Core Attributes of Effectively Managed Wastewater Collection Systems

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Developed in partnership by:

APWA
AMERICAN PUBLIC WORKS ASSOCIATION

ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

NACWA
A Clear Commitment to America's Waters

Water Environment Federation®
Preserving & Enhancing the Global Water Environment

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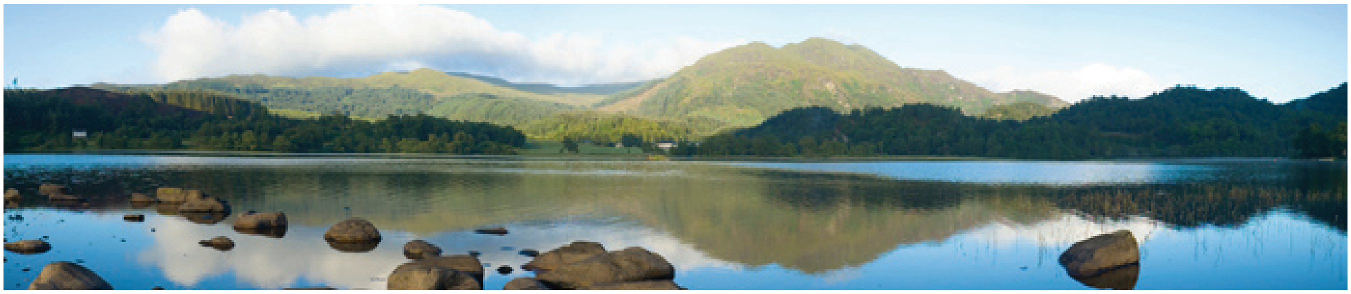


1.0 Introduction and Purpose

The American Public Works Association (APWA), American Society of Civil Engineers (ASCE) National Association of Clean Water Agencies (NACWA) and the Water Environment Federation (WEF) are committed to advancing effective management of our nation's wastewater infrastructure and to providing wastewater treatment plants (WWTPs) with tools for maintaining infrastructure in the most responsible, efficient way possible.

The wastewater collection system is a critical element of the wastewater infrastructure in the United States. The Clean Water Act generally prohibits sanitary sewer overflows (SSOs) discharges to waters of the U.S. However, the U.S. Environmental Protection Agency (EPA) has not established national guidance for design or operation of sanitary sewer systems. As a result, separate sanitary collection system managers still do not have clear, consistent national guidelines on which to base management of their systems.

In response, the above-named organizations worked collaboratively to engage a broad group of industry stakeholders to identify and develop good engineering practices and core attributes essential to managing and operating separate sanitary collection systems. Collectively, these organizations are referred to in this document as the Core Attribute Partner Organizations or "Partner Organizations."

Many states have used their existing authority under statute to develop programs for management and oversight of collection systems. This patchwork of programs has had some success in parts of the country, but there is no consistently applied national guidance upon which collection system managers can rely. These core attributes were defined to present the key principles that support a good management system. Many communities have developed programs and incorporated specific technologies and tools that go above and beyond the performance levels resulting from these core attributes. They are recognized as necessary to meet specific local objectives. The core attributes are intended to support existing state programs, not to conflict with or preempt state efforts.

In the absence of clear federal guidance, the Partner Organizations have developed these baseline attributes as fundamental elements in the effective management of sanitary sewer collection systems. These core attributes are intended to provide guidance for wastewater agency[1] collection system managers to evaluate their existing programs and confirm they are performing according to industry good engineering practices, or have practices that are lacking and need enhancement. Implementation of a collection system management program incorporating these attributes will vary from one system to the next based on size, organizational structure, and the character of the waste stream, the history of the system, needs, and availability of resources. Through development and implementation of a management program encompassing these attributes, wastewater agencies can provide efficient and effective collection system maintenance and operation while protecting public health and the environment.

The following core attributes should be used in conjunction with other industry documents that expand on these engineering approaches. References have been provided to key resources available from the Core Attribute Partners and other organizations, including manuals of practice, research projects, and case studies for wastewater agencies and collection system managers interested in more detail.

1 Collection systems may be operated by a wastewater agency or as publicly-owned community infrastructure. This document uses the term "wastewater agency" or "agency" to refer to the system operator.

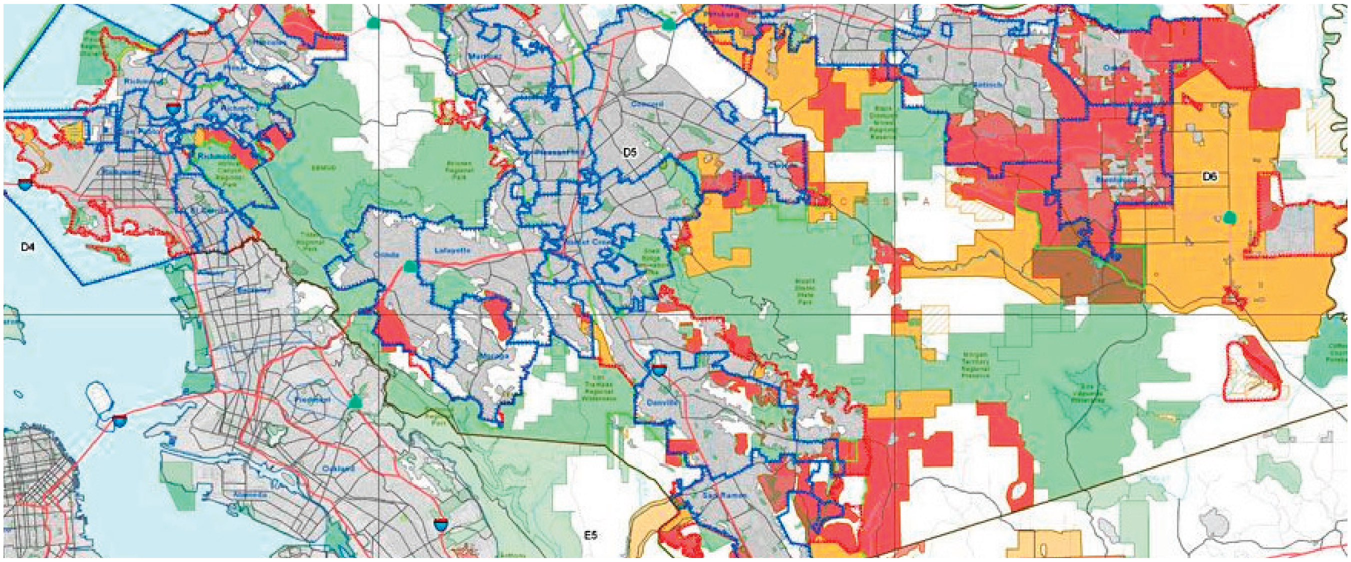
2.0 Core Attributes

The efficient operation and management of collection system assets is critical to minimizing performance failures and potential effects. Efficient operation and maintenance of a collection system requires several essential elements regardless of a wastewater agency's local performance requirements. Documenting programs, practices, and protocols helps produce successful and efficient performance of collection systems. The Core Attribute Partners jointly have developed a list of essential attributes for the efficient management of the wastewater collection system:

- Implement and maintain a system inventory and information management system.
- Implement and maintain a records management system.
- Adopt and implement a safety and training program.
- Develop and implement an overflow, emergency response, and reporting procedures.
- Perform timely and adequate system operation and maintenance.
- Develop and implement source control measures.
- Conduct system structural condition assessment and evaluation.
- Conduct system hydraulic capacity assessment, evaluation, and assurance.
- Adopt and use standard design, construction, and inspection attributes.
- Develop and implement a communication and outreach program.
- Develop and implement procedure to identify and enact program monitoring, measurement, and modifications.
- Ensure adequate and sustainable funding revenue source and reliable accounting practices.

Because there is significant interdependence among these attributes, it is important that all 12 are implemented as part of an integrated program to provide a properly managed and operated system. They are discussed in greater detail in this document.

While it is anticipated that effectively managed wastewater collection systems, regardless of size, will have elements of the core attributes, it is anticipated that operators of larger collection systems will address these attributes in greater detail than operators for small systems. In developing a comprehensive program based on these attributes, each wastewater agency should review its legal authority to ensure that it is sufficient to implement the planned program.



Core Attribute 1:
System Inventory and Information Management

Description

To efficiently manage the collection system, the wastewater agency needs to provide staff with suitable resources to enable effective collection, storage, evaluation, forecasting, and communication of data and information. Design, construction, and maintenance information needs to be readily available to meet a wastewater agency's performance goals and system maintenance requirements. The wastewater agency should plan, design, and implement data and information systems and processes the way it would a capital improvement project.

The information management system needs to be able to identify and locate system assets, relevant attributes, performance records, and reporting documents. The type and extent of information management system will vary based on system size and the wastewater agency resources. Many wastewater agencies use geographic information system (GIS) for storing, managing, analyzing, and mapping spatially referenced information of the collection system. Wastewater agencies also can use an information database that is integrated within a maintenance management system and linked to GIS.

Benefits

Effective system inventory and information management programs can provide several benefits to the wastewater agency and public:

- Provides necessary information to effectively respond to service requests.
- Improves knowledge of system components and connectivity.
- Allows efficient operation and maintenance system wide.
- Generates consistent and reliable planning and forecasting information to improve management decisions.
- Builds confidence in analysis and decisions.
- Reduces unexpected service disruptions and other risks.
- Supports continual improvement of system.
- Creates the validation of needs assessment within a Capital Improvement Plan (CIP).

Elements

Asset Identification and Documentation

Knowledge of what assets are in the collection system and how they are connected provides the foundation for achieving performance goals. Size and complexity of the collection system and performance goals will influence how asset data are stored and displayed. Procedures are needed for keeping system attributes current with system additions or modifications.

Data and Process Needs Assessment

When a wastewater agency wants to begin or improve their data management program, they must first understand the way data flows through their organization. Managers use data mapping to chart where or how data is generated, where it resides, and how it is used. Managers also can use this exercise to identify data gaps and needs internally and externally.

Information Management Plan Development

The wastewater agency's goals and results of needs assessment form the basis for an information management plan. The plan should include short- and long-term prioritized data needs. The plan should assess what data will be collected; who is responsible for its generation and integration throughout the wastewater agency; where it will reside from creation to storage; and what resources and schedules are required to accomplish the work. The plan should outline data needed to determine if each functioning level of the wastewater agency is meeting performance objectives.

Information Management Plan Implementation

The implementation plan will include a sequence of activities and a schedule for implementation. Standard protocols, staff training programs and ongoing systems performance evaluation should be included in the implementation plan.

Process Monitoring Adjustments

Managing and analyzing data is a continuous process. The plan will include performance targets established for various operating levels of the wastewater agency. The information management system should be designed to provide reports that show performance results over specified periods. The results can be compared with performance targets to enable appropriate process adjustments.

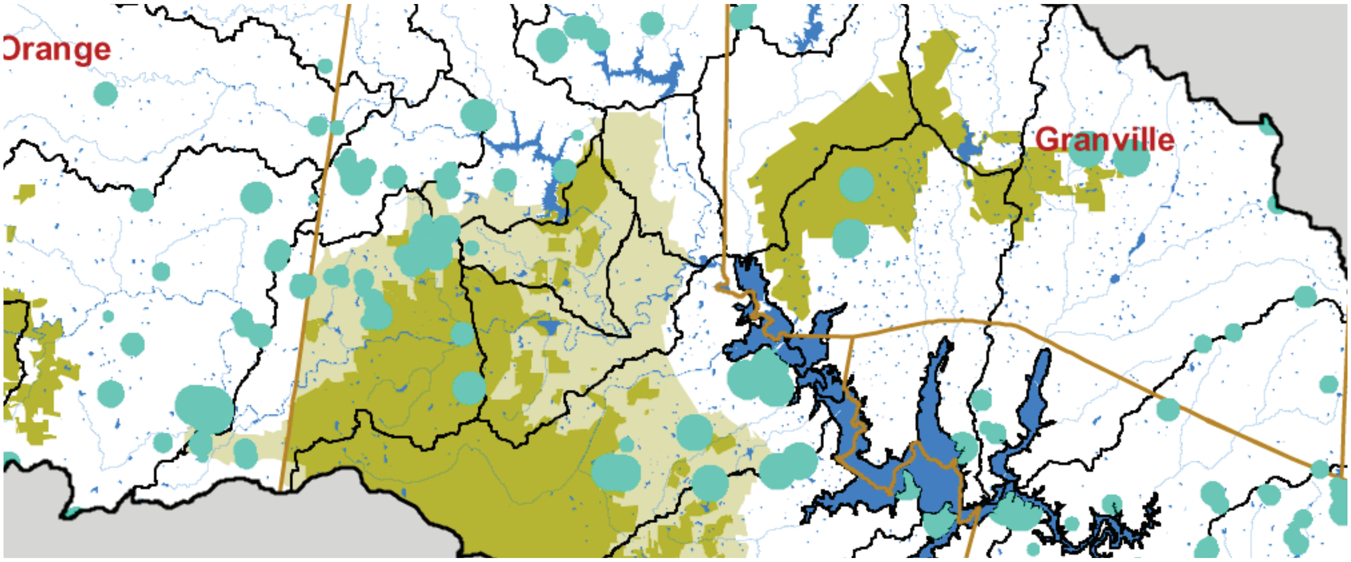
Resources

Arbour, R., and Kerri, K. (2009) *Collection Systems; Methods for Evaluating and Improving Performance, 2nd edition*; Office of Water Programs, California State University: Sacramento, California.

National Association of Clean Water Agencies (2004) *Continual Improvement in Utility Management: A Framework for Integration*; National Association of Clean Water Agencies: Washington, D.C.

Water Environment Federation (2009) *Wastewater Collection System Management,* 6th edition, Manual of Practice No. 7; Water Environment Federation: Alexandria, Virginia.

Water Environment Federation (2006) *Guide to Managing Peak Wet Weather Flows in Municipal Wastewater Collection and Treatment Systems*; Water Environment Federation: Alexandria, Virginia.



Core Attribute 2:
Maintenance Management System

Description

Keeping records of maintenance activities is essential to track performance, optimize maintenance, and identify areas requiring frequent attention. Maintenance management systems enable utilities to track and document system maintenance and performance. Many wastewater agencies use maintenance vehicles equipped with onboard computer systems that provide online access to maps, inventory, maintenance history, and work orders. Staff are provided quick access to field information and can close work orders as work is completed.

Benefits

An effective maintenance management system can provide several benefits to the wastewater agency and public:

- Organizes and distributes customer comments and complaints to appropriate staff.
- Issues work orders to staff.
- Tracks performance against targets for key measures.
- Tracks cost of repairing or maintaining specific assets, asset groups, or types of asset groups.

Elements

Maintenance management systems are moving away from handwritten documents to computer software programs.

Maintenance Management System Software
Several software programs can integrate work-order history, asset attribute data, analysis, and GIS visualization. Wastewater agencies may find it beneficial to integrate multiple software database applications.

Maps of the Collection System
Wastewater agencies use maps to help plan and communicate information. The type of mapping system used should consider and address the enterprise user and data needs. Application and database design are important tasks in mapping system development.

Maintenance Records
Data should be kept up to date and accurate, so that maintenance systems can enable success of other activities, such as preventative maintenance. Documentation and reporting also helps develop critical parts inventory or need for special performance testing. These systems are fundamental tools to maintenance staff and system managers.

Resources

National Association of Clean Water Agencies (2004) *Continual Improvement in Utility Management: A Framework for Integration*; National Association of Clean Water Agencies: Washington, D.C.

Office of Water Programs, California State University – Sacramento (2010) *Operation and Maintenance of Wastewater Collection Systems*, 7th edition, Volume 2; Office of Water Programs, California State University: Sacramento, California.

Paracher, M. (1998) *Wastewater Collection System Maintenance*; Technomic Publishing Co.: Lancaster, Pennsylvania.

Water Environment Federation (2009) *Wastewater Collection System Management*, 6th edition, Manual of Practice No. 7; Water Environment Federation: Alexandria, Virginia.

Water Environment Federation (2006) *Guide to Managing Peak Wet Weather Flows in Municipal Wastewater Collection and Treatment Systems*; Water Environment Federation: Alexandria, Virginia.

Core Attribute 3:
Safety and Training

Description

Safety and training programs are integral parts of any well-managed collection system. Collection systems, by their nature and location, can be dangerous places to work. Workers regularly are exposed to hazardous structures, materials and atmospheres, vehicular traffic, and biological contaminants. It is important to provide hazard communication so that employees know and understand the hazards they may encounter while doing their job. Most states require specific safety training commensurate with the challenges faced by collection system workers. Training also may include continuing professional education. In many states there are requirements for continuing education to maintain, or renew licenses or certification.

Emergency response training also is important and is covered in detail in Core Attribute 4: Overflow Emergency Response Plan. At a minimum, wastewater agencies should train employees on how to respond to basic anticipated emergencies and, if possible, conduct a tabletop exercise to see how the plan works in simulated emergency conditions.

Benefits

Effective safety and training programs offer several benefits to the wastewater agency and public:

- Reduce insurance premium rates.
- Increased productivity.
- Reduction in lost-time accidents.
- Better regulatory compliance.
- More knowledgeable workforce.

Elements

Hazard Communication

The Occupational Safety & Health Administration (OSHA) requires employers to inform their workers of hazardous materials and locations. There are several ways to accomplish this task:

- Right-to-know (RTK) program—identifies hazards and teaches employees how to minimize the risks.
- Material safety data sheets (MSDS)—provide information on specific hazardous materials that employees use on the job. This information typically is kept in a central location accessible to employees.

- Product labeling—provides on-the-container information regarding a specific product.
- Location identification—employers are required to tell their employees about specific locations in the collection system that may be hazardous, and what safety measures the employee should use for each. For example, this may include specific manholes, pump stations, and meter pits.

Safety Training

Depending on organization size and employees skills, either in-house trainers or safety consultants can provide safety training. Most programs require retraining at regular intervals. Regulatory inspectors may require proof of training through documentation. All programs should be tailored to the specific needs of the wastewater agency. A good safety program addresses but is not limited to, the following elements:

- Confined space entry and rescue,
- Blood borne pathogens,
- Lock out/tag out (LOTO),
- Ladder safety,
- Fire extinguisher training,
- Trench excavation,
- Safe vehicle operation,
- Ergonomics of lifting,
- Hazard communication,
- Chemical awareness,
- Personal protective equipment (PPE),
- Work zone safety, and
- Right-to-know (RTK).

Other Staff Development Needs

Collection system employees need to keep up with the professional development, regulatory changes, and technological advances. In some states, it is mandatory for certified or licensed collection system operators to take professional development classes to maintain their certifications. Professional associations (i.e., WEF, NACWA, APWA. ASCE and American Water Works Association), along with colleges and technical institutions, typically provide these training opportunities.

Adequate Workforce Resources

The agency should evaluate their resources to ensure the adequate implementation of these core attributes at the established levels of service.

Resources

Office of Waters Program, California State University (2003) *Operation and Maintenance of Wastewater Collection Systems*, 6th edition, Volumes 1 and 2; Office of Waters Program, California State University: Sacramento, California.

Water Environment Federation (2009) *Wastewater Collection System Management*, 6th edition, Manual of Practice No. 7; Water Environment Federation: Alexandria, Virginia.

Core Attribute 4:
Overflow Emergency Response Plan

Description

Sanitary sewer overflows (SSOs) emergency response plans should include protocols and resource alternatives necessary to effectively respond, control, report, and mitigate an event. Advanced response preparation to an SSO event which could be under emergency conditions is crucial to managing the collection system to protect human and environmental health and other wastewater agency values. A timely and effective response to SSOs is a fundamental objective of emergency response management and should conform to a risk based prioritization process.

The protocols for reporting and notification will depend on many site specific factors with State regulatory or public health organizations specifying the minimum requirements for various classes or categories of overflows.

Benefits

An effective overflow emergency response plan offers several benefits to a wastewater agency and the public:

- Enhance the protection of public health and the environment.
- Provide compliance with regulations and permits.
- Maintain trust with the public, the regulatory agencies and the non-governmental organizations.
- Minimize the wastewater agency's exposure and liability from claims, enforcement, or litigation.

Elements

Overflow Response Planning

Written procedures for assessing, notifying, containing, clearing the cause, documenting, estimating the volume, sampling and analysis, posting warning signs, and conducting necessary cleanup should be developed and implemented. Collection system managers should develop and implement Overflow Response Plans in cooperation with the Local and/or State Public Health Officials, if possible. Response priorities will depend on the local circumstances. However, stopping and/or containing the overflow should generally be the highest priorities followed by containing, minimizing or preventing SSOs from reaching the storm-drain system, and limiting public health effects.

Following are the key suggested activities to include in an SSO response plan. Implementation sequence is based on site-specific needs, regulatory requirements, and expectations. The first items listed below should be performed as rapidly and simultaneously if possible. The amount of detail provided for each activity will depend on the wastewater agency or regulatory agency.

- Perform initial SSO investigation and assessment of root cause
- Provide adequate traffic control as necessary for worker protection and public safety,
- Correct or stop SSO cause(s)
- Establish containment of SSO,
- Perform final volume estimate,
- Perform cleanup including chemical disinfection, if appropriate,
- Sample receiving waters, if required,
- Provide notification and report, and
- Document the incident, including recording in information management system.

Prior to the start of construction by in-house crews or outside contractors, an approved on-site or readily accessible wastewater flow bypass system and emergency response plan should be in place. Contractors should be instructed to take immediate action to stop overflows caused by their activities, using the emergency response plan. These requirements should be included in the contract documents and discussed at the preconstruction conference.

Notification Procedures

The overflow emergency response plan should outline notification steps and include a comprehensive contact list. The notification extent, media, and manner depend on the severity and potential effect of the overflow. The notification lists should include up-to-date information for contacts and officials. SSOs should be reported in accordance with federal and state laws, and other permit requirements.

Procedures for Overflow Emergency Response Planning and Training

The emergency response plan should be clearly documented and available to wastewater agency personnel and the public. It should be used as a resource in emergency response training. Wastewater operation and maintenance staff should be trained on emergency response procedures on regular basis. New employees should receive this training as part of their orientation and attend refresher courses according to the day-today responsibilities.

Essential Resource Preparedness Procedures

Following are suggested steps necessary to confirm a wastewater agency's readiness to respond to overflows:

- Standardize containment, cleaning, and response equipment.
- Maintain emergency equipment.
- Stock or have immediate access to critical parts.
- Train staff and designate stand-by personnel.
- Secure contracts to acquire additional equipment, if needed.
- Establish contracts to acquire cleanup and construction services on an emergency basis (on-call emergency contracts).
- Provide quick, accurate, updated system maps.
- Develop support or mutual aid agreements with neighboring agencies.

Resources

American Society of Civil Engineers (Under Cooperative Agreement with EPA, Project No. CP-828955-01-0) (2004) *Solutions for Sanitary Sewer Overflows*.

American Society of Civil Engineers (Under Cooperative Agreement with EPA) (2000) *Protocols for Identifying Sanitary Sewer Overflows (SSOs)*.

California Collection System Collaborative Benchmarking Group (2004) *Best Practices for Sanitary Sewer Overflow Prevention and Response Plan,* California Collection System Collaborative Benchmarking Group: Oakland, California.

Office of Water Program, California State University – Sacramento (2010) *Operation and Maintenance of Wastewater Collection Systems,* 7th edition, Volume 2; Office of Water Programs, California State University: Sacramento, California.

Paracher, M (1998) *Wastewater Collection System Maintenance*; Technomic Publishing Co.: Lancaster, Pennsylvania.

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Water Environment Federation (2009) *Wastewater Collection System Management*, 6th edition, Manual of Practice No. 7; Water Environment Federation: Alexandria, Virginia.

Water Environment Research Foundation (2003) *Effective Practices for Sanitary Sewer and Collection System Operations and Maintenance;* Water Environment Research Foundation: Alexandria, Virginia.

Core Attribute 5:
Collection System Maintenance

Description

Proper maintenance of a collection system provides for the safe conveyance of wastewater to the treatment plant and mitigation of gases. Maintenance also maintains system flow performance with the design service capacity. An operation and maintenance (O&M) program should use an asset management approach for scheduling and implementing inspection, maintenance, cleaning, and repair of the system. Type and level of maintenance needs will vary based on system size and characteristics such as age and materials. The frequency and schedule of maintenance activities is an important element in development of an effective maintenance program. Managers should develop a schedule to perform maintenance in a timely manner based on history and collection system performance and other risk based criteria.

Benefits

Effective maintenance program provides several benefits to a wastewater agency and the public:

- Averts or minimizes public health and the environment impacts
- Reduces backups and sewer overflows.
- Reduces odors in communities.
- Minimizes backup claims.
- Optimizes resources and reduce overall operation and maintenance costs.
- Increases the service life of the facilities.
- Minimizes potential and exposure to enforcement and third-party litigation.
- Enhancing the image of the wastewater agency.
- Maximizes available system hydraulic capacity.

Elements

Preventative Maintenance Practices

Maintenance of collection system hot spots, or high-priority areas, is an important element of maintenance and typically is the most time and resource consuming. Maintenance of hot spots requires high-frequency maintenance of known problem locations within the system. These include locations that have regular blockages because of grease buildup, root intrusion, or vandalism. The frequency of maintenance for these hot spots varies and should be documented.

Routine maintenance schedule and frequency depends on system performance and risk factors, maintenance history, and the latest maintenance findings. Wastewater agencies should undertake routine evaluation and maintenance based on field findings. For example, if the maintenance crew sees minimal buildup, then staff should recommend a less frequent cleaning schedule to reduce cost. If, on the other hand, field maintenance finds severe buildup or blockage, then staff should recommend a more frequent scheduled cleaning as a proactive risk management measure. The cause of the frequent blockages should be determined and eliminated if possible. Quality assurance and quality check of cleaning quality is essential in providing maintenance staff with the feedback necessary to evaluate performance. Some communities have automated the data and quality control process to reduce costs, allow more focused quality control, and produce quicker results.

There are several cleaning methods and tools for collection systems. Use of each varies based on the site, condition, and type of debris.

Hydraulic cleaning typically is used for debris buildup and grease accumulation. High-velocity flushing machines most typically are used with various types of cleaning nozzles. Balls, bags, kites, scooters, and tires also are used in large collection systems or siphons to create a constriction thereby increasing the water velocity which scours the debris and advances it downstream for eventual removal.

Mechanical cleaning typically is used to remove roots and heavy debris from collection systems. Bucketing machines are used mainly for debris removal from large collection systems.

Preventive maintenance of pump stations should be performed on a set schedule to confirm that system components are operating properly, especially those related to backup power and control system. Scheduling routine preventative maintenance and inspection of the backup power and electrical systems should be conducted on a set schedule in alignment with the manufacture's recommendations and based on historical performance. Mechanical equipment and emergency backup systems should be tested during scheduled maintenance activities to verify adequate operation of system and alarms.

Wet well cleaning also is a critical element of preventive maintenance. In addition, staff should be trained routinely on applicable preventative maintenance procedures and standard operating procedures. Key replacement components should be identified, and adequate inventory of these components should be readily available.

While difficult to clean due to the typically limited access points, force main preventive maintenance should include routine visual inspection of the force main route for evidence of potential leaks or surface depressions. All valves installed on the force main piping should be included in a routine preventive maintenance program as well.

Proactive Maintenance Program

Proactive maintenance includes system components that are not subject to focused maintenance, are not experiencing any performance issues, and have no history of contributing to overflows or blockages. Maintenance of these components will need to be conducted on a set schedule but with much less frequency.

As part of this proactive maintenance program, a regular, system wide cleaning should be developed and implemented. Wastewater agencies often target a five- to 10-year cleaning cycle, but longer or shorter intervals may be needed based on site-specific conditions and parameters, especially for small-diameter, local systems. A more aggressive schedule could be implemented for the first cycle and then, using that data, a more realistic schedule could be established. Maintenance should be done based on either a sewer-shed or a specific geographic area to increase effectiveness and minimize cost. Prioritizing theses basins or areas as part of this program is essential where you want to start with the ones that have the highest potential for a problem or consequence of a problem. Visual inspection is another component to proactive maintenance in which a wastewater agency sends crews to an area to physically inspect flow in the maintenance hole to determine if there is any issue with the system. These visual inspections are set on either an annual or biannual frequency.

Proactive maintenance for pump stations is critical and includes the following activities and components:

- Estimate retention time and provide onsite stationary power backup for pumping plants with limited retention time at peak flow based on a wastewater agency's risk criteria. Identify low points in the system where overflows may occur because of pump station failure.

- Locate, store, and secure mobile power generators at key geographical locations to provide adequate response times.
- Identify the proper generator for each pump station.
- Develop "pump around" plans, redundant power sources, or dual-barrel mains for each facility. Use auxiliary equipment and components.
- Use a simplified telemetry system or a more complex SCADA system, based on site-specific conditions and needs.
- Provide pump redundancy.
- Standardize, as much as possible, the size and type of equipment to allow for exchange and ease of troubleshooting and repair.

Resources

American Society of Civil Engineers (Under Cooperative Agreement with EPA, Project No. CP-828955-01-0) (2004) *Solutions for Sanitary Sewer Overflows*.

Office of Water Programs, California State University – Sacramento (2010) *Operation and Maintenance of Wastewater Collection Systems*, 7th edition, Volume 2; Office of Water Programs, California State University: Sacramento, California.

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Water Environment Federation; American Society of Civil Engineers (2009) *Existing Sewer Evaluation and Rehabilitation*, 3rd edition; Manual of Practice No. FD-6; ASCE Manuals and Reports on Engineering Practice No. 62; McGraw-Hill: New York.

Core Attribute 6:
Source Control

Description

Maintenance issues such as blockages and overflows could be caused or increased by what is discharged into the system. Controlling what is discharge into the collection system can assist in enhancing and improving the collection system performance.

Benefits

Source control programs targeted to control sources provide benefits to wastewater agencies and the public:

- Reduced maintenance frequency downstream of sources.
- Reduced overflows due to blockages.

Elements

Fats, Oils, and Grease Control

Fats, oils, and grease (FOG) buildup in collection systems is a significant cause of blockages and overflows in a collection system. Controlling the sources from food service establishments, multi-family residential units, and residential properties, as well as, ensuring proper maintenance and cleaning of collection systems dramatically can reduce FOG blockages and overflows. A program should consider the following:

- Adequate sizing of grease traps,
- Inspection of grease establishments on a regular basis,
- Furnishing informational and educational resources on grease prevention techniques to both residential and grease-producing establishments, and
- Inputting grease-producing establishments on GIS.

Root Control

Root intrusion in collection systems is another source of blockages and overflows. Control of root intrusion in combination with routine maintenance dramatically can reduce blockages and overflows. A chemical root-control program is effective in controlling growth. A program should include several tasks:

- Identify those areas where standard maintenance practices are not cost effective because of the speed and density of root growth within laterals and mains.
- Introduce specifically formulated chemicals to identified problem areas to retard or eliminate intrusive root

growth which are compatible with plant operations and in compliance with applicable regulatory requirements.
- Provide public outreach materials to educate the public on areas to avoid planting deep-root plants and trees.

Corrosion Control

Unmanaged corrosion degradation of the sewer system can lead to eventual pipe collapse or blockages that may contribute to overflows. Developing a corrosion-control program for collection systems that are susceptible to corrosion can be effective. A corrosion control program should help a wastewater agency do the following:

- Identify where corrosion is occurring,
- Identify the type of corrosion occurring,
- Identify the cause of corrosion, and
- Determine a cost-effective short and long-term control method.

Application of chemicals to the waste stream can not only provide structural protection and reduce the rate of corrosion but also reduce odor problems. Chemicals used could include but are not limited to magnesium hydroxide solution, caustic soda solution, hypochlorite, peroxide, nitrates, and iron salts. Some wastewater agencies are spraying the crown of the collection system pipes that are susceptible to corrosion with magnesium hydroxide. This provides a buffer from corrosion. The application is typically done annually.

Vandalism Prevention

Vandalism—when debris and foreign material intentionally are introduced into a segment of the collection system—can be a source of blockages. A wastewater agency may need to develop and implement a Vandalism Prevention Program to protect its sewer system from damage and the potential for an SSO attributed to vandalism. A Vandalism Prevention Program should consist of several steps:

- Lock down maintenance hole covers to discourage vandalism where practical.
- Refer problem to appropriate law enforcement governmental agencies to investigate and prosecute the vandals.
- Provide ongoing education and outreach efforts to explain why it is important to not introduce inappropriate materials into manholes.

Odor Prevention and Control

The best odor control is prevention or source control. Prevention starts with the appropriate design and construction that maintains minimum design flow velocities and conveys the flow with the least turbulence.

In areas where adequate design parameters cannot be achieved, control of collection system gases may have to be implemented. This may include chemical treatment or installation of biofilters, scrubbers, or air treatment facilities.

Effective cleaning and removal of debris in the system is an important preventive measure to reduce hydrogen sulfide generation. In addition, access structure sealing can also help in controlling the emission of odors.

System monitoring for hydrogen sulfide levels and pressure levels is a preventive measure that enables corrective action to be taken and minimize odor complaints. In addition, mapping odor complaints to identify priority areas for necessary corrective action is a helpful tool to supplement preventable measures.

Resources

American Society of Civil Engineers (Under Cooperative Agreement with EPA, Project No. CP-828955-01-0) (2004) *Solutions for Sanitary Sewer Overflows*.

Paracher, M. (1998) *Wastewater Collection System Maintenance*; Technomic Publishing Co.; Lancaster, Pennsylvania.

Water Environment Federation (2004) *Managing the Water and Wastewater Utility;* Water Environment Federation: Alexandria, Virginia.

Water Environment Federation (2009) *Wastewater Collection System Management,* 6th edition, Manual of Practice No. 7; Water Environment Federation: Alexandria, Virginia.

Core Attribute 7:
Structural Condition Assessment and Evaluation

Description

Sewer pipes deteriorate at different rates for many reasons. It is important to know the structural condition of the sewer because deteriorated pipes can collapse and cause a blockage or sinkhole if not addressed in a timely manner. In addition, as other utilities and structures are installed, sewer pipes in good condition could be damaged or broken. Structural condition assessment can identify these situations and enable timely repair.

Assessment methods and tools are most commonly dependent upon the pipe or structure's size, material, date of construction, and accessibility. Similar to capacity-related inspection, technologies structure inspection can be a progressive series of inspection techniques. Inspections often capture structural and capacity problems in the same inspection. Closed circuit television (CCTV) is a popular structural inspection technique. It is important to have an easy-access retrieval storage system for any videos so that it can be used for comparison with future videos.

Benefits

Systematic structural condition assessment and evaluation provides many benefits to a wastewater agency and the public:

- Helps minimize collection unexpected system failure, blockages, and overflows by identifying potential problems before they occur.
- Provides information that can be used to identify, predict, and prioritize necessary capital improvement projects.
- Helps wastewater agency prioritize maintenance, rehabilitation and repair activities.

Elements

The key element of this program is the combination of inspection technique and of the conversion of the observed or recorded data into assessment knowledge. This knowledge then can be used to determine the need for priority of repair, rehabilitation, or replacement. An analysis of system performance, maintenance history, age, materials, or structural risk analysis should be used to help prioritize collection systems for CCTV inspection. The extent of the system that should be inspected by CCTV should be based on what supports the wastewater agency's performance objective and then more specifically what information about the system is progressively revealed by the execution of other, more cost-effective inspection techniques.

Each sewer reach or segment is assessed and ranked based on an adopted ranking or risk-based system. Utilizing the data from previous inspections, a projection can be developed to predict the percentage of the collection systems that will need different types of repair, rehabilitation, or replacement. This could be then translated into a financial implementation plan for collection system rehabilitation.

Resources

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Core Attribute 8:
System Hydraulic Capacity Assessment, Evaluation and Assurance

Description

Once the design capacity of the system conveyance components are established it is important to continuously assess, evaluate, and assure that the expected design capacity performance is met. Several tools and activities are available to support these practices, including computer models, flow monitors, and field investigation equipment and software. The mix and selection of these will be site specific. Operations and maintenance data also can provide valuable information about system capacity, especially where problems have been observed and reported. Proper application of the analysis activities and tools enables the wastewater agency to (1) characterize the capacity status of different segments of the system, (2) identify areas with capacity limitations, (3) predict areas with future capacity limitations, (4) undertake efforts to quantify and reduce inflow and infiltration (I/I) to manageable levels, (5) quantify capacity requirements, and (6) plan, design, and implement corrective or preemptive actions to maintain system design capacity and performance.

Benefits

An effective hydraulic capacity assessment, evaluation, and assurance program provides many benefits to a wastewater agency and the public:

- Enhance the protection of public health and the environment.
- Reduces backups and sewer overflows.
- Minimizes backup claims.
- Optimizes resources and reduces overall planning, engineering, and operation and maintenance costs.
- Supports sound wastewater system, land-use planning, and development practices.
- Minimizes potential for and exposure to enforcement actions and third-party litigation.
- Confirms available hydraulic capacity.
- Provides information required for management infiltration/inflow.

Elements

Flow Monitoring and I/I Assessment

Flow monitoring in conjunction with rainfall monitoring is an effective tool for quantifying the rainfall dependent inflow and infiltration and assessing the hydraulic performance of a portion of the system. A network of flow monitoring provides a more comprehensive assessment of the system. The design of the flow monitoring network will vary according to the purpose of the monitoring effort.   As part of the hydraulic assessment, quantifying the flow discharge from satellite system entering the system is essential to provide a holistic analysis of the system needs.

Computer Modeling

Computer models have evolved rapidly over the past three decades and are now a widely used tool for hydraulic analysis of collection systems and integration of results with wastewater treatment plants. Computer models enable system hydraulics to be simulated under a variety of conditions, including varying antecedent moisture conditions, existing conditions, and a variety of future scenarios that include expansion, changes, and improvements. System response and adequacy can be simulated for various inputs such as increases in infiltration/inflow (I/I) from intense precipitation or I/I reduction from system rehabilitation, or increasing dense service populations. Modeling is used in cost-effectiveness analysis to help determine the best mix of capacity restoration alternatives. However, the need and extent of modeling varies based on the specific needs of the system.

Field Investigation

Condition and capacity related field investigations of the collection system usually involve a progressive sequence of inspection technologies. Investigation techniques such as manhole, lamping, smoke and dye testing, sonar, and CCTV can help characterize system conditions that affect the hydraulic capacity of the system. Direct entry for larger conduits can provide useful information about system conditions. Operation and maintenance records that identify system performance problems (e.g., basement flooding complaints) can provide additional insights on system capacity, especially when evaluated in combination with flow monitoring data, characterized overflow points, and computer model simulations.

Resources

American Society of Civil Engineers (Under Cooperative Agreement with EPA, Project No. CP-828955-01-0) (2004) *Solutions for Sanitary Sewer Overflows*.

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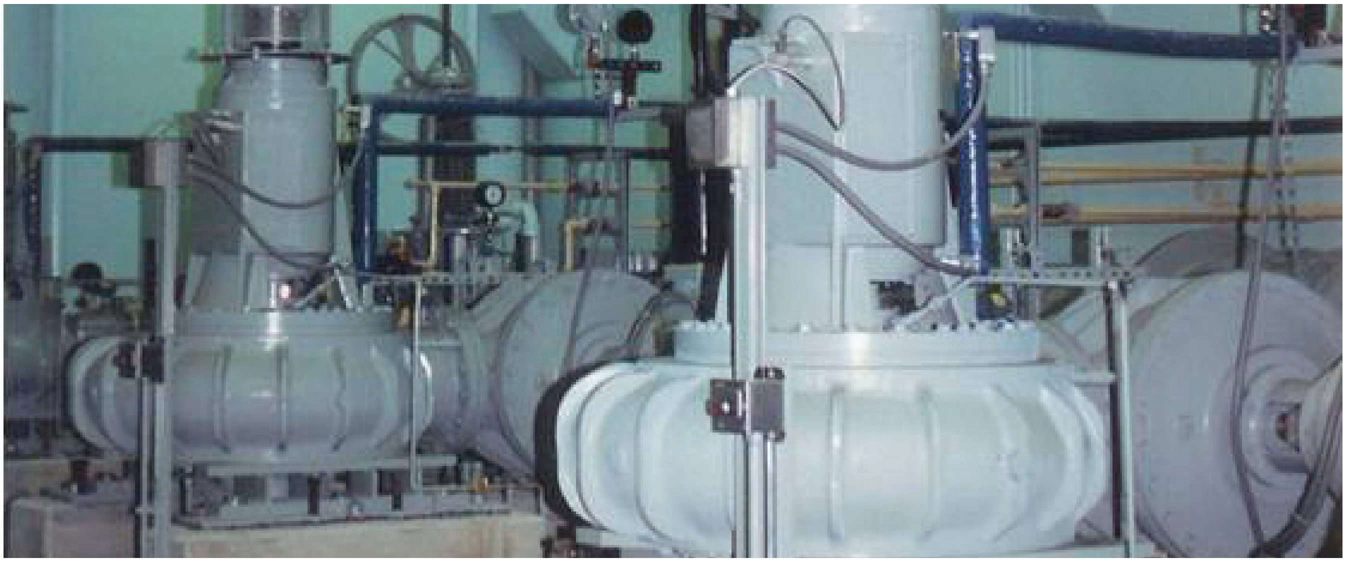

Core Attribute 9:
Standard Design, Construction, and Inspection

Description

Proper design, construction, and inspection is necessary to enable the collection system projects address the wastewater collection needs of the community, meets regulatory standards, and provides for efficient, reliable service at the best cost.

Standard design, construction, and inspection start with recognition of the need for new collection system facilities. Several important steps are required to make the initial concept a reality. *Planning* involves developing design criteria necessary to provide that the final facilities fulfill needs and expectations of the system. This requires understanding short- and long-term local needs for the system and regulations applying to the new facilities. *Design* brings the concepts identified in the planning process to paper and provides a set of documents (plans and specifications) that will be used to construct the facilities. Efficient design requires understanding the engineering and science involved in the technology and knowledge of current construction practices and materials. *Construction* builds the actual facilities that are planned and designed. *Inspection* helps resolve issues that arise during construction and confirms that the facilities are constructed as planned and designed.

Benefits

Effective collection system design, construction, and inspection provide many benefits to the wastewater agency and the public:

- Provides necessary wastewater collection systems to protect public health and the environment.
- Provides that local wastewater management service needs are addressed.
- Provides that regulatory requirements are met.
- Provides a system that minimizes infiltration and exfiltration of wastewater.
- Maximizes the use of public money by providing the best facilities at the least cost.
- Minimizes O&M requirements over the life of the facilities.
- Provides efficient service and maximum life.

Work Elements

Planning

The project typically begins with the identification of a need, which may be to provide new service, replace an existing system, or address a regulatory requirement. The planning step describes and records project needs, including performance criteria, which are used to size facilities. For a new collection system project, a preliminary sizing and routing and cost estimate is drafted.

Design

The design must take into account issues of performance such as minimum and maximum flow rates, flow velocities, life-cycle costs, and maintenance issues. At this stage, the location and slope of the system is defined; rights-of-way and property needs are identified (and often purchased), and a cost estimate and construction bidding documents are prepared. Typically, the regulatory authority reviews and approves the design at this stage. Local construction permits are obtained and other necessary elements are completed so that the project can be set out for construction bidding.

Construction

The construction contractor typically is determined by competitive bidding, although other forms of selection such as emergency direct award or sole source are sometimes used. The project should be constructed as designed, using the materials and procedures specified. The owner and permitting authorities need to approve any significant changes, which should be documented. Testing of new pipe typically is required to show that it is watertight and meets project requirements.

Inspection

The wastewater agency owner provides inspection of construction to assure that the project is constructed as designed and specified. The inspection for a collection system project will verify that the pipe and appurtenances have been installed correctly for line and grade and with the proper materials. The inspector should perform or witness tests of installed pipe. It is a good idea to CCTV a new sewer to verify its condition and establish a baseline for subsequent inspections. Some wastewater agencies require tests of CIPP and manhole rehabilitations as well as new pipe construction.

Resources

Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental (2004) *Recommended Standards for Wastewater Facilities, Ten States Standards,* 2004 ed.; Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers: Albany, New York.

Office of Water Programs, California State University – Sacramento (2003) *Operation and Maintenance of Wastewater Collection Systems*, 6^{th} edition, Volume 1; Office of Water Programs, California State University: Sacramento, California.

Water Environment Federation; American Society of Civil Engineers (2007) *Gravity Sanitary Sewer Design and Construction*, 2nd edition; Manual of Practice No. FD-5; ASCE Manuals and Reports on Engineering Practice No. 60; Water Environment Federation: Alexandria, Virginia.

Core Attribute 10:
Communication and Outreach

Description

Communication and outreach with customers, constituents, and other stakeholders is critical to effectively managing a wastewater collection system. To be effective, communications must be ongoing, open, timely, and *two-way*, with reciprocal information sharing.

Key stakeholders for collection system operators include policymakers, customers, local residents and businesses, regulatory agencies, local health officials, environmental organizations, community and business groups, neighboring agencies and systems, and employees. Effective communications with each of these groups will require different techniques that are tailored to their specific interests and perspectives and the situation.

Effective communication and outreach goes well beyond the historic reactionary approach when facing crisis situations, service disruptions, spills, unflattering press coverage, legal challenges, or rate increases. Wastewater agencies should practice proactive, ongoing information sharing regarding system needs, challenges, and programs and opportunities for meaningful involvement planning, enhancements, and improvements.

Communication and outreach should be integral to planning efforts. Collection system managers should develop strategies for ongoing communication and outreach as part of their multiyear strategic plan. Efforts should be incorporated into crisis management documents and exercises, including clearly delineated protocols, procedures, and resources in the same manner that these are defined for critical operations.

Benefits

Effective communication and outreach provide many benefits to the wastewater agency and the public:

- Strengthens understanding, trust, and collaboration between system operators and stakeholders.
- Builds support in times of crisis and when funding and resources, through educated stakeholders.
- Improves participation when educated customers and community members leads efforts, for example, to reduce discharge of FOG into drains and other intrusions out of the system.

Elements

To be effective, communication and outreach must be ongoing, reaching key stakeholders on a regular basis. Following are some of the many elements of successful programs:

- Publications—fact sheets, brochures, booklets, flyers, door tags, bill stuffers, newsletters, work notices, and updates.
- Emergency phone lines to report spills or problems.
- Prompt information on operational problems and service disruptions affecting customers.
- Websites, podcasts, and videos.
- Displays, exhibits, posters, and banners.
- Facility tours.
- School curricula, visits, programs, and contests.
- Talks and presentations to city councils, civic groups, interest clubs, and community organizations.
- Collaboration and positive interactions with non-governmental organizations.
- Discussions with community leaders and members in planning new facilities, upgrading existing facilities, and rate changes.
- Speakers and community ambassadors.
- Information exchange workshops.
- Media presence—feature stories or appearances on radio and television or community cable programs and community cable announcements.
- Newspaper presence—feature stories, press releases, press events, and paid advertisements.

Resources

AWWA Research Foundation (2005) *Message Management: Effective Communications;* AWWA Research Foundation: Denver, Colorado.

AWWA Research Foundation (1995) *Public Involvement Strategies: A Manager's Handbook;* AWWA Research Foundation: Denver, Colorado.

Campbell, D. and Cherniak, M. (2005) *Manage for Success;* Office of Water Programs, California State University: Sacramento, California.

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Core Attribute 11:
Monitoring, Measurement and Program Modifications

Description
As part of efficient management, managers should routinely track and evaluate system and program performance and make necessary modifications and adjustments.

Benefits
Routinely reviewing system performance and implementing necessary program adjustments or changes provides many benefits to the wastewater agency and the public:

- Optimizes resources.
- Enhances performance and achieves results.
- Validates effectiveness and needs.
- Reports progress.
- Engages staff and stakeholders while maintaining their support and trust.

Work Elements
Monitoring, Measurement and Modifications
The following is a summary of suggested activities for effective monitoring, measurement and program modifications.

- Identify performance measurements for data collection, analysis, and review.
- Maintain a data management and reporting system.
- Implement routine monitoring, measurement, and modification.
- Compare performance against locally specific performance targets and identify potential areas for improvement.
- Be aware of similar wastewater agency performance measures and targets.
- Compare performance on a routine basis to identify performance trends within a wastewater
- agency.
- Allocate resources to deficient areas.
- If the results of performance trends vary outside the wastewater agency's levels of acceptability develop how to address and document the improvement action.

Performance Measures

Performance measures should vary at different levels of the organization but support the level above it and the overall mission of the agency. Selected metrics will establish performance criteria for system components. These metrics will then be applied in the evaluation of individual staff members and organizational groups based upon specific work activities. The following are examples of commonly used, but not mandatory, performance measures for collection systems:

- Number of SSOs per 100 miles of mainline sewer.
- Number of backups per 100 miles of mainline sewer.
- Number of system failures per 100 miles of mainline sewer.
- Customer service calls.
- Odor complaints.
- Ratio of peak wet weather flow to peak dry weather flow.
- Rainfall derived infiltration and inflow (RDII) per acre.
- RDII per linear foot of pipe.
- RDII per inch of rain per linear foot of pipe.
- RDII per inch of rain per inch-diameter.
- Percentage of calls that are repeats.
- Percentage of problems cleared per month.
- Percentage of system cleaned annually.
- Percentage system televised annually.
- Percentage system inspected annually.
- Percentage system renewed annually.
- Percentage of corrective work orders.
- Percentage of preventative work orders.
- Collection systems maintenance cost per mile.
- Percentage of work orders completed per month.
- Fleet costs per total O&M (by function).
- Value of capital additions/net asset value.
- Overtime costs.

Resources

American Society of Civil Engineers (Under Cooperative Agreement with EPA) (1999) *Optimization of Collection System Maintenance Frequencies and System Performance.*

Arbour, R. and Kerri, K. (2009) *Collection Systems: Methods for Evaluating and Improving Performance,* 2nd edition; Office of Water Programs, California State University: Sacramento, California.

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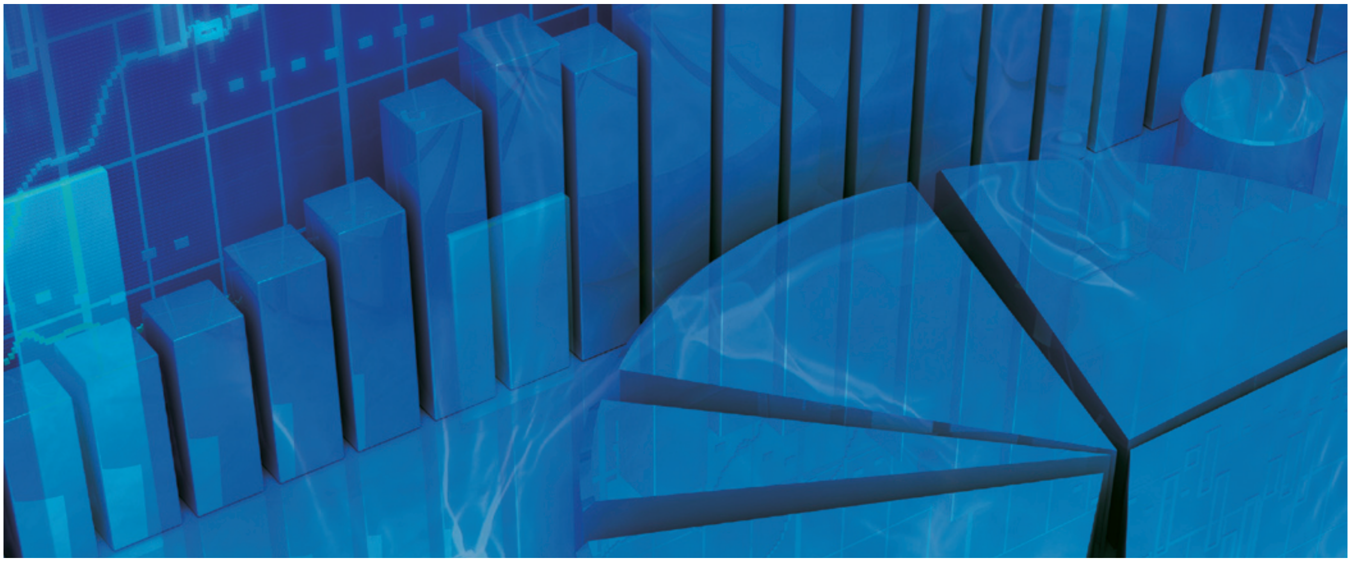

Core Attribute 12:
Adequate Funding

Description
Develop adequate revenue stream and effective accounting practices to support the effective management of the system.

Benefits
Having a sustainable and adequate revenue stream and effective accounting practices provides many benefits to the wastewater agency and the public:

- Separates the wastewater collection system funding from the vulnerable general fund.
- Protects the wastewater collection system activities from cuts in general funds.
- Provides reliable source of funds.
- Prevents transferring of funds and assets to other municipal needs.
- Reduces political influence in distribution of funds.
- Enhances performance and achieves results.

Elements
Rate Structure Characteristics

Rate structures should be designed to recover costs in a fair and equitable manner and should accommodate various community considerations and policy directions. A growing community needs to consider how it will fund expansion costs (will growth pay for growth, or will the cost be shared among all customers?). An established community without major capital improvements planned may use a pay-as-you-go philosophy to fund its capital improvements, while one that is making major capital improvements may use debt financing to smooth out rate impacts. A community trying to encourage conservation may have an increasing block rate structure. There is no “best” rate structure that will work for every community. Some issues to consider are:

- Fairness and equitability
- Debt financing policies
- Conservation goals
- Growth policy
- Simplicity

Revenue Requirements

The first step in designing a rate structure is to determine the revenue required to operate and maintain (including replacement) the wastewater system. Rate revenues can also be used to fund all or a portion of capital costs for expansion and process improvements. It is advisable to project revenue requirements for at least a few years to minimize fluctuations in rates.

Cost of Service

The next step is to allocate the costs to customer classes. Potential classes include:

- Residential
- Commercial
- Industrial
- Governmental
- Institutional

Costs are typically allocated based on flow and strength. Suspended solids and biochemical oxygen demand are two strength characteristics that are commonly used.

Rate Structure

The Federal Clean Water Act requires any agency that receives grant funding to adopt a system of charges to assure that each recipient of wastewater services pays its proportionate share of the costs of operating and maintaining the system. One of the most straightforward ways to do this is to base the charges on water consumption. This works particularly well if the same agency provides both water and wastewater services due to the availability of data. In cases where there are multiple water providers within a wastewater agency's service area, it may be too difficult to use water data as the basis for billing.

If this method is not feasible, flat rates can be employed. However, different rates must be developed based on user classes. Residential and commercial customers typically have different rates, and these classes may be further refined. Rates for residential customers may be set based on number of bedroom or bathrooms. Rates for commercial customers may be based on type and size of the business.

In flat rate structures, all costs are recovered through a fixed charge. Volumetric rate structures often contain a minimum component to recover fixed costs, such as meter reading, billing, and customer service, while recovering the remaining costs through the volumetric-based portion of the bill. The Federal Clean Water Act does allow reduced rates for low-income residential customers.

Some regional systems have developed and included rates to account for peak wet weather flows from satellite system above acceptable levels. These rates are included in the form of higher rates and/or penalties. In many cases, the added fees could be used by the satellite systems to reduce the peak wet weather flow to the acceptable levels.

Additional Funding Sources

In addition to user charges, revenues may be received from property or sales taxes or the general fund of a city or county. Any user fees not applied to the operating costs of the system may be used for capital improvements. Separate capital facilities charges may also be used to fund improvements required for new development. Grants and debt financing can also be used to fund capital improvements.

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Appendix B – Acronyms

APWA	American Public Works Association
ASCE	American Society of Civil Engineers
CCTV	Closed Circuit Television
CIP	Capital Improvement
EPA	United States Environmental Protection Agency
FOG	Fats, Oils and Grease
GIS	Geographic Information System
I/I	Inflow/Infiltration
LOTC	Lock Out, Tag Out
MSDS	Material Safety Data Sheet
NACWA	National Association of Clean Water Agencies
PPE	Personal Protection Equipment
O&M	Operations and Maintenance
OSHA	Occupational Safety and Health Agency
RDII	Rainfall Dependent Inflow and Infiltation
RTK	Right to Know
SCADA	Supervisory Control and Data Acquisition
SSO	Sanitary Sewer Overflow
WEF	Water Environment Federation