

# **DRIP DISTRIBUTION OF DOMESTIC WASTEWATER**

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## **Summary**

**This publication provides an overview of drip distribution of domestic wastewater. It discusses the concepts and the various components of drip distribution, discusses soil loading rates, system configuration and provides an design example.**

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# DRIP DISTRIBUTION OF DOMESTIC WASTEWATER

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Subsurface drip distribution, also known as drip or trickle irrigation, is a viable alternative for dispersing septic tank effluent into the environment. Drip irrigation is used extensively in agriculture for supplying water to plants when needed. Irrigation implies a need for water by plants and is applied only when needed. However, when applied to dispersing domestic wastewater into the environment, it is more related to distribution than irrigation as the effluent has to be distributed regardless of the soil moisture content and plant needs.

The parameters are different so it should be referred to as **drip distribution/dispersal** and not drip irrigation. Drip dispersal is becoming more popular as a means of dispersing domestic waste water into the environment especially in the more temperate regions. It is also being used in the cold climates in more protected areas such as woods, in heavy vegetative areas and well manicured lawns areas that receive snow cover. There is still concern about shallow placement in open areas, such as well manicured lawns in the cold climates with limited snow cover. Systems are sized to serve individual homes and to serve very large commercial establishments.

The advantages of drip distribution over other dispersal units such as in-ground trenches, bed, at-grades and mounds are that it 1) distributes the effluent more uniformly over a larger area, 2) promotes lower localized loading rates/dose, 3) provides longer contact time with the soil and 4) places the effluent in contact with the soil biota which are most active in the upper soil horizons.

A drip distribution system consists of a 1) wastewater pretreatment unit, 2) pump tank, pump, filter and controls, 3) dispersal unit consisting of supply and return line (flush line), emitters, check valves and vacuum breakers assembled into one or more zones and 4) management plan.

## System Components

### 1. Wastewater Treatment Unit:

There are two approaches to treating the wastewater prior to discharging the effluent to the dispersal

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

unit, namely, 1) mechanical filtration (anaerobic or septic drip) or 2) aerobic treatment such as ATUs, sand filters, peat filter or biofilters.

**Mechanical filtration systems** consist of forcing the septic tank effluent under high pressure through 100 - 150 micron filters which are automatically back flushed with the solids discharged to the septic tank. The filters, usually disk filters, are part of a hydraulic unit that includes a pump, water meter, solenoid valves and control panel. For home size systems the units are contained in a heated insulated box located near the pump chamber with the pump located in the pump chamber or in the insulated box. For larger units serving commercial facilities, the hydraulic unit is usually located in a small, insulated building with the pump located in the unit.

Figure 1 shows the complete system utilizing a mechanical filtration unit ( American Manufacturing, 1999). The system requires a septic tank, sized for the establishment, and a pump or dose chamber. The pump chamber must have surge capacity or flow equalization as these

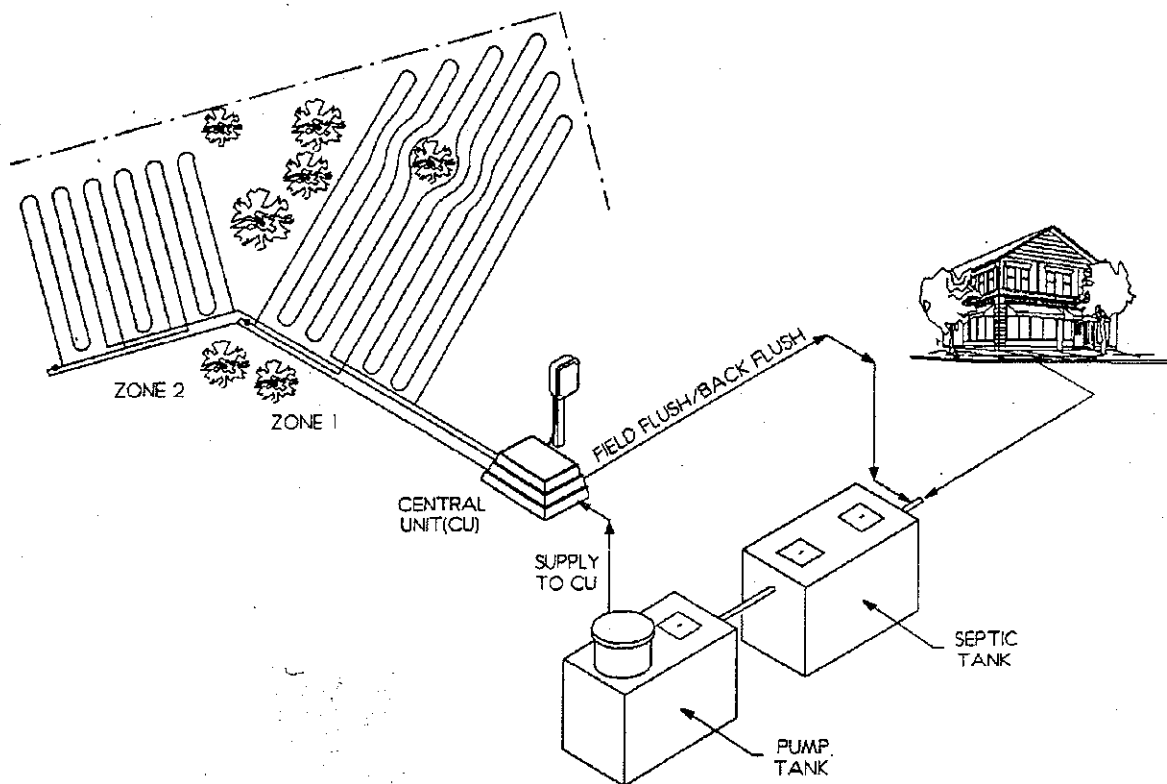


Fig. 1. Drip distribution system utilizing a mechanical filter showing two zones ( American Manufacturing, 1999).

Units are time dosed, not demand dosed. The effluent in the dose tank is pumped to the mechanical filter assembly, which is housed in a box or small building depending on size. The disk filters, two or more depending on size of the unit, remove the solids as the effluent passes through the filters.

The filters normally have openings in the range of 100 - 150 microns. Spin filters have also been used.

The unit is instrumented to back flush the filters before each cycle of operation with the solids laden flush water entering the house waste line about 4 ft from the septic tank inlet (not shown on the figure). The filter removes the suspended solids to protect the downstream emitters from plugging. There is very little change in BOD, nitrogen, fecal coliform concentrations and other parameters. Because of the relatively high oxygen demand (BOD and nitrogen) there is the potential for soil clogging around the emitters if the oxygen demand is not met. Experience has shown that this is normally not a problem but it can be if the loading rates are high and BOD is high. This unit can also be used with aerobically treated effluent such as sand filters and aerobic units.

**Aerobically treated effluent systems** consist of a septic tank/sand filter, peat filter, biofilter or one of the many types of ATUs commercially available. Figure 2 shows an example of such a unit (Geoflow, 1996). There are variations depending on the manufacturer. Also, the unit described above for mechanically filtered effluent can be used with aerobically treated effluent. When properly operated and maintained, the effluent entering the drip system will have very low BOD and TSS (less than 20) and normally lower fecal coliform counts than the mechanically filtered effluent. The coliform count will be dependent on how effective the pretreatment/ treatment unit is in reducing pathogens as measured by fecal coliform counts. The effluent is then normally passed through a 100- 150 micron disk filter, spin filter or very small sand filter to remove any solids that may pass through the treatment unit or are inadvertently introduced into the dose tank. Because of the low oxygen demand remaining in the effluent, soil clogging should not occur around the emitters because of the low amount of organic matter entering the soil. The effluent is normally timed dosed which requires flow equalization or surge capacity in the pump chamber but some home sized systems are demand dosed. Dosing rate and frequency must be matched to soil conditions as will be described later.

## **2. Pumps, Filters, Pressure Regulator, Disinfection and Controls.**

Each system type will have its own criteria for pumps, filters, pressure regulators and controls. Some units may contain disinfection units. This discussion will be general and the manufacturer's design recommendations must be followed.

**Pumps:** For the mechanical filtration unit, the pump is sized to handle the flow and pressure required for the filters and for forcing the effluent through the dispersal lines. Typical pressures in the dispersal lines range upwards to 60 psi with filter back flush pressures up to 150 psi. The pump must also be sized to provide adequate flow volume and pressure for back flushing the filters. The pump must be capable of providing a minimum of 2.0 ft/sec of velocity in the drip tubing for regular field flushing of the lines to minimize build-up of bacterial growth on the tube lining which slough off and plug the emitters.

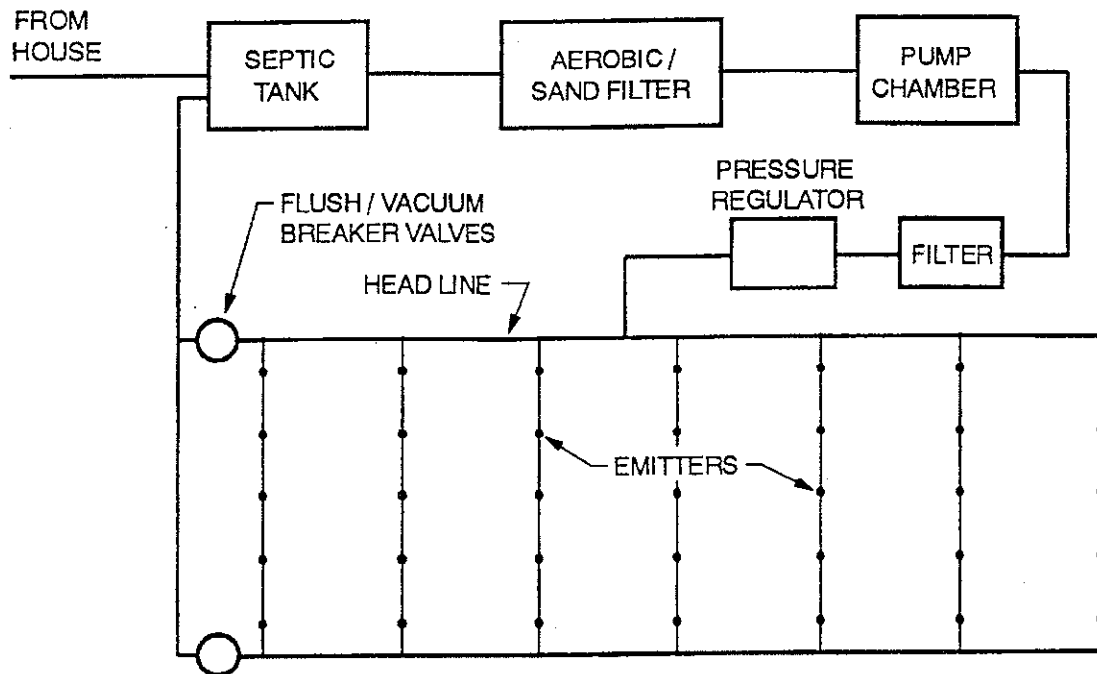


Fig. 2. Drip distribution system utilizing aerobically treated effluent (Geoflow, 1999).

For the aerobically treated units, the pump must be sized to handle the flow and pressure requirement of the dispersal unit. In-line pressures, in the range of 15 to 20 psi, are common with flow rates dependent upon the number of emitters. Flushing velocities of 2.0 fps must be satisfied if flushing is included. One manufacturer recommends less for tubing lined with bactericide. Automatic flushing should be incorporated which will require a control panel. However, when aerobically treated effluent is used, some small systems are manually flushed, either by opening the valve and turning on the pump or by connecting a garden hose to a special vacuum breaker and the house water supply with discharge to the pretreatment unit.

**Filters:** The filters are considered to be the heart of the drip system especially for the mechanically filtered units. The filter protects the emitters by removing the solids from the effluent stream. The filter opening, measured in microns, is usually 7-8 times smaller than the emitter opening. There are several types of filters including:

**Disk filter:** Disk filters consist of a stack of disks with a hollow core with a very narrow, grooved spaces/ridges between the disks. The filter comes in various sizes (gpm) and various spacings (microns). Typical spacing for drip dispersal is 100 to 150 microns. Wastewater passes from the outside to the inside of the disk with solids accumulating on the outside of the disk. Periodically, the flow is reversed with filtered water, from an adjacent disk, flushing the solids

off the surface with the discharge entering the inlet pipe to the septic tank. Filters need to be inspected periodically and hand cleaned if necessary.

**Spin filter:** Spin filters consist of a screen cylinder enclosed in a casing. For small drip systems the filters range in size from 3/4" to 1.5" with a typical mesh size of 150 and micron rating of 104. Other sizes and openings are available. A prescribed effluent flow rate, dependent upon filter size, enters one end of the cylinder at an angle to create a turbulence which helps keep the screen clean. There is a small ball valve at the end opposite the inlet which is opened periodically (manually) with the accumulated solids flushed out of the cylinder and returned to the pretreatment unit. With a solenoid valve and controls, the unit can be set to discharge solids on a scheduled basis. The screen may need to be removed periodically for hand cleaning especially if it filters septic tank effluent.

**Disinfection:** If the effluent is applied beneath the surface, disinfection is normally not required but some situations may demand disinfection prior to subsurface discharge. Disinfection should be incorporated if the emitters discharge to the ground surface. Disinfection will be either by chlorine or UV light. Units for both small and large on-site systems are available.

**Controls:** Systems can be operated on demand with the only controls being the on-off floats and alarm. These systems require periodic manual flushing of the filters and lines and manually switching between zones. These systems are typically limited to small single family residences and used with aerobically treated effluent. For all other systems especially mechanically filtered effluent, the system will be automatically controlled with a programmable logic controller which controls the amount and time of dose, alternates between zones, automatically flushes the lines and back flushes the filters. It is recommended that all systems be time dosed especially larger systems. Manually operated systems may have higher maintenance requirements.

### 3. Dispersal Unit

The dispersal unit consists of a supply line, manifold, tubing with emitter, check valves, common return line ( field flushing line), and air relief valves/vacuum breakers. System configuration will be dependent upon the area available for dispersal. This discussion will be more generic and limited to the essential components. Refer to the manufactures literature for alternatives such as looped systems, zone loading with equal and unequal absorption fields. Figures 1 and 2 provide an example of the various components.

**Supply Line:** The supply line extends from the pump/hydraulic unit to the manifold of a given zone. The size will be dependent upon length and design flow rate. Each zone will normally have its own supply line. Some home size units, with aerobically treated effluent, may have a single supply line serving several zones where the flow is manually alternated by turning several valves, periodically ( alternating yearly instead of alternating between doses).

**Manifolds:** The supply manifold connects the supply line to a series of drip lines (tubes containing emitters). The return manifold connects the drip lines to the return line. Figures 3 and 4 shows two types of manifolds. One is a single line with drip lines connected along its length (Fig. 3). The other unit consists of a short manifold with small diameter ( $\frac{1}{2}$  to  $\frac{3}{4}$ " ) PVC pipe connecting the manifold to each emitter line (Fig. 4). The return manifolds, in both cases, are similar to the supply

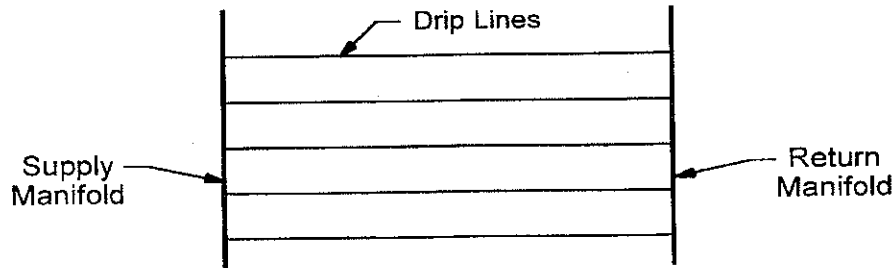


Fig. 3. Single supply and return manifold with drip line connecting along its length.

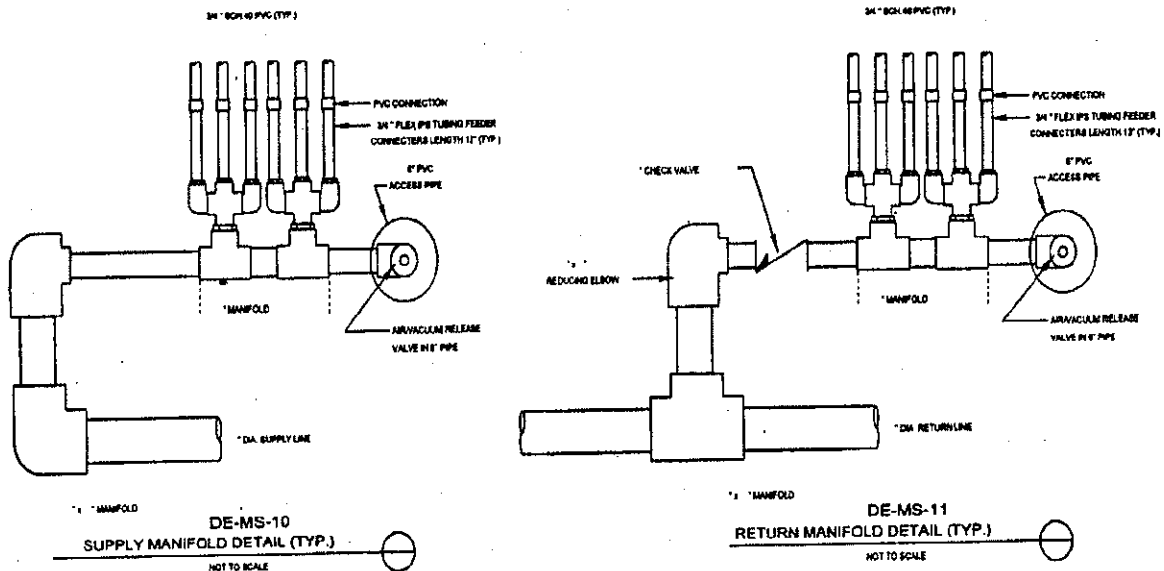


Fig. 4. Short (compressed) supply and return manifold (Wastewater Systems Inc, 1999).



manifold. The single line manifold interconnects all drip lines within the zone and is usually larger with more volume while the short (compressed) manifold isolates drip lines from one another (located on the up slope edge) and has a smaller volume. When the pump shuts off the effluent remaining in the manifolds and tubing will seek the lowest level. The designer must design to minimize the amount of effluent that will flow to the lowest level of the system so as to avoid overloading a portion of the unit. The advantage of the short manifold is that it eliminates flow from one drip line to a lower line thus reducing overloading in the lower portion of the system when the supply and return manifolds are installed at the upper edge of the zone. The short return manifold is installed at the lower edge of the zone when drainage of the supply and return lines are desired due to freezing concerns. However, with a heavy vegetative cover, freezing may not be a concern. Other things can be done to reduce the movement of effluent after the pump shuts off.

**Drip Line:** The drip line is a 1/2" diameter polyethylene tube that comes in large coils that is easily placed in the soil. Internal emitters are embedded every 24" along the length of the tube. Drip lines with emitters spaced at 6 and 12" are available and may be appropriate to use with higher strength BOD wastewater. External emitters, which "plug" into the drip line, are also available. Drip line can be purchased with or without an internal coating on the interior to minimize bacterial growth on the internal surface. Emitters are also available with a herbicide impregnated to reduce root penetration into the emitters.

As with any tube or pipe, each type has its friction loss characteristics. Laterals are limited to a certain length depending on the flow rate so as to maintain a certain pressure in the line. Curves and tables from the manufacturers are available for estimating pressure loss along the length of the tubing. For example, the pressure drop in tubing for flushing velocities (1.6 gpm and 2 fps) is 26 ft in 250 linear feet of tubing (American Manufacturing, 1999).

**Zones:** The drip lines are configured into zones with the number of zones dependent on the design flow and size of system. Zones can be configured in several ways with the supply line and return lines on opposite ends of the zone or on the same end. Figure 1 shows two zones and Figure 2 shows one zone. A minimum of 2 zones is recommended in most cases especially for mechanically filtered effluent.

**Run:** A run is defined as the distance between the supply and return manifolds when they are on opposite ends of the zone with no looping or it is the length of one tube along the length of the zone if both manifolds are on the same end (Fig. 5).

**Lateral:** The lateral is defined as the length of tubing extending from the supply manifold to the return manifold. If manifolds are on the opposite end of the zone, then the run equals a lateral with no looping. If both manifolds are on the same end of the zone and the drip tube extends out and loops back to the return manifold, then the lateral equals two runs (Fig. 5). The tubing can be looped several times with the length limited due to acceptable pressure loss along its length.

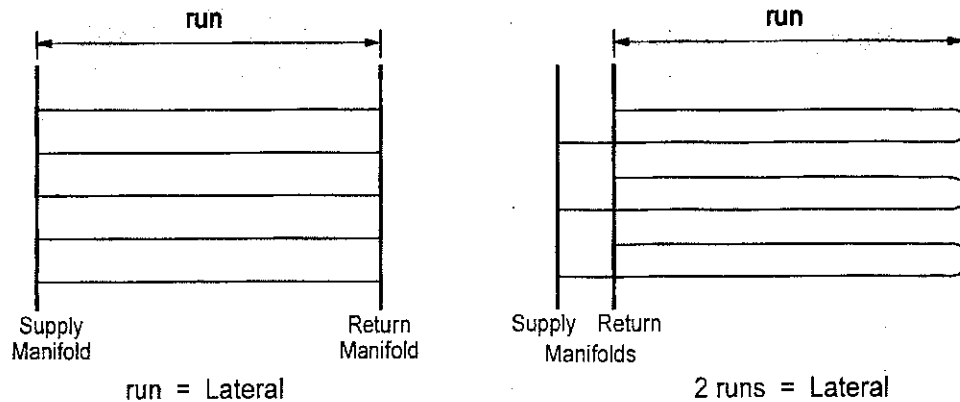


Fig. 5. Run is identified as one drip line the length of the zone while a lateral is defined as one drip line from the supply manifold to return manifold.

**Emitters:** There are two types of emitters, namely, 1) pressure compensating or 2) turbulent or non-pressure compensating.

**Pressure compensating emitters:** This emitter is designed to compensate for different pressures with the discharge rate the same for pressures of 10 psi to 70 psi (Wastewater Systems, 1999) (Fig. 6). The performance curve is flat for pressures ranging from 10 to 70 psi with the discharge rate dropping off as pressure drops off below 10 psi at which time the emitter acts as a turbulent flow emitter. A typical flow rate is 0.61 gph with emitters available for higher or lower discharge rates. Pressure compensating emitters will provide uniform application on both sloping and level sites while under pressure. These emitters do not compensate for drain back after the pump has shut off.

**Turbulent or non-pressure compensating emitters:** The discharge rate will vary with the in-line pressure (Fig. 6). Table 1 gives the discharge rate for various pressures for one type of non-pressure compensating emitter. Other emitters will have different discharge rates. If emitters are installed at different elevations, the discharge rates will be higher in the emitters at the lower elevations than those at higher elevations. However, the difference may be minimal if the in-line pressures are high and the elevation difference is small. For example, if all things are equal except elevation, a 10 ft elevation difference would be a 4.3 psi difference in pressure resulting in about a 15-20% difference in discharge rates depending on the in-line pressure.

For both the turbulent and the pressure compensating emitters on sloping sites, the lower emitters will discharge more effluent following the dose cycle as the upper lines will drain down to the lower lines. Methods are available to minimize the movement of effluent between emitters and will be discussed later.

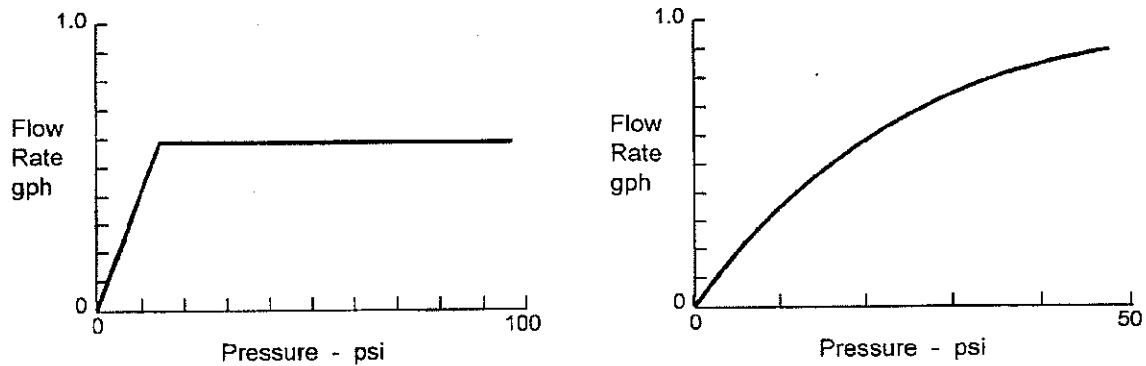


Fig.6. Flow rates vs pressure for pressure compensating (left) and turbulent emitters (right). These curves illustrate the difference and do not represent specific emitters. Table 1 give flow rates for an emitter.

Table 1. Turbulent emitter flow rates for various pressures for a given emitter(Geoflow, 1999)

Pressure (psi)	Flow (gph)
10	0.93
15	1.13
20	1.32
25	1.49

**Return Line:** The return line connects the return manifold to the pretreatment unit (normally the septic tank). The purpose of the return line is to convey the flush water during the flushing cycle to the pretreatment unit. To provide proper scouring of the drip lines, flow rates of at least 1.6 gpm flow at the outlet end of the laterals is necessary (Wastewater Systems Inc., 1999). If there are 5 laterals per zone, the flushing flow rate is 8.0 gpm. Depending on the configuration, the supply line and the return line can be at the same end of the zone or at opposite ends. A common return line can serve several zones with the proper location of check valves.

**Air Relief Valve/Vacuum Breakers:** When the pump shuts off, effluent will flow to the low point of the zone or laterals creating a suction on part of the system. Air relief valves/vacuum breakers, installed at the high point in each zone, release the suction after the pump shuts off which in turn minimizes the amount of soil pulled into the drip tube via the emitters. Even with the air relief valve/vacuum breaker located at the high point, some localized suction will occur resulting in some soil being pulled into the unit via the emitters. Regular flushing will remove the soil particles and remove bacterial slime build up on the tubing wall which if left unchecked will slough off and enter the emitters.

The air relief valve/vacuum breakers should be placed in a vertical 4" PVC pipe with cap or valve boxes with covers. Insulating the 4" pipe or valve box will minimize freezing in cold weather systems. Vacuum breakers come in various sizes and shapes. If manual flushing is desired, it can be done through the air relief valve/vacuum breaker if the valve/breaker has a threaded top. Inexpensive valves/breakers may not be as reliable as larger more expensive valves/breakers. Valves/breakers, on occasion, may stick open allowing the effluent to flow out of them. Periodic observation is desirable.

**Connections of Drip Line to Manifold:** Connecting the supply and return manifolds to the drip lines must be made with flexible PVC pipe or tubing (preferred) or with rigid PVC. The drip line must not be connected directly to the manifolds due to the potential for kinking. Kinked lines will not function properly. When installing laterals with loops, flexible PVC should be used. The drip line must not be looped as it will likely kink. If the drip lines are spaced 12" apart, it may be difficult to loop even with flexible PVC tubing. One method is to loop the first run with the third or fourth run to avoid a sharp curvature created when trying to connect adjacent runs.

**Drainage:** When the pump shuts off, the remaining effluent in the drip line and manifolds will drain out through the emitters. On sloping sites and to some extent on level sites, it will flow via the tube and manifolds to the lowest point where it will flow out the emitters. This may cause severe overloading and breakout on the ground surface especially in larger systems and on slowly permeable soils. Things that can be done to minimize this from happening are:

1. Keep each zone as small as reasonable.
2. Use the small compressed manifold with small diameter pipes as there will be less residual effluent in this manifold than in larger single pipe manifolds. Also, this compressed manifold isolates drip lines from one another as it is normally placed on the up-slope side of the zone.
3. Isolate each lateral by elevating the ends slightly to reduce gravity flow out of the lateral and elevating the loop on a looped system to keep the effluent in their respective run.
4. Keep each run or lateral on the contour.

**Saturated Soils:** If the soils become saturated around the tubing during dosing or due to heavy rainfalls, ground water will flow into the drip line through the emitters and travel in the pipe to the pump chamber, provided the pump chamber is at a lower elevation, unless there is a check valve in the supply line. If soil saturation occurs during pumping, lower dose volumes may correct the problem. If it occurs during heavy rains, there is not much that can be done other than to install a check valve in the supply line. Placement of the drip line as high in the soil profile will minimize the problem. To provide sufficient separation distance on very shallow seasonal saturation sites, it may be desirable to install the drip distribution system in a modified mound (Converse and Tyler, 1999). For a modified mound the soil is tilled, several inches of sand is placed, the drip distribution lines are placed and covered with sand with 6 -8" of soil placed over the top of the sand. Width and length and drip line spacing is dependent upon the sand and soil loading rates.

## Design Principles

Subsurface irrigation designs for agricultural purposes are based primarily on estimated evapotranspiration, rainfall and plant needs with less emphasis on soil type and characteristics (NRAES, 1985). However, when the primary concern is for effluent dispersal and not meeting plant requirements, the design is usually based on the hydraulic conductivity and how much water the soil will accept. If it were based only on plant needs, then wastewater storage would need to be incorporated in the design to store effluent during wet periods and provisions would need to be added to provide supplemental water during dry periods.

**Since soil dispersal, without storage, is the primary emphasis for effluent drip dispersal** especially on home size systems and small community systems, then the design procedures will be similar to those used for other treatment/dispersal units such as in-ground trenches, at-grades and mounds.

### 1. Wastewater Source:

As with all soil based treatment/dispersal units, the quantity and quality of the effluent applied must be assessed when sizing the system. **Both organic loading rates and hydraulic loading rates must be considered.** Unfortunately, there is very little information available on organic loading rates which affects the oxygen demand. For all soil treatment/dispersal units, if the oxygen demand (BOD, nitrogen) is not met, then a clogging mat will develop over time regardless of the method of application (gravity, pressure or drip). The potential for clogging mat development is greatly reduced when applying septic tank effluent via drip distribution because 1) the effluent is applied in the upper horizon, where oxygen is more readily available and 2) the effluent is applied more uniformly and more frequently. Since the oxygen demand is essentially met with aerobic treatment (low BOD and nitrogen converted to nitrate), the hydraulic loading rate for aerobically treated effluent can be higher than for septic tank effluent based on organic strength. Therefore system sizing will be dependent upon the type of pretreatment (septic or aerobic) and the soil conditions. High strength wastes ( BOD and FOG (fats, oils and greases)) must be treated to either typical domestic septic tank effluent levels or to aerobically treated effluent levels depending on the type of drip system. If not, excessive soil clogging and poor drip performance may result.

### 2. Loading Rates:

When applying effluent to soils there are two **design concepts** that needs to be considered. They are **1) estimating the infiltration rate into the soil and 2) estimating the ability of the soil to move the effluent away from the system.** As a result there are several loading rates that need to be considered when designing drip dispersal. They are:

**Areal loading (footprint):** The areal loading rate (gpd/ft<sup>2</sup>) is the amount of effluent applied over the entire area dedicated to treatment/dispersal. If the drip line is spaced 2 ft apart with 24" spacing of emitters along the drip line, then each emitter serves 4 ft<sup>2</sup> of footprint (Fig. 7). If each lateral is spaced one foot and the emitters are spaced 12" along the drip line, then each emitter serves 1 ft<sup>2</sup> of footprint. For the same areal loading rate, the emitter serving the 1 ft<sup>2</sup> area would

discharge 1/4 the effluent/dose than the emitter serving the 4 ft<sup>2</sup> application. This approach may be appropriate when dealing with high oxygen demanding wastewater as it gives 4 times the number of treatment points and more access to oxygen. However, system sizing will be affected with 4 times the emitters.

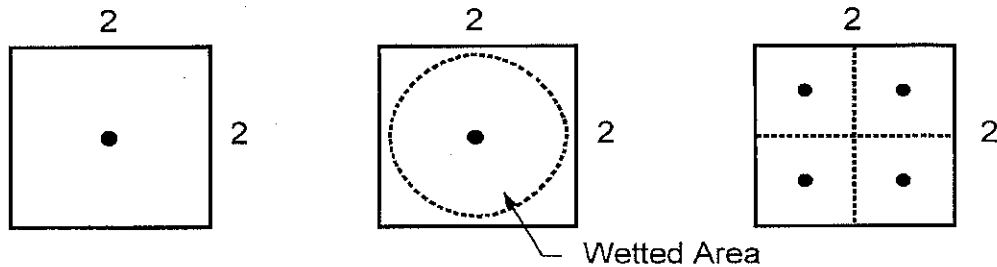


Fig. 7. Plan view showing the concept of areal loading rates for 2 ft emitter spacing and 1 ft emitter spacing. Also shown is an example of what a wetted area may look like. Typically the effluent will not cover the total area assigned to the emitter.

Table 2 gives the estimated areal loading for aerobically treated effluent with low BOD and Table 3 gives the estimated areal loading for mechanically filtered effluent (septic drip). Although the various soil types do not exactly match, comparison of the tables shows that the loading rates suggested for aerobically treated effluent (Table 2) are considerably higher than for the filtered septic tank effluent only (Table 3). The difference is primarily due to differences in organic loading and oxygen demand. Table 4 gives the loading rates for Wisconsin Comm. 83 code for on-site systems based on soil morphology. The soil loading rates (areal) for effluents with BOD and TSS < 200 > 30 mg/L should be comparable to Table 3 and the soil loading (areal) rates for effluents with BOD and TSS < 30 should be comparable to Table 2.

Table 2. Recommended soil loading rate for various soil textures receiving aerobically treated effluent using 24" spacing between lines and emitters (Geoflow, 1999).<sup>1</sup>

Soil Texture	Loading Rate(gpd/ft <sup>2</sup> )
Coarse Sand	2.0
Fine Sand	1.6
Sandy Loam	1.3
Loam	0.9
Clay Loam	0.6
Silt-Clay Loam	0.4
Clay Non-Swell	0.2
Clay-Swell	0.1
Poor Clay	0.075

<sup>1</sup> These values are guidelines and state codes should be used where appropriate. Consult Geoflow (1999) for additional information relative to loading rates.

Table 3. Loading rates for mechanically filtered effluent (septic drip) based on hydraulic loading, organic loading and fats/oils and greases (American Manufacturing, 1999).

SEPTIC DRIP HYDRAULIC LOADING RATES							
TEXTURE GROUP	ESTIMATED PERC RATE (MPI)	SOILS GROUP	USDA TEXTR CLASS	HYD. LOAD HIGH GPD/SQ FT	HYD. LOAD LOW GPD/SQ FT	HYD. LOAD HIGH GPD/LF	HYD. LOAD LOW GPD/LF
I	0-15	SANDS	S,L S	0.40	0.30	0.8	0.6
IIA	16-25	COARSE LOAMS	SL,L	0.30	0.23	0.60	0.46
IIB	26-45	MED. LOAMS	SL,L,SCL	0.23	0.20	0.46	0.40
IIIA	46-70	SILT LOAMS	SiL,CL	0.20	0.15	0.40	0.30
IIIB	71-90	CLAY LOAMS	CL,SiCL	0.150	0.125	0.30	0.25
IVA	91-120	CLAYS	SC,SiC,C	0.125	0.075	0.25	0.15
IVB	ABOVE 120	FINE CLAYS	C	0.075	UNDER .075	0.15	0
SEPTIC DRIP ORGANIC & GREASE LOADING RATES							
TEXTURE GROUP	ESTIMATED PERC RATE (MPI)	SOILS GROUP	USDA TEXTR CLASS	BOD HIGH #/D/LF	BOD LOW #/D/LF	FOG HIGH #/D/LF	FOG LOW #/D/LF
I	0-15	SANDS	S,L S	0.002000	0.001500	0.000160	00.000120
IIA	16-25	COARSE LOAMS	SL,L	0.001500	0.001150	0.000120	0.000092
IIB	26-45	MED. LOAMS	SL,L,SCL	0.001150	0.001000	0.000092	0.000080
IIIA	46-70	SILT LOAMS	SiL,CL	0.001000	0.000750	0.000080	0.000060
IIIB	71-90	CLAY LOAMS	CL,SiCL	0.000750	0.000625	0.000060	0.000050
IVA	91-120	CLAYS	SC,SiC,C	0.000625	0.000375	0.000050	0.000030
IVB	ABOVE 120	FINE CLAYS	C	0.000375	0	0.000030	0

Contaminant Concentrations are based on: (BOD5 300mg/L, 0.25#/Day/100 gal.)  
 (FATS, OILS & GREASE (FOG) 25mg/L,  
 0.02#/Day/100gal.)

Table 4. Maximum soil application rates based upon morphological soil evaluations.  
This is table ( 83.44-2) in Wisconsin Adm. Code 83. (2000).

Soil Texture	Soil Structure	Maximum Monthly Average	
		BOD <sub>5</sub> > 30 ≤ 220 mg/L TSS > ≤ 150 mg/L (gal/ft <sup>2</sup> /day)	BOD <sub>5</sub> ≤ 30 mg/L TSS ≤ 30 mg/L (gal/ft <sup>2</sup> /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 or strong	0.5	0.9
Fine sand	Massive or weak	0.4	0.6
Loamy fine sand	Moderate or strong	0.5	0.9
Loamy fine sand	Massive or 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 or strong	0.5	0.8
Loam	Weak, weak platy	0.4	0.6
Loam	Massive	0.3	0.5
Silt loam	Moderate or 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 or 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 or 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 or 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 or strong	0.2	0.3
Sandy clay	Massive or weak	0.0	0.0
Clay	Moderate or strong	0.2	0.3
Clay	Massive or weak	0.0	0.0
Silty clay	Moderate or strong	0.2	0.3
Silty clay	Massive or weak	0.0	0.0

Note: > means greater than, ≤ means less than or equal to, N/A means Not Applicable.



**Infiltrative Surface Rate:** The infiltrative surface is defined as the surface area in contact with the effluent as it infiltrates into the soil. The infiltrative surface in drip dispersal is typically the area around the emitter but it can also include the surface area of the drip line as in many cases the effluent will move along the drip line before fully infiltrating into the soil. In a gravel trench or chamber trench the typical infiltrative area is the bottom/side walls of the trench. Assuming that the effluent moves along the length of the drip line, every 5 linear feet of drip line has about 1 ft<sup>2</sup> of infiltrative area. If each emitter serves a 2 by 2 ft infiltrative area, then the calculated infiltrative rate is approximately 10 times the areal loading rate. If each emitter serves 1 by 1 ft infiltrative area, then the calculated infiltrative area is approximately 5 times the areal loading rate. Thus, the actual infiltration rate for drip is considerably greater than that used for in-ground trenches, at grades and mounds. However, since the effluent is applied very slowly several times a day, the soil will accept it at a higher rate. The ratio of infiltrative rate to areal rate is dependent upon the configuration as noted above. However, we must be careful not to organically overload the infiltrative area so as to avoid clogging mat development at the interface. The organic strength (BOD) is the reason that septic tank effluent is loaded at a lower rate than aerobically treated effluent.

**Linear Loading Rate:** The linear loading rate (LLR) is defined as the amount of effluent applied along the length of a single drip line in gpd/lf of drip line. This concept relates to the soil's ability to move the effluent away from the drip line. Table 3 gives values for various soil textures on the basis of gpd/lf. However, other factors such as depth to limiting condition and soil permeability beneath the system need to be considered which are not taken into account in Table 3. These numbers were generated based on the areal loading rate and 2 ft spacing. (As noted they are exactly half the areal loading rate). Converse, (1998) discusses linear loading rate and how it is estimated. Tyler, (2001), provides linear loading rates for various soil/site conditions. Table 3 also gives a BOD and FOG (fats oils and greases) in lbs/d/lf.

**Landscape Linear Loading Rate:** The landscape linear loading rate (LLLR) is defined as the amount of effluent applied along the length of the drip system or zone in gpd/lf of system along the contour. For example, if there were 10 drip lines in a system along the contour, the LLLR would be 10 times the LLR for a given drip line. It relates to how much effluent can be applied per linear foot of system along the contour so that the effluent, moving vertically, horizontally or combination of both, can get away from the system. Fig. 8 shows the linear loading rate concept as it relates to system configuration.

**Instantaneous Loading Rate:** Instantaneous loading rate relates to how much can be applied per dose (gph/dose) so that the soil will accept it. If more is applied than can be "instantaneously" moved away from the emitter through gravity and matrix potential, then the soil around the emitter becomes saturated. If the emitter continues to discharge effluent, it will create a channel to the ground surface (chimney effect). This channel provides the least resistance to flow and the saturated flow around the emitter will move upward through the channel during future doses (Fig. 9). If this happens, it probably means that the dose volume/emitter (gallons/dose) is too large. To remove the chimney effect, it may require

physically breaking up the channel. Time dosing of short duration over demand dosing will minimize potential for developing the chimney effect.

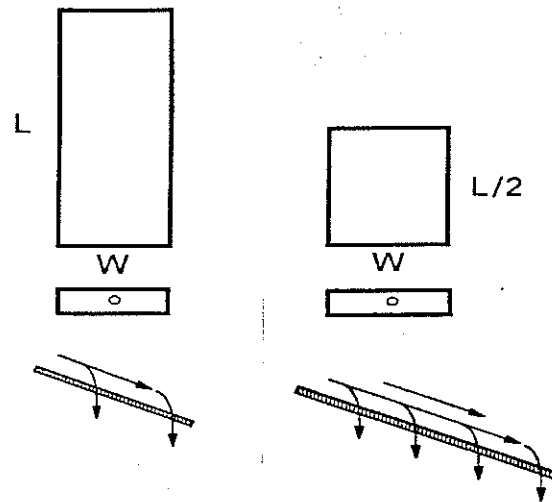
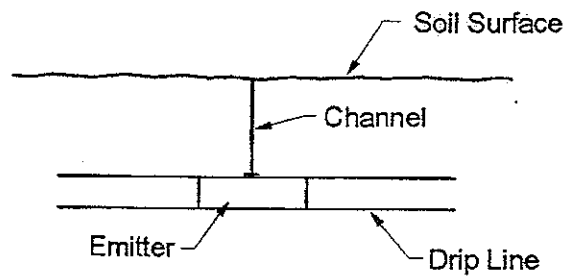


Fig. 8. Lineal loading rate relates to the ability of the soil to move the effluent away from the system. In this case, both configurations have the same area and the same areal loading rate. However the linear loading rate of the right configuration is twice that of the left configuration.



### Chimney Effect

Fig. 9. The chimney effect is where the effluent finds its way to the ground surface instead of infiltrating into the surrounding soils. High instantaneous loading rates can create this problem.

The designer may need to do a better job of matching the emitter discharge rate to the soil type and its ability to move effluent away from the emitter. An emitter that discharges at 1.0 gph may be appropriate for some soil conditions but not for others. An emitter that discharges 1.0 gph for 30 minutes discharges the same amount of effluent as a 0.5 gph discharge in 60 minutes but the lower discharge rate may allow the soil to assimilate the effluent better than the higher discharge rate. Unfortunately, we do not have tables matching emitter discharge rate and dose time to various soil conditions. Figure 10 shows the dispersion of effluent from an emitter based on soil type and a number of conditions such as evapotranspiration and soil moisture content.

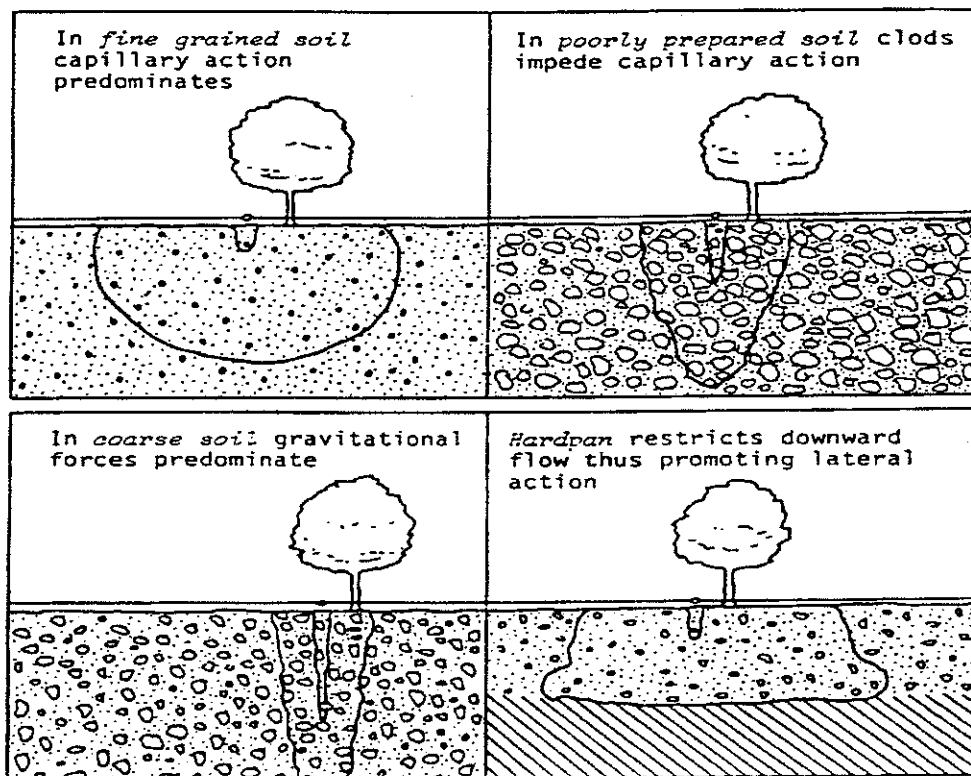


Fig. 10. Wet zones by soil Type (NRAES, 1985). These patterns are based on soils being relatively dry and the patterns may be different for drip distribution of effluent as more water is being added than typically is added for plant needs.

### 3. Separation Distances:

Separation distances from the drip line to seasonal saturation should be at least 12" to provide for unsaturated flow for final polishing of the effluent and to minimize surface breakout during extremely wet periods. Converse and Tyler (1998a and b) found that soil, receiving aerobically

treated effluent, had no fecal coliform detects, based on median values, below 12" if loaded under typical loading rates and if the effluent had low fecal coliform counts. For aerobically treated effluent with higher fecal counts, the separation distance may need to be greater. Also, for mechanically filtered effluent, the separation distance may need to be greater as data shows that there is very little fecal coliform reduction as they pass through the filter. Bohrer and Converse (2001) evaluated performance beneath drip systems receiving aerobically treated effluent and mechanically filtered effluent. For the aerobically treated effluent with low fecal counts, there were no detects found beneath 12" and no detects found beneath 24" for mechanically treated effluent. Short frequent doses allow the soil to better treat the effluent (more contact time) so the separation distance for septic tank effluent dispersed near the soil surface may not need to be as great as is typical for other systems such as in-ground trenches receiving septic tank effluent. Further study needs to be done to delineate separation distance for both aerobically treated and mechanically filtered effluent.

#### **4. Climate:**

Freezing is of concern in cold climates. However, in wooded areas where forest debris is left in place and snow accumulates, the drip unit continues to function very well if buried 6- 8" beneath the ground surface. Installation in well manicured lawns still remains a concern in cold climates. It is recommended to cover the system the first winter if a good vegetative cover has not yet been established. The temperature of the effluent entering the drip may be important. Aerobically treated effluent, such as via a recirculating filter, is at a lower temperature than septic tank effluent entering the drip line. It may be necessary to install drip lines deeper in northern climates. Bohrer and Converse (2001) monitored temperatures around and below the drip line and found temperatures below 32°F at sites with heavy vegetation. However, the systems continued to function throughout the winter. Proper design and installation procedures must be implemented to avoid system failure in cold climates.

#### **5. Application Schedule:**

It is recommended to apply the effluent in short pulses many times per day so as to allow the effluent to better infiltrate away from the emitters which will minimize surface breakout. Applying the daily load at one time may cause breakout in slowly permeable soils and reduce the soils ability to adequately treat the effluent especially in the more permeable soils such as sand.

#### **6. System Configuration:**

On slowly permeable soils where vertical movement of effluent away from the system may be minimal, the linear loading rate must be considered (Converse, 1998; Converse and Tyler, 1990; Converse, et al, 1990). Surface breakout may be a problem if the landscape linear loading rate is too great especially during wet periods when the soil system is stressed. Thus, longer and narrower systems are appropriate in slowly permeable soils with restrictive horizons for drip distribution as it is for mounds or at-grade units. During dry periods when ET is the greatest, this concern is minimized as much of the effluent is removed through ET with less reliance on moving the water

away from point of entry. Also, it may be appropriate to place drip lines at 12" spacing instead of 24" spacing to assist in getting the water away from the emitters. This will reduce the linear loading rate on the drip lines but will not change the landscape linear loading rate. Also, it will not reduce the footprint area required but will give 4 times as many emitters and reduce the instantaneous loading rate. If emitter spacing is reduced after the design is completed, (increasing number of emitters), recalculation will have to be made to make sure the pump delivers the required pressure and flow rate.

## **7. Large System Considerations:**

Large system design will provide greater challenges than smaller systems for the most part because of the larger quantity of effluent that needs to be dispersed into the environment. With large systems it is more critical to make sure that the effluent moves away from the system or surfacing will result.

Evaluation of **ground water mounding** beneath the large system is much more critical than it is in small systems where for the most part it is ignored. A more intensive soil/site evaluation will be necessary to try to predict ground water mounding and the soil's ability to move the effluent away from the system. Soil loading rates, as shown in table 2, 3 and 4, may be too high for large systems especially in the slowly permeable soils with high seasonal saturation, not because the soil can accept the effluent but because of its inability to move the effluent away from the system. Loading rates as low as 0.1 gpd/ft<sup>2</sup> may be very appropriate for large systems.

Linear loading rates becomes very important in larger systems. Dividing the large system into a number of zones dispersed throughout the landscape so one does not influence the other may be one way to overcome some of the limitations as these smaller systems become independent of one another. In all designs, it is extremely important that system hydraulics has been designed correctly so that the minimum velocities and pressures throughout the system are met.

## **Design Example**

**This design example is offered to give the reader a general sense of the design process. It is important that the designer follow the recommendations of the manufacturer as each one has their own design procedures.**

Design an on-site wastewater treatment unit for a 3 bedroom home that incorporates drip distribution. The site is located in a cold climate. The soil conditions consist of a 0 - 8" silt loam soil with moderate fine subangular blocky structure with friable consistence; 8 - 16" silt loam soil with moderate medium platy structure with friable consistence; 16 - 22" silty clay loam with weak medium subangular blocky structure with firm consistence. Seasonal saturation starts at 18" based on mottles. The site is grass with no trees. Site slope is 8%. Available distance along the contour is 125 ft and distance along the slope is 30 ft.

## 1. Design Wastewater Flow:

Use a design wastewater flow of 450 gpd (150 gpd/bedroom) but the actual flow will be in the range of 50 gpd/c.

## 2. Specify the Effluent Quality:

For this example the waste water is treated aerobically through a septic tank - sand filter or septic tank- aerobic unit with BOD and TSS of less than 30 mg/l. The effluent should also pass through a spin filter to remove any solids inadvertently added after being treated aerobically or any solids carry over from the ATU.

### a. Field Area Required.

Evaluate the soil profile for loading rates and location of drip line. For this example use the BOD < 30 mg/L column in Table 4 or the loading rates in Table 2. The depth of the drip line is dictated by the location of the water table. Converse and Tyler (1998a and b), based on fecal movement beneath modified mounds and at-grades, suggest a separation distance of 12" for effluent quality with less than 1000 fecal coliform/100 mL (90% of the time and detect of 1 fecal coliform/gram of dry soil). For pretreatment units consistently producing fecal coliforms with  $<10^4$  col./100 mL the separation distance is greater. Bohrer and Converse, 2001, evaluated fecal coliform and e-coli movement beneath drip systems and showed no fecals were detected 24" below the drip line receiving septic tank effluent and recommends one foot of separation for sites receiving fecal counts < 1000 col./100 mL.

If the pretreatment unit produces less than  $10^3$  col./100 mL (typically single pass sand filter) the tubing can be placed 6" -8" beneath the soil surface. If the fecal coliform count is typically between  $<10^4 >10^3$  col./100 mL ( normally the case for aerobic units and recirculating filters), the site will need to be modified by adding sand to the surface to obtain the desired distance. For this site use a single pass sand filter for pretreatment (gives fecal coliform counts <1000 col./100 mL) with tubing at 6" beneath the soil surface. This places the tubing in the silt loam horizon (top horizon) but within 2 in. of next horizon which is clay loam. The respective loading rates are 0.8 and 0.6 gpd/ft<sup>2</sup> (Table 4). The conservative approach is to use the 0.6 gpd/ft<sup>2</sup> areal loading rate. Table 2 suggests an areal loading rate of 0.6 gpd/ft<sup>2</sup>. For this example use 0.6 gpd/ft<sup>2</sup>.

Linear loading rates must also be considered for this site because of the platy structure at about 8" and seasonal saturation at 18 in. Traditionally as water moves downward, it would tend to move horizontally as it approaches the restrictive layer. However, with drip the flow regime may be different. Linear loading rate assesses the ability of the soil to move the water away from the drip line. Table 3 gives a linear loading rate of 0.3 gpd/lf of drip line for clay loams but does not consider other factors such as soil structure, soil consistence and distance to limiting conditions. This number is for an individual drip line. The landscape linear

loading rate relates to the system size and takes into account other factors that affect water movement. Converse (1998) provides a discussion on selecting linear loading rates and Tyler (2001) provides design values for various soil and site conditions. For this example use a landscape linear loading rate of 4 gpd/lf.

Use a soil loading rate (areal) of 0.6 gpd/ft<sup>2</sup> and landscape linear loading rate of 4.0 gpd/lf.

$$A = 450 \text{ gpd} / 0.6 \text{ gpd/ft}^2 = 750 \text{ ft}^2$$

$$\text{Length along the contour} = 450 \text{ gpd} / 4 \text{ gpd/lf} = 112.5 \text{ ft}$$

**b. Determine Emitter Spacing Along Emitter Line and Emitter Line Spacing.**

Use emitter spacing of 2 ft (typical) and emitter line spacing of 2 ft.

Each emitter will serve a 4 ft<sup>2</sup> area.

**c. Emitter Discharge per Day Based on Soil Loading Rate.**

$$4 \text{ ft}^2 * 0.6 \text{ gpd/ft}^2 = 2.4 \text{ gpd discharge}$$

Note: This assumes that the effluent will move away from the emitter via capillary action and matrix potential (Fig. 7). Observations indicate that the flow may move along the emitter line and not necessarily spread out over the 4 sq. ft.

Based on this loading rate and assuming that the effluent moves along the tubing, the infiltrative loading rate will be:

$$\text{Drip line surface area} = 0.75" \text{ dia (outside)} * 3.14 * 24" / 144 \text{ in}^2 / \text{ft}^2 = 0.393 \text{ ft}^2$$

$$\text{Infiltrative Loading Rate} = 2.4 \text{ gpd} / 0.393 \text{ ft}^2 = 6.1 \text{ gpd/ft}^2 \text{ or 10 times the areal loading rate.}$$

**d. Number of Emitters, Length of Emitter Line and Number of Emitter Lines.**

$$\text{Number of emitters} = 750 \text{ ft}^2 / 4 \text{ ft}^2 / \text{emitter} = 188 \text{ emitters}$$

$$\text{Length of emitter line} = 188 \text{ emitters} * 2 \text{ ft/emitter} = 376 \text{ ft.}$$

$$\text{Number of emitter lines} = 376 \text{ ft} / 112.5 \text{ ft length} = 3.3$$

Round up to 4 lines or total of 450 ft of drip line with 225 emitters.

### e. Configuration.

There are several configurations that can be chosen.

#### **Option 1: Single Zone:**

The zone consists of two loops (4 runs of 112.5 ft each) with the supply and return manifold/line at the same end of the zone, and the vacuum breaker on the up slope edge of the unit. The system is demand dosed with manual flushing of the lines periodically by opening a valve and turning on the pump.

#### **Option 2: Two Zones:**

Each zone consists of one lateral (2 runs of 112.5 ft each) with the supply and return manifold/line at the same end of the zone with the air relief valve/vacuum breakers on the up slope edge of each unit. Zones are spaced 5 ft apart. The system is time dosed alternating between zones. System is automatically flushed.

**Comments:** Each option has its advantages and disadvantages. Option 1 has minimal controls and provides the least cost system. It has a higher risk of surfacing during peak use because of demand dosing. The risk of effluent surfacing at the lower run is greater during drain down (after the pump shuts off) as the effluent in the up-slope lines will flow to the lower run after each dose. Option 2 is more costly but provides for time dosing (preferred) and automatic flushing. Each zone is separated resulting in less drain down in the lower run. Option 1 can have time dosing and automatic flushing. Both systems will have operation and maintenance costs.

In both cases the lateral length must be within the manufacturer's commended maximum lateral length to stay within the maximum pressure loss. If the design lateral length is greater than allowed, either reduce the length (check linear loading rate) and add more laterals or move the return manifold to the other end opposite the supply manifold. In both cases check the pump flow rate because additional lateral.

**Note:** It may be appropriate to double the amount of drip line in each option with minimal expense. Doubling the drip line will double the pump flow rate for both emitter flow and flushing flow. If space is limited, which it is not in this case, place the drip lines on 1 ft centers. (The example does not take this into account.) If space is not limited, add the additional drip line at 2 ft centers. The LLLR remains the same with the areal, LLR and instantaneous loading rates reduced by half (Fig. 8).



**f. Emitter flow rate.**

The emitter selected can be pressure compensating or turbulent flow emitters. Select a pressure compensating emitter with a 0.61 gpm flow rate. Higher flow emitters could be selected but the risk of surfacing may be greater in the finer textured soils.

**g. Pump Flow Rate and Dose Volume (Option 1 only for this example).**

Assume 18 doses per day

$$\text{Pump flow rate} = 225 \text{ emitters} * 0.61 \text{ gph} / 60 \text{ min/hr} = 2.28 \text{ gpm}$$

Dose volume = 450 gpd / 18 doses/day = 25 gpdose This volume should be adjusted to the actual use in the home. If actual water usage is known adjust the volume/dose accordingly. If not, assume 5 people in this example at 50 gpd/person or 250 gal/day. The dose volume is 14 gpdose (250 gpd/18 doses/day).

Pump should be sized to incorporate flushing. For flushing use 1.6 gpm/per lateral if the pipe does not have coating to minimize bacterial growth on the side wall. If it does, then 0.8 gpm/lateral will be sufficient for aerobically treated effluent. (The ASAE standard is 0.8 gpm/lateral for drip irrigation). For Option 1, there are 2 laterals resulting in 3.2 gpm flow rate plus the emitter flow rate of 2.3 gpm or total of 5.5 gpm. For Option 2 the flow rate would be 1.6 gpm (each zone has 1 lateral and flushed separately) plus the emitter flow of 1.65 or total 3.2 gpm.

**h. Pressure Head.**

Select the pump that gives the desired flow rate at the following head.

Supply line	- 5 ft (assumed for this site)
Elevation head	- 8 (assumed for this site)
Spin filter	- 5 (assumed, need to get actual value)
Drip line	- 23 (friction loss in 230 ft of drip line during flushing)
Return line	- <u>5</u>
Total	46 ft

The emitters will provide a constant flow rate between 10 and 70 psi (pressure compensating emitters). In this case the head in the drip line during non-flushing operation will have approximately 12 psi. It may be desired to select a pump with a higher head for the given flow rate. It is better to oversize slightly than undersize the pump.

## I. Summary.

### Option 1:

Absorption area = 8 by 112.5 ft.

One zone.

Two laterals ( 4 runs) with each lateral 225 ft long with runs spaced 2 ft apart.

Supply manifold and return manifold - 4 ft of 1" or 1-1/4" PVC pipe.

Number of emitters = 225.

Pump flow rate at 5.5 gpm at 46 ft (includes flushing).

Number of doses per day = 18.

Dose vol. = 25 g/dose based on design, 14 g/dose based on 5 people @ 50 gpd/c.

Dose time = 6.1 minutes.

## j. Placement.

### Field :

Plow the tubing in with vibratory plow used for placing of telephone line or similar plow on the contour. Allow the grass to grow and accumulate to provide insulation for winter time. (Caution should be used in placing it in a well manicured lawn in the cold climates because of threat of freezing)

### Wooded area:

Sparsely populated: Weave the tubing around the tree trunks staying far enough away to minimize damage to tree roots.

Heavily populated: It will be difficult or near impossible to weave the tubing around the trees. Some of the trees may need to be cut off at ground level. Considerable hand work and some trenching with backhoe with narrow bucket may be required.

## Maintenance

As with all complex wastewater treatment and dispersal units, there is more maintenance than required with the standard septic tank soil absorption unit. Manufacturers have their own set of maintenance requirements. Maintenance on the treatment unit (septic tank/ sand filter or aerobic unit) will be similar as for other applications. Maintenance on the drip distribution unit includes 1) flushing on a regular basis, 2) cleaning of the filters and 3) monitoring pressure to determine if the emitters are plugged. These and other maintenance requirements are listed by the manufacturer.

**Caution:**

There has not been a lot of experience using drip distribution of domestic waste especially in cold climates. There are still many unanswered questions about drip dispersal of wastewater. Agricultural designs are used when water is needed. For effluent dispersal the system must work year around in all types of conditions. The approach used in this paper was to ignore evapotranspiration and infiltrate all of the wastewater. The assumption is that the effluent will disperse over the 4 ft square area through capillary action and matrix potential. If not, then surface breakout may be a potential problem especially in wet conditions and slowly permeable soils. Thus, until we get further experience, caution should be exercised. If the system is undersized, additional lines could be installed such as at 1 ft spacings instead of the two foot recommended.

This publication serves as a guide to better understand drip distribution. It is a work in progress and will be revised as we learn more about drip systems. If you are going to design a system, use the manufacturers' guidelines for designing, construction and maintenance. Ask for assistance from the manufacture rep.

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