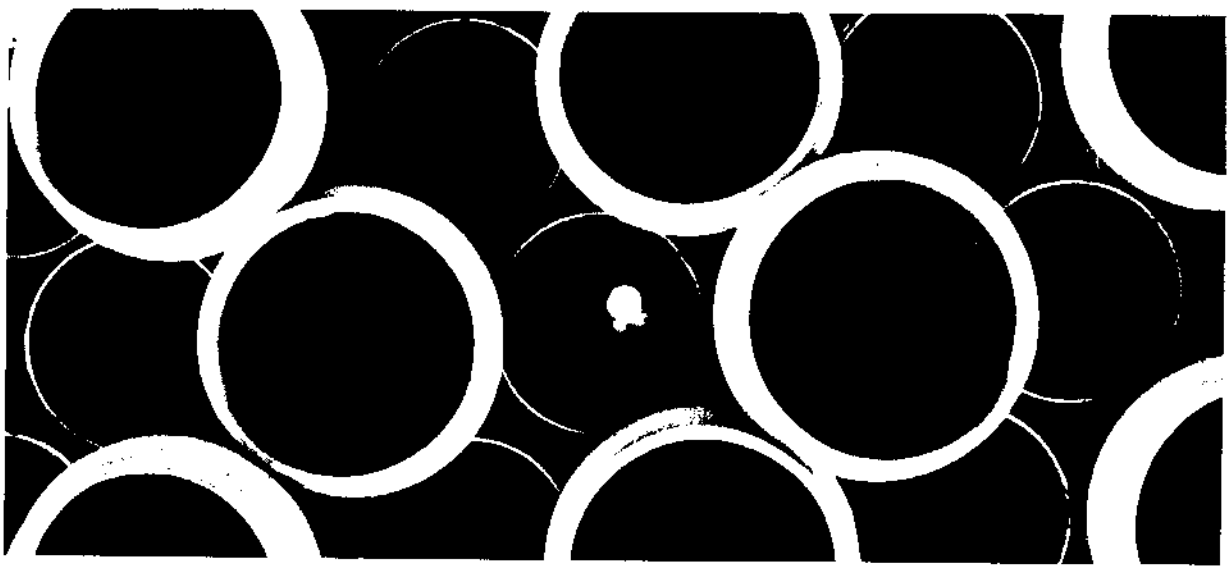
Design and Installation of Low-Pressure Pipe Waste Treatment Systems



Craig Cogger Bobby L. Carlile Dennis Osborne Ed Holland

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Design and Installation of Low-Pressure Pipe Waste Treatment Systems

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Introduction

Many sites under consideration for development in North Carolina are not suitable for on-site sewage disposal by conventional septic systems. Among these sites are some which do have enough depth and area of usable soil to provide safe disposal via low-pressure pipe (LPP) systems. LPP systems are not a panacea for all the unsuitable soils of North Carolina, but they are useful for some specific conditions where conventional systems have frequently failed.

This manual specifies the procedures and materials to be used for successful siting, design, installation and maintenance of residential LPP systems. Use of proper materials and techniques is critical to the success of the LPP, as well as to all other ground absorption systems. Many engineers, sanitarians, contractors and designers are unfamiliar with LPP construction, and these instructions are designed as an aid to them. Although those who design, build and use septic systems can benefit from this report, it must always be used in cooperation with the local health department. The local health department must first approve a site, and then assign waste flow and soil loading rates.

This manual covers design and installation of small LPP systems suitable for homes and small businesses. Principles are similar for larger commercial and institutional systems, but the special requirements of those systems are not addressed.

CHAPTER 1

What Is Low-Pressure Pipe Distribution?

A 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 operation 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 pollution. Shallow soils are not deep enough to purify the effluent.

The LPP system has three design improvements to help overcome these problems. These 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 seasonally high-water table.

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

- two-compartment septic tank
- pumping chamber
- submersible effluent pump and level controls
- high-water alarm
- supply line and manifold
- distribution laterals
- 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 PVC pipes containing small holes (⅛ inch to ¼ inch) spaced three to five feet apart. The pipes are placed in narrow trenches six to 18 inches deep, spaced five or more feet apart. Under low pressure [0.7 to two pounds per square inch (psi)] 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. The alarm would turn on, signaling the homeowner of failure.

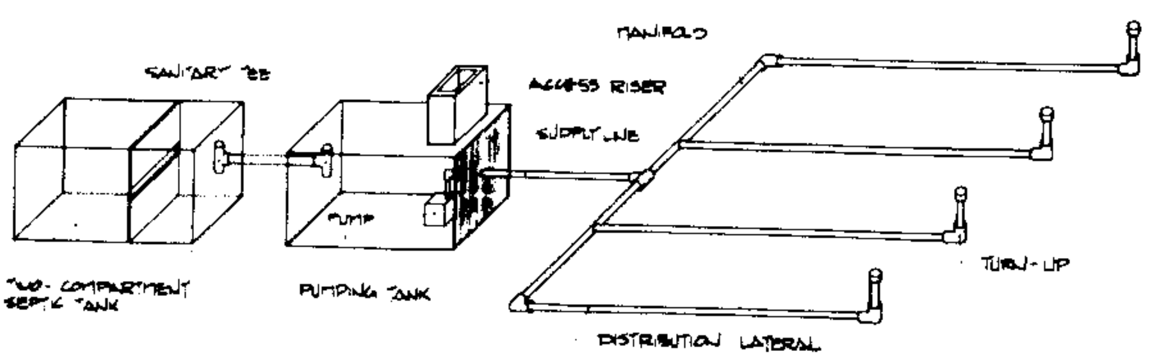


Figure 1. Basic components of a low pressure pipe system

CHAPTER 2

Site and Soil Requirements for LPP Systems

The suitability of an LPP system for a given site is determined by the soil, slope and available space, as well as by the anticipated waste flow. The criteria below are a set of practical guidelines that may be modified by individual county health departments.

Space requirements

The distribution network of most residential LPP systems occupies from 1000 square feet to 5000 square feet of area depending on the soil permeability and design waste load. In addition, an area of equal size must be set aside for future repair or replacement of the system. Space between the existing lateral lines is not a suitable repair area, unless the initial spacing between lines is 10 feet or wider. The septic tank, pumping chamber, distribution field and repair area are also all subject to horizontal setbacks from wells, property lines, building foundations, etc., as specified in local or state regulations [10 NCAC 10A .1912(a)]. Although it is not feasible to integrate all of the site and soil setback criteria into a general lot size requirement, an undeveloped lot smaller than one acre will not usually be acceptable for an LPP system.

Soil requirements

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 trenches and any underlying restrictive horizons such as consolidated bedrock or hardpan, or to the seasonally high, water table. LPP trenches can be placed as shallowly as eight to 12 inches deep, giving a minimum soil-depth requirement of 20 to 24 inches. The soil must be of suitable or provisionally suitable texture, structure and permeability, as defined in state regulations (10 NCAC 10A .1920). In some cases where the depth to the seasonal water table or restrictive horizons is less, a modified LPP may be installed using imported fill. Great care must be used in building these systems. Their design and construction are covered in Chapter 8.

Topography

Low-pressure distribution fields located on slopes require special design and installation procedures (Chapter 7). The distribution field of any LPP system should be at an elevation equal to or higher than the pumping chamber. This prevents the gravity flow or inadvertent siphoning of effluent from the pump chamber to the field when the pump is not operating. If the field must be lower than the pump tank, then the system must be designed to ensure that effluent cannot leave the pump chamber when the pump is turned off.

Drainage requirements

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 the LPP system.

CHAPTER 3

Layout of an LPP System

The next three chapters are a step-by-step procedure for designing an LPP system. There is no one LPP that fits all sites—each must be designed individually. Additional procedures used when designing LPP systems on sloping sites and where fill is used are covered in Chapters 7 and 8.

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 150 gallons per day (gpd) for each bedroom (BR) in the house.

Example:

For a 3-BR house:
Flow = 150 gpd/BR x 3 BR = 450 gal

Step 2. Determine the loading rate. Estimate soil permeability during the field evaluation and determine the wastewater-loading rate using Table 1.

Example:

For a sandy clay loam:
Loading rate = 0.25 gpd/ft^2
Note: Waste flow and loading rates must be determined by the local health department before the LPP system can be designed.

Step 3. Compute the total area needed for the absorption system using the equation: Area = flow/loading rate.

Example:

Using flow and loading rates calculated above:
Area = 450 gpd/0.25 gpd/ft^2 = 1800 ft^2

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 ft^2/5 ft = 360 ft

Table 1. Maximum loading rates for LPP systems based on soil texture and estimated permeability

USDA Soil Texture*	Estimated Permeability	Maximum Loading Rate**
	min/in.	*gpd/ft^2*
Sand, loamy sand	20	0.50-0.40
Sandy loam, silt loam	20-40	0.40-0.30
Sandy clay loam, clay loam	40-60	0.30-0.20
Silty clay loam, sandy clay	60-90	0.20-0.10
Silty clay, clay	90-120	0.10-0.05

*This table does not consider the effects of clay mineralogy on soil permeability. A sandy clay composed of 1:1 clays may be more permeable than a clay loam of 2:1 clays.

**These loading rates should be used only for calculating the size of LPP systems - not for other types of systems.

Step 5. Calculate gravel requirements. To fill a six-inch wide trench six inches deep with gravel, 1.5 yards (1.9 tons) is needed per 100 feet of line.

Example:

For 360 ft of line:
Gravel needed = (360 ft/100 ft) x 1.5 yds
= 5 yds

Size of septic and pumping tanks

Septic-tank volume is determined according to state and local regulations, and is the same as a conventional system. The pumping tank should provide one day for emergency storage; thus, it should be at least twice the volume (V) of the daily waste flow.

Example:

For a 450 gpd waste flow:
V pumping tank = 450 gal x 2 = 900 gal

Location of system

The LPP should be located in the best available soil on the lot. All setback requirements from wells, lot lines and waterways must be observed. The exact location of the tanks as well as drainage and landscaping improvements must be noted. A repair or replacement space on suitable soil equal in area to the absorption field must be located.

Shape of absorption field

When selecting the best shape to fit in the desired location, lines must be placed on the contour. Also, lines should not extend more than 70 feet from the manifold (supply line) due to excessive friction loss. When using larger lateral lines, the manifold must be placed in the center of the distribution system rather than along the side (Figure 2). For a layout example, see Figure 3.

Landscaping and drainage

All landscaping, filling and site drainage to be done before and after the LPP installation must be recorded in detail on the improvements permit.

Depth of lines

Lines are normally placed 18 inches deep. Shallower placement will be necessary in soils with shallow water tables, bedrock or restrictive horizons in order to meet the one-foot vertical separation requirement.

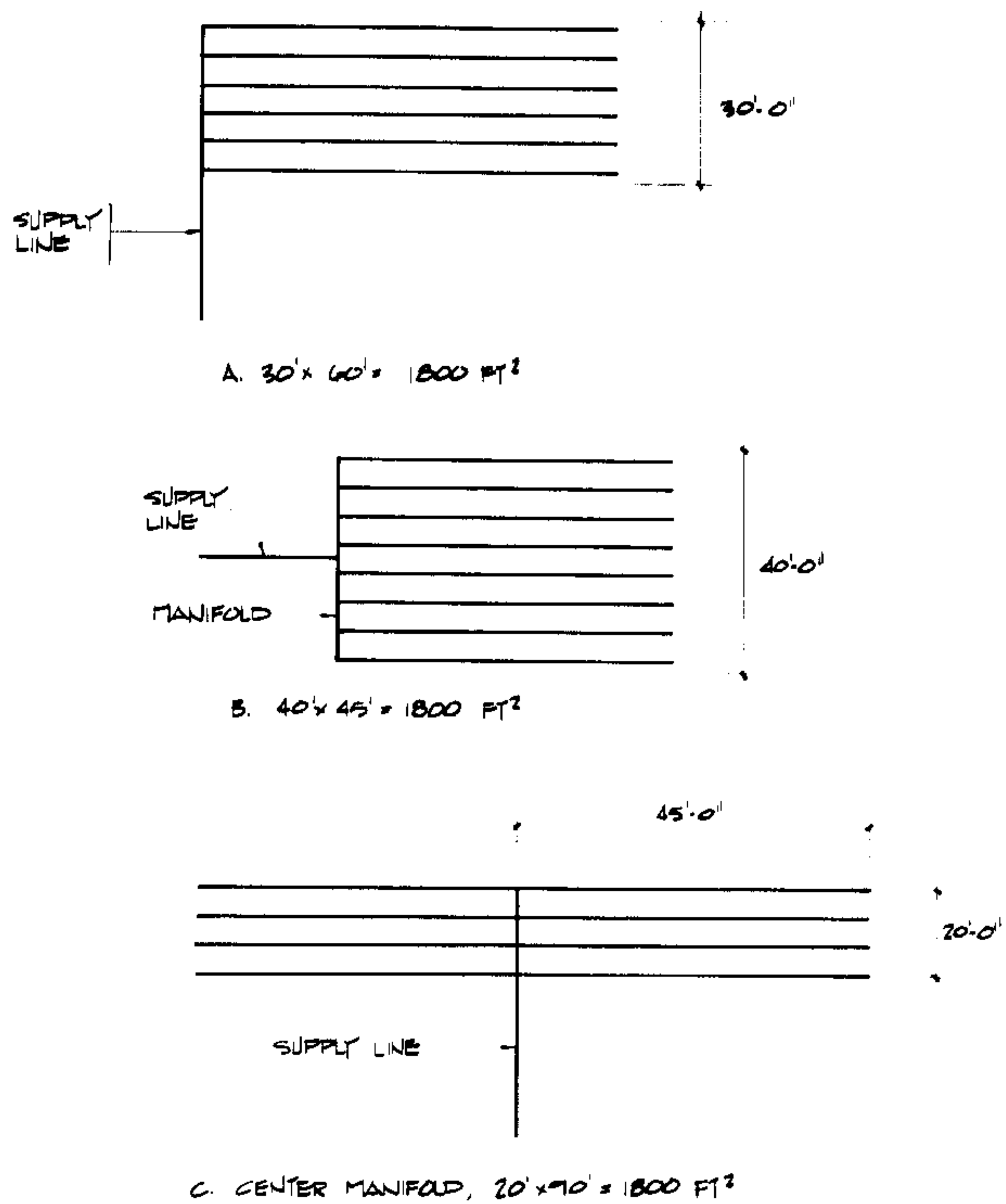


Figure 2. Three possible shapes of an 1800 ft² LPP distribution field

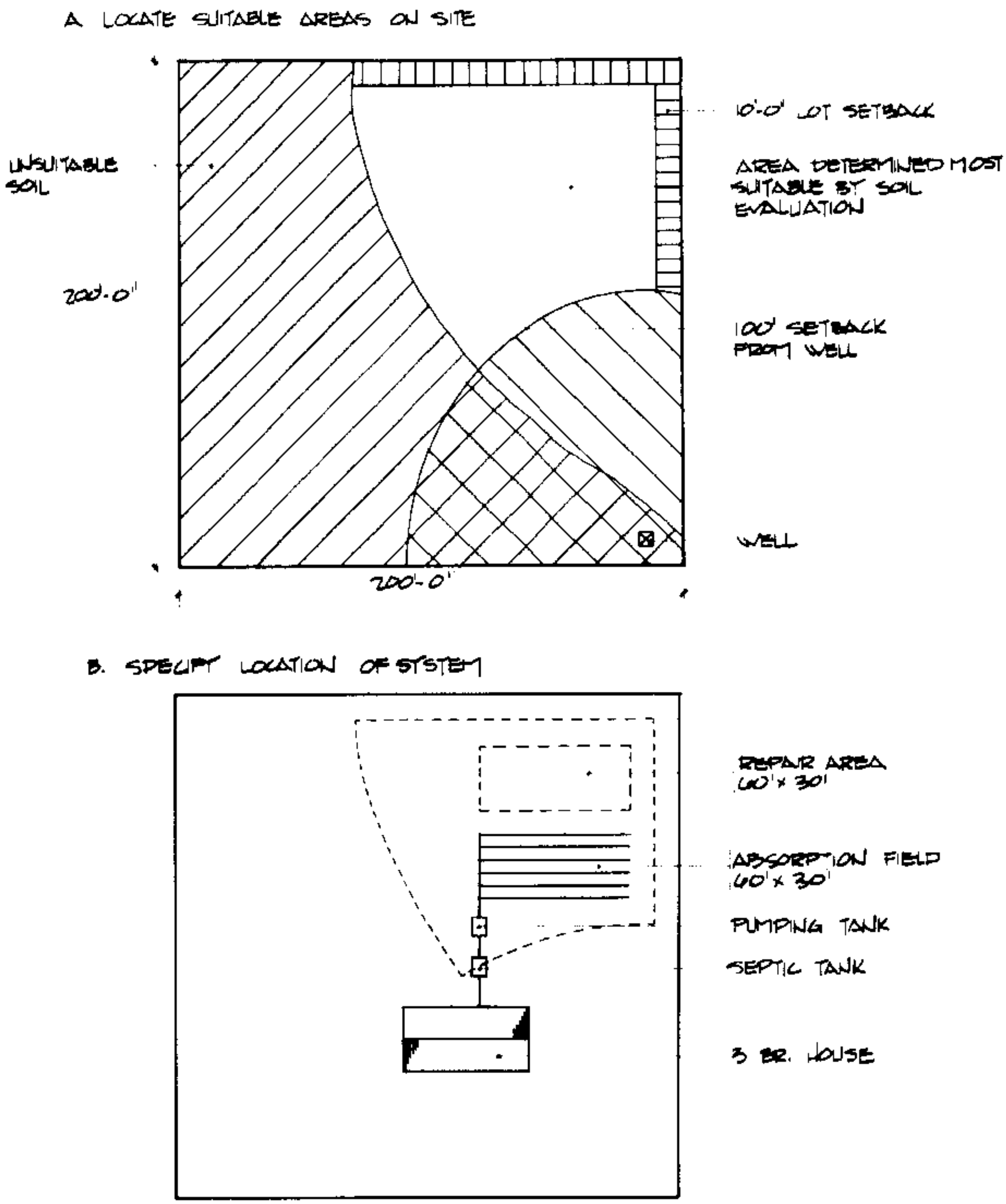


Figure 3. Layout of a sample system

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 two to four feet (0.9 to 1.7 psi). Lower pressures do not provide uniform delivery of effluent. Higher pressures cause local scouring of the gravel and soil in the trench bottoms. The 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 two to four feet for adequate performance; holes must be ⅛ inch or greater in diameter, and hole spacing can range from three to five feet. On sloping lots, it may be necessary to have holes as small as 3/32 inch and spacing greater than five feet, in a part, but not in all of the system as explained in Chapter 8. The best starting values for calculation are a 5/32-inch hole diameter, five-foot hole spacing and three feet of pressure head.

Step. 1. Calculate the number (no.) of holes.
No. holes = length of line/hole spacing

Example:

For a system with 5-ft hole spacing and six 60-ft lines:
No. holes/line = 60 ft/5 ft/hole
= 12 holes/line
Total holes = 12 holes/line x 6 lines
= 72 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 = 0.50 gpm
Flow rate/line = 0.50 x 12 holes = 6.0 gpm
Total flow rate = 0.50 x 72 holes = 36 gpm

For systems where the absorption field is at a lower elevation than the pump, a ¼-inch siphon-breaker hole must be drilled in the supply line in

Table 2. Flow rate as a function of pressure head and hole diameter in drilled PVC pipe

Pressure Head		Hole diameter (in.) 3/32	1/8	5/32	3/16	7/32
ft	*psi*			*– Flow rate (gpm) –*		
1	0.43	0.10	0.18	0.29	0.42	0.56
2	0.87	0.15	0.26	0.41	0.59	0.80
3	1.30	0.18	0.32	0.50	0.72	0.98
4	1.73	0.21	0.37	0.58	0.83	1.13
5	2.16	0.23	0.41	0.64	0.94	1.26

the pumping tank. This hole will prevent inadvertent siphoning of the contents of the pump tank into the 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 36 gpm flow rate and a siphon-breaker hole.
Total flow rate = 36 gpm + 2 gpm = 38 gpm

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. Total head = elevation head + pressure head + friction head.

Elevation head is the difference in elevation from the pump to the end of the manifold. Remember that the pump will be four feet 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 down 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 head.
Friction head = 1.2(pipe friction)

Table 3. Friction loss per 100 feet of PVC pipe

	Pipe diameter (in.)					
Flow	1	1¼	1½	2	3	4
gpm	*Friction loss (ft)*					
1	0.07					
2	0.28	0.07				
3	0.60	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

Example:

For a 70-ft supply line with a 2-in. diameter and a 36-gpm pumping rate:
Pipe friction = (70 ft/100 ft) x 2.2 ft
= 1.5 ft
Friction head = 1.2 x 1.5 ft
= 1.8 ft

Step 2. Calculate total head.

Example:

For a system with 5-ft elevation head from pump to end of the lines, 3-ft pressure head, 1.8-ft friction head:
Total head = 5 ft + 3 ft + 1.8 ft
= 9.8 ft

The system will require a pump with a capacity of 36 gallons per minute 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 pump manufacturer. Examples of performance curves are shown in Figure 5. It is important to use the performance curve for the specific brand and size of pump to be used. Performance curves vary among brands.

Step 3. Select a pump of proper capacity. Consult the appropriate performance curve. The system requirements of flow and total head (36 gallons per minute at 10 feet) intersect at a point which must fall below the performance curve. If the point falls above the curve, then the pump is too small.

Example:

This point in Figure 4 falls below the curve; therefore, the pump is adequate.

When the chosen pump is too small, there are several options to consider:

- Select a larger pump.
- Reduce the total head requirement by reducing the pressure head (two feet is the minimum). This has a large effect, as a lower pressure head will also lower the flow rate and friction head.
- 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 (⅛-inch is the minimum) or by increasing hole spacing.
- Raise the pump by placing more blocks underneath it.

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 0.4-horsepower pump will be adequate with judicious selection of the other parameters.

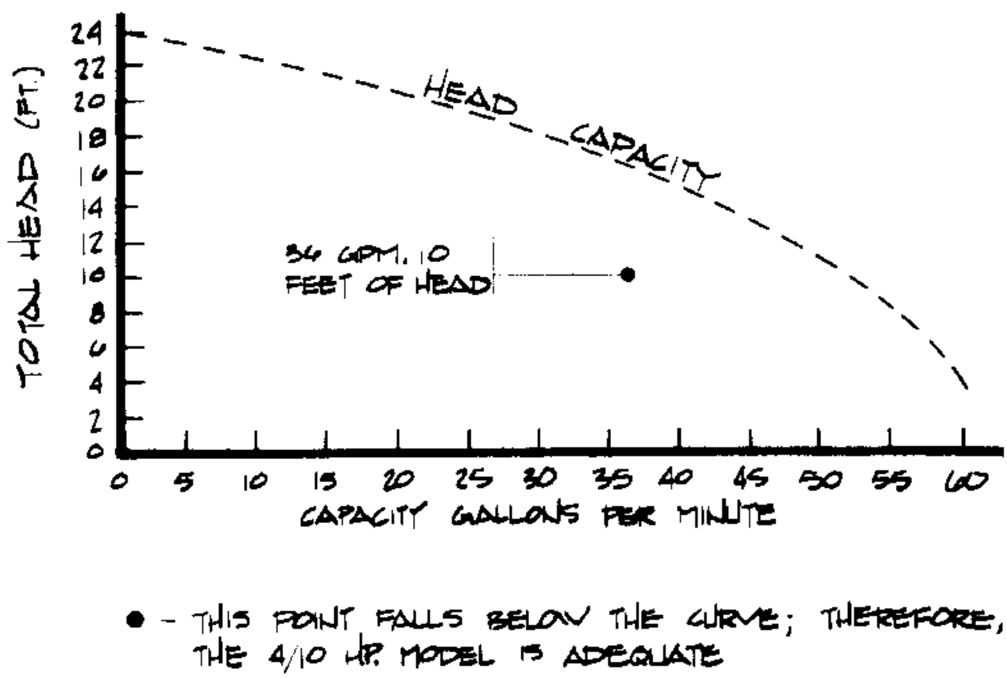


Figure 4. Comparing pumping requirements to performance curves

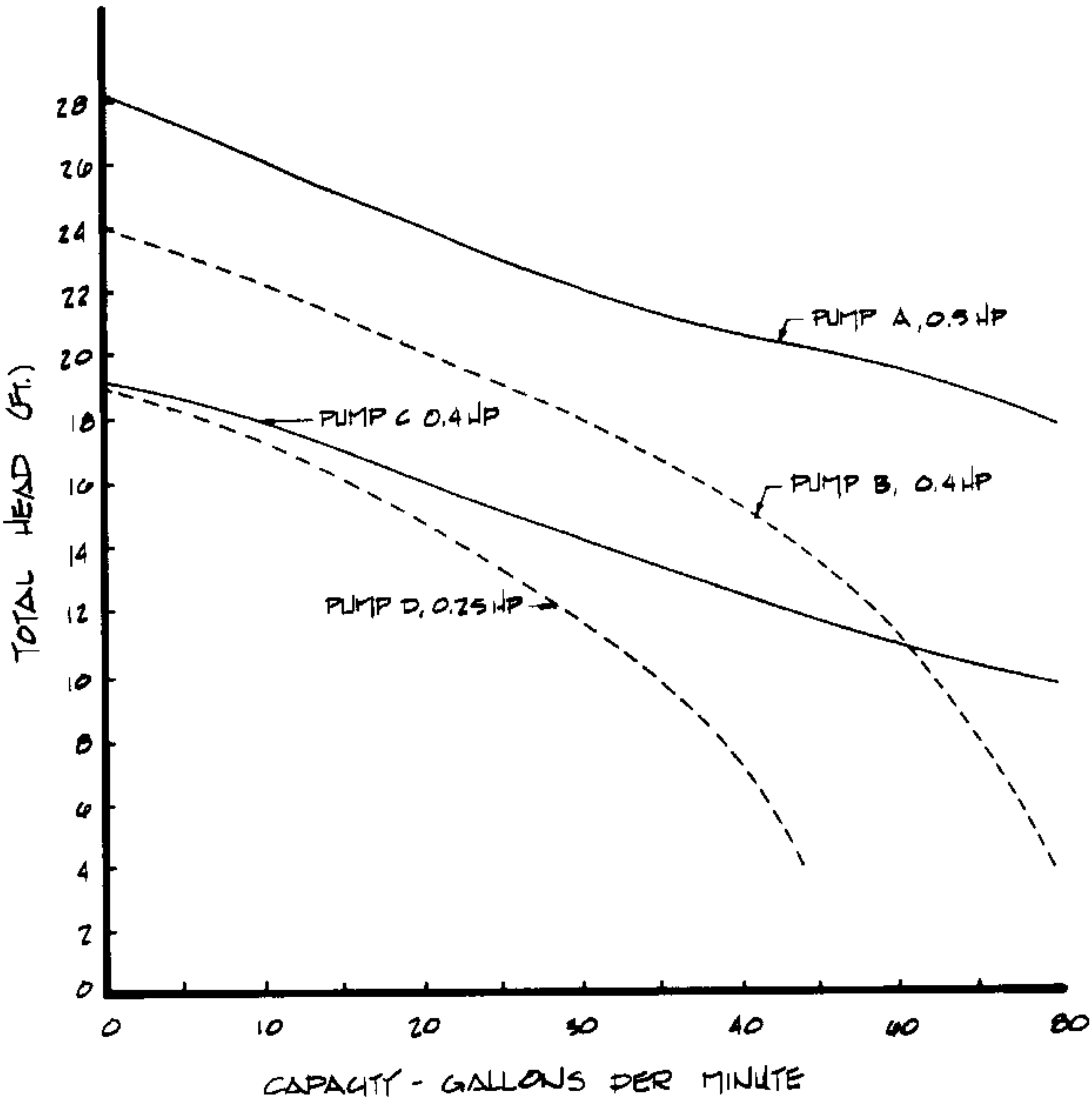


Figure 5. Examples of performance curves (capacity vs total head) for four submersible effluent pumps

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 dose = V supply + 5 (V 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 PCV pipe

Pipe Diameter	Storage Capacity 160 psi	Storage Capacity Schedule 40
in.	*gal/100 ft*	*gal/100 ft*
1	5.8	4.1
1¼	9.0	6.4
1½	12.5	9.2
2	19.4	16.2
3	42.0	36.7

Example:

1. Supply line = 70 ft of 2-in. pipe
   V supply = (70/100) x 19.4 gal
   = 13.6 gal
2. Lateral lines = 360 ft of 1¼-in. pipe
   V lateral = (360/100) x 9.0 gal
   = 32.4 gal
3. V dosing = 13.6 gal + 5 (32.4 gal)
   = 176 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: Dosing depth = (V dose/V tank) x liquid depth of tank.

Example:

For a 900-gal pumping tank, 4-ft liquid depth (bottom of tank to outlet tee); 180-gal dose:
Dosing depth = (180 gal/900 gal) x 4 ft
= 0.8 ft = 9.6 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 storage = V supply + V laterals

Example:

V storage = 13.6 gal + 32.4 gal
= 46.0 gal

Step 2. Compare to ¼ daily waste flow.

Example:

450 gpd x ¼ = 112 gal
46.0 gal < 112 gal
No check valve needed.

CHAPTER 5
Equipment Specifications

All necessary equipment and tools should be clearly listed so they can be obtained prior to building an LPP. 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 3) should be filed 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 6) and the pump system (Figure 7) are useful for counting the fittings.

Septic tank and pumping chamber

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

The septic tank receives wastewater directly from the house. It is sized according to state and local regulations for conventional systems (10 NCAC 10A .1907). The septic tank must be of two-compartment design for maximum solids retention. It is very important that the septic tank and pumping chamber are watertight. One-piece tanks are best. When using two-piece tanks, the tongue-in-groove joint must be carefully sealed with asphalt rope mastic.

Effluent from the two-compartment septic tank flows by gravity through a four-inch solid PVC pipe to the pumping chamber. The pumping chamber should have a liquid capacity of at least two times the daily wasteflow from the house, and can be a single-compartment design.

Both the septic tank and pumping chamber must be provided with aboveground concrete or masonry (or their equivalent) manhole risers to provide easy access for clean-out and pump service. The riser should be placed over the primary chamber of the septic tank and above 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 runoff and groundwater to the tanks.

Pipe and fittings

All pipes and fittings in an LPP system should be made of PVC plastic. PVC is lightweight, easy to use and resists corrosion. All joints must be sealed with an appropriate PVC-solvent cement. The supply manifold from the pumping chamber to the LPP distribution field is usually 1½-inch or two-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 above the pump to allow easy removal or replacement. Lateral lines are usually made of 1¼-inch PVC. Appropriate holes in the laterals are drilled on site (Chapter 6).

PVC pipe may be of thin-wall (160 psi) or Schedule 40 specifications, but must be of the straight length variety. Thin-wall (160 psi) PVC is usually cheaper than Schedule 40. A globe or gate valve for final pressure adjustment is installed in the supply manifold inside the pumping chamber. The valve should be made of PVC or bronze, whichever is cheaper. 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 aboveground 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 (Chapter 4), it should also be installed with threaded fittings in the pump chamber to provide easy access for maintenance.

Pump, float controls and alarm system

A good-quality, submersible effluent pump must be used in 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,

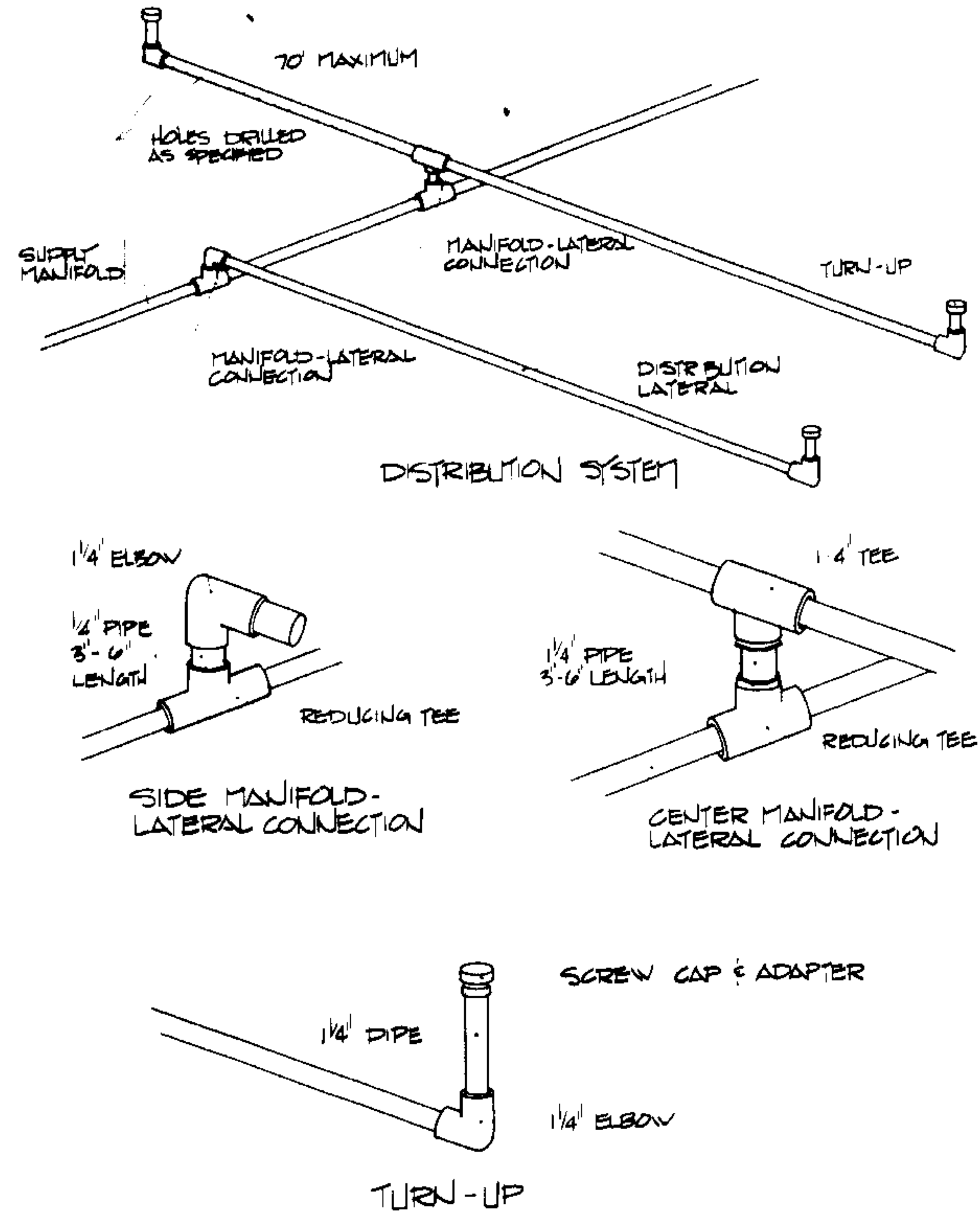


Figure 6. Details of distribution system

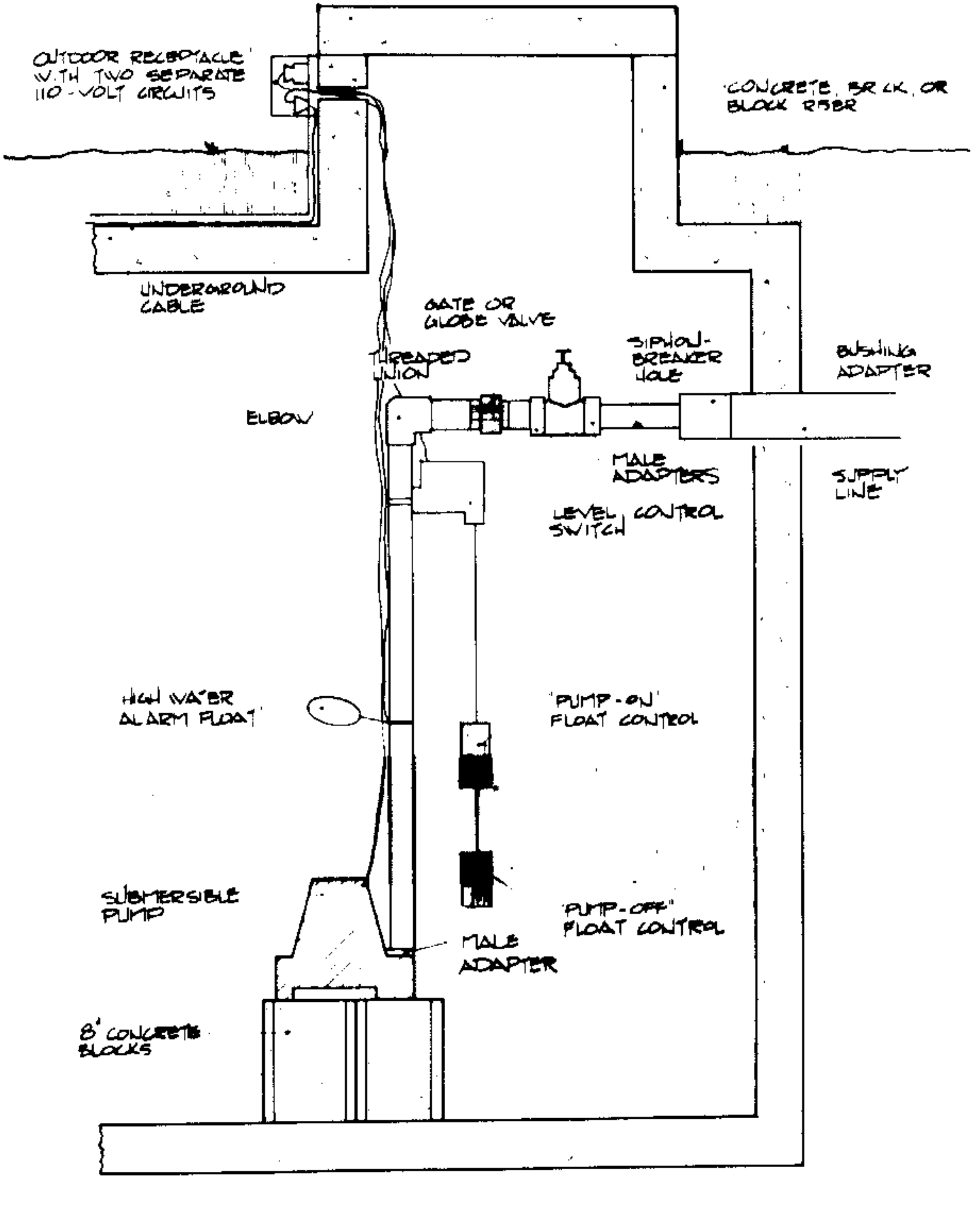


Figure 7. Details of pumping chamber

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 ¼ horsepower to 4/10 horsepower generally provide sufficient capacity for residential 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 6). The pump control system must be adjustable to meet the recommended loading rates for different sizes and shapes of pumping chambers. The controls must also be sealed against entry of corrosive and explosive gases from the effluent and should have NEMA (National Electrical Manufacturing Association) approval.

The two types of switches which have proven the most useful are magnetic, level-control switches and sealed, mercury switches. The magnetic level control consists of two floats suspended from a sealed, magnetic switch. This switch has been reliable and the pumping volume is easily adjusted. 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 some mechanical float switches have not been 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, there must be a separate float control for the high-water alarm. This may be a sealed, mercury-float switch mounted several inches above the on float. The high-water alarm should consist of a light bulb and/or 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 should 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 (or audible) signal in the home whenever the water exceeds the normal "pump-on" level in the tank.

Gravel

LPP systems require about six inches of gravel in the lateral distribution trenches. Gravel size should be from ⅜ inch to one inch. Pea gravel or crushed rock may be used, but it must be washed. Gravel placement is discussed in Chapter 6.

Home water-saving devices

Any home with an LPP system must be equipped with low-flow showerheads (three gallons per minute) and low-flush commodes (3½ gallons or less per flush) in order to minimize the hydraulic load on the system. Those devices are a simple, low-cost way of reducing water consumption with no inconvenience to the homeowner. They are required by the North Carolina Building Code in all new construction. Low-flow showerheads and retro-fit dams for commode tanks should be used in any existing home where an LPP is installed.

CHAPTER 6

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 is done with a small trenching machine that will excavate a cut four to 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 rags)
- 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. 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 creating 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 8.

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 two-compartment septic tank is installed in the same way as a conventional system. Wastewater from the house flows directly into the large compartment of the tank. The pumping chamber is installed next to the septic tank, but its direction must be reversed so that the tee end becomes the inlet end adjacent to the septic tank. The lower invert of the tee 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 PVC pipe. Inlet and outlet openings around the pipe must then be sealed with mortar.

The tank access lids must be equipped with water-tight masonry or concrete risers to at least six inches above grade. These 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 1¼-inch elbow or tee on the lateral (Figure 6). 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 (See Chapter 7).

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 with mortar until after the pump is in place.

Lateral lines

The lateral trenches are usually cut 18 inches deep. Some soil profiles will require shallower placement. 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. Small earthen dams are placed at the beginning of each lateral trench, and at 20-foot intervals thereafter, to help maintain uniform distribution of effluent along each trench. The dams can be tamped into place or left uncut from the soil (Figure 8). Lateral trench bottoms are then lined with three to six inches of gravel (remember to put no gravel in the supply manifold trench).

The 1¼-inch 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 two to three feet from the manifold; the last hole should be drilled two to three feet from the end of the lateral. Holes must not coincide with the earthen dams. 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, it can be sealed by wrapping with duct tape. Lateral pipes are placed holes-down in the trenches. A short turn-up with a capped end is at the end of each lateral (Figure 8). The capped end must be brought up above or flush with the final grade. 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 to four 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. Finally, the trenches are backfilled with topsoil. Turn-ups should then be cut to appropriate lengths, fitted with caps and (if desired) protected with short segments of four- or six-inch PVC or terra cotta.

Pump and controls

Details of pump installation are show 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 "pump-on" is positioned to pump a specified volume of effluent (Chapter 4). The high-water 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 ¼-inch 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 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, watertight box. Some level-control switches have such a

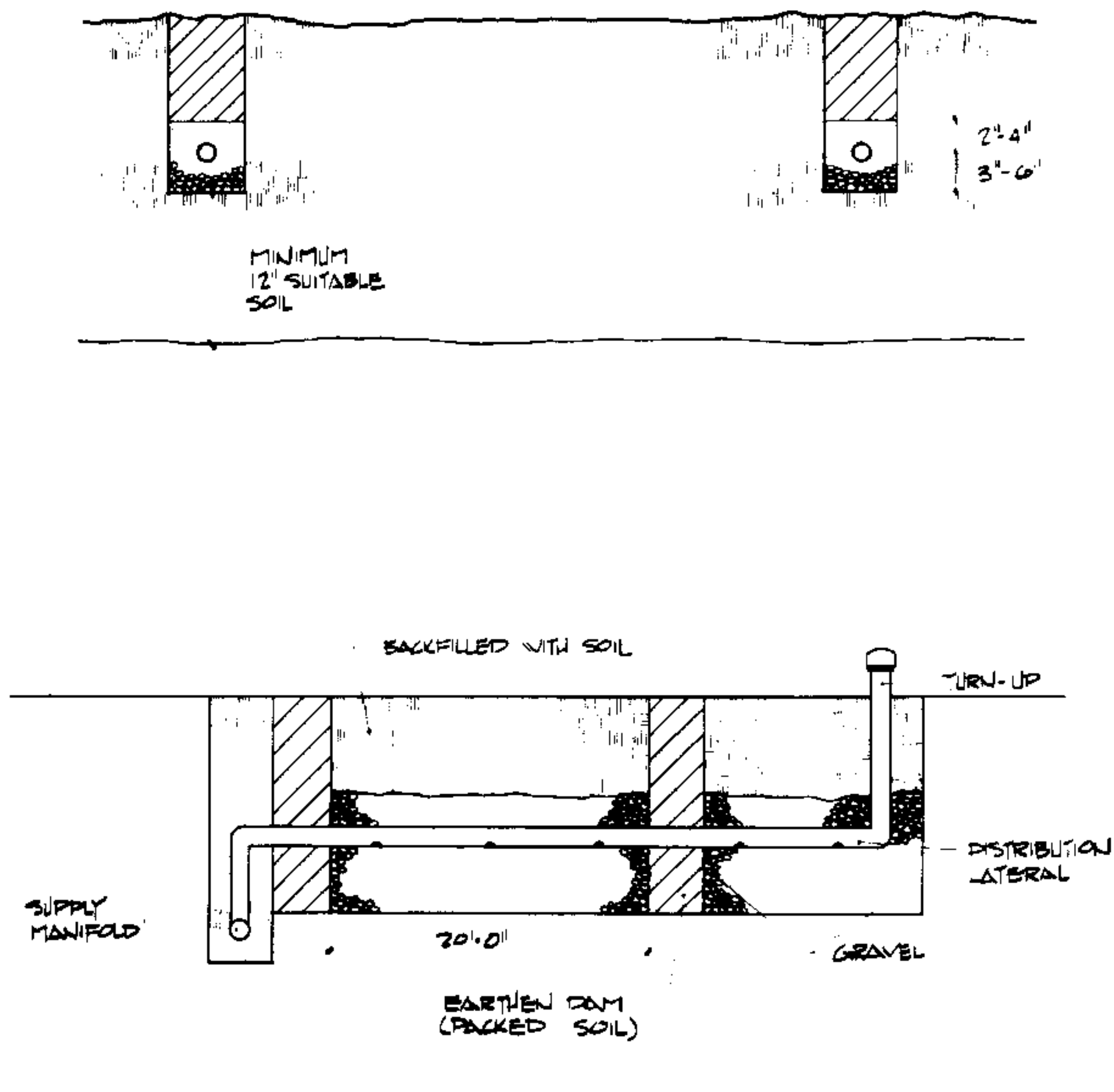


Figure 8. Details of absorption trenches

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.

Proper 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 four-foot length of pipe (preferably clear) to a threaded adapter that will screw onto the turn-up adapters.
- Replace the turn-up cap with the pipe and 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 the pipe. 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 7

LPP Design and Installation on Sloping Ground

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

Layout

The procedure is similar to that in Chapter 3, with careful emphasis placed on the following points:

- Lateral trenches must be placed on contour and earthen dams installed as needed to ensure even distribution of effluent in each trench (Figure 9).
- The effects of slope can be lessened by making systems as long and narrow as possible across the contour (Figure 2C, page 6). This design uses fewer and longer lines, decreasing the elevation difference between the highest and lowest lines.
- Systems with more than four feet of elevation difference between the highest and lowest laterals cannot be designed with a single manifold. Separate manifolds for the upper and lower lines must be used (Figure 9b). 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 from uphill.
- 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 (Figure 10).
- Installation on slopes greater than 30 percent is not recommended unless installation is to be done entirely by hand.

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. All the loads are then balanced by modifying the design of individual lines where needed.

Determine 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.

Example:

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 (pg 8) 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 large 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 1 (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.

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

Example:

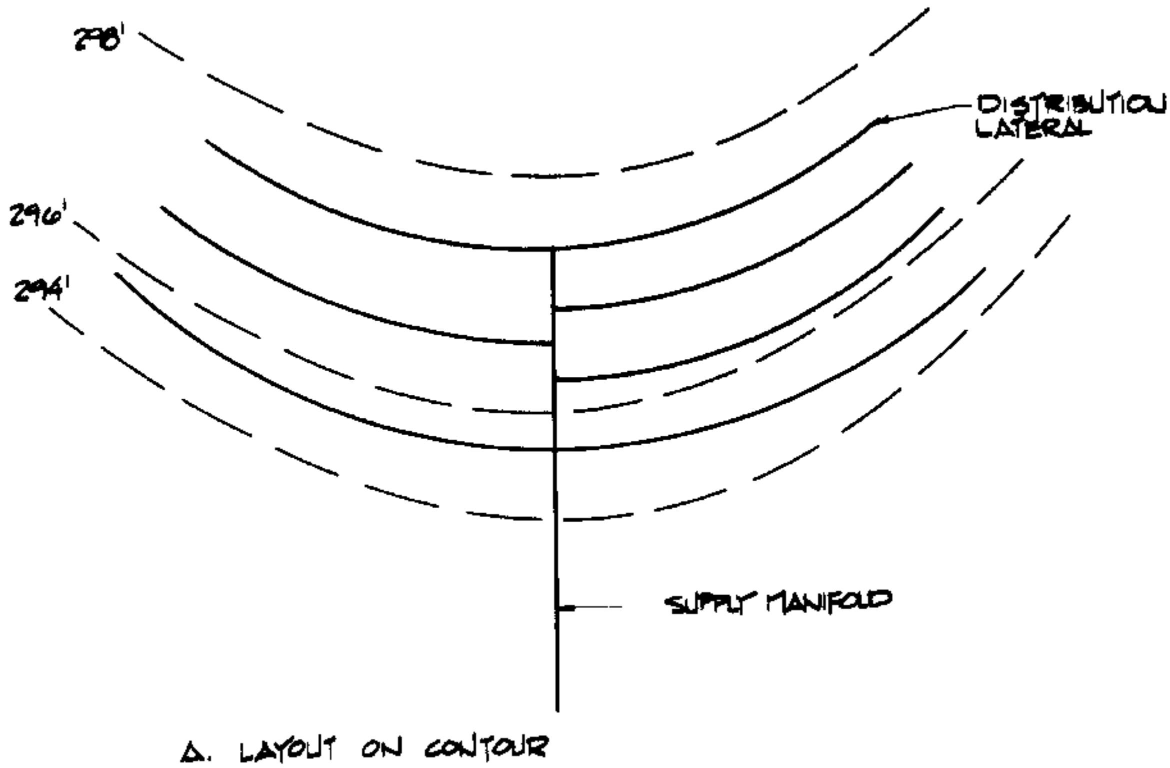
For the system above:
Dosing rate = 5.8 + 6.0 + 6.0 + 6.0 + 6.2 gpm
= 30.0 gpm
(Add 2 gpm if a siphon-breaker hole is needed.)

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 ¼-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



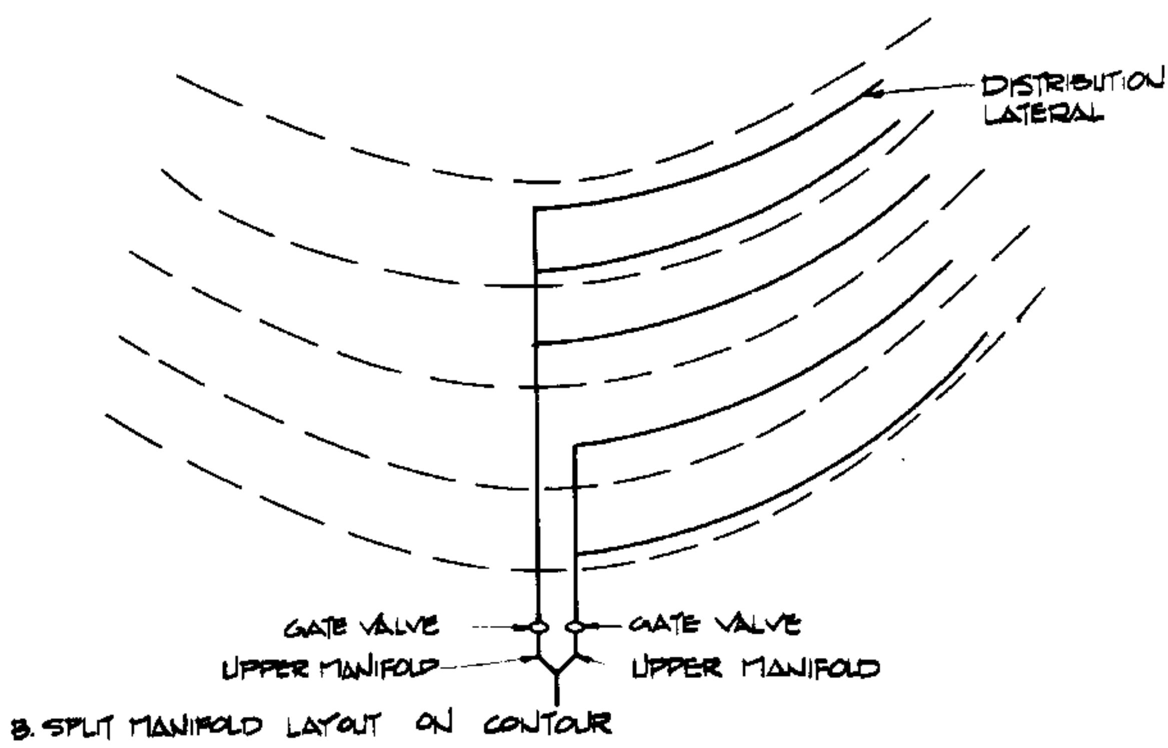


Figure 9. Layout of LPP systems on slopes

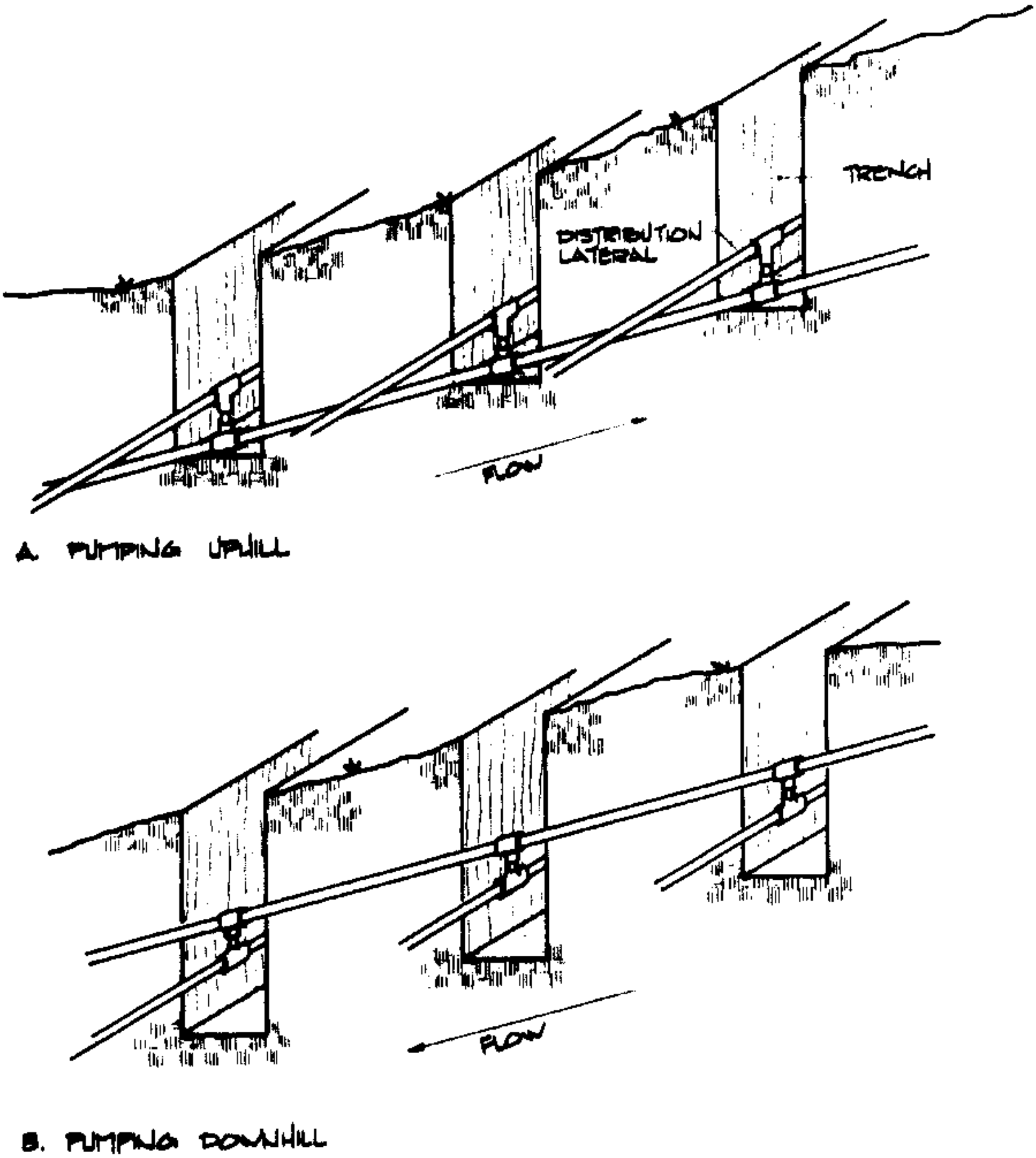


Figure 10. Manifold placement on slopes

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 ft.

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.

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 1¼-inch diameter because they are easier to adjust than larger valves. Reducing adapters will be needed to fit these valves into larger diameter manifolds.

Table 9. Establishing a subsystem

Subsystem	Line	Elevation and Round Off (Steps 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

CHAPTER 8

Modified LPP Systems Using Fill

Most sites with a restrictive horizon or a seasonally high, water table within 24 inches of the surface are not suitable for a standard LPP system. Many are not suitable for any soil-absorption, waste-treatment system. But some of these sites can be used for waste treatment if the soil is supplemented with fill that has been carefully selected and added.

When there is 16 inches to 24 inches of usable soil on an acceptable site, a modified LPP can be installed. The soil must have suitable or provisionally suitable texture, structure and permeability (10 NCAC 10A .1920). After the addition of fill, trenches are placed as shallowly as three inches to four inches into the natural soil. The design and installation of the modified LPP are discussed below.

When there is less than 16 inches of usable soil, a mound system can be built, where the distribution lines are placed above the soil surface in imported fill. The design and construction of mounds is discussed in the manual, *Design and Installation of Mound Waste Treatment Systems* published by UNC Sea Grant.

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 fill = total area x depth of fill
V fill = 70 ft x 40 ft x 1 ft
= 2800 ft^3

Step 3. Convert to cubic yards.

Example:

V fill = 2800 ft^3/27 ft^3 per yd^3
= 104 yd^3

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

Installation

The success of a modified LPP depends on the care used in selecting and incorporating the fill material. The fill must have a sandy loam or loamy sand texture. The fill should not be hauled or worked wet.

As with all LPP systems, the site must be protected from traffic. Prior to incorporating the fill, brush and small trees should be removed and the soil suface loosened using a cultivator or garden 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 system 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 very small crawler tractor with a blade or a roto-tiller with a blade. The fill is then tilled 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 tilled, 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 Chapter 6.

CHAPTER 9

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 Improvements Permit. This helps clarify the responsibilities of the property owner, contractor and permitting agency and helps avoid last-minute surprises when issuing a Certificate of Completion. Items on the Improvements Permit (and associated design specifications for the LPP system) should be inspected by the permitting agency in four stages as outlined in Appendix 4.

Installation inspection

Regulatory agencies are strongly recommended to withhold the Certificate of Completion until all the above requirements are satisfied. A checklist similar to Appendix 4 should be completed and filed each time a system is installed to ensure completion of the requirements.

Operation inspections

A properly designed and installed LPP system requires very little maintenance. Several routine items should be checked periodically and an extra pump should be readily available. LPP systems should be observed by the regulatory agency one, three, six and nine months after initial installation, and every six months thereafter. An inspection report should be completed and filed each time the system is checked. A sample format is shown in Appendix 5.

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 habits. 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.

Pressure head in the upper and lower laterals should also be checked and adjusted one month after installation and annually thereafter (Chapter 6). Proper pump and float-control operation should be checked during all routine inspections. If the alarm panel has a "push-to-test" 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.

Appendix 1. Design specifications for example LPP (Chapters 3 and 4)

File a copy of this sheet along with an accurate sketch for each LPP designed.

Daily waste flow	450 gal
Septic tank size	1200 gal
Pumping tank size	900 gal
Effluent loading rate	0.25 gal/ft^2/day
Absorption area	1800 ft^2
Total length of laterals	360 ft
Lateral diameter	1¼ in.
Lateral configuration	6 x 60 ft lines
Supply line length	70 ft
Supply line diameter	2 in.
Manifold placement	side
Hole size*	5/32 in.
Hole spacing	5 ft
Number of holes	72
Pressure head	3 ft
Flow per hole	0.50 gpm
Total flow	36 gpm
Elevation head	5 ft
Friction head	1.8 ft
Pressure head	3 ft
Total head	9.8 ft
Pump requirements	36 gpm, 9.8 ft of head
Storage volume in laterals	32.4 gal
Storage volume in supply line	13.6 gal
Total storage volume	46.0 gal
Dosing volume	180 gal
Dosing depth	10 in.
Check valve needed?	No

*Data on hole size, spacing, pressure head and flow must be listed for each line for systems where lines are different (such as sloping lots).

Appendix 2. Pipe and fittings for example LPP (Chapters 3 and 4)

Type	Size	Quantity	Description
Pipe, 160 psi	4 in.	10 ft	Connects septic tank to pumping tank
Pipe, 160 psi	2 in.	70 ft	Supply manifold
Pipe, 160 psi	1½ in.	10 ft	Connects pump to supply manifold
Pipe, 160 psi	1¼ in.	380 ft	Laterals plus extra length for turn-ups
Tee*	2 x 2 x 1¼ in.	5	For joining manifold to first 5 laterals
Elbow	2 x 1¼ in.	1	For joining manifold to last lateral
Elbow	1¼ in.	12	6 for joining laterals to manifold 6 for turn-ups
Male adapter	1¼ in.	6	For turn-ups
Threaded cap	1¼ in.	6	For turn-ups
Male adapter**	1½ in.	3	1 for pump outlet 2 for gate valve
Elbow	1½ in.	1	For pump to supply line connection
Bushing	1½ x 2 in.	1	For pump to supply line connection
Threaded union	1½ in.	1	For quick removal of pump
Gate valve	1½ in.	1	PVC or brass
PVC glue	1 qt	1	
PVC primer	1 qt	1	

*Details of these connections are shown in Figures 5 and 6.

**Size of this adapter and the following fittings depend on size of pump outlet.

Appendix 3. Other supplies for example LPP

Type	Size	Quantity	Description
Pump	0.4 hp	1	Submersible effluent pump
Switch		1	Sealed level controls adjustable to 10 in. drawdown
Alarm		1	Sealed mercury float switch and alarm light
Wiring			Approved outdoor receptacle, wire and conduit for 110V service
Septic Tank	1200 gal	1	Two compartment
Pumping Tank	900 gal	1	Single-compartment septic tank
Risers		2	Concrete risers or well tiles, or blocks and mortar—to raise tank lids six in. above final grade
Lids		2	To fit on risers
Gravel	¾-1 in.	5 yds.	Washed
Concrete blocks		2	Raised support for pump
Nylon rope		8 ft	To remove pump from tank
Mortar			To seal around supply line and riser
Grass seed			If needed to establish grass cover
Lime			
Fertilizer			
Mulch			

Appendix 4. LPP Construction Inspection Checklist

Site Identification

Site Preparation — Date ______

1. Is the site in the right location? ______
2. Roped off and protected from traffic? ______
3. Small trees and brush cleared? ______
4. Provisions for site drainage? ______
5. Fill incorporated with underlying soil? ______
6. Distribution field shaped to shed water? ______
7. Lines staked out properly? ______
8. Comments ______

Construction Check — Date ______

1. Tanks:
   - Proper size and type? ______
   - Installed properly? ______
2. Manifold and laterals:
   - Depth of gravel suitable? ______
   - Placement of dams? ______
   - Holes drilled properly and placed downward? ______
   - Manifold and laterals connected properly? ______
3. Water conservation devices installed in house? ______
4. Comments ______

Operation Check — Date ______

1. Pump and switches operating? ______
2. High water alarm operating? ______
3. Electric receptacle outside pump tank? ______
4. Pressure head in lateral lines?
   a. Lowest ______
   b. Highest ______
5. Comments ______

Final Landscaping — Date ______

1. Site shaped to shed rainwater? ______
2. Any low areas? ______
3. Diversion drains? ______
4. Downspout drains directed away from system? ______
5. Seeded and mulched? ______
6. Comments ______

Appendix 5. Maintenance Checklist

Site Identification Date ______

System Type ______

Site Examination

1. Any rainfall in last 3 days? ______
2. Effluent ponded on surface? ______
3. Indications of recent ponding? ______
4. Ground above system damp and mushy compared to surrounding area? ______
5. Noticeable odor of sewage? ______
6. Other

If any "Yes" answers, sketch location and extent on back of page.

Site Maintenance

1. Condition of vegetable cover ______
2. Site drainage (roof water, ditches, etc.) ______
3. Riser and lid ______
4. Turn-ups ______
5. Erosion ______

Pump Examination

1. Pump and switch properly plugged in? ______
2. Pump operating? ______
3. Switch operating? ______
4. Good seal where supply line leaves tank? ______
5. Quality of effluent
   - Greasy? ______
   - Sludge accumulation? ______
6. Measure pressure head and adjust.
   - Initial head ______
   - Adjusted head ______
7. Comments on problems noted above. ______

Comments From Homeowner. ______

Additional Observations. ______