Guidelines for the Sampling/Testing of Innovative/Alternative Disposal Technologies for Sewage Treatment and Disposal

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GUIDELINES FOR THE SAMPLING/TESTING OF INNOVATIVE/ALTERNATIVE DISPOSAL TECHNOLOGIES FOR SEWAGE TREATMENT AND DISPOSAL

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CHAPTER 1

INTRODUCTION

The use of an individual sewage disposal system (ISDS) is common in areas where sewer line is not available. While the use of a standard septic tank-leaching field system as an ISDS is approved by state and local regulating agencies in areas where such system can be used successfully, there are many innovative/alternative sewage treatment and disposal technologies in the market which can be more cost-effective than the standard septic tank-leaching field system. Many of these innovative/alternative (I/A) technologies claim better treatment of sewage , resulting in a better effluent quality such that a reduction of the size of leach fielding is justified. Regulating agencies are evaluating the performance of these I/A technologies in the field in order to make a decision if or not the claim is justifiable before a license is granted to a vendor of the I/A technologies. In general the vendors have to submit performance data to the regulating agencies for the evaluation.

I/A technologies vary from simple system components such as open bottom drain pipes or chambers to complicated systems with aerobic-anoxic-aerobic biological processes aiming at BOD, suspended solids, nitrogen, or even phosphorus removal. There is no standard guideline on what testing is to be done on these I/A technologies. There are issues on sampling procedure (location, frequency, grab or composite), chemical analysis, data interpretation, and the reasoning on leaching field size reduction. It is not unusual that the vendors seek advice and look for a guideline from the regulating agencies so that they can better prepare their application document. The review of application and approval of the I/A technology use is a time consuming process. Often the agencies are not satisfied with the performance data and request more data or better data to justify the vendor's claim.

The purpose of this work is to establish a guideline on the sampling/testing and data interpretation of I/A technologies. The guideline will benefit both the vendors as well as the regulating agencies by indicating the type of meaningful data and correct interpretation of data to be submitted. This will speed up the application approval process and make it less costly in marketing the technologies.

The second chapter of his document addresses many critical issues concerning the terminology, sampling procedure, chemical analysis, and data interpretation that apply to the I/A technologies. The third chapter divides the I/A technologies into groups and presents the requirements of sampling, testing, and show of proof of the claim of drainage field reduction specifically for each group.

CHAPTER 2

TECHNICAL ISSUES FACING THE INNOVATIVE/ALTERNATIVE DISPOSAL TECHNOLOGIES

In this chapter, technical issues on the function of a septic tank, nitrogen removal, nitrogen analysis, leaching field size reduction, phosphorus removal, and number of samples/testing are examined.

2.1. Septic Tank.

Basically a standard septic tank-leaching field ISDS consists of a tank with a Tee inlet or a baffle, and a Tee outlet. The capacity of the tank is sufficient to provide one to two-day hydraulic detention time of the incoming sewage. The tank is followed by a distribution box and a leaching field with sufficient leaching area for sewage disposal. In the septic tank, the sewage solids settle out and the scum floats to the top with the partially treated effluent distributed to the drainage pipes and leaching trenches/chambers/bed. While practically all the settleable solids are removed by the septic tank, the relatively short hydraulic detention time in the anoxic condition does not allow significant BOD and TSS removal. In general an average of 250 mg/l of BOD and 250 mg/l of TSS are assumed for the household sewage quality, and typically the septic tank effluent contains 125 mg/l of BOD and 125 mg/l of TSS.

Nitrogen removal by the septic tank is minimal. Some nitrogen is removed by acidogenic and methanogenic organisms through cell synthesis. However nitrogen removal through cell synthesis is very small in the slow anaerobic condition. More importantly the nitrogen is only transformed to cellular nitrogen which stays in the system either as the settled solids at the tank bottom or leaves with the septic tank effluent. No net removal of nitrogen occurs. The organic nitrogen in the sewage solids and organisms also go through some chemical and biological transformation through fermentation. As a result, some organic nitrogen is converted to ammonia nitrogen which goes back into the sewage in the tank. Only periodic pump-out of septic tank solids provides the opportunity of net nitrogen removal.

Another possibility of nitrogen removal in the septic tank is through recycling of a nitrified effluent from an I/A technology to the septic tank. There the nitrate in the nitrified effluent of an I/A process is reduced to nitrogen gas which escapes to the atmosphere through a vent. Without the recycling of nitrified effluent into the septic tank or without solids pump-out, no net nitrogen is removed in the septic tank. More discussion relating to nitrogen removal is presented in Section 2.3.

Sewage sampling from the septic tank is conducted routinely in ISDS system evaluation. An effluent sample can be taken from the outlet pipe or from the distribution box. However a sample taken from within the septic tank does not represent an influent sample because the influent flow is mixed in with the septic tank content. A true influent sample has to be taken from the inlet pipe before it goes into an mixed in with the septic tank content. This requires a 24-hour composite sampler because of the extremely fluctuating characteristics of the household sewage. Information on the influent sewage quality, however, is not vital because we are more interested in the septic tank effluent quality which affects the leaching field performance. Recognizing the damping effect of the septic tank on the sewage quality fluctuation due to its relatively large storage capacity, the quality of the effluent is relative uniform throughout the day. Random grab samples therefore can be taken in lieu of a 24-hour composite sample. In order for a vendor to make a certain claim of BOD/TSS and nitrogen removal from a septic tank, however, 24-hour composite samples from a septic tank influent pipe and effluent samples from the distribution box need to be taken for analysis.

2.2. Leaching Field Size Reduction.

Vendors claim that a leaching field size reduction is justified because the BOD and TSS concentrations of their I/A technologies are better than a septic tank effluent. As was mentioned before, we generally assume 250 mg/l of BOD and TSS for a household sewage and 125 mg/l of BOD and TSS for a septic tank effluent. Any I/A technology produces an effluent with BOD and TSS concentrations consistently less than 125 mg/l is qualified to apply for a leaching field size reduction. Indeed this is the reason behind the Laak's formula which is widely used by engineers to estimate the leaching field size reduction.

The Laak's formula takes the following form:

$$\text{Adjusted Area} = \text{Standard Area Required} \times [(\text{BOD} + \text{TSS})/250]^{1/3}$$

It can be seen that with BOD and TSS both at 125 mg/l in the effluent such as a septic tank effluent, a standard area is required. If an I/A technology produces an effluent with 30 mg/l of BOD and SS,

$$\begin{aligned}\text{Adjusted Area} &= \text{Standard Area Required} \times [(30+30)/250]^{1/3}\\ &= 0.62 \text{ Standard Area Required}\\ &\text{or } 38 \text{ percent reduction}\end{aligned}$$

It is important to keep in mind that the formula assumes a typical 125 mg/l of BOD and TSS concentration in the septic tank effluent. In reality the septic tank effluent may fluctuate. The USEPA study (Table 6-1, Design Manual, Onsite Wastewater Treatment and Disposal Systems, 1980, p. 100) lists ranges of septic tank effluent BOD as 7-480, 64-256, 70-385, 30-280, and TSS as 10-695, 43-485, 48-340, and 8-270. If the septic tank has an effluent less than 125 mg/l of BOD and TSS consistently, then the Laak's formula would give too much credit to the I/A technology for a leaching field size reduction. The following example is used to illustrate the point:

BOD/TSS of a septic tank effluent, mg/l = 120/100
(I/A technology influent)

BOD/TSS of the I/A technology effluent, mg/l = 80/50

According to the Laak's formula,

$$\begin{aligned}\text{Adjusted Area} &= [(80+50)/250]^{1/3} \times \text{Standard Area Required}\\ &= 0.8 \text{ Standard Area Required}\\ &\text{or } 20\% \text{ size reduction}\end{aligned}$$

However the septic tank effluent has better than the average BOS/TSS quality, i.e., 120/100 as opposed to 125/125 mg/l, part of the credit for size reduction should not be given to the I/A technology.

$$\text{Adjusted Area} = [(120+100)/250]^{1/3} \times \text{Standard Area Required}$$
$$= 0.96 \text{ Standard Area Required}$$

or 4 % size reduction

Therefore the actual credit given to the I/A technology should be (20 - 4) or 16 %.

One can argue that the I/A technology should be given the full 20 % credit of leaching field size reduction. However that is only reasonable when the data submitted by the vendor can truly reflect the long term historical performance of the septic tank. One cannot discount the sporadic nature of data collected by most vendors and therefore cannot overlook the fact that the septic tank effluent BOD/TSS concentration can be significantly different from 125 mg/l. Less credit may be given to I/A technology for leaching field size reduction. In other words, if the vendor's data show the septic tank effluent BOD/TSS consistently at 120/100 mg/l, then 4 % out of 20 % credit of size reduction should be taken out to be conservative. This conservative approach requires that the vendors have to submit both the septic tank effluent and I/A technology effluent data on BOD/TSS, preferably long term historical data instead of sporadic data.

This extra calculation for the correction of leaching field size reduction is not necessary for two situations. One is that the I/A technology does not use a septic tank. The effluent BOD/TSS of the I/A technology can be directly applied to the Laak's formula. The other situation is that the treated effluent of the I/A technology is recirculated to the septic tank, e.g., for denitrification. In this latter case, the septic tank content is diluted by the recirculated flow which significantly dampens the fluctuation of effluent quality. The conservative approach of making the size reduction correction as proposed is deem not necessary.

2.3. Denitrification and Nitrogen Removal

Nitrogen removal is important where the ISDS is used in a nitrogen limitation area. Although nitrogen can be removed from sewage by using a chemical or chemical-physical process, there is no I/A technology commercially available today using such process. Most commonly a biological nitrification-denitrification process is used. This process uses nitrifying organisms to oxide ammonia-N to nitrite and nitrate in one step followed by a reduction of nitrite/nitrate using denitrifying organisms to form nitrogen gas in another step. Stripping the nitrogen gas off from the treated sewage effluent constitutes the nitrogen removal from the system.

There are I/A technologies in the market that carry out the nitrification-denitrification steps in addition to BOD and TSS removal. However many other I/A technologies in the market also claim nitrogen removal without providing a necessary chemical or chemical/physical step or the nitrification-denitrification steps. Some provide aeration of the sewage with or without septic tank pretreatment, and some provide fixed media biological oxidation and claim nitrogen removal . For example one vendor provides aeration of the septic tank effluent and subsequent biological solids settling and filtering. By showing that the effluent total Kjeldahl nitrogen (TKN) is less than the influent TKN by 50 %, the vendor claims denitrification in the system. This claim is not valid for several reasons. The first one is that TKN is not equivalent to total nitrogen. Some forms of nitrogen are missing in the TKN analysis. Consequently TKN reduction by 50 % does not prove that there is a 50 % total nitrogen removal. More of this will be discussed in the Section 2.4 later. Secondly, some regulating agencies define denitrification as total nitrogen removal equal to or more than 50 % from the system. This is not consistent with the true definition of denitrification. Unless the vendor's aerated sewage effluent is nitrified and further processed through either returning to the septic tank or to a separate anoxic tank with carbon source, the sewage nitrogen is not removed. Thirdly, some TKN transformation takes place in cell synthesis. In other words, ammonia-N is converted to cellular nitrogen (organic nitrogen in the form of protein or amino acids inside the bacteria). The settled organisms through the endogenous respiration process will in time release the nitrogen in the form of organic nitrogen and ammonia nitrogen back into the sewage. If sewage samples are taken from such a system where biological solids are allowed to accumulate over a long period of time (septic tank with infrequent pump-out), the nitrogen content will rise and TKN removal will be minimal. Only when the biological solids are pumped out frequently will the system show significant nitrogen removal. It should be recognized that the nitrogen removal in this case is a physical removal by solids pump-out which is different from denitrification. If the vendor claims nitrogen removal from the system without going through a chemical/physical or a true nitrification/denitrification process, the credit should be given to solid pump-out or solid filtration alone, which all other systems in the market can do.

There is a proposal that regulating agencies use 19 mg/l total nitrogen as a threshold of nitrogen discharged from I/A systems. This is based on that fact that typically a septic tank effluent contains 38 mg/l of total nitrogen and 50 % reduction of total nitrogen is imposed on any I/A technology claiming to be a nitrogen removal system. The 50 % reduction of nitrogen or a discharge of 19 mg/l of total nitrogen to the leaching field may or may not mitigate the problem in a nitrogen limitation area. A proper nitrogen loading allowable in such an area in pounds of nitrogen per unit area should be studied. Together with data of population density and estimated amount of sewage flow, the nitrogen content of the I/A treated effluent in that area can then be established. In other words, the required performance of any I/A technology for nitrogen removal is site specific. This stipulation should be added to the 50 % nitrogen reduction which in many cases may result in much lower nitrogen concentration required for the I/A technologies.

2.4. Nitrogen Analysis

TKN consists of organic nitrogen and ammonia nitrogen. It does not include nitrite and nitrate nitrogen. Total nitrogen includes organic, ammonia, nitrite, and nitrate nitrogen. In a highly nitrified effluent such as an effluent after an extended period of aeration or a long contact time with the fixed media, the TKN concentration is much smaller than that of the influent but the total nitrogen concentration remains essentially the same if a non-filtered sample is analyzed. The only change is the transformation of ammonia nitrogen to nitrate nitrogen. This is why TKN reduction alone cannot be used to show nitrogen removal in a system where nitrification- denitrification occcurs.

As was mentioned previously, cell synthesis taking place in the septic tank and in the aeration tank, if it is a part of the I/A technology, is merely a form of nitrogen transformation. There is no net total nitrogen removal. The longer the biological solids stay in the system without removal, either by pump-out or filtering, more of the solid form of nitrogen will be converted back to ammonia nitrogen which goes back into the sewage.

The critical issues here are three-fold. First, is the sewage sample analyzed for nitrogen a filtered sample or non-filtered sample? Only the non-filtered sample will give the total nitrogen, i.e., organic and ammonia nitrogen including the cellular nitrogen, as well as nitrite and nitrate. The acid digestion step in the nitrogen analysis will be able to release the cellular nitrogen and breaks it down to ammonia nitrogen. A filtered sample will exclude the cellular nitrogen. The difference can be significant depending on the biological solid content in the sample.

Secondly, laboratory filtering of solids is much more efficient than any I/A system available in the market. As more solid is removed, less total nitrogen remains in the sample. As a result, too much credit is given to the I/A system if laboratory filtered samples are used in the vendor's data.

Thirdly, where are samples taken from the septic tank or from the aeration tank treatment system? If nitrogen analysis is done for filtered samples, it makes no difference where the samples are taken. However if nitrogen analysis is done for non-filtered samples, the sampling location is critical. For example a sample from the top portion of the septic tank above the sludge zone versus a non-stratified sample (a composite sample as a mixture of samples from different layers including the sludge zone), or a sample from the clarifier effluent versus an aeration tank effluent, both make significant difference in the solid content and therefore the result of nitrogen content.

Considering all the issues aforementioned, it is better to standardize the parameter defining the capability of nitrogen removal by I/A technologies. First TKN reduction should not be used as a substitution of total nitrogen reduction. Many vendors submit data of significant TKN reduction as their systems are able to carry out nitrification but no subsequent denitrification. Total nitrogen analysis will be able to show that without denitrification, their total nitrogen reduction is minimal. Therefore only total nitrogen data will be considered.

Secondly, nitrogen analysis should be carried out for non-filtered samples only. Those I/A technologies producing effluents with more biological solids will contribute more nitrogen to the leaching field and the organic nitrogen will eventually be converted to inorganic nitrogen in the soil, adding to the nutrient pollution problem. Laboratory filtering will give the I/A technologies which produce effluents with higher biological solids undeserved credits of nitrogen removal.

Thirdly, both 50 % or better reduction of total nitrogen as well as 19 mg/l or lower of effluent total nitrogen should be used together as a performance requirement for nitrogen removal I/A technologies. A new septic tank or a newly pumped out septic tank would have a lower effluent nitrogen content and therefore an effluent of 19 mg/l of total nitrogen for an I/A technology can be easily reached. The 50 % nitrogen reduction requirement assures that the I/A technology did accomplish significant nitrogen removal. On the other hand, if the septic tank has a much higher nitrogen content, a 50 % reduction may not be sufficient. The 19 mg/l of total nitrogen guarantees an acceptable effluent nitrogen content. As stated previously in Section 2.3, a better approach to consider if or not a nitrogen removal I/A technology can be applied to a site is to consider the nitrogen loading of the specific site. Only then a nitrogen pollution situation can be mitigated.

2.5. Phosphorus Removal

Phosphorus in sewage can be removed through chemical precipitation such as lime precipitation or through soil adsorption in the leaching field. Some phosphorus sensitive areas may require the installation of ISDS with a capability of P removal. There are some I/A disposal technologies in the market claiming P removal prior to the application of the effluent to the leaching field. No lime precipitation is employed in their systems. No explanation of P removal mechanism in their systems is given. Also how consistent the P removal occurs in their systems is not documented.

Phosphorus is removed by sewage bacteria through cellular synthesis. However the amount of P removal through cell synthesis is very small. Recently it became known that Acinetobacter could remove significant amount of phosphorus from sewage. Some Aeromonas and Pseudomonas are also capable of storing significant amount of polyphosphates in the cells.

Under anaerobic conditions, the fermentation products such as acetate and propionate produced by the facultative organisms are assimilated by phosphorus removing organisms. The assimilation is aided by energy made available from the hydrolysis of the stored polyphosphates. Accumulation of PHB, a carbohydrate product, also occurs at this stage. When the anaerobic condition is subsequently changed to aerobic, the PHB is broken down while the soluble phosphorus in the sewage is taken up in large quantities, forming polyphosphates as a storage product in these organisms. The phenomenon is known as luxurious P uptake. The biological nirification-denitrification treatment train using anaerobic-aerobic process with a recirculation of the aerobic effluent back to the anaerobic reactor is suitable for the growth of these P removing organisms. The major proprietary processes for biological P removal such as Phostrip, Modified Bardenpho, and A/O processes have been developed based on this concept. Consequently some I/A sewage disposal technologies using an anaerobic-aerobic scheme could remove significant amount of P along with nitrogen removal. Monitoring the P contents of the septic tank influent and aerobic treatment unit effluent will be able to tell what level of P is removed.

It should be noted, as in the case of nitrogen removal, only non-filtered samples should be analyzed to give the true indication of the change of total-P which includes both the soluble-P and the particulate P (cellular P). Also solids pump-out from the septic tank (assuming solids are returned to the septic tank) is even more critical to P removal than N removal. Transformation of cellular or organic P back to phosphate is much more rigorous than N transformation. The phosphates go back to the sewage which negates the P removal capability of the system.

2.6. Number of Samples/Testing

The amount of sampling/testing data for any particular I/A technology should be consistent for all applications. If, for example, five years of performance data are required , the data should not be one year data for each of five systems installed and tested. Instead it should be five consecutive years of testing data for each of the five systems. Sporadic data such as testing only once or twice a year do not mean much in I/A technology testing. Most systems are passive and a wide range of performance can be expected. Also it should be pointed out that most I/A technologies do not fail in the early years. Therefore data in later years are more meaningful.

The performance of any system testing should have some statistical significance. It is suggested here that for new construction a minimum of six samples/testing in one year or one season (if for seasonal use) should be carried out. With six data points in one year for 5 consecutive years, there are thirty data points from which a log-probability plot can be prepared. Such data treatment is useful to show how reliable the system performed. For existing houses using I/A technology in remedial situations, data collected in early years are as good as in later years. It is suggested here that 4 times a year of sampling/testing for two consecutive years would be sufficient.

Finally, sampling and testing should be carried out by a third party and an independent testing laboratory.

CHAPTER 3

GUIDELINES FOR THE SAMPLING/TESTING OF INNOVATIVE/ALTERNATIVE DISPOSAL TECHNOLOGIES

3.1. I/A Technology Categories

In this section, I/A disposal technologies for sewage treatment and disposal are divided into different groups according to their functions and physical arrangements. The guidelines on the sampling and testing of these systems are discussed for each group in later sections.

Based on the available I/A disposal technologies in the market today, they can be divided into five (5) different groups as follow:

1. Innovative/alternative trench/chamber/bed to replace the standard trench/chamber/bed. No treatment enhancement and therefore no leaching field size reduction is claimed for this group.

2. Innovative/alternative trench/chamber/bed to replace the standard trench/chamber/bed. There is treatment enhancement and therefore a leaching field size reduction is claimed.

3. Innovative/alternative system following a septic tank treatment prior to leaching field application. Leaching field size reduction is claimed.

4. Innovative/alternative technologies as a stand alone treatment system without a septic tank pretreatment. Leaching field size reduction is usually claimed.

5. Miscellaneous system.

Within each group there are numerous technologies/systems in the market and within each technology/system there may be different models each with a slightly different design. In addition, some of the technologies are modified by adding or deleting component(s) or changing the system configuration.

Consequently the sampling/testing of each technology is discussed generically to avoid redundancy.

3.2. I/A Trench/Chamber/Bed with no Treatment Enhancement

This group of I/A technology replaces the conventional drainage pipes, or chamber, trench, or bed with similar units made of light weight material such as high density polyethylene (HDPE) and of different structure design for "better" distribution of sewage to the field. Examples of I/A technology in this group are :

INFILTRATOR SYSTEM	(Drawings in Appendix A-1)
BIODIFFUSER	(Drawings in Appendix A-2)
CULTEC	(Drawings in Appendix A-3)
ENVIROCHAMBER	(Drawings in Appendix A-4)

Since there is no treatment enhancement claimed by these technologies, there is no need for sampling and testing.

Each vendor has proposed a way to determine the surface area of leaching unit from which the number of units of the system required and the total leaching field size can be determined. It is essential that the effective leaching area of each of these technologies is equal to or better than the effective area provided by the conventional leaching trench/chamber/bed. Some technologies do not provide stone as in the conventional system. The stones provide better sewage distribution as well as a medium for the development of a biomat which is helpful to the biological treatment of the sewage. The biomat on the stones also helps to trap some sewage solids which in turn helps to minimize the soil clogging problem in the leaching field. The claim by some vendors that a drainage system without stone is better is scientifically unsound.

3.3. I/A Trench/Chamber/Bed with Treatment Enhancement

Each technology in this group has, in addition to the distribution trench/ chamber/bed similar to the conventional one, a special provision of sewage treatment usually in the form of filtration. An example of this group of I/A technology is the ELGEN IN-DRAIN. The In-Drain unit is a plastic core wrapped in an AMOCO 4550 geotextile fabric. A standard type B unit, 36"x48"x7", provides 5 square feet of the fabric area per square foot of In-Drain bottom area. The geotextile fabric serves as a good filter of sewage solids as well as the support for a biomat. The biomat further removes BOD and TSS from the sewage. This is the base or justification of leaching field size reduction (see Appendix B).

In order to determine the percentage of leaching field size reduction for the In-Drain or similar system on the same bases as for the other I/A disposal technologies, the BOD and TSS concentrations of the sewage that has passed through the geotextile fabric or a similar filtering material have to be determined. These filtered effluent BOB/TSS concentration values are then entered into the Laak's formula for the calculation of the leaching field size reduction. The suggested sampling/testing guidelines are presented in the following:

A. Sampling Location

A sample representing the septic tank effluent taken from the outlet pipe of the septic tank or from the distribution box.

A sample representing the sewage that has passed through the geotextile fabric or other filtering material.

If the system has not provided a convenient sampling location, such as in the case of In-Drain units, the vendor in the State requiring a testing program should provide a half-pipe, parallel to the drainage pipe and directly under the In-Drain units. The half-pipe should have a minimum slope of 1/8 -inch per foot leading to a sump from which samples can be taken.

B. Sampling Type

Random grab samples are adequate. The size of a conventional septic tank provides close to two days of hydraulic detention time. The effluent quality is relatively uniform. There is no need to take 24-hour composite samples for both the septic tank effluent and the fabric filtered effluent.

C. Sampling Frequency

In a testing program required by the State, at least six times per year or four times per season for seasonally used household, taken at regular intervals are recommended.

Avoid taking samples too early in a testing program for a newly constructed system and for any seasonally used system. It may take several weeks to establish or reactivate a biomat reaching the equilibrium state, giving a steady treatment performance. For a seasonally used system, particularly the use is sporadic or infrequent, samples in the latter part of the season are more indicative of the system performance. A noticeable biomat may or may not develop on the filtering material in one season.

D. Sampling Analysis

BOD and TSS concentration, with the data directly used for calculating the leaching field size reduction.

3.4. I/A Technologies Following Septic Tank Pretreatment

The majority of the I/A disposal technologies belong to this group. They could be as simple as adding a PVC filter to the outlet of a septic tank, ZABEL FILTERS (Appendix C-1), or inside a septic tank at the outlet end, such as OSI Screened Vault (OSI Effluent Filter Appendix C-2), POLYLOK PL-122 EFFLUENT FILTER (Appendix C-2a), and SIM/TECH FILTER in a pump chamber (Appendix C-2b), to remove solids before the effluent gets to the drainage field. Many systems use post-septic tank suspended aeration or fixed media aeration or trickling filter units followed by clarification and/or filters to remove the biological solids before entering the leaching field. Examples of these systems are NORWECO SINGULAIR (Appendix C-3), FAST (Appendix C-4), BIOCLERE (Appendix C-5), and WATERLOO BIOFILTER (Appendix C-6). Others use a sand filter to treat the septic tank effluent with or without recirculation of the filtered effluent before discharging to the leaching field. Examples of this group are AIRR RECIRCULATING SAND FILTER (Appendix C-7), SANECO INTERMITTENT SAND FILTER (Appendix C-8), PURAFLO PEAT

BIOFILTER (PURAFLO is also a stand alone treatment unit, see Appendix D-4), and many other filtration technologies in development.

A. Sampling Location

Basically samples of the septic tank effluent and the effluent at the end of the I/A system before its discharges into the leaching field, e.g., at the distribution box, are required.

However, more than BOD and TSS removal, many of this group of I/A systems may claim to be a nitrogen removal system. This usually is accomplished by returning part of the aerobically treated effluent back to the septic tank. Assuming that sufficient nitrification has taken place in the aerobic treatment unit (aeration tank, trickling filter, sand filter etc), the portion of the effluent returned to the septic tank is denitrified. Consequently a significant portion of the nitrogen can be removed. To monitor nitrogen removal, septic tank effluent and effluent at the end of the I/A system should be sampled for total nitrogen analysis

It is assumed for all systems in this category that no segregation of blackwater and greywater for separate treatment in order to achieve nitrogen removal. When blackwater and greywater are separated for treatment, the system is considered a stand alone treatment system in the next category.

B. Sampling Type

Random grab samples are adequate.

C. Sampling Frequency

Six times a year or four times a season are recommended. Avoid taking samples too early in newly constructed system or for seasonally used system.

D. Sampling Analysis

BOD and TSS concentration for the samples with the data entering the leaching field size reduction calculation. Samples are also analyzed for total nitrogen (non-filtered samples including both the particulate and dissolved nitrogen).

E. Nitrogen Removal Interpretation

Since nitrified effluent may be recirculated back to the septic tank and denitrification is taking place in the septic tank, the septic tank effluent nitrogen content is lower than that of a typical septic tank effluent. As a result, the nitrogen content of the I/A technology may be 19 mg/l or lower but nitrogen removal may be less than 50 %. In other words the 50 % nitrogen removal requirement should not be applied in this situation.

3.5. I/A Technology as a Stand Alone Treatment System Without a Septic Tank Pretreatment

Many commercially available I/A systems do not follow the conventional scheme of a septic tank pretreatment of the total household wastewater as a first unit of the treatment train. The blackwater may be separated from the greywater, each going into its own septic tank for pretreatment. Further treatments follow and later on the two streams of flow are combined and discharged to the leaching field. Other I/A systems eliminate septic tank pretreatment all together. Each of these I/A systems is unique and requires a separate consideration of sampling/testing procedure.

A. RUCK SYSTEM

The RUCK system is a nitrogen removal system. A household blackwater is plumbed separately from the greywater. The blackwater enters a blackwater septic tank followed by a buried, aerobic sand filter. The greywater is plumbed to a greywater septic tank. The nitrified blackwaster from the sand filter either is pumped or flows into the greywater septic tank for the denitrification process which occurs under anaerobic conditions with the greywater serving as a carbon source. The system is a single pass-through system, achieving significant removal of BOD, TSS, and total nitrogen (Appendix D-1).

The sampling location for the RUCK SYSTEM should be at the greywater septic tank effluent for BOD and TSS. The data can be used for leaching field size reduction calculation using the Laak's formula. Quantification of total nitorgen removal is more complex. For influent total nitrogen concentration determination, both the blackwater septic tank sample, N_b, and the greywater septic tank sample, N_g, have to be analyzed. Also the average daily flow of blackwater, Q_b, and the average daily flow of greywater, Q_g, should be known. The combined influent total nitrogen is calculated using the following formula:

$$\text{Influent total nitrogen} = (Q_b \times N_b + Q_g \times N_g) / (Q_b + Q_g)$$

For the determination of the total nitrogen of the RUCK SYSTEM effluent, the greywater septic tank effluent should be sampled and analyzed.

With samples taken and analyzed for these locations aforementioned, one can determine if or not the criteria of 50 % total nitrogen removal and 19 mg/l total nitrogen allowable in the effluent have been met.

B. AMPHIDROME

This system consists of an upflow bed column with a granular media as a aerobic fix-film treatment process for BOD and TSS removal as well as nitrification. This fix media treatment process is followed by a second column containing filter media in anoxic condition for denitrification. Additional carbon source is added to the second column to accelerate the denitrification process.

The effluent of the second column should be sampled and analyzed for BOD, TSS, and total nitrogen. In addition, influent samples to the system should be taken and analyzed for total nitrogen. The data are required for the determination of leaching field size reduction and whether or not AMPHIDROME is a nitrogen removal system.

If the carbon source is added to the second column intermittently, 24-hour composite samples instead of grab samples from the effluent should be taken for BOD, TSS, and total nitrogen analysis.

C. CROMAGLASS

This system is a sequencing batch reactor (SBR) which is a fiberglass tank with three compartments. The first compartment equipped with retention sreeens serves as a primary settling chamber. The second compartment serves as an aeration tank, and the third compartment periodically receives the flow at preset intervals for final settling of the biological solids. The effluent is discharged to a leaching field (Appendix D-2).

Although nitrification may take place, no denitrification occurs. The system is not considered a nitrogen removal technology. Samples from the third compartment effluent can be taken for BOD and TSS determination for leaching field size reduction.

D. JET MODEL J-353

This is an extended aeration process using a tank with a primary settling zone, followed by a aerobic treatment zone with fixed media and an aspirator, followed by a secondary clarifying zone. The settled solids are returned to the aeration zone.

This is not a nitrogen removal system since no denitrification takes place. Samples from the secondary clarifying effluent should be taken for BOD and TSS determination for the calculation of leaching field size reduction.

E. JET MODEL J-335 INDIVIDUAL HOME TERTIARY TREATMENT SAND FILTER

This is a system with a modular sand filter as an additional system component following the JET MODEL J-353 unit. A pump directs the backwash/recirculation flow back to the primary settling zone of the JET MODEL J-353 unit. The system can be considered as a nitrogen removal system only if an anoxic condition can be established in the primary settling zone and nitrification takes place in the sand filter so that the backwash/recirculation flow will be denitrified in the primary settling zone.

The sand filter effluent should be sampled for the determination of BOD, TSS, and total nitrogen. In addition, the influent flow to the primary settling zone should be sampled and analyzed for total nitrogen determination.

F. BIOCYCLE WASTEWATER TREATMENT SYSTEM

The BIOCYCLE wastewater treatment system is a circular concrete tank divided into several compartments. The household wastewater enters the system (see Appendix D-3) first into the septic tank section A, which is subdivided into a compartment serving as a primary sedimentation tank and another compartment serving as a septic tank for anaerobic treatment of the settled wastewater. The flow next enters compartment B which is equipped with air diffusers serving as an aeration tank for aerobic oxidation of the wastewater organic. This aerobic chamber provides a minimum volume of 0.25 m^3 per capita. Some models provide a biological filter or a biological contactor in place of the aeration compartment. From the aeration compartment, the wastewater enters compartment C serving as a secondary clarifier for biological solids separation. A sludge hopper is provided together with a solid removal system capable of removing the settled solids from the entire floor area of the sludge hopper. Chamber D houses a pump for delivering the treated effluent to the soil adsorption system. For discharge overland, this chamber also serves as a disinfection tank with a mimimum contact time of 30 minutes. Neither nitrification nor denitrification is claimed for this treatment system. Samples from the outlet of the tank can be taken for BOD and TSS determination for leaching field size reduction calculation.

G. PURAFLO PEAT BIOFILTER

The Puraflo Peat Biofilter is a modular pre-engineered biofiltration system that utilizes natural peat fiber as a biofilm media. The fiber is the residue of cotton grass plants extracted from raised bog peats having a water absorption capacity of 400-700%. It has an average air filled porosity of 51% and an cation exchange capacity of 124 meq/100 g. Also the fibers have a high pH buffer capacity as well as a high temperature buffering capacity, with a surface area of 2 x 10^6 m^2/m^3. The peat media are contained in pre-assembled polyethylene modules 7.08-ft long x 4.58-ft wide x 2.5-ft deep. The effluent from a septic tank or from a sewer (as a stand along treatment unit) is distributed to the modules via a flow splitting manifold. The effluent is distributed over the peat media by a re-installed rectangular grid with large diameter openings to prevent clogging. The treatment processes including filtration, absorption, adsorption, ion exchange, and microbial oxidation take place in the modules. A single pass mode is primarily used, but the units can be operated in a recirculation mode (see Appendix D-4).

The modules are pre-assembled with either weep-holes at the base for drainage, no weep-holes (sealed units) for piping to other disposal systems, or partial weep-holes with pipe on sealed end to sample chamber. A sample chamber provides access to the sample pipes for performance testing purposes.

3.6. Other I/A Technologies

Each technology in this group is unique and very different from any of the other I/A technology groups. Some technology in this group may not have any liquid discharge.

Many composting toilet systems in the market are basically a biological process whereby the human waste is turned into a humus-like end product by naturally-occurring organisms. Only the blackwater enters the system which is contained, going through the natural biological process of treatment, and stored within a receptacle until removed for disposal. A separate greywater treatment and disposal system is still needed.

Since there is no water flushing provided for composting toilets, the only end product is the humus like substance with no liquid discharge. No leaching field is required for the system. The greywater ISDS is a separate consideration.

A. BIOLET XL

The BIOLET XL is an automatic toilet (see Appendix E-1) collecting waste products, feces, urine, and toilet-paper in a heated bin. Naturally occuring microorganisms in the waste products oxidize the waste organics into stable forms. Thermostatically controlled heaters, one located in the air stream of the pressure chamber/cassette and one in the bottom of the unit evaporate the excess liquid not absorbed by the composting material.

B. VAULT TYPE COMPOSTING TOILET

This type of composting toilets. e.g., Clivus Multrum, does not need any energy source and therefore no heat is provided for excess liquid evaporation. The large vault is inclined to allow excess liquid to drain to a separate chamber. The natural ventilation through a roof vent allows liquid evaporation at a slower rate than using an electric heating device (see Appendix E-2).

CHAPTER 4

GUIDELINES FOR THE DESIGN AND USE OF SAND FILTERS IN THE STATE OF RHODE ISLAND

There are more and more sand filters coming into the market of the innovative/alternative systems for sewage treatment and disposal. This chapter provides a guideline for the design and review of sand filter systems and thus a consistent approach of reviewing and approval of the application of this type of technology in the state of Rhode Island can be used in reference to this chapter. The material presented in this chapter was primarily prepared by George Loomis at the University of Rhode Island for the Technical Advisory Committee for the Review and Approval of the Innovative/Alternative Disposal Technologies for Sewage Treatment and Disposal of Rhode Island Department of Environmental Management.

Guidelines for the Design and Use of Sand Filters in the State of Rhode Island

Preface

The purpose of this document is to provide an orderly guideline for the design and review of sand filter systems for use in treating residential strength wastewater. This document uses various terms to describe the *level of importance* of different design criteria. The terms used are:

1. May: Optional, but consider this criteria.
2. Should: Optional, but a well-accepted practice. A wise or advisable choice.
3. Must or shall: Not optional. The wastewater field's present state of knowledge mandates use as described.

A glossary of wastewater terms is included in Appendix A to help familiarize the reader with new terminology. Figures referenced in the text are located in Appendix B of this document. These guidelines are not intended to be a step-by-step procedure to designing and installing sand filter systems. They are intended to provide general information to the designer, installer and maintenance provider.

Introduction

Sand filters have been used for wastewater treatment for over one hundred years. In the past 20 years, sand filters have been used more frequently for single family homes. In that time, their design has been refined and treatment levels have become reliable and predictable. Sand filters when designed, installed, and operated properly will provide effluent BOD_5 and TSS levels of less than 10mg/l. Sand filters are efficient nitrifying units, and can reduce septic tank effluent ammonia-nitrogen levels from 35-55 mg/l to less than 5mg/l by passage through a single pass sand filter.

Sand filters can reduce fecal coliform levels from 10^6 colony forming units (cfu)/ 100ml in septic tank effluent to 10^3 cfu / 100 ml in sand filter effluent. Single pass sand filters can remove 10 to 35% of the total nitrogen in septic tank effluent, while pressure dosed recirculating sand filters can remove 20 to 60 % of the total nitrogen (USEPA, 1980;, Ronayne et al., 1982; Anderson et al., 1985; Pell and Nyberg, 1989a,b,c; Ball, 1991; Loudon, T.L., 1996; Peebles et al., 1991; Gold et al.,1992; Piluk and Peters, 1994; Emerick et al., 1997).

Different types of sand filters have different design criteria, sand media specifications, and corresponding hydraulic loading rates. The sand media used in the filters, and the microorganisms that reside in them, are responsible for much of the wastewater treatment. Sand filter media quality is crucial to the operation and longevity of the filter.

To assure good wastewater treatment, sand media with the proper sand uniformity and effective size must be used with the appropriate sand filter type and hydraulic loading rate.

Types of Sand Filters Covered by this Guidance

This guidance is intended for the design of sand filters receiving residential strength wastewater which should not exceed the following parameters: Biochemical Oxygen Demand (BOD_5) of 250 mg/l; total suspended solids (TSS) of 150 mg/l; fat, oil, and grease (FOG) of 25 mg/l; and total Kjeldahl nitrogen (TKN) of 75 mg/l.

The types of sand filters covered by this guidance document are:

Recirculating Sand Filters (RSF) -Multiple pass sand filter (Figure 1)

Sized at 5.0 gallons/ square foot /day. Wastewater is loaded 3-5 times the forward flow of wastewater from the dwelling per day.

R.S.F. Treatment Process Summary - Wastewater, having received primary treatment in a septic tank or equivalent unit, flows by gravity to a recirculation (mixing) tank. In doses controlled by both a programmable timer and float switch, the mixed fresh wastewater and partially treated filter effluent is applied to a bed of sand media (actually of small gravel sized particles). This mixed wastewater is dispersed over the filter surface in a PVC distribution network surrounded in pea stone. Wastewater trickles down through the sand media, where biological treatment occurs.

The treated R.S.F. effluent is collected in an underdrain at the bottom of the filter and discharged back to the recirculation tank. There it mixes with fresh incoming wastewater, a small amount gets discharged to the drainfield, and the cycle begins again. Typically, a buoyant-ball check valve (usually called a "Mickey Mouse" valve) is used to control discharge and recirculation. Treated wastewater is discharged to a drainfield for additional treatment.

Single Pass Sand Filter (SPSF) (Figures 2A - 2D)

1. Low Rate single pass filter loaded at 1.25 gallons/square foot/day.
2. High Rate single pass filter loaded at 2.5 gallons/square foot/day.

SPSF Treatment Process Summary - Wastewater, having received primary treatment in a septic tank or equivalent unit, is pressure dosed to a bed of specified sand media. Wastewater applications to the filter surface are controlled by both a programmable timer and float switch. Wastewater is dispersed over the sand filter surface in a PVC distribution network surrounded in pea stone. Wastewater trickles down in unsaturated flow through the sand media, where biological treatment occurs.

The treated wastewater (sand filter effluent) is collected in an underdrain at the bottom of the filter and discharged either by gravity or by pressure to a approved drainfield, where additional treatment occurs.

High rate SPSFs are recommended for sites where space considerations are a primary concern. Low rate SPSFs are recommended for sites where maximum removal of pathogenic organisms is desired. Applicable locations are: critical resource areas such as drinking water reservoir watersheds, shallow water table soils locations where shallow dug wells provide potable water, sites in close proximity to shellfishing grounds, and areas where recreational water contact issues are a concern.

Because all three of these sand filter designs are capable of reducing waste strength to below secondary treatment levels (i.e. BOD and TSS below 30 mg/l), they may be allowed a reduction in conventional drainfield size and may allow the use of innovative and alternative drainfield designs. Because of size and space considerations, most single pass sand filters are designed for flows of less than 1,000 gallons per day.

Recirculating sand filters, because of the higher hydraulic loading rates, utilize larger sized sand media, but have a smaller size footprint and tend to be more economical for larger flows. With the addition of an anaerobic zone provided by the recirculation tank, nitrogen removal will be greater in the recirculating sand filter than in a single pass sand filter. Conversely, pathogen removal efficiency is better in single pass sand filters. This is due primarily to the finer sand media particles used in a single pass filter which physically screens out larger septic microbes. In addition, the lower hydraulic loading rates in single pass sand filters create longer retention times in the filter for treatment processes to occur. These treatment characteristics should be considered when siting sand filters in critical resource areas.

Tanks

All tanks and containers used in a sand filter system **must be watertight**, otherwise the systems will not function properly. Leaks will allow groundwater to infiltrate into tanks and be pumped onto filters, subsequently saturating them. Similarly, under deep groundwater conditions, wastewater leaking out of a septic tank will not be dosed to the sand filter and treatment will be short circuited.

All septic, recirculation and pump tanks should be either vacuum tested or water tested with their access risers in place before use. It is recommended that any tank used in a sand filter system be guaranteed watertight by the tank manufacturer, the installer, or the designer doing construction oversight. All tanks shall have a watertight riser to grade at both the inlet and outlet end for servicing. All seams or joints in, and between, the septic tank and riser shall be watertight. The risers should be mechanically bonded to the tank in a way that provides both structural integrity and watertightness.

To water test a tank, seal the tank inlet and outlet. Next, fill the tank with tap water to 2 to 4 inches above the joint between the riser and tank and let stand for 24 hours. If there is a water loss, refill, mark the water level and let stand for two more hours. There should be no additional water loss.

Vacuum testing of tanks should be done by a qualified contractor or tank manufacturer experienced in performing this procedure. It is recommended that the tank be constructed, installed and tested in accordance with American Society for Testing and Materials (ASTM) Standard C-1227-97A.

To help achieve the maximum level of primary treatment, two compartment septic tanks (divided in a 2/3 and 1/3 configuration) shall be used with all sand filter systems (Figures 3B, 4). A typical recirculation tank for a recirculating sand filter is shown in Figure 5. Tank volume requirements are shown in Table 1.

Table 1. Tank size requirements for sand filters receiving domestic strength wastewater.

# of Bedrooms	SPSF*	RSF*	
	Septic Tank (gallons)	Septic Tank (gallons)	Recirculation Tank (gallons)
2	1250	1000	1000
3	1500	1250	1000
4	1500	1500	1250
5	1750	1750	1250
6	2000	2000	1500
7		2250	1500
8		2500	1750
9		2750	2000
10		3000	2250

* SPSF= single pass sand filter; R.S.F.= recirculating sand filter

For recirculating sand filters with design flows in excess of 1,500 gpd, septic tanks shall be sized at 2.0 X daily design flow; recirculation tanks shall be sized at 1.5 X daily design flow. Routine hydraulic surge storage capacity in tanks housing sand filter pumps shall be a minimum of 10% of the tank volume. Minimum emergency hydraulic storage volume capacity in tanks housing sand filter pumps shall be a minimum of 10% of the tank volume.

In situations where sand filters are being designed for seasonally-used vacation homes and summer rental homes, where daily design flows may often be exceeded, it is strongly recommended that tank sizes be increased by a minimum of twenty (20) percent.

If sand filters are being designed for high strength wastewater (exceeding the waste strength concentrations mentioned above), careful consideration must be paid to tankage volumes to assure protection of the sand filter. Wastewater from kitchen and food processing facilities must first pass through a grease tank with at least a 3 day, and preferably a 5 day hydraulic retention time, before mixing with the main blackwater stream. A three day hydraulic retention time may be adequate to trap fats, oil and grease. However, peak flows, wash water temperature, and detergents can influence fats, oil, and grease tank removal efficiency. Tankage volume should be increased to allow for adequate cooling and coagulation time.

Pumps and Effluent Screens

Sand filters submitted under this guidance shall be pressure dosed utilizing programmable timers. Intermittently pressure dosing effluent provides even distribution of wastewater over the filter surface, minimizing the chance of localized saturation in the filter, and promotes better wastewater treatment. Several small incremental wastewater doses promote better treatment potential than a few larger doses. Likewise, storing peak flows in the system's tankage and time dosing wastewater (using a programmable timer, see Figure 5) to a sand filter surface over a 24 hour clock also promotes better wastewater treatment.

Pumps should be sized to provide a minimum of five (5) feet of head pressure at the distal end of each distribution lateral in the sand filter. Most pump manufacturers will provide pump calculations for individual sand filter designs and requirements.

All effluent should be prescreened using an effluent filter/screen before it is dosed onto the sand filter. This screen/filter assembly helps protect the pump and sand filter surface from excessive solids.

When designing a single pass sand filter, dosing pumps delivering wastewater to the filter surface shall be located in a screened pump vault (Figure 7) placed directly in the second compartment of a two compartment septic tank (Figure 2A, 2B, 4A). The screened pump vault and the two compartment tank help protect the pump and sand filter from solids.

An alternate design for a single pass sand filter, may include a pump located in a separate pump chamber/tank following the septic tank (Figure 2C, 2D). In this case, flow from the septic tank to the pump chamber is by gravity. When using this configuration, an effluent filter or screen shall be placed on the outlet of the septic tank (i.e. the primary tank). Any pump located in a separate pump chamber/tank preceding a sand filter shall be positioned off the bottom of the chamber/tank a minimum of six (6) inches.

When a recirculating sand filter is used, the pump dosing the sand filter should be located in the separate recirculation tank which follows the septic tank (Figure 1). Flow from the septic tank to the pump chamber/tank is by gravity. An effluent filter/screen shall be placed on the outlet end of the septic tank to help trap solids and keep solids carryover to the recirculation tank to a minimum (Figure 4B). The sand filter dosing pump located in the recirculation tank shall be placed in a screened pump vault.

In the tank housing the pump mechanism which doses the sand filter, a hydraulic storage capacity above the working level of the tank shall be provided to accommodate power outages or service periods. This emergency storage capacity volume shall be a minimum of 100 gallons or 10% of the tank volume (whichever is greater), and shall be positioned above the pump high water alarm but below the tank inlet invert.

The effluent transmission line shall be a 1 ¼ PVC (Class 200 minimum) pipe. This pipe should be sloped either back to the pump tank or towards the sand filter to clear the line after each dose. This is done to prevent freezing in cold weather. If the pipe slope is towards the filter, an anti-siphon device should be used on the pump discharge assembly to prevent siphoning.

Sand Filter Specifications

Filter Enclosure

A. It is essential that the enclosure containing the sand media is watertight to prevent groundwater from flooding the system and to prevent untreated effluent from leaking out of the filter. The enclosure shall be a monolithic concrete slab and walls or a 30 mil PVC liner with all patches, repairs and seams having the same physical properties as the parent material. If using PVC liners all seams shall be factory welded or secured with the appropriate resilient sealant.

B. Any penetrations in concrete enclosures must be formed with the appropriate precast knockout. To assure a watertight connection it is recommended that an appropriately-sized PVC coupling or watertight rubber boot be cast into the concrete wall and the underdrain pipe be glued or clamped into the coupling/boot. Likewise, all transport pipes delivering wastewater to the filter should also be glued.

C. Any penetration through the PVC liner wall shall be done with a PVC boot attachment glued to the liner with the appropriate resilient sealer. Two (2) inches of fine sand shall be placed beneath the bottom of the liner to bed and protect it against sharp objects. The sand bedding material should be compacted to eliminate settling. When using a PVC liner, the support walls shall be rigid and made of plywood (or equivalent) and 2x4 construction to hold the liner in place during installation. The points of all screws and fasteners used in construction shall face away from the liner. The walls shall be backfilled evenly as the filter sand is placed into the enclosure. This will prevent the walls from bowing outward as the filter is filled with sand media. When backfilling the enclosure, avoid fill material with sharp stones which can penetrate the PVC liner after the plywood rots away. Overdigging the hole should be avoided; minimal backfilling on bottom and sides provides a more stable enclosure.

Underdrain

A. A four (4) inch diameter PVC Schedule 40 slotted underdrain collection pipe shall be placed directly on the bottom of the enclosure. Underdrain slots should be ¼" wide, 2 ½" deep and spaced 4" apart. To avoid the slots being pushed down into the liner and covered by liner material, the slots shall be faced upwards (12 o'clock position) The distal end of the pipe shall be brought to grade and covered with a removable cap. This shall serve as a vent/cleanout and observation port. In a filter with a pump basin located in the center of the sand filter where two underdrain pipes converge, only one (1) of the underdrain pipes needs to be brought to the surfaced and capped. The underdrain pipe can lay level or have no more than a 0.5% grade towards the drainfield or separate or incorporated pump chamber. In larger filters, underdrain pipes shall be spaced apart a maximum of ten (10) feet on center.

B. The underdrain pipe shall exit the enclosure through a precast exit hole when using a concrete container. The interface between pipe and exit hole shall be sealed and made watertight. A cast-in place PVC coupling is recommended (see Filter Enclosure section above). Appropriate stainless steel clamps (two clamps are recommended) shall seal the PVC boot around the underdrain pipe when using a PVC liner.

C. A minimum of four (4) inches of ½" to ¾" clean washed stone is placed over and immediately around the underdrain pipe only. Avoid angular and sharp stone which could damage a PVC liner.

D. Eight (8) inches of 3/8" clean washed pea stone shall be placed at the inside bottom of the enclosure. This should be mounded over the washed stone covering the underdrain.

E. Care should be taken to make certain that the above mentioned layers are installed properly. This layering sequence will prevent sand filter media from washing into the underdrain pipe of the filter.

F. Install an observation port consisting of a vertical four (4) inch perforated or slotted PVC pipe wrapped in filter fabric with a fixed cap on the bottom end. This shall be brought to finished grade and have a removable cap to facilitate observation of water level in the filter. The bottom cap shall be placed directly on the filter liner. This observation port shall be located approximately two (2) feet in from the filter perimeter.

Installation of Sand Filter Media

A. Sand media shall be selected for the appropriate application based on the enclosed sand filter media guidelines (see Table 2).

B. No filter fabric of any kind shall be placed between the 3/8" pea stone covering the filter base and the overlying sand media (Figure 9, Underdrain Detail).

C. Sand should be a minimum of twenty-four (24) inches deep and be thoroughly washed and as free of fines as possible.

D. It is recommended that the sand media be placed in level eight (8) inch lifts in the filter and wetted slightly during installation to promote even settling. It is important not to wet the sand too much because particle stratification may occur.

E. After the required amount of filter sand has been added to the filter, place three (3) inches of 3/8" washed pea stone over the filter sand. After the distribution laterals have been installed atop the pea stone and pressure tested, install shields over each orifice on the distribution laterals, add two (2) more inches of pea stone to cover the distribution laterals. No filter fabric of any kind should be placed between the sand and pea stone layers.

Distribution Laterals

A. Septic tank effluent applied to a sand filter is distributed over the sand surface using small diameter, pressure rated PVC pipe. For this guideline the distribution manifold shall be 1 ¼ inch PVC (Class 200 minimum) and the distribution laterals shall be ¾ to 1 inch Schedule 40 PVC. (Note: Small lateral and orifice sizes are recommended to provide the highest possible scouring velocity in the laterals, minimize orifice clogging, and provide as even distribution of wastewater as possible.)

B. A series of 1/8 inch diameter holes (orifices) shall be made in the top of the distribution laterals (12 o'clock position) and spaced according to the dosing requirements of the system (see Figure 9). Generally, the orifice spacing is based on a 2 to 2 ½ foot grid pattern to best utilize the filter surface. This grid will be smaller (typically 14 inches to 18 inches) when using the high rate filters. Holes should be drilled downward through both the top and bottom of the pipe (12 and 6 o'clock positions) **at every fifth orifice** along a lateral to allow drainage after a dose and to prevent lateral freezing.

C. Designs should account for a minimum of five (5) feet of head pressure at the distal end of each sand filter distribution lateral.

D. The high rate single pass sand filter should be dosed between ¼ and ½ gallon per orifice per dose. Single pass sand filters should receive 18-24 equal wastewater doses per day. Recirculating sand filters should receive 24-48 equal wastewater doses per day. Pump manufacturers will usually help provide pump calculations to assist with this design requirement.

E. Orifice shields, placed over each of the orifices, shall be used to protect the orifices from being blocked by pea stone.

F. Schedule 40 PVC or equivalent sweep elbows (also called turnups) shall be attached to the distal end of each lateral to facilitate maintenance and inspection. A standard ninety (90) degree elbow **should not** be used here. The sweep elbow end should be closed off with either a ball valve or a threaded cap. The threaded end should accommodate attachment of a ten foot length of clear PVC pipe to be used to determine initial squirt height at the distal lateral ends and subsequent squirt heights upon routine inspection/maintenance visits. Difference in distal squirt height relative to the initial reading will signal maintenance requirements during subsequent visits. The sweep end is also the location through which lateral maintenance will occur (see Operation and Maintenance section).

G. In the case of buried single pass sand filters, the ends of the sweep elbows shall be readily accessible by means of an access box or port brought to the ground surface. High density plastic irrigation valve access boxes/ports are often used for this purpose.

H. The distal ends of laterals in a recirculating sand filter, which are readily accessible by pushing aside a small amount of pea stone, do not need sweep elbows (turnups). These lateral ends should have threaded ball valves onto which a distal head measurement pipe can be attached. This ball valve will also be the location through which lateral cleaning will occur (see Operation and Maintenance section).

Cover Material

A. For buried single pass sand filters, a light-duty non-woven filter fabric shall be placed on top of the uppermost layer of pea stone, between the pea stone and the topsoil cover material. This will eliminate fine soil particles from clogging the pea stone. Avoid using heavy filter fabrics because they can limit gas/oxygen movement into and out of the sand filter.

B. A maximum of eight (8) inches around the center pump basin and six (6) inches on the filter edges of loamy sand or sandy loam topsoil and a grass cover are recommended to complete the installation. The finished grade for any sand filter should be slightly higher than the surrounding grade and crowned, if possible, to prevent surface water from flowing onto the filter.

C. When using a recirculating sand filter, cover the filter with pea stone to two (2) to four (4) inches over the top of the lateral end ball valve.

D. **Note: Sand filters should not be placed in a depressional area on a property, where stormwater is likely to collect during rainfall events. Care should be taken to not bury the filter too deeply or cover the filter top with soil material that could compact excessively (especially when moist). This could limit the gas/oxygen diffusion through the filter surface and cause filter hydraulic failure.**

E. **Avoid placing buried single pass sand filters in a high traffic area where they would receive excessive foot traffic. A minimum buffer of ten (10) feet should be maintained between the filter and neighboring trees and shrubs. Water-loving trees and shrubs shall not be placed adjacent to sand filters, because their root systems can cause system damage.**

F. **Under no circumstances should heavy equipment, vehicles, or impermeable surfaces/materials be allowed over a finished sand filter. At a minimum, this would result in poor treatment, system failure, broken components, or financial expense to the homeowner.**

Sand Filter Media Specifications

A sieve analysis of the sand media to be used should be conducted to assure that its effective size and uniformity are appropriate for the intended use. When sampling the stock piled sand media, samples should be taken from several locations within the pile to assure a representative sample for analysis. The standard method to be used for performing particle size analysis should comply with one of the following:

1. The sieve method specified in ASTM D-136 and ASTM C-117.
2. The method specified in Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples, Soil Survey Investigation Report #1, U.S. Department of Agriculture, 1984.

Important Note: To prevent clogging in the filter, all sand media must be well washed and as free of fine particles and dust as possible.

Table 2. Sand Filter Loading Rates and Media Specifications

Sand Filter Type	Design Loading[1] Rate (gal/ft^2/day)	Uniformity Coefficient $(D_{60}+D_{10})$	Effective Size (D_{10}) mm	Acceptable Sand Specifications
Single pass low rate	1.25	<3	0.33	(Figure 10))
Single pass[2] high rate	2.5	<2.5	0.65	(Figure 11)
Recirculating[3]	5.0	1.3-2.5	1.5-3.0	(Figure 12)

[1] Based upon forward flow.
[2] Dosing rate equals ¼ to ½ gallon/orifice/dose.
[3] Recirculation rate equals 3-5 times forward flow/day; dosing rate shall be adjusted to provide for this recirculation rate. It is recommended that the filter be dosed once every half hour (frequent small doses promote better treatment).

<u>Requirements for All Sand Filters:</u>

1. A programmable timer, to control and adjust the number of doses per day, length of dose time, and the duration of time between doses.

2. A high water alarm, pump, and float switch(s) set to override the programmable timer in the event of timer malfunction or temporary excessive water use.

3. A pump control panel with an elapsed time run meter and a dosing event counter (pump impulse counter) for each pump in the system.

4. A routine hydraulic surge storage capacity in the tank from which effluent is pumped onto the sand filter. This surge storage capacity shall be a minimum of 10% of the tank volume capacity , and shall be positioned between the elevation of the timer operating float switch and the high water alarm/timer override float switch.

5. An emergency storage capacity in the tank from which effluent is pumped onto the sand filter. This zone shall be positioned above the elevation of the high water alarm/timer override float switch and below the tank inlet invert. This storage volume shall be a minimum of 10% of the tank volume capacity.

<u>Requirements for Recirculating Sand Filters:</u>

1. A separate recirculation tank with a hydraulic capacity (in gallons) of 150% of the design daily household flow.

2. A recirculation buoyant-ball check valve to split the return flow from the sand filter. The ball when seated should maintain the liquid level in the recirculation tank at 80% of tank liquid capacity. The liquid capacity is determined by the elevation of the timer operating float switch.

3. Flows may also be split by using a barrier or weir at the bottom of the filter. In this case a separate collection drain will be necessary to direct flow to the drainfield (20-30%) and the recirculation tank (70-80%).

4. A recirculation ratio from 3:1 to 5:1. Note that a 3:1 recirculation ratio returns 3 parts (3/4) of the sand filter effluent back to the recirculation tank, while discharging 1 part (1/4) of the sand filter effluent to the drainfield.

Operation and Maintenance Requirements for Sand Filter Systems

WARNING - Before doing any work on either the wiring to the level control floats and pumps in the vault, tanks, or on the control panel, pull the fuse and switch the circuit breakers in the control panel to the OFF position (see Figure 5). Do not enter a confined space without using proper equipment and following safety precautions.

A. Immediately after any sand filter system has been installed, the squirt height of the distribution laterals needs to be determined, recorded in the maintenance record and left on site (usually in the system electrical control box). Measuring the squirt height is done by attaching a graduated length of clear PVC pipe to the end of the sweep elbow accessed by removing the inspection port cover (in a recirculating sand filter, the straight end of the lateral can be accessed by pushing aside the pea stone). The pump is turned on, the sweep end opened, and the wastewater height in the clear pipe is measured and recorded.

B. A minimum of five (5) feet of distal head pressure is recommended to discourage orifice clogging. If, upon subsequent measurement, the height of the squirt increases by more than 20 %, a significant number of orifices are plugged with solids. A bottle brush attached to a plumbers snake is pushed down each lateral to unplug the orifices.

C. With the bottle brush removed, the pump should be manually engaged and each lateral line can be flushed out through an attached garden hose to the inlet side of the septic tank. Alternately, a short piece of hose can be used to flush loosened solids into a bucket which can be dumped into the septic tank.

D. Usually a sand filter in continuous use will require lateral flushing / bottle brush treatment once a year. Sand filters operating above their daily design flow may require more frequent lateral flushing; the frequency based upon the results of the distal lateral head pressure test. Seasonally-used sand filters may not need yearly lateral flushing, but their lateral squirt height should be checked once per year, and maintenance performed as needed.

E. The squirt height in recirculating sand filters can be determined by spreading aside the pea stone surface covering one of the distribution laterals, removing an orifice shield, and measuring the squirt height with a tape measure placed next to the stream.

F. The surface of all sand filters should be kept free of debris. If the sand filter is an "open" filter covered with pea stone instead of turf, the sand filter surface should be kept free of weeds and grasses. This surface can be lightly raked to remove leaves, etc. and weeds and grasses should be removed when they first appear.

G. On a yearly basis, shallow drainfield lines (if part of the system design) should be snaked with a bottle brush and flushed. Seasonally-used systems may not require yearly flushing, but they should be inspected yearly, and flushed as needed, based upon inspection results.

H. Once a year all electrical components should be checked for function. All float switches should be activated and timers should be checked against the desired setting. All float switches should be hosed down to prevent scum accumulation. All wiring should be neatly bundled and placed out of the operating path of the float switches.

I. The septic tank and pump tanks should be measured for sludge and scum accumulation. This should occur every 1-3 years, the frequency depending on household usage and occupancy. More actively-used systems should be placed on the more frequent sludge/scum measurement schedule. This can easily be done as part of the annual maintenance. If sludge and scum levels warrant, have those tanks pumped.

IMPORTANT! If fiberglass or polyethylene tanks are used, it is important to monitor ground water levels before pumping septage or to schedule pumping of tanks for late Summer or early Fall to avoid tanks floating (this time period may differ depending upon weather conditions). Pumping concrete tanks during periods of high groundwater may also cause tank floating problems. The yearly inspection process will facilitate the scheduling of tank pumping to avoid emergency pumping situations. All tanks should be filled with tap water immediately after septage pumping is completed.

J. The effluent filter in the septic tank should be hosed off on a yearly basis, and whenever the septic tank is pumped. Systems operating above their design flows may require more frequent effluent filter cleaning.

K. **Effluent filters located in a recirculation tank should be checked a minimum of every six months for accumulation of slime growth.** If the pump is located in a pump vault, this slime growth may necessitate the removal and cleaning of the vault, pump and the effluent filter, if so equipped.

L. If the pump vault is removed, the vault should be filled with clean water from a garden hose as it is being lowered back into the septic tank. This will prevent the screen from being fouled with solids in the tank and will also make it easier to submerge.

M. All slime material hosed off of filters, pumps and vaults should be placed into the **inlet end of the septic tank.**

N. All tanks should be visually inspected for watertightness and structural soundness when maintenance is performed.

O. In the event of an alarm, the alarm can be silenced by pushing the red button on the outside of the control panel. In most cases the alarm will be due to a temporary high water situation caused by too much water entering the system at a particular time. This will be self correcting in most cases. If the alarm keeps coming on or if the red light on the outside of the panel stays on for a prolonged period of time after the alarm is silenced there may be a more serious problem such as a clogged effluent filter, "full" septic tank, or mechanical malfunction.

P. The high water alarm will come on if the volume of water used at a particular time is more than what is accommodated for discharge in the usual dosing process. An alarm may go on if the occupancy or water use of the house or facility is more than typical. These are referred to as "nuisance alarms" and do not mean there is a system problem. If the nuisance alarm persists, the dosing schedule and amounts can be changed to help correct the problem. In some cases, persistent alarms may indicate a more serious problem which needs to be addressed.

Q. At each visit, readings from elapsed run time meters, event counters, and water meters should be recorded on the data cards (usually stored in the electrical control panel).

R. At each site visit, a sample of the sand filter effluent should be collected to visually check for effluent clarity. This sample should be clear and odor-free.

Glossary of Wastewater Terms

Biochemical Oxygen Demand - Five Day (BOD_5): A five day laboratory test which determines the amount of dissolved oxygen used by microorganisms in the biochemical oxidation (breakdown) of organic matter. BOD concentrations are used as a measure of the strength of a wastewater.

Dosing Tank: A tank which collects wastewater and from which discharges it into another treatment or dispersal step; equivalent to a dosing chamber.

Drainfield (conventional): An area in which perforated piping is laid in drain rock-packed trenches for the purpose of distributing the effluent from a wastewater treatment unit.

Distribution Laterals (pressure dosed): Usually small diameter PVC pipe with orifices evenly spaced, used to uniformly distribute wastewater over a treatment zone in an enclosed component or drainfield.

Effective (Particle) Size, (E.S.= D_{10}): The size of a sand filter media grain in millimeters, such that 10% by weight of the media sample is smaller.

Effluent: Liquid that is discharged from a septic tank, filter, or other on-site wastewater system component.

Fecal Coliform (bacteria): Coliform bacteria specifically originating from the intestines of warm-blooded animals, used as an indicator of pathogenic bacterial contamination.

Filter: A device or structure for removing suspended solid, colloidal material, or BOD from wastewater.

Filter Fabric: Any man-made permeable textile material used with foundations, soil, rock, or earth.

Filter Media: The material through which wastewater is passed for the purpose of treatment.

Single Pass Sand Filter: A sand filter in which primary treated wastewater is applied periodically, providing intermittent periods of wastewater application, followed by periods of drying and oxygenation of the filter bed. Wastewater applied to the surface of a single pass sand filter flows through that filter media once before going onto the next treatment step.

Particle Size: The diameter (in millimeters) of a soil or sand particle, usually measured by sedimentation or sieving methods.

Particle Stratification: Separation of particles according to size due to movement of particles in either air or water.

Recirculating Sand (Gravel) Filter: A sand (gravel) filter which processes liquid waste by mixing sand filter filtrate with incoming septic tank effluent and recirculating it several times through the sand filter media before discharge to a final treatment/dispersal unit.

Sand Filter: A biological and physical wastewater treatment unit consisting (generally) of an underdrained bed of sand to which primary treated effluent is periodically applied. Filtrate collected by the underdrain(s) is then transferred from the filter to an approved soil absorption system or other treatment step. Pretreatment of wastewater prior to the sand filter step, can be provided by either a septic tank or another approved treatment device.

Sandy Loam: Soil in which the sand fraction is still quite obvious, containing 25% or more medium sand. It is dominantly a loam, which is composed of sand, silt, and clay particles.

Total Suspended Solids (TSS):, measure of solids that either float on the surface of, or are in suspension in, water or wastewater. A measure of wastewater strength, often used in conjunction with BOD_5.

Uniformity Coefficient (C.U.): A numeric quantity which is calculated by dividing the size of a sieve opening which will pass 60% by weight of a sand media sample by the size of the sieve opening which will pass 10% by weight of the same sand media sample. Note that 50% of the sample is retained between the two. The uniformity coefficient is a measure of the degree of size uniformity of the sand particles in sand media sample. As the U.C. value approaches one (1), the more uniform in particle size the sand media is. The larger the U.C., the less uniform the particle size.

$$CU = \frac{\text{Particle Diameter}_{60\%}}{\text{Particle Diameter}_{10\%}} = \frac{D_{60}}{D_{10}}$$

Wastewater: Water-carried human excreta and/or domestic waste from residences, buildings, industrial establishments or other facilities.

Acknowledgments

This document was based on the regulations and guidelines developed for the states of Washington and Oregon. Those documents are *"On-Site Sewage Disposal Rules"*, State of Oregon, Department of Environmental Quality, April 1, 1995 and *"Guidelines for Sand Filters"*, Washington State Department of Health, Technical Review Committee, June, 1996.

The publication entitled "*Pressure-Dosed Sand Filter Pretreatment Systems*" North Carolina Innovative Wastewater System No. IWWS-97-1, dated May 1, 1997 by Michael Hoover was also used as a source.

The media sizing criteria as used in Figures10-12 was adapted from information provided by Orenco Systems, Inc., Sutherlin, OR, and from the Washington *"Guidelines for Sand Filters"*.

Drafts of this document were reviewed and approved by the Technical Advisory Committee of the University of Rhode Island Cooperative Extension On-Site Wastewater Training Program.

The authors of this document thank the following outside reviewers for their helpful comments: To Be Completed.

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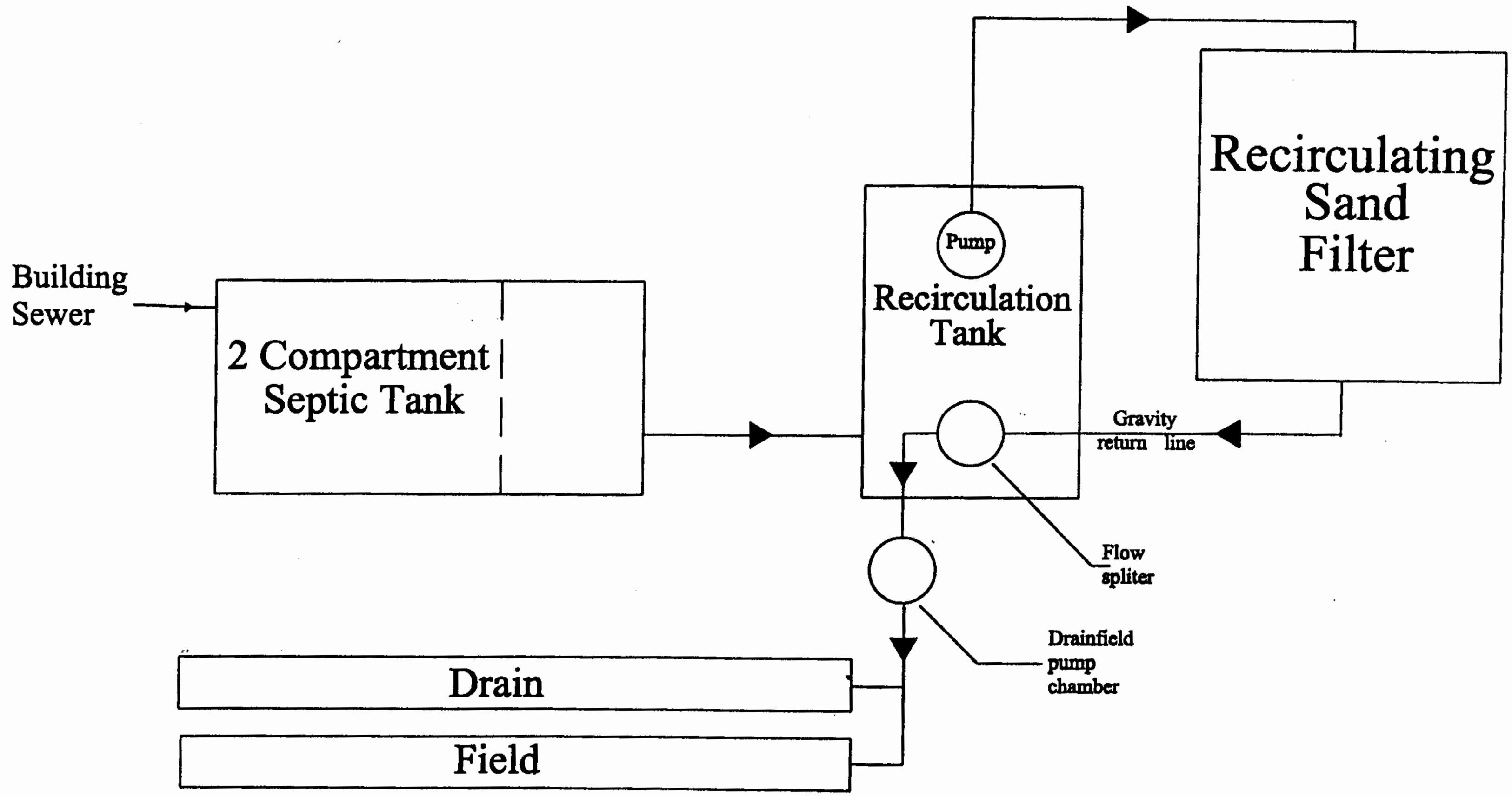


Figure 1: Schematic of a recirculating sand filter.

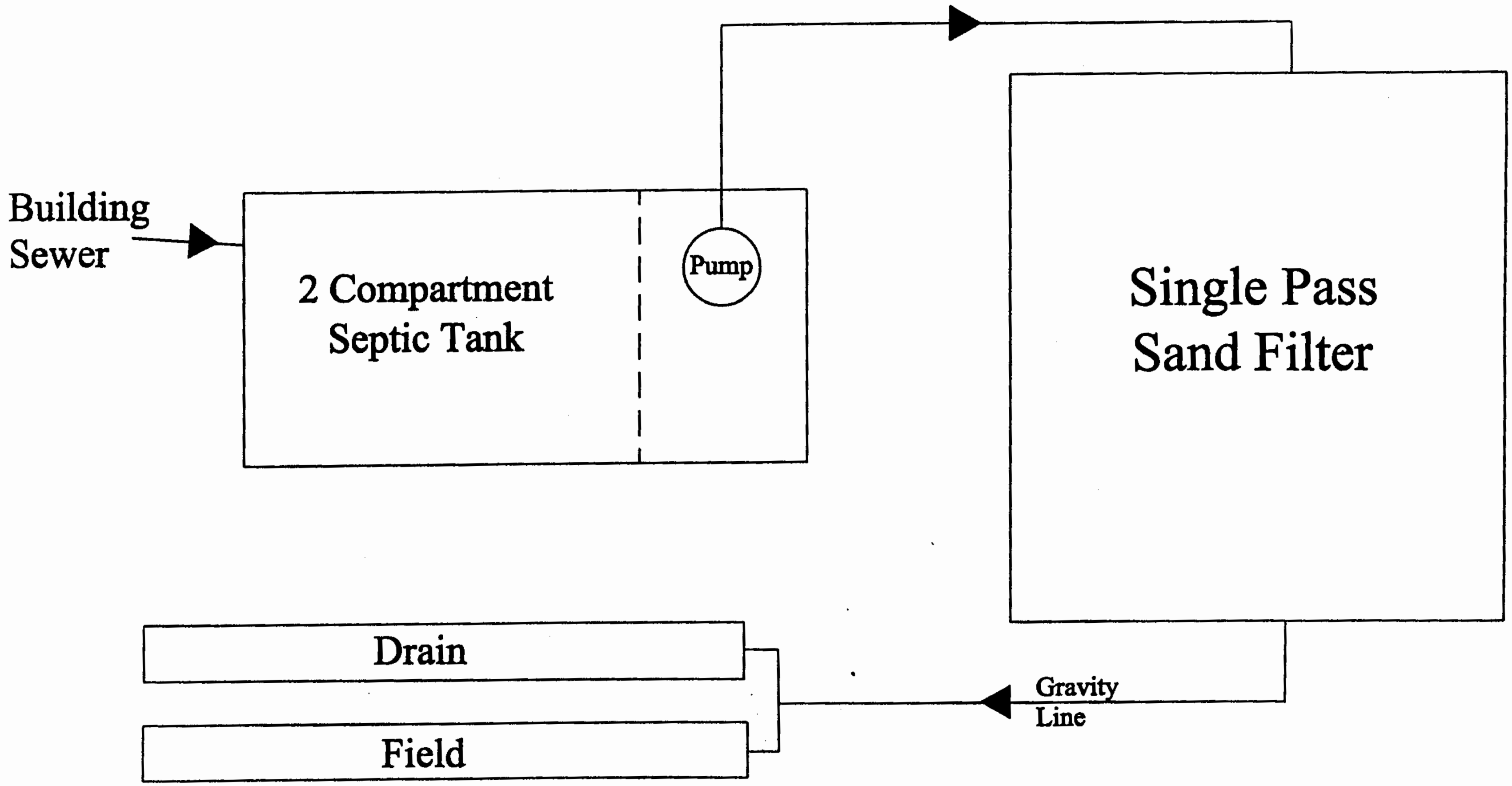


Figure 2A: Single pass sand filter with gravity drainfield.

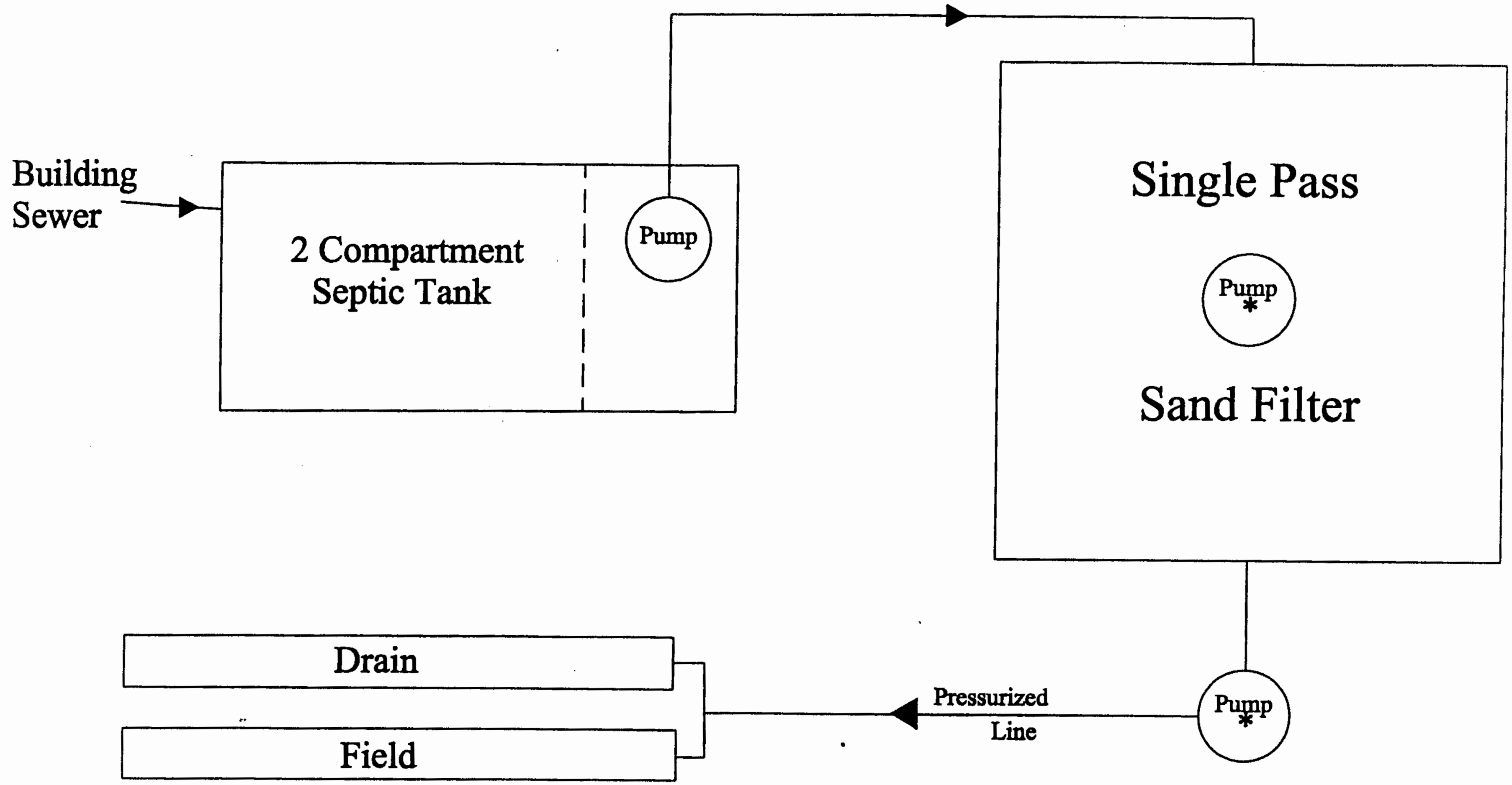


Figure 2B: Schematic of single pass sand filter with pressurized drainfield.
* Possible pump vault locations for pressurized drainfield.

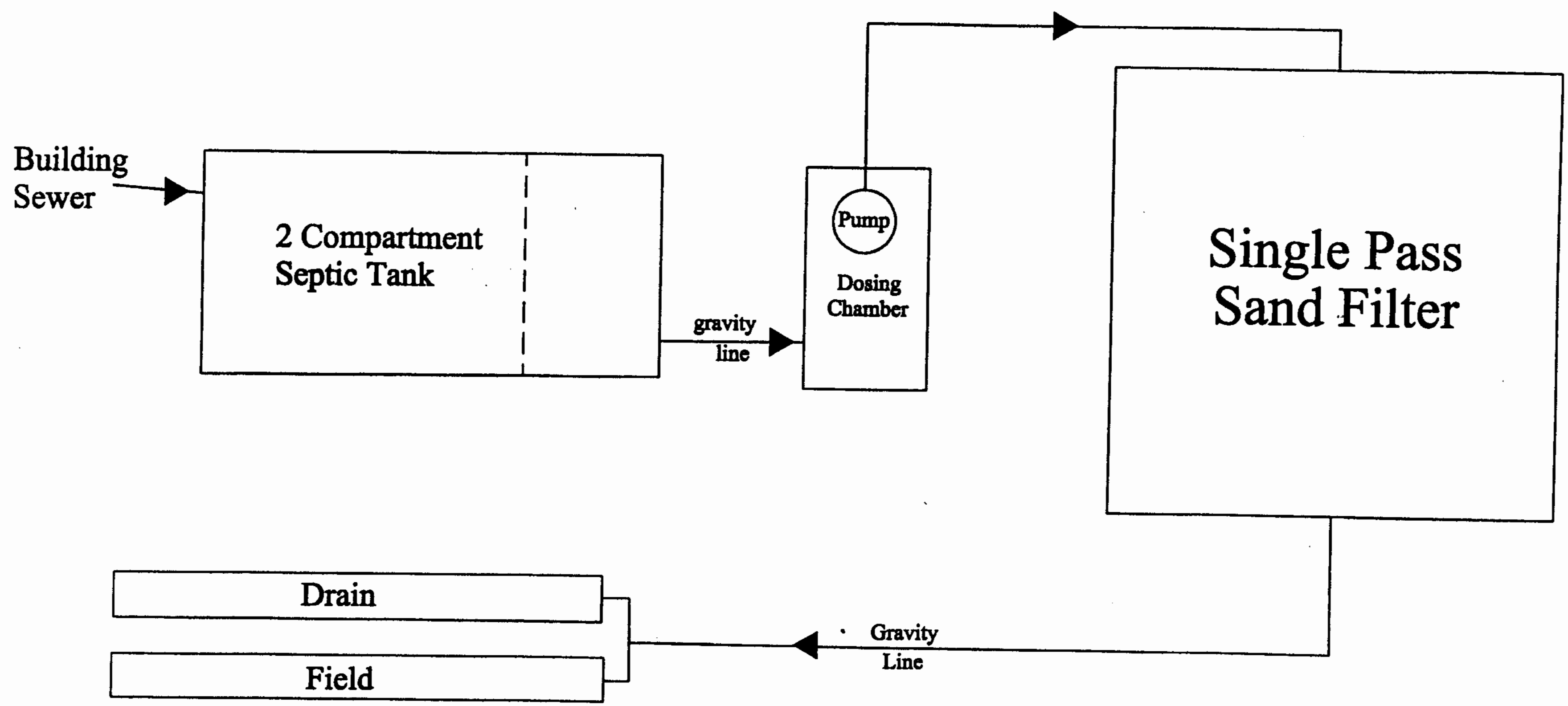


Figure 2C: Schematic of a single pass sand filter with separate dosing chamber and gravity discharge to drainfield.

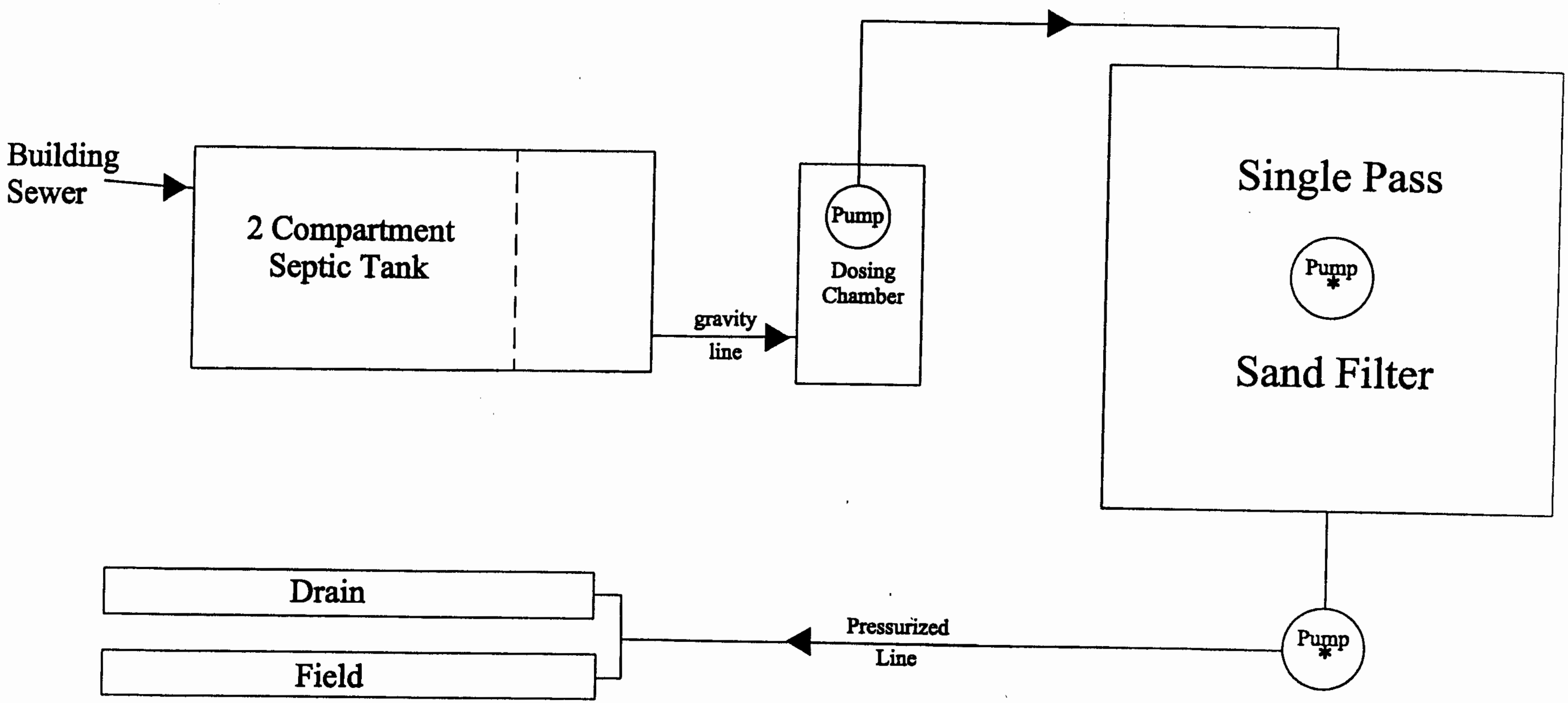


Figure 2D: Scematic of single pass sand filter with separate dosing chamber and pressurized discharge to drainfield.

*Possible pump vault locations for pressurized drainfield .

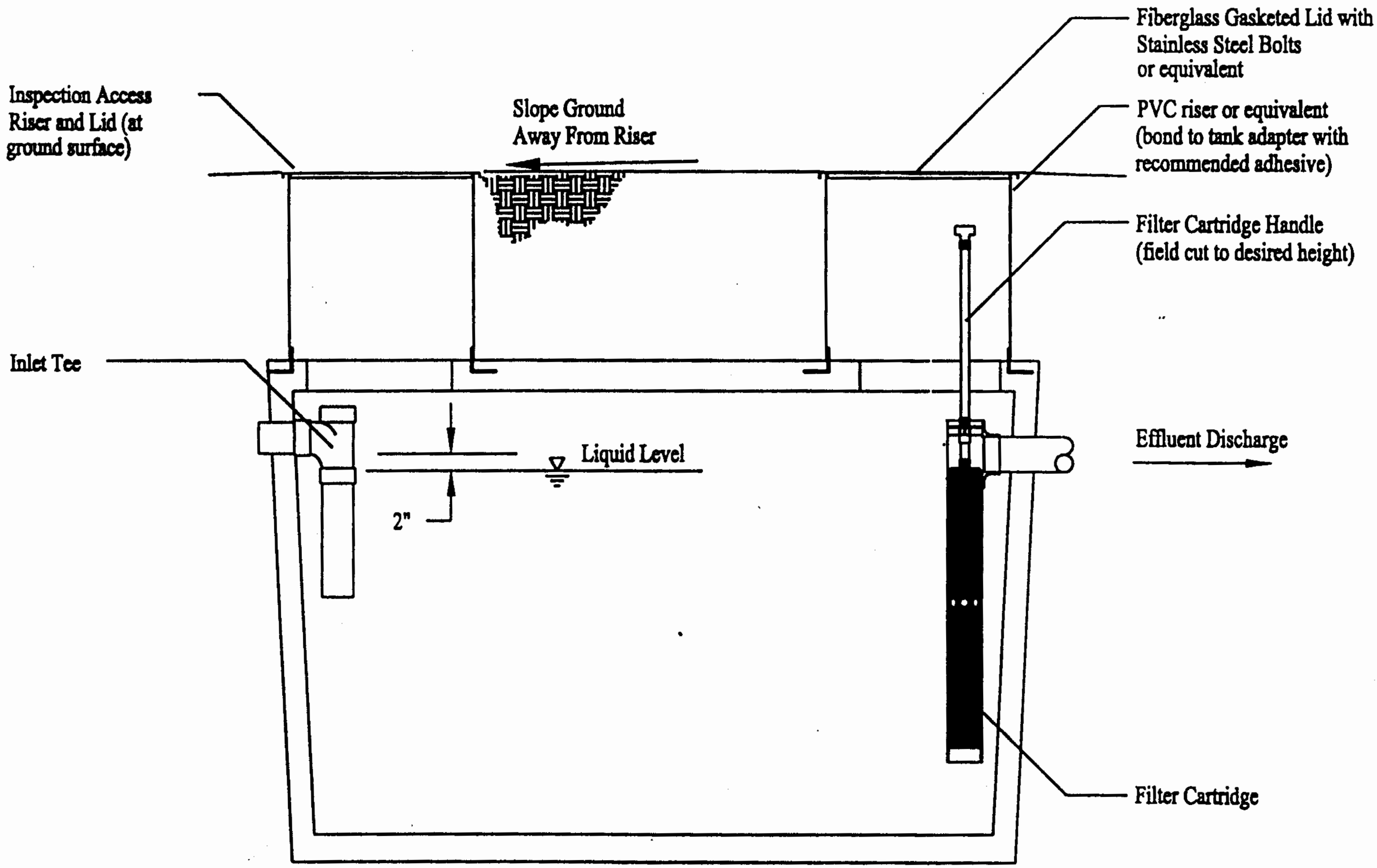


Figure 3A: Single compartment septic tank with effluent filter.

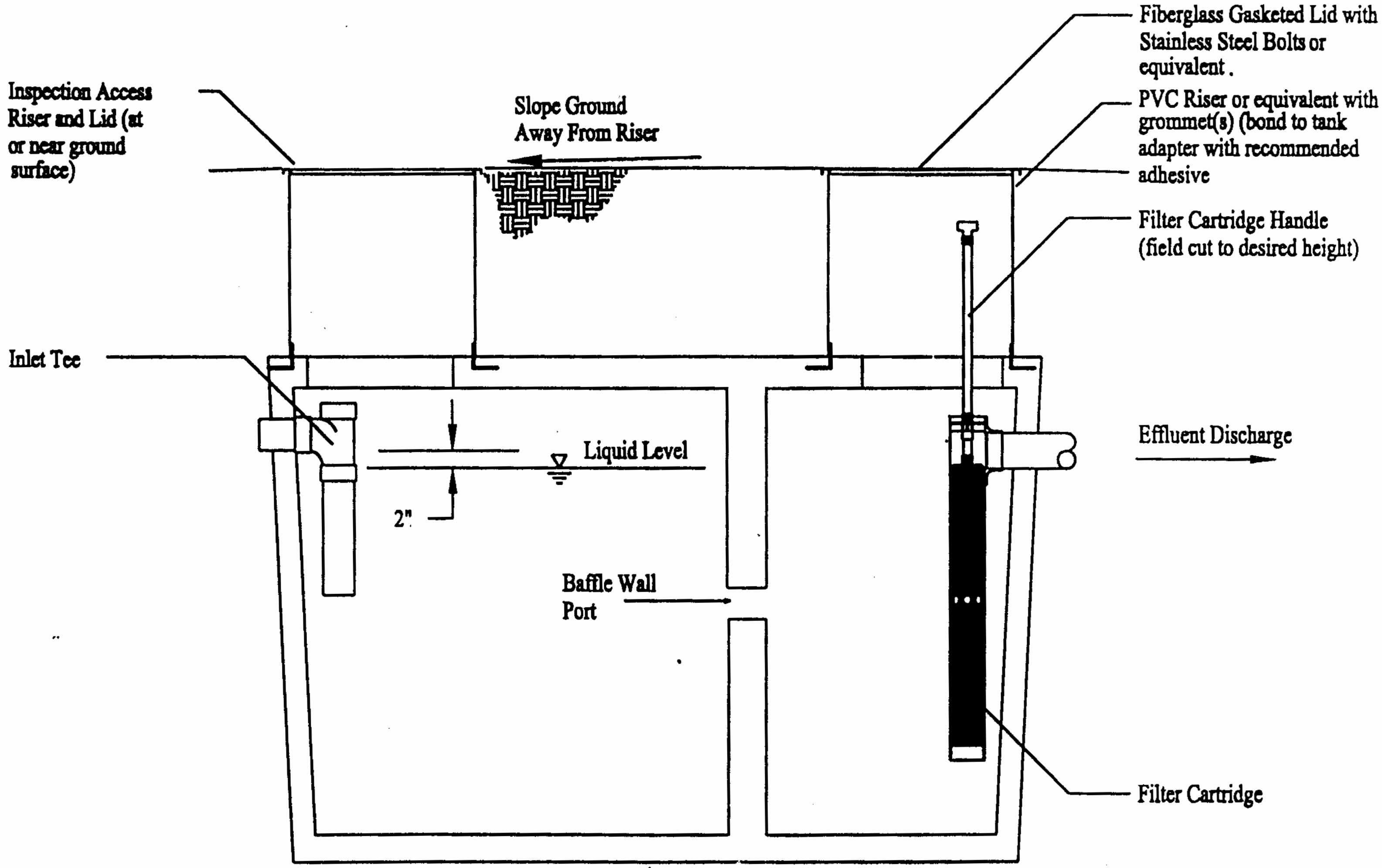


Figure 3B: Two compartment septic tank with effluent filter.

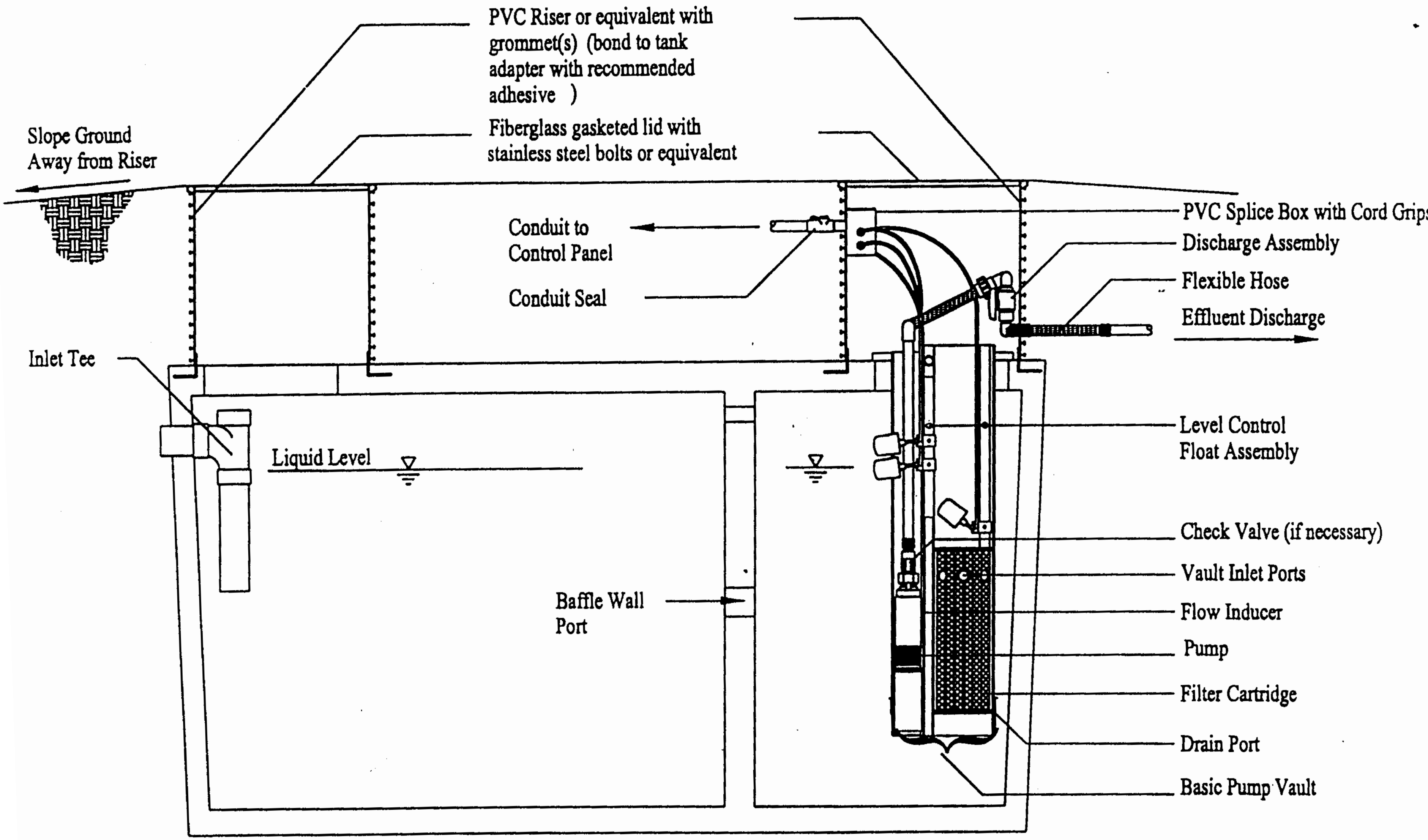


Figure 4 Two compartment septic tank with pump vault.

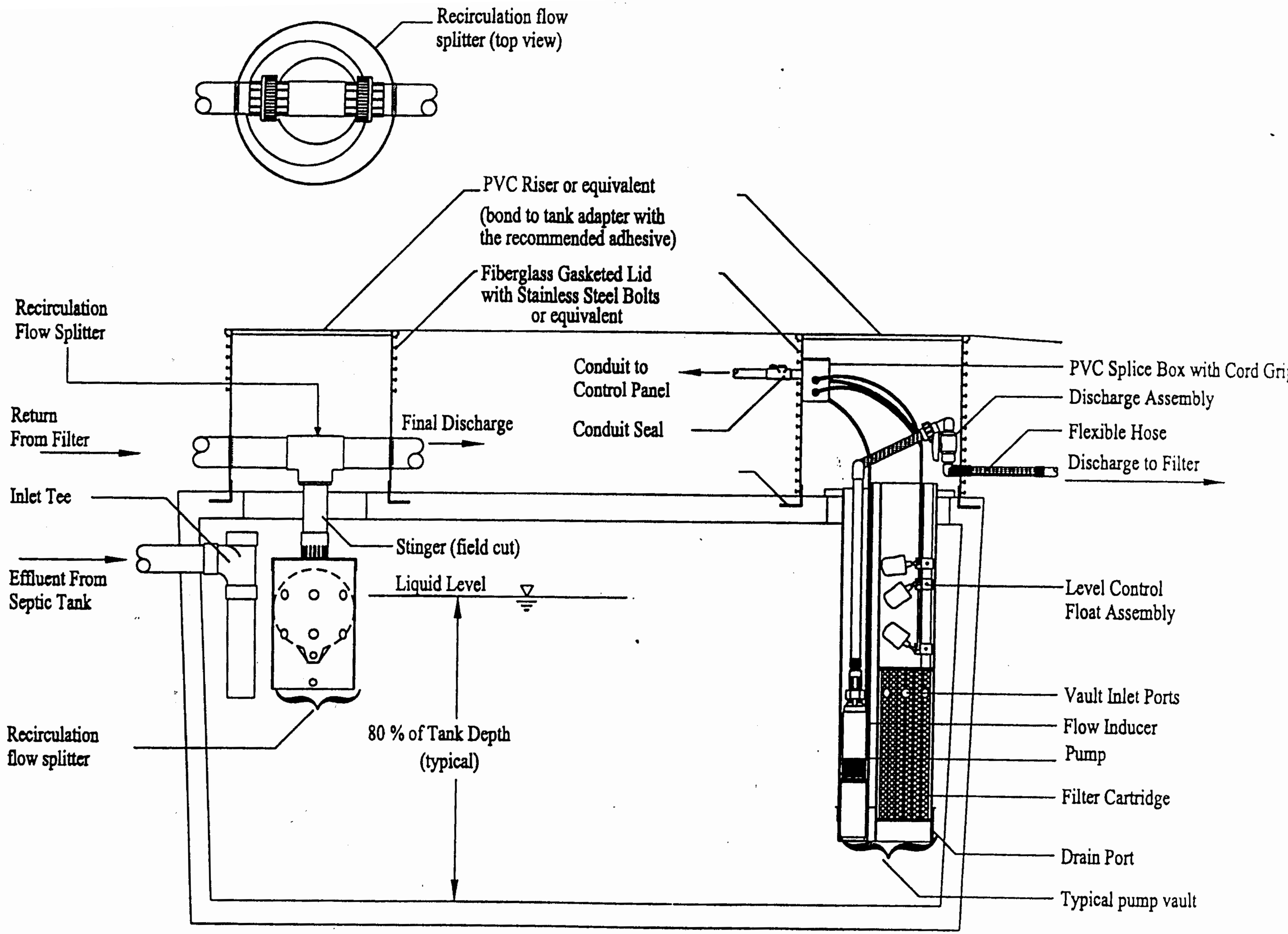


Figure 5: Recirculation tank.

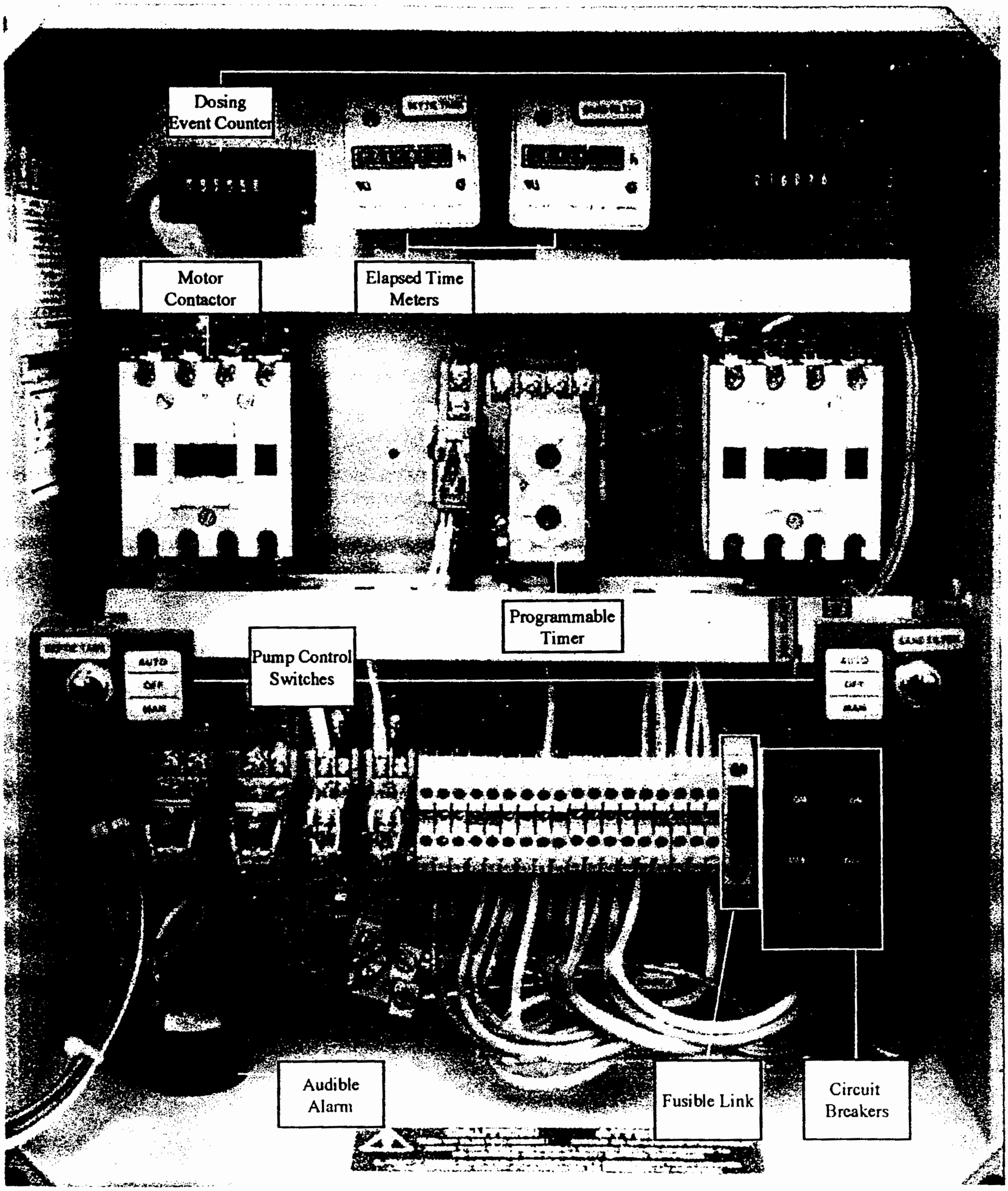
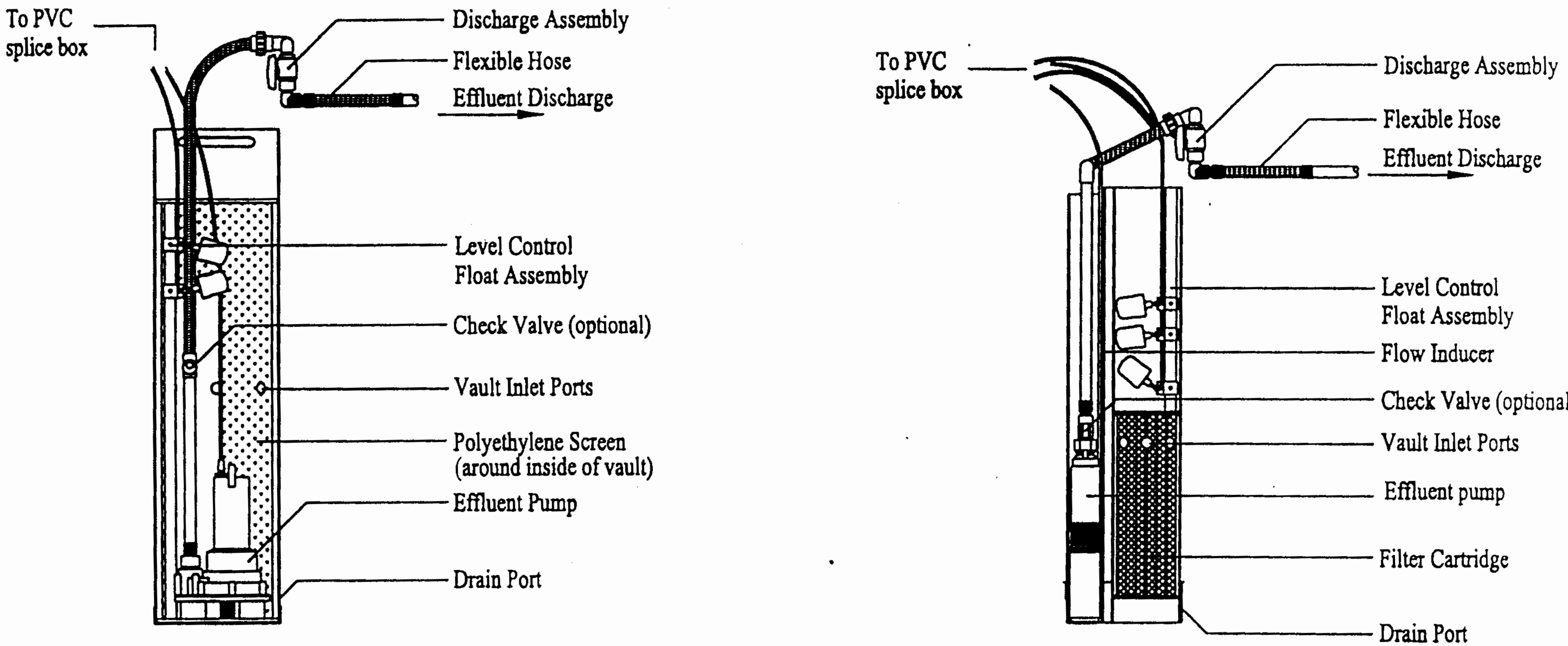


Figure 6: Electrical control panel box.



Pump vault with centrifugal pump.

Pump vault with high head turbine pump.

Figure 7: Typical pump vault assemblies.

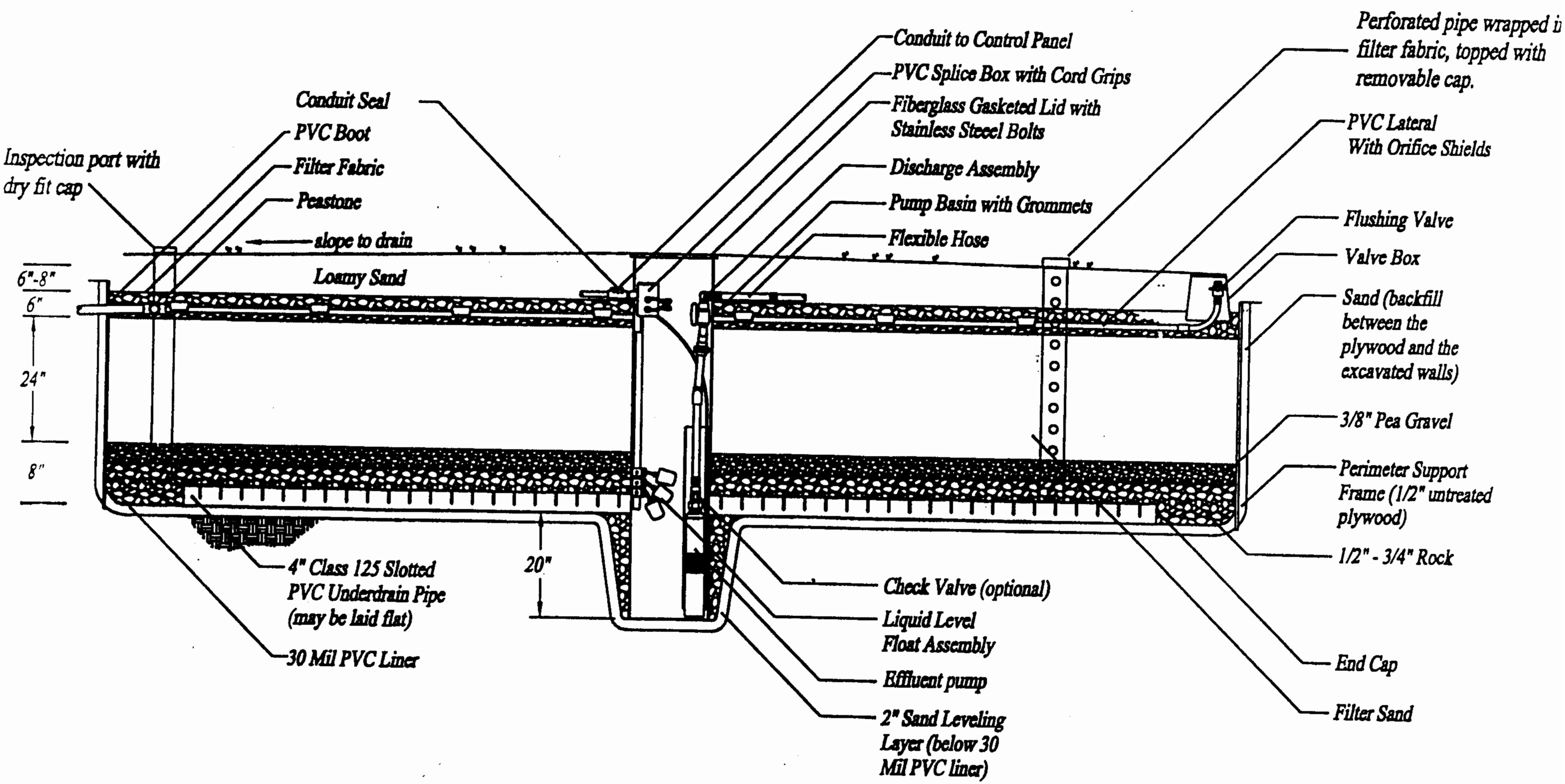


Figure 8A: Single pass sand filter with pump discharge (cross section).

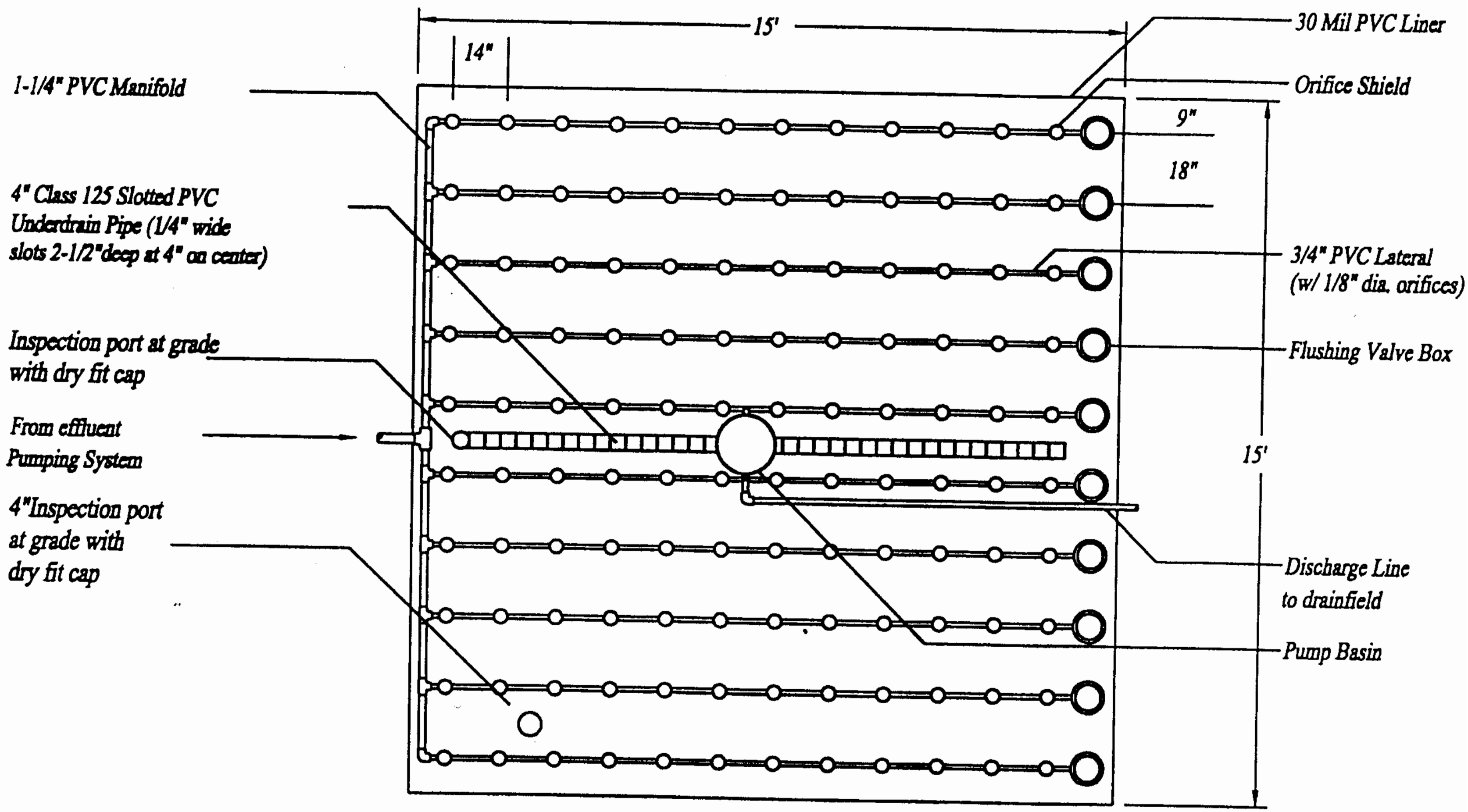


Figure 8B: Single pass sand filter with pump discharge (plan view).

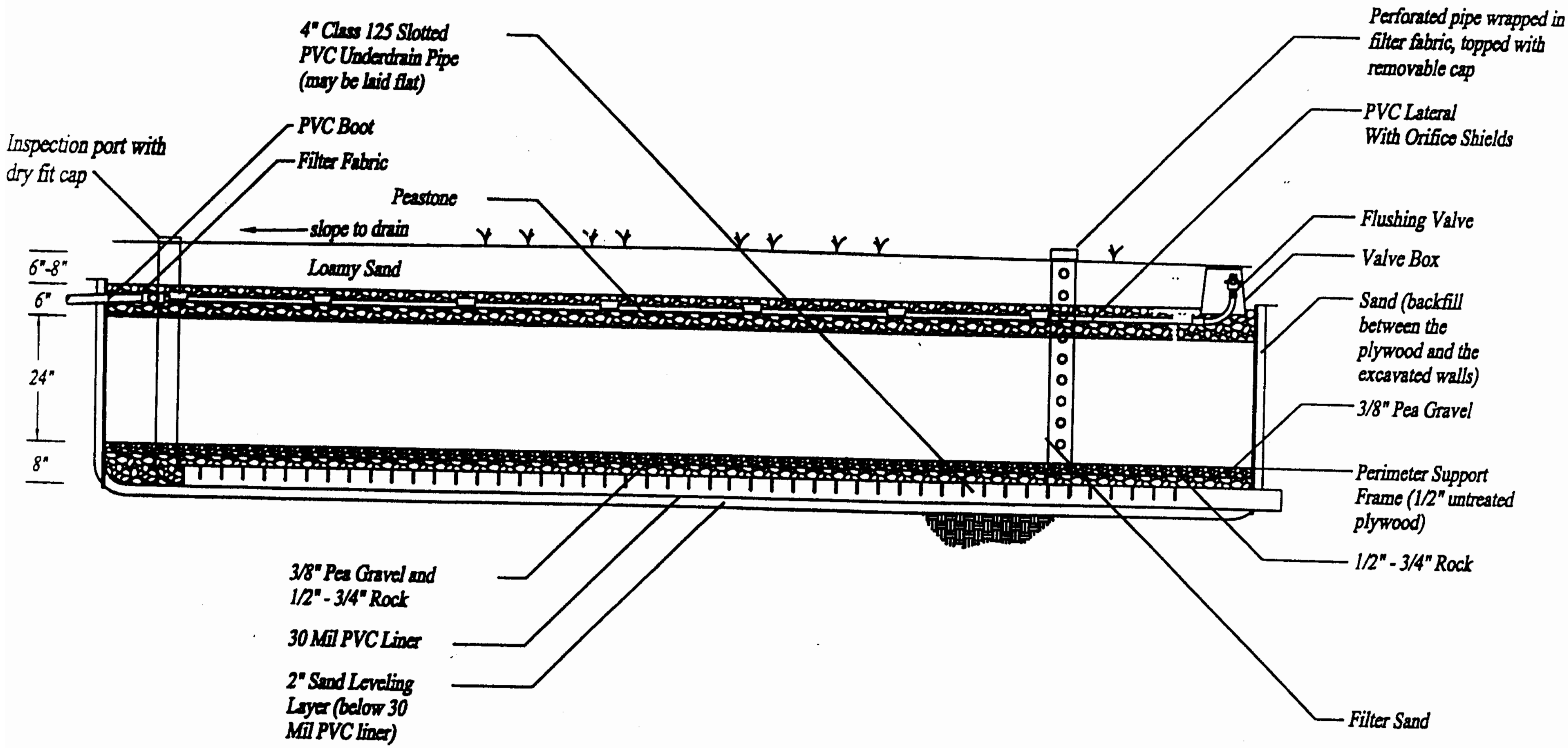


Figure 8C: Single pass sand filter with gravity discharge (cross section).

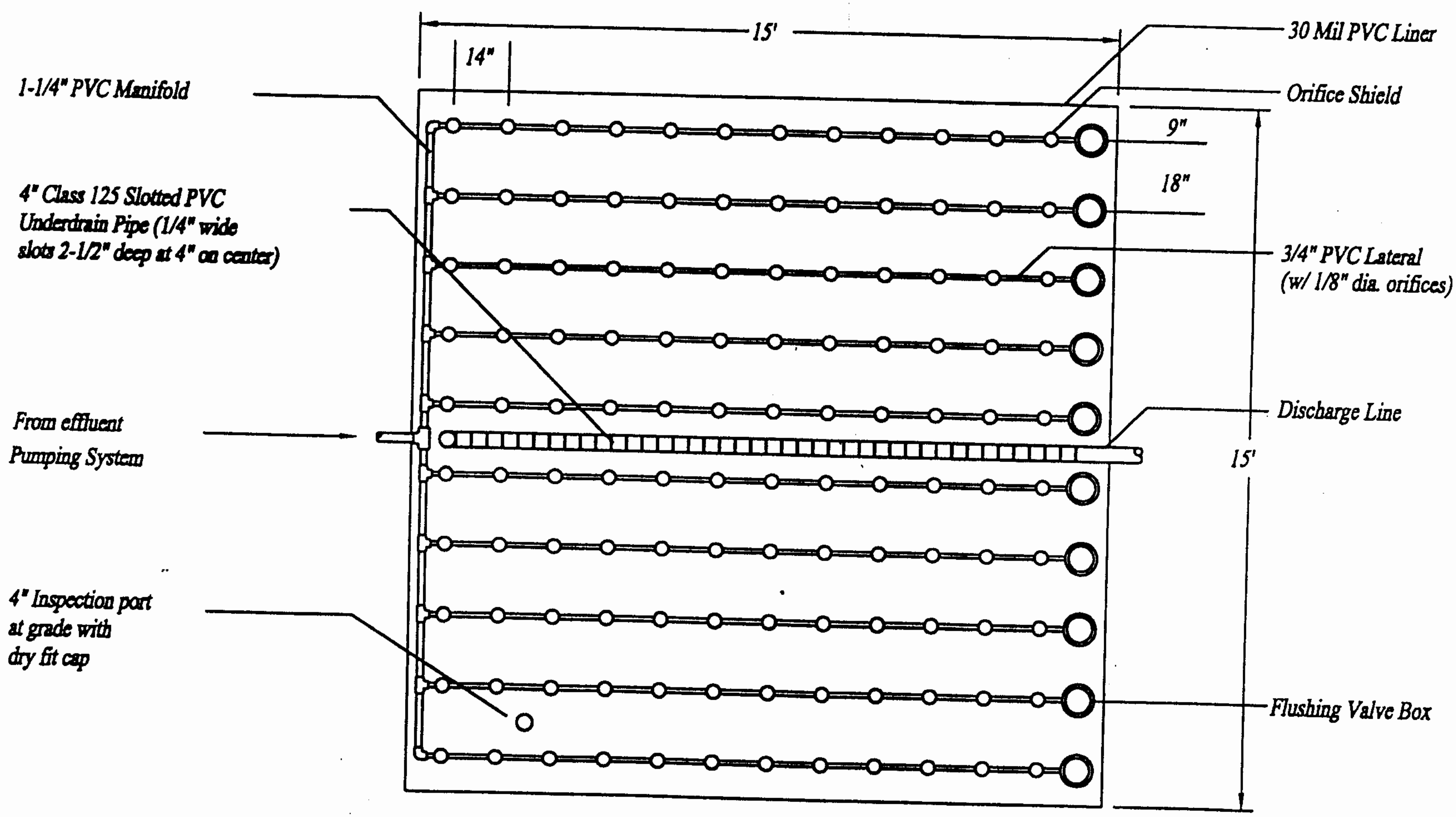


Figure 8D: Single pass sand filter with gravity discharge (plan view).

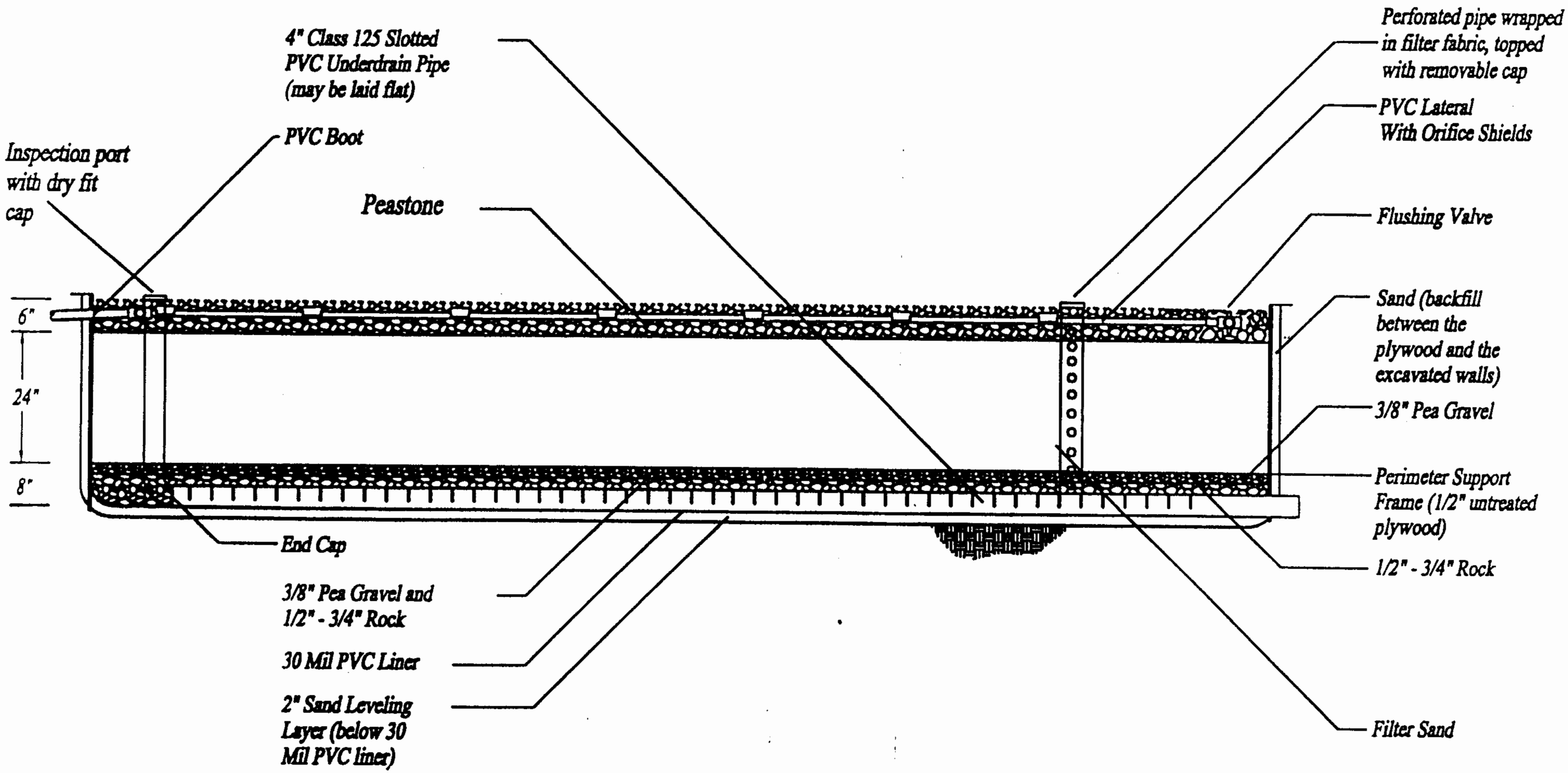


Figure 8E: Recirculating sand filter with gravity discharge (cross section).

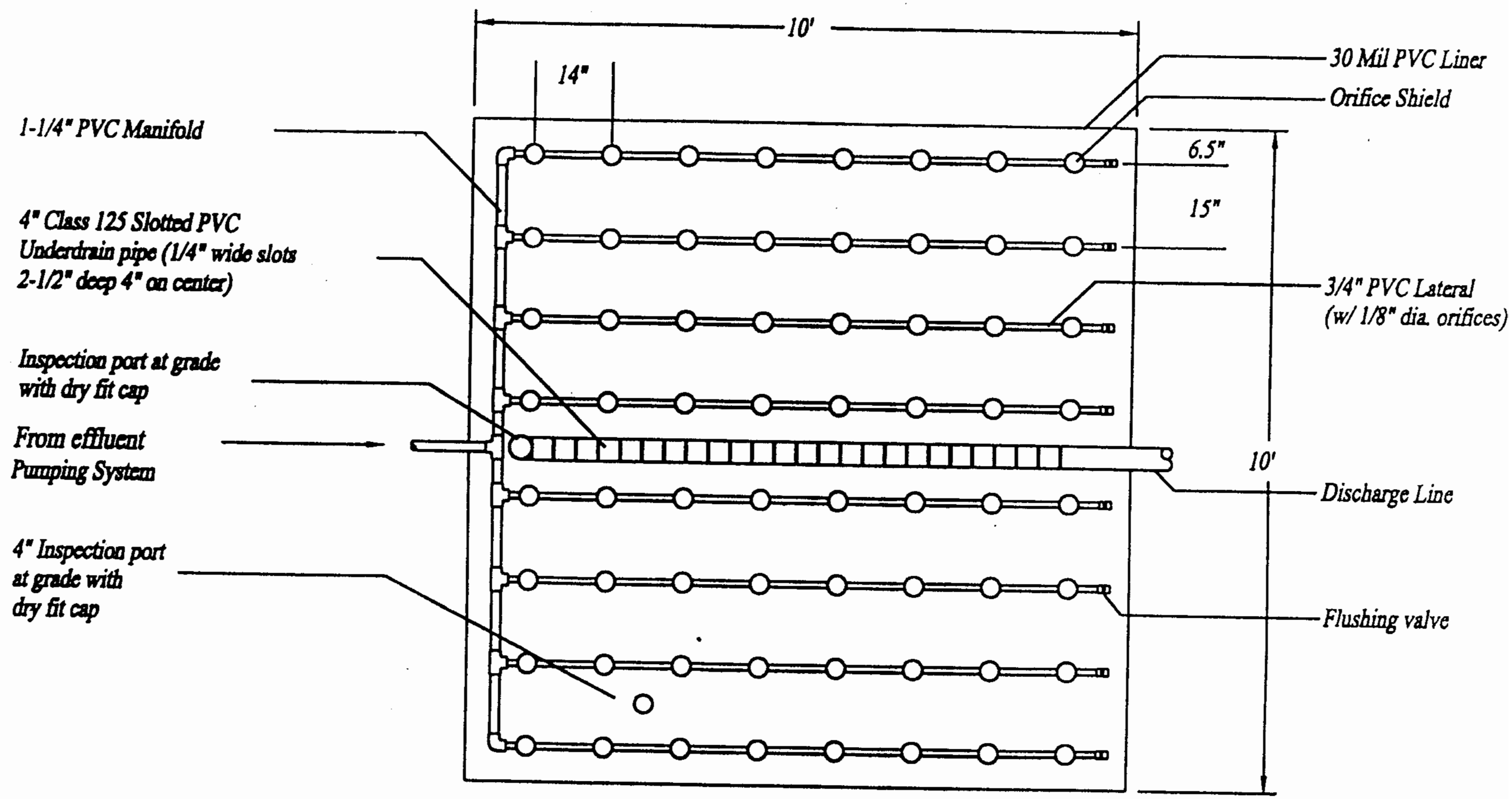


Figure 8F: Recirculating sand filter with gravity discharge (plan view).

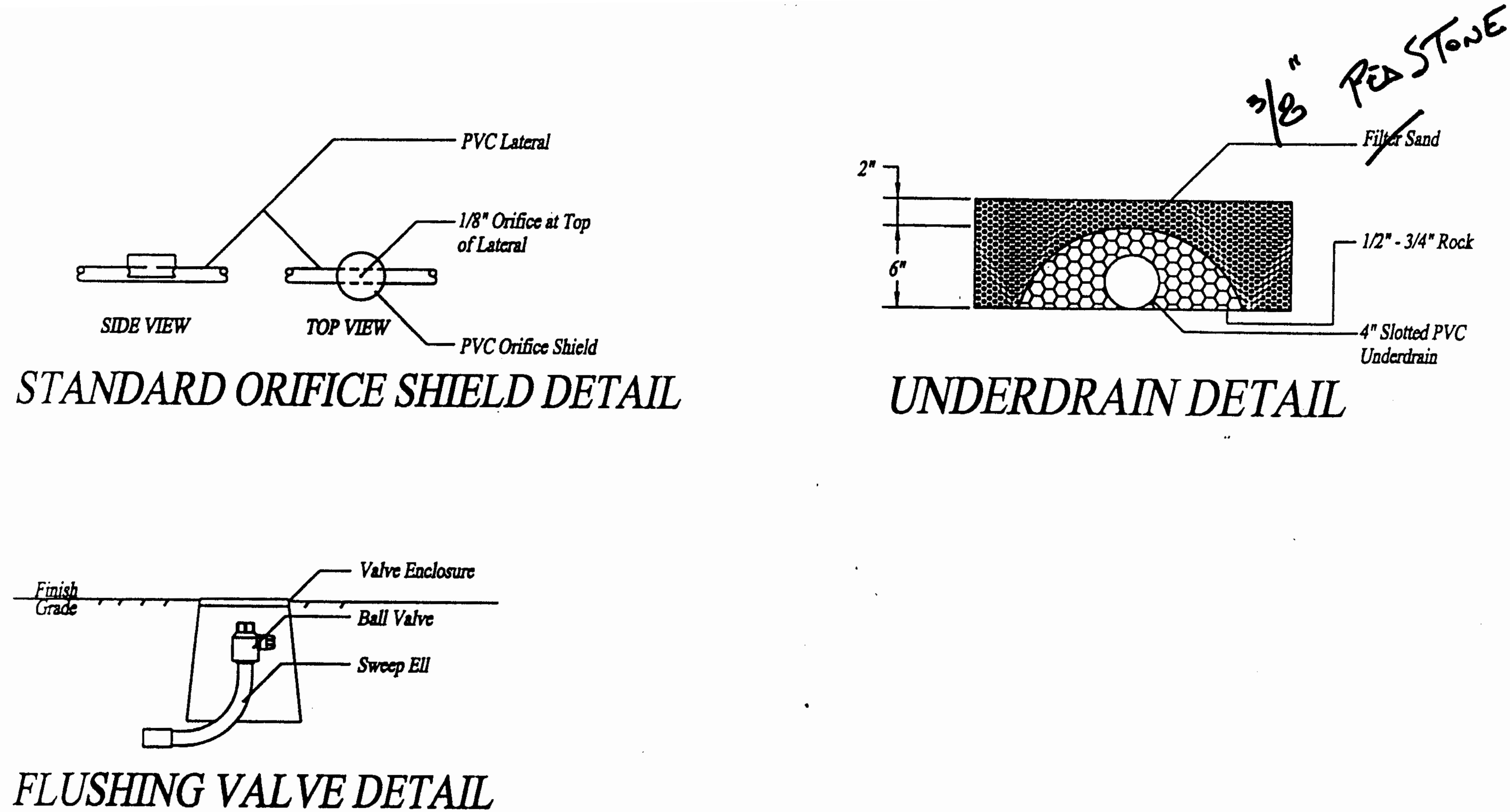


Figure 9: Schematic of sand filter components.

Figure 10: Low rate single pass sand filter media specifications. (Design loading rate=1.25 gal/sq.ft./day; based upon forward flow)

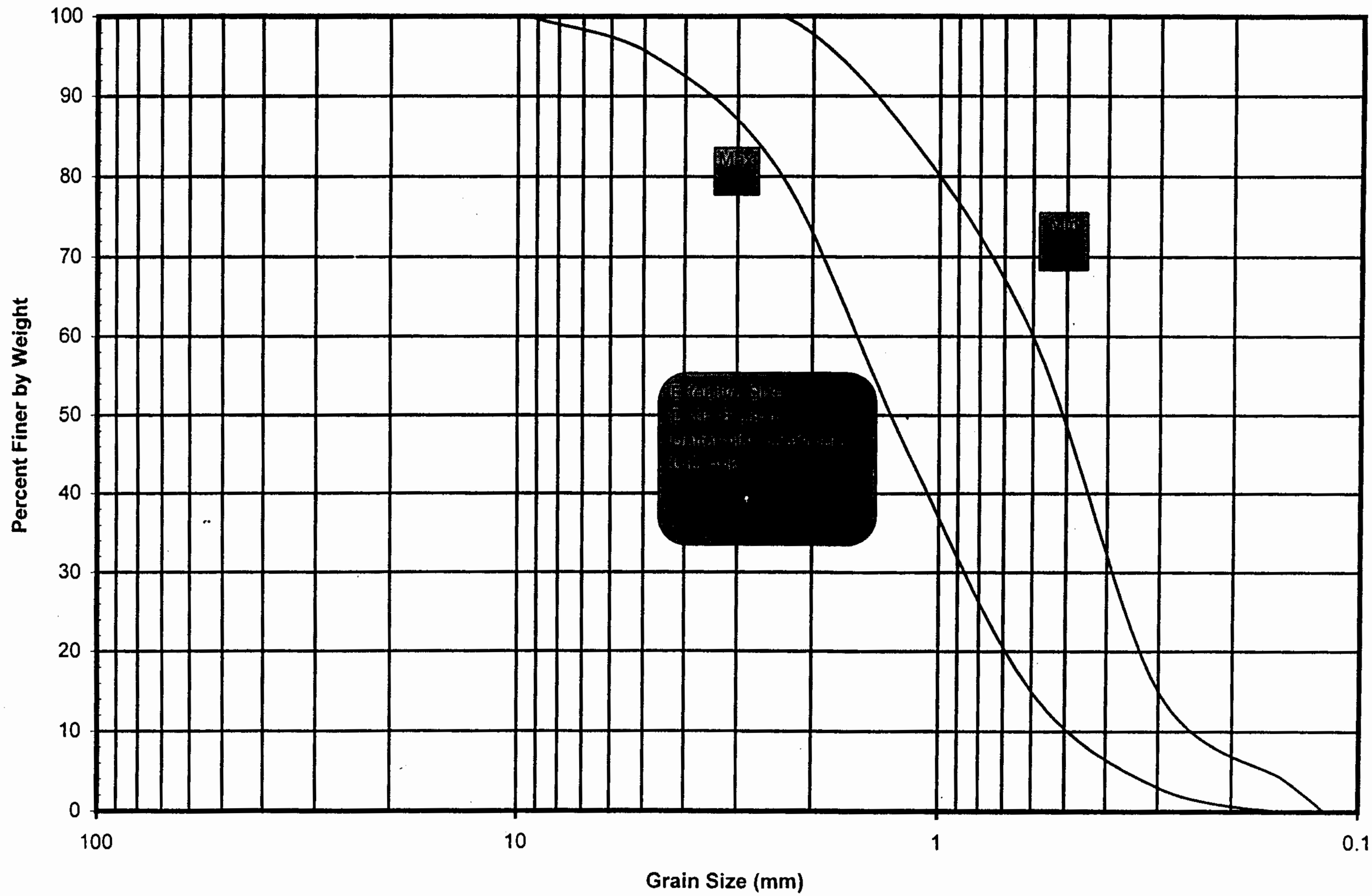


Figure 11: High rate single pass sand filter media specifications. (Design loading rate=2.50 gal/sq.ft./day; based upon forward flow)

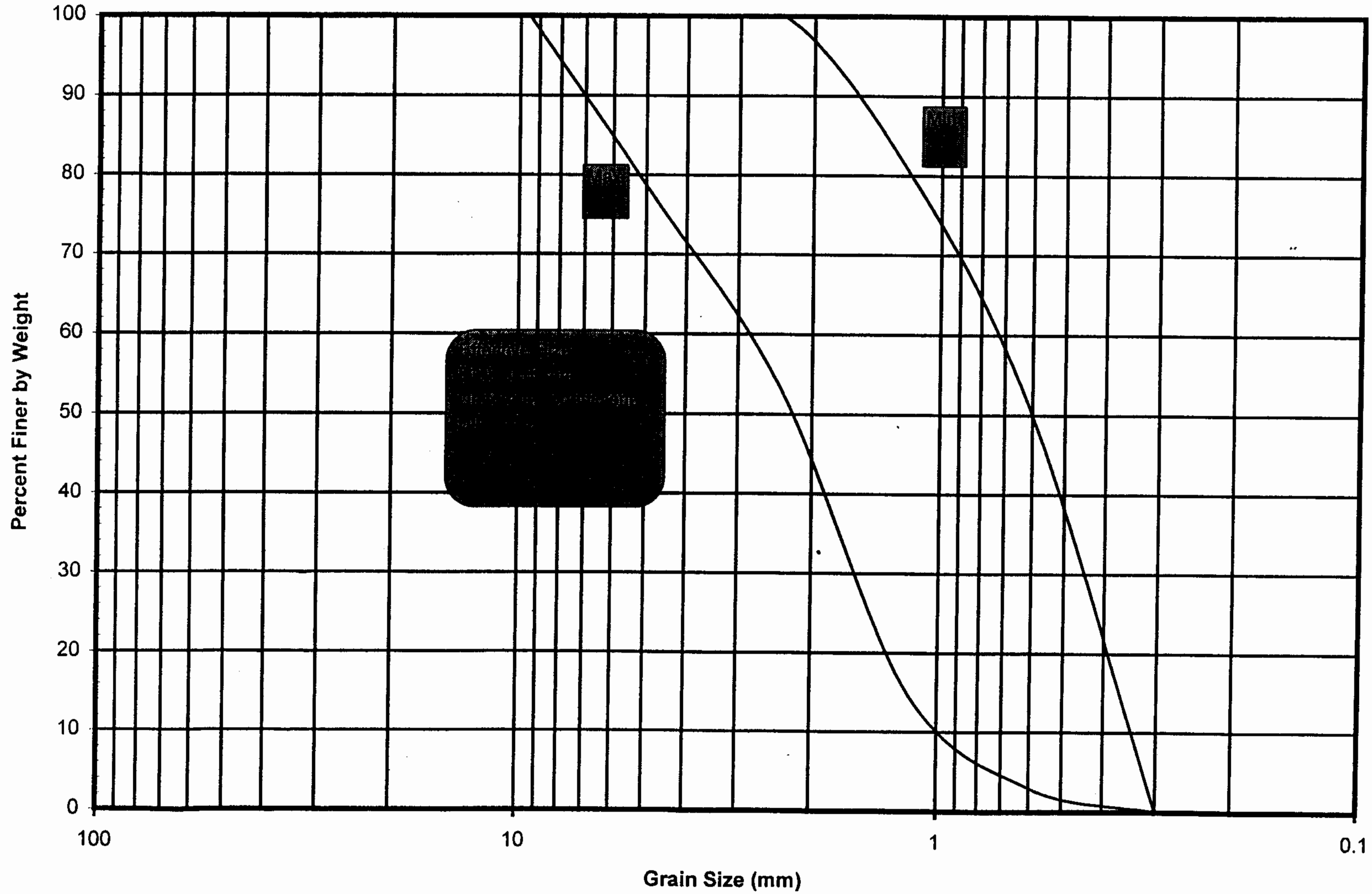
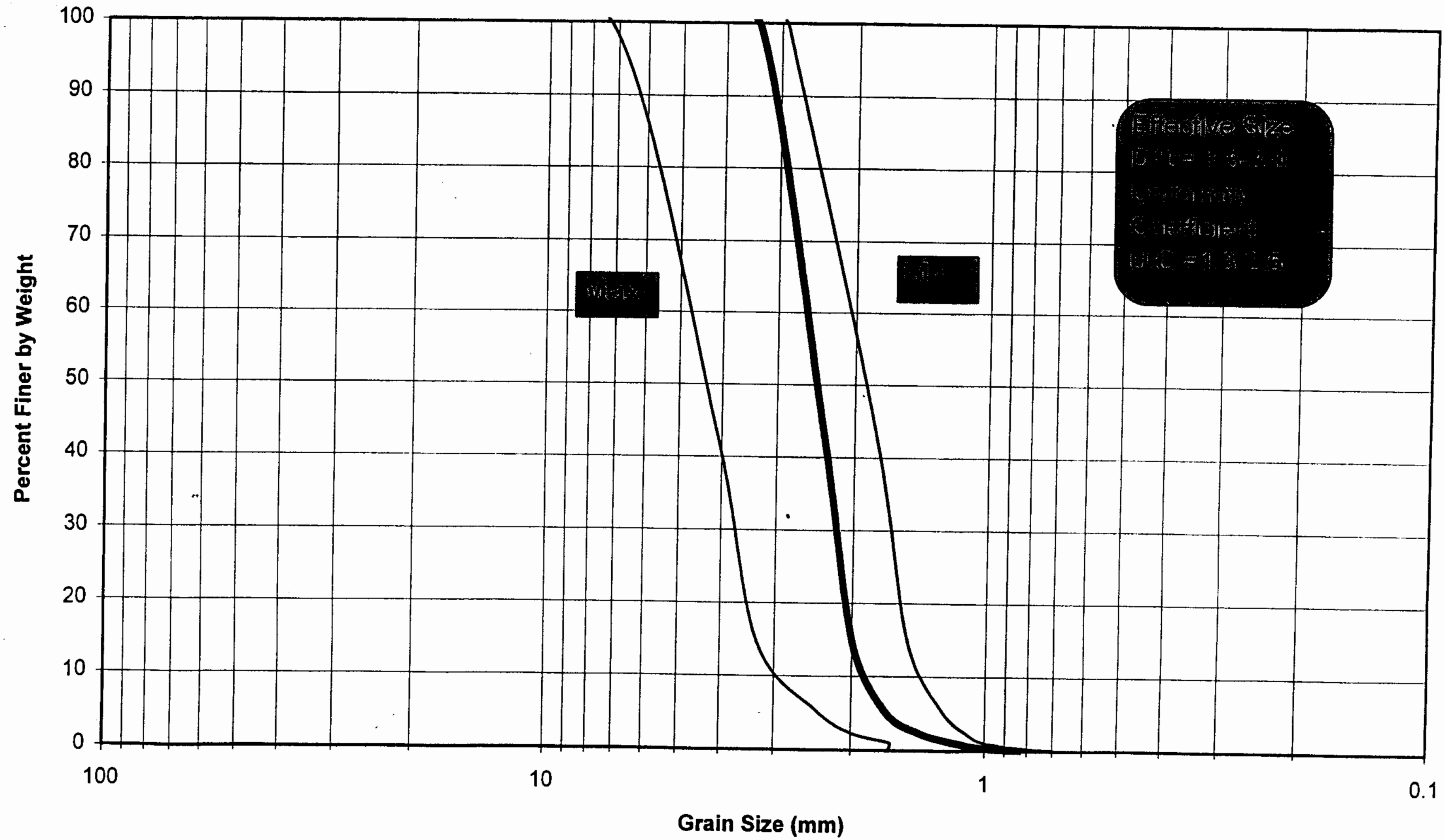


Figure 12: Recirculating sand filter media specifications. (Design loading rate=5.0 gal/sq.ft./day; Based upon forward flow.)



Appendix A

Drawings of I/A Trench/Chamber/Bed with no Treatment Enhancement

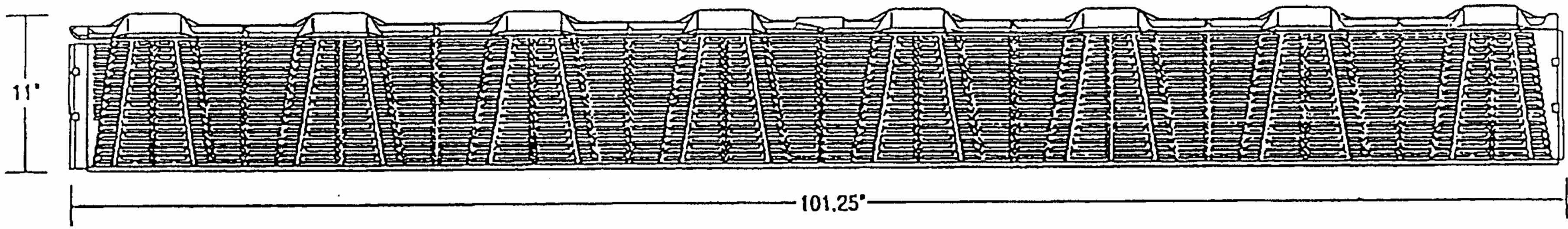
A-1: INFILTRATOR SYSTEM

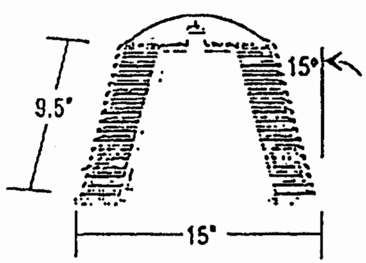
A-2: BIODIFFUSER Chamber

A-3: CULTEC

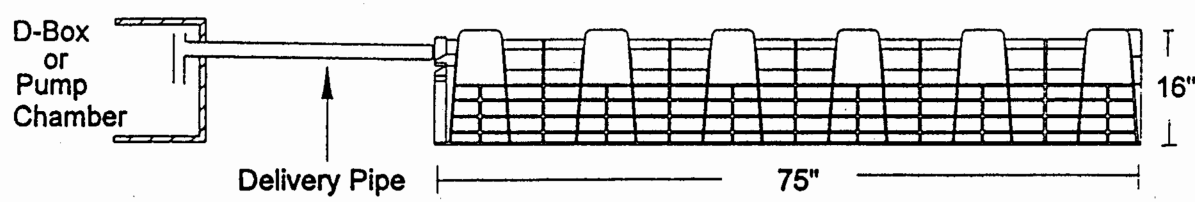
A-4: ENVIROCHAMBER

THE EQUALIZER 24™

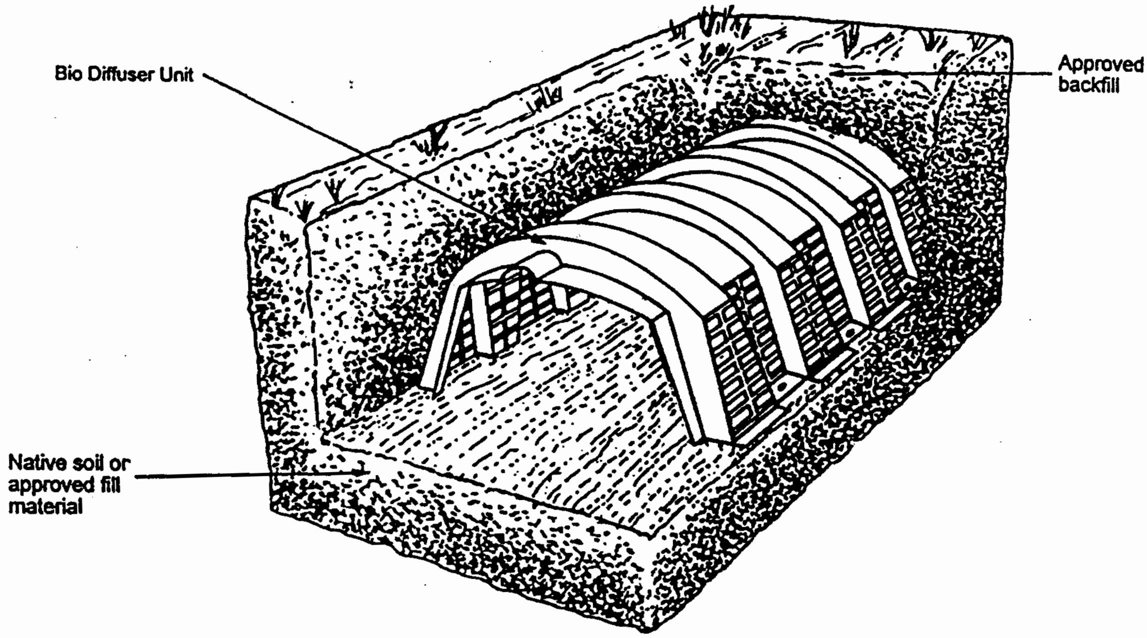




Equalizer 24 Chamber	
Size	15" x 101.25" x 11"
Weight	23 lbs.
Volume	33.3 gal./4.45 ft³



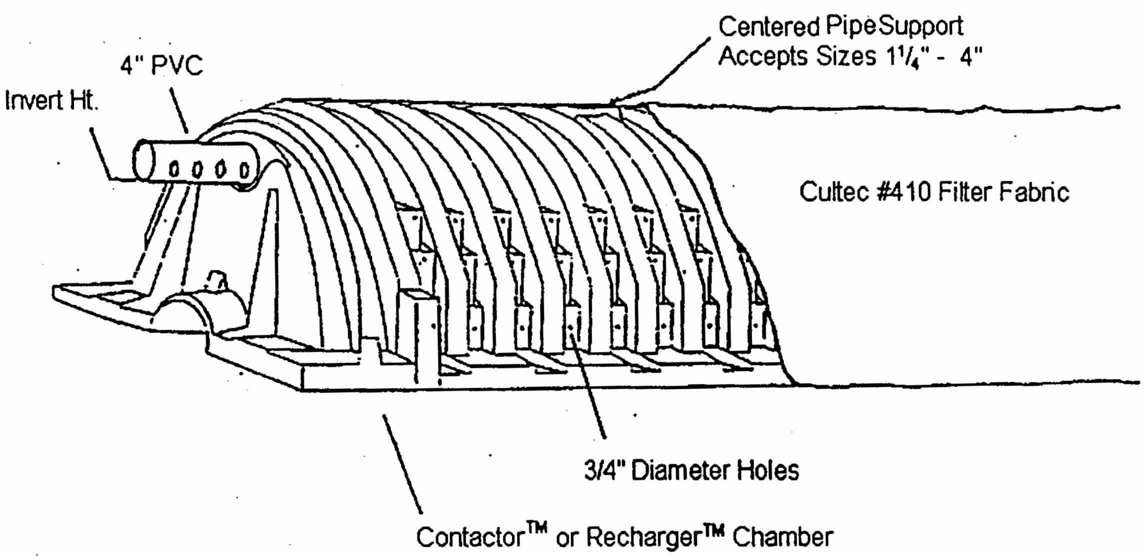
Side view of High Capacity Infiltrator (after, Infiltrator Systems, Inc.)



BioDiffuser™ chamber in a typical trench configuration (modified, PSA Inc.)

Description of Components

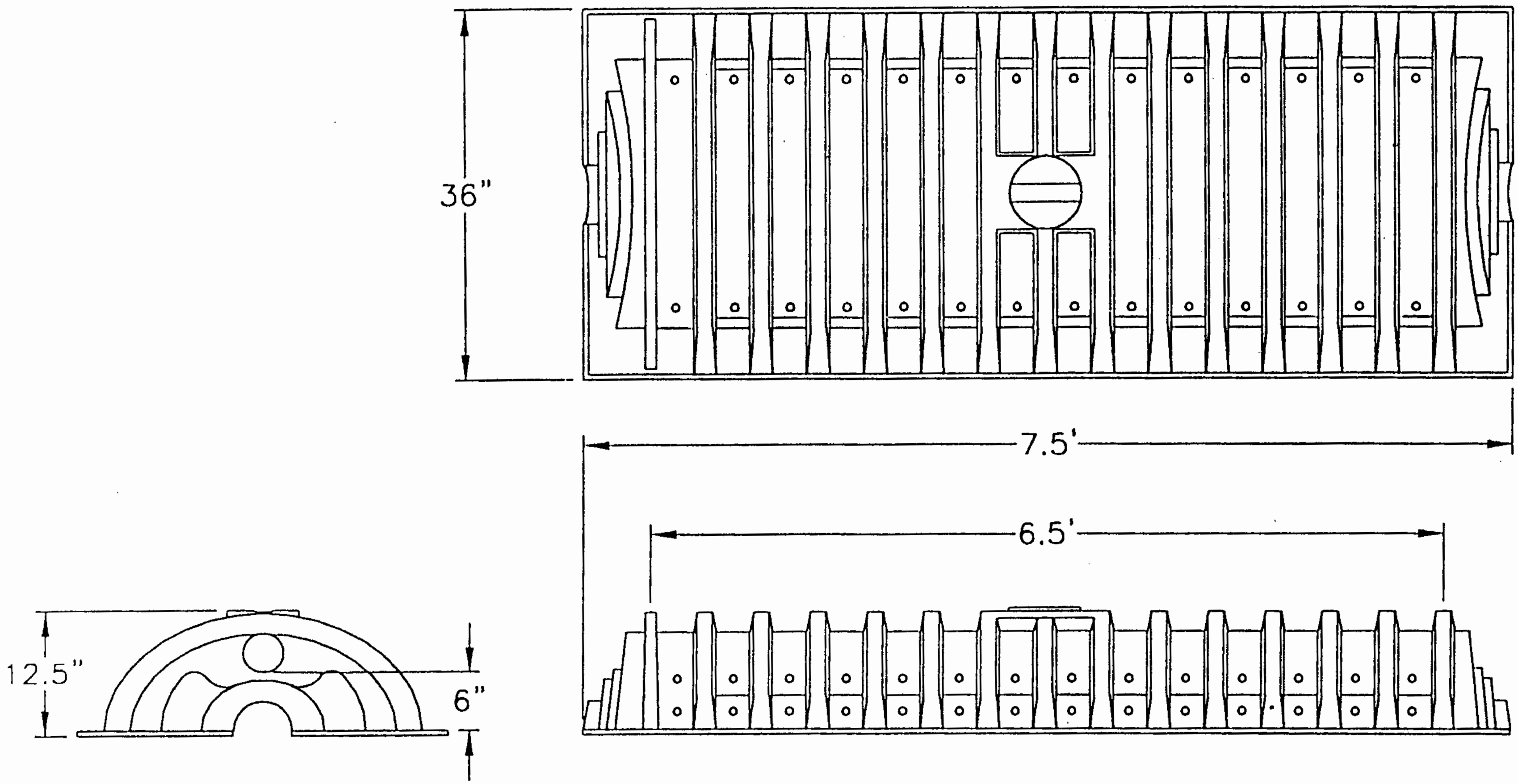
The standard model BioDiffuser™ chamber is molded from high density polyethylene (HDPE). Dimensions of the Standard model are 76" x 34" x 14" (L x W X H). The unit's sides are designed with slanted ribs permitting 9" of infiltrative surface per side below the invert of the distribution pipe. The side wall and bottom area provide 27.44 ft^2/unit in trenches. The rib design is reinforced and allows for installation without filter fabric. The chamber units have a load bearing rating by AASHTO of H-10 (16,000 lbs/axle) with 12" of soil cover and an AASHTO rating of H-20 (32,000 lbs/axle) with 17" of soil cover. Load bearing capacity make the units suitable for placement under trafficked areas or parking lots. The effective depth of the pipe invert is 9" providing 100 gallons of storage capacity per standard unit.



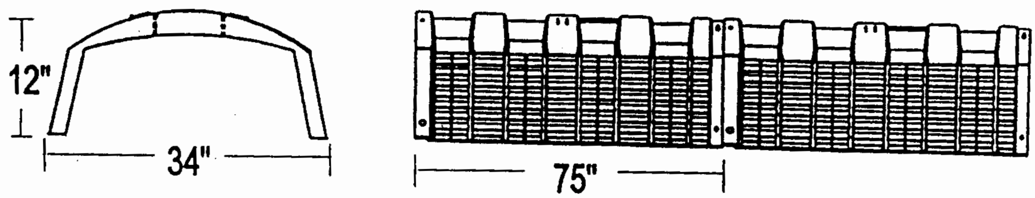
Cultec Contactor™ and Recharger™ System
(modified after, Cultec, Inc., Brookfield, CT)

Contactor 100

Length	7.5'
Lay Up Length	6.5'
Width	36"
Height	12.5"
Capacity	125 gal.
Weight	
H-10:	33 lbs.
H-20:	41 Lbs.



CULTEC, INC.
878 FEDERAL ROAD
BROOKFIELD, CT 06804



Front and side view of Standard EnviroChamber
(modified after, Hancor, Inc., Findley, OH)

Description of Components

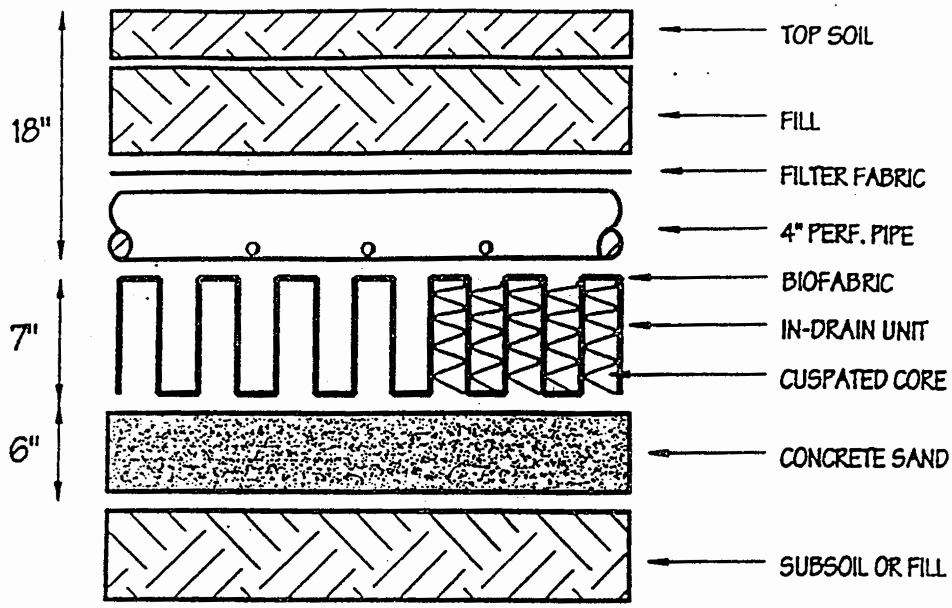
The EnviroChamber system is molded from high density polyethylene (HDPE) and available in Standard and High Capacity models. Dimensions of the Standard model are 34" x 75" x 12" (L x W x H). The High Capacity model is 34" x 75" x 17.5". The unit's sides are designed with slanted ribs permitting 8" and 14" of infiltrative surface per side below the invert of the distribution pipe in the Standard and High Capacity models, respectively. The side wall and bottom area provide 26.04 ft^2/unit for the Standard unit and 32.29 ft^2/unit for the High Capacity unit. The rib design is reinforced and allows for installation without filter fabric.

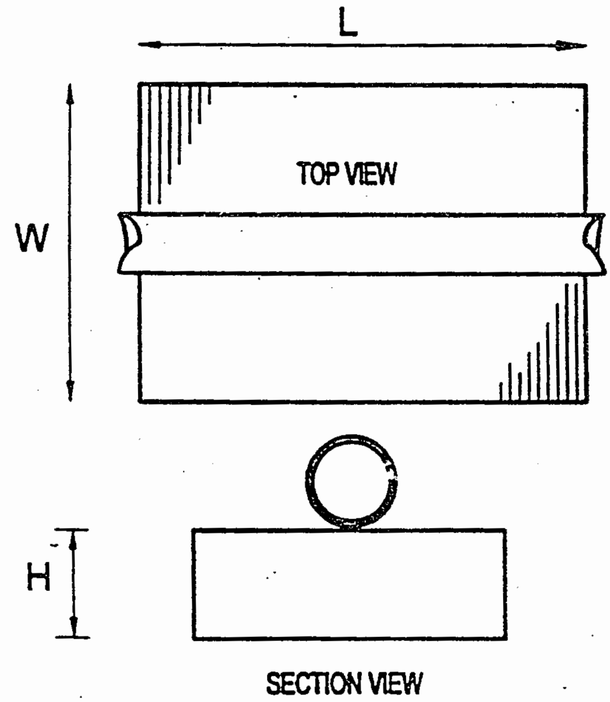
APPENDIX B

Drawings of ELGIN IN-DRAIN and typical layout

I/A Trench/Chamber/Bed with Treatment Enhancement

ELJEN IN-DRAIN CROSS SECTION (NTS)





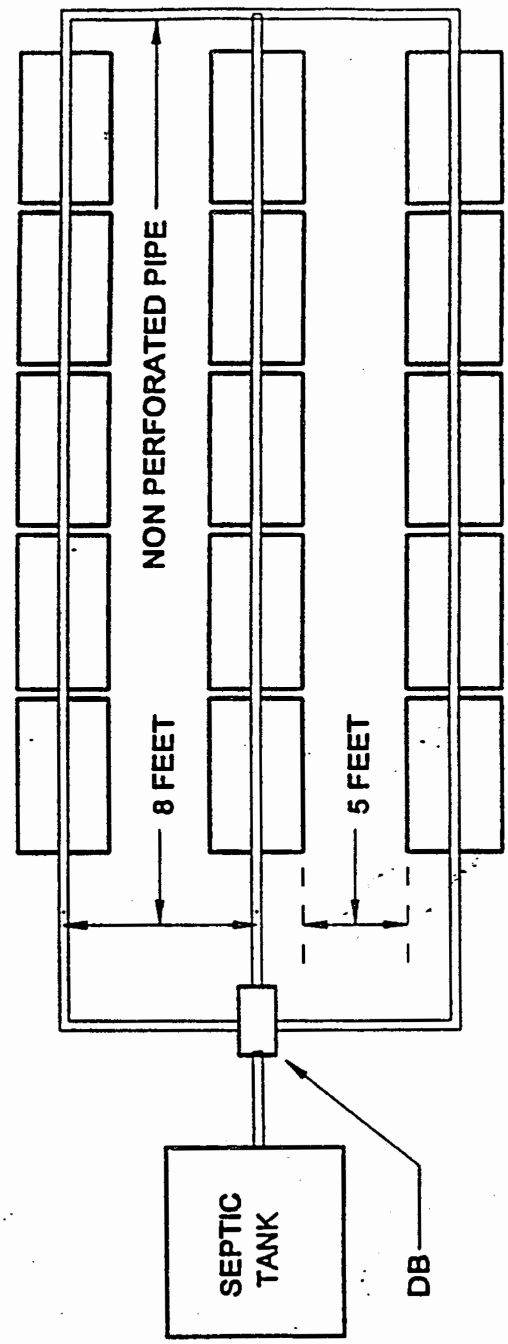
L	TYPE B	48"
W	TYPE B	36"
H	TYPE B	7"

Description of Components

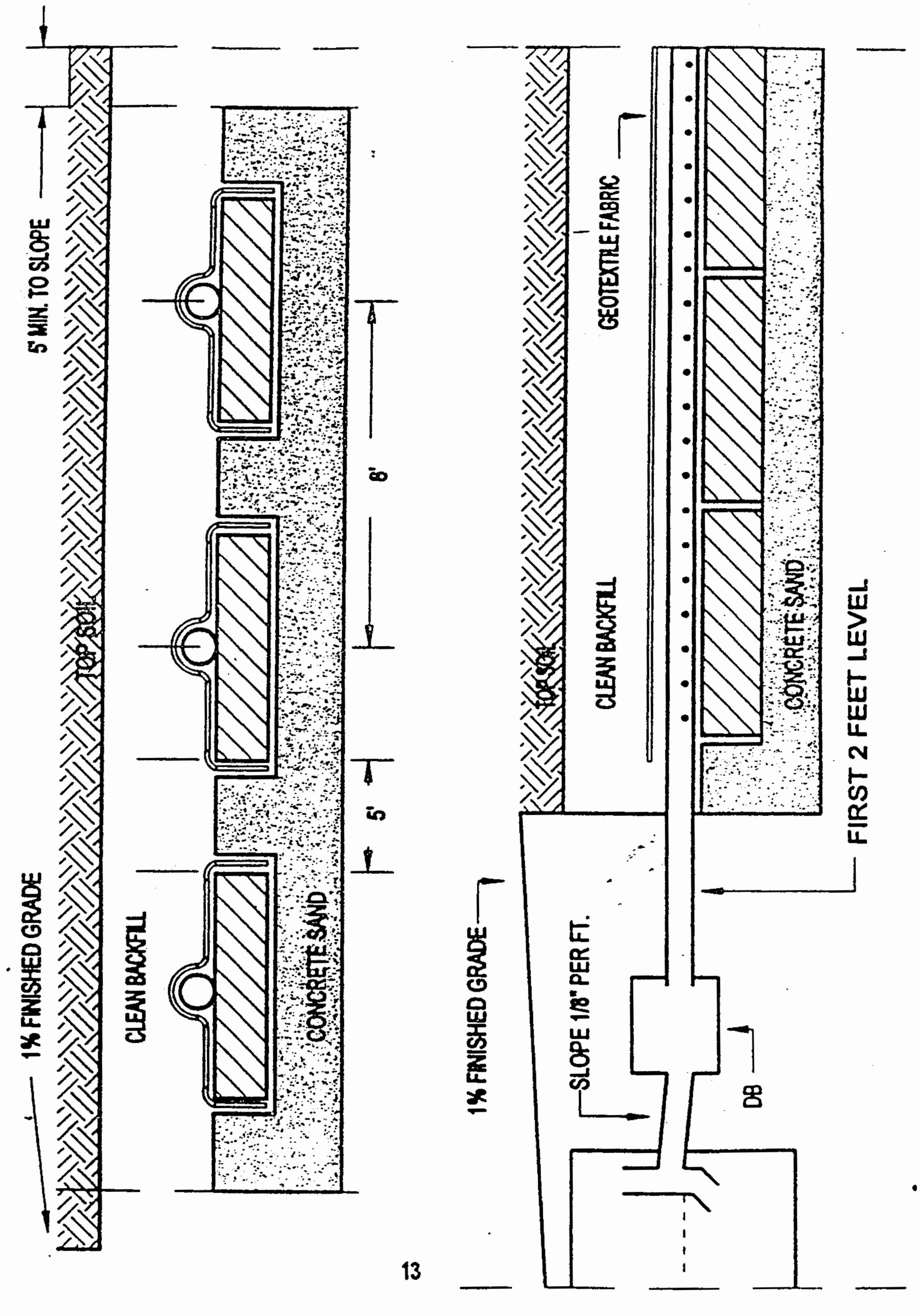
The In-Drain module is 48" x 36" x 7" (L x W x H). The effective depth below the invert of the distribution pipe on this unit provide 7" of infiltrative surface per side. The allowable infiltrative surface area is 6.2 ft^2/linear foot of trench including the additional 6" of sand on the sides and below the In-Drains. Geotextile cover fabric keeps fines out of the In-Drains.

A biologically active slime layer is formed on Bio- Matt fabric where aerobic treatment of the effluent occurs. Up to 10 ft^2 of fabric is provided for each square foot of soil interface.

TYPICAL LEACH FIELD LAYOUT (NTS)



IN-DRAIN CLUSTER DESIGN (NTS)



APPENDIX C

Drawings of I/A Technologies following Septic Tank Pretreatment

C-1: ZABEL FILTERS

C-2: OSI Screened Vault (OSI Effluent Filter)

C-2a: POLYLOK PL-122 EFFLUENT FILTER

C-2b: SIM/TECH FILTER

C-3: NORWECO SINGULAR

C-4: FAST SYSTEM

C-5: BIOCLERE

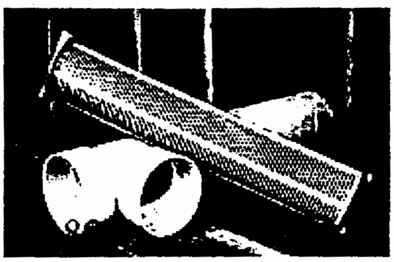
C-6: WATERLOO BIOFILTER

C-7: AIRR RECIRCULATING SAND FILTER

C-8: SANECO INTERMITTENT SAND FILTER

A1800

[redacted]



1. Product Name:

Zabel A1800 Residential Wastewater Filter, U.S. Patent Nos.: 5,382,357; 5,482,621; Canadian Patent No: 2,135,937; Other patents pending.

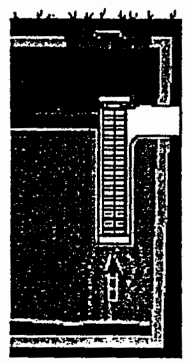
2. Model Numbers:

A1800 Case & Cartridge & Reducer ; A1801 Cartridge Only

3. Application:

Single family homes no more than four bedrooms.

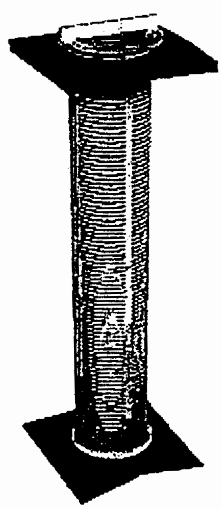
4. Performance Specification



4.1. Model A1800: Maximum daily flow - 800 gpd.
4.2. Multiple Filters may be installed in manifolds to handle larger flows.
4.3. TSS: Average reduction in TSS within 6 months of installation - 40 percent in typical residential wastewater.

5. Materials:

All materials are non-corrosive PVC

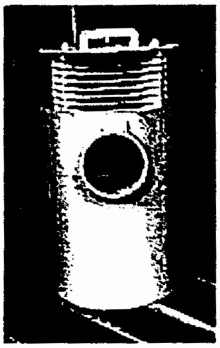


6. New System Installation:

Center the top of the 4-inch Filter Case under an Outlet Access Lid opening at least 8 inches in diameter. Securely fasten the bell coupling of the case by a PVC solvent weld connection to the 4-inch PVC pipe extending through the outlet wall opening of the tank. The pipe extending thorough the tank end wall may be any four schedule four-inch pipe.

A100

Comm[illegible]ential



1. Product Name:

Zabel A100 Commercial & Residential Effluent Filter, U.S. Patent: 4,710,295

2. Model Numbers:

A100 Case & Cartridge; A101 Cartridge Only; A100-HIP Case & Cartridge; A101-HIP Cartridge Only

3. Applications:

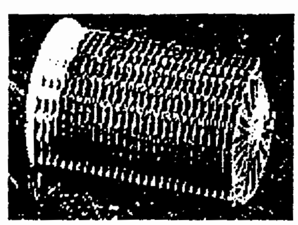
Apartments, trailer parks, schools, churches, shopping centers, and offices; Septic dump stations and community treatment plants; Single and Multi-family homes

4. Performance Specification

4.1. Model A100: 3,000 gpd, 7.5 gpm
4.2. Model A100-HIP: 4,500 gpd, 11.25 gpm
4.3. Multiple Filters may be installed in manifolds to handle larger flows. Use a Zabel Flow Control Plate Model FC100 to set the effluent flow to predetermined limits.
4.4. TSS: Reductions in TSS within six months of installation - 50 to 90 percent. The higher the pre-filtered TSS the greater the percentage of reduction.
4.5. BOD5: Reduction in BOD5 within six months of installation - 20 to 45 percent is dependent on the make-up of the wastewater.

5. Materials:

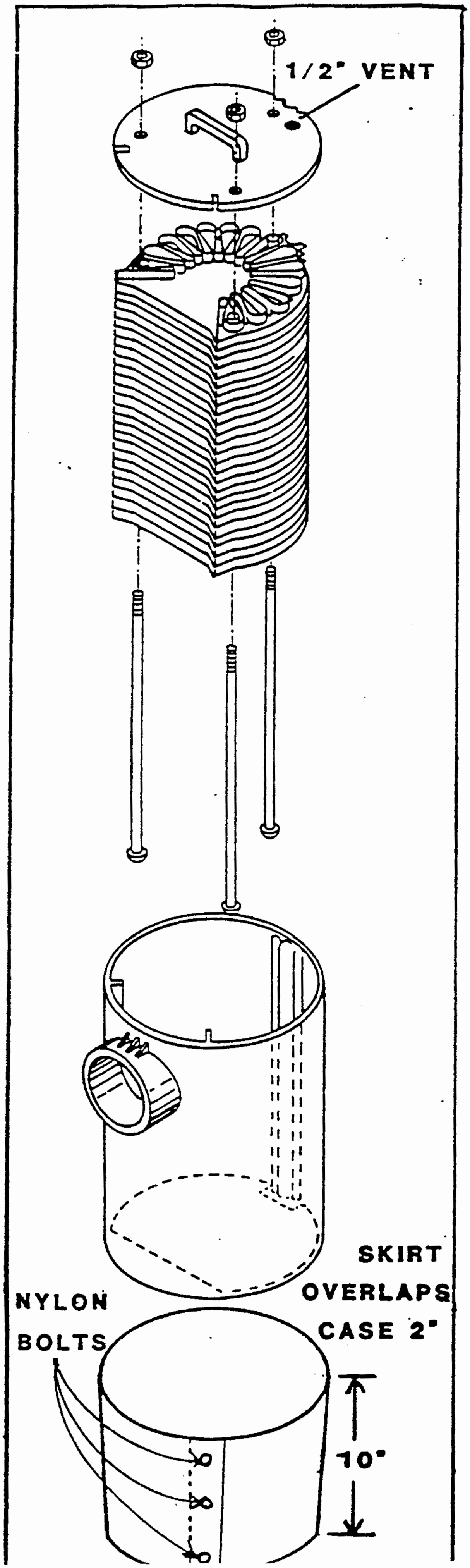
All materials are non-corrosive.

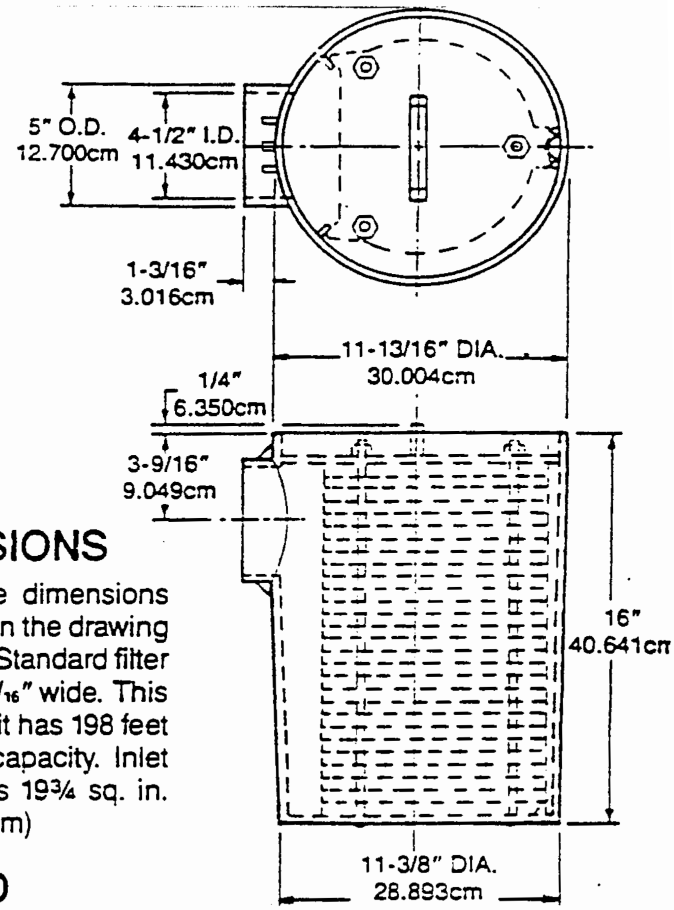


5.1. Case & Lid - PVC; Filter discs - Polystyrene; Rods - Polyethylene; Nuts - Nylon

6. New System Installation:

Center the top of the 12 inch Filter Case under an Outlet Access Lid opening at least 16 inches in diameter. PVC solvent weld the bell coupling connection to the 4 inch Schedule 40 PVC exit pipe





DIMENSIONS

Approximate dimensions are shown on the drawing at the right. Standard filter spacing is 1/16" wide. This compact unit has 198 feet of filtering capacity. Inlet open area is 19¾ sq. in. (127 cubic cm)

TESTED

Many years of residential, commercial, and laboratory use have helped to develope the unique patented *Zabel Disc Dam Filter Plates.* These Disc Dams provide the most economically feasible method of this type now available. This design even permits limited garbage disposal use in systems protected by the *ZABEL MULTI-PURPOSE FILTER.* The Filter removes a high percentage of suspended solids from the effluent stream.

EASY INSTALLATION

The *ZABEL MULTI-PURPOSE FILTER* discharge pipe simply slides into the effluent opening. Normal PVC cementing procedures are all that are needed to complete the installation to the effluent discharge line. A riser to ground level is desirable.

VIRTUALLY SELF-CLEANING

Many of the particulates are filtered out of the effluent and held on the upstream side of the Disc Dams. Bacterial action and the natural loss of particulate buoyancy occurs. Solids simply drop back to the bottom of the tank through the return holes in the Disc Dams. Natural tank flow and bacterial digestion prevent solids from building up under the Filter. If cleaning is required, the Disc Dams can easily be rinsed with water.

SPECIFICATIONS

Case: sewage/acid-resistant ETHYL 7042 COMPOUND
Filter DISCS Dow STYRON 484 Impact Polystyrene
Filter-plate bolts: HD polyethylene [white].
Weight: 15 pounds. Patent Pending

Skirt: sewage/acid resistant Trovidur 150 PVC

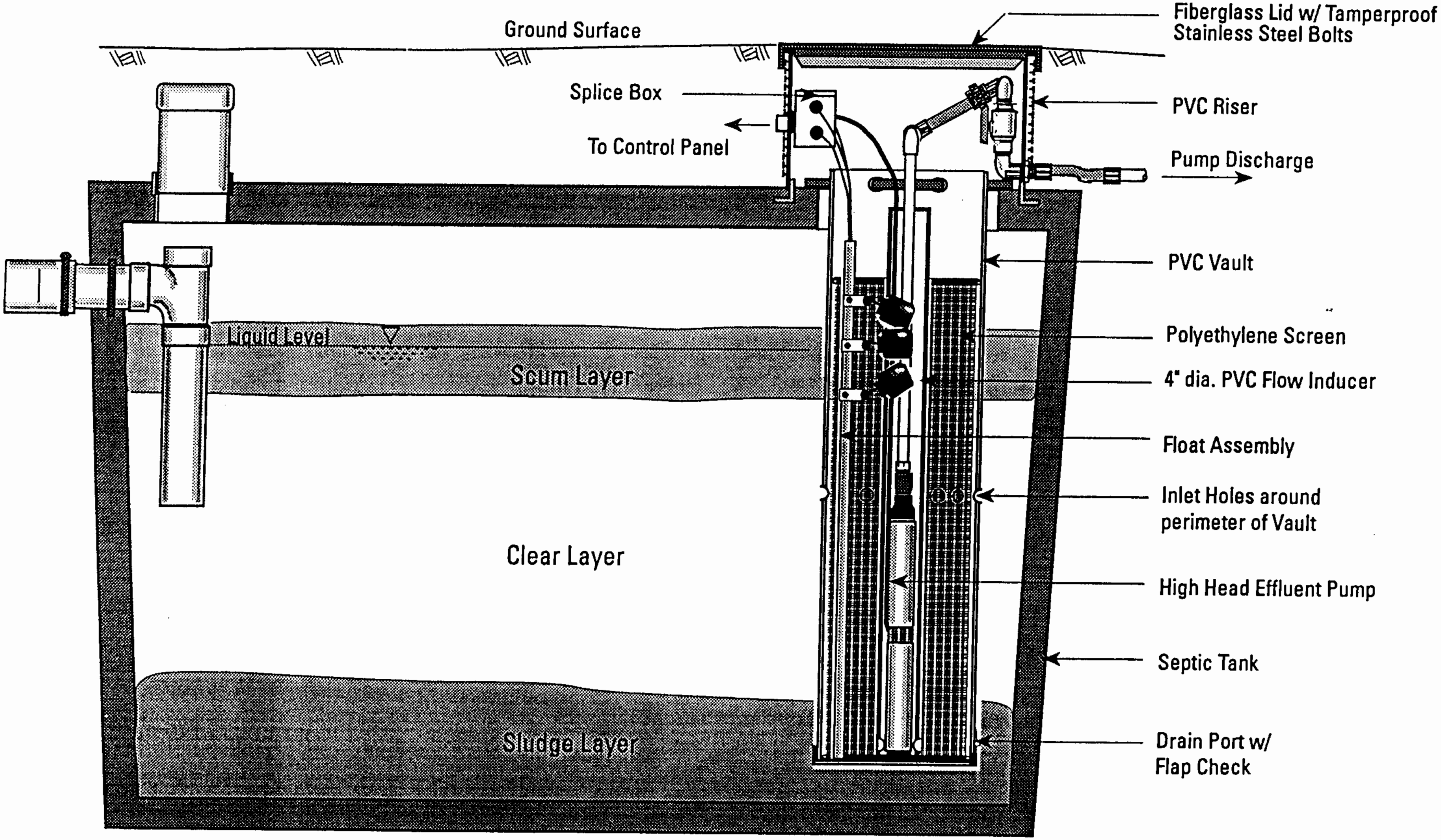
TYPICAL OSI SCREENED VAULT IN SINGLE COMPARTMENT SEPTIC TANK

Orenco Systems® Incorporated

814 AIRWAY AVENUE
SUTHERLIN, OREGON
97479-9012

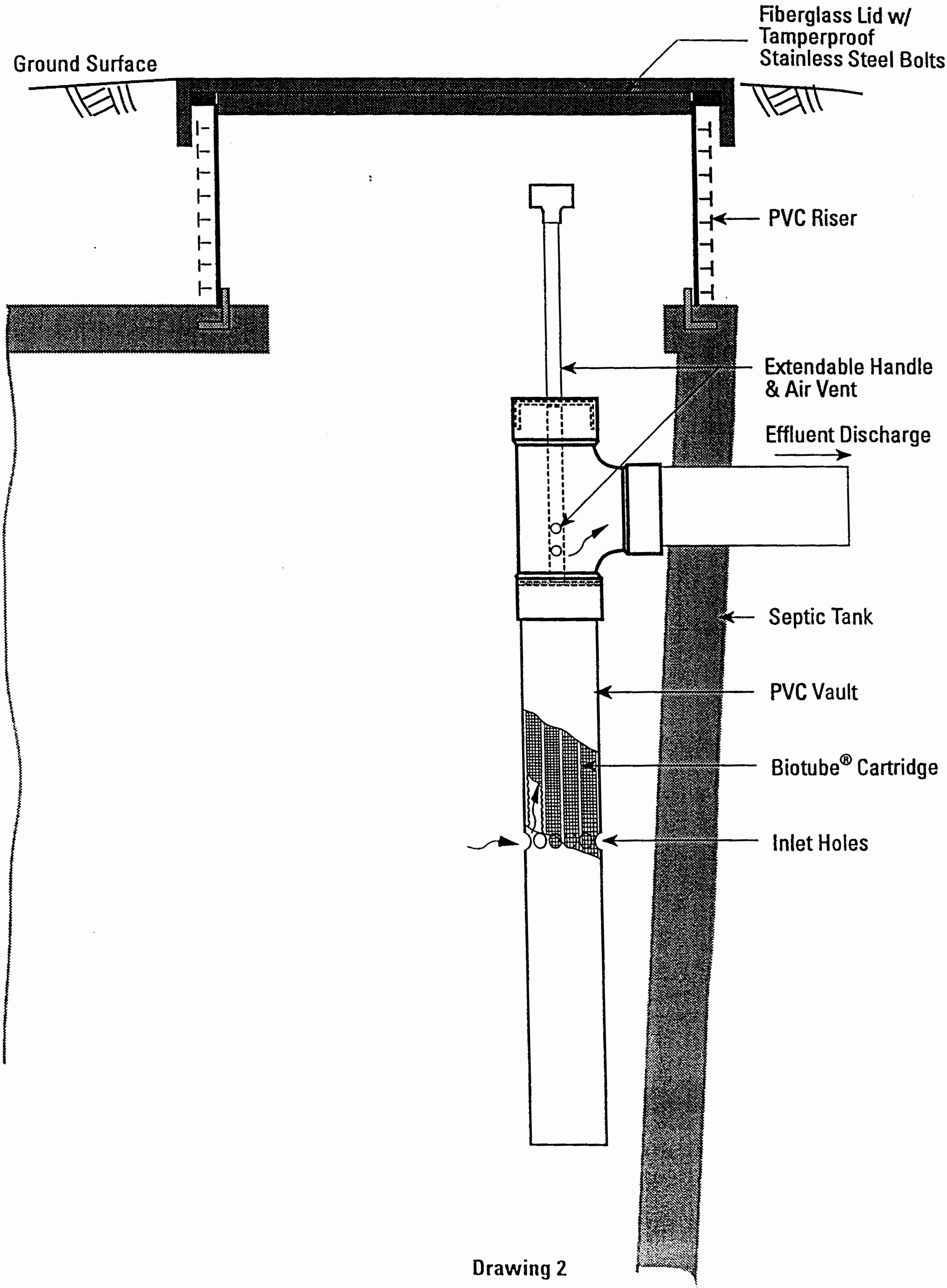
TELEPHONE:
(541) 459-4449

FACSIMILE:
(541) 459-2884



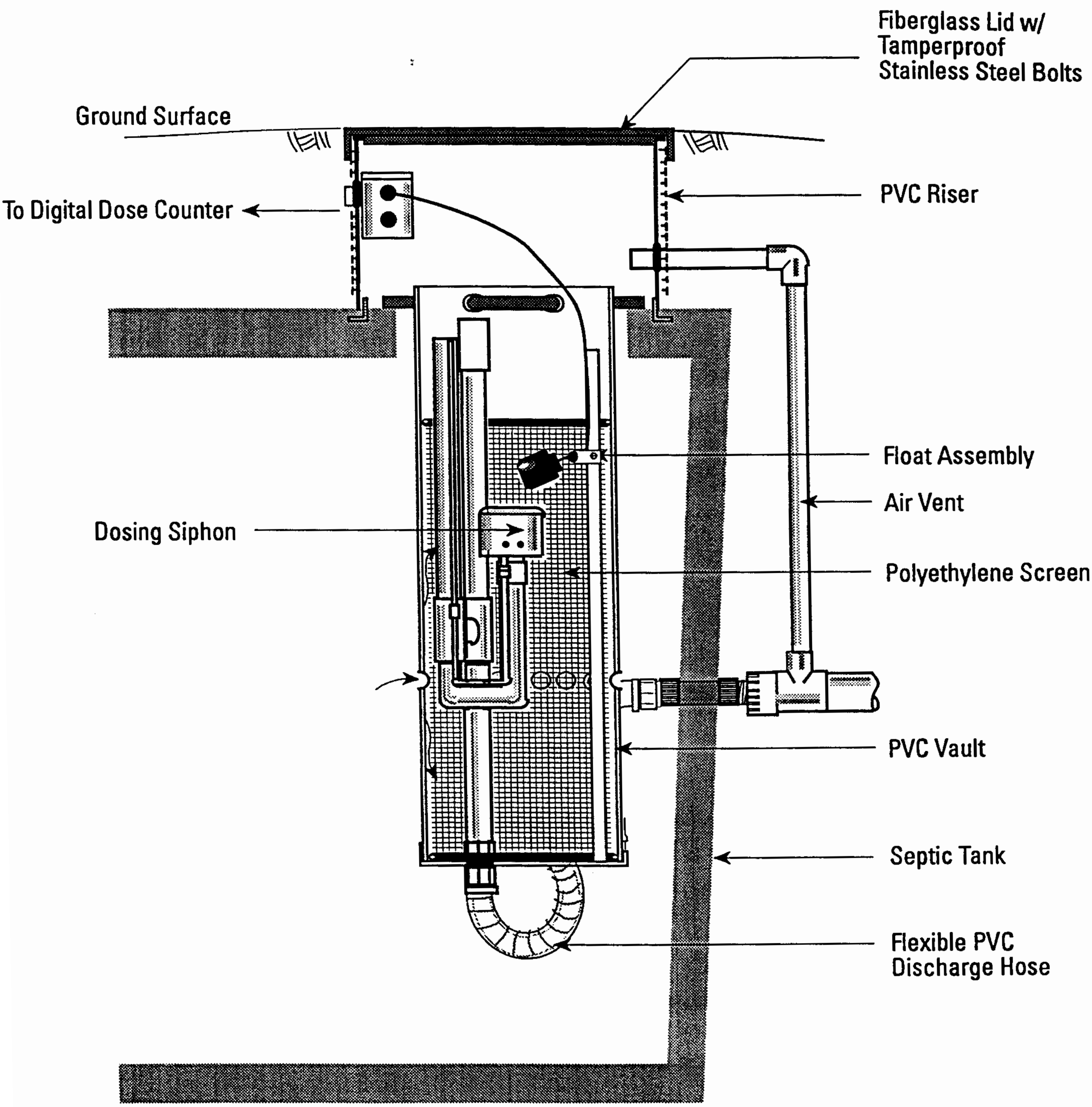
Drawing 1

OSI Biotube® Effluent Filter Installed in a Septic Tank
(4" Dia. Model Shown)



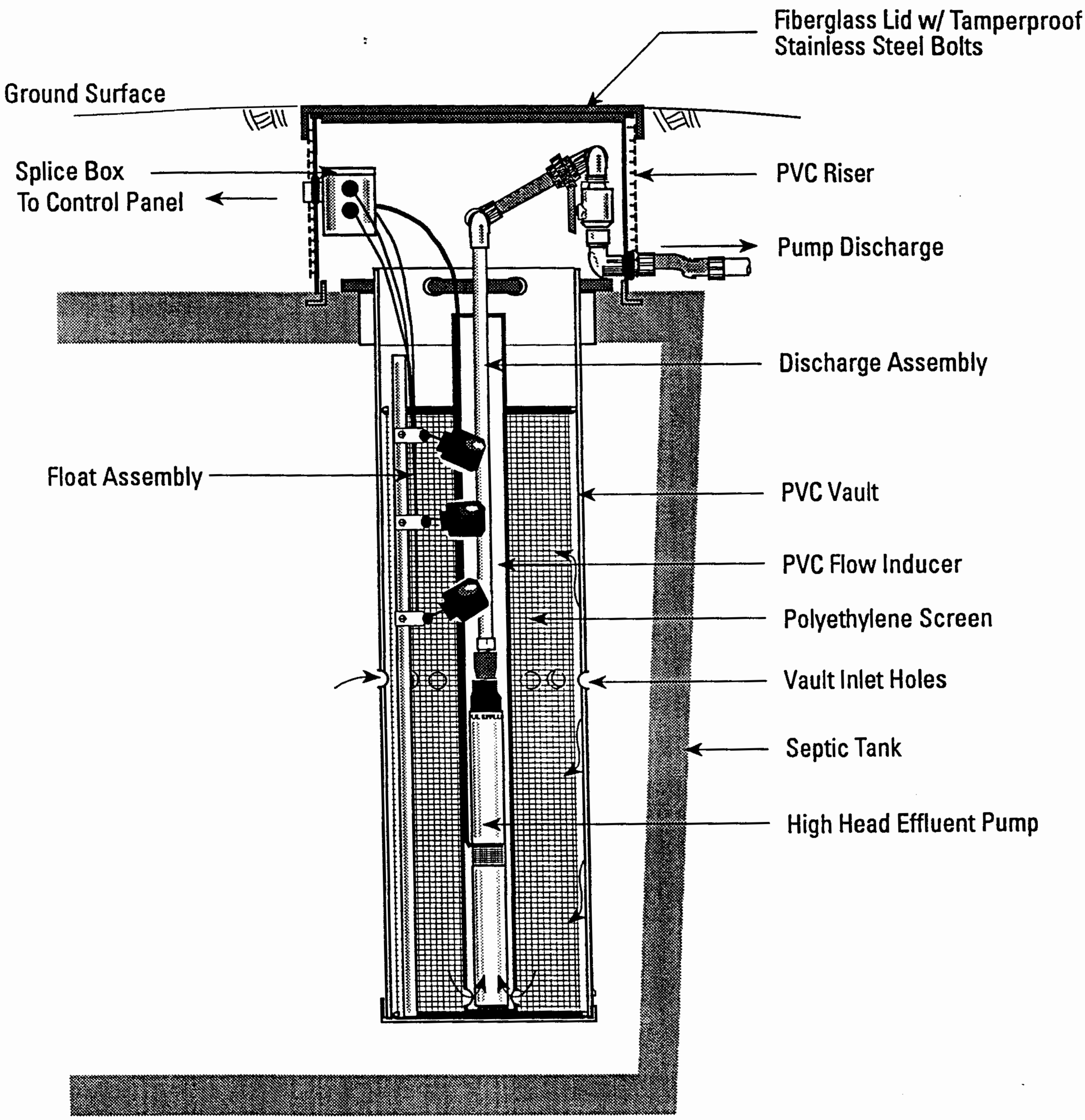
Drawing 2

2" Dia. Dosing Siphon / Screened Vault Installed in a Septic Tank



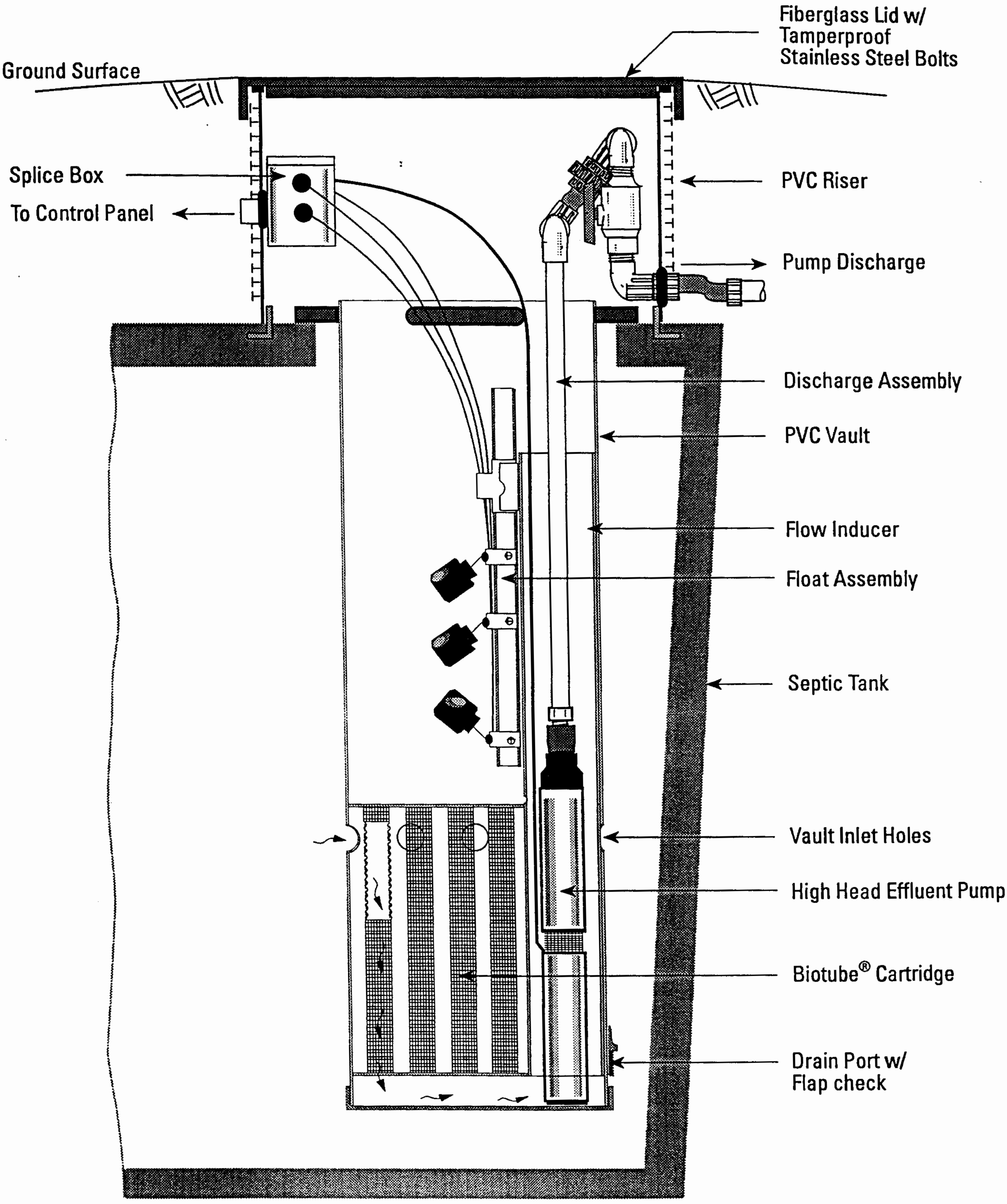
Drawing 3

OSI Screened Pump Vault Installed in a Septic Tank



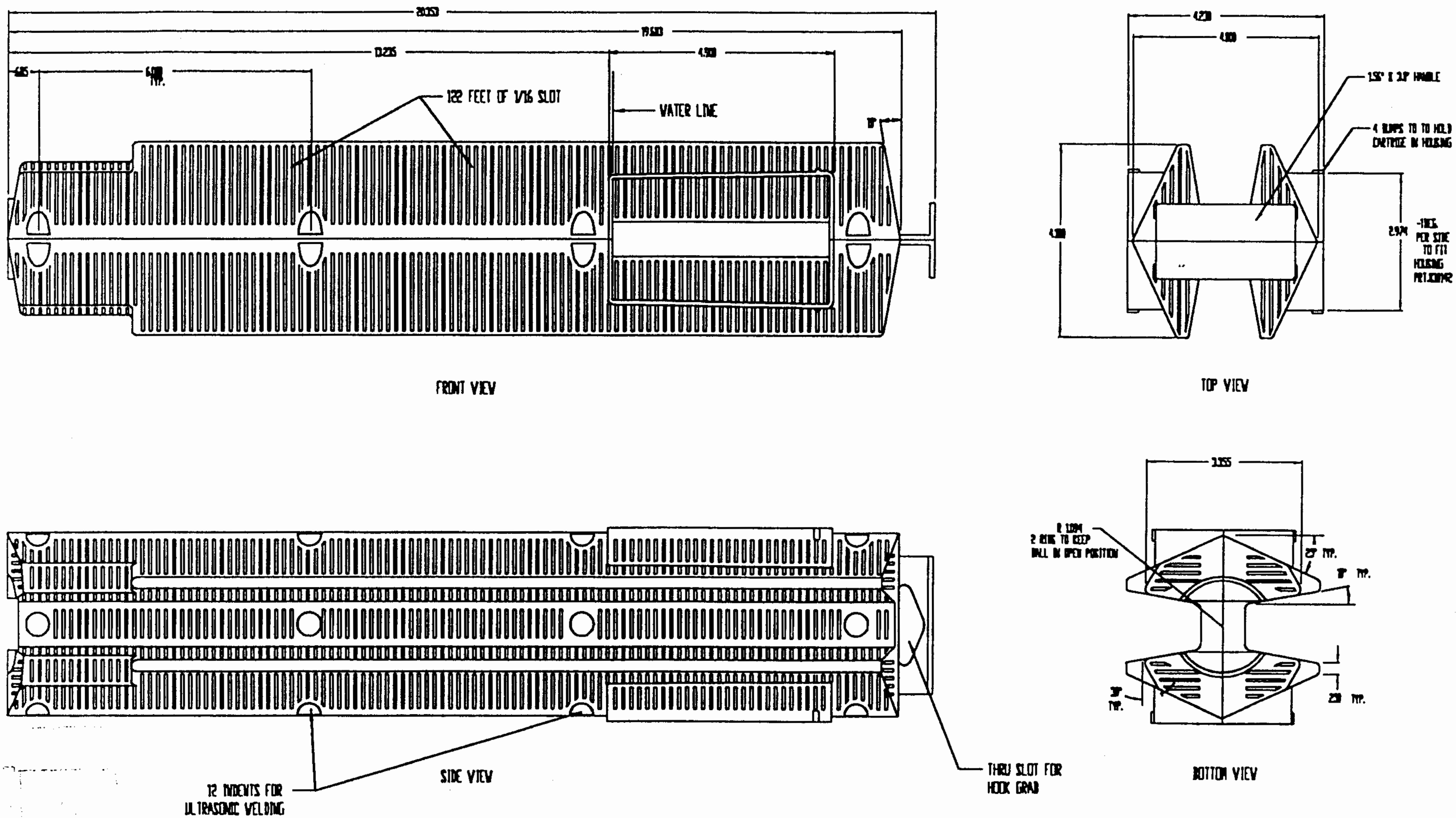
Drawing 4

OSI Biotube® Screened Pump Vault Installed in a Septic Tank



Drawing 5

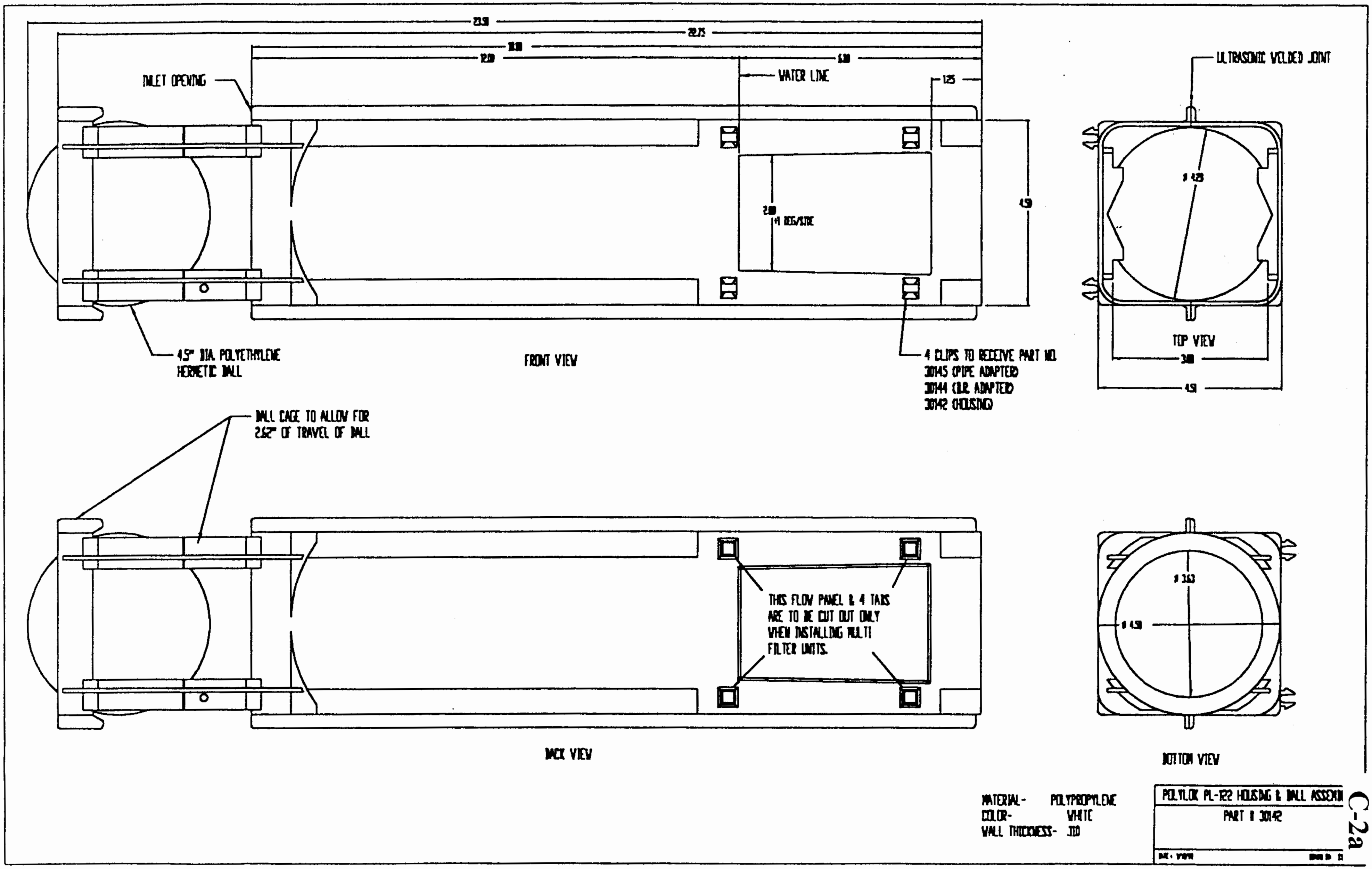
C-2a

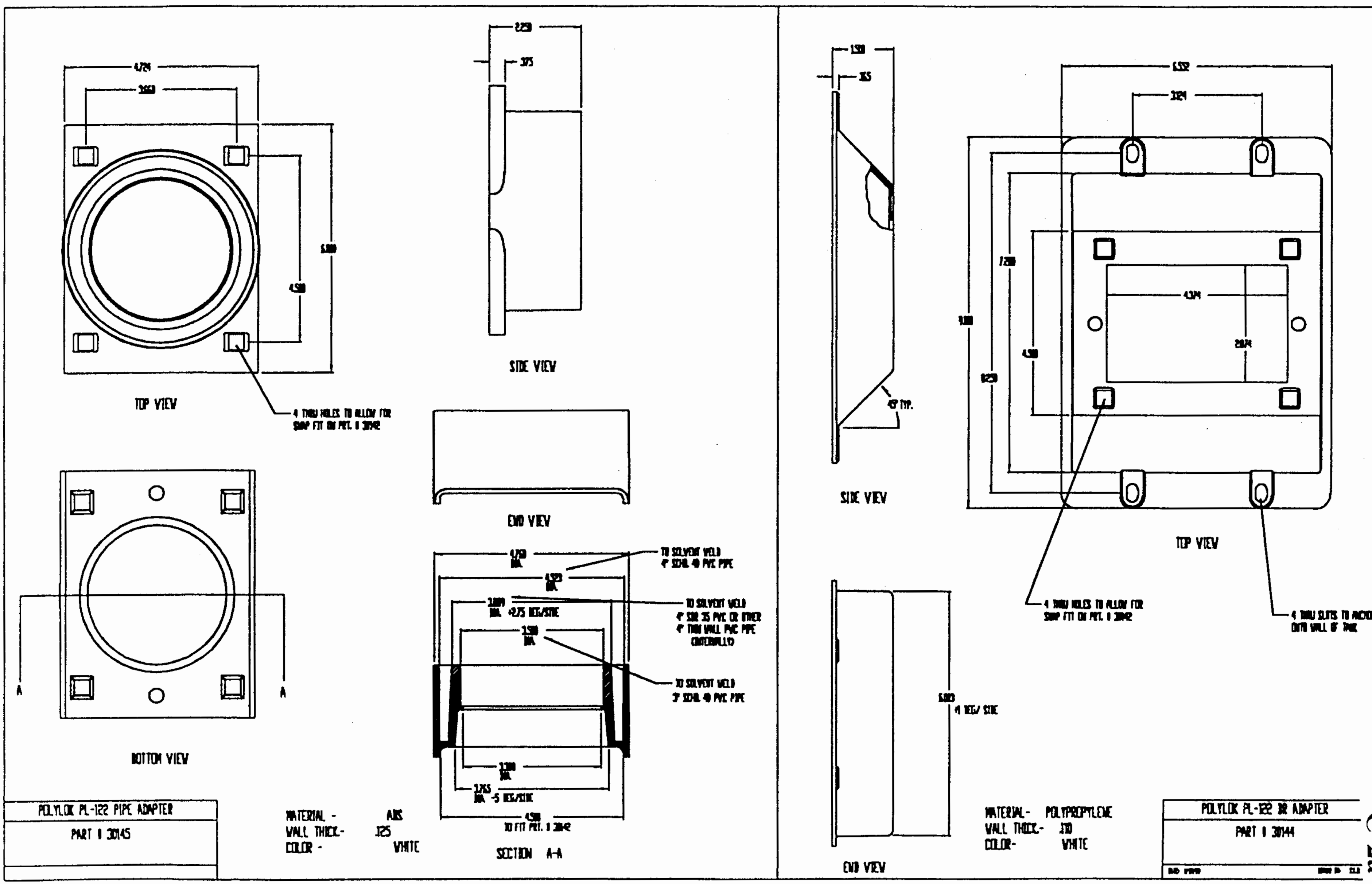


MATERIAL- POLYPROPYLENE
COLOR- BLUE
WALL THICKNESS- .095

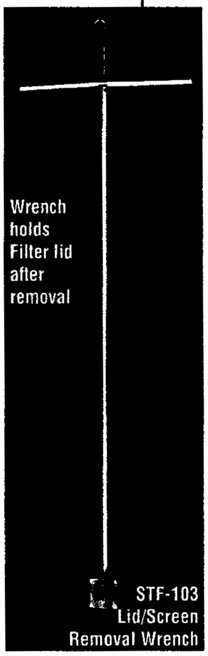
POLYLOK PL-122 FILTER CARTRIDGE
PART # 30141

C-2a

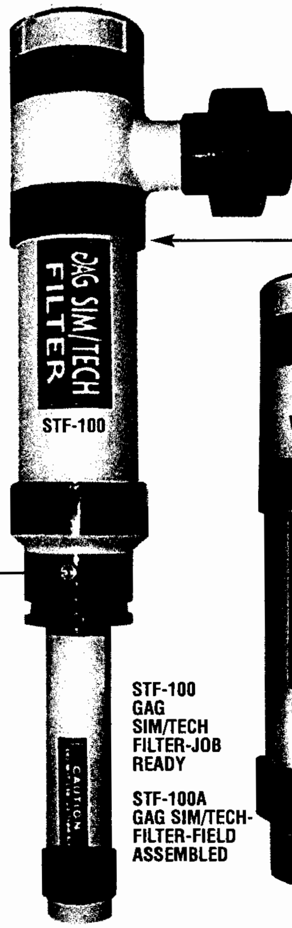

ULTRASONIC WELDED JOINT
INLET OPENING
WATER LINE
TOP VIEW
FRONT VIEW
4.5" DIA. POLYETHYLENE HERMETIC BALL
4 CLIPS TO RECEIVE PART NO. 30145 (PIPE ADAPTER) 30144 (LR ADAPTER) 30142 (HOUSING)
BALL CAGE TO ALLOW FOR 2.62" OF TRAVEL OF BALL
THIS FLOW PANEL & 4 TABS ARE TO BE CUT OUT ONLY WHEN INSTALLING MULTI FILTER UNITS.
BACK VIEW
BOTTOM VIEW
MATERIAL- POLYPROPYLENE
COLOR- WHITE
WALL THICKNESS- .110
POLYLOK PL-122 HOUSING & BALL ASSEMBLY
PART # 30142


TOP VIEW
4 THRU HOLES TO ALLOW FOR SNAP FIT ON PRT. # 30142
BOTTOM VIEW
SIDE VIEW
END VIEW
TO SOLVENT WELD 4" SCHL 40 PVC PIPE
TO SOLVENT WELD 4" SDR 35 PVC OR OTHER 4" THIN WALL PVC PIPE (EXTERNALLY)
TO SOLVENT WELD 3" SCHL 40 PVC PIPE
TO FIT PRT. # 30142
SECTION A-A
POLYLOK PL-122 PIPE ADAPTER
PART # 30145
MATERIAL - ABS
WALL THICK- .125
COLOR - WHITE
45° TYP.
4 THRU HOLES TO ALLOW FOR SNAP FIT ON PRT. # 30142
4 THRU SLOTS TO ANCHOR ONTO WALL OF TANK
MATERIAL- POLYPROPYLENE
WALL THICK.- .110
COLOR- WHITE
POLYLOK PL-122 DR ADAPTER
PART # 30144

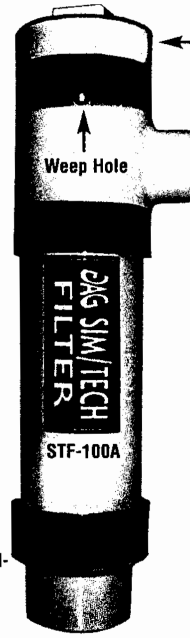
Engineered For Performance



STF-103
Lid/Screen
Removal Wrench



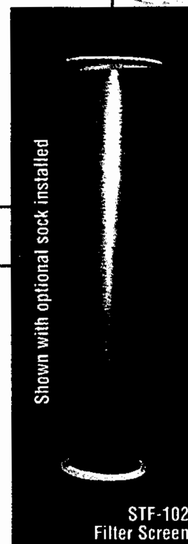
STF-100



STF-100A

STF-100
GAG
SIM/TECH
FILTER-JOB
READY

STF-100A
GAG SIM/TECH-
FILTER-FIELD
ASSEMBLED



STF-102
Filter Screen

STF-104
Sock

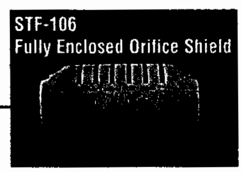

STF-103A
Screen
Removal
Tool


STF-105
Wire Cage

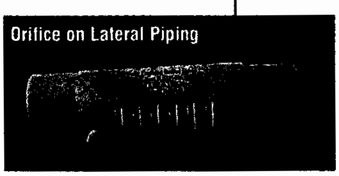

STF-101
Pressure Alarm Switch


STF-107
Sim/Tech Tank Alert
w/Latching Light
Includes Sensor Float

STF-106
Fully Enclosed Orifice Shield



Orifice on Lateral Piping



An absolute must for low pressure systems. Provides even distribution on lateral piping from all orifices by separating the orifice from the drain media.

Equipment List

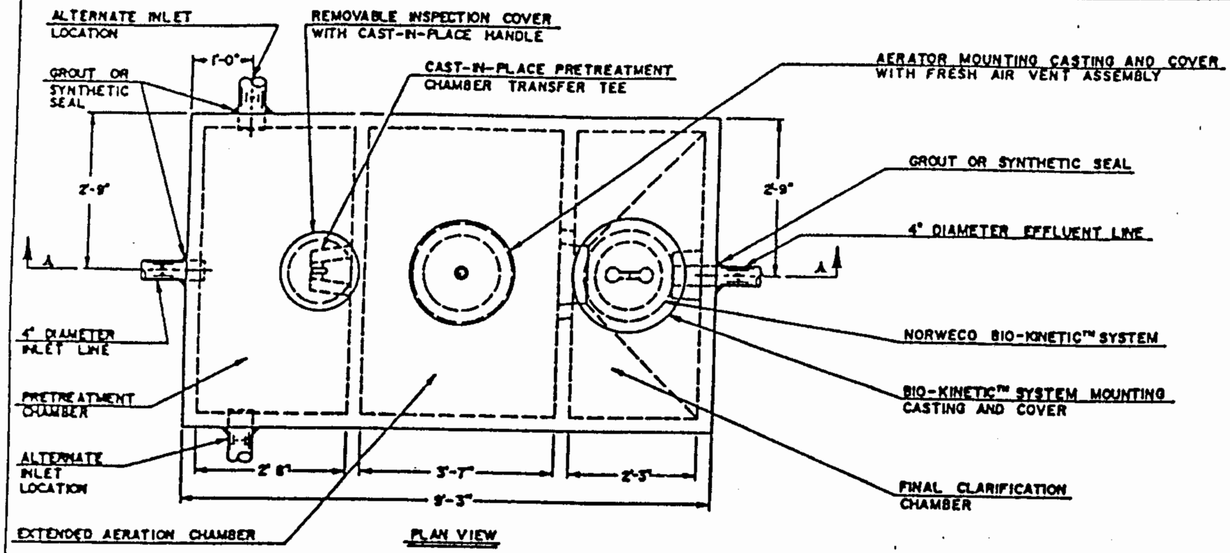
- STF-100 GAG Sim/Tech Filter-Job Ready
- STF-100A GAG Sim/Tech Filter-Field Assembled
- STF-101 Pressure Alarm Switch
- STF-102 Extra Filter Screen
- STF-103 Lid/Screen Removal Wrench
- STF-103A Screen Removal Tool
- STF-104 Sock
- STF-105 Wire Cage
- STF-106 Fully Enclosed Orifice Shield
- STF-107 Sim/Tech Alert w/Latching Light (Includes sensor float)

Restrictions and Specifications

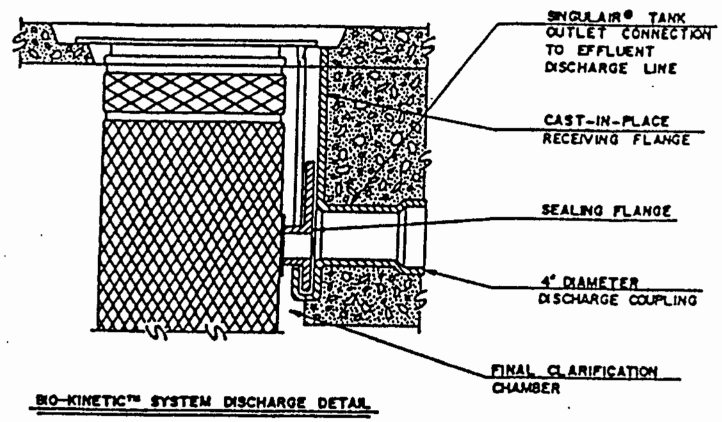
Total Head Loss .5002ft. or .21psi
Flow Rate with a Clean Screen = 120,672 GPD at 1psi
Flow Rate with a 95% Plugged Screen = 114,912 GPD at 1.8psi

Pump chamber detailed drawings and/or CAD disks for the Sim/Tech Filter are available upon request, at no cost, to help aid in your blueprint and drafting needs.

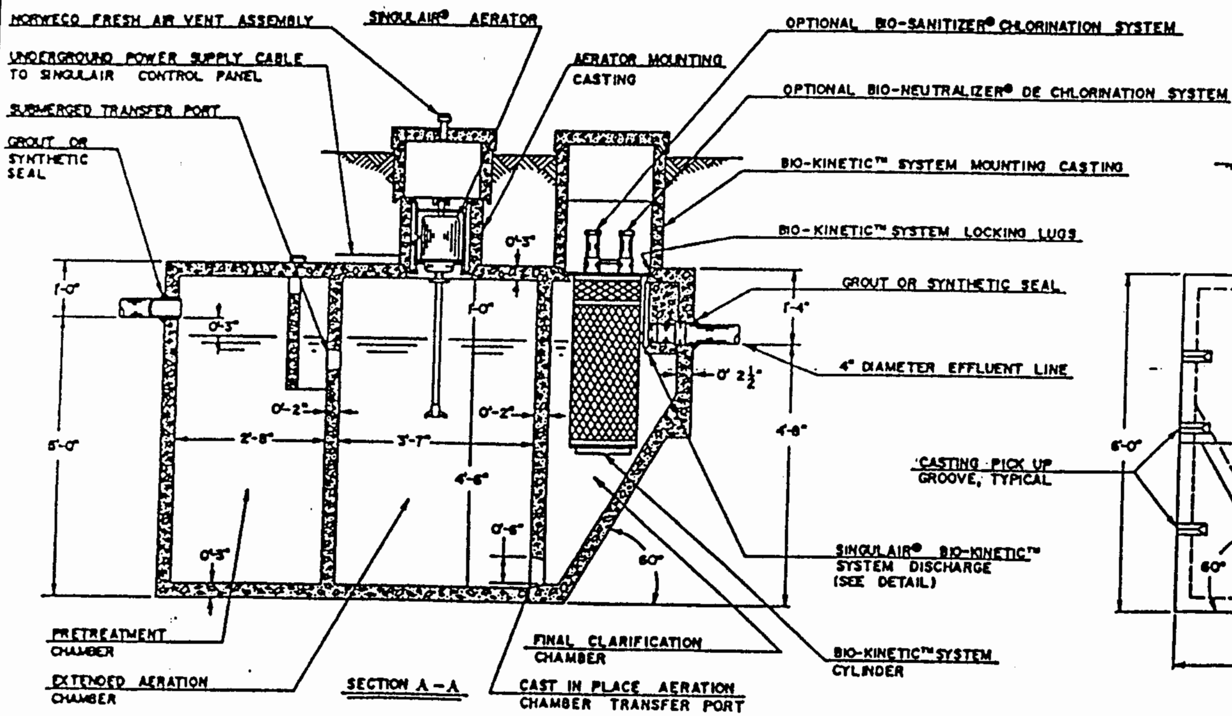
Protected Under U.S. Patent #5,885,452



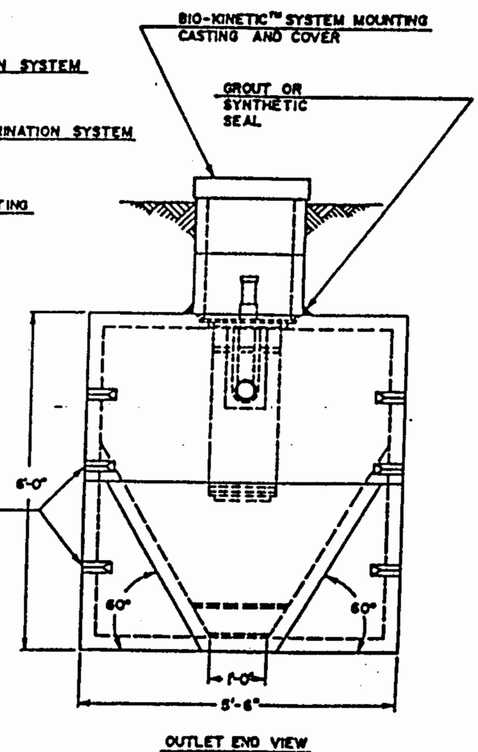
PLAN VIEW



BIO-KINETIC™ SYSTEM DISCHARGE DETAIL



SECTION A – A



OUTLET END VIEW

GENERAL NOTES

1. FALL THROUGH SINGULAIR® PLANT FROM INLET INVERT TO OUTLET INVERT IS FOUR INCHES. INLET INVERT IS TWELVE INCHES BELOW TANK TOP
2. ON DEEPER INSTALLATIONS, PRECAST RISERS MUST BE USED TO EXTEND AERATOR MOUNTING CASTING AND BIO-KINETIC™ SYSTEM MOUNTING CASTING TO GRADE. INSPECTION COVER ON PRETREATMENT CHAMBER MUST BE DEVELOPED TO WITHIN TWELVE INCHES OF GRADE.
3. TANK REINFORCED PER ACI STD. 318-83.
4. REMOVABLE COVERS ON RISERS WEIGH IN EXCESS OF SEVENTY FIVE POUNDS EACH TO PREVENT UNAUTHORIZED ACCESS.
5. CONTACT THE LOCAL LICENSED SINGULAIR DISTRIBUTOR FOR ELECTRICAL REQUIREMENTS.
6. TOTAL SYSTEM CAPACITY: 1300 GAL.

U.S. AND FOREIGN PATENTS PENDING

© MCMXCII

NORWECO

SINGULAIR BIO-KINETIC WASTEWATER TREATMENT SYSTEM

MODEL 800 - 500 GPD

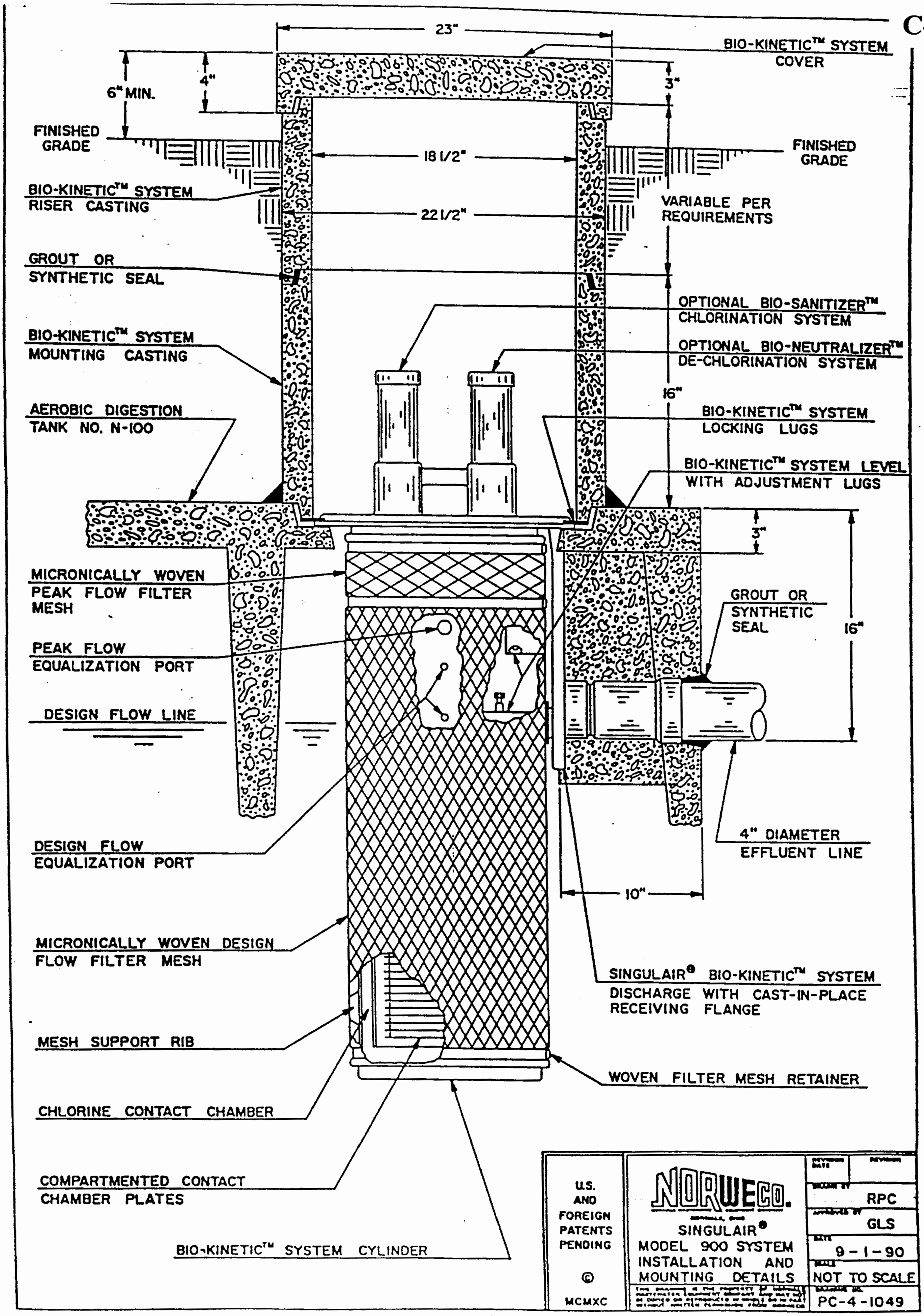
K.M

R.S

8-21-92

N.T.S.

PC-4-1124


23"
BIO-KINETIC™ SYSTEM COVER
6" MIN.
4"
3"
FINISHED GRADE
FINISHED GRADE
18 1/2"
BIO-KINETIC™ SYSTEM RISER CASTING
22 1/2"
VARIABLE PER REQUIREMENTS
GROUT OR SYNTHETIC SEAL
OPTIONAL BIO-SANITIZER™ CHLORINATION SYSTEM
BIO-KINETIC™ SYSTEM MOUNTING CASTING
OPTIONAL BIO-NEUTRALIZER™ DE-CHLORINATION SYSTEM
16"
AEROBIC DIGESTION TANK NO. N-100
BIO-KINETIC™ SYSTEM LOCKING LUGS
BIO-KINETIC™ SYSTEM LEVEL WITH ADJUSTMENT LUGS
3"
MICRONICALLY WOVEN PEAK FLOW FILTER MESH
GROUT OR SYNTHETIC SEAL
16"
PEAK FLOW EQUALIZATION PORT
DESIGN FLOW LINE
4" DIAMETER EFFLUENT LINE
DESIGN FLOW EQUALIZATION PORT
10"
MICRONICALLY WOVEN DESIGN FLOW FILTER MESH
SINGULAIR® BIO-KINETIC™ SYSTEM DISCHARGE WITH CAST-IN-PLACE RECEIVING FLANGE
MESH SUPPORT RIB
WOVEN FILTER MESH RETAINER
CHLORINE CONTACT CHAMBER
COMPARTMENTED CONTACT CHAMBER PLATES
BIO-KINETIC™ SYSTEM CYLINDER
U.S. AND FOREIGN PATENTS PENDING
©
MCMXC
NORWECO
SINGULAIR®
MODEL 900 SYSTEM
INSTALLATION AND MOUNTING DETAILS
RPC
GLS
9-1-90
NOT TO SCALE
PC-4-1049

SPECIFICATIONS
SINGLE HOME FAST® TREATMENT SYSTEM
STATE OF MASS.

GENERAL
The contractor shall furnish and install (1) one Single Home FAST® treatment system as manufactured by BIO-MICROBICS, Inc. The treatment system shall be complete with all needed equipment as shown on the drawings and specified herein.

The principal items of equipment shall include: FAST® system insert, blower assembly, controls, alarms, ventilation system, and all other appurtenances required for proper installation and operation. The Single Home FAST® unit shall be situated within a 1250 gallon (minimum) tank, as shown on the plans. The contractor shall provide coordination between the FAST® system and tank supplier with regard to fabrication of the tank, installation of the FAST® unit, and delivery to the job site.

Equipment shall be furnished to the project site factory tested and assembled. Separate subassemblies subject to damage in shipment or handling shall be packaged or crated for on-site contractor installation.

OPERATING CONDITIONS
The Single Home FAST® treatment system shall be capable of treating the wastewater produced by typical family activities (bath, laundry, kitchen, etc.) ranging from (1) one to (10) ten members. This equates to a maximum hydraulic capacity of 500 gallons per day, and a maximum organic capacity of 1.8 pounds of BOD_5 per day.

MEDIA
The FAST® media shall be manufactured of rigid PVC. It shall be supported by the fiberglass insert. The media shall be of such a design that bacterial growth is uniform over all media surfaces. The media shall be fixed in position and contain no moving or wearing parts, and shall not corrode. The media shall be designed and installed to ensure that sloughed solids immediately descend through the media to the bottom of the septic tank.

BLOWER
The Single Home FAST® unit shall come equipped with a regenerative type blower capable of delivering 22 CFM of free air at a pressure of 35 inches of water. The blower assembly shall include an inlet filter with replaceable filter element.

The blower shall be driven by a 1/2 HP, 3450 RPM, 115 volt, single phase, 60 hertz, horizontal, totally enclosed and fan cooled electric motor.

REMOTE MOUNTED BLOWER
The blower shall be mounted remote from the Single Home FAST® unit on a contractor supplied concrete base. A one-piece rectangular housing, hinged at the base, shall be provided with a tamperproof type lock. A local disconnect shall also be provided under the housing. The discharge air line from the to the Single Home FAST® unit shall be provided and installed by the contractor. The discharge air line must be the same or larger diameter as the blower discharge.

ELECTRICAL
The treatment system shall be designed to operate on standard household current. The input power required is 115 volts, single phase, 60 hertz, 20 amps. All conduit and wiring between the electrical control panel and the power supply and between the panel and blower shall be furnished and installed by the contractor.

[ ] INDOOR CONTROLS
Controls for the system shall be mounted in a Nema 1 enclosure located within the residential dwelling and shall be as detailed on the plans.

[ ] OUTDOOR CONTROLS
Controls for the system shall be mounted in a Nema 4 enclosure located outside the residential dwelling and shall be as detailed on the plans.

ALARMS
The alarm system shall consist of a visual alarm to indicate failure of the blower. The alarm shall be located as shown on the plans.

[ ] AUDIBLE ALARM (OPTIONAL ITEM)
The alarm system shall also include an audible alarm horn. The audible alarm shall be equipped with a silence switch for manual silencing of the alarm horn.

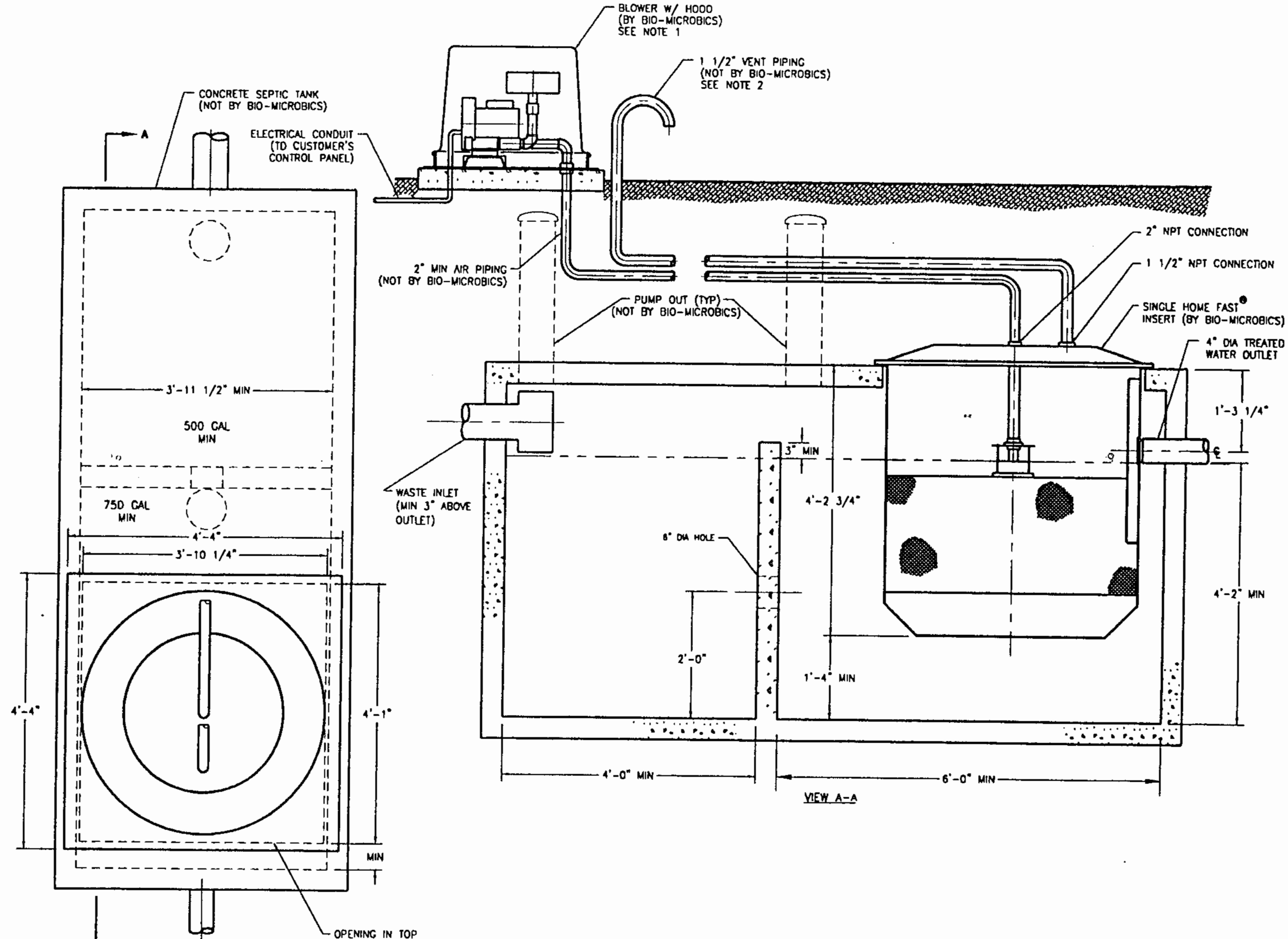
INSTALLATION AND OPERATING INSTRUCTIONS
Installation of the Single Home FAST® treatment system shall be done in accordance with the written instructions provided by the Manufacturer. Operation manuals shall be furnished which will include a description of operation and system upkeep procedures.

STARTUP
The Manufacturer shall provide the services of a factory trained representative for a maximum period of one day on-site to perform initial startup of the FAST® system and to inspect the operation and installation of the equipment.

WARRANTY
The Manufacturer of the Single Home FAST® treatment system shall warrant for two years from date of shipment that the equipment he provides will be free from defects in material and workmanship.

In the event a component fails to perform as specified or is proven defective in service during the warranty period, the Manufacturer shall repair or replace such defective part. The replacement or repair of those items normally consumed in service, such as oil, grease, etc., shall be considered as part of routine maintenance and upkeep.

It is not intended that the Manufacturer assume responsibility for contingent liabilities or consequential damages of any nature resulting from defects in design, material, or workmanship, or delays in delivery, replacement or otherwise.



PLAN VIEW

VIEW A-A

NOTES

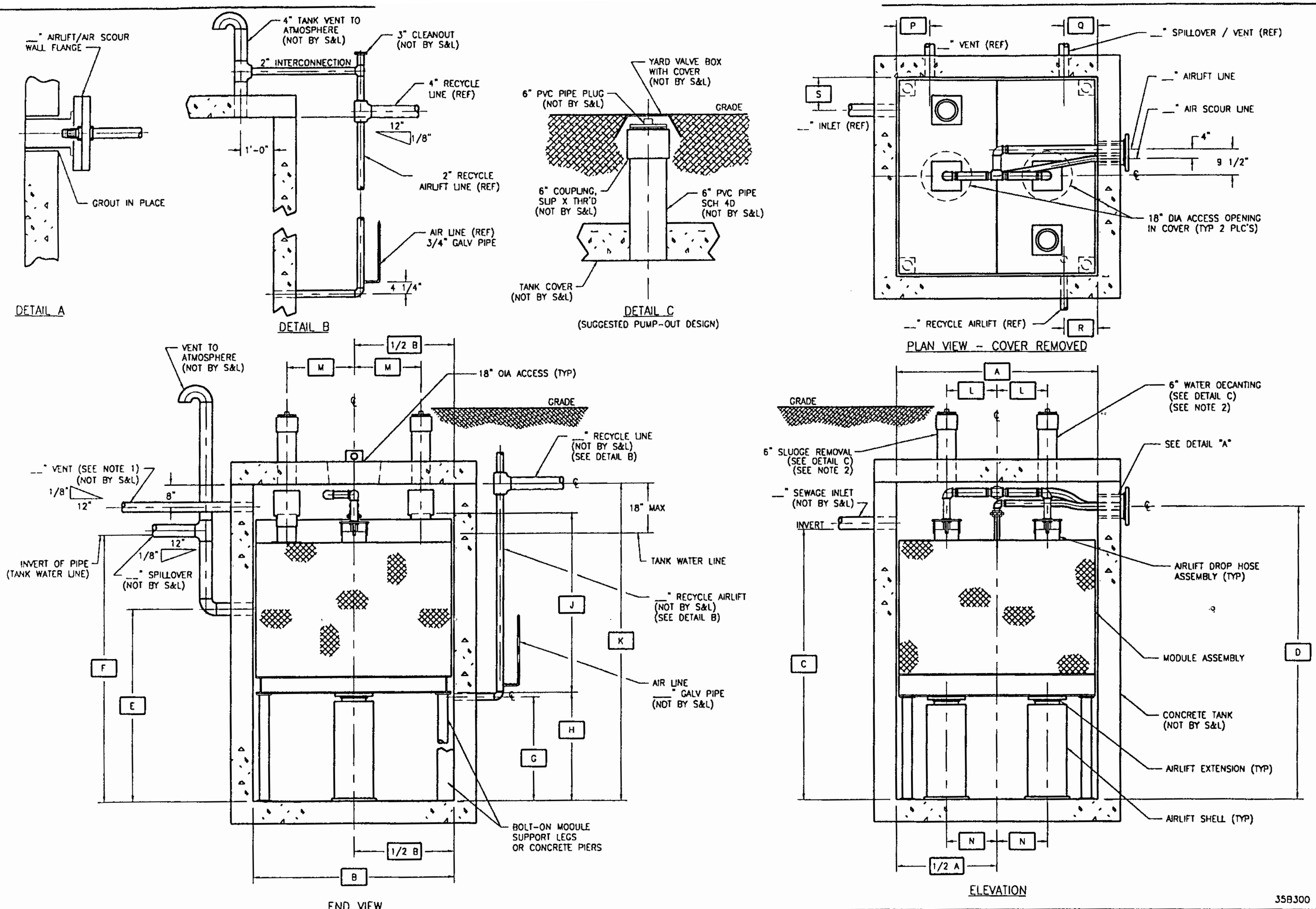
1. BLOWER MUST BE WITHIN 100 FEET OF FAST® UNIT. FOR DISTANCES GREATER THAN 100 FEET - CONSULT FACTORY.
2. RUN VENT TO DESIRED LOCATION AND COVER OPENING WITH INSECT SCREEN.
3. COPYRIGHT (C) 1996 BIO-MICROBICS, INC.

SHEET 1 OF 1

DRAWN BY: J. DURBIN	DATE: 7/29/96	ALLOWABLE TOLERANCES	FOR
CHECKED BY: BMN	DATE: 7/29/96	FRACTIONS -	SINGLE HOME FAST® WITH REMOTE BLOWER FOR THE STATE OF MASSACHUSETTS
APPROVED BY: NASH	DATE: 7/29/96	DECIMALS -	
SCALE: NTS	CODE: 9	ANGLES -	SIZE / U/M EA / WT.
© Bio-Microbics, Inc. 1996			FILE NAME HFMA102_ / PLOT SCALE 32
			SERIAL NO / DWG NO HFMA102_ / REV

LET | ECN NO | DATE | BY APPV'D | ORIGINAL ISSUE

BIO-MICROBICS



35B300

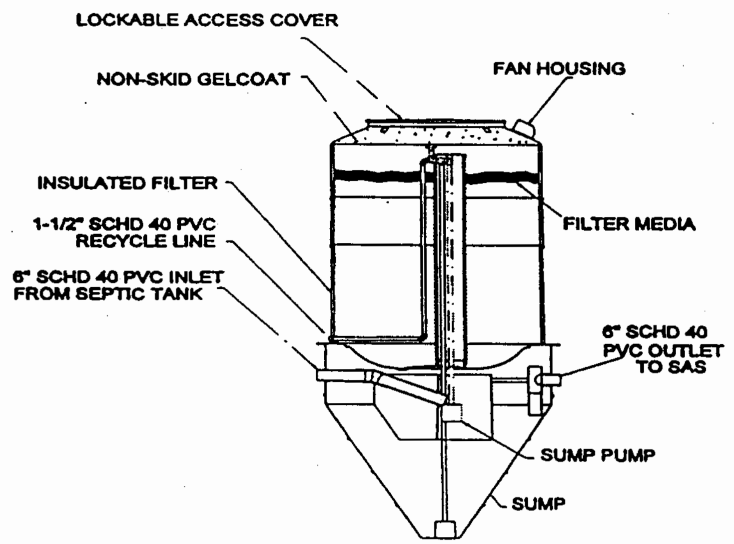
NOTE:

1. THE MEDIA TANK VENT PIPE IS SIZED TO LIMIT VENT BACKPRESSURE TO 12 IWC WITH A MAXIMUM LENGTH OF 50', 3 ELBOWS AND A GOOSENECK. VENT SHALL BE INDEPENDENT OF BUILDING VENT SYSTEM.
2. ACCESS PIPES THROUGH TOP OF TANK MUST LINE UP WITH PUMP-OUT PIPES.
3. COPYRIGHT (C) 1994 SMITH AND LOVELESS INC.
4. SEE CHART ON SHEET 2 FOR DIMENSIONS.

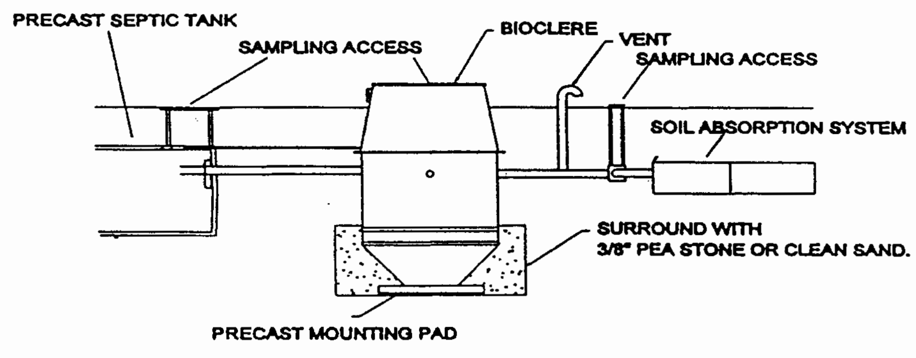
SHEET 1 OF 2

DRAWN BY:	J. DURBIN
DATE:	5/9/96
CHECKED BY:	
APPROVED BY:	
ALLOWABLE TOLERANCES	FRACTIONS – ; DECIMALS – ; ANGLES –
SCALE:	NTS
CODE:	9
LET / ECN NO / DATE / BY APPV'D	
ORIGINAL ISSUE	N96-52
FOR	FAST® SEWAGE TREATMENT PLANT MODULAR FAST® MODEL K-____
SIZE	
U/M	EA
WT.	
FILE NAME	/A/SALES/35B300_
PLOT SCALE	1=24.0C
SERIAL NO	
DWG NO	35B300
REV	

Smith & Loveless, In

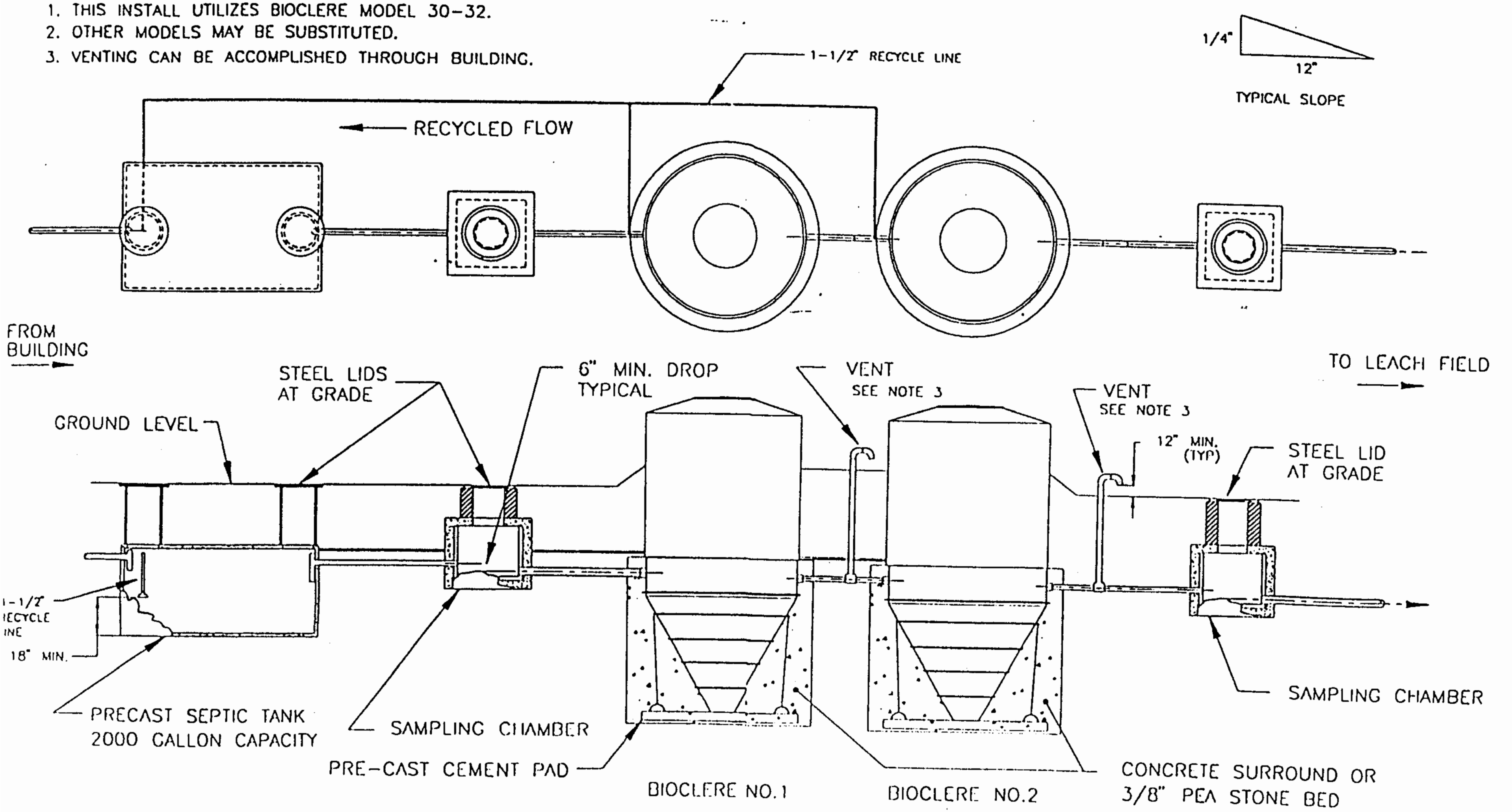


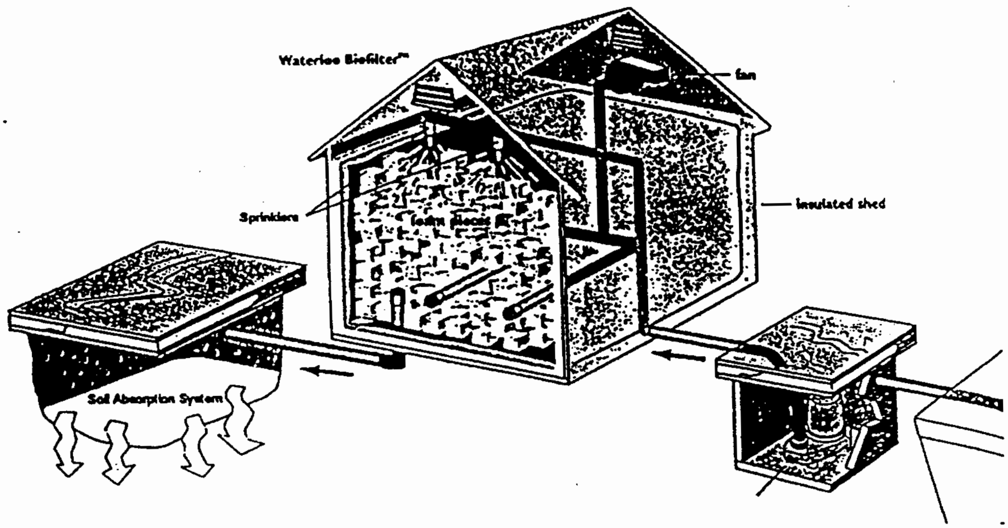
MODEL 24/30 W/ 1600 SERIES SUMP



Typical Bioclere system, (after AWT Environmental, New Bedford, MA)

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

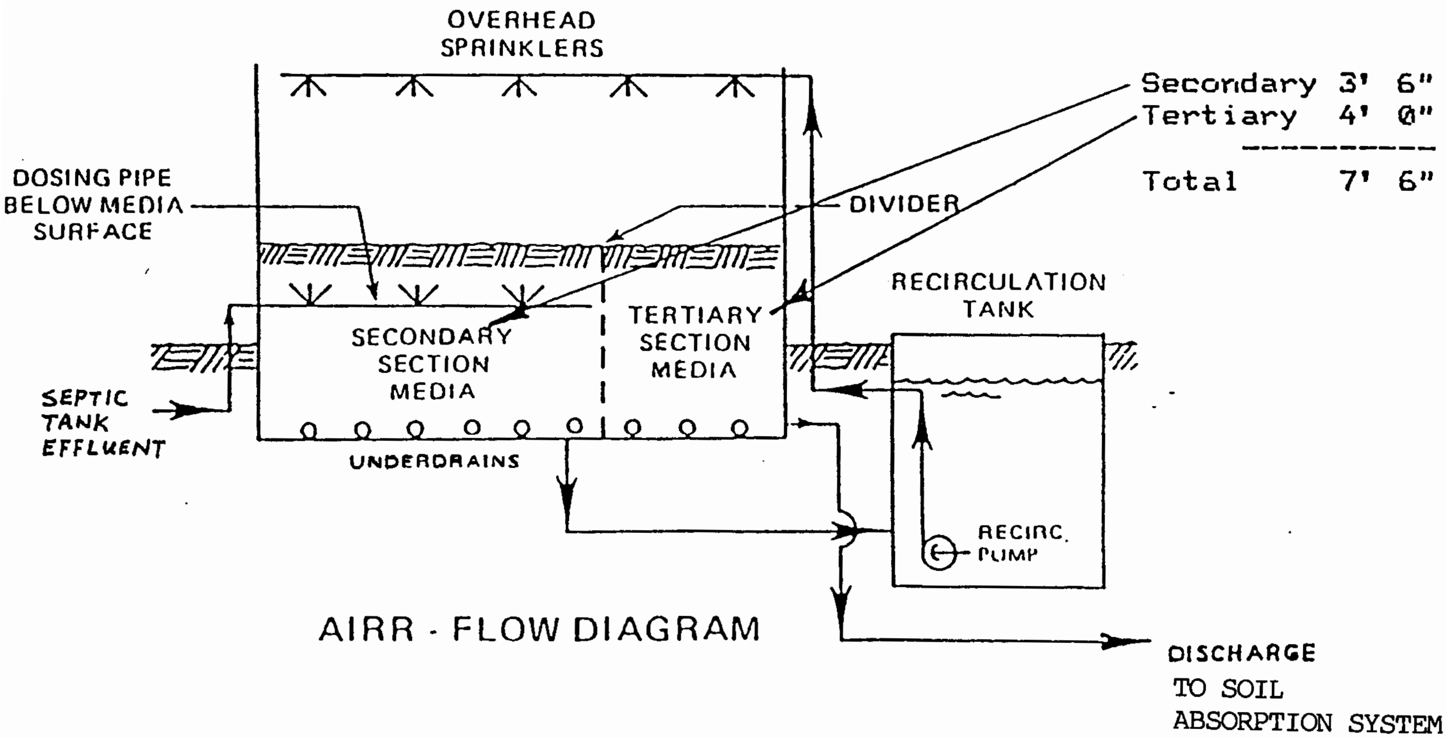




The Waterloo Biofilter™, (After, Waterloo Biofilter Systems, Inc. Ontario, Canada)

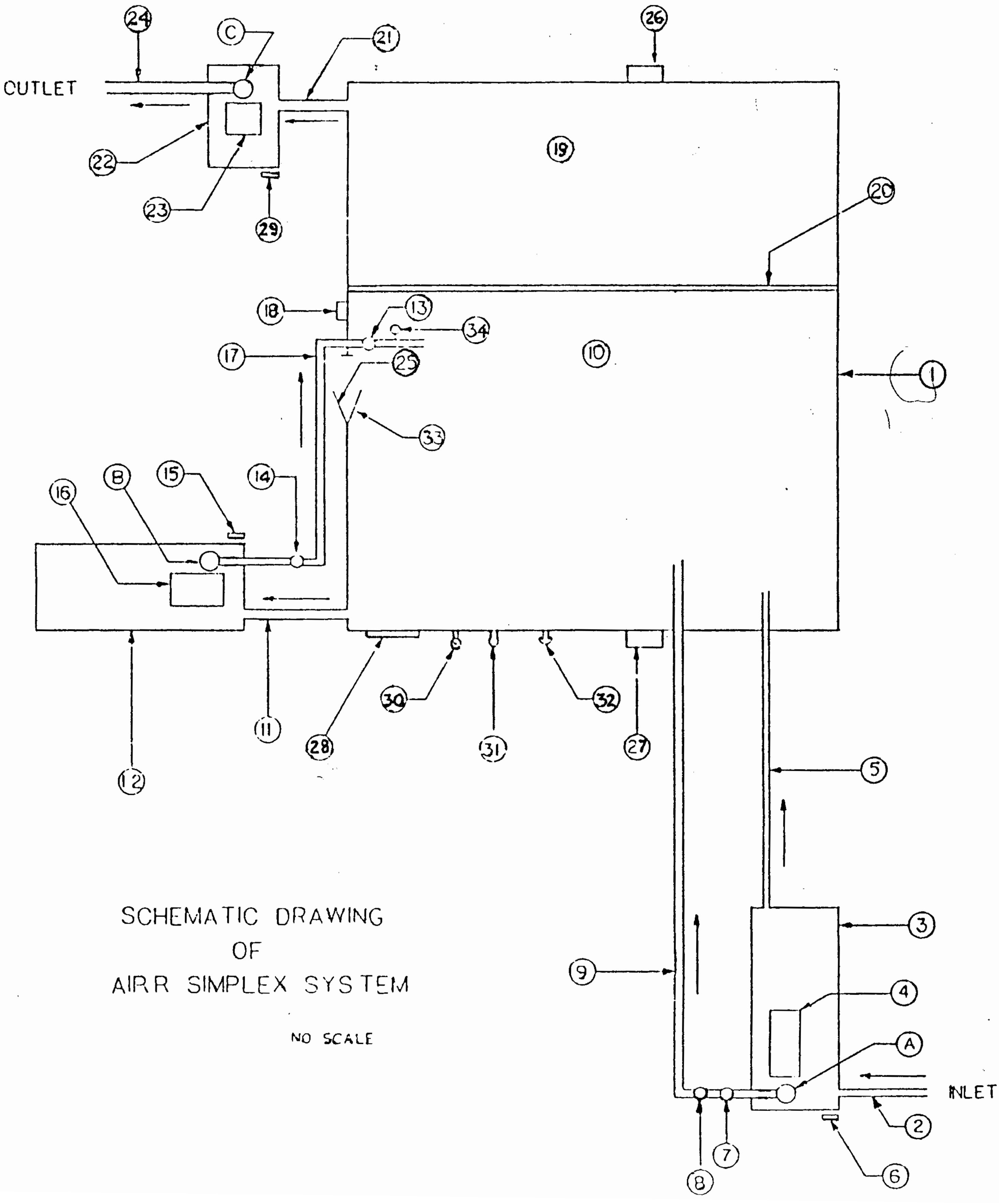
Description of Components

The Waterloo Biofilter is installed in series between a septic tank and the soil absorption system. The Biofilter System contains mesh modular baskets filled with filtering material. Septic tank effluent is pumped and applied to the filter through a sprinkler system, all housed in a shed. Support media are provided in an aeration zone below the medium and a collection area. Effluent discharge through a 2” or larger outlet. Pump controls may include a timer and emergency floats or can be dosed on demand in small 4-gallon doses.



AIRR - FLOW DIAGRAM

SCHEMATIC SIMPLEX SYSTEM



SCHEMATIC DRAWING
OF
AIRR SIMPLEX SYSTEM

NO SCALE

GLOSSARY FOR AIRR SIMPLEX UNIT

(1) AIRReactor enclosure

(2) Effluent delivery pipe from septic tank.

(3) Dosing tank

(A) Dosing pump and screen

(4) Dosing tank access portal

(5) Vent pipe for dosing tank

(6) External electrical con- connections for dosing pump and controls

(7) Check valve for dosing pressure line

(8) Gate valve for dosing pressure line

(9) Dosing system pressure line

(10) Dosing section (secondary treatment)

(11) Drain pipe to recirculation tank

(12) Recirculation tank

(B) Recirculation pump

(13) Gate valve for recirculation pressure line

(14) Check valve for recirculation pressure line

(15) External connections for recirculation pump and controls

(16) Recirculation tank access

(17) Pressure line from recirculation pump to sprinklers

(18) Light switch

(19) Tertiary treatment section

(20) Barrier between secondary and tertiary sections

(21) Drain pipe from tertiary system

(C) Discharge pump

(22) Discharge tank

(23) Discharge tank access

(24) Discharge pressure line

(25) Access to AIRR treatment sections

(26) Air vent

(27) Air vent

(28) Electrical control and testing box

(29) External connections for discharge pump and controls

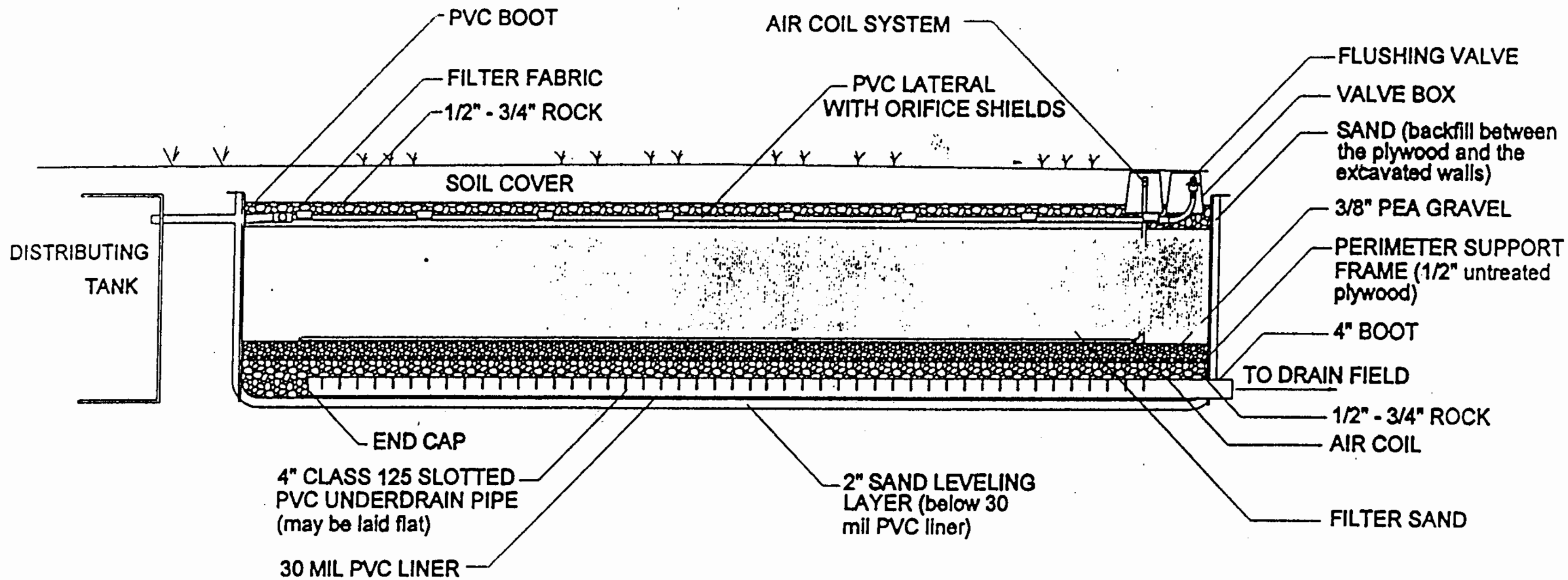
(30) Fresh water tap

(31) Warning light

(32) Warning buzzer or bell

(33) Inner access door to AIRR unit

(34) Pressure gauge



SANECO (Orenco) Intermittant Sand Filter (modified after Orenco, Inc)

APPENDIX D

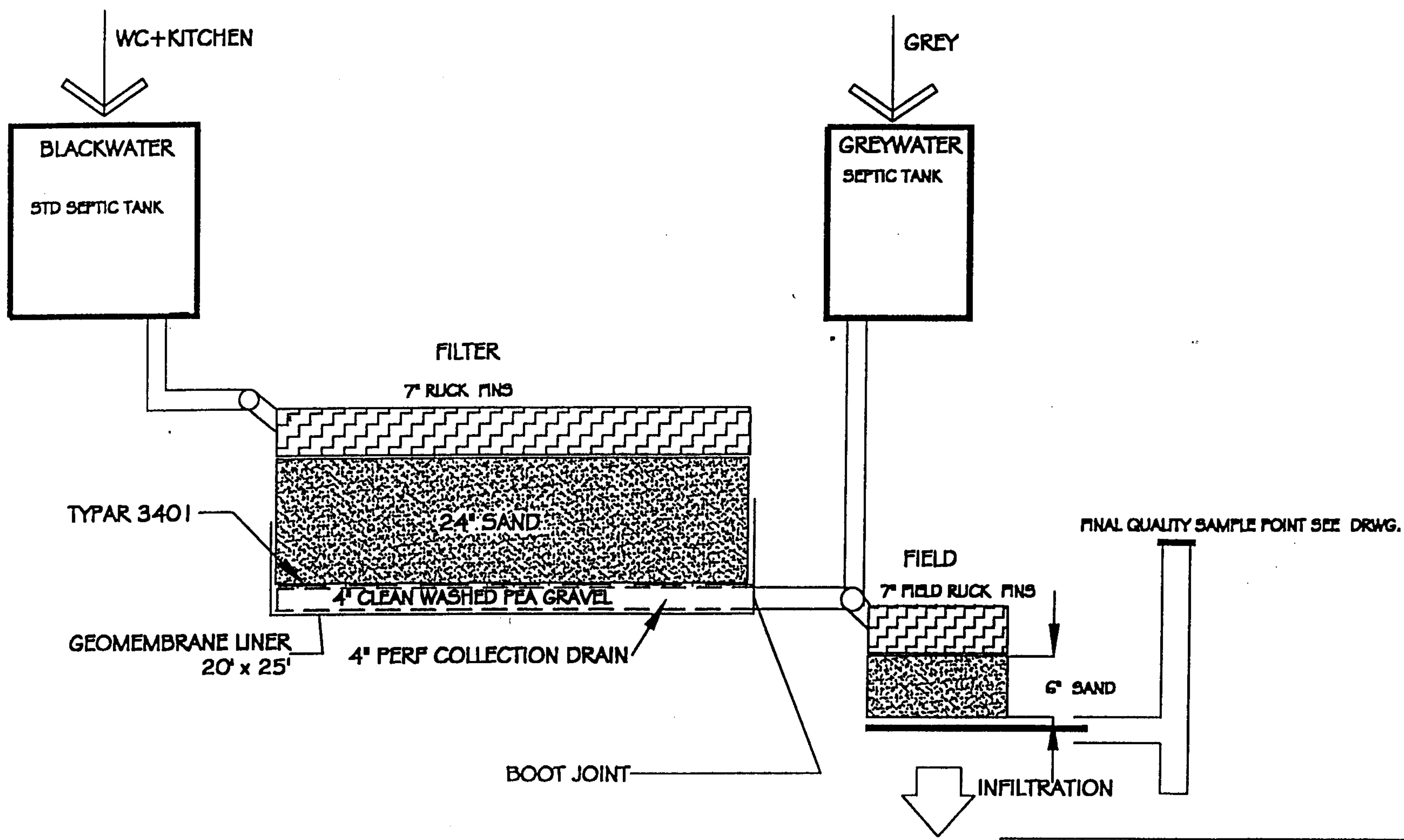
Drawings of I/A Technologies as a Stand Alone Treatment System without a Septic Tank Pretreatment

D-1: RUCK System

D-2: CROMAGLASS

D-3: BIOCYCLE

D-4: PURAFLOW PEAT BIOFILTER

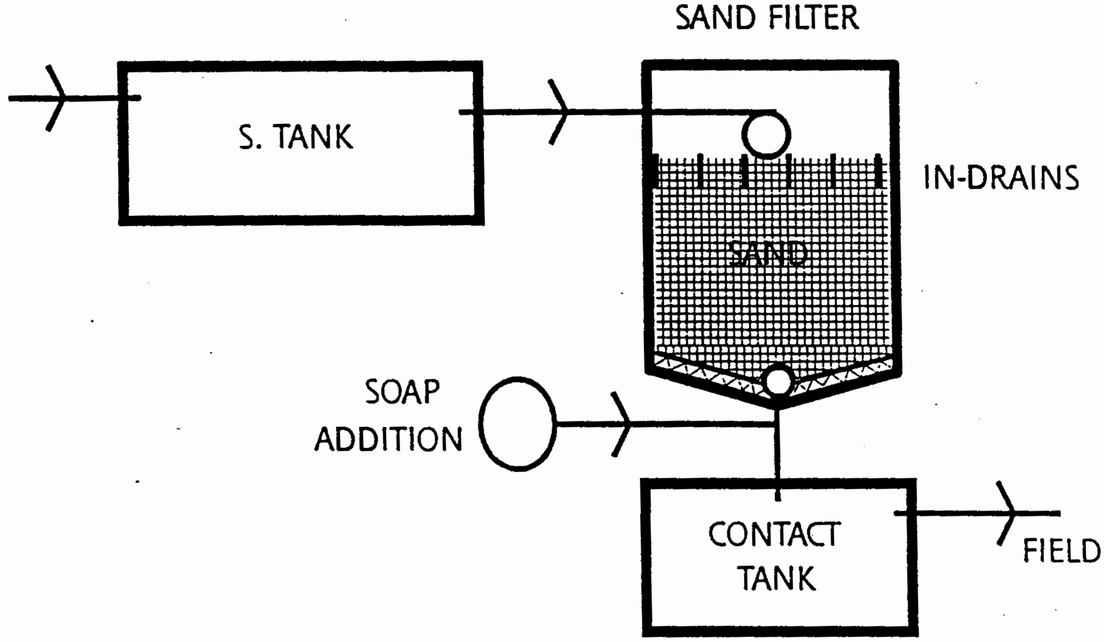


FILTER SIZE IS CALCULATED BY DESIGNER

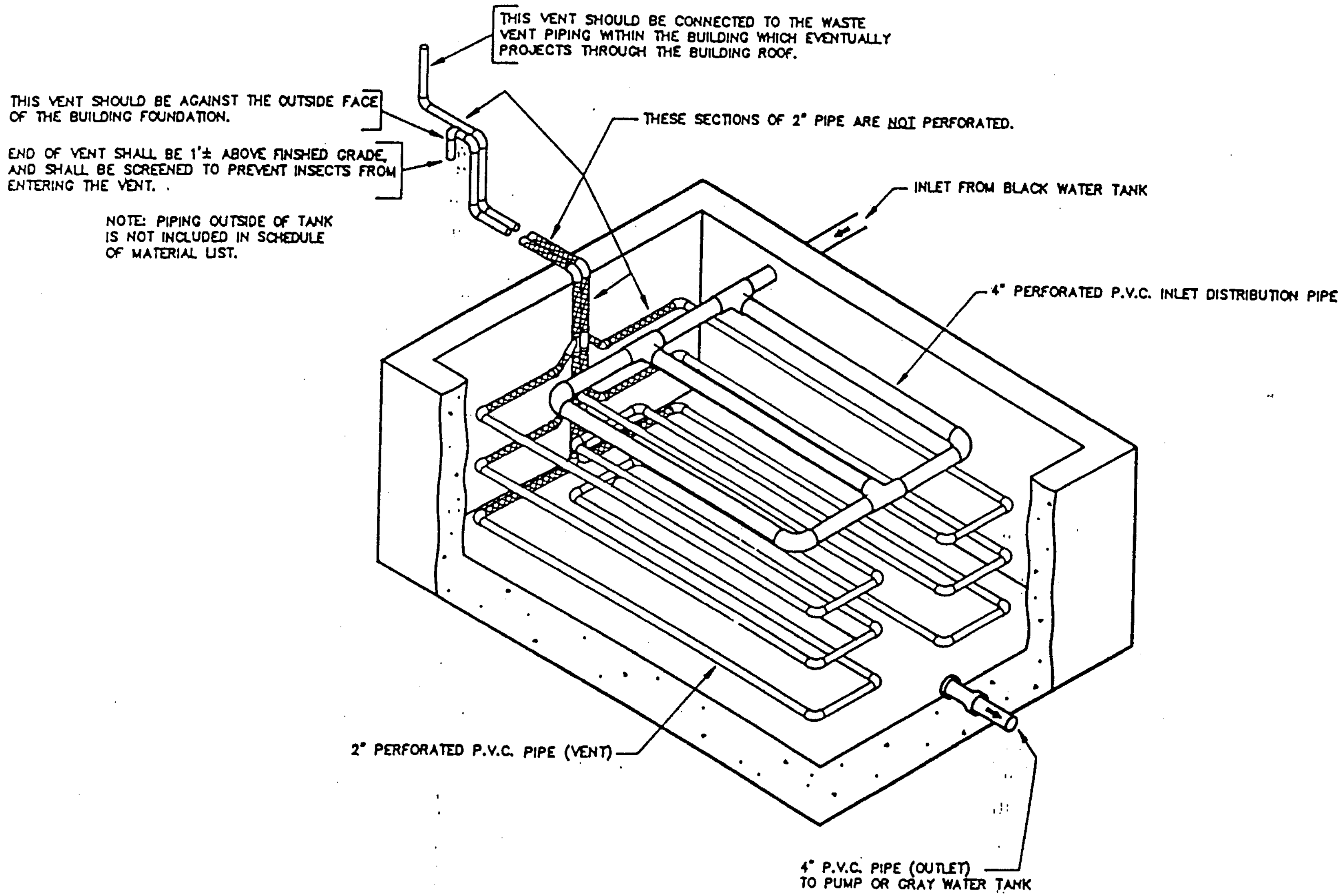
SAND: ES > 0.16mm, PASSING # 200 < 5%, UC < 5

RUCK SYSTEMS ®
TYPICAL

R. LAAK, Ph.D., P.E.

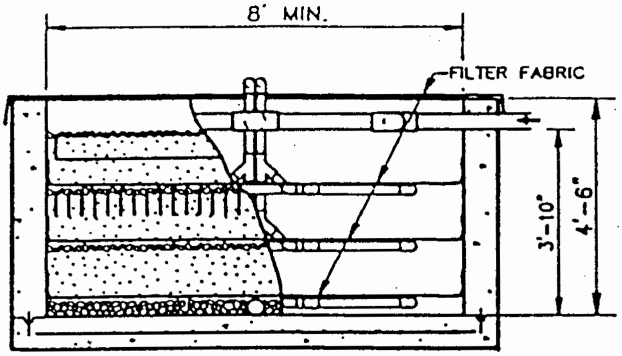


RUCK COMMERCIAL TYPE
MAXIMUM NITROGEN REMOVAL OVER 90%

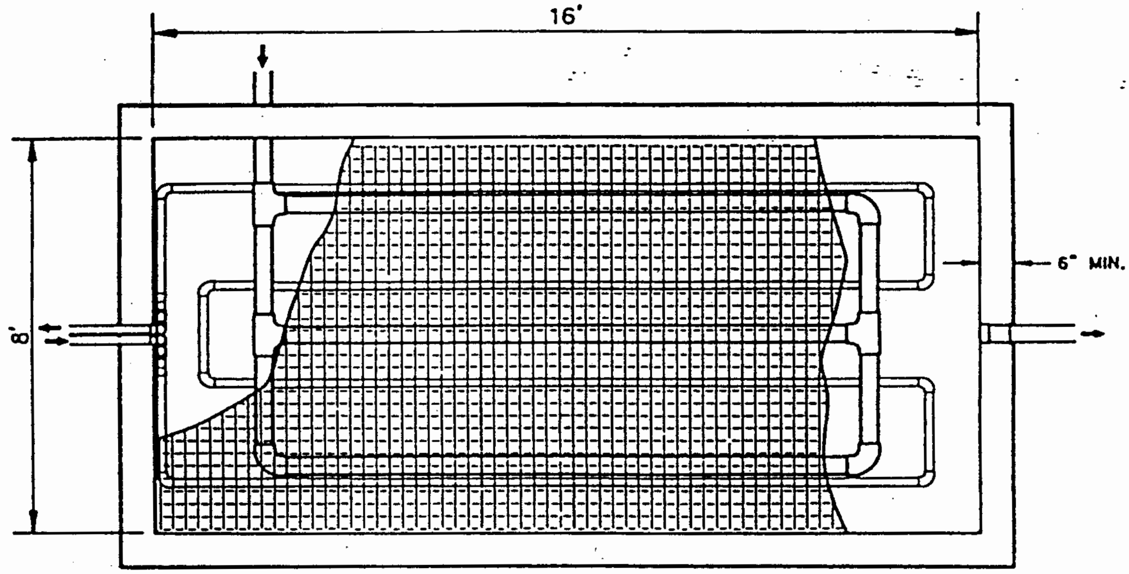


SAND FILTER – ISOMETRIC PIPING

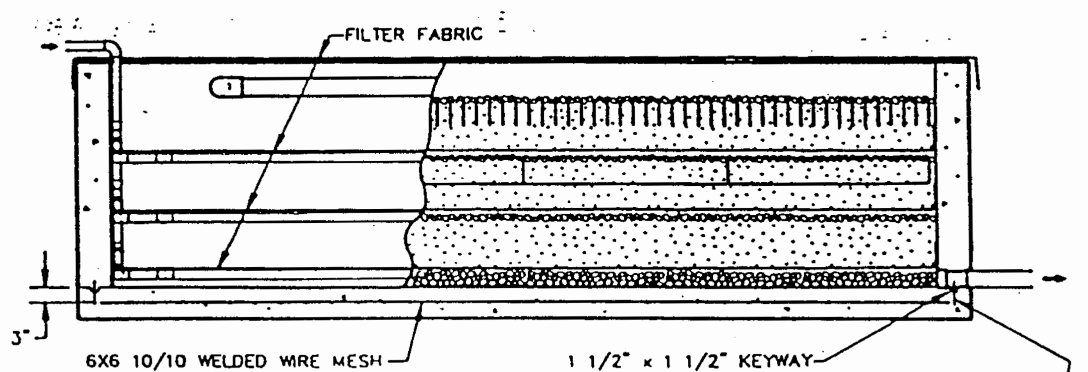
SCALE: NONE



END VIEW



PLAN VIEW

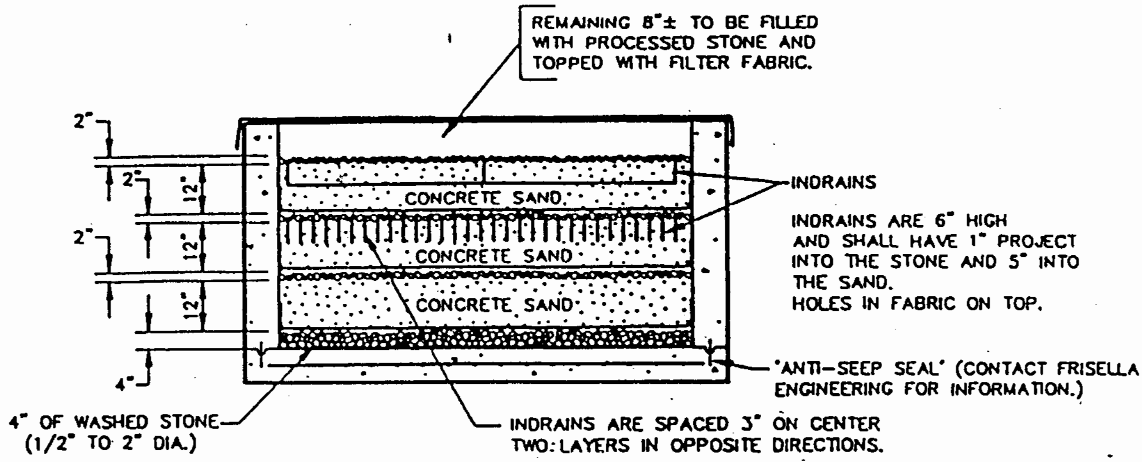


SIDE VIEW

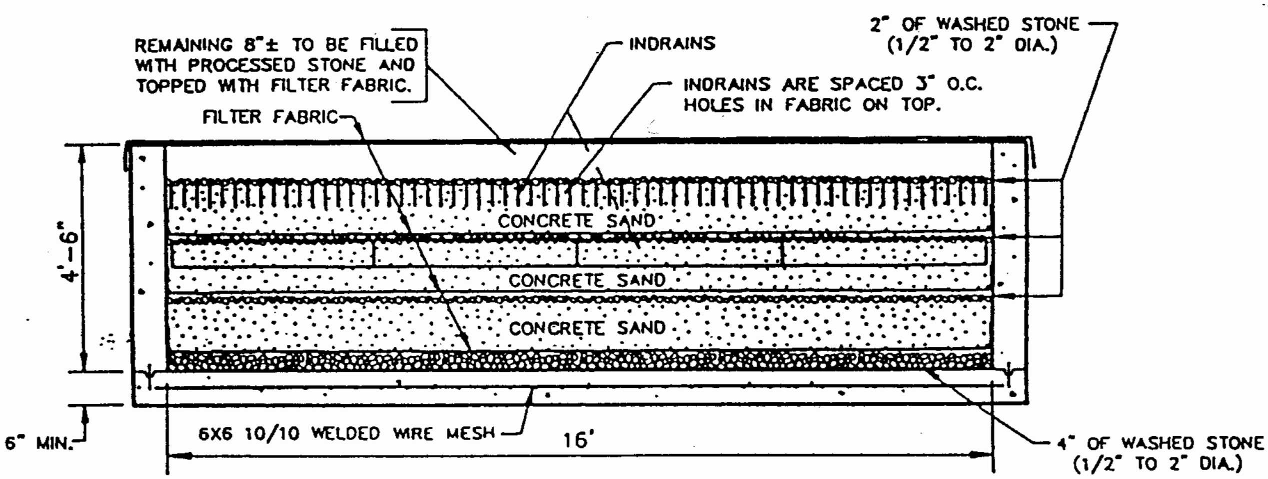
FIGURE 3. – SAND FILTER

VIEW SHOWING PARTIAL SAND, STONE AND INDRAINS, AND PARTIAL PIPING LAYOUT.

SCALE: NONE



END VIEW

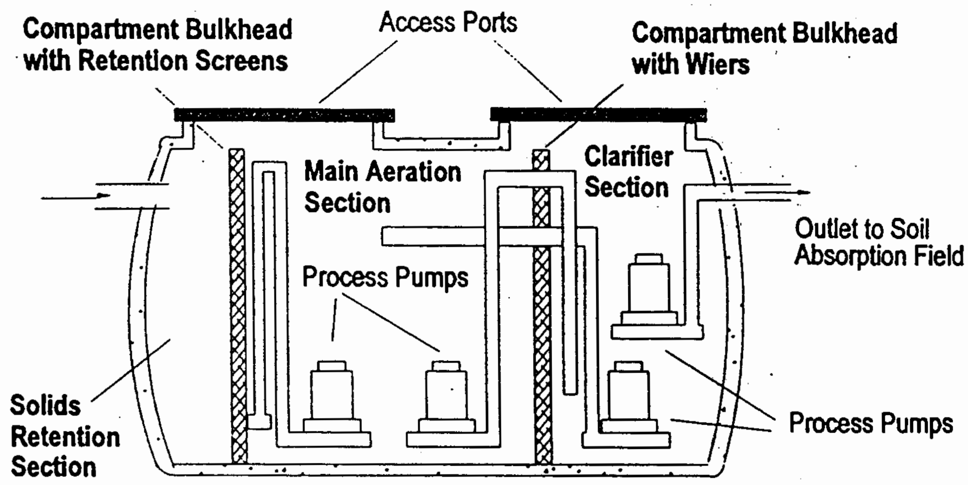


SIDE VIEW

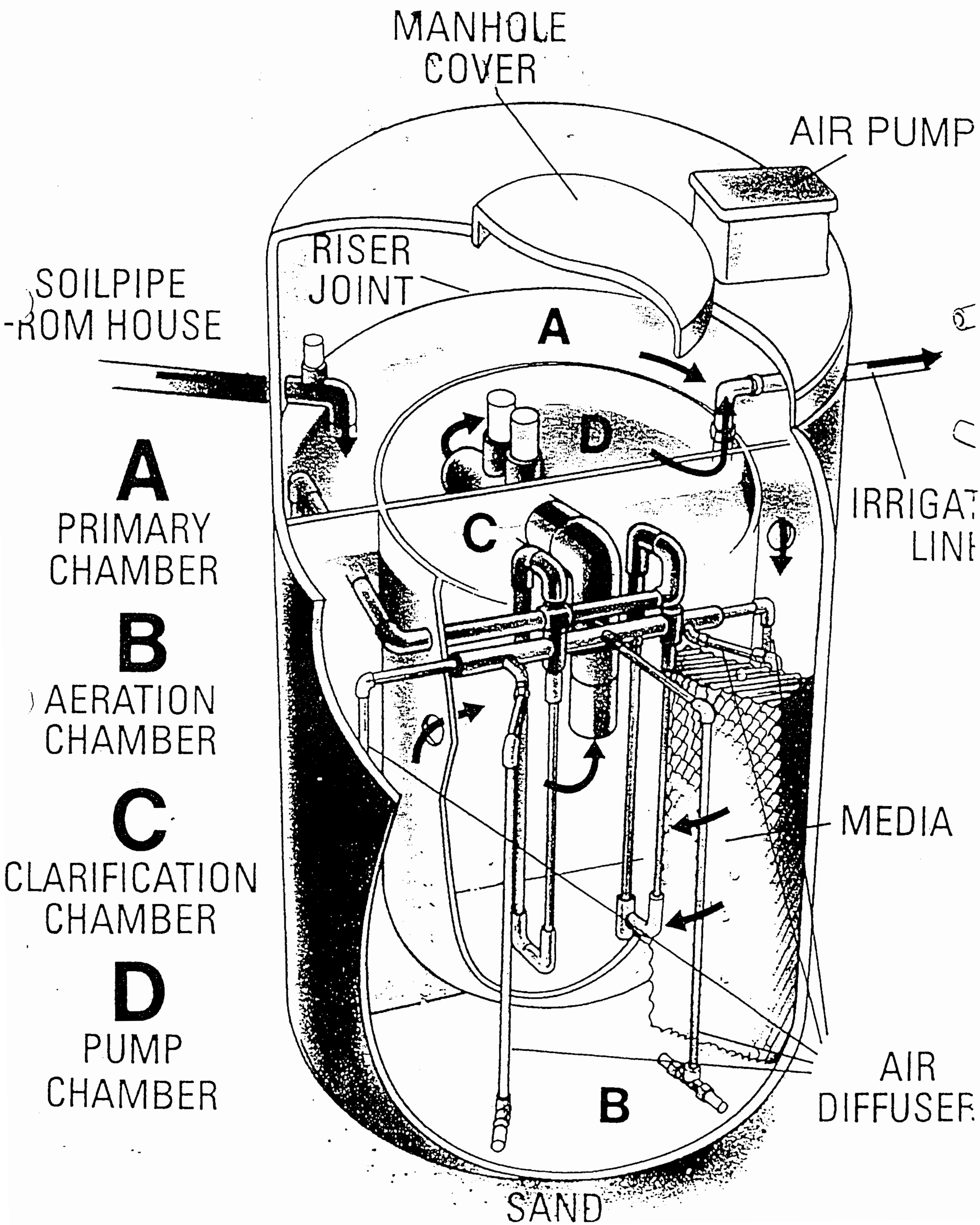
FIGURE 2. – SAND FILTER – NO PIPING SHOWN

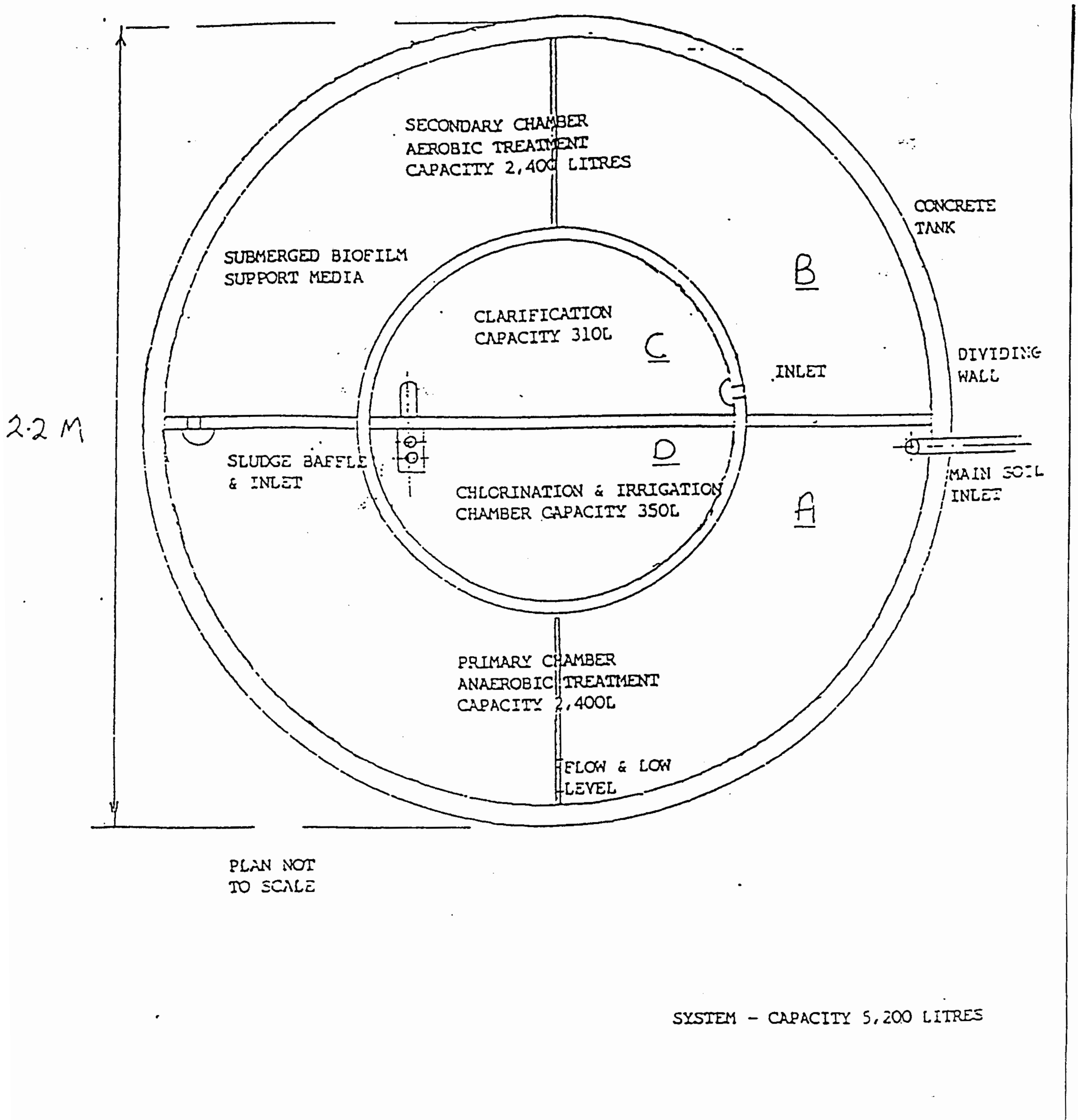
PLACEMENT OF STONE,
SAND AND INDRAINS.

SCALE: NONE

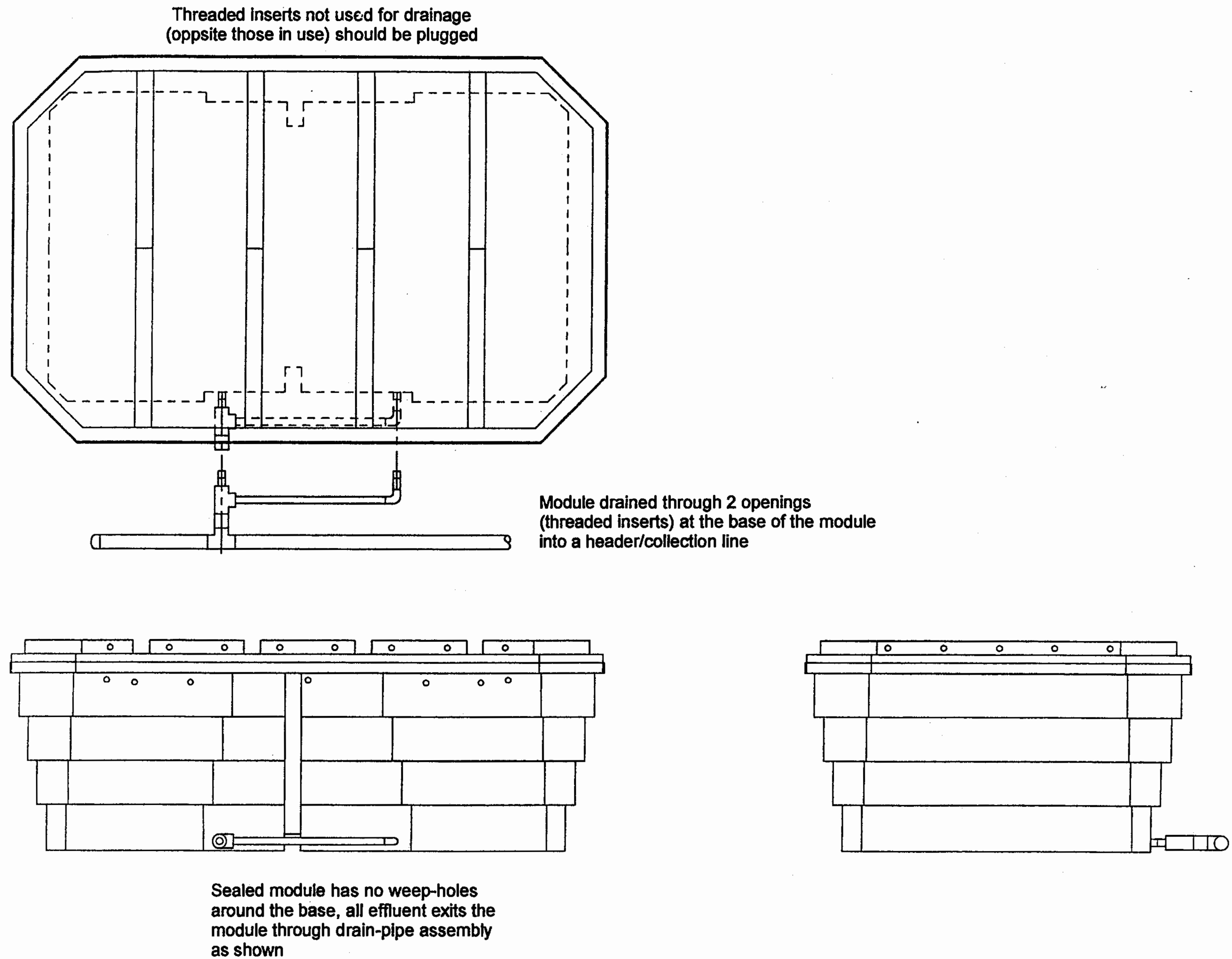


Typical Cromaglass unit (after Cromaglass CA-30, Cromaglass, Inc.)


MANHOLE
COVER
AIR PUMP
RISER
JOINT
SOILPIPE
-ROM HOUSE
A
D
C
A
PRIMARY
CHAMBER
B
AERATION
CHAMBER
C
CLARIFICATION
CHAMBER
D
PUMP
CHAMBER
IRRIGA
LIN
MEDIA
AIR
DIFFUSER
B
SAND



Design Outline of the Single-Tank Biocycle Wastewater Treatment System.

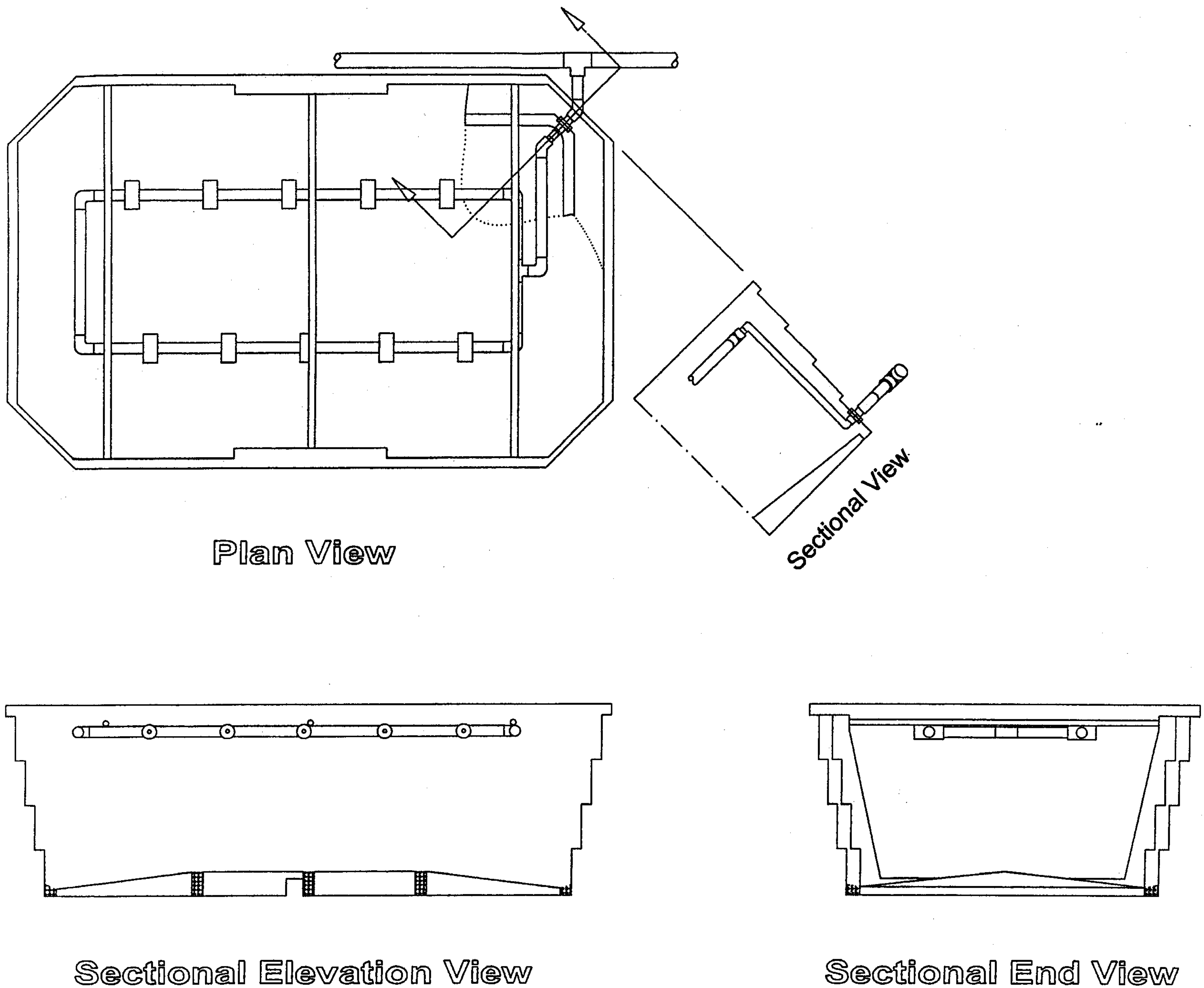


JAN. 15, 1998
DWG. BY: GMO'D

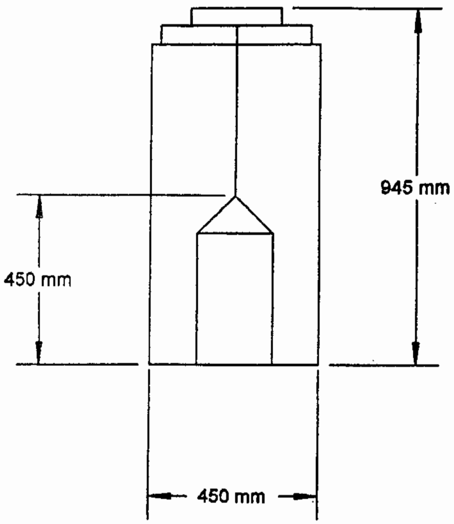
Scale 1:20

Drawing Title:
DRAIN PIPE DETAIL

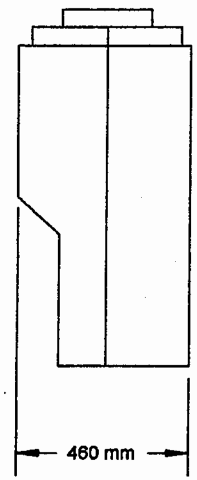
Project Reference:
PURAFLO PEAT BIOFILTER



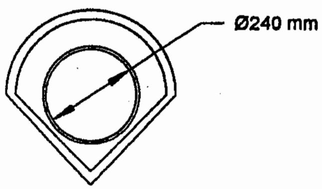
JAN. 15, 1998 DWG. BY: GMO'D	Scale 1:20	Drawing Title: **MODULE GRID DETAIL**	Project Reference: **PURAFLO PEAT BIOFILTER**



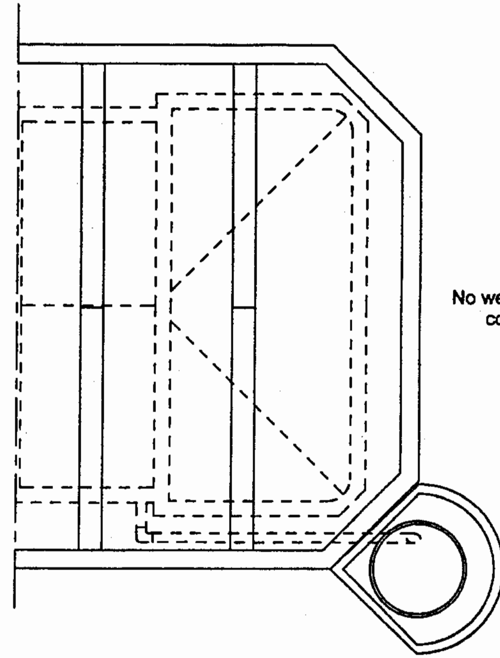
ELEVATIONAL VIEW

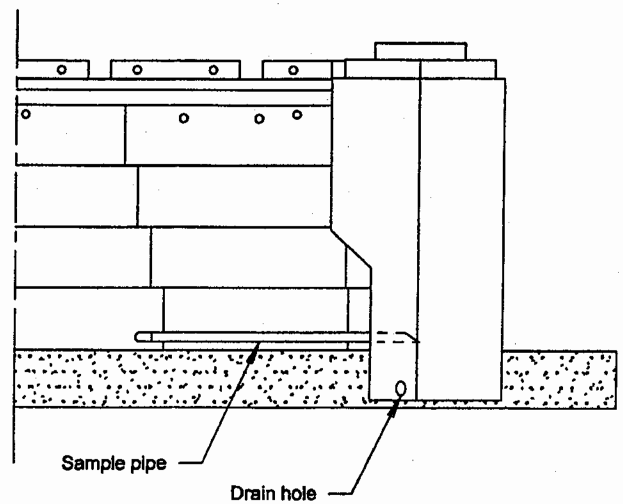


END VIEW



PLAN VIEW





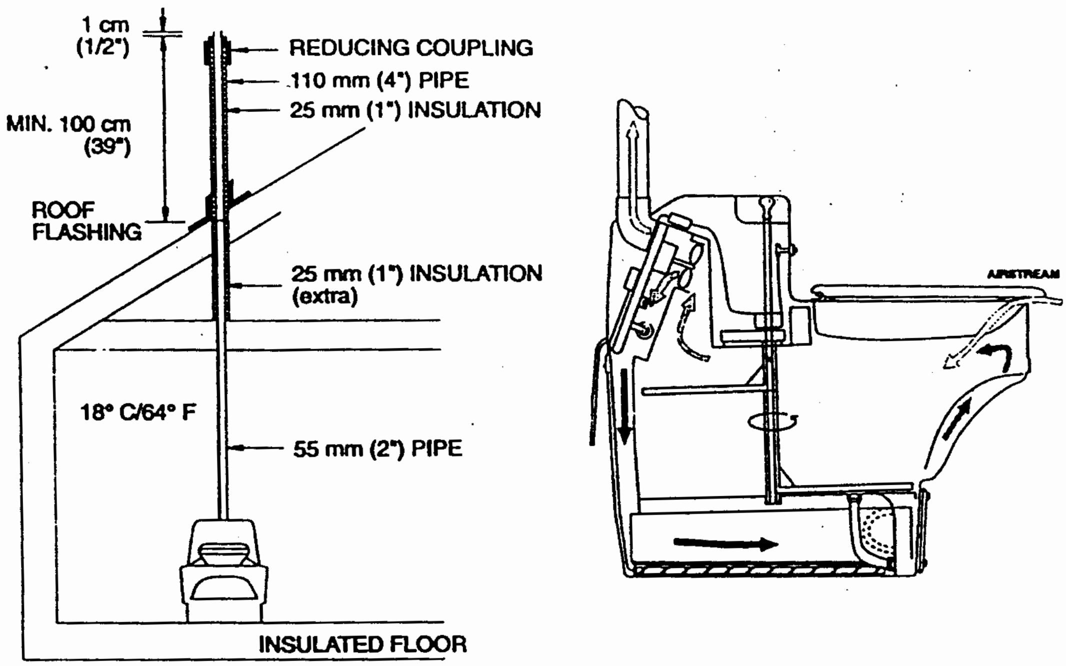
JAN. 15, 1998 DWG. BY: GMO'D	Scale 1:20	Drawing Title: **SAMPLE CHAMBER DETAIL**	Project Reference: **PURAFLO PEAT BIOFILTER**

APPENDIX E

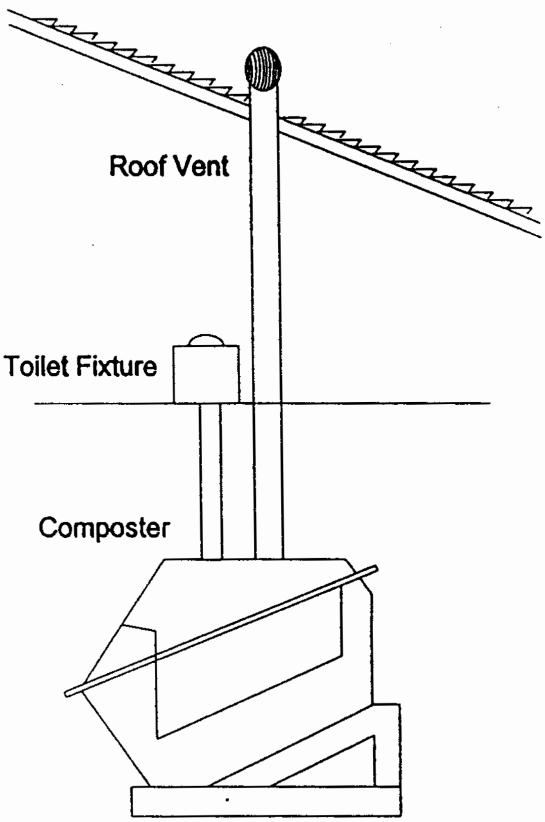
Drawings of Other I/A Technologies

E-1: BIOLET XL

E-2: Vault Type Composting Unit



BioLet XL Automatic Toilet (after BioLet USA, Inc.)



Typical Vault Type Composting Toilet