evaluation remained in the range of 7.3 to 8.5, within the required range of 6.0 to 9.0.

Effluent BOD_5 concentrations during the stress testing ranged from 5 to 17 mg/l, well below the required 60 mg/l. Likewise, the effluent suspended solids ranged from 5 to 14 mg/l during the stress test, well below the required 100 mg/l.

BIOCLERE™ Onsite Wastewater Treatment Systems



AWT environmental, inc.

BIOCLERE™

AWT Environmental, Inc.

The BIOCLERE™ Advantage

Bioclere™ is a modified trickling filter for the secondary treatment of wastewater as well as the conversion and reduction of nitrogen. Designed for years of dependability, its fixed film biological process is stable and inexpensive to operate. Bioclere™ modular units have flow capacity between 200 and 26,000 GPD.

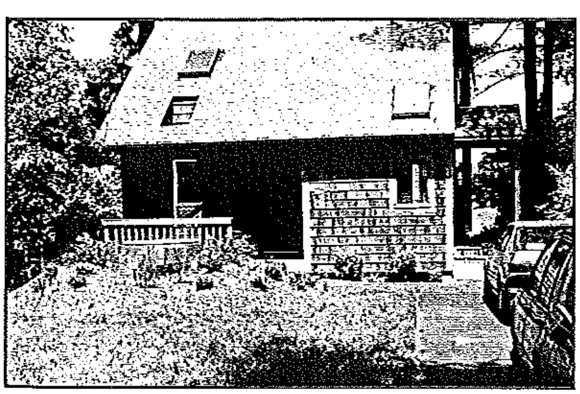
Bioclere™ reduces the biochemical oxygen demand (BOD_5) and total suspended solids (TSS) to levels meeting or exceeding NSF and EPA standards. As wastewater trickles through the biological filter, organic material is absorbed into the biological mass which forms on the media surface. Secondary sludges, which slough off the self-purging filter, return to the primary tank. Clarified wastewater is displaced to the disposal area.

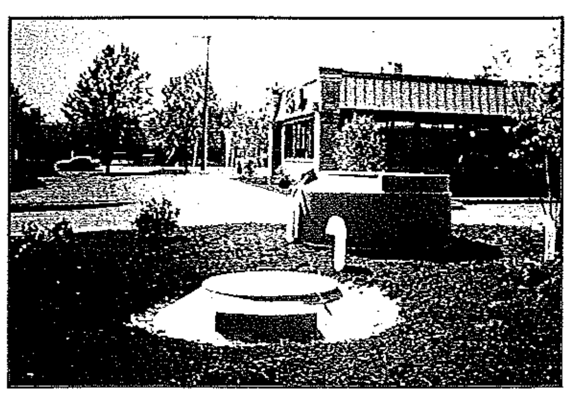
The modular units can be installed in parallel for larger flows; or in series to achieve higher levels of treatment. Bioclere™ is sealed and insulated to minimize the impact of seasonal temperature variations on the treatment process. The biofilter is positioned over a clarifier containing pumps that maintain a consistent dosing pattern throughout flow variations.

Bioclere™ self-contained units require minimal onsite assembly, reducing installation costs. Bioclere™ is easily integrated between the primary tank and distribution box in new or existing treatment facilities. Fresh water may be used to commission the Bioclere™ process and pre-test the control sequence if the initial wastewater supply is minimal. The biological growth necessary to sustain treatment is rapidly established in the biofilter.

BIOCLERE™ Nutrient Reduction

Bioclere™ may be designed to reduce nitrogen or phosphorus in wastewater. Nitrogen is reduced substantially and cost-effectively by recirculating treated wastewater from the Bioclere™ to the primary settling tank. In larger systems, a nitrifying Bioclere™ is added to the process chain. Bioclere™ units are also adaptable for reliable phosphorus precipitation.



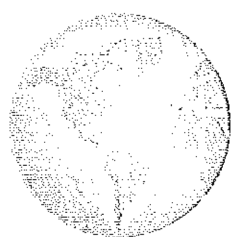


BIOCLERE™ Features

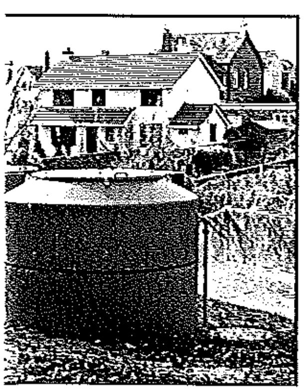
- Low capital investment; low installation, operating and maintenance costs
- Modular units for increasing capacity
- Passive gravity flow system utilizes existing septic tank and leaching facilities
- Relieves existing biologically overloaded facilities
- Corrosion and UV resistant components
- Sealed and insulated unit for stable, quiet processing
- Energy-efficient, self-managing process
- Infinitely adjustable recirculation (minimizes impact of flow variations)
- Process unaffected by external temperature variations
- Internal flow stabilization (minimizes need for equalization chambers)
- Designed for high-strength waste streams
- Nutrient removal and disinfection easily added to the process chain

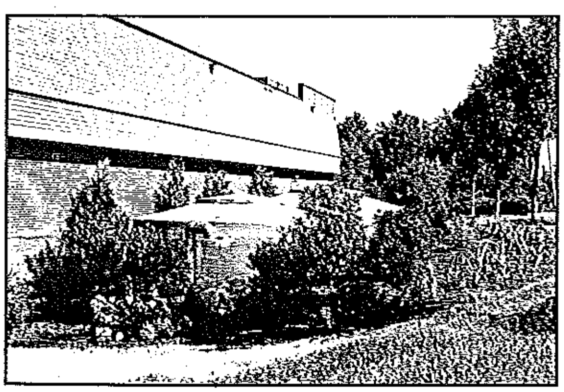
Typical Applications

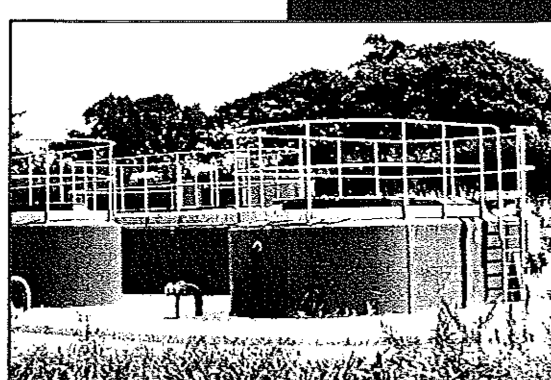
- Private homes
- Isolated small communities
- Schools
- Nursing homes
- Restaurants
- Supermarkets
- Small shopping malls
- Camp grounds
- Farms
- Service stations
- Organic industrial effluents
- Organic pretreatment for existing systems

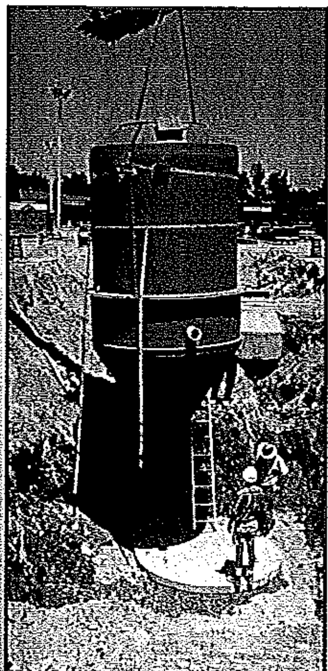


BIOCLERE™









Summary of Bioclere Analytical Results Previously Tested To Criteria C-9 by National Sanitation Foundation

		Median	Average	Min.	Max.	Interquartile Range
Temperature °C	influent	13	13.2	10	17	11 - 14
	septic tank effluent	11	10.9	5	15	8 - 14
	effluent	11	11.4	5	16	8 - 14
pH	influent	7.5	7.6	7.3	7.9	7.5 - 7.7
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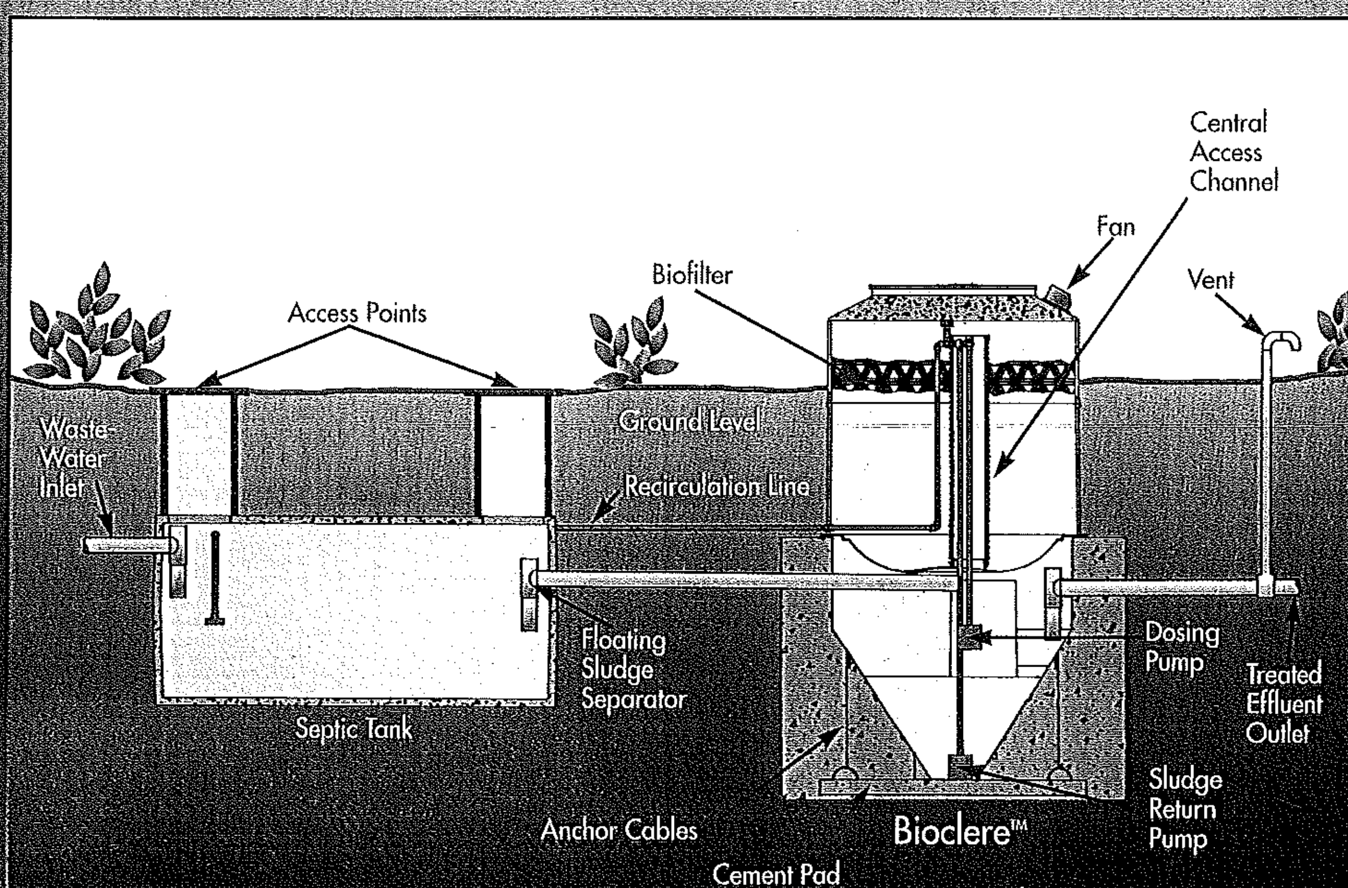
	septic tank effluent	73	74	44	100	62 - 86
	effluent	11	13	5	45	8 - 16
Suspended Solids (mg/L)	influent	120	141	54	720	97 - 160
	septic tank effluent	40	47	18	200	33 - 52
	effluent	13	17	5	50	8 - 24
Volatile Suspended Solids (mg/L)	influent	100	111	37	430	77 - 120
	septic tank effluent	32	37	13	160	26 - 42
	effluent	10	14	5	35	7 - 20
Dissolved Oxygen (mg/L)	effluent	5.6	5.9	3.4	10.2	4.7 - 6.5



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