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SMALL SCALE WASTE MANAGEMENT PROJECT

Soil Dispersal Units with Emphasis on Aerobically Treated Domestic Effluent

by

James C. Converse and E. Jerry Tyler

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SOIL DISPERSAL UNITS WITH EMPHASIS ON AEROBICALLY TREATED DOMESTIC EFFLUENT

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Effluent is dispersed to surface or subsurface waters, evaporated/transpired or reused. The effluent should be disinfected if surface dispersal is practiced. Transpiration/evaporation dispersal can not be relied on for total dispersal in humid climates. However, it can be seasonally significant if the dispersal units are shallow so the roots can absorb the effluent. This paper will concentrate on subsurface treatment and dispersal.

Separation Distance

Research and experience have established loading rates and separation distances to soil saturation, bedrock or other limiting conditions for septic tank effluent. In Wisconsin the separation distance is 3 ft from the infiltrative surface to the limiting condition based primarily on attenuating pathogens with fecal coliforms as the indicator. Since sand filters and aerobic units reduce the number of fecal coliforms, less soil separation is required to "polish" off the remaining fecal coliform indicators and presumably the pathogens. Thus a treatment credit could be given in equivalent "feet" of soil.

Less separation distance is needed if highly pretreated effluent is applied to the soil instead of septic tank effluent on unclogged soil (Converse and Tyler, 1998). As a result, the Safety and Building Division, State of Wisconsin, is allowing separation distance "credits" on **replacement on-site systems** that have as the pretreatment unit a single pass sand filters or an aerobic unit for sites that meet certain requirements (Baldwin and Burks, 1998). The separation is as follows:

Pretreatment Type	Infiltrative Surface to Limiting Condition
Septic Tank	3 ft
Aerobic Units*	2 ft
Single Pass Sand Filter*	1 ft

* Of this distance, a minimum of 6" must be in-situ soil. This may change with implementation of new code to " of which 4" is below the A horizon if it exists".

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Note: Names of products and equipment mentioned in this publication are for illustrative purposes and do not constitute and endorsement, explicitly or implicitly.

Treatment "credits" are also being proposed for the new code based on the fecal count and not on the type of pretreatment unit (Kaminski, 1998). Table 1 (Table 83.44-3 in the proposed code) lists the separation distances for $>10^4$, $>10^3$ - $<10^4$, $<10^3$ col./100 mL. The separation distances are 3 ft for effluent with $>10^4$ col./100 mL, 2 ft for effluents with $>10^3$ - $<10^4$ and 1 ft for effluents with $<10^3$ col./100 mL for most soil texture/structure combinations except for very coarse sands and sands with coarse fragments where the separation distances are greater in all cases (Table 1).

Soil Loading Rates

Soils absorption units, receiving septic tank effluent, are sized based on the expectation that a clogging mat will develop. The design loading rate for a given soil is based on the interaction between the clogging mat and the soil morphological characteristics (texture, structure and consistence). Clogging mats develop primarily due to a lack of oxygen (anaerobic conditions) at the infiltrative surface resulting in an accumulation of organic matter and a reduction of the infiltration rate. This condition occurs because the demand for oxygen is much greater than the soil's ability to deliver, through diffusion, the amount of oxygen needed to treat the organic matter under aerobic conditions, resulting in the formation of a clogging. Also the transfer of oxygen by diffusion and the movement of water is much slower in the clay soils than in the sandy soils and the transfer through wet soils is slower than drier soils because water is filling more of the pores in the wet soils.

The clogging mat provides an excellent medium for wastewater treatment as it reduces the hydraulic conductivity and water flow through the soil, creating a restrictive layer. Without a clogging mat, hydraulic conductivities are higher resulting in higher loading rates if clogging mats did not develop. If wastewater with much less organic matter (low BOD) is applied to the soil, observations have shown that clogging mat development is retarded and probably will not form if there is sufficient oxygen present to maintain aerobic conditions. Since highly pretreated effluent, such as from sand filters, aerobic units, biofilters and peat filters, is applied to the soil interface, higher infiltration rates should be maintained in the soil unit. If higher infiltration rates are maintained, then higher loading rates can be applied resulting in "downsizing" of the absorption unit. Tyler and Converse (1994) proposed increased loading rates for highly pretreated effluent., Table 2 provides for downsizing based on the organic matter strength (BOD, TSS) of the effluent. Typically BOD and TSS concentrations greater that >30 mg/L represent septic tank effluent and those with <30 mg/L represent highly pretreated effluent from units such as sand filters, recirculating sand filter, peat filters, biofilters and constructed wetlands.

System Configuration based on Linear Loading Rate.

When configuring a soil treatment/dispersal unit, it is important to understand how the effluent disperses away from the system after it enters the soil. This is true for all systems regardless of the type of effluent; septic tank or highly pretreated. For example, the scenario could be: septic

Table 1. Separation Distances to Limiting Conditions and Minimum Depth of Unsaturated Soil Required for Different Fecal Coliform levels in the Effluent (Table 83.44-3 of proposed Comm. 83 code). TABLE STILL DRAFT FORM AS OF JAN. 1999.

Soil Texture	Soil Structure	Fecal Coliform $>10^4$cfu/100 ml	Fecal Coliform $>10^3$ - $\leq 10^4$cfu/100 ml	Fecal Coliform $\leq 10^3$ cfu/100 ml
Very coarse sand or coarser	N/A[b]	120	60	30
Coarse sand	N/A[b]	60	36	24
Loamy coarse sand (w/ ≤35% coarse fragments)	N/A[b]	60	36	24
Loamy coarse sand (w/ >35% ≤60% coarse fragments)	N/A[b]	120	60	30
Loamy coarse sand (w/ >60% coarse fragments)	N/A[b]	NC	NC	NC
Sand (w/ ≤35% coarse fragments)	N/A[b]	36	24	12
Sand (w/ >35% ≤60% coarse fragments)	N/A[b]	120	60	30
Sand (w/ >60% coarse fragments)	N/A[b]	NC	NC	NC
Loamy sand	N/A[b]	36	24	12
Fine sand	Weak to strong	36	24	12
Fine sand	Massive	36	24	12
Loamy fine sand	Weak to strong	36	24	12
Loamy fine sand	Massive	36	24	12
Very fine sand	N/A[b]	36	24	12
Loamy very fine sand	N/A[b]	36	24	12
Sandy loam	Moderate to strong	36	24	12
Sandy loam	Weak, weak platy	36	24	12
Sandy loam	Massive	36	24	12
Loam	Moderate to strong	36	24	12
Loam	Weak, weak platy	36	24	12
Loam	Massive	36	24	12
Silt loam	Moderate to strong	36	24	12
Silt loam	Weak	36	24	12
Silt loam	Weak platy	36	24	12

Table 1. Continued.

Silt loam	Massive	36	24	12
Sandy clay loam	Moderate to strong	36	24	12
Sandy clay loam	Weak	36	24	12
Sandy clay loam	Weak platy	36	24	12
Sandy clay loam	Massive	36	24	12
Clay loam	Moderate to strong	36	24	12
Clay loam	Weak	36	24	12
Clay loam	Weak platy	36	24	12
Clay loam	Massive	36	24	12
Silty clay loam	Moderate to strong	36	24	12
Silty clay loam	Weak	36	24	12
Silty clay loam	Weak platy	36	24	12
Silty clay loam	Massive	36	24	12
Sandy clay	Moderate to strong	36	24	12
Sandy clay	Massive to weak	36	24	12
Clay	Moderate to strong	36	24	12
Clay	Massive to weak	36	24	12
Silty clay	Moderate to strong	36	24	12
Silty clay	Massive to weak	36	24	12

Note a: Influent quality as per s. Comm 83.44 (2)
Note b: Structure will not affect performance
N/A means Not Applicable
NC means No Credit
≤ means less than or equal to
> means great than

Table 2. Application Rates of Two Effluent Qualities of Domestic Effluent Based on Soil Morphological Characteristics (Table 83.44-2 of proposed Comm. 83 code). TABLE STILL DRAFT FORM AS OF JAN. 1999.

Soil Texture	Soil Structure	Maximum Monthly Average	
		$BOD_5 > 30 \leq 220$ mg/L $TSS > 30 \leq 150$ mg/L (gals/sq ft/day)	$BOD_5 \leq 30$ mg/L $TSS \leq 30$ mg/L (gals/sq ft/day)
Coarse sand or coarser	N/A	0.7	1.6
Loamy coarse sand	N/A	0.7	1.4
Sand	N/A	0.7	1.2
Loamy sand	Weak to strong	0.7	1.2
Loamy sand	Massive	0.5	0.7
Fine sand	Moderate to strong	0.5	0.9
Fine sand	Massive to weak	0.4	0.6
Loamy fine sand	Moderate to strong	0.5	0.9
Loamy fine sand	Massive to weak	0.4	0.6
Very fine sand	N/A	0.4	0.6
Loamy very fine sand	N/A	0.4	0.6
Sandy loam	Moderate to strong	0.5	0.9
Sandy loam	Weak, weak platy	0.4	0.6
Sandy loam	Massive	0.3	0.5
Loam	Moderate to strong	0.5	0.8
Loam	Weak, weak platy	0.4	0.6
Loam	Massive	0.3	0.5
Silt loam	Moderate to strong	0.5	0.8
Silt loam	Weak, weak platy	0.2	0.3
Silt loam	Massive	0.0	0.2
Sandy clay loam	Moderate to strong	0.4	0.6
Sandy clay loam	Weak, weak platy	0.2	0.3
Sandy clay loam	Massive	0.0	0.0
Clay loam	Moderate to strong	0.4	0.6
Clay loam	Weak, weak platy	0.2	0.3
Clay loam	Massive	0.0	0.0
Silty clay loam	Moderate to strong	0.4	0.6
Silty clay loam	Weak, weak platy	0.2	0.3
Silty clay loam	Massive	0.0	0.0
Sandy clay	Moderate to strong	0.2	0.3
Sandy clay	Massive to weak	0.0	0.0
Clay	Moderate to strong	0.2	0.3
Clay	Massive to weak	0.0	0.0
Silty clay	Moderate to strong	0.2	0.3
Silty clay	Massive to weak	0.0	0.0

Note: > means greater than
$\leq$ means less than or equal to
N/A means Not Applicable

tank effluent is readily accepted by the mound sand at the aggregate/sand interface but not all the treated effluent, after passing through the sand, is accepted by the in-situ soil resulting in a breakout at the toe. Had the mound been made longer and narrower, there may not have been any leakage out the toe of the mound. This problem may be further exacerbated when dispersing highly pretreated effluent into the soil environment if downsizing the soil dispersal unit is done incorrectly. **In most situations for highly pretreated effluent, it is not a question of the ability of the soil accepting the effluent load but the ability of the soil to convey the effluent away from the soil dispersal unit.**

Therefore, for all conditions (both effluent quality and soil conditions) but especially in difficult sites, the configuration of the soil absorption unit must be considered. The linear loading rate for the site must be considered when designing the system. If the flow is vertical with no limiting conditions such as a restrictive layer or seasonal saturation, then linear loading rate is not a major concern except for maybe oxygen diffusion. If there are restrictions then linear loading rate is important (Tyler and Converse, 1985;. Converse, 1998). **The linear loading rate is defined as:**

> ***the amount of effluent applied daily along the landscape contour. It is expressed in gallons per day per linear foot along the contour.***

For sites with extremely high water table, shallow restrictive layers or slowly permeable soils, long narrow units, instead of short wide units, are necessary so the effluent can be conveyed away from the unit. Fig 1. shows the effect of effluent moving horizontally away from the system. The soil loading rate on both areas is identical. If all of the wastewater moves away horizontally, the unit on the right has to move twice as much effluent away per linear foot than does the unit on the left. If it can't do it hydraulically, then toe leakage will occur.

System Selection and Landscape Position

The type of soil absorption unit selected will be dictated by the soil and site conditions. To maximize the uptake of nutrients and evapotranspiration, shallow systems are desired. In the finer textured soils, the surface horizon is usually more permeable. Thus, it is recommended that the unit be installed as shallow as possible. Pressure distribution is preferred as it distributes the effluent and allows for final treatment (polishing) as the effluent moves through the soil. Gravity flow is not recommended as it may permit excessive loading in one area which may preclude final treatment (polishing) before the effluent reaches the ground water. However, septic tank effluent can be gravity fed as a biological clogging mat forms greatly assisting in treatment. The following steps are used in system selection:

1. Determine the effluent quality produced by the pretreatment unit based on fecal coliform concentration and BOD and total suspended solids concentrations.

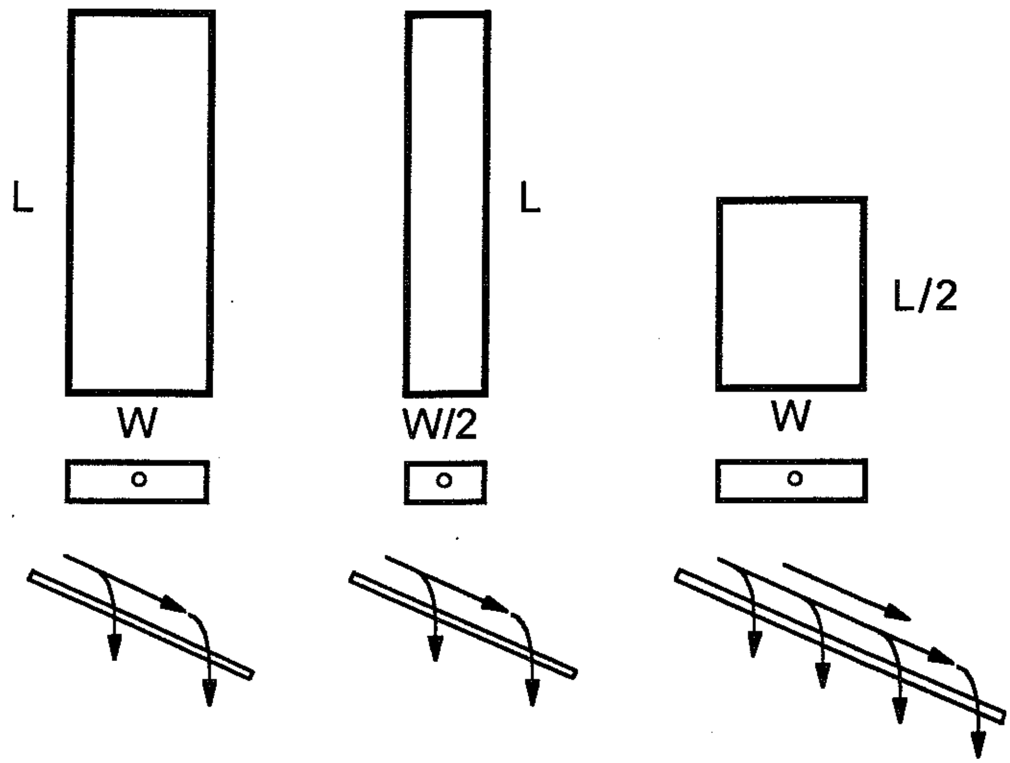

Fig. 1. These three diagrams illustrate how downsizing configuration affects linear loading rates. The left diagram represents the full size system. The middle one represents a half size system (bottom area) resulting in twice the soil loading rate and the same linear loading rate. The right one also represents a half size system (bottom area) resulting in twice the soil loading rate and also twice the linear loading rate.

2. Assess the depth from the ground surface of the limiting condition such as seasonal saturation, bedrock or other restrictive layers that may imped flow or reduce the treatment capability of the soil.

3. Match the pretreatment unit with a soil treatment unit that meets the soil depth criteria. (Table 3)

4. Evaluate soil profile data for morphological features of texture, structure and consistence, for estimating loading rate.

5. Size the soil dispersal unit based on morphological features of the site and loading rates from Table 2.

6. Evaluate the site for linear loading rate to determine the configuration of the site. (See Converse, 1998 for better understanding on estimating linear loading rate).

Table 3. Matrix of dispersal units for separation distance and effluent quality. This matrix is suitable for all soil texture/structure combinations on Table 1 except for the very coarse sands and sands with fragments. Table can be used with some adjustments.

Depth to Limiting Condition (In.)	Effluent Quality (Col./100 mL) (Separation Distance -In.)		
	$>10^4$	$>10^3 - <10^4$	$<10^3$
60	In-ground trench Drip distribution	In-ground trench Drip distribution	In-ground trench Drip distribution
54	Shallow trench Drip distribution	In-ground trench Drip distribution	In-ground trench Drip distribution
48	Shallow trench Drip distribution	In-ground trench Drip distribution	In-ground trench Drip distribution
42	Shallow trench Drip distribution	Shallow trench Drip distribution	In-ground trench Drip distribution
36	At-grade Drip on surface	Shallow trench Drip distribution	Shallow trench Drip distribution
30	Mound	Shallow trench Drip distribution	Shallow trench Drip distribution
24	Mound Drip in mound	At-grade Drip on surface	Shallow trench Drip distribution
18	Mound Drip in mound	Modified mound[1] Drip in mod. mound	Shallow trench Drip distribution
12	Mound Drip in mound	Modified mound Drip in mound	At-grade Drip on surface
6[2]	Mound Drip in mound	Modified mound Drip in mod. mound	Modified mound Drip in mod. mound

[1]Modified mound- mound has been modified from mound either with less sand fill or reduced aggregate area.

[2] When limiting condition is between 6-12" the risk of toe leakage is increased. Systems must be long and narrow to minimize toe leakage.

Types of Soil Dispersal Units

Table 3 gives a matrix of the dispersal units suitable for a given site based on separation distance from the ground surface and the effluent quality. Other types may be suitable or variations of the type given may be appropriate. For example in-ground trenches are listed but in-ground beds may be appropriate for a given site. Narrow absorption areas (trenches) are preferred over wider absorption areas (beds).

Effluent distribution: Effluent distribution in soil treatment/dispersal units is either by gravity or pressure distribution. Gravity is the preferred method by owners and designers and is by far the most common. Systems receiving septic tank effluent by gravity typically form a clogging mat at the infiltrative area which greatly assists in treating the effluent. Some systems, such as the mound, require pressure distribution as it provides a uniform flow along the length of the unit and it also reduces localized overloading in the sand.

A clogging mat does not form at the infiltrative surface on systems receiving highly pretreated effluent. If effluent is discharged to these units by gravity, localized overloading results which may compromise the ability of the soil to provide the final polishing of the wastewater. Without this "polishing effect" the potential for fecal coliform and pathogen reaching the ground water is by far greater than if the effluent is distributed via pressure distribution where it is uniformly distributed over the infiltrative. Also small frequent doses utilizing time dosing is superior to large less frequent doses utilizing demand dosing. **Pressure distribution is recommended for soil dispersal units receiving aerobically treated effluent using either demand or time dosing. In fact pressure distribution is required in Wisconsin using either demand dosing or time dosing.**

a. In-ground trench

The in-ground trench or bed has been the standard soil absorption unit. Fig. 2 shows a cross section utilizing aggregate as the medium. Chambers, large diameter tubes, or other media can substitute for the aggregate. Distribution is by gravity or pressure distribution depending on effluent quality.

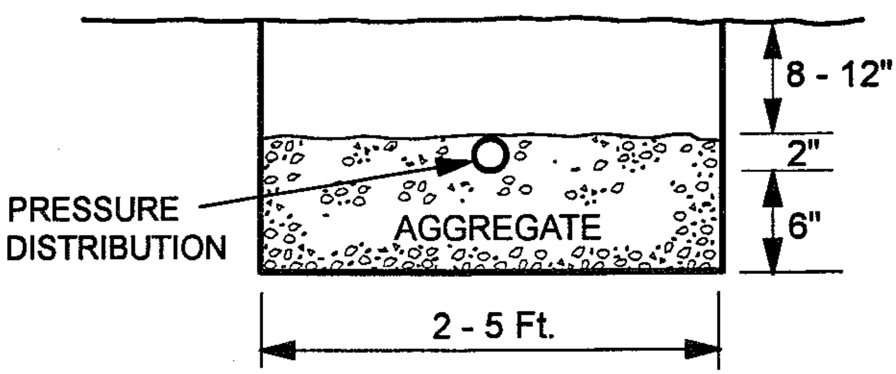

Fig. 2. Cross section of in-ground trench.

b. Shallow In-ground Trench

Shallow in-ground trenches are identical to the in-ground trench but located higher in the soil profile with a soil cover mounded over the top of the trench. Typically the infiltrative surface is beneath the original ground surface with soil mounded over the top of the aggregate as shown in Fig. 3. The top of the aggregate can extend above the original ground surface. Other media such as chambers may substitute for the aggregate. The differentiation between the shallow trench and at-grade is the shallow trench is formed into the native soil with a level bottom and the at-grade is placed on the native soil.

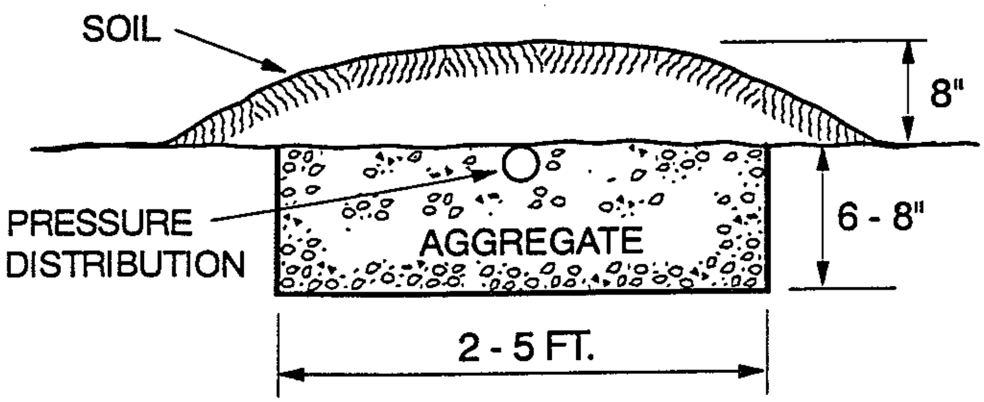

Fig. 3. Shallow in-ground gravel trench.

c. Gravelless - Half Pipe Trench

Figure 4 shows a shallow trench utilizing a 12 in. dia. PVC pipe or a 12" plastic corrugated pipe cut in half. This unit can be used in place of the gravel shallow trench. In the Oregon Code (1995) this unit is equivalent to the 24 in. wide gravel trench. However, it is questionable whether the infiltration through the bottom area of this unit is any greater than that of gravel and thus the loading rate should be the same for both the

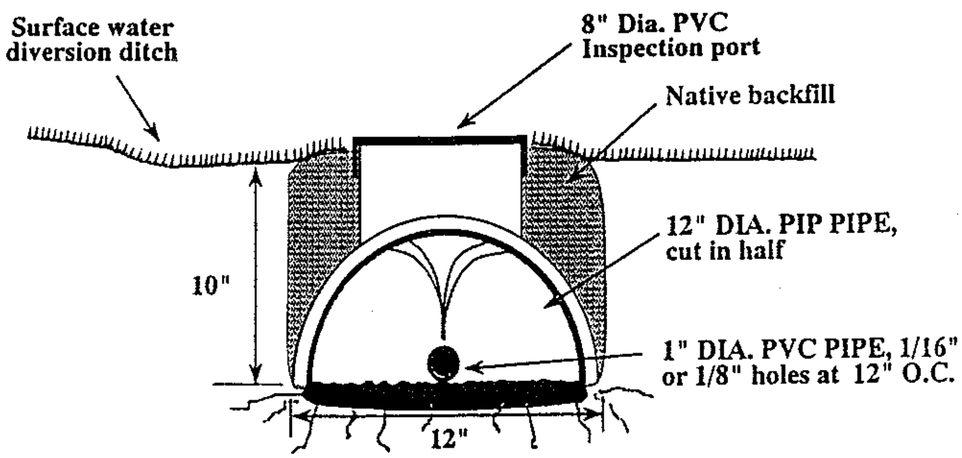

Fig. 4. Gravelless trench utilizing half of PVC pipe (Orenco, Inc).

gravelless and aggregate units. Other methods may be possible to create a narrow, shallow trench with an exposed soil surface such as chamber systems. Smaller diameter pipes can be used. This system requires a pressure distribution network to distribute the effluent along the length of the trench. Since this trench is only 12" wide, the length of trench required is 3 times that of a 3 ft wide or 5 times that of a 5 ft wide shallow in-ground (Fig. 3) trench if the same soil loading rates are maintained.

d. At-grade Unit

Figure 5 shows a cross section and plan view for an at-grade unit. Converse et al. (1990) provide details on siting design and construction of the at-grade unit utilizing septic tank effluent. Criteria are the same for highly pretreated effluent except the separation distance and loading rates used is determined in Tables 1 and 2, respectively.

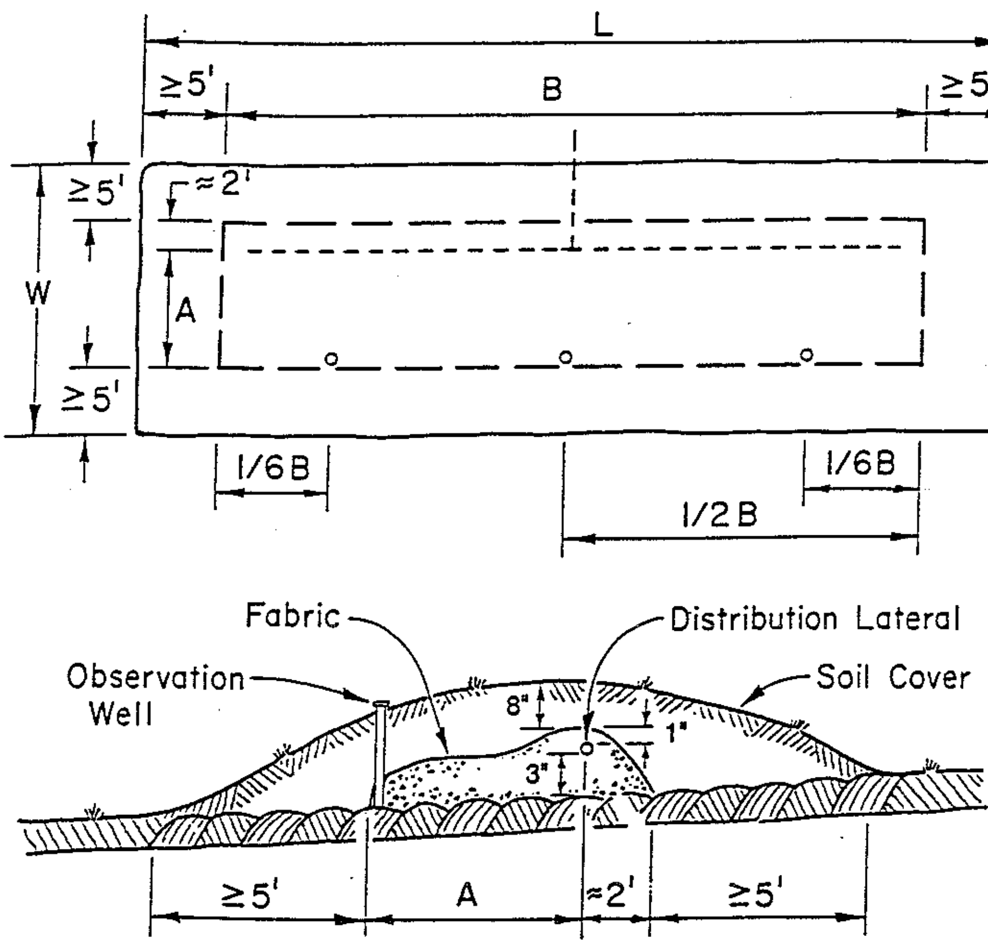

Fig. 5. Cross section and plan view of at-grade soil treatment/dispersal unit.

e. Mound Unit

Fig.6 shows a cross section and plan view of a Wisconsin mound unit. Converse and Tyler (1990) provide details on siting, design and construction of the mound utilizing septic tank effluent. Criteria are the same for highly pretreated effluent except the separation distance and loading rates used is determined in Tables 1 and 2, respectively. Mounds are typically located on sites with more restrictions so linear loading rate sizing is extremely important.

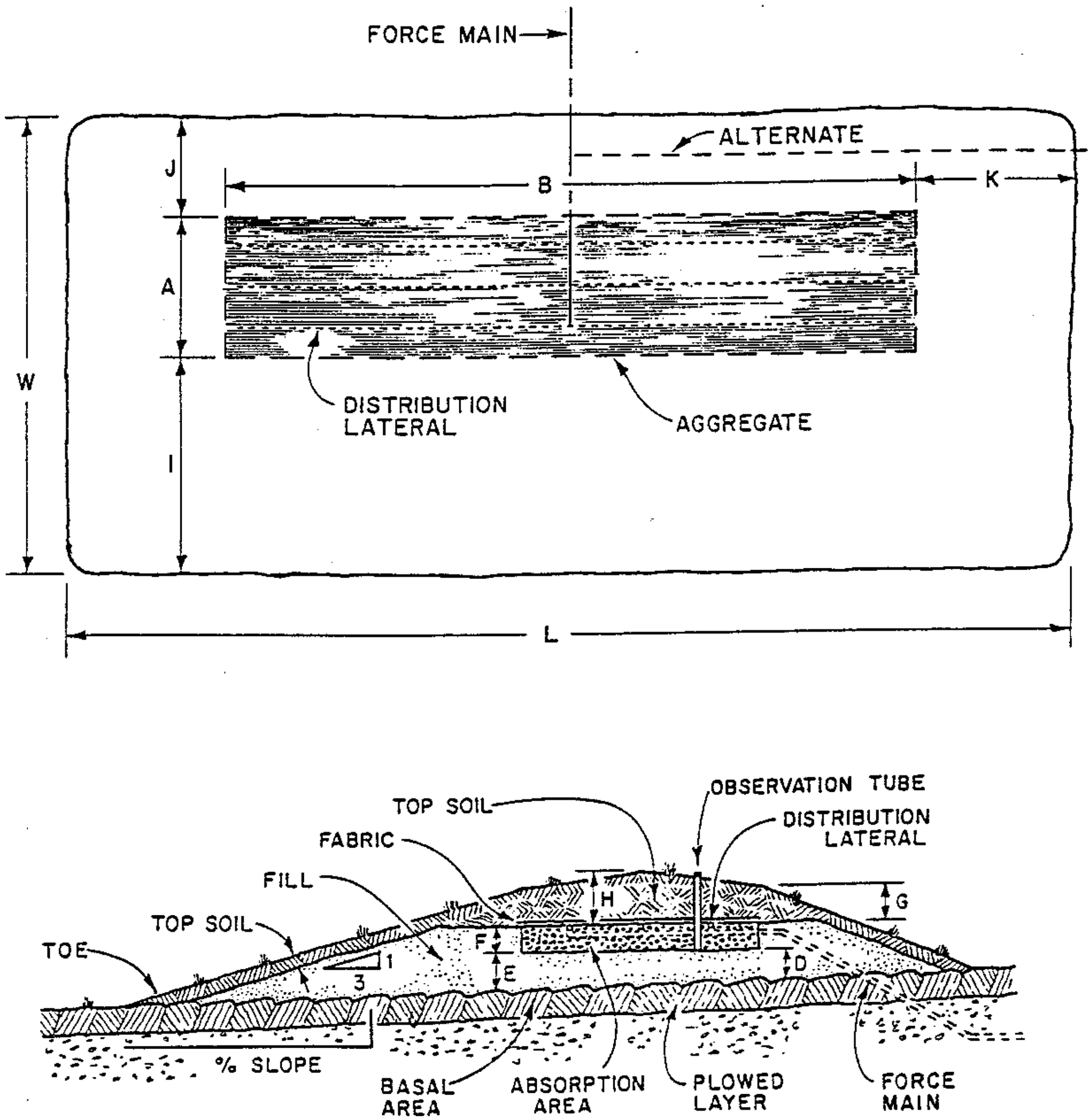

Fig. 6. Cross section and plan view of mound soil treatment/dispersal unit.

f. Modified Mound Unit

This unit was developed for sites, receiving highly pretreated effluent, with seasonal saturation <12in. below the ground surface with emphasis on slowly permeable soils such as silty clay loams and clay loams (Fig. 7). The four (4) inches of sand provides additional treatment area and allows the effluent to flow down slope through the sand and infiltrate into the slowly permeable surface horizon. The aggregate area is reduced to account for the higher quality pretreated effluent. Additional sand can be added to accommodate an aerobic unit with higher fecal coliform counts (>10^3 - <10^4 co./ 100 mL, Table 1). Linear loading rates in the range of 3-4 gpd/lf are not unusually for these difficült sites resulting in long narrow systems.

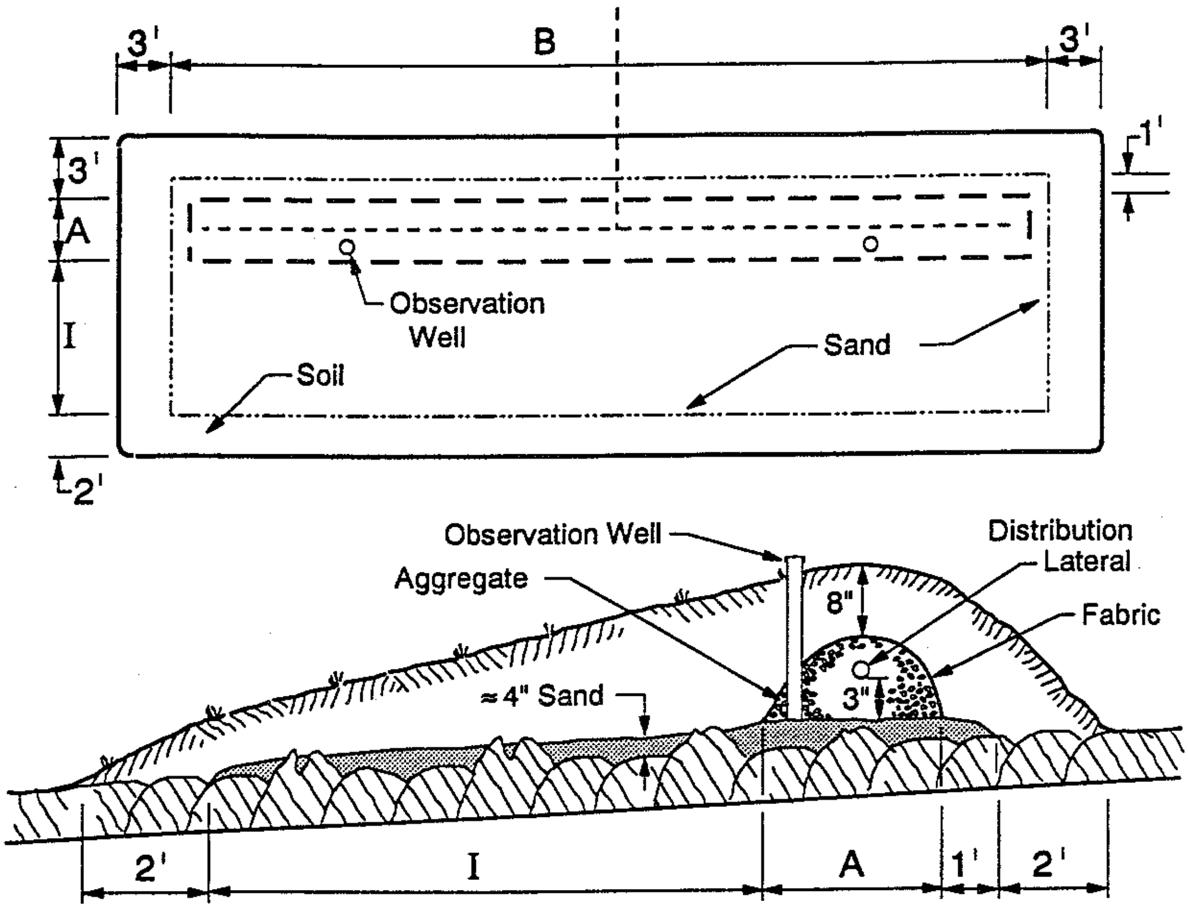

Fig. 7. Modified mound soil absorption unit for aerobically treated effluent.

Converse and Tyler (1990) provide the siting, design and construction details for the Wisconsin mound with many of the same principles applying to the modified mound. During construction, consider placing the 4" of sand and then chisel plowing the sand and the soil which should allow for better incorporation of the sand into the soil. This is not done on the Wisconsin Mound as the sand is too thick. Mold board plowing will elevate the system compared to chisel plowing, defeating one of the reasons for using the modified mound over the mound. Sand incorporation into the soil is not as good with moldboard plowing as with chisel plowing.

The soil loading rate, the sand loading rate and the linear loading rate must be determined for each site based on the soils report and site constraints. Once these are estimated, the system length and width can be determined. A pressure distribution network is required for the unit. Design and construction procedures are the same as for the Wisconsin mound system (Converse and Tyler, 1990) except that the amount of sand used is considerably less.

f. Drip Distribution

Drip distribution (also known as subsurface irrigation) is a viable method of dispersing highly pretreated effluent into the soil. This units should be called drip distribution instead of subsurface irrigation as irrigation refers to providing water when the plants need it on a seasonal basis and not on a year around basis under all soil moisture conditions as is needed for effluent dispersal.

There are two types of drip distribution. One type takes septic tank effluent, filters out the suspended solids (~100 micron filter) and delivers it to the distribution unit. This is referred to as septic drip by some. The other type is to deliver highly pretreated effluent such as from a sand filter, aerobic unit or peat filter, to the distribution unit.

Septic drip: Septic drip consists of a septic tank with filter, a pump chamber with pump, a hydraulic unit with disk filters and controls to provide for back flushing the filters and a pump in the pump chamber pressurizes the total system with pressures ranging between 10 and 70 psi. Back flush pressures for the filters reach over 100 psi. Provisions are made to automatically flush the drip tubing periodically. Other components consist of manifolds, zones and vacuum breakers.

Drip for aerobically treated effluent: The system consists of a 1) pump chamber following the pretreatment unit, 2) a spin filter or other filter to remove any debris entering the pump chamber or solids carry over from the pretreatment unit and 3) a number of feet of ½" flexible drip tubing with emitters located normally 2' on center with 2' spacing between laterals. Provisions are made to automatically flush the drip tubing periodically. Other components consist of manifolds, zones and vacuum breakers. Figure 8 provides a schematic of a typical drip for aerobically treated effluent (Converse, 1999).

The linear feet of drip line will be dependent upon the soil texture, structure. Septic drip systems have a lower loading rate than drip for highly pretreated effluent. The tubing can be placed shallow or deep in the soil profile but currently must meet the separation distances outlined in Table 1. Placing it very shallow in the soil profile allows the plant roots access to the moisture and nutrients. Provisions can be made to use it during the winter months such as 1) placing the system in areas that normally don't freeze such as wooded areas or areas with heavy vegetative cover, 2) placing a section deeper in the soil for winter use or 3) using it at sites such as summer campgrounds which don't generate effluent during the winter months.

A drip system with tubes buried 4-7" beneath the ground surface in a grove of small walnut trees served as the dispersal unit for a residence during the very cold winter of 1995-96 in South Central Wisconsin and has continued to operate successfully ever since. Another one of similar design but in an open field with vegetation has been in operation since Fall, 1997. Four other units are operational in Wisconsin during winter 1998-99 with a number of units operating in Northern Minnesota.

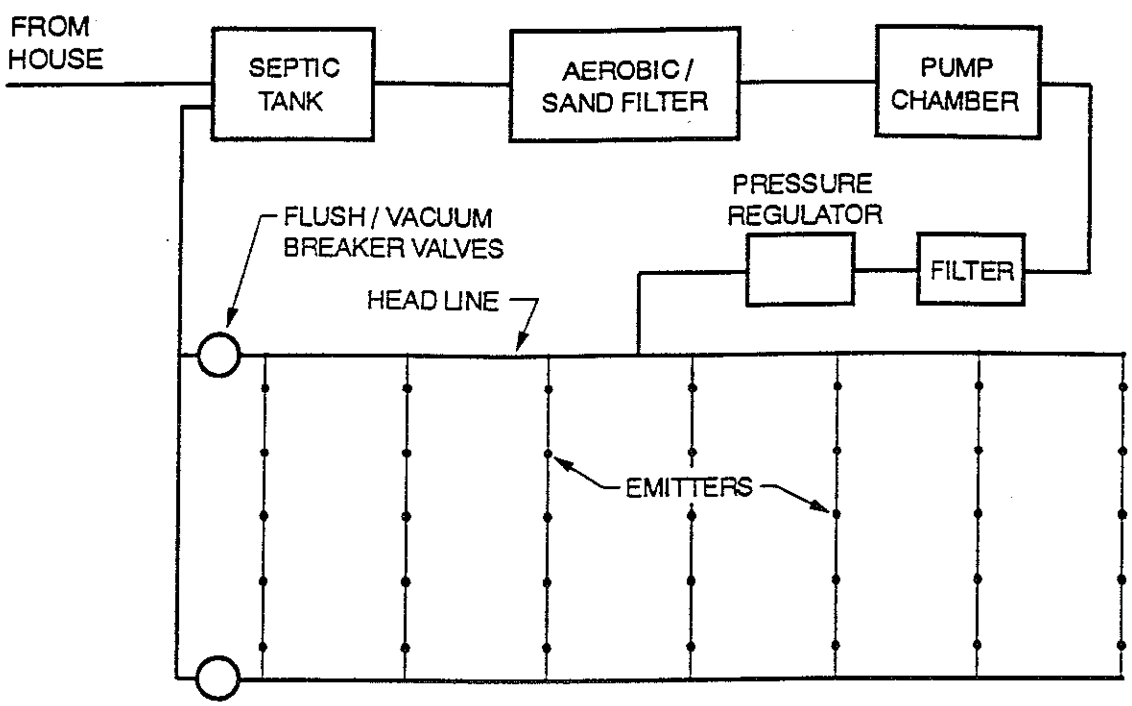

Fig. 8. Drip distribution for highly pretreated effluent.

To provide additional separation distance to limiting conditions, the soil surface can be tilled with sand placed on the till. The surface of the sand is leveled along the slope with the sand having the same slope as the natural soil. The drip lines are placed parallel on the surface spaced from 6 - 24" apart. About 2" of sand is placed on top with about 6-8" of soil cover over the sand. This can be done for both the septic drip and the aerated drip systems.

g. Renovating an Existing Soil Absorption Unit

Soil absorption units failing due to biological clogging can be renovated using highly pretreated effluent from aerobic units or sand filters (Converse et al., 1997). The State of Wisconsin has approved this technology as an alternative to a new system provided certain soil/site criteria are met. Contact local county office in charge of on site systems.

System Design

Design a soil dispersal unit for highly pretreated effluent from a pretreatment unit such as a sand filter, aerobic unit or constructed wetland. The steps are:

1. Evaluate the soils report for 1) system type, 2) soil loading rate and 3) linear loading rate. For this example use the soil test report located in Appendix A. Note the following points about the soil test report:

    a. The limiting condition is at 11, 12, 9, 14" with the limiting condition set at 9" below the ground surface. The proposed code (table 1) requires either 12" or 24" of separation depending on the quality of effluent produced. For this discussion, we will assume that the pretreatment unit consistently produces an effluent less than 1000 col./100 mL. Table 2 shows that the systems of choice is a modified mound or drip distribution. The modified mound will be selected (Fig. 7). This will require the placement of 3-4" of coarse sand (mound specification) on the surface.

    b. Based on the soil texture, structure and consistence, a soil loading rate has been established for the surface horizon of 0.6 gpd/ft^2 (Table 2 for silty clay loam with moderate structure) which is 1.5 times the loading rate for septic tank effluent.

    c. The linear loading rate is a measure of the ability of the effluent to move away from the dispersal unit. It is an estimate based on experience of water moving vertically and horizontally through the various soil profiles, soil permeability, site slope and depth to limiting conditions. Converse and Tyler (1990), Converse et al. (1990), Converse (1998) show how linear loading rates are applied to mounds and at-grade units. On shallow and/or slowly permeable soils, the linear loading rate (LLR) will be in range of 3 -4 gpd/lf. It is always desired to make units long and narrow. Fig. 1

shows the concept of linear loading rate in that the figure on the left and middle have half the linear loading rate of the unit on the right. For this site use a linear loading rate of :

LLR = 3.0 gpd/lf.

This linear loading rate was selected based on: (See soils report)

1. The seasonal saturation is at 9-12" at which time the effluent will be forced to move horizontally.

2. Horizon 2 and 3 consist of clay loam with firm consistence, both of which will slow the vertical flow and force effluent to move horizontally.

3. Horizon 4 is silty clay with a weak structure and firm consistence. This horizon will slow up the vertical flow during unsaturated conditions forcing the effluent to move horizontally with some moving vertically.

d. Use the coarse sand loading rate in Table 2.

Sand Loading Rate = 1.7 gpd/ft^2.

2. Using these various loading rates, size the dispersal unit.

a. Length of Absorption Area (B)

B = Design Flow Rate / Linear Loading Rate = DFR / LLR

= 450 gpd / 3 gpd/lf = 150 ft

(The design flow rate is 450 gallons based on 3 bedrooms and 150 gallons/bedroom/day)

b. Width of Absorption Area (A)

A = Linear Loading Rate / Sand Loading Rate = LLR / SLR

= 3 gpd/lf / 1.7 gpd/ft^2 = 1.76' Round off to 2 ft.

c. Width of Basal Area (A+ I)

A +I = Linear Loading Rate / Soil Loading Rate = LLR/SoLR

= 3 gpd/lf / 0.6 gpd/ft^2 = 5.0 ft.

I = 5 ft - 2 ft = 3.0 ft

d. Extend the soil cover around the system out a minimum of 2 ft. Extending it further will reduce the side slopes which may be desirable as slopes will be quite steep.

Dispersal Unit Length = 2 end slopes + B = 4 + 150 = 154 ft

Dispersal Unit Width = upslope + A + I + down slope = 2 + 2 + 3 + 2 = 9 ft

Note: - Caution

This is the design based on the linear loading rate and the soil and sand loading rates. Theoretically this design should work. However, systems installed in the field so far have been larger than this. The width of the sand (I + A), calculated as 5 ft, has normally been about 8-10 ft in the past, so it may be appropriate to increase it to about 8 -10 ft on more slowly permeable soils. The experimental units have a center feed with valves at the inlet of the laterals so half or all the system can be used. The costs of these additions are minimal.

3. Design a distribution network for the unit.

Pressure distribution is used to distribute the effluent along the length of the unit. It is also preferred as it provides a more uniform effluent distribution and allows the soil to better polish the effluent before it reaches the ground water. Gravity distribution will concentrate the wastewater into a small area and possibly overload a given area resulting in toe leakage.

a. The following is recommended:

- Orifice diameter and spacing: 1/8" holes on 2 ft on centers.
- Lateral distal pressure: 5 ft. (Assume 5 ft at inlet end).
- Lateral diameter - See Table 4 for maximum lengths for various diameters.
- Use orifice flow rates of 0.41 gpm for 1/8" opening with 5' of head.
- Orifices located downward (Upward for half pipe or exposed infiltrative area, but must drain after dosing in cold climates).
- Center feed networks. If manifolds are needed use 1 1/4" diameter pipe for small systems (2 lateral/side).

- All laterals and manifolds are Schedule 40 PVC pipe.

b. For this system consider the following network design

- Lateral length - 75 ft
- Lateral diameter - 1.25" (Table 4)
- Number of orifices - 37 per lateral (2' spacing)
- Number of laterals - 2 with center feed (single line on each side of feed)
- Number of orifices - 74
- Manifold - None as center feed with single line
- Flow @ 5 ft of head - 30 gpm (0.41 gpm @ 5 ft head)
- Pump capacity:

  Flow: 30 gpm

  Head: Elevation lift
  Force main friction loss
  In-line pressure - 5 ft

- Net dose volume - 5 times the void volume of laterals

1.25" pipe has void volume of 0.064 gallon per foot.

0.064 gallons/foot X 150 ft X 5 = 48 gallons/dose.

Table 4.Maximum length of distribution laterals for Schedule 40 PVC pipe sizes having 1/8 in. orifices spaced 2 ft with 5 ft of head at lateral end. (Loudon, 1995).

Lateral Diameter (in.)	Maximum Length (ft)	No. of Orifices	Total Flow (gpm)	Input Head (ft)
1.0	52	26	11.0	6.1
1.25	84	42	17.8	6.2
1.5	108	54	22.9	6.1
2.0	166	83	35.1	6.2

System Construction

Construction of the dispersal unit is just as important as design and siting. Improper construction will lead to an inferior operating unit. Construction practices for dispersal units, receiving highly pretreated effluent, are very similar to those receiving septic tank effluent. The following steps are specific to the modified mound but most apply to all systems.

1. Lay out the dispersal unit on the contour.

2. Remove the excess vegetation but not the sod. Trees and shrubs must be cut off at ground surface and removed. Excessive grass and weeds should be mowed and removed for easier tilling.

3. Check the moisture content of the soil prior to tilling/excavation. It must be sufficiently dry at the contact surface to avoid smearing and compaction during tillage. For shallow trenches this area is the bottom of the trench. For mounds and at-grades, it is the top 8".

4. Place 3 - 4" of sand on the surface and then chisel plow or chisel plow and then place the sand. The soil clods can protrude through the sand especially down slope of the aggregate. Mold board plowing is not recommended as the sand/soil contact is not as good. It will also raise the mound height about 4-6". **Till out to the width and length of the mound.**

5. Place sand over most of the tilled area except for 2 ft around the perimeter set aside for the soil cover tie in.

6. Level the sand, somewhat, where the aggregate is to be placed and place 4" of aggregate. With the limited sand, it may be difficult to get it level with the soil clogs. Try avoid placing more sand as it will raise the height of the system. Place the observation tubes to the sand/aggregate interface.

6. Place the distribution network and cover the laterals with 1" of aggregate by raking aggregate already placed.

7. Place geotextile fabric over the aggregate but not the sand.

8. Cover the entire area with top soil carrying the top soil out several feet from sand and aggregate to provide slope. Make sure the area beneath the soil extending beyond the sand is tilled prior to placement of the top soil so as to tie the top soil into the existing soil.

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APPENDIX A

SOILS REPORT BASED ON SOIL MORPHOLOGY

In evaluating soil loading rates for on-site wastewater treatment and dispersal, Wisconsin has adopted the soil morphological properties approach where the trained certified soil tester evaluates the soil based on soil texture, soil structure and soil consistence to determine soil loading rates. Additional evaluation includes estimating distance to limitations of soil saturation (mottling) and bedrock.

Wisconsin Department of Industry, Labor and Human Relations
Division of Safety & Buildings

SOIL AND SITE EVALUATION REPORT

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Page ___ of ___

in accord with ILHR 83.05, Wis. Adm. Code

COUNTY: Buck
PARCEL I.D. #:
REVIEWED BY: DATE:

Attach complete site plan on paper not less than 8 1/2 x 11 inches in size. Plan must include, but not limited to vertical and horizontal reference point (BM), direction and % of slope, scale or dimensioned, north arrow, and location and distance to nearest road.

APPLICANT INFORMATION–PLEASE PRINT ALL INFORMATION

PROPERTY OWNER: John Doe

PROPERTY OWNER'S MAILING ADDRESS: 514 Deer Drive

CITY, STATE: Yearling, WI ZIP CODE: PHONE NUMBER: ( )

PROPERTY LOCATION
GOVT. LOT SE 1/4 SW 1/4, S 6 T 3 N, R 21 E (or) W

LOT # BLOCK # SUBD. NAME OR CSM #

☐ CITY ☐ VILLAGE ☒ TOWN Fawn NEAREST ROAD Buck Fever

[x] New Construction Use [x] Residential / Number of bedrooms 3 [ ] Addition to existing building ______
[ ] Replacement [ ] Public or commercial describe ______

Code derived daily flow 450 gpd Recommended design loading rate .4 bed, gpd/ft² .5 trench, gpd/ft²
Absorption area required 375 bed, ft² 375 trench, ft² Maximum design loading rate .4 bed, gpd/ft² .5 trench, gpd/ft²
Recommended infiltration surface elevation(s) (surface) ft (as referred to site plan benchmark)
Additional design / site considerations deep chisel plowing recommended
Parent material glacial drift Flood plain elevation, if applicable -- ft

S = Suitable for system U = Unsuitable for system	CONVENTIONAL	MOUND	IN-GROUND PRESSURE	AT-GRADE	SYSTEM IN FILL	HOLDING TANK
	☐ S ☐ U	☐ S ☐ U	☐ S ☐ U	☐ S ☐ U	☐ S ☐ U	☐ S ☐ U

SOIL DESCRIPTION REPORT

Boring # 1

Ground elev. 98.1 ft.

Depth to limiting factor 11"

Horizon	Depth in.	Dominant Color Munsell	Mottles Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	Roots	GPD/ft² Bed	GPD/ft² Trench
1p	0-10	10yr 2/1		sicl	2mabk	mfr	as	2m-f	.4	.5
2	10-11	10yr 4/4		cl	2msbk	mfi	cs	1m-f	.4	.5
3	11-22	10yr 4/4	f1f 10yr5/6	cl	2msbk	mfi	cs	1m-f	.4	.5
4	22-29	10yr 5/4	czd 10yr5/8 + 10yr7/1	sic	1fsbk	mfi		1f	n.p.	.3

Remarks: ______

Boring # 2

Ground elev. 98.0

Depth to limiting factor 12"

Horizon	Depth in.	Dominant Color Munsell	Mottles Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	Roots	GPD/ft² Bed	GPD/ft² Trench
1p	0-10	10 yr 2/1		sicl	2mabk	mfr	as	2m-f	.4	.5
2	10-12	10yr 4/4		cl	2msbk	mfr	cs	1m-f	.4	.5
3	12-19	10yr 4/4	f1f 10yr5/6	cl	2msbk	mfr	cs	1m-f	.4	.5
4	19-29	10yr 5/4	c2d 10yr5/8 + 10 yr 7/1	sic	1msbk	mfi		1f	n.p.	.3

Remarks: ______

CST Name:—Please Print Jack Jones Phone:
Address:
Signature: Date: CST Number:

(15)

PROPERTY OWNER ______________________

PARCEL I.D. # ______________________

SOIL DESCRIPTION REPORT

Boring # 3

Ground elev. n.t. ft.

Depth to limiting factor 9"

Horizon	Depth in.	Dominant Color Munsell	Mottles Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	Roots	GPD/ft² Bed	GPD/ft² Trench
1p	0-9	10yr 2/1		sicl	2fsbk	mufi	as	2m-f	n.p.	n.p.
2	9-20	10yr 4/4	fzf 10yr 5/6	cl	2fsbk	mvfi	cs	1m-f	n.p.	n.p.
3	20-29	10yr 6/4	czd 10yr 5/8+ 10yr 7/1	sicl	1fsbk	mfi			.2	.3

Remarks: ______________________

Boring # 4

Ground elev. 97.4 ft.

Depth to limiting factor ____

Horizon	Depth in.	Dominant Color Munsell	Mottles Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	Roots	GPD/ft² Bed	GPD/ft² Trench
1p	0-12	10yr 2/2		sicl	2msbk	mfr	cs	2f	.4	.5
2	12-14	10ry 4/4		cl	2msbk	mfr	cs	1f	.4	.5
3	14-22	10yr 4/4	flf 10yr 5/6	cl	2msbk	mfr	cs	1f	.4	.5
4	22-55	10yr 5/4	czd 10yr 5/8 + 10 yr 7/1	sic	1fsbk	mfi			n.p.	.3

Remarks: ______________________

Boring # ____

Ground elev. ____ ft.

Depth to limiting factor ____

Horizon	Depth in.	Dominant Color Munsell	Mottles Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	Roots	GPD/ft² Bed	GPD/ft² Trench

Remarks: ______________________

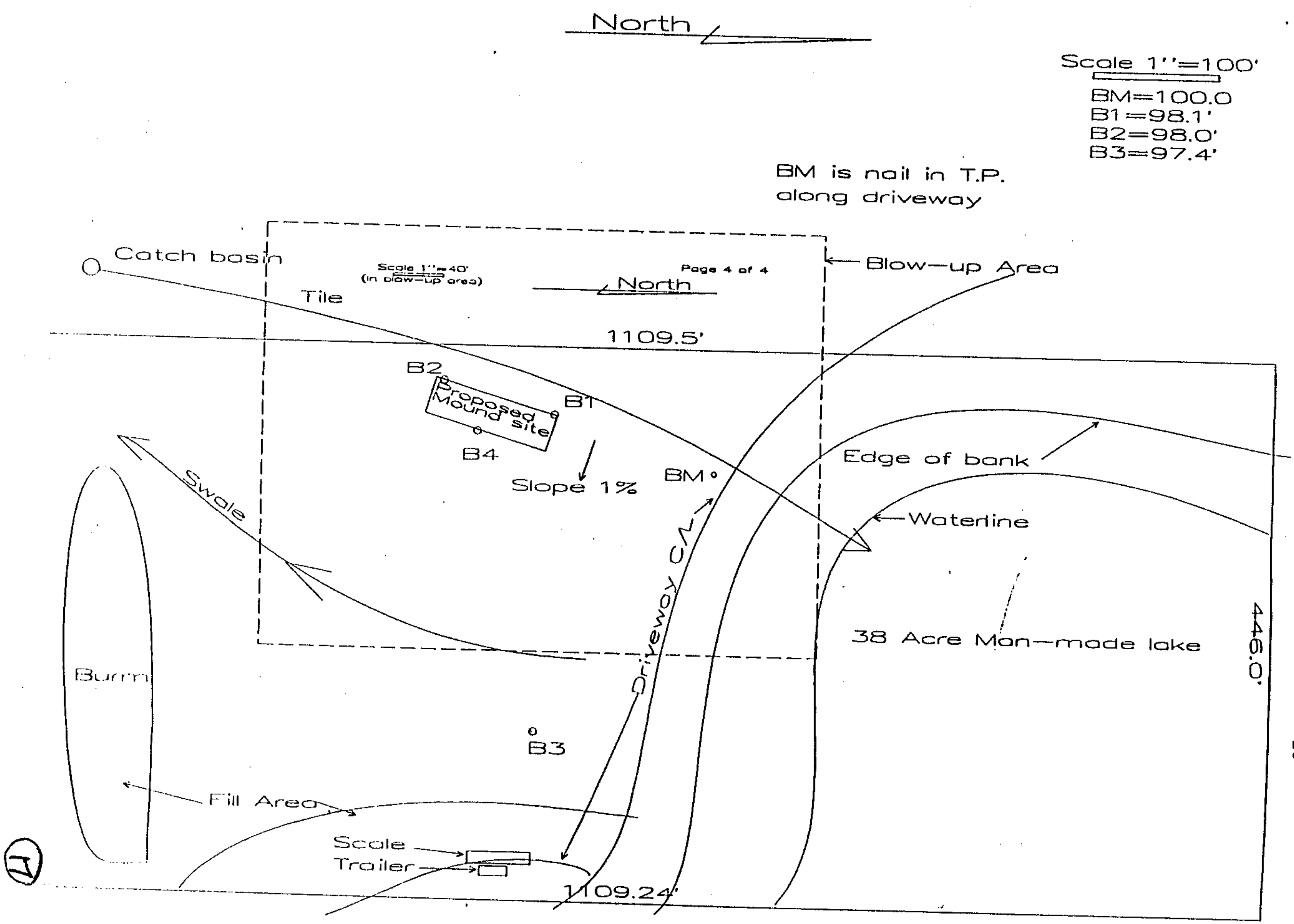
Boring # ____

Ground elev. ____ ft.

Depth to limiting factor ____

Horizon	Depth in.	Dominant Color Munsell	Mottles Qu. Sz. Cont. Color	Texture	Structure Gr. Sz. Sh.	Consistence	Boundary	Roots	GPD/ft² Bed	GPD/ft² Trench
									16	

Remarks: ______________________


North
Scale 1''=100'
BM=100.0
B1=98.1'
B2=98.0'
B3=97.4'
BM is nail in T.P.
along driveway
Catch basin
Scale 1''=40'
(in blow-up area)
Page 4 of 4
North
Blow-up Area
Tile
1109.5'
B2
Proposed
Mound site
B1
B4
Slope 1%
BM
Edge of bank
Waterline
Swale
Driveway C/L
38 Acre Man-made lake
446.0'
Burm
B3
Fill Area
Scale
Trailer
1109.24'
17