Asset Management and Sustainability

Every wastewater collection system and treatment plant is a community asset that is comprised of many other assets that need to be maintained. Assets such as pumps, pipes, valves and gauges need to be inventoried, assessed for condition and criticality, and maintained regularly to extend service life.

NYWEA

Environmental Finance Center
Syracuse University

Chapter 2:
Asset Management and Sustainability

Overview of Asset Management

All wastewater systems are made up of assets, some that are buried and some that are above ground. The physical components that make up a wastewater system may include: pipes, valves, tanks, pumps, blowers, screens, sophisticated electrical and control equipment, and any other component that supports the conveyance and treatment of wastewater for your community. The assets lose value over time as the system ages and the assets deteriorate and, eventually, will need to be rehabilitated or replaced. In addition, these assets require regular maintenance, repairs, rehabilitation, inspections, and possibly improvements throughout their lives.

As the assets deteriorate, it may be more difficult to deliver the quality of service that residents have come to expect, and to meet the requirements of the regulatory agencies. The costs of operating and maintaining these wastewater systems will increase as the assets age, and the community may be faced with excessive costs that it can no longer afford.

There is an approach that can assist the community in making better decisions on managing aging assets, and better planning for the future. This approach is called asset management, and it includes techniques that have been refined by many organizations that own and operate assets. The International Infrastructure Management Manual (NAMS 2011) defines the goal of asset management as, "meeting a required level of service in the most cost effective way through the planning, acquisition, operation, maintenance, rehabilitation and disposal of assets to provide for present and future customers."

"The costs of operating and maintaining these wastewater systems will increase as the assets age, and the community may be faced with excessive costs that it can no longer afford."

A community should care about managing its wastewater utility assets in a cost effective manner for several reasons:

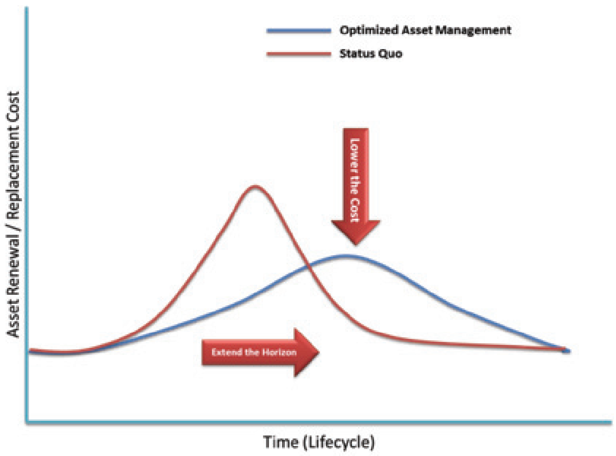
1. These assets represent a major public or private investment
2. Well run infrastructure is important for economic development
3. Proper operation and maintenance of a wastewater utility is essential for public health and safety
4. Water and wastewater assets provide an essential customer service
5. Asset management promotes efficiency and innovation in the operation of the system

The intent of asset management is to ensure the long-term sustainability of the wastewater infrastructure. By helping the utility make better decisions on when it is most appropriate to repair, replace, or rehabilitate particular assets and by developing long-term inspection, maintenance, renewal, and funding strategies, the community can ensure its ability to protect the environment and public health by having a healthy sustainable wastewater system.

Plunger pump at Lake Placid WWTP.

Benefits of Asset Management

There are many positive benefits of asset management. Communities that fully embrace asset management principals may achieve many or all of these benefits. Organizations may receive some of these benefits just by starting an asset management program. The benefits of asset management include, but are not limited to, the following:



Lower lifecycle costs.

- Better operational decisions and more efficient operations
- Increased knowledge of the condition, maintenance requirement and location of the assets
- Better internal communication and communications with customers
- Greater ability to plan and pay for future repairs and replacements
- Increased knowledge of what assets are critical to the community and which ones are not
- Improved emergency response
- Improve financial health and bond rating
- Setting rates based on sound operational information
- Have more efficient and focused operations
- Capital improvement projects that meet the true needs of the system
- Reduce environmental violations due to failed or poorly performing assets
- Improve the security and safety of infrastructure assets
- Better succession planning

Organizations should strive to achieve as many benefits as they can with their asset management program.

Core Components of Asset Management

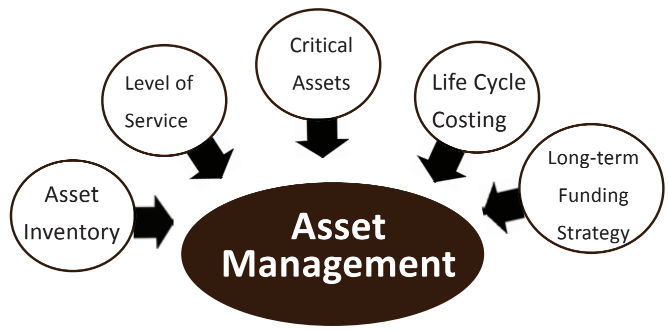
There are five core components of any comprehensive asset management program. Each of these five components will be discussed in greater depth:

1. Asset Inventory
2. Level of Service
3. Critical Assets
4. Life Cycle Costing
5. Long-term Funding Strategy

Asset Inventory

The first component of any asset management program is the asset inventory. This is most important as it underlies all other aspects of asset management. The types of questions that should be addressed in developing asset inventories are:

- What do we own?
- Where is it?
- What condition is it in?
- What is its remaining useful life?
- What is its value?



Asset Management Components.

What Do We Own?: The most fundamental question a wastewater utility can ask is what assets does it have? It is absolutely critical for a utility to understand what it owns. It is hard to manage something effectively if the utility doesn't know what that "something" comprises.

Although "what do I own?" is a seemingly straightforward question, it is not always easy to answer. The difficulties arise from several factors: some of the assets are underground and cannot be seen; assets generally are put in at different times over a long period of time; records regarding what assets have been installed may be old, incomplete, inaccurate or missing; and staff turnover in operations, maintenance and management may limit the historical knowledge of system assets. Given these difficulties, it will probably not be possible to form a complete asset inventory the first time it is attempted. It is important to recognize that the goal is to form the best inventory possible and develop an approach to adding to or improving the data over time.

To develop the initial inventory, several approaches can be used and these are listed below. However, the utility should be as creative as possible with other approaches to obtaining this information.

- Determine who was operating, managing and/or owning the system at the time of the major construction periods (when a large number of assets were installed). Interview these individuals and gather as much information as possible regarding their recollections of what assets were installed and where. If there are maps of the system, these can be used during the discussions.
- Examining any as-built or other engineering drawings of the system.
- Visually observe or perform field reconnaissance of above-ground or visible assets (e.g., pump stations, manholes, treatment plant assets).
- Estimates on buried assets using above ground assets as a guide (e.g., using manholes to estimate locations, size and types of pipe between the manholes)

Several approaches may be necessary to get a good start on the asset inventory. Use as many approaches as necessary to get the best initial inventory of assets.

Where Are My Assets?: The next question in inventorying the assets is where are they? Once one knows what assets there are, it is important to know where they are. This component involves two steps:

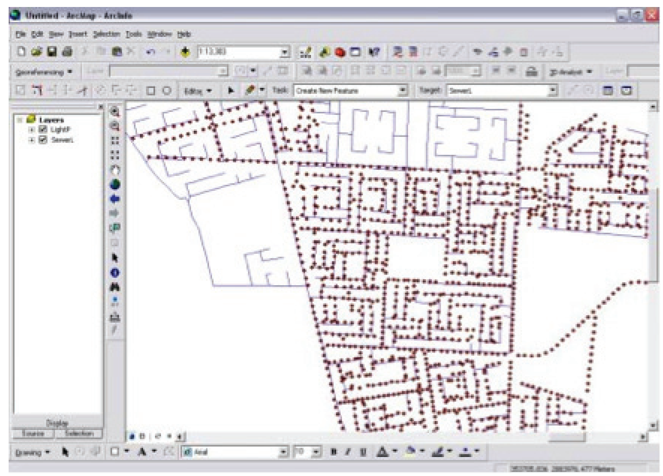
1. Mapping the assets
2. Putting a location in the inventory

In terms of mapping, the most important factor is to have a visual picture of the asset locations, especially the buried assets. The map can be as simple (hand drawn) or more complex (Geographic Information System – GIS). The most important factor is that it is useable to find the assets, track any changes to the asset, and can be used to track failures in the system. The second aspect involves putting a location in the asset inventory indicating where the asset is located. Generally, this would be a facility, building, floor, room, or possibly an area where assets are located. These location descriptions are necessary for above ground assets located at treatment plants, pump stations and other facilities. It is also useful to assign all assets a type or class to each asset (i.e., valves, pumps, motors, manholes, etc.).

What is the Condition of the Assets?: After the asset inventory is developed, it is important to know the condition of these assets. A condition assessment can be completed in many different ways, depending on the capability and resources available. The simplest approach is to gather people who have current or historical knowledge of the assets and capture the information they have on paper or electronically. The group can then select an appropriate condition ranking approach:

- 0 through 5 (example in table)
- A through F
- Excellent through Unacceptable

The team can then look at the inventory of assets and rate the condition of each asset using the selected



GIS Map of Wastewater Collection System Assets.

approach. This method uses the best information available and does not require the collection of specific data or advanced investigations in order to rate the condition of the assets.

A more sophisticated approach, or next step after the initial ratings are assigned, could include systematic data collection, such as CCTV of the sewers, organized manhole inspections, and other asset condition assessment methodologies.

What is the Remaining Life of the Assets?: All assets will eventually reach the end of their useful lives, depending on the type of asset; it will either reach that point through amount of use or age. For example, a pump will wear out sooner if it is used more and will last longer if it is used less. The actual age of the pump is not as important as the amount of work the pump has done. On the other hand, pipe assets wear out based more on the length of time in the ground. If a pipe is in the ground for decades, it has had considerable time to

Condition Rating	Condition/Description	Maintenance Required
0	New	Normal
1	Perfect/Excellent Condition	Normal
2	Minor Defects Only	Minor
3	Backlog Maintenance Required	Significant
4	Requires major renewal	Renew
5	Almost unserviceable	Replace

Condition rating.

contact the soil around it and the wastewater within it will contribute to its corrosion.

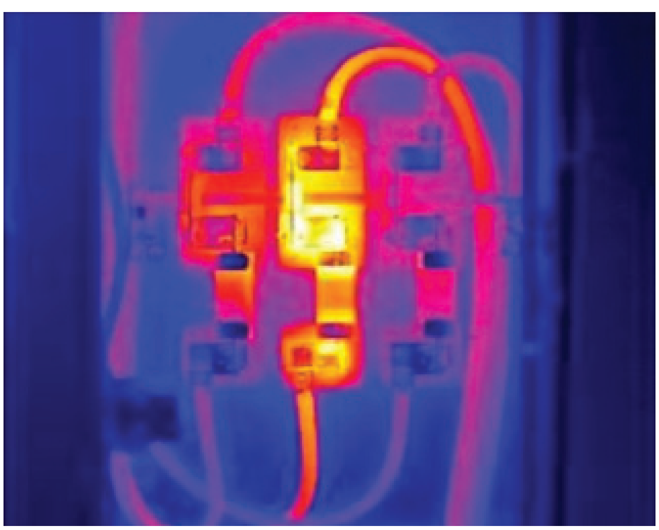
There are many additional factors that will affect how much life an asset will have. Factors such as poor installation, defective materials, poor maintenance and corrosive environment may all shorten an asset's life. Factors such as good installation, high quality materials, proper maintenance, and a non-corrosive environment will tend to lengthen an asset's life. Because of these site-specific characteristics, asset life must be viewed within the local context and its particular conditions. Clay sewer pipe may last 100 years at one location, and 30 years at another. It is best to make judgments on asset life based on past experience, system knowledge, existing and future conditions, prior and future operation and maintenance. In the absence of any better information, default values for the asset type can be used as a starting point. However, over time, an organization should use its own experiences to refine the expected life of assets.

What is the Value of the Assets?:

Generally, when utilities consider the value of assets, they think about the cost of initially installing the assets. This cost has no importance other than historical information or it can be used by a system that depreciates the costs of assets over time. However, the installation cost does not have a direct bearing on what it will cost to replace that asset when it has reached the end of its useful life. The asset may not be replaced by the same type of asset (e.g., clay pipe may be replaced by PVC pipe) or it may be replaced by a different technology entirely. Furthermore, costs of various assets may change drastically over time, such that the cost of installing pipe in 1956 in no way reflects the costs of installing pipe 60 years later in 2016. Some prices may increase, such as materials, while technological advances may decrease other costs. The real value of the assets is the cost it would be to replace the assets and allow (as a minimum) the same service to be delivered.

Although the idea behind an asset value is relatively simple, obtaining costs for the asset replacement is not easy. Small utilities may not have the expertise to estimate replacement costs. In these cases, the utility should either estimate in the best manner possible or leave this portion of the inventory blank for the initial stages of the asset management strategy. This information can be added later as the system gathers more information or expertise, and better determines which assets are most critical and need to be replaced in the near future.

If estimation is done, the possible approaches include:



Conditions Assessments with Thermopgraphy.

Vibration Conditions Assessment.

- Information regarding the cost per linear foot from recent projects can be used for linear assets such as gravity sewers and pressure mains
- Recent work done on neighboring systems
- Resources such as the Environmental Facilities Corporation, Rural Development, Environmental Finance Center, or New York Department of Environmental Conservation may have cost information for similar recent projects around the state
- Standard references such as the RS Means can be used to develop rough estimates
- Contact local vendors for estimates of equipment costs

Organizing the Asset Inventory

There are many options regarding how to manage the data collected and developed for the assets. Specific options include:

- Commercially available software for asset inventory, which will likely have other features including maintenance management
- Generic database software such as Microsoft Access
- Spreadsheet software
- Hand written inventory

The best option is a specifically designed asset management software program. This type of program provides the greatest level of flexibility in terms of use and is already programmed to contain asset inventory data. However, this type of program may be expensive and will require a computer system to make it accessible to the appropriate operational and management personnel. There are many software vendors that make packages to support these features, some specific to wastewater utilities. Some parameters that go into selecting the best software solution to manage the asset management data include:

- The size of the utility
- The number and nature of the assets the software will manage
- The available computer network and hardware
- Information technology support available to the utility
- Existing software owned and utilized by the utility
- Specific functionality desired
- Cost

Software costs may vary from free software available through the Environmental Protection Agency (CUPSS) to sophisticated software tools that cost several hundred-thousand dollars. There are software tools in every price range with the features and capabilities for any size utility.

The next option, generic database software, is much less expensive but will require a time commitment on the part of someone within the utility with the skills to set up the database and input the data. This option will, however, allow the utility to customize the tool to their specific needs.

Generic database software.

If the utility cannot initially purchase software, or develop a custom database for their asset inventory, they should develop a plan for how they will get a software tool in the future. For example, if they need to purchase a computer or software, they should begin setting aside funds for that purpose.

The other options available, spreadsheets and handwritten inventories should only be considered temporary solutions until the system can obtain a database of some type (the first two options). Neither of these approaches allows the system to easily categorize information and both should be considered temporary. Neither spreadsheets nor handwritten data allow the type of querying and analysis that an advanced asset management program requires.

Summary

It is critical for utilities to understand that they do not need to get bogged down with the details of the data quality when creating the initial asset inventory. The most important step is to develop at least a rudimentary asset inventory with the characteristics mentioned. The data quality can be improved over time as more information is discovered and the staff becomes more comfortable with the concepts of asset management.

Utilities should also be careful to not let themselves get overwhelmed in this step. This step is important but it should not be all consuming. The utility should complete this step to the extent possible and then move on to the other steps. In taking a long-term view of asset management, utilities should consider ways in which they can make the inventory more sophisticated. As an example, a GIS map and database may be a goal within five years. Utilities can also work with neighboring communities or parent towns or counties to share GIS equipment or GIS specialists to reduce the costs for all participants.

Level of Service

A Level of Service Agreement (LOS) defines the way in which the utility owners, managers, and operators want the system to perform over the long term. The LOS can include any technical, managerial or financial components the system requests, as long as all regulatory requirements are met. The established LOS should become a fundamental part of how the system is operated.

Why a Level of Service Agreement? There are two key facets to asset management – defining the level of service the system will strive to provide its customers over the long term; and, determining the most efficient and economical way to deliver that service (the least cost approach). Therefore, determining and detailing the level of service that the system is going to provide is a key step in the overall process.

Level of Service Agreement: This is the document that will spell out the service the system is to provide – it is a multi-faceted tool that can fulfill a wide array of purposes further described as follows:

- Communicate the system's operation to the customers (residential, industrial or commercial)
- Determine critical assets
- Provide a means of assessing overall system performance
- Provide a direct link between costs and service
- Serve as an internal guide for system management and operations staff and the board
- Provide information for system annual report or annual meeting presentation
- Reduce system costs through customer involvement

UV disinfection.

Customer Communication

It is important for a water or wastewater utility to communicate with its customers to avoid confusion, bad feelings, accusations of improper operation, and to make clear what the customer's expectations should be.

Determine Critical Assets

The LOS can be one factor in determining critical assets. Further considerations for determining critical assets are discussed in the next section. An example of how the LOS can impact criticality is where a system's LOS includes the factor: "Effluent water quality standards will be met 100 percent of the time." If the system has no redundancy in the wastewater disinfection system, this asset will be a critical asset for the system. It must be kept operational at all times in order to meet this level of service.

Provide Means for Assessing Overall System Performance: If at least some of the LOS factors include measurable items, the system can keep information regarding how well they are meeting these criteria and use that as one measure in assessing the overall operation. For example, consider a system that includes the following measures in its LOS:

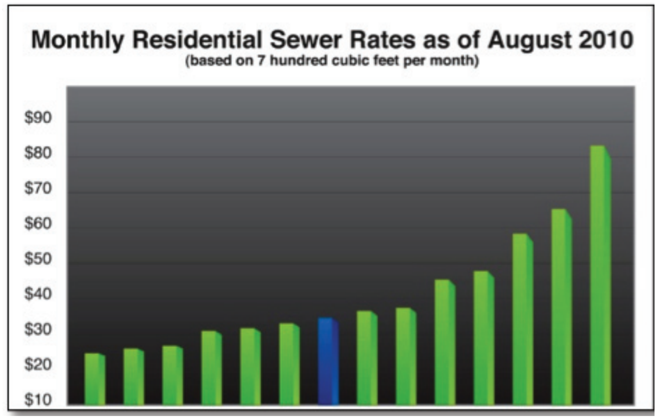
- Sewer main breaks will be repaired within six hours of initiation of repair 95 percent of the time.
- Customer complaints will be responded to within 24 hours, Monday through Friday.
- System will meet all state and federal regulations. All of these items are measurable if the system collects the appropriate data. Assume the system has the following data from its past year of operation:
- 250 sewer main breaks occurred, 230 were fixed in less than six hours
- 30 complaints were received, all 30 responded to within 24 hours
- System met all regulations; no violations. Based on this data, the system met some, but not all of its LOS factors. The following items were met:
- The customer complaints were responded to on time
- The system met all the state and federal regulations. The following items were not met:
- Sewer main breaks were not repaired within six hours

The utility can look at these results and determine the items that it needs to work harder on in order to meet the level of service requirements.

Provide Direct Link between Costs and Service: There is a direct link between the Level of Service provided and the cost to the customer. When a higher LOS is provided, the costs to the customers will increase. This relationship provides an opportunity for the wastewater system to have an open dialogue with its customers regarding the LOS desired and the amount the customers are willing to pay for this level of service.

Serve as Internal Guide to System Operation and Management: It is much easier to operate or manage a system when the operations and maintenance staff as well as the management staff understand the goals and priorities of the operation. Defining the LOS sets these goals for the system. These goals allow the operations staff to have a better understanding of what is desired from them and the management has a better understanding of how to use staff and other resources more efficiently and effectively. Checking how well the system is meeting LOS also allows the management to shift resources if need be from one task to another to meet all the goals more effectively.

What is the Minimum Starting Point for the Level of Service? All systems must operate within the state and federal regulations and requirements. These regulations are generally specified in the Clean Water Act and Safe Drinking Water Act, but there are



Residential Sewer Rates.

additional rules and regulations at the state and federal level. All systems should already be aware of these rules and should already be following them. Because there are many elements to the regulations, it is not necessary to spell out conformance with each and every regulation in the LOS. Instead, the LOS could contain a basic statement indicating that "the system will meet all applicable state and federal regulations." Alternatively, the LOS may include statements that describe categories of compliance such as, "will meet all water quality requirements," "will conform to all operator certification requirements," or "will meet all requirements of the open meetings act."

What Else Should be Included in the LOS? The maximum level of the LOS is defined by the maximum capabilities of the assets. A system cannot include something within a LOS that the system is not capable of doing. Within the range of the minimum (regulations) and maximum (capabilities of assets) there are numerous items a system could include within its LOS. Some considerations for level of service are:

- Number and duration of service interruptions (such as backups) experienced by customers.
- Number of times and quantity of untreated wastewater discharged per year.

- Quality of treated effluent: Does it comply with federal/state standards? Does it satisfy community expectations? Does it impact the health and safety of the community?
- Time to respond to customer complaints or questions.
- Nature of system's "environmental footprint" — is it a "green" system?
- Outreach and public education.
- Opportunities for customer input and involvement.

The LOS does not have to be lengthy; it can concentrate on a few key items the utility really wishes to focus on. It can also start out with a few items and grow from there to include additional items as the system gains more experience with asset management.

Critical Assets

Not all assets are equally important to the system's operation; some assets are highly critical to operations and others are not critical at all. Certain assets or types of assets may be critical in one location but not critical in another. For example, one system may believe their bar screen is a critical asset because it lacks redundancy and has been known to fail. Another system may feel their bar screen is not a critical asset because they have a redundant screen and adequate spare parts to fix the broken bar screen quickly. A system must examine its own assets very carefully to determine which assets are critical and why.

Determining Criticality: In determining criticality, two questions are important. The first is how likely the asset is to fail and the second is the consequence if the asset does fail. Criticality has several important functions, such as allowing a system to manage its risk and aiding in determining where to spend operation and maintenance dollars and capital expenditures.

As a first step in determining criticality, a system needs to look at what it knows about the likelihood that a given asset is going to fail. The data available to assist in this determination is: asset age, condition assessment, failure history, historical knowledge, experiences with that type of asset in general, and knowledge regarding how that type of asset is likely to fail. An asset may be highly likely to fail if it is old, has a long history of failure, has a known failure record in other locations, and has a poor condition rating. An asset may be much less likely to fail if it is newer, is highly reliable, has little to no history of failure and has a good to excellent condition rating.

The following describes each of the components that can go into a determination of likelihood of failure. Any additional information or resources that a system has to supplement these components should be considered also.

Asset Age: The asset's age can be a factor in determining likelihood of failure, but should not be a sole factor. Over time, assets deteriorate, either from use or from physical conditions such as interaction with wastewater or soil, and are more likely to fail. There is no "magic age" at which an asset can be expected to fail. An asset's useful life is highly related to the conditions of use, the amount of maintenance, the original construction techniques, and the type of material it is constructed out of. A piece of ductile iron pipe may last 75 to 100 years in one application, 150 years in another, and 50 years in yet another. Rather than being sole predictor of likelihood of failure, age should be supplemental to other information. If there are no other issues with an asset than its age, the likelihood of failure can still be relatively low even if the asset is quite old.

Asset Condition: One of the most important factors in determining an asset's likelihood of failure is the condition of the asset. As the asset's condition deteriorates, it will become much more likely to fail. It is important, therefore, to make the best attempt possible to give the asset a reasonable condition assessment. The condition assessment should also be updated over time, so that criticality can likewise be updated. Assets given poor or fair condition ratings are more likely to fail than those given excellent or good ratings. When the asset condition is combined with other factors, the utility can begin to make predictions regarding the likelihood of a given asset failing.

Failure History: It is important to monitor when assets fail and record the type of failure that occurred. This information should be as specific as possible to assist in understanding its failure modes. Track when the asset failed (or at least when the failure was discovered), how the failure was determined (customer report, operator observation, etc.), type of failure, specific location of failure, and any field observations that may help explain the failure (lack of bedding sand, subsidence of soil, overheating, etc.) Also track failure history on all of the asset types or categories.

Past failure is not a complete predictor of future

It's important to be prepared for any type of failure.

failure, but it can provide some indication of the likelihood of future failure, especially if detailed information on the failures is collected and reviewed. If the asset failed because its construction was poor or the pipe was severely corroded, it is likely to fail again unless some action was taken to correct the problem. If the asset failed because a construction crew broke the pipe, it is not likely to fail again if this is the only failure the pipe had. If a pipe has failed several times in the past few years, it would be more likely to fail again.

General Familiarities with the Asset: Although likelihood of failure is site specific, some guidance regarding likelihood of failure can be gained by examining experience with that type of asset in general. For example, if there is a history of a certain type of pump failing frequently after five years of use, and you have that type of pump and it is currently four and a half years of age, the asset may be given a higher likelihood of failure than it would be if there was no general experience of this type.

Knowledge of the Asset: John Moubray defines failure as follows: "Failure is defined as the inability of an asset to do what its users want it to do." In that regard, asset failure can be any time the asset is not able to meet the level of service the system wants. For example, a meter may be reading, but reading 25 percent less than what it should be reading. If the LOS states, "all meters will read within a 10 percent accuracy range" then this meter reading 25 percent less has failed, even though it is still operational. This is not a failure in the classical sense – i.e., a meter leak or a plugged meter – but it is failure in the sense that it is not meeting the operational expectations.

Failure in the more classical sense depends on the type of asset. Passive assets (such as pipes) decay over time and active assets (pumps, motors) decay with use. Passive and active assets do not fail in the same manner so they must be considered differently.

The factors discussed above can be taken together to predict how likely an asset is to fail. The rating can be a simple rating on a scale from 1 to 5 or may be more sophisticated. The ability to produce a more sophisticated failure rating is dependent on the amount and quality of data available. It may be necessary to start with a more basic analysis and then increase the sophistication over time as more data, knowledge and experience are developed.

In terms of the consequence of failure, it is important to consider all of the possible costs of failure. The costs include: cost of repair, social cost associated with the loss of the asset, repair/replacement costs related to collateral damage caused by the failure, legal costs related to additional damage caused by the failure, environmental costs created by the failure, and any other associated costs or asset losses. The consequence of failure can be high if any of these costs are significant or if there are several of these costs that will occur with a failure. Further information on each of these factors is presented below.

Cost of Repair: When an asset fails, it will be necessary to fix the asset in some way. Depending on the type of the asset and the extent of the failure, repair may be simple or extensive. A small leak in a pipe can be repaired with a clamp. A chlorine pump can be replaced with a spare pump or perhaps the diaphragm can be replaced inside the pump. The cost of the repair of the failed asset should be considered in the analysis of the consequence of failure. If the asset can be repaired easily and without a tremendous financial cost, then there is a lower consequence. If the cost of repair is higher, then the consequence of the failure is also greater.

Social Costs Related to Asset Failure: When an asset fails, there may be an inconvenience to the customer. In some cases, this inconvenience may be minor, while in other cases, the social costs may be much higher. If a sewer backs up or collapses there may be flooding or other significant impact to some residents. When an asset fails, in some cases, damage may be caused to other assets unrelated to the wastewater system. Examples of this type of damage would be the following: a sewer collapses causing a sinkhole which then causes damage to the foundation of a building or a house, or causes major sections of a road to collapse. The damage from the pipe failure without the sinkhole would be fairly minimal. With the sinkhole, there is collateral damage including the road, the building or house. Another example would be a sewer pipe leak that leaks sewage into a home or yard or onto a schoolyard or playground. In this type of case, a significant amount of cleaning will be required to restore the building, house or property. The utility will be held responsible for this collateral damage, so the costs related to this type of failure

Asset failure never comes at a convenient time; better management means better preparation.

need to be considered in the assessment of costs of the consequence of failure. There are likely also significant political consequences to a failure such as this.

Legal Costs Related to Asset Failure: In some cases, individuals or businesses may sue the utility for damages or injuries caused by an asset failure. These costs would be in addition to the costs of repairing and replacing damaged property or other assets.

Environmental Costs Related to Asset Failure: Some types of asset failures can cause environmental impacts. The costs related to these impacts may not always be easy to assess in monetary terms. However, some attempt should be made to establish some type of monetary value to the environmental consequences. An example of an environmental cost related to a failure would be a sewer pipe that leaked sewage into a waterway or onto land. A value, either monetarily or qualitatively, would need to be placed on this type of consequence.

Reduction in Level of Service: The assets must be in working order to deliver the level of service desired by the utility and its customers. If the assets fail, the ability to deliver the desired level of service may be compromised. An asset that has a major impact on the ability to meet the LOS would be considered more critical to the system than an asset whose failure would not have a significant impact on the LOS.

Other Factors to Consider with Failure or Loss of Asset: The costs in this category are any other costs that can be associated with an asset failure that are not adequately defined within the previous categories. Sometimes referred to as the "Triple Bottom Line," the goal is to identify and incorporate a broader economic evaluation of impacts of asset failures that include: financial, social, and environmental impacts. Some examples include loss of confidence in the wastewater system or loss of the utility's image. Certain types of failures may negatively impact the public's confidence in the water or wastewater system and this may have a cost to the system. Examples include: loss of income related to the inability to provide service for a period of time, loss of the service itself, or health impacts to workers or customers. Other examples include:

- Traffic Congestion
- Aesthetics
- Habitat Protection
- Health Factors
- Noise and Odor
- Air Quality
- Safety

In assessing the consequence or cost associated with the asset failure, the system should consider all the costs associated with all of the categories above. The assessment can be a simplistic ranking of the consequences from 1 to 5. In this type of structure, the assets would be ranked against each other, but a specific monetary amount would not be calculated for the failure of each asset.

Assessing Criticality: Assessing criticality requires an examination of the likelihood of failure and the consequence of failure as already discussed. The assets that have the greatest likelihood of failure and the greatest consequences associated with the failure will be the assets that are the most critical.

A technique such as a ranking table as presented here can be a good place to start in assessing criticality.

To use this table, estimate the probability of failure for each asset from 1 to 5 with 5 being very high probability of failure and 1 being a very low probability of failure. Then assess the consequence of failure for each asset from 1 to 5 in the same manner. Using the number for probability of failure, move across the row until the column associated with the number for consequence of failure is reached. Alternatively, move down the column for the consequence of failure until the row for probability of failure is reached. Locate the number that is in the box where the row and column intersect. That is the number for criticality for that asset. Once an analysis of this type is done, the results can be reviewed to determine if they make sense to the utility. If the utility does not believe the results for a particular asset make sense (i.e., the asset seems to have the wrong relative ranking), a re-evaluation can be completed to achieve reasonable results.

Multiplied		**Consequence (Cost) of Failure**				
		1	**2**	**3**	**4**	**5**
Probability of Failure	**1**	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

Assessing Asset Risk.

Criticality Analysis over Time: The condition of the asset will change over time as the consequences related to failure may also change. Costs of repair may go up, the community may grow, new roads may be built or similar factors may occur that cause the consequence of failure to change. Therefore, it is necessary to periodically review the criticality rankings and make adjustments to account for changes in the likelihood of failure and the consequence of failure. The criticality analysis must be kept up to date to ensure that the utility is spending its time and resources on the appropriate assets as discussed in the next section. Also, the analysis must incorporate replacement of assets. If an asset that was critical primarily due to its likelihood of failure is replaced with a new asset, the criticality number will go down since the likelihood of failure is much less.

Life Cycle Costing

Lifecycle Asset Management focuses on management options and strategies considering all relevant economic and physical consequences, from initial planning through to disposal. The Lifecycle components include:

- Asset Planning
- Asset Design
- Asset Creation/Acquisition/Construction
- Financial Management
- Asset Operation and Maintenance
- Asset Condition and Performance Monitoring
- Asset Rehabilitation/Renewal
- Asset Disposal
- Asset Audit and Review

As communities begin to develop their Asset Management plans, these components can seem overwhelming. It does not make sense to try to begin with all components at once. Therefore, this manual will guide you through the basics of the components that can easily be started.

Options for Dealing with Assets Over Time:

There are four basic strategies for managing assets over time:

1. Operate and maintain the existing assets
2. Repair the assets as they fail
3. Rehabilitate the assets
4. Replace the assets

These options are intimately connected to each other. Choosing to do more or less of one impacts how much of the others is done, whether or not the other is done at all, or the time frame in which one of the others is done. For example, choosing to spend more on operating and maintaining assets will decrease the need to repair the asset and will increase the amount of time until the asset needs to be replaced. Choosing to rehabilitate an asset will postpone the need to replace the asset. This will also reduce the amount of operation and maintenance that needs to be done and may reduce the need for repairs.

Each of these options has its own costs and considerations. The expenditure of funds becomes a balance between monies spent in each of these four categories. The purpose of asset management is to try to determine the optimal way to employ resources between each of these categories, while maintaining the LOS desired. Generally, the most expensive option is replacement of the assets. Therefore, keeping the assets in service longer by performing routine maintenance, while still meeting LOS conditions, will usually be the most economical for the utility over the long term.

Asset Operation and Maintenance: Operation and maintenance (O&M) functions relate to the day-to-day running and upkeep of assets and are particularly relevant to short-lived dynamic assets (such as pumps) where deterioration through lack of regular maintenance may result in rapid failure.

Properly operating and maintaining assets is critical to the success of the overall asset management program. O&M is directly linked to Level of Service and Critical Assets. Some key points of an O&M program are to have regular maintenance that is performed on assets.

1. Performing the correct O&M procedures regularly achieves maximum asset life and reduces O&M costs
2. Documenting and Standardizing O&M procedures helps utility personnel to operate all assets within acceptable operational levels and ensures that each person is following the same routines.

By standardizing the operations of all assets, maximum asset life can be obtained (assuming that periodic maintenance is performed as required).

In order to develop O&M procedures the reference materials must be located. Reference materials include manufacturer and vendor O&M manuals, process and instrumentation drawings, vendor submittals, shop drawings, specifications, pictures, design data, design drawings, as-built drawings, and interviews with experienced staff.

Developing operational procedure s includes:

1. Creating a title for the procedure that appropriately describes it, so it is easily identified. (e.g., "Annual Maintenance of Aeration Blowers")
2. Introduction: lists associated information such as the reason for the procedure, responsible parties, desired outcomes, safety procedures, lockout / tag out requirements, required materials, special equipment requirements, and notification requirements
3. Steps and/or Activities: example – "Step 1, Shut power off at the breaker located on the south wall labeled for the Aeration Blower to be worked on."
4. Note any cautions or hazardous conditions with each step or activity before the activity is performed

Maintenance procedures can be initially developed using vendor-supplied information, and enhanced over time based on experiences and staff knowledge.

If standard procedures are not implemented system wide, O&M procedures will be created on an ad-hoc basis, which can lead to fluctuations in process efficiencies, discord between operations and maintenance, increased asset downtime, wasting of chemicals and energy, and other similar problems.

The greatest reward for developing O&M procedures is that all maintenance activities are backed by management and standardized across all shifts by all personnel. It is also a useful way to determine what and how many spare parts should be kept on hand for both routing and emergency maintenance. This ensures consistency of personnel activities, product quality and O&M costs. The application of standardized maintenance procedures can reduce asset downtime and ensure lifetime productivity.

Asset Maintenance.

Operation and Maintenance and Critical Assets

One of the purposes for identifying critical assets is to allow the utility to make more informed decisions regarding the use of its operation and maintenance dollars. As discussed previously, the most critical assets are those assets that are likely to fail and have a significant consequence if they do fail. Therefore, it is most advantageous to the utility to spend the greatest portion of its operation and maintenance budget on assets that are critical to delivering the established levels of service.

Repair of Assets: In addition to operating and maintaining the assets, systems will need to plan for the repair of assets as they fail. Systems need to consider how long they will keep an asset in service prior to replacement of the asset. To some extent, these two items—repair and replacement—are off-setting.

If more resources (personnel and money) are spent on repair, there will be a decreased need for replacement. On the other hand, if greater resources are applied to replacing the assets, fewer resources will be applied to repair. There is a balance between how much to spend in each category: maintenance, repair, and replacement to achieve the most efficient system.

In developing a wastewater system repair schedule, the utility must determine its own approach to repairing verses replacing assets. The utility will need to decide when it is spending more money (including personnel hours) to repair the asset than it would cost to replace the asset.

Replacement of Assets: Eventually, all assets will need to be replaced. There will reach a point where the asset can no longer be kept in service through maintenance or repair or where the asset is no longer capable of meeting the LOS, either economically or may not have sufficient capacity. At that point, the asset will need to be replaced. Replaced assets can either be part of a replacement schedule or a capital improvement plan.

In both cases, the assets are replaced. The main difference is that the replacement schedule includes those items that are routinely replaced, smaller dollar replacements, and items replaced using the water or wastewater system revenues or reserve funds. The capital improvement plan indicates items that are major expenditures that do not routinely occur and that generally require outside funding for at least a portion of the project.


Sometimes repair is not possible and equipment must be replaced. Good maintenance strategies can prevent catastrophic failure.

Repair and Replacement Schedule: A replacement schedule should be developed that indicates assets that will be replaced within the next 20 years. This schedule can also be expanded to include programmed maintenance or repair, making it a Repair and Replacement Schedule. The types of activities that can be included here are major repair elements, such as a pump rebuilds, tank overhauls, digester cleaning, sewer rehabilitations, etc. This Schedule does not replace the operation and maintenance schedules discussed above, but works in conjunction to develop the total management strategy for each asset and forecast total lifecycle costs. The repair/ replacement schedule reflects those elements that are major budget items and that will occur routinely, but much less often than daily, weekly or monthly. These are generally items that are annually or greater in schedule and that constitute a major expenditure.

The schedule should include all of the recurring and non-recurring items for a minimum 20 year period, ideally the replacement schedule should forecast into the future enough to cover one complete life-cycle of each asset in the inventory. The Repair and Replacement Schedule should be updated annually so that it is always at least 20 years into the future.

The type of information to include on a Repair and Replacement Schedule includes:

- Year
- Asset Identifier
- Asset Criticality Score
- Description
- Estimated Cost
- Method of Estimation
- One Time or Recurring
- Time Period of Reoccurrence

It is absolutely critical that the items in the Repair and Replacement Schedule be considered in the rate setting process. These items must be funded out of system revenues, so they must be accounted for in the annual budget and reflected in the sewer rates. The Schedule will probably not be uniform from year to year in terms of amount of expenditure. To address this issue, you may wish to set an annual annuity payment to cover the Repair and Replacement Schedule expenses over the long term. Some years, the payment would be greater than that year's expenses, so money would go into a Repair and Replacement Reserve fund. Other times, the amount collected would be less than required so the additional funds would come from the reserve account.

The annual annuity set would have to be sufficient to cover all of the expenses over the 20 year or forecasted period. It may need to be increased over time if expenses increase and it can be decreased if it turns out too much money was dedicated to this purpose.

Capital Improvement Planning

A long-term capital improvement plan should look at the needs for current and the future. Ideally, the planning period would be at least 20 years, with a minimum of five years. It is understood that the specific expenditures and needs in the latter years forecasted, say 20 or more years, are more speculative than the needs for the first five to 10 years. However, the inclusion of the needs for this longer time period will provide a better opportunity for planning for the capital needs of all assets in the inventory.

Annual Review of Asset Replacement Projects: Asset replacement projects will be included in the Repair and Replacement Schedule and the Capital Improvement Plan. It is a good idea to review both of these documents on an annual basis to determine if all of the listed projects are indeed necessary. Sometimes another look at the list may reveal that some projects can safely be pushed back for several years or may not be needed due to changing conditions. Alternatively, the projects may also have changed in terms of specifically what technology or approach is best. The types of questions to examine in the completion of this type of review include the following:

- Is the reason/need for the project still valid?
- Have the costs changed since originally projected?
- Is there a better approach or a better technology that can be used to address the need?
- Can the project be safely delayed?
- Does the project need to be completed sooner?
- Is there a method of rehabilitation that could be used rather than replacement to save costs?
- Would it be more reasonable to reduce the LOS than increase the asset's capability?
- Will funding be available for the project?

Each year, the overall Repair and Replacement Schedule and Capital Improvement Plan must be revised to reflect completion of the current year's projects or the new schedule for those projects if they were not completed, any changes to the projects on the list, and to add the additional year at the end of the project period to keep the list at least 20 years.

Long-Term Funding Strategy

The first four components of the asset management strategy should lead to a discovery of what actions are most appropriate to take to manage the system at the desired level of service at the lowest life-cycle cost. The final factor in the asset management strategy is determining the best manner in which to sustainably fund the operation and maintenance, repair, rehabilitation, and replacement of assets. There are several sources of funding available to a system, so it is important to evaluate the item needing funding and the various options.

Funding Sources Available:

The sources of funding for the overall operation and maintenance of a wastewater system, including asset repair, replacement and rehabilitation include the following:

System revenues:

- User fees
- Hookup fees
- Stand-by fees
- Late fees
- Penalties
- Developer impact fees
- System reserve funds
- Emergency reserves
- Capital improvement reserves
- Debt reserves

System generated replacement funds:

- Bonds
- Taxes

Non-System revenues:

- State grants
- State loans
- Federal grants
- Federal loans
- State or federal loan/grant combinations

Rates and Asset Management: System revenues are a major component of an asset management plan. The system revenues will fund the operation and maintenance of the system; there generally are no outside funding sources for routine operation and maintenance of a wastewater utility. In addition, the rates will need to fund reserve accounts for emergencies, repairs and debt coverage (for any loans.)

A well developed rate structure will take into account needs for the current year as well as needs for future years, through reserve accounts. For example, if it is anticipated that a new regulation will require a higher level of treatment, the system should be collecting money through the rates to help pay for the needed equipment to meet the anticipated permit requirements.

The rate structure should also anticipate routine replacements of parts, particularly those parts that wear out regularly. If one engages asset management concepts to assist in setting rates, the rates may increase as the system moves from traditionally being underfunded (i.e., collecting insufficient revenues to cover all expenses) to being properly funded. However, rates that are set based on sound asset management principles are very defensible to the public. Asset management brings transparency to the process so that it is clear on what the rate is based. The more clearly the rate can be defended, the more likely it is to be accepted by the public.

There are many sources of rate setting assistance, including trainings and free rate setting tools and programs. Any approach that includes all costs of operation, considers the long-term view, includes reserve accounts, and considers conservation or other utility goals, is acceptable.

Sustainability

What Does "Sustainable" Mean?

The 1987 Bruntland report from the World Commission on Environment and Development defined sustainability as, "meeting the needs of the present generation without compromising the ability of future generations to meet their needs." Applying this to infrastructure, sustainability means having an active and effective program for renewal and replacement of components at a rate that allows for that infrastructure to continually serve a community into the future. Achieving sustainability requires the establishment of a long-term plan to gradually and continually repair, rehabilitate and replace all infrastructure assets (asset management) — a plan that ensures wise spending practices and a stable revenue stream for continuous support of needed future investments.

What Does Sustainable Water Infrastructure Look Like For My Community?

The path to sustainability is the same for a community as it is for the nation and has two basic elements:

1. Costs that include infrastructure replacement and operations, and
2. The revenue stream to support those costs.

Because of under-investment in the past, many communities have a gap between costs and revenues that can only be closed by pressure on those two variables. Strategies must be developed which lower the long-term costs or raise revenues to meet those costs. For most communities, the solution will lie in both, with the control of costs limited by the opportunities for efficiency and the raising of revenues limited by how much the members of a community can afford to pay.

What Can Be Done to Help Ensure Infrastructure in My Community is Managed Effectively?

Managing today's utilities is a complex and challenging endeavor. Across the wastewater sector, there are numerous programs to help utilities manage various aspects of their operations. In an effort to develop a common framework for utility management, the US Environmental Protection Agency (USEPA) and six major professional associations in the water sector have come together to define and promote an approach through the Effective Utility Management (EUM) partnership. Based on the experiences and recommendations of leading utility managers from across the nation, EUM is built around "Ten Attributes of Effectively Managed Water Sector Utilities," -- a structured, 360-degree framework for assessing utility operations and tackling the area's most important to improving utility-wide performance and efficiency. The goal of the EUM initiative is to help utilities address a full range of challenges and help them move toward sustainable operations and infrastructure.

While these associations have enthusiastically endorsed the EUM framework and the Ten Attributes, they were actually developed by utilities for utilities. They are based on improvement initiatives that many utility managers have already implemented to save money for their communities, help keep rates at affordable levels, and help improve their economic competitiveness. In addition, these utilities have also been able to improve their environmental performance by using the Effective Utility Management approach. The Ten Attributes include:

1. Product Quality
2. Customer Satisfaction
3. Employee and Leadership Development
4. Operational Optimization (efficiency)
5. Financial Viability

6. Infrastructure Stability (management of assets)
7. Operational Resiliency (safety and security)
8. Community Sustainability (environmental sensitivity)
9. Water Resource Adequacy
10. Stakeholder Understanding and Support

Five Things Local Officials Should Do to Support Sustainable Water Infrastructure

1. **Manage Infrastructure for the Long Term:** The demands of daily operations and the constraints of tight budgets can make it difficult to invest the time and resources necessary for successful long-term planning. However, managing and planning for the long term reduces overall costs and leaves the community with a legacy of sustainability.

The communities across the world that are leading the way in infrastructure sustainability have adopted and institutionalized an approach called Asset Management. When all the parts of an Asset Management effort are working together, the community will know where it stands and where it is going, and each investment made will give the greatest value for the infrastructure's dollar.

2. **Maximize Dollars through Efficiency:** Regional water quality issues, high energy costs, and the increasing impacts of a changing climate, have elevated water treatment and energy efficiency to one of the most pressing concerns in the water sector.

Drinking water and wastewater services are typically the largest energy consumers of municipal governments, accounting for 30 to 40 percent of total energy consumed—no community can afford to pay for inefficiency.

Energy Efficiency—Why Pursue It?: An estimated three percent of national electricity consumption, equivalent to approximately 56 billion kilowatts (kW), or $4 billion, is used in providing drinking water and wastewater services to communities each year. The good news is that water and wastewater plants often have the potential to reduce energy use by 15 to 30 percent. Depending on the size of the utility, this can save thousands, or even hundreds of thousands of dollars in operating costs, which can be applied to needed infrastructure.

Water and wastewater treatment facilities in New York State alone consume more than billion kWh of electricity per year. New York State Energy Research and Development Authority (NYSERDA) is a public benefit corporation created in 1975 with the goal of reducing the state's petroleum consumption. Today, NYSERDA's aim is to help New York meet its energy goals: reducing energy consumption, promoting the use of renewable energy sources, and protecting the environment. NYSERDA has numerous programs that municipalities can take advantage of to help identify and fund energy efficiency measures for a municipality.

The Village of Old Forge was recognized for their Asset Management Plan.

What is the first step in pursuing it? Work with utilities to identify areas for energy savings by pursuing an initial energy audit. Then make it a priority to support targets and strategies for improvement. Make sure least life cycle cost solutions become part of the utility's ongoing business model, as part of an asset management program.

Utilities also have numerous opportunities for onsite production of energy. Some of the country's leading utilities have combined efficiency and onsite generation to offset the need for outside energy sources; in some cases, coming close to 100 percent self-powered.

3. **Ask About Alternative Solutions:** Leading wastewater sector utilities are finding new, innovative ways to meet the challenges of their aging infrastructure. Each community's wastewater and stormwater needs and challenges are unique. As stewards of the community, local officials can facilitate the exploration of viable alternative solutions that:

- Have lower long-term costs than traditional approaches, and
- Provide the best overall benefits to the community.

Technology is constantly evolving, and successful strategies are being employed across the country every day. Ask for an analysis of the alternative solutions available in order to spark new ideas for meeting your own community's needs.

Green Infrastructure can be both a cost-effective and an environmentally preferable approach to reduce stormwater and other excess flows entering combined or separate sewer systems. Runoff reducing approaches include: green roofs, trees and tree boxes, rain gardens, and porous pavements.

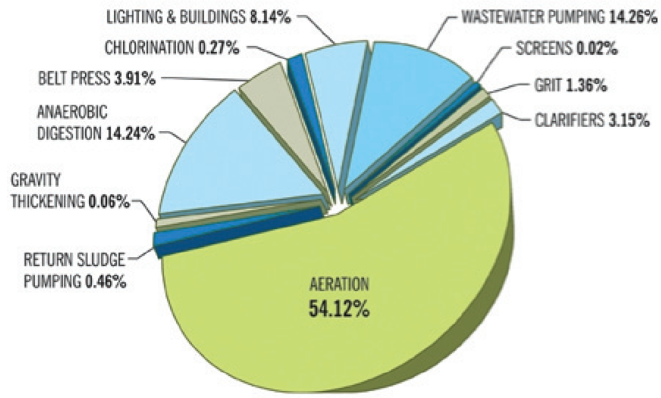
Smart Growth is development that serves the economy, the community and the environment. It changes the terms of the development debate away from the traditional growth/no growth question to, "how and where should new development be accommodated?" It also affects long-term wastewater infrastructure needs. Sprawl and poorly planned growth has, in many cases, left everyone with more extensive infrastructure to support and maintain—and by growing "smartly," the community's future infrastructure can be put on a more sustainable footing.

Use the best technology. Innovative, cost-effective technologies can make a real difference in a wide variety of infrastructure investments. Some examples include:

- Lining existing pipes instead of replacing them.
- Using pipe inspection technologies to target the portions of pipes that most require attention.
- Using nutrient removal technologies.
- Using automated systems.
- Using biosolids that are by-products of wastewater treatment.

On-site/Decentralized Wastewater Management can be a viable and cost-effective alternative to centralized wastewater collection and treatment. Septic system regulation is usually a state, tribal and local responsibility. The USEPA provides information to homeowners and assistance to state and local governments to improve the management of septic systems and prevent failures that could harm human health and water quality.

4. **Talk about Sustainable Wastewater Infrastructure:** Community support of long-term wastewater infrastructure investment is critical to achieving a greater level of sustainability. Local officials play a key role in communicating the state-of-the-community infrastructure, the value of infrastructure investments, and the benefits to the community.



Wastewater Energy Consumption

Community awareness is vital to securing support for the investments that all communities must make, and to securing the funding to do so.

Communicating why wastewater infrastructure is important includes these key elements:

- Have the answers about rates
- Additional resources
- Communicating why water infrastructure is important

The Water Environment Federation (WEF) has developed "Water is Life and Infrastructure Makes it Happen," an education program designed to teach the value of water infrastructure and the importance of investing in its long-term stability.

Additional campaign materials provided on the WEF website include:

- Successful communication campaign case studies
- Communication Toolkit (bill stuffers, media guide, presentation material, sample press releases, etc.)

Talking Points: The National Water Research Institute has established a Utility Branding Network to help water sector organizations communicate the value of the services they provide to their communities.

Have the Answers about Rates: Most of the funding for wastewater infrastructure comes from the revenues generated by utilities. No local official needs to be told that rates for these essential services are a touchy point for their constituents; however, holding rates steady for the long term is not sustainable. Due to inflation, the revenues that utilities bring in today will have less buying power in the future; therefore, keeping rates steady actually decreases a utility's budget each year.

One way to support sustainability of a community's infrastructure is to know and communicate the facts about water rates to its constituents.

Additional Resources: Liquid Assets: The Story of Our Infrastructure—this PBS documentary has been shown all around the country and has proven very effective at communicating the value of water sector infrastructure and the challenges that many communities face. Get it shown in your community!

5. **Initiate or Expand Collaboration:** Local officials are in a unique position to ensure that all the right people are talking and working together toward long-term infrastructure sustainability. The right collaborations can produce both cost savings and better, multi-benefit solutions for each community. Below are examples of some of the realms where "collaboration gaps" can occur. Consider where greater collaboration might benefit your community and initiate or expand a dialogue with key stakeholders.

- Collaboration among drinking water and wastewater and stormwater
- Collaboration across the watershed
- Collaboration among water sector, city planning and other infrastructure sectors

Collaboration among Drinking Water, Wastewater and Stormwater: All three of these utilities or departments have issues that overlap as they address water issues in the community. Drinking water is used and becomes wastewater. Wastewater effluent and stormwater enter the streams and/or aquifers, which are used as drinking water sources. All three need a plan for their infrastructure renewal. Coordinated renewal and an integrated plan for all aspects of water in a community achieve efficiencies and help ensure long-term supply. While many communities have all three areas working closely together, others have drinking water, wastewater and stormwater issues addressed by distinct departments and could benefit from increased coordination.

Water Collaboration across the Watershed: Reach outside of the community to partner with others who affect the drinking water and wastewater infrastructure. Upstream wastewater discharges and stormwater management affect downstream drinking water supplies. Higher capability utilities can share experiences and strategies with lower capability ones. Collaborating to buy chemicals in bulk, share resources and expenses, or even consolidate some functions with other utilities in the same watershed can achieve economies of scale—and make dollars go further.

This Chapter prepared by Timothy Taber, PE, BCEE, Associate at Barton & Loguidice, P.C.

Rain garden at Mott Road Elementary School in Central New York.