Chapter 9
Collection System Technologies

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COLLECTION SYSTEM TECHNOLOGIES

9.1 INTRODUCTION

A. **Purpose.** The purpose of this chapter is to identify and screen collection system alternatives that could be used to provide sanitary sewer service in areas served by a new wastewater treatment facility.

9.2 COLLECTION SYSTEM ALTERNATIVES

A. **Introduction.** The final layout and design of a collection system depends on several factors. The key factors include the type of collection system technology, the topography of the service area, utilities located in the road right-of-way (ROW), groundwater elevations, and the location of the treatment and treated water recharge site(s). Some of these factors will be determined early on in the planning process, while many of the site-specific factors are typically decided during the design process.

The installation of a wastewater collection system in the road ROW is very disruptive to traffic activity, especially since the busiest construction period often coincides with the summer tourist season. The use of trenchless technology to install a collection system must be considered during the planning and design processes to minimize disruptions. Trenchless technology is technology that allows installation of wastewater collection and transmission mains without digging a trench along the entire road ROW.

At the beginning of the planning process for a potential collection system, the system coverage must be estimated to calculate system length and system costs. Each type of collection system technology offers some flexibility on how (or where) individual sewers are installed, but the overall system coverage for the various technologies will generally be the same.

Several types of sanitary sewer collection systems are in use throughout the United States, each with advantages and disadvantages. Careful analysis must be performed during design in the area being sewered to determine the feasibility of a particular collection system. The purpose of this chapter is to identify collection system alternatives that could be used to connect future service areas to a wastewater treatment facility. The chapter presents several different types of collection systems and the associated advantages and disadvantages of each.

B. **Gravity Sewers and Lift Stations.** The most prevalent type of collection system is a traditional gravity sewer. This type of system involves the installation of sewers at a constant downhill gradient. The slope is designed to maintain a sufficient velocity within the sewer line to ensure that all solids stay suspended within the waste stream. The minimum size of a typical sanitary sewer is 8-inches. The pipe size increases proportionally with the expected wastewater flow. The sewer is installed at a constant slope until its depth becomes so great that a sewage pumping station (lift station) is needed to "lift" the flow to a wastewater treatment plant or to another gravity sewer. In flat terrain, several lift stations may be required before the flow is pumped to a treatment facility.

In most situations, homes along a gravity sewer connect into the system with gravity service connections from the building to the collector sewer. Houses that are below the street elevation use small pumps and a small diameter force main (1 to 2-inches) for discharging to the collector sewer.

The installation cost and ease of construction of a gravity sewer depend greatly upon the topography within a particular area and on the specific soil types. In areas where topography is consistently increasing or decreasing, the sewers can be installed close to minimum depth. In very hilly areas, deep sewers and/or lift stations may be required. This can significantly increase construction costs when compared with other options.

Advantages of gravity sewers include the following:

- A properly designed and installed gravity sewer requires little maintenance.
- A gravity system can be easily expanded to serve additional areas.
- The potential for odors in a properly designed gravity sewer is low.
- A gravity system is reliable, since it is not dependent upon electrical power for operation. When lift stations are used on collector sewers, electrical generators are provided to supply power during a power outage.

Disadvantages of gravity sewers include:

- Gravity sewers are installed at a constant slope, and thus can require deep excavations as the topography changes. They also have practical limitations in depth.
- If not installed properly, gravity sewers are prone to infiltration from groundwater, which reduces the wastewater carrying capacity of the pipe, increases pumping costs, and can affect treatment capacity and process effectiveness at the downstream treatment facility.
- May be limited by availability of appropriate lift station locations.
- Manholes required at change of direction which increases the amount of pipe cutting required thus adding to the potential loading of inflow and infiltration (I/I).

C. **Pressure Sewers with Grinder Pumps.** A pressure sewer system requires the installation of a grinder pump to serve each building or group of buildings. Wastewater flows by gravity into a pump chamber, where the sewage is shredded and pumped into a pressure sewer, eventually discharging to a gravity main or directly to a treatment facility. This type of technology has become more widely used over the past 20 years and is particularly suited to areas where there is a need to minimize excavation.

The typical pressure in this type of system is 5 to 40 pounds per square inch (psi). Pressure systems can be expanded to serve additional areas up to a design limit of 60 psi. Typically, systems can be expanded to serve a large number of additional homes, but the overall expansion capability tends to be less than that of a gravity sewer.

When connecting the pressure sewer lines into a gravity line or directly to a lift station, odor control systems may be required at the discharge point to mitigate odors created in the pressure sewer pipe. Also, manholes at the discharge point should be protected from corrosion resulting from high hydrogen sulfide concentrations.

Advantages of a pressure sewer include the following:

- The collection main is installed at a relatively shallow depth and is independent of grade changes. This allows shallower excavation, lower piping construction costs, and less overall disruption to the area due to a shorter installation construction period.
- A pressure sewer can serve areas of hilly terrain or marginal slope.

- The pressure sewer in the street is not subject to infiltration as a gravity sewer would be.
- The shredding action of the pump eliminates the need for a larger-size collection system. Pressure sewers tend to be much smaller diameter than a typical sanitary sewer, ranging from 1-1/4-inch to 4-inches, depending upon the expected design flow.

Disadvantages to this type of system include the following:

- Each building or group of buildings in the system would have to be equipped with a pump unit, which increases operation and maintenance requirements. Spare parts must be maintained for these units to minimize disruption of service.
- Each pump unit is dependent upon electrical power for proper operation; since the pumps are located at individual homes, municipal backup electrical power is typically not provided. Storage capacity is typically built into each pump chamber (normally 60 gallons). However, in a prolonged power outage, it would be possible for the wastewater flow to exceed this capacity and back up into the pipelines within the structures. This can be remediated by providing electrical connections on each pump unit to allow a service crew to connect a portable generator and pump out each unit during times of prolonged power outage.
- This system is more sensitive to seasonal flow conditions than a gravity sewer. In areas with extreme seasonal fluctuations, minimum flow conditions must be carefully quantified to be sure the sewage flow can properly travel through the system. If inadequate flow exists, solids can harden within the sewer and cause blockages.
- Training would be required to familiarize operating staff with maintenance of the pumps and pressure sewers.
- Ownership (purchase, install, own, maintain and operate) considerations need to be resolved prior to installation.

D. **Septic Tank Effluent Sewers.**

1. **General.** Septic tank effluent sewers use either new or existing septic tanks and are designed to transport septic tank effluent to a treatment facility. The use of septic tanks prevents a large portion of solids and grease from entering the sewer. An effluent screen located upstream of the discharge point helps to keep solids out of the sewer.

Septic tank effluent sewer systems require septic tank maintenance, including routine pumping and treatment of septage. Each septic tank should be inspected during sewer construction to replace those tanks that provide inadequate service. Inadequate tanks include those that are prone to infiltration, are insufficient in size, have inappropriate inlets or outlets, or do not meet current Title 5 requirements.

When connecting septic tank effluent into existing gravity systems, odor control systems may be required at the discharge point and downstream pump stations to mitigate odors caused by the hydrogen sulfide content in the effluent. Manholes at the discharge point should be protected from corrosion, which can occur as a result of the high hydrogen sulfide concentrations.

There are two types of septic tank effluent collection systems: (a) septic tank effluent pump systems; and (b) septic tank effluent gravity systems. A discussion of each system is presented in the following sections.

2. **Septic Tank Effluent Pump (STEP) System.** The STEP system involves the installation of an effluent pump immediately downstream of the septic tank (or within a baffled chamber of the septic tank), which pumps the effluent to a pressure sewer. Thus, the system is very similar to a pressure system.

The STEP system has the following advantages:

- The system can serve in areas of hilly or flat terrain.
- The pumps and piping can be installed at shallow depths, reducing construction costs and overall disruption associated with excavation.
- The pressure sewer in the street is not subject to infiltration, as a gravity sewer could be.
- Septic tank effluent pumps tend to be less expensive than grinder pumps because the need for a shredder is eliminated.
- Fewer solids are transported in the system, which reduces the potential for sewer blockages caused by solids deposition.

The STEP system has the following disadvantages:

- The septage must be periodically pumped from the individual septic tanks.

- The system relies on electrical power to operate the pumps and will not function during power outages. However, the pumps are frequently installed in tanks with relatively large storage capacity.
- A large number of pumps are required, which creates greater maintenance requirements of this system when compared to a gravity sewer.
- Hydrogen sulfide buildup is common within these pipelines, increasing the potential for odors and corrosion.
- Training is required to familiarize operating staff with maintenance of the pumps and pressure sewers.
- A treatment plant that receives flow from this type of system must be carefully designed because it will not receive the higher organic loading that is typically needed for biological nitrogen removal treatment processes.

3. **Septic Tank Effluent Gravity (STEG) System.** The STEG system can be used to transport effluent from septic tanks to a pumping station or treatment facility. Layout of the system is very similar to a gravity system.

Advantages of STEG sewers include the following:

- A flatter slope can be maintained in comparison with gravity sewers, because most of the larger solids have been removed in the septic tank. The flatter slope will allow the piping to be installed at shallower depths.
- The lack of solids allows smaller diameter pipes to be installed. Sizes typically range from 4 to 6-inches versus 8-inches or greater for a typical gravity sewer.
- Cleanouts can be installed instead of manholes, reducing installation costs.
- Very little maintenance is required on this type of system when compared to a pressure or vacuum system unless lift stations are used.

STEG sewers have the following disadvantages:

- The septage must be periodically pumped from the individual septic tanks.
- Hydrogen sulfide buildup is common within these pipelines, which increases the potential for odors and corrosion.
- They are not adaptable to hilly terrain.

- A treatment plant that receives flow from this type of system must be carefully designed because it will not receive the higher organic loading that is typically needed for biological nitrogen removal treatment processes.

E. **Vacuum Sewers.** Vacuum sewers are smaller in diameter than traditional gravity sewers and rely upon a vacuum created within the pipeline to draw the sewage towards a lift station. A vacuum pump located at the lift station pumps air out of the sewer, creating a vacuum inside the sewer. Sewage from individual homes flows by gravity to a vacuum valve pit. As sewage fills a chamber in the bottom of the valve pit, a sensor activates an automatic vacuum valve. When the valve opens, sewage is drawn into the sewer because of the pressure difference between the sewer and atmospheric pressure outside the valve. Each subsequent opening of the valve draws the sewage further downstream until it reaches the lift station, where it is pumped to a gravity sewer or treatment facility.

Advantages of vacuum sewers include:

- Vacuum sewers can be installed at shallow depths, which can reduce installation costs and excavation time.
- The infiltration potential tends to be low. Infiltration can occur if a pipe leaks or breaks in areas where the line is completely submerged in groundwater.
- Vacuum stations can be equipped with emergency generators, which allow the system to remain in operation during power outages. Power is not required at each property service like a grinder or STEP system.

A vacuum system has the following disadvantages:

- A vacuum must be constantly maintained in the pipeline for the system to work. Malfunctions in the line can affect the entire system and must be fixed quickly to keep the system operational. Leaks or malfunctions may also be difficult to locate.
- The potential for odor generation at the lift station is greater due to the vacuum pump air flow. This air flow must be treated to minimize odors.
- Operator training would be required to gain sufficient knowledge to operate and maintain the vacuum pipelines, vacuum lift stations, and emergency response procedures.
- This type of system is not readily adaptable to hilly terrain.

- To design a properly operating system, the design flows must be estimated as accurately as possible, and a detailed route survey must be performed. Vacuum systems are sized for specific cases and cannot be easily expanded to serve large numbers of additional homes.

F. **Combination of Technologies.** In many cases, the combination of terrain, soil conditions, and congestion of an area prevents one single type of sewer system from being cost effective. In these situations, the combination of two or more methods may achieve an optimum solution. The combination most widely used is pressure sewers discharging to gravity sewers.

In some cases, it is not feasible to combine methods due to the inherent characteristics of the specific technology. Septic tank effluent systems are designed to transport only liquids using a small diameter pipe. Thus, any other type of system which carries solids should not be able to connect into this system. Also, septic tank effluent systems are designed to lessen the organic loading to a treatment plant, and this advantage would be minimized if a septic tank effluent system discharged into a sewer carrying all the solids.

When considering a combination of technologies during design, a careful review should be made of the local conditions, and cost estimates should be prepared which include construction as well as operating and maintenance costs.