

# Sanitary Sewers

## What is a Sanitary Sewer?

Sanitary sewers, or wastewater pipelines, transport wastewater from homes and businesses to a centralized treatment plant. Along the way, some extraneous water may enter pipelines either from stormwater or groundwater, a problem commonly known as infiltration and inflow (I/I). Once wastewater reaches the plant, it is treated and returned to the environment. Wastewater conveyance and treatment are important because they help to prevent waterborne illnesses and promote general sanitation.

Sanitary sewers differ from storm sewers, which collect snowmelt and rainwater from sidewalks, yards and roadways and route it to nearby surface water. Although stormwater is generally not treated, some systems have implemented filtration devices to remove certain pollutants.

Sanitary sewers also differ from combined sewers, which transport both stormwater and wastewater to a centralized treatment plant. Many older sewer systems in U.S. city centers consist primarily of combined sewers but are surrounded by sanitary sewers in newer areas.

The sanitary sewer system contains sewer laterals that connect individual buildings to main sewer pipelines. However, sanitary sewers are more than a network of pipes. They are an entire conveyance system that includes pump stations, force mains, manholes, storage facilities and other components.

According to the U.S. Environmental Protection Agency (U.S. EPA), in 2010 there were approximately 16,000 sanitary sewer systems in the United States with over 740,000 miles of public sewer lines and 500,000 miles of private lateral sewers, serving about 190 million people.

## Sanitary Sewer Design

Most sewer systems are designed to take advantage of gravity flow. Therefore, their design depends heavily on topography, with sewer lines sloping downward toward a wastewater treatment plant at a lower elevation than the tributary system.

In areas with flat terrain, pipes are buried on a gradient, starting shallow, and going deeper until excavation becomes uneconomical. Then, a pump or lift station moves wastewater into a new pipe section at the minimum burial depth, which is typically five feet of cover. In areas with limited topographic relief or places where excavation is impossible, wastewater may be conveyed through pressure pipelines (for instance, force mains) by pump or vacuum.

Sanitary sewer design is also based on projected flow—the amount of wastewater that will move through the system based on population, industrial and commercial contributions, and inflow and infiltration. New sewer system design must conform to state and local regulations, many of which follow *Recommended Standards for*

*Wastewater Facilities*. But in general, when selecting pipe size and slope, consideration should be given to proper estimation of peak design flow. Pipelines should also support flow velocities that are appropriate for self-cleansing but are not so high as to cause pipe damage. Other system design considerations include land use, surface loading, sub-surface conditions and pipe material. Commonly used materials include chloride (PVC) pipe, prestressed concrete cylinder pipes, and ductile or cast iron pipes.

## Sanitary Sewer Overflows

A properly designed, operated and maintained sanitary sewer system is meant to collect and convey all of the wastewater that flows into it to a wastewater treatment plant. However, occasional unintentional discharges from municipal sanitary sewers – called sanitary sewer overflows (SSOs) – can occur. Overflows can result in sewage flowing into yards, streets or nearby streams as well as in basement backups in which sewage enters the first floor of a building.

During wet weather, infiltration and inflow can cause SSOs when flow exceeds the maximum system

capacity. These peak wet weather flows can also cause serious operating problems at wastewater treatment facilities. In addition, SSOs can occur during dry weather due to broken pipes or when flow becomes obstructed by debris, such as grease, roots, paper products, sand, and grit.



**Crack with infiltration (courtesy of Bergmann, Rochester, New York)**

## Prevention of SSOs by Design

For simpler systems, engineers have traditionally used Manning's equation (steady-state) for designing new and replacement pipes and pump stations. Using this equation, the system's capacity or flow rate is determined by cross-sectional area, hydraulic radius, slope and roughness (friction). For complex systems, it is common to apply more sophisticated methods that account for dynamic flow behavior.

In both cases, computerized programs are available through the public or commercial domain to perform these calculations. Advances in data availability, computing power and analytical software provide engineers and managers with better tools for planning and designing for capacity and overflow control. However, regardless of the tools or equations applied, designers should consider long-term operations and maintenance (O&M) concerns.

## SSO Regulations

Through the U.S. EPA's National Pollutant Discharge Elimination System, collection system owners are expected to address SSOs. Although there is no national regulatory program specific to SSOs, a number of U.S. EPA regions and state agencies have initiated programs to address them. EPA Region 4's [Management, Operation, and Maintenance \(MOM\) Program](#) is one example, along with state programs such as those in California, Oklahoma, and North Carolina. At this time, the U.S. EPA is considering modifications to the NPDES program concerning SSOs and peak flow management. The likely end result of this effort will be changes to sanitary sewer regulations.

## Sewer Use Ordinances

Sewer Use Ordinances (SUOs), established by the collection system, supplement building codes in directing sewer construction, O&M, and usage of sewer systems. In addition, SUOs provide guidance with respect to private

property assets, whereas construction codes do not. User charge rates are frequently adopted as part of SUOs and can help assure adequate funding for sanitary sewer systems when rate structures are based on equitable allocation of costs to different classes of customers. Some SUOs also require collection systems to set up regular O&M schedules. Operators and sewer departments establish O&M schedules through computerized maintenance management systems (CMMS) that track work orders and customer complaints.

### Key Components of Sewer Use Ordinances:

- Requirements for ownership and establishing sewer service
- Sewer use restrictions
- Maintenance
- Inspection and enforcement
- User charges and fees
- Private property financing

## Operation and Maintenance

A well designed O&M program with diligent implementation is critical to properly maintaining sewer system performance. Poor maintenance results in system deficiencies, such as blockages and mechanical failures, which can cause SSOs. Therefore, routine inspections are an important part of regular O&M.

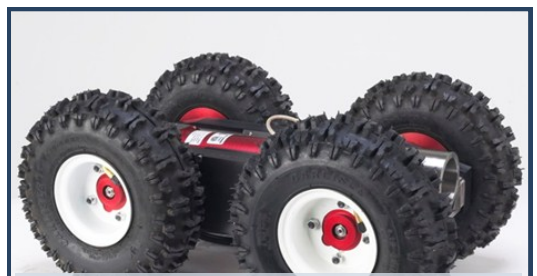
Wastewater utilities use inspection results to develop standardized defect coding for manhole and sewer assets. The [National Association of Sewer Service Companies](#) (NASSCO) certifies sewer analysts under the Pipeline Assessment Certification Program (PACP), the Manhole Assessment Certification Program (MACP) and the Lateral Assessment Certification Program (LACP). These programs provide the consistency needed to create comprehensive and reliable data for

use in prioritization, planning and renovation of collection systems.

Inspection techniques range from surface, manhole, and physical entry inspections to smoke and dye testing to technology-based methods involving cameras, lasers or sonar devices. According to the Water Environment Research Foundation, most gravity sewers are 4 to 12 in (10 to 30 cm) in diameter, and only eight percent are at or above 36 in (91 cm), the size many consider safe for man entry. However, new technologies allow operators to inspect smaller pipelines and decrease the need for confined space entry. In addition, some technologies can assess pipe condition without dewatering, saving time and money.

One of the most common inspection methods is closed-circuit television (CCTV), in which a camera is propelled through sewer lines in order to acquire video data and collect information on various defects that may occur in the pipe. Sewer scanning and evaluation technology is similar, providing a CCTV frontal image along with a 360 degree view of the pipe interior.

Laser-based scanning techniques create a surface profile of the pipe—identifying defects, debris buildup and more. Additionally, Ground Penetrating Radar technologies are available to identify voids outside of the pipe, and ultrasonic technologies can accurately measure wall thickness and density. Emerging technologies include omni-directional cameras, acoustic measuring techniques and wave impedance probes.



Self-propelled camera (courtesy of Aries Industries, Inc., Waukesha, Wisconsin)

## Sanitary System Improvements

Sewer system improvement programs are established, in general, to meet the following capacity-related objectives: 1) provide sufficient transport and treatment capacity for existing and future flows during both dry- and wet-weather conditions; 2) comply with regulatory requirements for capacity assurance and SSO avoidance; and 3) meet the level of service expected by customers to avoid system surcharging that may lead to basement or service backups.

As infrastructure ages, it becomes more susceptible to deterioration, clogging and collapse. Infiltration and inflow also become progressively worse, contributing to hydraulic overload and SSOs. Therefore, improvements via pipeline rehabilitation and replacement techniques are necessary to maintain system performance, renew the life of the system, and address SSOs.

Additional conveyance and supplemental storage are two more ways of addressing SSO problems in particular.

## Pipeline and Manhole Repair, Rehabilitation and Replacement

When a problem is identified in an existing sewer system, usually through one of the inspection methods listed above, pipes must be repaired, rehabilitated or replaced. Point repairs apply to short segments of pipe and allow the pipe to function to the end of its useful life. Repair techniques range from grouting to robotic localized repair to sleeves and liners. In contrast, pipeline rehabilitation can extend the life of the pipe and provide structural strength. The most widely used rehabilitation



**Segmental sliplining**

(courtesy of Southwest Pipeline & Trenchless Corp., Gardena,

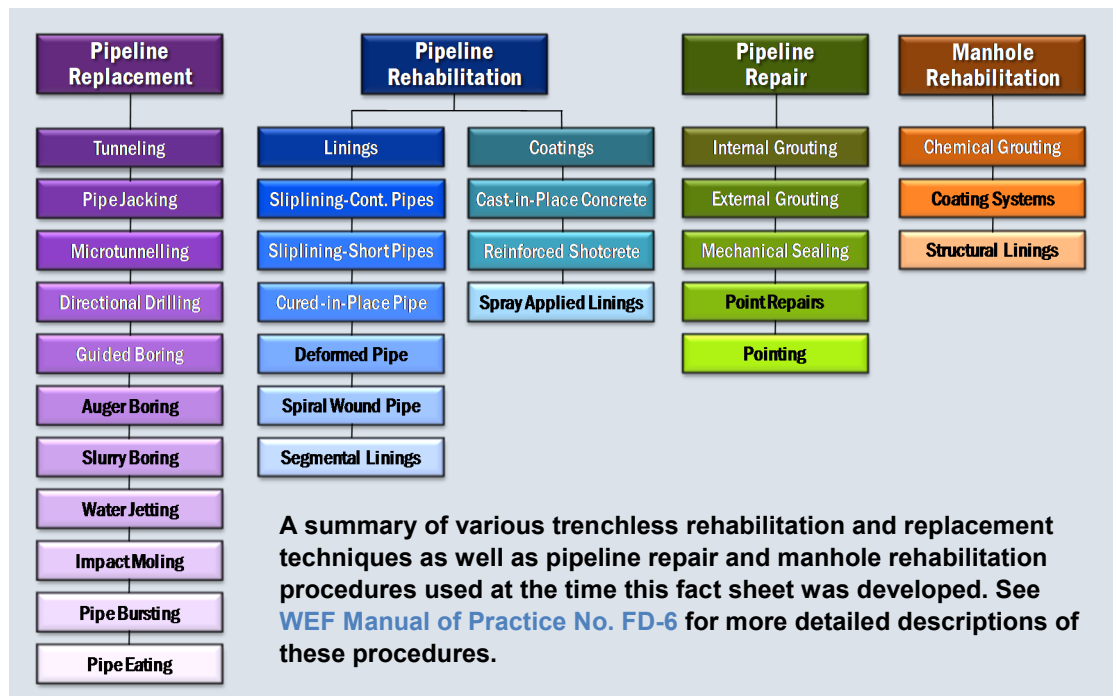
techniques involve liners, but can also include panel systems and coatings. Finally, replacement can be accomplished through either conventional open-cut or trenchless methods, which are techniques that minimize soil disruption. Most trenchless techniques use the old pipe as a guide or require a carrier pipe. Various trenchless methods are listed under pipeline replacement and pipeline rehabilitation in the figure below.

## Lateral Repair, Rehabilitation and Replacement

Two types of laterals connect sanitary sewer mains to building connections, upper and lower laterals. Lower laterals connect mains to a cleanout near the property line and are typically, but not

always, owned and maintained by the collection system. Upper laterals run from this cleanout to the customer's home and are typically, but not always, owned and maintained by the property owner.

Many wastewater utilities repair, rehabilitate or replace lower laterals. Yet, few property owners perform similar maintenance on the upper lateral or even recognize that it is their responsibility. However, private property laterals can account for half of I/I entry. Therefore, some wastewater utilities have developed programs to help property owners address lateral problems. This topic is beyond the scope of this fact sheet, but more information on these programs is available through WEF's [Private Property Virtual Library](#).



## WEF Resources

### Alternative Sewer Systems

MOP FD-12, Second Edition. 2008.

### Gravity Sanitary Sewer Design and Construction

MOP FD-5, 2nd Edition. 2007.

### Wastewater Collection Systems Management

MOP 7, 6th Edition. 2008.

### Existing Sewer Evaluation and Rehabilitation

MOP FD-6, 3<sup>rd</sup> Edition. 2009.

### Guide to Managing Peak Wet Weather Flows in Municipal Wastewater Collection and Treatment Systems. 2006.

### Private Property Virtual Library

[www.wef.org/PrivateProperty/](http://www.wef.org/PrivateProperty/)

### Prevention and Control of Sewer System Overflows

MOP FD-17, 3<sup>rd</sup> Edition. Coming summer 2011.

### Perspectives on Collection Systems Rehabilitation and Replacement – Webcast series. 2010-2011

Collection Systems annual specialty conference

## Citations

U.S. Environmental Protection Agency. "Review of Sewer Design Criteria and RDII Prediction Methods." January 2008. EPA/600/R-08/010

U.S. Environmental Protection Agency. "State of Technology for Rehabilitation of Wastewater Collection Systems." July 2010. EPA/600/R-10/078

U.S. Environmental Protection Agency. "Computer Tools for Sanitary Sewer System Capacity Analysis and Planning." October 2007. EPA/600/R-07/111

Great Lakes-Upper Mississippi River Board of State Public Health and Environmental Managers. "Recommended Standards for Wastewater Facilities." 2004.

Water Environment Research Foundation. "An Examination of Innovative Methods Used in the Inspection of Wastewater Systems." 2004.

## Acknowledgements

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