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Decentralized Systems Technology Fact Sheet
Low Pressure Pipe Systems

DESCRIPTION

Although not an alternative to all unsuitable soils, the low-pressure pipe (LPP) system has proven to be useful for some specific conditions, where conventional systems frequently fail. Less than one-third of the land area in the U.S. has soil conditions suitable for conventional soil absorption systems. Numerous innovative alternatives to the conventional septic tank soil absorption system have evolved in response to the demand for an environmentally acceptable and economical means of disposing domestic wastewater onsite and contending with the restrictive soil conditions common in many states.

Originating in North Carolina and Wisconsin, a LPP system is a shallow, pressure-dosed soil absorption system with a network of small diameter perforated pipes placed 25.4 to 45.7 cm (10 to 18 inches) deep in narrow trenches, 30.5 to 45.7 cm (12 to 18 inches) wide.

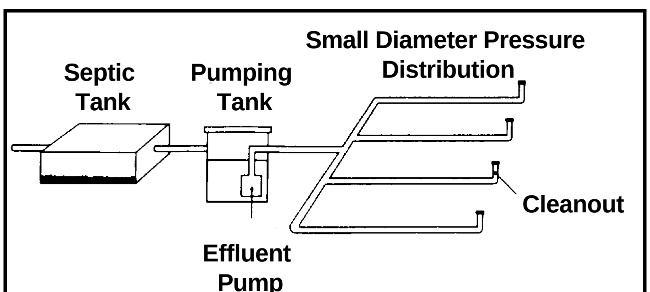
LPP systems were developed as an alternative to conventional soil absorption systems to eliminate problems such as: clogging of the soil from localized overloading, mechanical sealing of the soil trench during construction, anaerobic conditions due to continuous saturation, and a high water table. The LPP system has the following design features to overcome these problems:

- Shallow placement.
- Narrow trenches.
- Continuous trenching.
- Pressure-dosed with uniform distribution of the effluent.
- Design based on areal loading.
- Resting and reaeration between doses.

Process

The main components of a LPP system are (see Figure 1):

- A septic tank or an aerobic unit.
- A pumping (dosing) chamber (a submersible effluent pump, level controls, a high water alarm, and a supply manifold).
- Small diameter distribution laterals with small perforations (holes).



Source: USEPA, 1992.

FIGURE 1 LOW-PRESSURE PIPE SYSTEM

The septic tank is where settleable and floatable solids are removed and primary treatment occurs. Partially clarified effluent then flows by gravity from the tank to a pumping chamber, where it is stored until it reaches the level of the upper float control, which activates the pump. The level controls are set for a specific pumping sequence of 1 to 2 times daily, with each dose providing 5 to10 times the lateral pipe volume, which allows breaks between doses for the soil to absorb the effluent. The pump turns off when the effluent level falls to the level of the lower float control. However, the dosing mechanism and frequency may vary for different systems. The pumping chamber is usually sized to provide excess storage of at least one day's capacity (above the alarm float) in case there is a power failure or pump malfunction. If the pump or level controls should fail, the effluent would rise to the level of the alarm control, turning the alarm on.

The pump moves the effluent through the supply line and manifold to the distribution laterals in the trenches under a low pressure 0.91 to 1.5 meters (about 3 to 5 feet of pressure head). These laterals are a network of PVC pipes that have small, drilled, perforated holes, usually 0.4 to 0.64 centimeters (5/32 to 1/4 inches) in diameter and spaced at 0.76 to 1.5 meters (2 ½ to 5 feet) intervals (exact dimensions are determined for each system).

The laterals are placed in narrow gravel-filled trenches 254. To 46 centimeters (10 to 18 inches) deep and spaced 1.5 or more meters (5 feet) apart. The narrow trenches allow enough storage volume so that the depth of the effluent does not exceed 5.1 or 7.6 centimeters (2 or 3 inches) of the total trench depth during each dosing cycle.

APPLICABILITY

Chatham County, North Carolina

A study was conducted in Chatham County, North Carolina, to evaluate the effectiveness of a sand filter/LPP system in slowly permeable soils of a Triassic Basin. Subobjectives of this study were to evaluate the operation and functioning of system components, assess treatment effectiveness of a buried pressure-dosed sand filter, and determine the hydraulic capacity and wastewater treatment potential of this soil profile.

The system included a 3785-liter (1,000-gallon) septic tank, a Tyson flow splitter, two 3785-liter (1,000-gallon) dosing tanks, a pressure-dosed buried sand filter, and two similar side-by-side LPP drain fields. One drain field was dosed with septic tank effluent while the other drain field received sand filter effluent. This system was designed for a three-bedroom house and began operating in August 1988.

One-half of the effluent from the septic tank flowed into Pump Tank 1, which dosed the sand filter. Effluent from the sand filter drained into a dosing tank and was then pumped to the first drain field. The second half from the septic tank flowed into Pump Tank 2, which dosed the other LPP field. The LPP system consisted of lateral pipes (PVC) 3.2 centimeters (1.25 inches) in diameter, with 0.76 and 0.36 centimeter (5/32 and 9/64 inch) holes and buried in trenches 25.4 centimeters (10 inches) wide. The design loading rate on the drain field was .005 meters cubed per day per meters squared (0.13 gallons per day per square foot), and each drain field contained eight laterals on 1.5-meter (5-foot) centers.

It was observed during this study that the electrical and mechanical components performed quite well. There was excellent removal of fecal coliform organisms within 3 meter (10 feet) downslope of both drain fields, and little to no NO_3-N and NH_4-N were detected in perched waters downslope of the LPP drain field receiving sand filter effluent. The excellent nitrogen removal resulted from the nitrification that occurred in the sand filter and the denitrification that occurred due to shallow placement in a biologically active saturated zone.

The system performed well except for some partial clogging of the pressure distribution systems, breakage of some lateral turnups, and infiltration of perched water into the tanks. Extensive flushing of solids and fecal coliform occurred with large rainfall events (a 10.2 centimeter or 4-inch downpour associated with a hurricane). These observations indicate that the tanks should be watertight and require greater oversight and maintenance than conventional systems.

ADVANTAGES AND DISADVANTAGES

Some advantages and disadvantages of LPPs are listed below:

Advantages

- Shallow placement of trenches in LPP installations promotes evapotranspiration and enhances growth of aerobic bacteria.
- Absorption fields can be located on sloping ground or uneven terrain that are otherwise unsuitable for gravity flow systems.
- Improved distribution through pressurized laterals disperses the effluent uniformly throughout the entire drain field area.
- Periodic dosing and resting cycles enhance and encourage aerobic conditions in the soil.
- Shallow, narrow trenches reduce site disturbances and thereby minimize soil compaction and loss of permeability.
- LPPs allow placement of the drain field area upslope of the home site.
- LPPs have reduced gravel requirements.
- There is a significant reduction in land area required for the absorption system.
- Costs are comparable to other alternative typical distribution systems.
- LPPs overcome the problem of peak flows associated with gravity-fed conventional septic systems.

Disadvantages

- In some cases, the suitability could be limited by the soil, slope, and space characteristics of the location.
- A potential exists for clogging of holes or laterals by solids or roots.
- LPPs have limited storage capacity around their laterals.
- There is the possibility of wastewater accumulation in the trenches or prolonged saturation of soil around orifices.
- LPPs could experience moderate to severe infiltration problems.
- Regular monitoring and maintenance of the system is required; lack of maintenance is a sure precursor to failure.

DESIGN CRITERIA

Soil requirements

According to state/local regulations, a LPP system should be located in soils that have suitable or provisionally suitable texture, depth, consistence, structure, and permeability. A minimum of 0.3 meters (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. Also, a minimum of 0.5 to 0.76 meters (20 to 30 inches) of soil depth is needed for the entire trench.

Space requirements

The distribution network of most residential LPP systems utilizes about 93 to 465 meters squared (1,000 to 5,000 square feet) of area, depending on the soil permeability and design waste load. An area of equal size must also be available for future repair or replacement of the LPP system. If the space between the lateral lines will be used as a repair area, then the initial spacing between the lateral lines must be 10 feet (3 meters) or wider to allow sufficient room for repairs. Although size requirements for a LPP system vary depending on the site, in general, an undeveloped lot smaller than one acre may not be suitable for a LPP system.

Drainage requirements

The septic tank, pumping chamber, and distribution field should not be located in areas where hydraulic overloading could occur from surface runoff.

Two critical drainage requirements are surface water diversion and interception of shallow perched waters upslope of the system. These conditions are most important on sites with concave or lower slope positions with soils having a restrictive horizon near the surface. If this condition exists, surface water and perched groundwater must be diverted away from the LPP system.

Topography requirements

There are special design considerations for LPP distribution fields located on slopes. The distribution field must be elevated higher than the pumping chamber so that gravity does not cause the effluent to flow out of the pumping chamber and into the distribution field when the pump is not operating. If the topography does not allow for this, then the LPP system must be designed to ensure that effluent will not leave the pumping chamber when the pump is turned off (e.g., use of an anti-siphon hole or other control in the discharge piping in the pumping chamber).

PERFORMANCE

Two critical factors that affect the performance of a LPP system are dosing and distribution of the effluent. The first factor, the dosing and resting periods, helps maintain aerobic conditions in the soil and around the distribution trench. A LPP system cycles back and forth between aerobic and anaerobic conditions, which can lead to favorable conditions for nitrification and denitrification. During the aerobic resting period, nitrification occurs. When the system is loaded with wastewater, anaerobic conditions result in denitrification.

The second factor, distribution of the effluent, cannot be overemphasized in the performance of any LPP system. The effluent must be distributed evenly over the soil absorption field without hydraulically overloading it.

The suitability of a LPP system is affected by the soil, slope, available space, and anticipated wastewater flow.

OPERATION AND MAINTENANCE

A properly designed and installed LPP system requires very little ongoing maintenance. However, periodic inspection and maintenance by professional operators is required for performance. Studies have documented a 40 to 50 percent failure rate when maintenance was left to the homeowners rather than professionals. North Carolina now requires a minimum monitoring frequency of every 6 months by certified subsurface system operators.

The septic tank and pumping chamber should be checked for sludge and scum buildup and pumped as needed. Screens or filters can be used to prevent solids from escaping from the septic tank. However, some solids may accumulate at the end of the lateral lines, which should be flushed out once a year. Turnups installed at the distal ends of laterals facilitate this process.

The manufacturer's recommendations should be followed when servicing a LPP system in order to ensure longer life and proper function of the pumps and other mechanical/electrical components of the system. The pump should be removed annually for cleaning and inspection. Pump replacements should be selected based on the specific system design rather than the horsepower rating. The pump must be checked for signs of oil leakage, worn or broken components, or for damaged parts that need to be replaced. When reinstalling the pump, check the level switches to ensure proper operation. An elapsed run-time meter and pump impulse counter should be installed within the control panel to facilitate system troubleshooting and monitoring of performance.

In the event of a power failure or pump malfunction, a visible and audible alarm is activated when the effluent rises to the level of the alarm control. The alarm should be located at the control panel to facilitate testing by the professional operator. Listed in Table 1 are general operation and maintenance (O&M) tasks for large LPP systems.

Although the LPP system overcomes many of the problems associated with the conventional septic tank system, there has been documentation of some operational problems with small, poorly maintained, onsite LPP systems in North Carolina. Large LPP systems in North Carolina were shown to have similar problems as well, but on a larger scale because of the size of the systems. Careful site-specific designs and regular maintenance by trained, professional operators are essential for overcoming these problems. Large LPP systems can have problems such as:

- Excess infiltration: Drain fields are very susceptible to hydraulic overloading due to infiltration. In areas with improper drainage, leaky pump tanks can become sinks for nearby groundwater. Large systems that include extensive collection sewers have a higher probability of inflow/infiltration. Watertight septic tanks and pumping chambers are essential for system performance.

- Faulty hydraulic design: For optimum performance of the system, the pumps, supply lines, manifold, laterals, and orifices must be properly designed, sized, and located. Improper hydraulic design can result in problems such as localized overloading, excessive head loss, and nonuniform distribution. The dosing volume must be large enough (5 to 10 times the lateral pipe volume) to adequately pressurize the pipe network. The manifold should feed the highest lateral first in order to improve effluent distribution to the drain field.

- Drainage: Surface runoff must be diverted away from the LPP system. If the water table becomes high in level sites, groundwater beneath community-scale LPP systems can mound up into soil absorption field trenches and cause failure. The trenches on sloping fields can experience hydraulic overloading due to subsurface flow from higher areas.

- Improper installation: Since the performance of a LPP system is sensitive to any variations in hydraulic design, proper installation is essential. Some common installation problems are; incorrect orifice size and spacing, installation of undersized substitute pumps, incorrect adjustment of level control floats and pressure head, installation of laterals at incorrect elevations, and failure to install an undisturbed earth dam in each trench where the manifold feeds each lateral. Earth dams are used at the beginning of each lateral trench to prevent redistribution of effluent from higher trenches to those lower on the landscape. Dams are not used elsewhere in the trenches.

- Orifice and lateral clogging: Poor septic tank maintenance can result in solids reaching the soil absorption field and clogging the orifices. In some older LPP systems, it was observed that slime had built up in long supply lines, manifolds, and laterals. Current practice includes sleeving the small diameter laterals within a 10.2 centimeter (4-inch) diameter corrugated drainage tubing or drain field pipe and laying the small diameter distribution laterals such that the perforations point upward.

TABLE 1 GENERAL MAINTENANCE SCHEDULE

Component	O&M Requirement
Collection system	Check for I/I and blockages.
Septic tank	Check for solids accumulation, blockages, or damage to baffles, and excess I/I.
Pump septage as required.	
Pumping chamber	Check pumps, controls, and high water alarm. Check for solids accumulation and pump as required; check for I/I.
Supply lines	Check for pipe exposure and leakage in force mains.
Soil absorption field	Provide maintenance of field and field's vegetative cover; repair broken lateral turnups.
Check for erosion and surfacing of effluent.	

Source: Marinshaw, printed with permission, 1988.

COSTS

The cost of a LPP system depends on the contractor, the manufacturers, the site, and the characteristics of the wastewater. The overall cost of a LPP system is also largely determined by the capital and O&M expenses. The annual operating costs for LPPs include power consumption for the pumps, pipe and other miscellaneous equipment repair, replacement of the components, and monitoring costs for a professional operator.

In a 1989 study of LPP use among different counties in North Carolina, it cost an average of $2,600 to install a LPP system for a three-bedroom house. The average installation cost across counties ranged from $1,500 to $5,000 and was inversely related to the extent of LPP use within a county. Therefore, the more LPP systems that are installed within a community, the less the cost per system.

REFERENCES

1. Amoozegar, A.; E. W. West; K. C. Martin; and D. F. Weymann. Dec. 11–13, 1994. Performance Evaluation of Pressurized Subsurface Wastewater Disposal Systems. *On-Site Wastewater Treatment: Proceedings of the Seventh International Symposium on Individual and Small Community Sewage Systems*. Atlanta, Georgia.

2. Bomblat, C.; D. C. Wolf; M. A. Gross; and E. M. Rutledge. December 11–13, 1994. Field Performance of Conventional and Low Pressure Distribution Septic Systems. *On-Site Wastewater Treatment: Proceedings of the Seventh International Symposium on Individual and Small Community Sewage Systems*. Atlanta, Georgia.

3. Carlile, B. L. December 6–7, 1985. Soil Treatment Systems for Small Communities. *Proceedings of a Workshop on Utilization, Treatment, and Disposal of Waste on Land*. Soil Science Society of America. pp. 139–146. Madison, Wisconsin.

4. Cogger, C. G.; B. L. Carlile; and D. J. Osborne. 1982. *Design and Installation of Low-Pressure Pipe Waste Treatment Systems*. UNCA Sea Grant College Publication UNC-SG-82-03. North Carolina State University. Raleigh, North Carolina.

5. Hargett, D. L. 1984. *Technical Assessment of Low-Pressure Pipe Wastewater Injection Systems*. MERL. ORD. U.S. Environmental Protection Agency (EPA). Cincinnati, Ohio. Project Report Under Contract 68-03-3057, by RSE, Inc. Madison, Wisconsin.

6. Hoover, M. T. and A. Amoozegar. Sept. 18–19, 1989. Performance of Alternative and Conventional Septic Tank Systems. *Proceedings of the Sixth Northwest On-Site Wastewater Treatment Short Course*. pp. 173–203. University of Washington. Seattle, Washington.

7. Hoover, M. T.; A. Amoozegar; and D. Weymann. 1991. Performance Assessment of Sand Filter: Low Pressure Pipe Systems in Slowly Permeable Soils of a Triassic Basin. *On-Site Wastewater Treatment: Proceedings of the Sixth National Symposium on Individual and Small Community Sewage Systems*. Chicago, Illinois.

8. Hoover, M. T.; T. M. Disy; M. A. Pfeiffer; N. Dudley; and R. B. Mayer. 1995. *On-Site System Operation and Maintenance Operators Manual*. The National Environmental Training Center for Small Communities (NETCSC). West Virginia University. Morgantown, West Virginia.

9. Marinshaw, R. J. Feb. 8–9, 1988. Design of Large Low-Pressure Pipe Distribution Systems in North Carolina. *Presented at the National Environmental Health Association, Mid-Annual Conference*. Mobile, Alabama.

10. Sump and Sewage Pump Manufacturers Association (SSPMA). 1998. *Recommended Guidelines for Sizing Effluent Pumps*. SSPMA. Northbrook, Illinois.

11. Uebler, R. L. 1982. Design of Low-Pressure Pipe Wastewater Treatment Systems. 1982. *Southeastern On-Site Sewage Treatment Conference Proceedings*. North Carolina Division of Health Services and the Soil Science Department. North Carolina State University. Raleigh, North Carolina.

12. U.S. Environmental Protection Agency. May 1992. *Small Wastewater Systems: Alternative Systems for Small Communities and Rural Areas*. EPA 830/F-92/001. EPA Office of Water. Washington, D.C.

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