

INTRODUCTION

Many proposed building sites in Christian County are unsuitable for on-site sewage disposal by conventional Subsurface Sewage Disposal (SSD) due to the presence of such limiting site conditions as a high water table, shallow depth to rock or other restrictive layers or because of the heavy clay content of the soil. Some of these unsuitable conditions can be overcome and sanitary disposal of wastewater can be accomplished by utilizing alternative SSD systems. Alternative subsurface sewage disposal systems are those systems and techniques, approved by the Christian County Health Department that vary from the construction and installation procedures of conventional SSD systems. However, alternative systems should not be misrepresented as a panacea for all unsuitable soil conditions found in Missouri but only as a means to increase the range of suitable site conditions.

This manual specifies the procedures and material to be used for successful siting, design, installation and maintenance of one alternative system, the low-pressure pipe (LPP) system. Use of proper materials and techniques is critical to the success of LPP systems as well as to all other alternatives.

CHAPTER 1

What Is Low-Pressure Pipe Distribution?

A subsurface soil-absorption system must serve two purposes: 1) keep untreated effluent below the surface, and 2) purify the effluent before it reaches ground or surface water. The system works best when the distribution area is not saturated with water or effluent, allowing efficient aerobic bacteria to treat the wastes.

There are several conditions which frequently hinder the operations of soil-absorption systems. Clogging of the soil can occur from localized overloading during use or from the mechanical sealing of the soil-trench interface during construction. This clogging can cause effluent to break through to the surface, especially in fine-textured soils. Anaerobic conditions caused by continuous saturation due to overloading or a high-water table retard treatment, increasing the potential for a failure. Shallow soils may not be deep enough to purify the effluent.

The LPP system has three design improvements over conventional systems that help overcome these problems. They are:

- uniform distribution of effluent
- dosing and resting cycles
- shallow placement of trenches

Problems from local overloading are decreased when effluent is distributed over the entire absorption area. Dosing and resting cycles help maintain aerobic conditions in the soil improving treatment. Shallow placement increases the vertical separation from the system to any restrictive horizon or seasonal high-water table.

An LPP system is a shallow, pressure-dosed soil-absorption system (Figure 1). It consists of:

- septic tank
- single compartment dosing tank
- submersible effluent pump and level controls
- high water alarm
- supply line and manifold
- distribution system
- suitable area and depth of soil

When septic tank effluent rises to the level of the upper pump control, the pump turns on and effluent moves through the supply line and distribution laterals. These laterals are Schedule 40 PVC pipe containing small holes (5/32 inch to 1/4 inch) spaced 2.5 to 7.5 feet apart. The pipes are placed in narrow trenches 6 to 12 inches deep and spaced 5 or more feet apart. Under low pressure (0.7 to 2 pounds per square inch) supplied by the pump, septic tank effluent flows through the holes and into the trenches. It diffuses from the trenches into the soil where it is treated.

The pump turns off when the effluent level falls to the lower control. The level controls are set so that the effluent is pumped two to four times daily with resting periods in between to allow aerobic treatment of effluent. If the pump or level controls should fail, the effluent would rise to the level of the alarm control. and the alarm would turn on, signaling the homeowner of failure.

Figure 1. Basic components of a low pressure pipe system.

CHAPTER 2

Site and Soil Requirements for LPP Systems

The suitability of a LPP system for a given site is determined by the soil, slope and available space, as well as by the anticipated wastewater flow.

Space Requirements

The distribution network of most residential LPP systems occupies from 1000 square feet to 5000 square feet of area depending on soil permeability and design waste load. In addition, an area of suitable soil must be set aside for duplication or replacement of the system should a failure occur. This duplication area must be of sufficient size to install a complete system in accordance with regulations. Space between the existing lateral lines is not a suitable repair area. The septic tank, pumping chamber, distribution field and repair area are all subject to horizontal setbacks from wells, property lines, building foundations, etc., as specified in regulations.

An LPP system should be situated on the best soil and site on the lot. A minimum of 12 inches of usable soil is required between the bottom of the absorption field trench and any underlying restrictive horizons such as consolidated bedrock or hardpan, or to the seasonal high water table. LPP trenches are installed a maximum of 12 inches deep, giving a minimum soil depth requirement of 24 inches. However, up to 6 inches of a compatible fill material may be added to a site prior to the installation of a modified LPP system (Chapter 6). On a site where 6 inches of compatible fill material is proposed, the restrictive layer may be as shallow as 24 inches.

Slope

An LPP system designed for a level site will have the same pressure head for each lateral. This allows the distance between holes in each of the laterals to remain constant. However, LPP systems located on slopes require special design and installation procedures. LPP absorption fields should not be installed on slopes in excess of 10%, but in the event that 10% are to be used special design criteria are required. The elevation difference between any two laterals controlled by a common valve, will have a similar difference in their respective pressure head with the highest pressure head being found on the lowest lateral. When the disposal field is located lower than the pump, the system

must be designed to ensure that effluent is not siphoned out of the pump chamber when the pump is turned off.

Drainage

Depressions, gullies, drains and erosional areas must be avoided to prevent hydraulic overloading by surface runoff. Neither the septic tank, pumping chamber nor distribution field should be located in such areas. Surface water and perched groundwater must be intercepted or diverted away from all components of an LPP system. Where suitability of the soil is dependent upon adequate drainage, a curtain drain or draw-down drain must be installed to maintain the upper level of ground water one foot below the bottom of the lateral trench bottom. Where subsurface drainage is required, there must either be an outlet on-site or, if off-site, appropriate easements are necessary.

CHAPTER 3

Layout of an LPP System

The next two chapters are a step-by-step procedure for designing LPP Systems on level ground. There is no one LPP that fits all sites (each must be designed individually). Additional procedures used when designing LPP systems on sloping sites are covered in Chapter 5.

Estimating Contours

The area for the disposal system and reserve area, provided the reserve system is also an LPP system, should be gridded off in a 25 feet grid pattern. The grid should reference at least 2 permanent features so that it can be re-established at the time the system is laid out. Elevation shots should be recorded at every point where the grids cross. Intermediate elevation shots may be necessary on a site with steep or complex slopes.

Once elevation shots have been recorded (which must include either an elevation shot at the stub-out or over the proposed pump tank) a contour map should be prepared. When preparing a contour map, sites with very little relief may show 1 foot elevation differences between contour lines while contour lines with 2 or more feet elevation differences may be used on sites with more relief.

Size of the Absorption Area

The total amount of absorption area depends on two factors - the daily wastewater flow of the system and the absorptive capacity of the soil.

Step 1. Calculate daily waste flow. For residential systems, the estimated flow is 120 gallons per day (gpd) for each bedroom (BR) in the house.

Example: For a 3-BR house:

$$\text{Flow} = 120 \text{ gpd/BR} \times 3 \text{ BR} = 360 \text{ gpd}$$

Step 2. Determine the loading rate. Consult the soil evaluation form to find the soil loading rate.

Step 3. Compute the total area needed for the initial absorption system using the equation:

$$\text{Area} = \text{flow/loading rate.}$$

Example: Using flow and loading rates calculated above:

$$\text{Area} = 360 \text{ gpd} / 0.2 \text{ gpd sq. ft.} = 1800 \text{ sq. ft}$$

Note: This area does not include duplication area.

Step 4. Determine total length of distribution lines. Spacing between lines must be five feet or more to prevent overloading. Divide total area by five to obtain the total length of the distribution lines.

Example: Length = 1800 sq. ft / 5 ft = 360 linear ft.

Size of Septic and Pumping Tanks

The septic tank is sized in the same manner as for standard systems. (See Chapter 3). The pumping tank should provide ample room for emergency storage; thus, it should be at least twice the volume (v) of the daily waste flow.

Example: For a 360 gpd waste flow:

$$v \text{ pumping tank} = 360 \text{ gal} \times 2 = 720 \text{ gal}$$

Location of System

The LPP should be located in the best available soil on the lot. All set back requirements from wells, property lines and drainageways must be observed. The exact location of the system, including the tanks, the disposal field and drainage requirements, must be noted. An adequately sized repair area of suitable soil must be available.

Shape of Absorption Field

When selecting the best shape of an LPP system, to fit in the desired location, remember that laterals must be placed on the contour. The maximum length of each lateral line must be 70 feet (from the manifold to the turn up) due to excessive friction loss.

When using longer lateral lines, the manifold must be placed in the center of the distribution network rather than along one side. For a layout example, see figure 2.

Landscaping and Drainage

Any cutting or filling of a site may render it unsuitable for an LPP system. Surface water must be diverted away from the disposal area. On sloping site where a curtain drain is required, the drain shall be installed 6 inches into the restrictive layer. A positive outlet must be available either on-site or off-site easements will be required.

Depth of Lines

Lines are placed no deeper than 12 inches deep. Where a restrictive layer is 24 to 30 inches deep, up to 6 inches of fill material may be allowed in order to meet the one-foot vertical separation requirement between the bottom of the gravel trench and the restrictive layer.

CHAPTER 4

Dosing and Distribution System Design

The purpose of low pressure dosing is to provide uniform distribution of septic tank effluent over the entire soil absorption system. This is best achieved at a pressure head of 2 to 4 feet. Lower pressures do not provide uniform delivery of effluent. Higher pressures cause local scouring of the gravel and soil in the trench bottom. Proper dosing involves balancing the size of the distribution system with the dosing volume, pumping capacity, desired pressure and flow rate.

Dosing Rate

The dosing rate depends on the pressure head and the size and number of holes in the distribution lines. Pressure head can range from 2 to 4 feet for adequate performance; holes must be 5/32 inch or greater in diameter, and hole spacing can range from 2 1/2 to 7 1/2 feet. On sloping sites valves may be located on each lateral or variable hole spacing may be used as described in Chapter 5.

The dosing rate can be best estimated by calculating the flow utilizing a 5/32 inch hole diameter, five feet hole spacing and three feet of pressure head.

Step 1. Calculate the number of holes.

Number of holes = length of line/hole spacing.

Example: For a system with 5 ft. hole spacing and 60 feet lines:

Number of holes/line = 60 ft/5ft/hole = 12 holes/line

Total holes = 12 holes/line x 5 lines = 60 holes

Step 2. Determine the flow rate per hole. This is calculated from the hole size and pressure head using Table 2.

Example: For 3-ft. pressure head and 5/32-inch holes:

Flow rate = 0.50 gallons per minute (gpm)

Step 3. Calculate total dosing rate.

Example: Flow rate/hole = 0.05 gpm

Flow rate/line = 0.05 x 12 holes = 6.0 gpm

Total flow rate = 0.05 x 60 holes = 30 gpm

For systems where the absorption field is at a lower elevation than the pump, a 1/4 inch

siphon-breaker hole must be drilled in the supply line in the pumping tank. This hole will prevent inadvertent siphoning of the contents of the pump tank into the disposal field. An extra two gallons per minute must be added to the pumping rate to compensate for flow through the siphon-breaker hole.

Example: For a system with 30 gpm flow rate and a siphon-breaker hole.
 Total flow rate = 30 gpm + 2 gpm = 32 gpm

TABLE 2. Flow Rate as a Function of Pressure Head and Hole Diameter in Drilled PVC Pipe.

Pressure Head ft. psi	Hole diameter (in.)			
	5/32	3/16	7/32	1/4
1	0.29	0.42	0.56	0.74
1.5	0.35			
2	0.41	0.59	0.80	1.04
2.5	0.45			
3	0.50	0.72	0.98	1.28
3.5	0.54			
4	0.58	0.83	1.13	1.48
4.5	0.61			
5	0.64	0.94	1.26	1.65
5.5	0.66			
6	0.69	1.04	1.37	1.81

Pump Selection

The pump must have enough power to pump effluent at the calculated flow rate against the total head (resistance) encountered in the distribution system. The total head is the amount of work the pump must do to overcome elevation (gravity) and friction in the system at the specified pressure and flow rate.

$$\text{Total head} = \text{elevation head} + \text{pressure head} + \text{friction head.}$$

Elevation head is the difference in elevation from the pump to the highest lateral on the manifold. Remember that the pump will be four or five feet below ground level in the pumping chamber.

Pressure head is the pressure required for even distribution and is usually specified between two and four feet.

Friction head is the loss of pressure due to friction as the effluent moves through the pipes. Pipe friction is estimated using Table 3. When estimating pipe friction, use the length of the supply manifold, but not the lateral lines. Add 20 percent to the pipe friction estimate to account for friction loss in joints and fittings. Note that friction loss

varies with pumping rate as well as with pipe length and diameter.

The total head must be calculated to select the proper size pump.

Step 1. Compute friction loss.

Friction loss = 1.2 x pipe friction
Example: For a 2 inch diameter supply line 70 feet long and 32 gpm pumping rate:

$$\text{Pipe friction} = (70\text{ft}/100 \text{ ft}) \times 2.37 \text{ ft.} = 1.7 \text{ ft.}$$

$$\text{Friction head} = 1.2 \times 1.7 \text{ ft.} = 2 \text{ ft.}$$

Step 2. Calculate total head.

Example: For a system with 5 ft. of elevation head from the pump to the highest lateral, 3 ft. of pressure head and 2 ft. of friction loss:

$$\text{Total head} = 5 \text{ ft.} + 3 \text{ ft.} + 2 \text{ ft.} = 10 \text{ ft.}$$

The system will require a pump with a capacity of 32 gpm against 10 feet of head. It is always necessary to specify the total head when selecting a pump. The head and flow requirements are checked against the performance curve provided by the manufacturer. It is important to use the performance curve for the specific brand and size of pump to be used.

Step 3. Select a pump by consulting the appropriate performance curve. The system requirements of flow and total head (32 gpm at 10 ft. of head) intersect at a point which must fall below the performance curve. If the point falls above the curve, then the pump is too small.

When the chosen pump turns out to be too small, there are several options to consider:

- Select a larger pump.
- Reduce the friction-head loss by using a larger diameter supply manifold (two inches is a practical maximum for residential systems).
- Reduce the flow rate by using a smaller hole size or by increasing hole spacing (maximum distance being 7.5 ft).
- Raise the pump in the pump tank.

A combination of choices can be made. The goal is to design a system that works properly for the lowest possible price. A larger pump is an easy solution, but will be more expensive than one of the other options. For most residential systems a 0.3 to 0.5

horsepower pump will be adequate.

TABLE 3. Friction loss per 100 feet of PVC pipe

Flow gpm	Pipe diameter (in.)					
	1	1 1/4	1 1/2	2	3	4
1	0.07					
2	0.28	0.07				
3	0.06	0.16	0.07			
4	1.01	0.25	0.12			
5	1.52	0.39	0.18			
6	2.14	0.55	0.25	0.07		
7	2.89	0.76	0.36	0.10		
8	3.63	0.97	0.46	0.14		
9	4.57	1.21	0.58	0.17		
10	5.50	1.46	0.70	0.21		
11		1.77	0.84	0.25		
12		2.09	1.01	0.30		
13		2.42	1.17	0.35		
14		2.74	1.33	0.39		
15		3.06	1.45	0.44	0.07	
16		3.49	1.65	0.50	0.08	
17		3.93	1.86	0.56	0.09	
18		4.37	2.07	0.62	0.10	
19		4.81	2.28	0.68	0.11	
20		5.23	2.46	0.74	0.12	
25			3.75	1.10	0.16	
30			5.22	1.54	0.23	
35				2.05	0.30	0.07
40				2.62	0.39	0.09
45				3.27	0.48	0.12
50				3.98	0.58	0.16
60					0.81	0.21
70					1.08	0.28
80					1.38	0.37
90					1.73	0.46
100					2.09	0.55

Dosing Volume

Dosing volume is the amount of effluent pumped to the absorption field each time the pump runs. The dosing volume must be large enough to provide adequate distribution in the field and adequate resting time between doses, yet small enough to avoid overloading. The minimum dose to provide adequate distribution depends on the size of the supply and lateral network.

Step 1. Calculate minimum dosing volume.

$$V \text{ dose} = V \text{ supply} + 5 (V \text{ laterals})$$

The minimum volume is the sum of the supply-line volume and five times the volume of the lateral lines. The volume of the lines is calculated using Table 4.

TABLE 4. Storage capacity per 100 ft of PVC pipe

Pipe Diameter inch	Storage Capacity gal/100 feet	
	60 psi	Schedule 40
1	5.8	4.1
1 1/4	9.0	6.4
1 1/2	12.5	9.2
2	19.4	16.2
3	42.0	36.7

Example:

- (A) 1. Supply line = 70 ft. of 2-in. pipe
 $V \text{ supply} = (70/100) \times 19.4 \text{ gal.}$
- (B) 2. Lateral lines = 360 ft. of 1 1/4-in. pipe
 $V \text{ lateral} = (360/100) \times 9.0 \text{ gal.} = 32.4 \text{ gal}$
- (C) 3. $V \text{ dosing} = 13.6 \text{ gal.} + 5 (32.4 \text{ gal.}) = 176 \text{ gal.}$

Dosing two to four times per day provides adequate resting time. For a 450 gallon-per-day design, this would be a range of 112 to 225 gallons per dose (gal/dose).

Step 2. Select dosing volume.

Example: Selecting 180 gal/dose would give between two and three doses per day. This volume is larger than the minimum in Step 1. If water

use is less than 450 gpd, dosing will occur less frequently, providing longer resting periods between doses.

- Step 3. Compute the depth of effluent pumped per dose. In order to set the pump controls to deliver the proper dose, the depth of effluent to be pumped from the tank for each dose must be calculated. The computation is done using the following equation:

$$\text{Dosing depth} = (V \text{ dose}/V \text{ tank}) \times \text{liquid depth of tank.}$$

Example: For a 900-gal. pumping tank, 4-ft. liquid depth (bottom of tank to outlet tee); 180-gal. dose:

$$\text{Dosing depth} = (180 \text{ gal}/900 \text{ gal}) \times 4 \text{ ft.} = 0.8 \text{ ft.} = 9.6 \text{ in.}$$

The float control switch for the pump should be set for a 10-inch drawdown to provide automatic doses of 180 gallons.

Check-valve calculation

Any effluent which remains in the supply and lateral lines of a properly sited system will drain back to the pumping chamber when the pump shuts off. If this volume is too large, it can cause overuse of the pump and excessive consumption of electricity. A check valve may be needed to prevent this return flow to the pumping chamber, especially on a large system with a long pumping distance. Check valves should be avoided if possible because they may malfunction when used for septic tank effluent. In general, a check valve should only be used if the total storage volume of the pipes is greater than one fourth of the total daily waste flow.

- Step 1. Calculate storage volume.

$$V \text{ storage} = V \text{ supply} + V \text{ laterals}$$

Example: $V \text{ storage} = 13.6 \text{ gal} + 32.4 \text{ gal} = 46.0 \text{ gal}$

- Step 2. Compare to 1/4 daily waste flow.

$$\begin{aligned} 450 \text{ gpd} \times 1/4 &= 112 \text{ gal} \\ 46.0 \text{ gal} &< 112 \text{ gal} \\ \text{No check valve needed.} \end{aligned}$$

CHAPTER 5

LPP Design and Installation on Sloping Ground

A sloping site presents a special set of problems for an LPP design. The system must be carefully planned to obtain even distribution of effluent throughout the absorption area.

When a common valve is used to adjust the flow to different laterals on a sloping site, the pressure head on each lateral is different due to a different elevation. Each foot of elevation difference changes the pressure head by one foot. Also, perched water moving downslope onto the system and effluent moving from the upper trenches to the lower trenches can cause overloading. Pumping uphill or downhill to the absorption field can create additional problems. This chapter highlights changes in the design procedure which are necessary when designing LPP systems on slopes using variable hole spacing to achieve even distribution. Alternatively, valves may be placed on each lateral and all holes spaced on five feet centers.

Layout

The procedure for designing an LPP system on a sloping site using variable hole spacing is similar to that in chapter 3, with careful emphasis placed on the following points:

- * Lateral trenches must be placed on contour.
- * The effects of slope can be lessened by making systems as long and narrow as possible across the contour. This design uses fewer and longer lines, decreasing the elevation difference between the highest and lowest lines.
- * LPP systems with more than four feet of elevation difference between the highest and lowest laterals cannot be designed with a single manifold unless valves are used on every lateral. When separate manifolds for the upper and lower lines are used, each manifold must have its own pressure-control valve (gate or globe) for pressure adjustment.
- * Interceptor or curtain drains are often necessary to divert water moving down slope.
- * When it is necessary to pump downhill, distribution lines should be in deeper trenches than the supply manifold. The opposite is true for level or uphill systems.
- * It is critical on sloping systems that earthen dams be maintained between the lateral trenches and the manifold trench.
- * Installation on slopes greater than 30 percent is not allowed.

Dosing and Distribution

The design must compensate for differences in elevation head in order to achieve uniform distribution. The load on each line must be individually calculated and then balanced by modifying the design of individual lines where needed.

Determining dosing rate:

Step 1. Measure and record the elevation of each line. Make sure that each line is laid out on the contour (see example below for summary of steps).

Step 2. Round-off each elevation to the nearest half-foot.

Step 3. Compute the difference in elevation of each line from the highest line.

Step 4. Determine the pressure head on each line. First select the pressure head for the highest line. Then add the elevation difference (Step 3) to determine the pressure head on the lower lines.

Example: Calculate the pressure head on each line for a system with five 60-ft. lines with elevations shown below. Pressure head for the highest line is 2 ft. See Table 5 below.

TABLE 5. CALCULATING PRESSURE HEAD

Line	Elevation (Step 1)	Round Off (Step 2)	Difference (Step 3)	Pressure Head (Step 4)
FT				
1 Highest	359.2	359	0	2
2	358.6	358.5	0.5	2.5
3	358.2	358	1	3
4	357.9	358	1	3
5 Lowest	357.0	357	2	4

The pressure head should not exceed five feet on any of the lines. If it does, several modifications can be made. If suitable space is available, redesign the system, making it longer and narrower, thus covering less of a range in elevation. Remember that the lateral length is restricted to 70 feet or less, and the spacing to five feet or more.

As another option, lower the selected pressure head on the highest line and recalculate the heads on the remaining lines. The head on the highest line should be no less than one foot and is best kept at two feet.

Finally you can split the line into two or more manifolds. This is discussed in detail later in this chapter.

Step 5. Check to see if the pressure head exceeds five feet on any lines.

Examples: Highest pressure head is 4 ft.; therefore, no modifications need to be made.

Step 6. Determine the flow rate per hole for each line using Table 2 and the pressure heads calculated above. (See following example).

Step 7. Determine the flow rate for each line.

Example: Using the pressure heads above and assuming a 5-ft. hole spacing on 60-ft. lines (12 holes/line), prepare Table 6 below.

Table 6. Flow rate for each line

Line	Pressure Head (Step 4)	Flow Rate/Hole (Step 6)	Flow Rate/Line (Step 7)
	Ft.	GPM	GPM
1	2	.41	4.9
2	2.5	.46	5.5
3,4	3	.50	6.0
5	4	.58	7.0

The dose to the lower lines is larger due to the increased pressure head, while the dose to the upper lines is reduced, causing overloading of the lower lines. The flow rate should be balanced to within 10 percent among lines on the same manifold. It is wise to reduce the flow even lower in the lowest lines, because they receive an additional hydraulic load from downslope effluent movement from the upper lines.

Often the lengths of lateral lines vary. Some may be shorter than others to avoid obstacles such as larger trees, rocks or complex slopes. When this is the case, the flow rates of the lines cannot be directly compared. Rather the flow rates per foot of line must be calculated and these compared.

Step 8. Balance flow rate among lines. This can be done either by changing the number of holes or changing the size of the holes. The flow to lower lines can be reduced by increasing the hole spacing to greater than five feet or reducing the hole size to as small as 3/32 inch. But these sizes and spacings must not be used for an entire system.

Example: For the system in discussion, change the hole spacing to 4 ft. in line (highest) and to 6 ft. in line 5 (lowest). See Table 7 below.

Table 7. Balancing the flow rate among lines

Line	Hole Spacing	No. of Holes	Flow/Hole	Flow/Line*
	Ft.		GPM	
1	4	15	.41	6.2
2	4.5	13	.46	6.0
3,4	5	12	.50	6.0
5	6	10	.58	5.8

*For systems with lines of variable length, the flow rate/ft. is compared as described in Step 7.

When changing hole size or spacing to balance the flow it is very important to make the changes and instructions simple and clear. Hole placement and line installation should be inspected to ensure that they are done properly. It is preferred that a constant hole spacing and diameter be used, and ball valves installed on each lateral line for pressure adjustment.

Step 9. Calculate total dosing rate. The dosing rates for each line are added to obtain the total.

Example: For the system above:

$$\text{Dosing rate} = 5.8 + 6.0 + 6.0 + 6.0 + 6.2 \text{ gpm} = 30.0 \text{ gpm}$$

(Add 2 gpm if a siphon-breaker hole is needed.)

Pump Selection

The pump is chosen in the same manner as in Chapter 4. When pumping uphill the elevation head increases. If the hill is large enough it may become impractical to adjust the system for use with a 4/10-horsepower pump. It may be necessary to use a larger, more expensive pump.

If it is necessary to pump downhill, a 1/4-inch siphon-breaker hole must be drilled in the supply line in the pumping tank (Figure 7) to avoid unintentional continuous siphoning of effluent from the tank to the absorption field.

In some downhill systems, intentional siphoning can be used instead of pumping to provide distribution. A gravity-dosing siphon replaces the electric pump. Siphons of different sizes are available, and the siphon and dosing volume must be matched. The remainder of the system design is the same as when a pump is used.

The remaining steps in the design of LPP systems for sloping ground are the same as that for level ground (Chapter 4).

Design of split manifold systems

A split manifold system is used when the elevation difference between the lowest and highest lines exceeds four feet. The supply line is split into two or more manifolds, each connected to a subsystem of distribution laterals (Figure 9B). Each manifold is equipped with a gate or globe valve so the pressure heads on the subsystems can be adjusted separately. This allows each subsystem to act as an independent system although they may be operated from the same pump. The following is an example of a design where a split manifold is necessary.

Example: Lines are to be laid out on contours at 1319.8, 1318.4, 1317.0, 1315.2, 1313.7 and 1312.4 feet.

Steps 1-5: The procedure in the previous section is followed. The calculations are summarized in the following example.

Example: Pressure head of highest line is set at 2 ft. (See Table 8 below). The pressure head exceeds 5 ft. for 3 lines; therefore, a split manifold will be used.

TABLE 8. CALCULATING THE PRESSURE HEAD

LINE	Elevation (Step 1)	Round Off (Step 2)	Difference (Step 3)	Pressure Head (Step 4)
	ft			
1	1319.8	1320	0	2
2	1318.4	1318.5	1.5	3.5
3	1317.0	1317	3	5
4	1315.2	1315	5	7
5	1313.7	1313.5	6.5	8.5
6	1312.4	1312.5	7.5	9.5

Step 6. Split the system into two subsystems.

Example: Subsystem 1 (higher) = lines 1-3
Subsystem 2 (lower) = lines 4-6

Step 7. Repeat steps 1 through 5 independently for each subsystem.

Example: Set the pressure head at 2 ft. for the highest line of each subsystem. (See table 9 below). No pressure head exceeds 5 ft.; therefore, this system is satisfactory.

TABLE 9. ESTABLISHING A SUBSYSTEM

Subsystem	Line	Elevation and Round Off (Step 1,2)	Difference (Step 3)	Pressure Head (Step 4)
			ft.	
1	1	1320	0	2
	2	1318.5	1.5	3.5
	3	1317	3	5
2	4	1315	0	2
	5	1313.5	1.5	3.5
	6	1312.5	2.5	4.5

Follow the procedure of steps six through nine in the previous section to balance the flow rates and determine dosing rates.

Pump selection is done as in Chapter 4. When using a split manifold, the total friction loss decreases while the pipe volume increases. In many cases it may be best to decrease the diameter of the manifolds after they split. This will decrease the pipe volume, and may avoid the need for a check valve.

For most systems the gate or globe valves should be 1 1/4-inch diameter because they are easier to adjust than larger valves. Reducing adapters will be needed to fit these valves into larger diameter manifolds.

Modified LPP design

The only difference between designing a modified and standard LPP is the calculation of the fill requirements. The volume of the fill needed is the area to be filled multiplied by the depth of fill. The area to be filled is the absorption field plus a five-foot buffer around the edges.

Step 1. Calculate area to be filled. Add 10 feet to the length and width of absorption area to allow for buffer space.

Example: For a 60 ft. x 30 ft. absorption field to be filled 1 ft. deep:

Total area = 70 ft. x 40 ft.

Step 2. Calculate the volume of fill needed.

Example: $V_{\text{fill}} = \text{total area} \times \text{depth of fill}$
 $V_{\text{fill}} = 70 \text{ ft.} \times 40 \text{ ft.} \times 1 \text{ ft.} = 2800 \text{ sq. ft.}$

Step 3. Convert to cubic yards.

Example: $V_{\text{fill}} = 2800 \text{ sq. ft.} / 27 \text{ sq. ft. per sq. yd.} = 104 \text{ sq. yd.}$

The remaining design steps follow the procedure of Chapter 3 and 4.

Prior to incorporating the fill, brush and small trees should be removed and the soil surface loosened using a cultivator or plow. It is very important that the soil be worked only when dry. Working damp or wet soil can cause compaction and sealing, leading to failure of the system.

Fill is moved to the site using a front-end loader, being careful to avoid driving on the plowed area. The first load of fill is pushed into place using a crawler tractor with a blade. The fill is then plowed into the first few inches of natural soil to create a gradual boundary between the two. Failure to do this could ruin the system by forming a barrier to water movement at the soil-fill interface. Subsequent loads of fill are placed on the system and plowed in until the desired height is reached. The site should be shaped to shed water and be free of low spots before proceeding.

To install the LPP, follow the procedure discussed in Chapters 3, 4 and 5.

CHAPTER 6

Equipment Specification

All necessary equipment and tools should be clearly listed so they can be obtained prior to installation of the LPP system. To prepare this list, first consolidate the design specifications onto a single worksheet (Appendix 1). A copy of this worksheet along with an accurate sketch, including drainage and landscaping requirements (Figure 4), must be prepared for every system which is installed. Using this sheet, prepare a list of materials (Appendix 2). Be sure that the materials meet the requirements discussed below. A sketch of the distribution lines (Figure 5) and the pump system (Figure 6) are useful for counting the fittings.

Septic Tank and Pumping Chamber

As noted earlier, an LPP system has two separate tanks - an approved septic tank and a single compartment pumping chamber. If a conventional septic system is being repaired by an LPP, the existing septic tank can be used (after being pumped out and inspected), and only one additional tank installed.

Effluent from the septic tank flows by gravity through a four inch solid PVC pipe to the pumping chamber. The pumping chamber shall have minimum capacity of five hundred gallons (500 gals.), a liquid capacity of at least two times the daily wastewater flow from the house, and should be a single compartment design.

The pumping chamber must be provided with an above ground concrete or masonry (or their equivalent) riser to provide easy access for pump service. It is advisable to provide similar access to the septic tank for periodic clean out. The riser should be placed over the pump access hole in the pumping chamber. Risers should be wide enough to accommodate the existing lids on the tanks, should extend at least six inches above the finished grade of the site and should also be covered with a concrete lid. Standard well tiles can be used for the risers, provided that the inside diameter is larger than the access hole in the tank. All joints must be sealed to prevent the infiltration of surface or ground water to the tanks.

Pipe and Fittings

All pipes and fittings in an LPP system should be made of Schedule 40 PVC plastic. PVC is lightweight, easy to use and resists corrosion. All joints must be cleaned and sealed with an appropriate PVC cleaner and solvent cement. The supply manifold from the pumping chamber to the LPP distribution field is usually 1 1/2 or 2 inch PVC, depending on specifications of the system (Chapter 4). A bushing or reducer may be needed to adapt the pump to the supply manifold. There should always be a threaded PVC union or similar device above the pump to allow easy removal or replacement. Lateral lines are usually made of 1 to 1 1/2 inch PVC. Appropriate holes in the laterals are drilled on site.

PVC pipe must be of Schedule 40 specification with pressure fittings and of the straight length variety. A globe or gate valve for a final pressure adjustment is installed in the supply manifold inside the pumping chamber or on each individual lateral. The valve should be made of PVC or bronze. All other tees, elbows, caps and reducers in the distribution system should be made of PVC. The end of each lateral line is equipped with a capped "turn-up" that provides above ground access for clean-out or back-flushing (Figure 5). Using 45 degree elbows rather than 90 degree elbows for the turn-ups will make clean-out easier to do. Galvanized caps may be used if PVC is not available.

In the few instances where a check valve is necessary, it should also be installed with threaded fittings in the pump chamber to provide easy access for maintenance.

Pump, Float Control and Alarm System

A good quality, submersible effluent pump with oil lubricated bearings must be used in all LPP systems. An expensive grinder pump is not required because the septic tank effluent will be relatively free of solid material. A septic tank effluent pump or a submersible sump pump that will not be corroded by sewage should be used in the pumping chamber. Pumps with built in switches should be avoided, unless the switch can be adjusted for the quantity of water to be pumped. The selection of pump size is discussed in Chapter 4.

Pumps in the range of 1/4 horsepower to 4/10 horsepower generally provide sufficient capacity for resident LPP systems, but the pumping requirements for each system must be checked against the performance curve of the pump to be used. It is better to use a slightly larger pump than necessary, because the final pressure can be adjusted with the in-line gate or globe valve.

The controls for the pumping system include a switching control for turning the pump on and off and a high water alarm to signal pump malfunctions (Figure 5). The pump control system must be mercury switches and adjustable to meet the recommended loading rate for different sizes and shapes of pumping chamber. The controls must also be sealed against entry of corrosive and explosive gases from the effluent and shall have NEMA (National Electrical Manufacturing Association) approval. All electrical connections must be made outside of the pump chamber unless an "explosion proof box" is used.

Mercury switches are activated by a sealed float which contains a tube of mercury in contact with power leads. Best performance has been obtained using two switches - one to close the pump circuit and the other to open it. Automatic timers with backup mercury floats have been successful in a few systems where uniform timing of the doses was important. Diaphragm and mechanical float switches are not acceptable for LPP use. The range of adjustment is often inadequate and the switches do not provide good service in a sewage environment.

In addition to the on and off control floats, a separate mercury control switch is needed for the high-water alarm. This switch should be mounted several inches above the on float. The high-water alarm should consist of a light bulb and audible signal mounted over a sign marked "wastewater system alarm" in a visible place in the home, such as the kitchen or utility room. It must be on a separate electrical circuit from the pump power line, and be equipped with a test switch. The alarm is activated if the water level in the pumping tank rises above the "pump on" float control. The tank provides at least one day or more of excess storage capacity (depending on water use in the home) during which time the system must be repaired. Refer to Chapter 9 for repair and maintenance tips.

Complete control boxes for high water alarms are available commercially. Simpler and cheaper systems can be assembled by an electrician. There are two basic requirements for an alarm system:

- It must operate on a separate electrical circuit from the pump.
- It must activate a labeled and easily visible and audible signal in the home whenever the water exceeds the normal "pump on" level in the tank.

Gravel

LPP systems require a minimum of nine inches of gravel in the lateral distribution trenches. Gravel size should be from 1/2 inch to one inch. Pea gravel or crushed rock may be used, but it must be washed. If crushed limestone is to be used it must be washed to remove

finer and it can be no smaller than one inch. The trench rock shall be placed to a minimum depth of four inches (4") below the pipe and two inches (2") above the pipe.

FIGURE 14. LAYOUT OF A SAMPLE SYSTEM.

CHAPTER 7

Installation Procedures

The actual installation of an LPP is simple and straightforward, and can usually be accomplished by three or four people in one day.

Tools and Supplies

A backhoe is needed only for installation of the two tanks. All other excavation can be done with a small trenching machine that will excavate a cut six inches wide. A transit or similar instrument is necessary for staking out the lateral lines on sloping lots. Other tools needed for installation are:

- . Shovels, wheelbarrows - for moving gravel.
- . Electric drill (with power pack or generator, if necessary) - for drilling holes in lateral lines.
- . Drill bits
- . Hack saw, extra blades - for cutting PVC pipe to required lengths
- . PVC glue and cleaner
- . Mortar - to seal tank openings
- . Measuring tape
- . Electrical wiring tools

In addition to tools, a complete list of parts and materials should be compiled from a sketch of the system (See Appendices 2 and 3).

Site Preparation and Imported Fill

One of the most important concerns for an LPP system is to protect the site from soil disturbance by heavy equipment. Removal or compaction of the topsoil, especially during wet weather, may destroy the site's suitability for an LPP system. As soon as the absorption area has been designated, it should be flagged, roped off, and "quarantined" from construction traffic. No site preparation or LPP construction work should occur if the soil is wet. As a rule of thumb, if the soil is too wet to plow, it is too wet to disturb for system construction.

After the location is staked out and the soil is dry enough to plow, the site should be cleared of brush and small trees. If larger trees are removed, they should be cut off rather than uprooted in order to avoid created depressions and damaging the soil-pore network.

Provisions must be made for intercepting or diverting surface water and shallow groundwater away from the absorption area, septic tank, and pumping chamber. This can be done with grassy swales, open ditches, or curtain drains.

If the site requires imported fill to improve surface drainage, it must be incorporated evenly into the underlying natural soil. It is very important that no sharp interface remain

between the natural and imported soil layers. Before applying the imported fill to the absorption area, the ground surface must be tilled with a small plow or cultivator. Fill should be applied with a minimum of wheeled traffic on the area, and the area tilled again to ensure even mixing. A very small tractor should be used to spread the material around and to provide a convex shape to the area. There should be no low spots or depressions, and the final shape should shed, rather than accumulate rainwater. Use of fill to supplement the soil profile is discussed in Chapter 6.

After the area has been cleared and shaped, the location of the lateral lines and supply manifold should be accurately staked out according to design specifications. Each lateral line must be laid out along a level contour using a transit. One lateral may be higher or lower than the next one, but each individual lateral must be level. In no case should a lateral line be allowed to slope away from the manifold.

Tank Installation

The septic tank is installed in the same way as a conventional system. The pumping chamber may be a single compartment septic tank with its direction reversed so that the outlet end becomes the inlet end adjacent to the septic tank. The lower invert of the outlet end ensures proper gravity flow from the septic-tank outlet into the pumping chamber. The tanks are connected with an appropriate length of solid, four-inch Schedule 40 PVC pipe. Inlet and outlet openings around the pipe must then be appropriately sealed.

The tank access lids must be equipped with a water-tight masonry or concrete risers to at least six inches above grade. Treated wood risers may be used but must be secured by a hasp and lock device. These risers provide easy access for repair and inspection, and help keep surface water out of the tanks.

If an LPP is being installed to replace an existing conventional septic system, only one additional tank (the pump chamber) must be installed. However, the existing septic tank must be pumped out before installing the LPP.

Supply Manifold

The supply manifold conveys effluent from the pump to the distribution laterals. Any effluent remaining in the lateral lines when the pump shuts off should drain back to the pumping chamber through the supply manifold (unless the system is large enough to require a check valve). The manifold joins each lateral through a short riser pipe connecting a reducing tee on the manifold to a smaller elbow or tee on the lateral (Figure 4). This assembly places each lateral pipe about six inches higher than the supply manifold and helps prevent the back-flow of effluent from a higher lateral to a lower lateral. The individual riser units may be assembled earlier and glued in place between the laterals after the manifold is cut into segments. Because the lateral line is now several inches higher than the manifold, the manifold requires a trench six inches deeper than the laterals. In the special case of pumping downhill, the laterals are placed lower than the manifold.

After the supply manifold has been placed in its trench and lateral lines connected, it should be backfilled with tightly tamped soil. The supply manifold trench must not be backfilled with gravel, or the trench may become a conduit for downslope flow of effluent from the laterals. The outlet hole in the pumping tank should not be sealed until after the pump is in place. There must be a two (2') foot earth dam between the sidewalk of the manifold trench and the beginning of the lateral.

Lateral Lines

The separation distance between the trench bottom and the bedrock, in areas where there are cherty clay soils overlying highly permeable bedrock, shall be 4' or more. The Christian County Health Department shall also require the LPP trenches to be sand-lined if the soils have severely diminished treatment capability due to rock content in excess of 50%.

The lateral trenches are usually cut 18 to 22 inches deep. The depth of a given lateral trench should be uniform from the manifold to the end of the lateral. In no case should the trench bottom be allowed to slope away from the manifold. The lateral trench must not extend more than one or two feet beyond the end of the lateral pipe. Lateral trench bottoms are then lined with six inches of gravel (remember that gravel is not placed in the supply manifold trench).

The PVC pipes should be laid out and cut to proper lengths for the lateral lines. Holes are drilled (in a straight line) according to the design specifications after the laterals have been cut to their proper length. The first hole in each lateral should be drilled 3 feet from the manifold; the last hole should be drilled 3 feet from the end of the lateral. Holes are only drilled through one side of the pipe. If the drill bit should go through both sides, or if a hole is drilled in the wrong place, that section of pipe must be discarded.

Lateral pipes are placed holes-down in the trenches. A 3 feet turn-up should be located at the end of each lateral to adjust the pressure head. Once the pressure head has been adjusted, the turn-ups are cut off flush with the final grade and capped. As the trench is backfilled, the turn-up may be placed inside a short length of four or six inch PVC or terra-cotta pipe to protect it from lawn mower damage, while still providing easy access. When installing each lateral, care must be taken to ensure that the holes are down and the turn-up pointed upward before the quick-drying PVC glue hardens. Positioning of the lateral should be checked to make sure it is level in the trench.

After the lateral lines are in place and leveled, they are covered with another two inches of gravel. The earthen dams in the lateral trenches and near the manifold must be tightly tamped from the trench bottom to the ground surface. Once the gravel is in place, the trenches are covered with paper or straw prior to backfilling with topsoil. Turn-ups should be cut to appropriate lengths, fitted with caps and (if desired) protected with short segments of four- or six-inch PVC or terra-cotta.

The distance between laterals is 5' minimum on centers.

Pumps and Controls

Details of pump installation are shown in Figure 7. The pump must be placed on two concrete blocks set next to each other on the bottom of the tank. This prevents the pumping of any solid particles which can clog the LPP system. A piece of nylon rope or other non-corrodible material should be attached to the pump and to the outlet pipe for lifting the pump in and out of the chamber. The PVC outlet pipe is too fragile to support the pump.

Controls are fastened to the outlet pipe with clamps or brackets supplied by the manufacturer. The lower level control or "pump-off" must be positioned above the pump, so that the pump remains submerged at all times. The upper level control or "pump-on" is positioned to pump a specified volume of effluent (Chapter 4). The highwater control float is then mounted about three inches above the upper pump-on control. (Note: Care must be taken to ensure that the floats do not become fouled by other components in the tank such as the electric power cord or the lifting rope).

The pump outlet pipe should be connected to the supply manifold with a threaded PVC union to allow quick removal. The gate or globe valve must also be installed in the supply line (within the pump chamber) to allow final adjustment of the pressure. If effluent will be pumped downhill, a 5/32 siphon-breaker hole must be drilled in the bottom of the supply line before it leaves the pump tank. This breaks any vacuum in the system and prevents the inadvertent siphoning of effluent out of the tank. This hole is very important.

Power and control cords should be guided out of the pump chamber through a recessed channel or opening that will protect the cords from damage by the concrete lid.

Electrical Connections

As noted earlier, the pump and high-water alarm must be placed on separate electrical circuits. (If the pump circuit fails, the alarm must still be able to operate). Follow the manufacturer's recommendations for proper fuses or circuit-breakers. All electrical connections must meet the National Electrical Codes.

All electrical connections must be made outside the pumping chamber. Power cords from the pump and controls should be plugged into a NEMA-approved outdoor receptacle mounted outside of the pumping chamber. The receptacle must not be located inside the pumping chamber due to the corrosive and explosive gases that may form from the sewage.

Electrical connections may be made inside the pumping tank only if wired inside a sealed, "explosion proof" box. Some level-control switches have such a box built into the housing but are more expensive than the plug-in devices.

Wiring between the pumping chamber and the house should meet state and local code requirements. A lightning arrestor is recommended to protect the pump and controls from electrical surges.

Pump Operation Check

After all components have been installed and connected, the system should be checked for proper operation. With electrical power turned off, fill the pumping chamber with a garden hose (or allow effluent to accumulate) until the liquid rises to the level of the high-water alarm float.

Turn on the electrical power. The alarm light should go on in the house, and the pump should start operating. The alarm light should go off when the liquid level falls below the high-water float. The pump should turn off when the liquid reaches the lowest float control. Be sure the pump is still completely submerged.

Pressure Head Adjustment

The pressure head must be adjusted to match that specified in the design. The pressure head is measured as the height liquid will rise above the turn-up elbow when the pump is running. To adjust the head:

- * Glue a three foot length of clear pipe or tubing to a threaded adapter that will screw onto the turn-up adapters.
- * Replace the turn-up cap with the pipe adapter.
- * Turn the power on to allow liquid to rise in the pipe.
- * Adjust the gate or globe valve in the pumping tank until the effluent reaches the desired height in each line. Remember to include the distance below the ground surface to the lateral line when measuring the height.

Final Landscaping

After the LPP is installed, the following should be checked to ensure that the system will not be overloaded with excess rainwater and runoff:

- * The distribution field is shaped to shed rainwater and is free of low areas.
- * Curtain drains, grassy swales or ditches for diverting ground and surface water are properly installed.
- * Gutter and downspout drains are directed away from the system.

Any problems should be corrected before approving the system.

Finally, the entire area should be planted with grass in order to prevent erosion. The soil should be properly tilled, limed (if necessary) and fertilized before planting. After applying an appropriate grass seed, the area should be heavily mulched with straw or other suitable material.

CHAPTER 8

Inspection and Maintenance

The successful performance of an LPP relies on proper design and installation. The details for a given system, from site preparation to final landscaping, should be carefully specified on the Construction Permit. This helps clarify the responsibilities of the property owner, contractor and permitting agency and helps avoid last-minute surprises when issuing a final inspection approval.

Operation Inspections

A properly designed and installed LPP system requires very little maintenance. The individual home owner should routinely check the pump, alarm system, and condition of the disposal field. Any indications of a failure should be reported to the County Health Department as soon as possible.

Routine Maintenance

All septic tanks, whether for conventional or alternative systems, require occasional pumping. Sludge and scum accumulation should be checked annually. Virtually all solids will be retained in the first compartment of the two-compartment septic tank. Little or no accumulation should occur in either the second compartment of the septic tank or in the pumping chamber. The rate of sludge accumulation will vary with individual living habitats. Most septic tanks require pumping about once every four years.

Some LPP systems may gradually accumulate solids at the ends of the lateral lines. These should be removed at least once a year by unscrewing the caps on each of the turn-ups, and back-flushing the laterals with a garden hose.

The pressure head in the upper and lower laterals should also be checked and adjusted one month after installation and annually thereafter. Proper pump and float-control operation should be checked during all routine inspections. If the alarm panel has a "push-to-treat" button, it should be checked regularly. Pump maintenance should follow the manufacturer's recommendations.

Repair Procedures

The alarm light should go on whenever effluent in the pump chamber rises above the pump-on level control. This can occur for several reasons:

*Power failure: If there has been a power failure, effluent will continue to accumulate in the tank until power is restored. At this time the alarm may come

on for a brief period (less than 30 minutes), but will go off as soon as the pump draws down the effluent.

* Pump or switch failure: If the pump or level controls malfunction, they can be quickly replaced by unscrewing the PVC union and lifting the entire assembly out of the pumping chamber (use the nylon lift rope). Be sure to turn off the power supply, and disconnect all cords before removing or replacing the pump or control assembly.

* Clogged valve or discharge holes: If the distribution system becomes clogged, the tank will not be emptied. Back-flush the laterals and supply manifold if necessary.

Before replacing any components, make sure that the level controls have not simply become tangled. The problem can usually be isolated by checking the pump operation independently from the controls. Repair or replace the appropriate components.