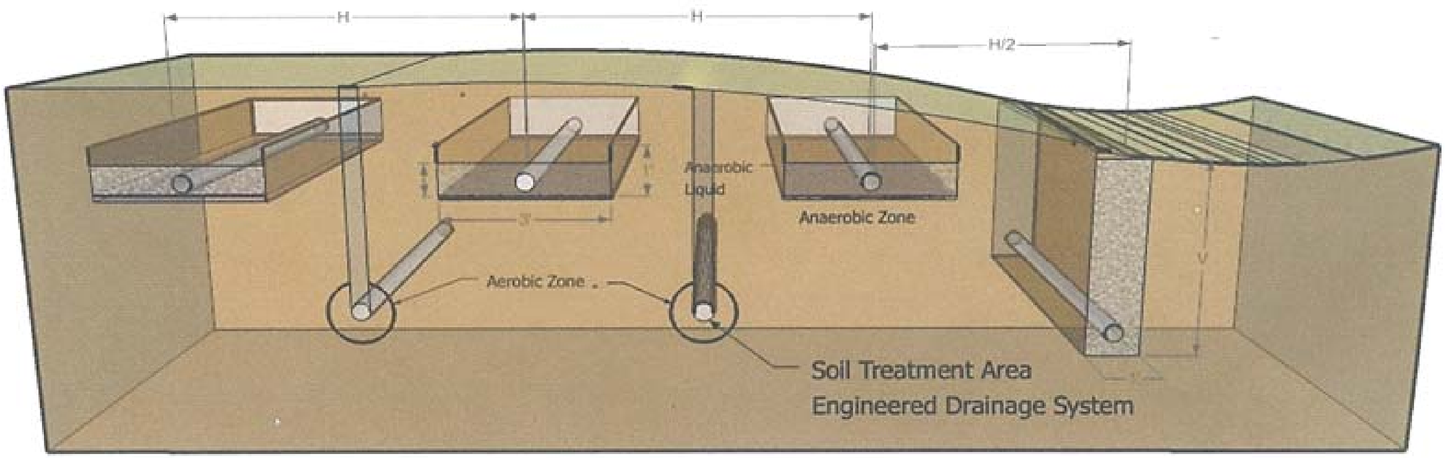
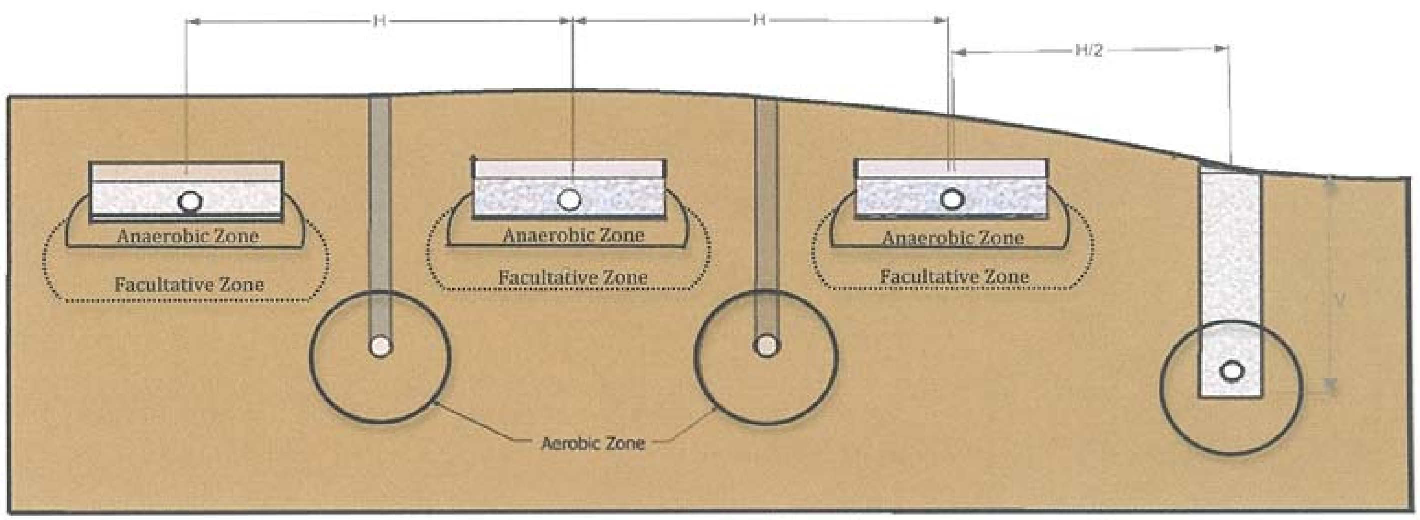
Household Sewage Treatment Systems

Report on
Maximizing Efficiency of Soil Treatment Area
Using Engineered Drainage



$$\text{flow} = q = AK\frac{dh}{ds} = AK\frac{\Delta h}{L}$$

and
Natural Microbiological Processes



$$\text{treatment} = v = \frac{f(S_n + A)}{t}$$

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HOUSEHOLD SEWAGE TREATMENT SYSTEMS

The Problem and Questions

Each of the various methods utilized today for the treatment of sanitary wastewater relies on microbes to consume the organic matter present in the discharge followed by a method to remove these same microbes from the water before it is released to environment. For most cities or towns, this system includes an extensive sanitary sewer system to collect the wastewater from each home and direct it into a central wastewater treatment plant, where highly efficient treatment occurs within a controlled environment. In these systems, the microbes are concentrated into a relatively small area, provided oxygen through blowers and associated piping within a configuration of tanks that allows for the treatment of large volumes of wastewater efficiently. The cost for this system is then shared among each of the dischargers.

When the concentration of homes is low however, as in rural areas and scattered low density subdivisions, the cost of constructing and maintaining this central collection system and the small municipal type treatment facilities becomes prohibitive given the relatively low number of users. In this case, the treatment and discharge of sanitary wastewater falls to the individual homeowner. On-site sewage treatment systems traditionally consist of an individual treatment tank (septic or aerated) to remove the majority of the wastewater pollutants followed by a subsurface dispersal system (leach field, mound system, or drip irrigation) that allows treatment to continue through the naturally occurring microbes in the wastewater and surrounding soils before the water enters the groundwater aquifer.

The design question for those on-site systems then becomes how to utilize the different types of soil in the most efficient and cost effective manner. The current methods are to dictate that the area of the home site will be large enough to allow infiltration of the wastewater into whatever soil is available. Soils are classified generally according to the Natural Resource Conservation Service (NRCS) as in the following table.

*From: "Small and Decentralized Wastewater Management System" by Crites Tchobanoglous

NRCS permeability classes for saturated soil

Soil permeability, in/h	Permeability class
<0.06	Very slow
0.06-0.2	Slow
0.2-0.6	Moderately slow
0.6-2.0	Moderate
2.0-6.0	Moderately rapid
6.0-20.0	Rapid
>20	Very rapid

If the soil permeability is low as in very slow or slow, the infiltration area needed becomes large. If the soil permeability is too fast, as in moderately rapid to very rapid the groundwater pollution potential becomes high because of the short period of time that the wastewater is in contact with the subsurface microbes, and again the isolation distance required becomes large, also resulting in needing a large area. In both these cases, the actual geology below the area is very important and must be evaluated along with the soil.

Various possibilities present themselves as to the more appropriate designs that may be successfully employed which result in the lower risk to the pollution of the water supply and environment. Should the emphasis be on adequately treating the wastewater and leaving it in the ground or discharging the treated wastewater on the surface of the ground? Which allows the greater opportunity to easily evaluate the impact on the water supply and environment?

For slow and very slow permeable soils, a further complication is the natural level of groundwater at certain times of the year. This condition is called a seasonal water table (or perched aquifer) which may be present in some soils for 2 to 4 months. This is not the water aquifer from which well water is withdrawn for potable uses, but is a relatively shallow section of slow draining soils that do not allow water infiltrating from the surface to pass through it as fast as it enters. The use of this seasonal water table as a water supply is just not feasible, due to the difficultly of withdrawing it in a timely manner in sufficient quantities to be useful. The presence of this seasonal water interferes or hinders the use of a conventional leach field for on-site disposal of sanitary wastewater because it creates an anaerobic condition that increases the time required for the microbes to purify the water. Anaerobic reactions in the soil are more complex and take longer than the preferred aerobic reactions that occur above the groundwater table.

The depth of this seasonal water and subsequently the rate in which surface water from an area drains may be controlled by subsurface drainage tile or pipes buried in the soil. This method of control is frequently employed within agriculture fields to reduce the soil saturation levels and increase crop yield. For on-site sewage treatment, the depths and spacing of these drainage tiles required to control the level of the seasonal water table while still permitting the wastewater in conventional leach trenches to achieve a desired degree of treatment is unknown and therefore the installation of drainage tiles within a wastewater dispersal field is not currently accepted. The result has been a requirement to install more advanced pretreatment systems, larger leach fields, and more above ground dispersal systems such as mound or drip irrigation facilities. Each of these alternatives incurs a significantly higher installation and operational cost to the home owner. But the question remains, can a series of drainage tiles be installed within a traditional wastewater leach field to lower the seasonal high water table enough to allow for effective aerobic wastewater treatment to take place? .

It is understood that in addition to discharging groundwater from the perched aquifer, the drainage tile will also collect and discharge the treated sanitary sewage that is dispersed from the leach lines. But is there a depth below the leach lines where the sewage is treated sufficiently through the natural soils for discharge to surface water?

The level of treatment that is achieved at various depths below the leach lines can be estimated by probing holes in existing leach fields containing different soil types. When holes are augured in close proximity of existing leach trenches, seepage water will accumulate in the bottom of the hole. Analysis of the seepage water will show the degree of purification or treatment that has occurred. The requirement or goal is to place the drainage tile at a depth and spacing which will optimize the removal of the drainable water while also permitting the needed detention time for wastewater reclamation to prevent pollution of either the ground water or surface water.

Can we maximize the drained water to permit the maximum detention time of the wastewater from the leach trench infiltration into the soil for the anaerobic – facultative – aerobic reactions to be completed particularly in the bottom volume which is aerobic? Can this question be answered by relationship between the observations and estimates of soil scientists in the soils report on the level of seasonal water table and particularly, clay content. Can the needed vertical and horizontal spacing of the drainage tile be related to level of seasonal water table? Is the vertical distance or the horizontal distance more critical? We know that on some soils a 6 to 8 foot horizontal spacing does remove the subsurface water but the current typical design spacing does not allow sufficient hydraulic head to push the wastewater being purified to the drainage tiles. Can a mathematical relationship be developed to optimize removal of all drainable subsurface water while also increasing the hydraulic head needed to optimize infiltration of wastewater such that it obtains sufficient detention time plus obtains reaeration near the drainage tile to give complete reclamation of the wastewater.

From "Environmental Soil Physics" by Daniel Hillel, pg. 494 "In principle, water will not spontaneously flow out of soil into a large cavity unless the pressure of soil water is greater than atmospheres. Drains must be located below the water table to draw water, and the water table cannot be lowered below the drains. Hence, the depth and spacing of drains is of critical importance. Insufficient depth of placement will prevent a set of drains from lowering the water table to the extent necessary. Too great depth might on the other hand, lower the water table excessively and thus deprive crop plants of a possible important source of water during drought period." However, for wastewater reclamation the maximum drawdown is needed. Will this approach help in optimizing wastewater treatment in slow draining soils? Will digging in existing leach fields begin to provide data and analysis to improve the design of soil treatment areas?

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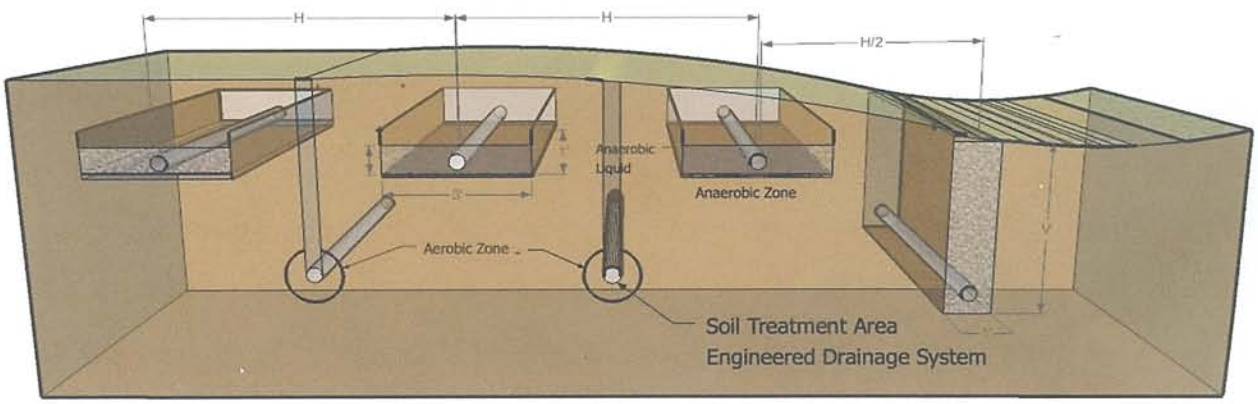

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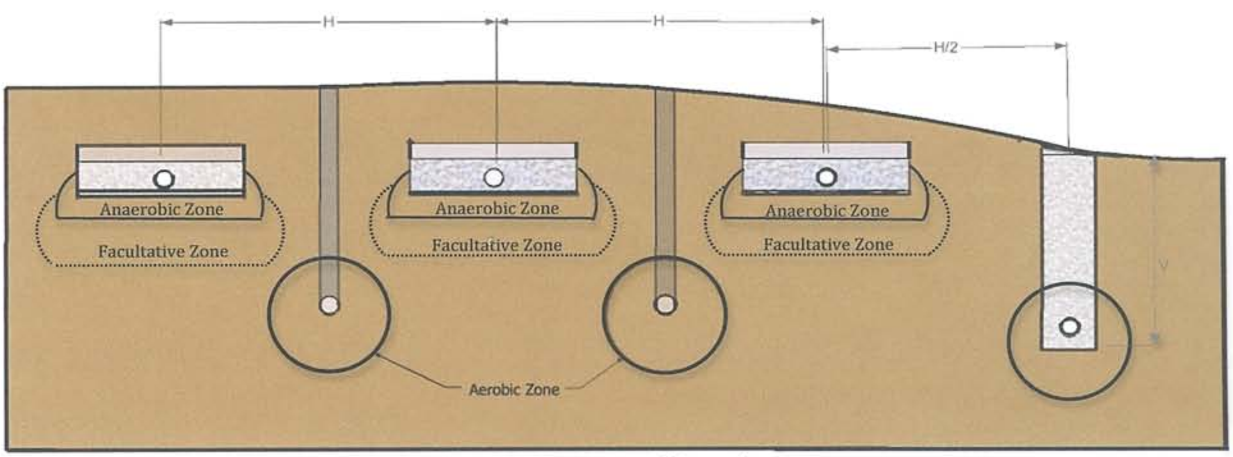

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DESCRIPTION OF PROPOSED ALTERNATIVE ENGINEERED SEWAGE DISPERSAL SYSTEM

The proposed engineered sewage dispersal system consists of a traditional leach field with subsurface drainage tiles located within the field to both reduce the seasonal (or perched) high groundwater table and improve subsurface drainage of the pretreated sewage. The historical concern with this concept has been that untreated sewage would be discharged into the surrounding streams as it passes from the leach pipes into the subsurface drainage system. However, the soil treatment area, or “leach field” can be viewed as an “attached growth bioreactor using native microorganisms,” when applying traditional biological wastewater treatment principles. . When considered in this manner, it is understood that treatment of the wastewater will continue to occur as the septic tank effluent passes through the subsurface soils. If given sufficient time in contact with the native microorganisms’ full treatment of the wastewater to within acceptable discharge standards can be expected to occur.

The objective of this engineered dispersal system is to identify the required detention time that the wastewater must be maintained within this natural soil bioreactor in order to achieve the appropriate level of treatment. If the depth of soil is identified for such treatment to occur, the operation of a traditional leach field located within poorly drained soils may then be optimized by strategically locating a subsurface drainage system within the field to maintain drain away both the treated wastewater and the perched water table.

The 100% saturation level in Blount soil, a somewhat poorly drained soil that is prevalent in Ohio, can be easily controlled with a properly designed and constructed subsurface drainage system as is typically accomplished in agricultural fields throughout the Ohio. The movement of septic tank effluent through the gelatinous film at the soil-wastewater interface in a leaching trench and 15" to 20" of Blount, or similar soil, with a hydraulic conductivity (permeability) of ±1.5" per day is believed to provide complete treatment of the wastewater. Proof of this understanding is required through testing and research however, before such a system can be permitted.

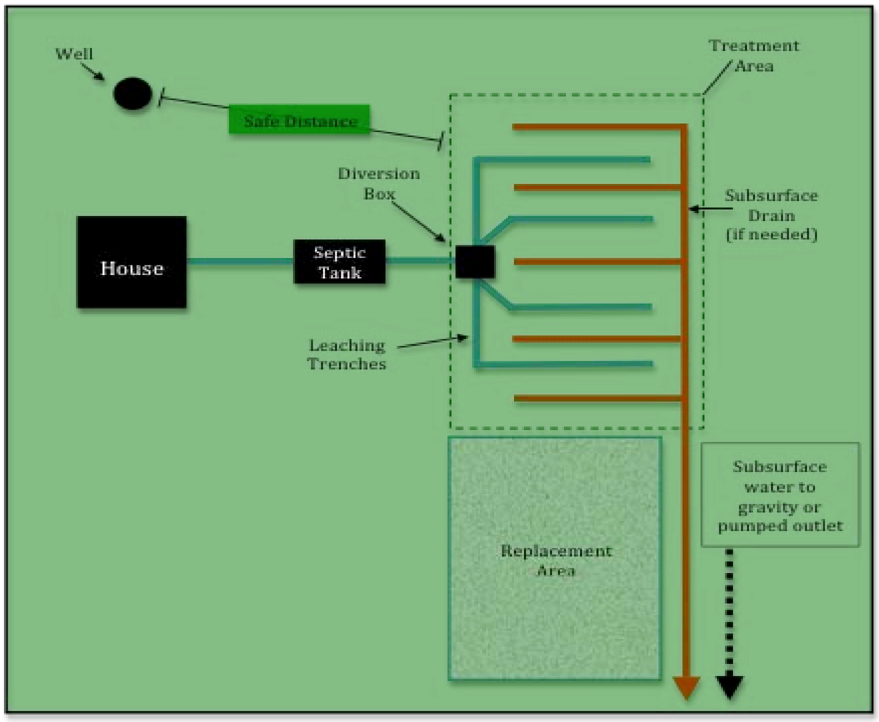
By sampling operating standard leach fields (soil treatment areas) in different soil types and at various depths and horizontal spacings relative to the leaching trenches, the rate of treatment through the native soils can be determined and subsequently used for locating where subsurface drainage systems may be installed within the field. In addition to this testing, construction of a soil treatment “laboratory” is proposed within a Blount soil field in Union County. This test field will include a traditional leach field with subsurface drainage pipes installed between the leach lines and be designed to permit both soil and water sampling in order to obtain meaningful results of how the system functions. The area of the soil treatment will be the same as currently required by the county regulations for 3 and 4 bedroom homes. This size may be reduced after several years of operation of the proposed system when results demonstrate the protection of public health and the environment. Sampling and analysis will show the relationship between soil hydraulic conductivity and microbiological performance capability related to detention time in leaching trench, soil-wastewater interface and the soil treatment area.

The seasonal variation in the depth of the water table (6"-18") has no significance in the treatment of wastewater as long as properly designed subsurface drainage pipes are installed carefully. Extensive and continuing literature research over more than two and a half years has not revealed a comparable investigation in Ohio soils or anywhere else with detailed, real world data and engineering analysis.

Much research and some actual fieldwork (with samples taken within the soil treatment area) have been done to investigate what happens when septic tank effluent is applied under the soil surface in a trench. The following exhibits and narrative present an experienced wastewater treatment engineer's observations and development of concepts for the engineered sewage dispersal system described within this report based on an integration of available data on geology and subsurface drainage as well as real-world data on one such system. Principles of drainage and the role of microorganisms in wastewater treatment are included in this report because both are important in optimizing use of the soil treatment area. A plan view of a typical design and layout of septic system and treatment area is illustrated in Exhibit 1.

Exhibit 1

Plan View of Well and Septic System Location



Safe distance between well and soil treatment area depends on soil hydraulic conductivity and geological formations. Also horizontal and vertical spacing of Leaching Trenches and subsurface drainage pipes depends on soil hydraulic conductivity, microbiological treatment capability, and Topography.

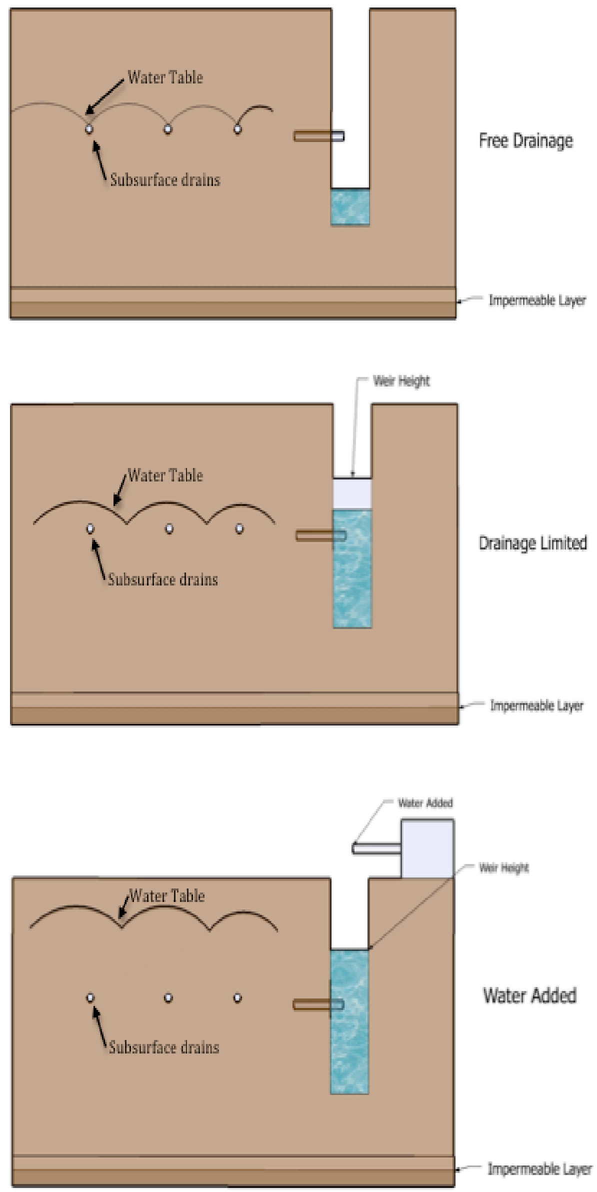
Groundwater and Seasonal Water Table Control

Results during this investigation and work by Dr. Larry Brown of the Ohio State University's Department of Food, Agricultural, Biological, and Environmental Engineering show that clay soils similar to the Blount Soils of Union County could be much more effectively utilized by the installation of a subsurface drainage system. Groundwater and water in perched conditions can be entirely controlled by a properly designed, constructed, and operated subsurface drainage system. This is graphically shown in Exhibits 2, 3, and 4.

If a slow draining soil area is encountered as in Exhibit 3, as the so called perched water, it can easily be lowered to any desired level by a system of subsurface drains. Depending on the local topography, the outlet from the subsurface drainage system may go to a gravity discharge. If the topography is level or flat, the subsurface drainage may be diverted to a constructed sump and then pumped to any desired surface discharge location as shown in Exhibits 4.

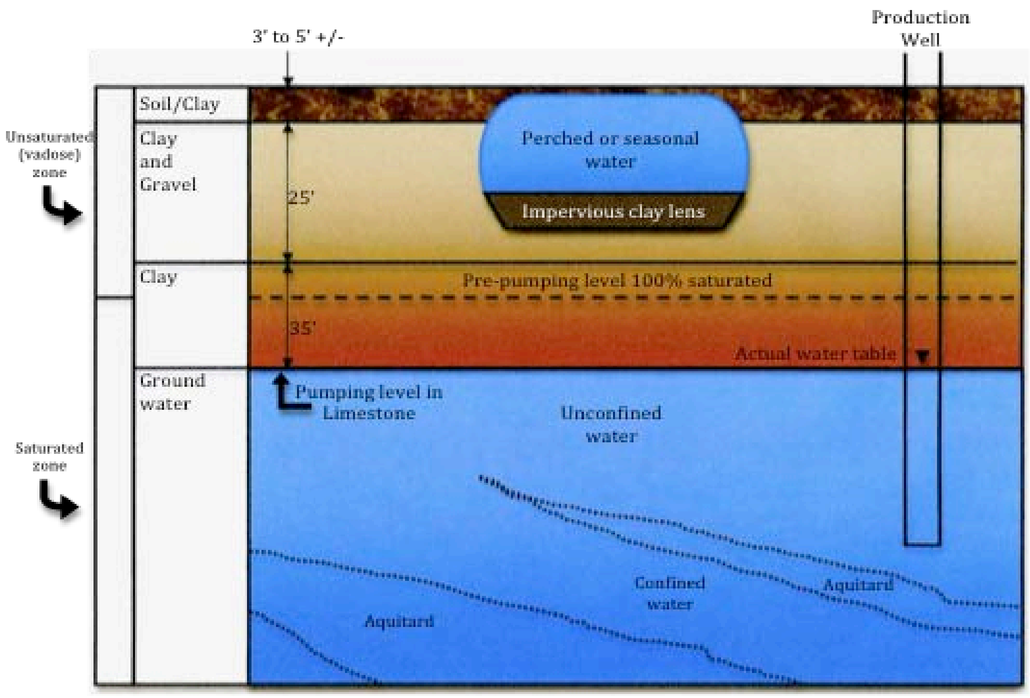
Drain pipe sizing is proposed to be the same as currently used according to county rules and regulations. The thickness of undisturbed soil will be determined by the hydraulic conductivity or permeability of the specific soil in the area. The thickness shall be adequate to provide a theoretical travel time of at least 21 days (or as determined through further testing) between the leaching trench bottom or side wall surface and drain pipes. The depth of the subsurface drain shall provide for a possible hydraulic head of minimum 24". The minimum thickness of undisturbed soil at any point shall be 12". No cheating!

Exhibit 2



Water Table Control with Subsurface Drains

Exhibit 3



Generalized cross-section illustrating the possible occurrence of perched water in soil near the surface. Actual water table can only be lowered with installed well points and pumping.

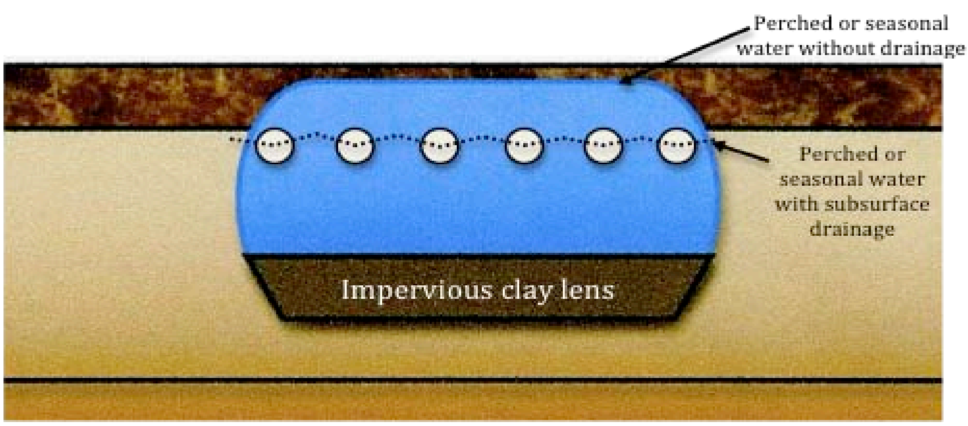
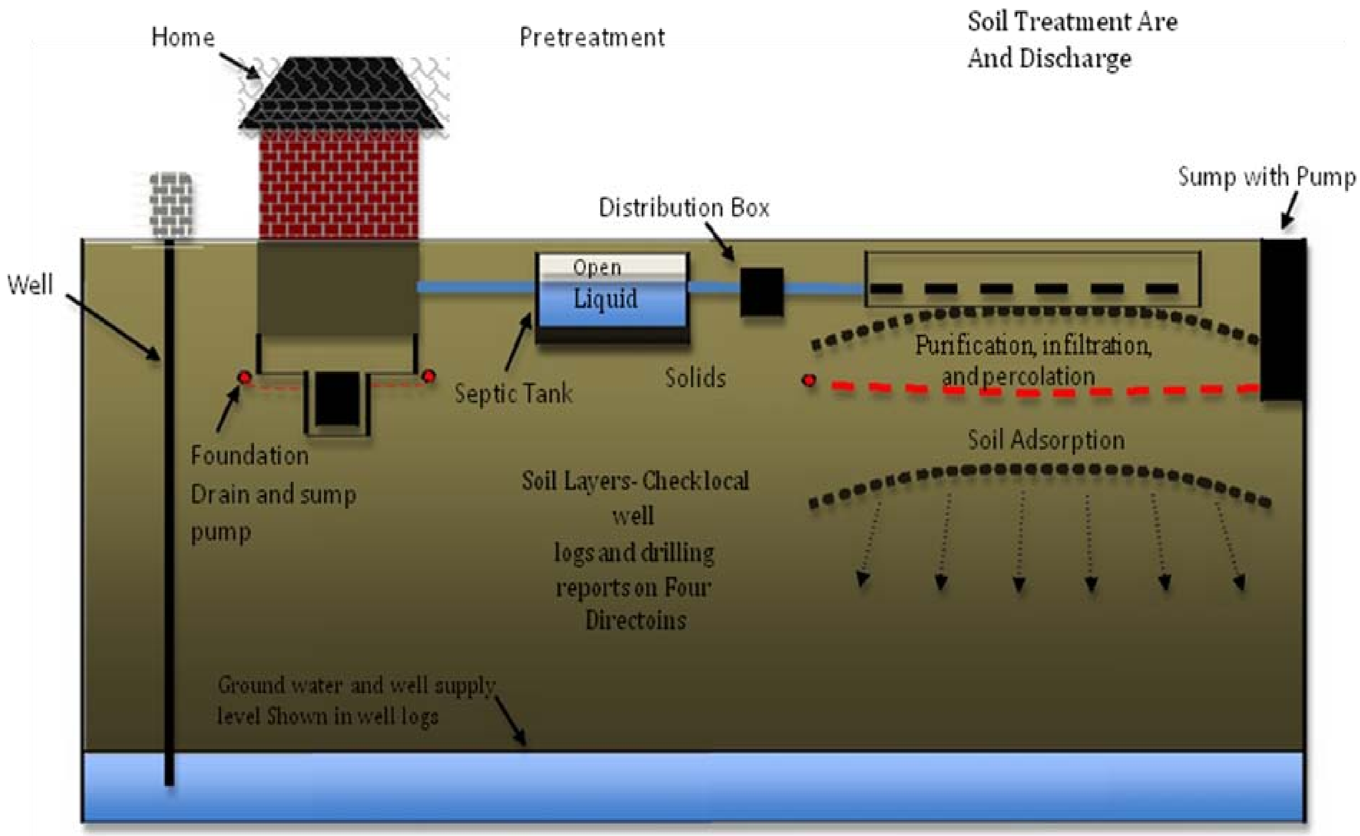


Illustration of how perched water is controlled and removed to any desired level using properly located subsurface drainage system. Subsurface drains may be directed to gravity or pumped outlet.

Exhibit 4



Cross-section of Well, Home, and Septic System

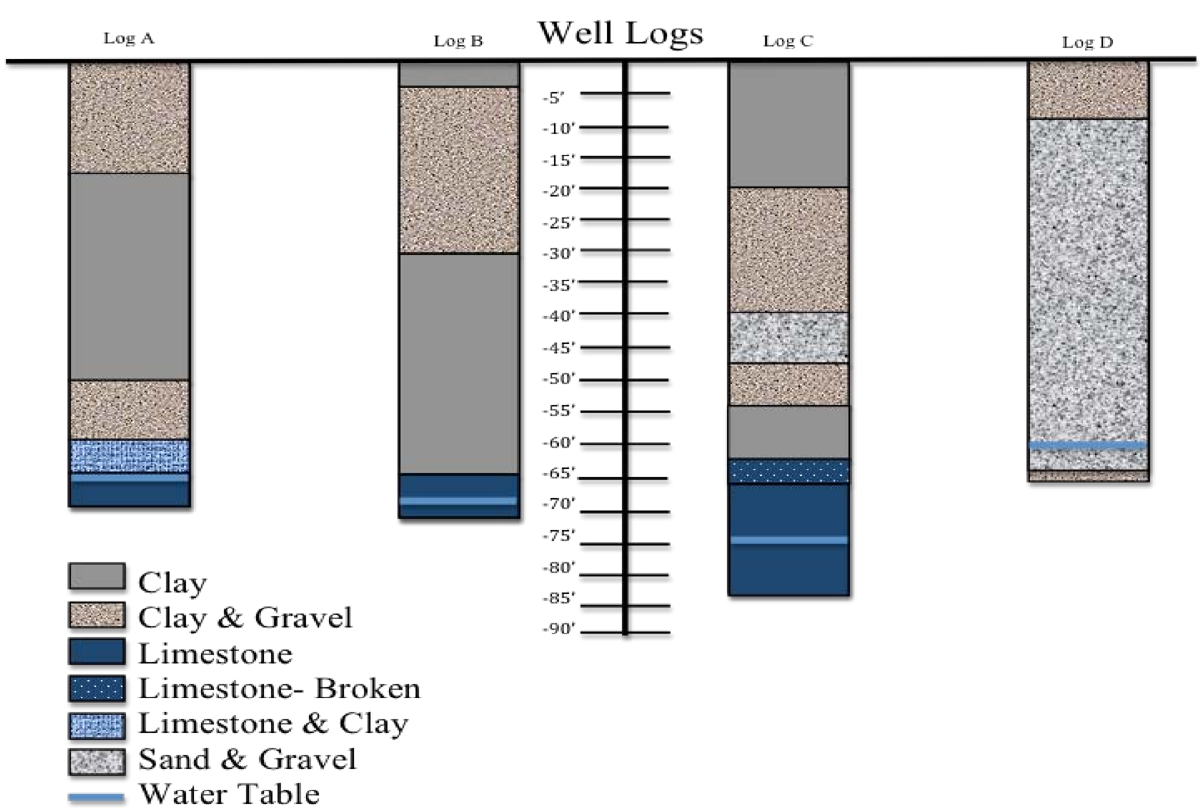
Need to determine Soil Hydraulic Conductivity (i.e. in inches per day or inches per hour) and Geological Formations as shown on Maps, Well Log, and Drilling Reports. This shows how a subsurface drainage system from the Soil Treatment Area could be taken to a sump located near the soil treatment area.

Geological Formations

Four well logs from ODNR records are included in this report as Exhibit 5 to illustrate the importance of information on geological formations. A review of the four logs showed that Log A, Log B, and Log C have more than adequate clay to dramatically slow the percolation of wastewater into the deeper well water aquifer. Well Log D does not have any reported clay layers between the surface and potential well water aquifer. Although wastewater applied to the soils in Well Log D will drain very rapidly, further treatment of the wastewater beyond that provided by the septic tank will be nonexistent. Perhaps if septic-soil treatment areas are placed in the vicinity of any well water supply from this aquifer (Log D), the water should be monitored annually or even more frequently. This would be especially true depending on the actual hydraulic conductivity of the soil in which the soil treatment area is placed.

The lot size and soil treatment area size need to be governed by the soil hydraulic conductivity of the specific location. Topography and resulting hydraulic gradient as well as available thickness of suitable soil and microbiological treatment capacity should further determine lot and soil treatment area size. The possibility exists of accomplishing the required degree of treatment above a very slow draining or a somewhat imperious soil layer by installing the subsurface drainage system at or within the restricting soil layer. If the lot topography precludes a complete gravity system, above surface drainage with a sump and pump system may be used.

Exhibit 5



Available Treatment Volume In Soil

The available subsurface treatment volume in soil after removal of groundwater can be used to provide the necessary detention time required for wastewater treatment. Additional explanation of this importance of this follows.

Wastewater Treatment

The purpose of the treatment of domestic wastewater is to remove suspended and soluble organic matter. Microorganisms are fundamentally important in the treatment process. In municipal wastewater treatment, an aerobic process called *activated sludge* (aka mixed liquor) is typically used, which requires a great deal of energy because of the aeration needed and produces voluminous amounts of biosolids. Following the activated sludge process, biosolids can be digested in an anaerobic process designed to produce methane. The amount of this biofuel often represents a substantial cost reduction in the energy expenditure in the plant. The anaerobic process of sludge digestion is relatively slow as compared to the aerobic/activated sludge process. This example shows that both aerobic and anaerobic processes may be used independently or in some combination to remove pollutants from wastewater. For a complete understanding of this subject, more details of sanitary engineering can be obtained through the books listed in the references.

Aerobic and Anaerobic Microbial Process

Depending on the process design and sources of energy for microorganisms, aerobic treatment may remove up to 98% of organic matter (measured as BOD_5) from the wastewater within 6-24 hours while producing voluminous quantities of solids or sludge. Anaerobic processes may take 10 to 20 days to accomplish the same extent of removal and therefore are typically used on highly concentrated waste streams. Anaerobic processes also result in the formation of a solids volume that is significantly less than aerobic systems. However, given sufficient time, the anaerobic system can produce an effluent of as good quality as the aerobic system.

Aerobic microbial oxidation of glucose can be described by the following mass balance equation:

Aerobic Biodegradation: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Similar equations showing the stoichiometry and O_2 requirement can be written for numerous biodegradable pollutants in domestic wastewater. The amount of oxygen consumed in these oxidation processes in commonly referred to as the biochemical oxygen demand (BODs), which is measured over a five-day reaction time.

Mass balance equations can also be written for anaerobic oxidation. For example, the following sequence demonstrates methane formation from glucose under anaerobic conditions, involving acetic acid as an intermediate.

$$C_6H_{12}O_6 \rightarrow 2CH_3\,COOH + 2H_2O$$
$$2CH_3\,COOH \rightarrow 2CH_4 + 2CO_2$$

$$2CO_2 + 8H_2 \rightarrow 2CH_4 + 2H_2O$$

In an anaerobic digestion process, the substrate carbon is often found in its most oxidized form, CO_2, and in its most reduced form, CH_4. In addition to anaerobic oxidation processes, microbially mediated fermentations occur during anaerobic digestion. These give rise to CO_2 , H_2 , alcohols and volatile fatty acids which are then subsequently converted to CH_4 in the ultimate anaerobic reactions.

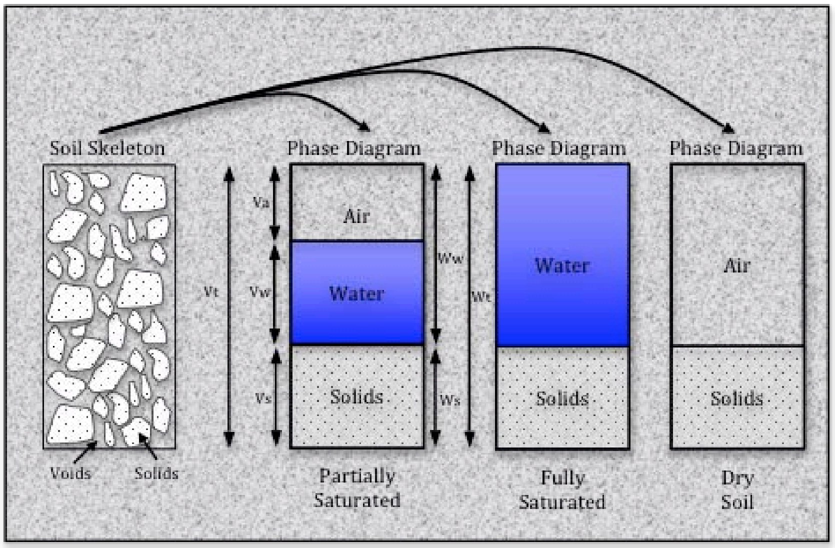
In a leach field there is a relationship between the (a) soil hydraulic conductivity which controls the detention time of the wastewater (b) degree of wastewater purification from microbiological activity, (c) thickness of soil required and (d) available hydraulic head. There is evidence that much of the purification takes place at the leaching trench bottom and sidewall wastewater-soil interface.

The detention or contact time is an important aspect of wastewater treatment both in aerobic and anaerobic processes. Microbes go through life cycles involving a growth, stationary, and death phase. Microbes have slow and rapid growth phases, as they biodegrade all the soluble organic matter. The microbial biomass and substrates vary over time and are subject to various in-situ conditions that enhance or impede growth biodegradation.

Within a traditional on-site dispersal system, the voids in solids within the soil structure, as depicted in Exhibit 6, provide the space and volume that can be viewed as a biological reactor. The solids provide a contact surface and the void volume provides physical space for microbial biomass development. For example, septic tank effluent moves through sand too rapidly to provide sufficient contact time for microbes. However, microbes develop as a biofilm layer on the contact surface over time. This layer on soil particles has a high density of microorganisms and exopolysaccharides and is highly active and important in treatment efficiency. It is this layer that the wastewater is in contact with as it infiltrates downward in the soil.

Septic tank effluents (when in the leaching trench and upon initial infiltration into the soil) are anaerobic by nature. Thus the zone of microbiological activity immediately below the leaching trench involves anaerobic transformations until the readily biodegradable organic material is degraded. Within some distance below the trench bottom the degradation has proceeded to a very low BOD_5 value and fecal coliform count. Sandy soils are good from an infiltration standpoint, but not so effective in entrapping organic material and bacteria. Clay soils are better than sandy soils from a treatment standpoint but limited from an infiltration standpoint. The rate of infiltration and treatment may be improved by varying the hydraulic head engineered into the leaching trenches and any subsurface drainage system.

Exhibit 6



This exhibit illustrates the void volume of typical soil when partially saturated, fully saturated, or completely dry. The void space for most soils in natural, un-compacted state is 40%-60%. A typical Soil Treatment Area may contain 6000-7000 c.f. of void space. With typical flow from a four-bedroom home, this may provide 40 to 80 days of detention time for microorganisms to biodegrade the suspended and soluble organic matter in the septic tank effluent. This is considered to be more than enough time for microorganisms to completely degrade the organic pollutants in domestic wastewater as discussed in the various references listed in the back of this report.

RESULTS OF ACTUAL FIELD INVESTIGATIONS IN UNION COUNTY, OHIO

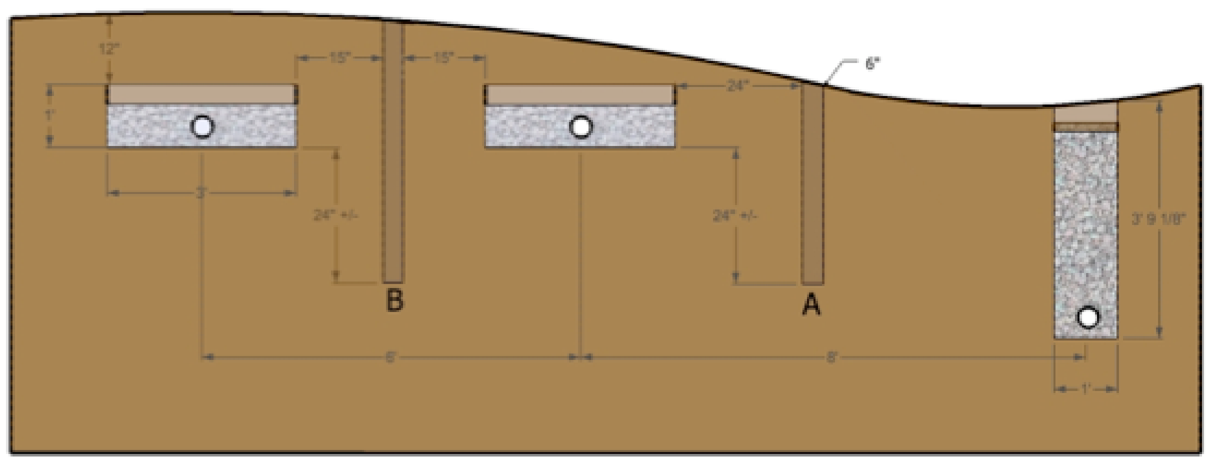
Water levels were measured in Blount Soil at various distances from an installed agricultural field tile. The distances from the tile ranged from 3 feet to 40 feet under different ground levels due to slight variations of topography. The water levels were measured daily from November of 2007 to the summer of 2008. Water levels were also measured in an operating septic system with samples being taken from sampling holes augured between laterals and adjacent to an outside lateral. The samples taken from between and below laterals were analyzed for BOD_5 and fecal coliforms.

Water in the ground moves up and down daily. When rain is falling the saturation level moves up and when rainfall stops the saturation level moves downward. The same is true when septic tank effluent is applied or discharged to the lateral system. In the Blount Soil of the area, the rate of dewatering, or lowering of the 100% saturation level ranged from 0.5 inches to 1.5 inches per day. The closer the sampling hole was to a field tile, the more rapid the rate. The tests showed that in this soil, the pattern was very similar to the results shown by Dr. Larry C. Brown in his report to the Ohio Department of Health (Brown, 2008). Monitoring holes within 2 to 3 feet of a tile had a significantly more rapid rate of dewatering than the holes 6 to 9 feet from dewatering tiles.

The field evaluation on the spacing of subsurface drainage in Blount Soil for this area showed that a spacing of 2 to 4 feet would be effective in lowering the 100% saturation level in monitoring holes by 1 to 2 inches per day. This find is significant and in contrast to the current regulations for leach field sizing in Union County, resulting in a range of flow equivalent to +/- ¼ inch per day.

Investigations were also conducted on an actual Septic Tank-Soil Treatment Area system constructed in September of 2007. Usage of this system started in January of 2008 with samples being collected from within the soil treatment area in July and August of 2008. The results are shown in Exhibit 7. These results show that treatment through 15” to 24” of Blount Soil is more than adequate for BOD5 and fecal coliform removal. The results also show that the distance from the edge of the lateral to the perimeter drain could be 24 inches. This would benefit the drainage properties of the soil while not impacting the quality of the discharge or the perimeter drain.

Work done by monitoring the 100% saturation level in Blount Soils of this area shows the value and importance of subsurface drainage. This work also demonstrates the need to obtain more data at points much closer than historically considered in soils of this type. In other words, 15” to 24” is more than adequate for separation of the lateral discharges and any subsurface drainage pipes. The actual travel time or detention time of the septic tank effluent between the bottom of the lateral and the sample points of “A” and “B” is estimated to be in the range of 15 to 45 days. This is considered to be more than enough time of contact with the microorganisms regardless of their aerobic or anaerobic activities. The theoretical functional process is depicted in Exhibit 8. A proposed engineered under-drain system designed for the soils of this type with a hydraulic conductivity of (+/-) 1 inch per day is shown in Exhibit 9 and on the front cover.



Sample Points In Existing
Septic Tank- Soil Treatment Area
11270 Crottinger Rd.
Plain City, Ohio 43064

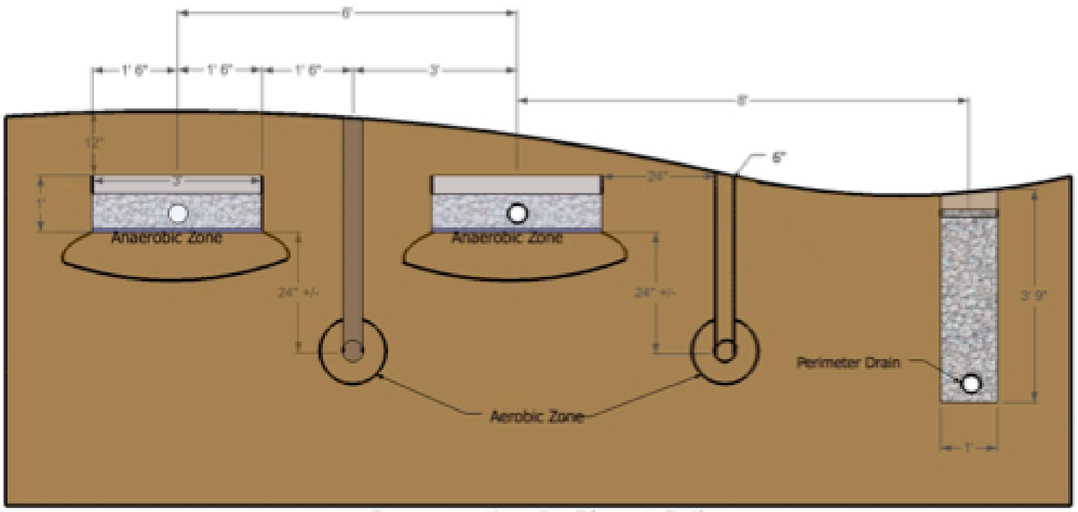
Exhibit 7

Results of Water Samples From A Leachfield in Blount Soils
In Union County, 6-7 Miles South of Marysville, Ohio

Date	**Specific Location**		**BOD** (mg/L)	**Fecal Coliform** (cfu/100mL)
7/7/08	11270 Crottinger Rd.	Perimeter Drain- Gradient drain 3' below lateral trenches. 8' from Lateral	< 3	150
7/7/08	11270 Crottinger Rd.	Pt. B- between Lateral trenches 3 and 4	6	< 50
7/18/08	11270 Crottinger Rd.	Pt. B- between Lateral trenches 2 and 3	3	< 50
7/18/08	11270 Crottinger Rd.	Pt. A- 24" from Lateral trench 1	(2)	< 50
8/13/08	11270 Crottinger Rd.	Pt. B- between Lateral trenches 2 and 3	4	250

1) All samples from sample holes dug 12" to 24" below Lateral trenches except as noted above.
2) Not enough sample for BOD even after 48 hours (Point A).

Exhibit 8



Cross-section In Blount Soil

Anaerobic- Facultative- Aerobic
Zones of Microbiological Treatment
in Soil Treatment Area of Blount Soils
Union County, Ohio

CONSTRUCTION TECHNIQUES AND PROTECTION OF AREA

Construction of the soil treatment area should only occur during the period of late spring to fall. Soil should be dry with minimum moisture content. Special attention to traction wheel spacing of any backhoe equipment is necessary to minimize compaction of soils during construction. The proposed subsurface underdrain system pipe could be installed using walk-behind ditching or trenching equipment after the installation of the leaching trenches. It is absolutely essential to maintain the selected minimum distance of undisturbed soil at all times between the leaching trench and any subsurface drainage pipe.

The 100% saturation level in the soil treatment area may at times during rainfall events be near the surface of the ground. Because of this, the ground surface will be safe to walk over and drive a small riding lawn mower on but, structurally, it will not support the weight of any vehicle or equipment any heavier. The soil treatment area should be designated and so marked to prohibit any equipment weighing more than a small riding mower from passing over it until sufficiently dry following rainfall.

Proposed Blount and Similar Soils Sampling and Testing Program

The following narrative and exhibit are intended to provide the basis of obtaining data from existing operating septic tank-leachfield systems in various counties in Ohio. The goal is to obtain data in Ohio soils in as many counties as possible.

Local health departments in each county will be given this report and any additional explanation needed to alert them to this opportunity to participate in this very important study. As manufacturers, contractors and individuals become aware of this study, they will have access to this report and program information. Local health department personnel, contractors, and others will be given specific other information as needed and available. In all cases the work will be accomplished with the cooperation and consent of the individual property owner.

The first step is to review the files of the local health department for any and all records on the specific system. The second step is to test the soil treatment area with a field tile probe to determine the location of the leach lines and surrounding gravel or a chamber type system. The next step is to locate any curtain and/or subsurface drain tile in the area. Testing with field tile probe should ensue to determine: (a) Leach line in multiple locations, (b) the width of the leaching trench, (c) the distance between laterals, (d) the distance to any curtain or subsurface drains and (e) the approximate depth of each. These data should be reviewed with dimensions on the installation drawing. When satisfied with location of pipes, the holes can be dug. All of this work needs to be performed when the surface of the ground is dry enough to walk-on.

Use of a 6- to 8-inch soil auger or post hole digger facilitates the digging of the holes in the soil. If the soil is Blount soil or similar in hydraulic conductivity (0.06 ± inches per hour or greater) (which is 1.44±/day), The first test hole should be approximately 24 inches from the edge of the first lateral trench. The whole should be 4' deep, depending on the moisture of the soil. If the soil is wet and sticky at the first location, it is recommended to move closer to the curtain or subsurface drain pipe. The probing and digging need to continue until the saturation profile can be defined. The soil over the curtain or subsurface drain pipe will be the driest. There are many variables such as time of last rainfall, amount of rain, hydraulic conductivity of the soil at the specific site, amount of wastewater in the lateral trench, level of flow (if any) in the curtain or subsurface drain, immediate surrounding topography in relation to the subsurface drain pipe and leach line trench, and season of the year that will also be monitored for each field that is tested.

If there is a curtain or subsurface drain outlet, the flow (if any) should be sampled for BOD_5 and fecal coliform tests. If there is little or no flow or the BOD and fecal coliform are very low, BOD_5 less than 5 mg O_2/l and fecal coliform less than 100 counts per 100 ml., then perhaps the curtain or subsurface drain is too far from the lateral trenches. The goal of the subsurface drain is to remove the ground water from the area to permit the addition of septic tank effluent, thereby feeding the microbes and removing the pollutants from the septic tank effluent. The unknown value is the detention time required in the soil to allow the microbes to completely degrade the organic pollutants. If wastewater moves too rapidly, as in sandy soil, the degree of purification per foot of sand thickness is inadequate. What has not been shown, demonstrated or evaluated in Ohio soils, is the degree of purification through 12″ to 24" of Blount (or similar soil) when the seasonal water table is controlled by subsurface drainage system.

The process of digging holes adjacent to the outside laterals should be repeated on both sides of the leach field at varying depths until water accumulates in the bottom of the 6-8 diameter inch hole. Water will seep into the open hole very slowly. If water is moving at 1 to 1.5 inches per day and the soil porosity is about 0.5 it may take ±12-24 hours to accumulate 2″ to 3″ of depth in the bottom of the hole. Water samples retrieved from the bottom of the hole should be delivered to a certified lab for analysis within the same day. If the sample cannot be delivered to the lab the same day, the sample can be refrigerated or put in a cooler with ice overnight. If it is possible to dig within 15″ of the outside laterals before obtaining enough water for analysis (200-300 ml) for BOD_5 and (50 to 100 ml for fecal coliform) the midpoint between two laterals should be located and the digging and sampling process be repeated by taking samples between the laterals 3 to 4 feet deep. Samples should also be taken from the septic tank effluent flowing into the leach field to identify the level of treatment occurring in the leach field.

Septic tank effluent should be applied to leach lines for a period of 8 months to 2 years minimum. The soil with an estimated permeability of 1 to 1.5 inches per day and septic tank effluent applied daily results in a liquid level in the trench of approximately 4″ to 8″ deep. The soil below the leach trench has to be saturated. Theoretically it will be saturated to 12″ to 36″ deep in 36 ÷1.5 =24 days. Certainly the soil below the trench is saturated to greater than 12″ to 36″ in 8 months or 240 days.

Water is moving at the rate of approximately 1 to 1.5″ per day in the subsurface of Blount soils. The quality of water at any point below the leach trench after being in the soil for varying periods should be evaluated. A sample obtained from the soil at 36″ to 48″ deep over a period of 1 day is representative of the water at a point in time approximately 20 days after application in the leach trench. Several samples taken at multiple points are representative for the analysis of the microbiological activity in the soil. This is similar to sampling well water to determine ground water quality. Because ground water quality changes very slowly and is in some cases considered relatively constant, ground water sampling for water treatment and water quality purposes is only collected monthly or annually. Furthermore, collection of test data at multiple sites containing different soil types will provide valuable data for how consistent the results are given different subsurface conditions.

Sample Methods

A review of a USGS study sampling methods indicated limited success when using piezometers installed at various depths and distance from leach lines and curtain drains. Samples could not be obtained from 12 out of 20 sites among 9 counties. Some conclusions were made as to the relative importance of the results obtained from the sampling and analysis of work over a period of time which must have exceeded 1.5 years. Actual sampling apparently began on 10-16-03 and continued to 1-21-04. Twenty-seven (27) and forty-one (41) samples were collected during the months of October, November, January, July, August and September, resulting in 189 (27 x 7) and 205 (41 x 5) data points since 7 and 5 parameters were analyzed. The details are shown on table 5 and table 6 of the report “Preliminary Investigation of Wastewater Related Contaminants near Home Sewage Treatment systems in Ohio-file report 2005-1282.” Any meaningful data appears to have been obtained in less than 10% of sampling events. BOD_5 and fecal coliform analyses were not part of this study. The analyses which were performed are not routinely included in any evaluation of wastewater treatment process performance. Some statements were made in the report as to presence of untreated wastewater in the vicinity of the sample points. Specific data supporting these statements are not found in the report. The methods and analysis used in this report resulted in the work not being very useful in evaluating the various soil treatment areas wastewater treatment performance or characterizing and contribution to any required vertical separation distance. In fact it was after a thorough review of the above report and discussion with the authors, that alternate methods of sampling and analysis more pertinent to characterizing microbiological treatment of wastewater in various soils was thought to be needed.

Digging holes closer to leach trenches both horizontally and vertically was thought to be a worthwhile investigation. Consideration of other techniques used to collect representative samples also appears to be warranted. The movement of the water throughout the soil treatment area and volume is very slow. In the case of Blount or similar soils it is a matter of inches per day at best. Therefore sampling frequency would appear to be related to the frequency of sampling well water. Well water is sampled only periodically. For water treatment purpose only monthly intervals are needed. For individual home needs including bacteriological quality probably annually for the well water would be more than adequate because the wastewater quality shows little fluctuation.

Samples of raw wastewater or influents are typically collected hourly or every 2 hours. As the wastewater moves through the treatment process the sampling is also on an hourly or shift basis (6-8 hrs). Once the wastewater treatment facility effluent is discharged to the environment, the receiving stream is typically sampled once or twice daily. Sometimes if specific studies are needed on the effect of the discharge on the stream, special studies as conducted over a day or more with much more frequent sampling.

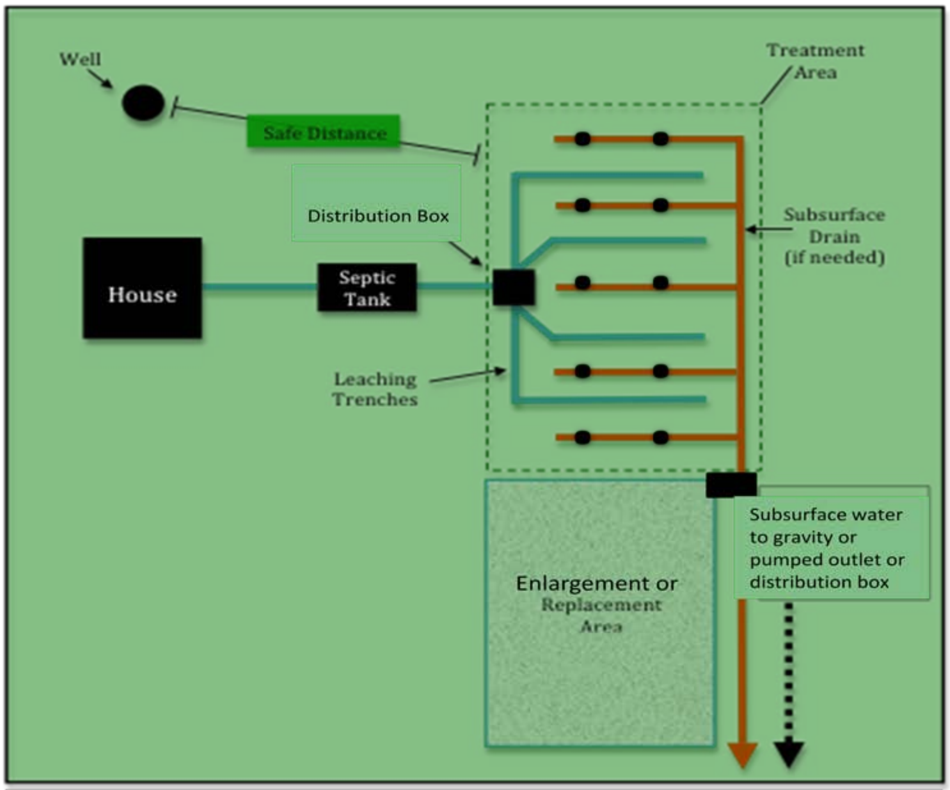
According to Standard Method for the Examination of Water and Wastewater, sampling should be representative of the rapidity by which the sampled flow is expected to change. Since ground water moves slowly (1 to 3 inches per day) the expected variation will be very low with time. Sampling in a “soil treatment area” in Blount or similar soil (approximately 1 to 3 inches per day hydraulic conductivity or permeability) once per month, when possible, would appear to provide a measure of representative conditions. The method of collecting the sample whether from a new or fresh hole dug to the appropriate point and existing ground water of that point allowed to accumulate or a continuously open hole in which the accumulating water is frequently or continuously removed before the actual sampling is collected is the question.

This question has been discussed with Professor Tuovinen of the Ohio State University Department of Microbiology and will be discussed with others during any approval process. The question will also be discussed and illustrated during testing with the various Local Health Departments contractors/ installers and manufactures who have indicated an interest in this study and investigation. The attached Exhibit 9 shows generally the locations for sampling investigations within a soil treatment area. It also shows possible design layout of a subsurface drainage system. Only after sampling and further analysis would the horizontal and vertical dimension be determined and/ or confirmed.

Work will begin after approval by Local Health Departments and ODH and continue as needed to be used to comment on any proposed “rules” in the future.

Exhibit 9

Possible Sampling Locations and Subsurface Drainage System Location



- Possible sampling and testing points to determine location of subsurface drainage.
- Monitoring point for BOD_5, fecal coliform and other analysis after construction

Note: If quality of the subsurface drainage effluent is unacceptable for surface water discharge it could be recycled to distribution box for further treatment.

REFERENCES

Babbitt, Harold E. Professor of Sanitary Engineering University of Illinois, Sewerage and Sewage Treatment-Seventh Edition, “Engineering In Public Health” First Edition (1952)

Brown, Dr. Larry C. *Modeling Water Table Elevations for Curtain-Drain Applications with On-Site Wastewater Treatment Systems in Ohio*. Final Report Submitted to the Ohio Department of Health March 24, 2008.

Crites, Tchobanoglous. *Small and Decentralized Wastewater Management Systems* (1998).

Fair, Gordon Maskew and Geyer, John Charles. *Water Supply and Wastewater Disposal*. Second Printing (January 1956).

Fangmeier, Delmar D., Elliof, William J., Workman, Stephen R., Huffman, Rodney L., Schwab, Glenn O. *Soil and Water Conservation Engineering*. Fifth Edition (2006).

Hillel, Daniel. *Environment Soil Physics* (1998).

Kahn, Lloyd. *Septic Systems Owner’s Manual* (2007).

Laak, Rein. *Wastewater Engineering Design for Unsewered Areas*. Second Edition (1986).

Maier, Raina M., Pepper, Ian L., Gerba, Charles P. *Environmental Microbiology*. Second Edition (2009).

McKinney, Ross E. *Environmental Pollution Control Microbiology* (2004).

McKinney, Ross E. *Microbiology for Sanitary Engineers* (1962).

Ringler, Joseph William. *Monitoring The Hydrology of Soils For On-Site Wastewater Treatment Systems Using Metric Potential Sensors.* (OSU Thesis, 2009).

Siegrist, Robert L. Ph.D. P.E. *Design for Wastewater Effluent Infiltration*. Small Flows Quarterly. Summer 2006, Volume 7, Number 3.

Slater, Brian, Mancl. Karen. *Soil and Site Evaluation for Onsite Wastewater Treatment*. OSU Bulletin 905. 2005.

Soil Survey of Union County, Ohio. USDA Soil Conservation Service, ODNR Division of Lands and Soil, and Ohio Agricultural Research and Development Center.

Standard Methods For The Examination of Water and Wastewater.

Stoeckel, Don. USGS, Columbus, Ohio. Personal Communication.

Tuovinen, Olli H., Ph.D. Professor, Department of Microbiology. Lecture Notes and Personal Communications.

U.S. Environmental Protection Agency. *Onsite Wastewater Treatment Systems Manual*. EPA/625/R-00/008. February, 2002.

Winneberger, John H. Timothy. *Septic-Tank Systems: A Consultant's Tool Kit.* Volume 1. Subsurface Disposal of Septic-Tank Effluents (1984).