Report of the Tennessee Advisory Commission on Intergovernmental Relations

The Condition of and Best Practices for Tennessee Wastewater Systems

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September 2024

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Report of the Tennessee Advisory Commission on Intergovernmental Relations

The Condition of and Best Practices for Tennessee Wastewater Systems

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State of Tennessee

Tennessee Advisory Commission on Intergovernmental Relations
226 Anne Dallas Dudley Boulevard, Suite 508
Nashville, Tennessee 37243

September 11, 2024

The Honorable Randy McNally
Lieutenant Governor and Speaker of the Senate

The Honorable Cameron Sexton
Speaker of the House of Representatives

Members of the General Assembly
State Capitol
Nashville, TN 37243

Ladies and Gentlemen:

Transmitted herewith is the Commission's report on its study of the operations and financing of Tennessee's wastewater utilities that was prepared in response to a request from County Executive and Tennessee Advisory Commission on Intergovernmental Relations (TACIR) commission member Jeff Huffman. Based on requests from other TACIR commissioners, the scope of the study was expanded to include looking at the governance structures of wastewater utilities, whether the members of their governing bodies are compensated, whether the compensation includes benefits and staffing issues at wastewater utilities. The Commission found that Tennessee has invested heavily in upgrading its wastewater infrastructure, but some systems are struggling to maintain their aging equipment while meeting growing service demands. It is likely that Tennessee's wastewater systems will need to spend billions to pay for the repair, replacement and expansion of their infrastructure. Some systems are having difficulty attracting and retaining certified wastewater operators, in part because of an aging workforce and difficulty attracting younger workers. Retention is also an issue for some systems, as operators often leave for better-paying jobs at other wastewater systems.

The Commission approved the report on September 11, 2024, and it is hereby submitted for your consideration.

Respectfully yours,

Senator Ken Yager
Chairman

Cliff Lippard
Executive Director

The Tennessee Advisory Commission on Intergovernmental Relations

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MEMORANDUM

TO: Commission Members

FROM: Cliff Lippard
Executive Director

DATE: 11 September 2024

SUBJECT: Wastewater Systems Operations and Finances Report—Final Report for Approval

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The attached Commission report is submitted for your approval. It was prepared in response to the request from County Executive and TACIR commission member Jeff Huffman that the Commission study the operations and financing of Tennessee's wastewater utilities. County Executive Huffman asked that the study examine

- the condition of Tennessee's wastewater systems,
- the number of wastewater systems that have enforcement letters from the Tennessee Department of Environment and Conservation (TDEC),
- the best practices for wastewater system management from other states,
- new technologies for wastewater system management that local governments could consider and would be permissible under TDEC rules,
- methods of wastewater system management that have not worked and should be avoided,
- the best methods for financing sewer lines and wastewater treatment plants, and
- the best methods to reduce the operating costs of wastewater systems.

Based on requests from other TACIR commissioners, the scope of the study was expanded to include looking at

- the governance structures of wastewater utilities, whether the members of their governing bodies are compensated; and whether the compensation includes benefits; and
- staffing issues at wastewater utilities.

The findings from the draft report remain unchanged, though staff did add some additional information from a new TDEC report on drip dispersal wastewater systems. In summary, the report finds

- Tennessee has invested heavily in upgrading its wastewater infrastructure, but some systems are struggling to maintain their aging equipment while meeting growing service demands;
- wastewater systems in Tennessee will likely need to spend billions to pay for the repair, replacement and expansion of their infrastructure;
- as of May 2024,
    - there were 57 local governments that operate wastewater systems with active enforcement orders;
    - there were also 13 other entities that operate wastewater systems with active enforcement orders—7 of the 13 are privately operated, 4 that are operated by schools, and 2 that are operated by the state;
    - there are 36 local governments that operate wastewater systems with sewer moratoriums;
- asset management plans can help systems manage their infrastructure needs more efficiently by prioritizing projects and planning for their funding;
- the use of the Effective Utility Management framework developed by the United States Environmental Protection Agency and other water and wastewater industry organizations can also help systems manage more efficiently;
- efficient energy consumption can help cut operating costs;
- research and interviews confirmed the risks of failing to properly manage equipment and assets;
- the best methods for financing sewer lines and wastewater treatment systems will likely involve a combination of funding sources including grants, loans or bonds depending on the project size and the individual circumstances that exist at the utility;

- wastewater treatment systems, to include a few in Tennessee, are using technologies and processes that help them to extract resources from wastewater like water for irrigation, nutrients for fertilizers, and biogas for fuel;
- most of the public wastewater systems in the state, 82%, are operated by municipalities, and the municipalities' governing bodies oversee them;
- compensation for the people who serve on the public wastewater systems' governing bodies varies across the state with 65% of respondents to a survey by Commission staff reporting that they compensate their board members, with amounts ranging from $50 per month to $17,000 per year;
- benefits also vary, with 32% of respondents offering health insurance, 22% providing vision insurance, and 20% offering dental insurance;
- 17% of respondents to the Commission staff survey said they had difficulty attracting and retaining certified wastewater operators, in part because of an aging workforce and difficulty in attracting younger workers; and
- retention is also an issue, as operators often leave for better-paying jobs at other wastewater systems.

Staff added information to the report from TDEC's Report on the Performance of Wastewater Systems Utilizing Drip Dispersal in Tennessee, which was released after the last commission meeting. TDEC's report summarizes the findings of its recent survey evaluating the performance of decentralized wastewater systems using drip dispersal for land application across the state. This was the first comprehensive evaluation of its kind in Tennessee. Over 370 decentralized wastewater systems in the state rely in some way on the land application of wastewater through drip dispersal; however, only 360 are currently operational according to TDEC's survey results.

The purpose of the TDEC survey was to observe how the soil handled the water discharged by the systems and report the results to help guide design engineers, entities that operate wastewater systems, and future development efforts. The most common and difficult challenge these systems face is the hydraulic overload of the soil profile—when incoming wastewater flow exceeds the system's design limiting the soil's ability to drain properly and the system's ability to adequately treat the effluent. TDEC observed and documented non-compliance in 51% of the surveyed systems. They noted the instances of non-compliance ranged from wastewater completely bypassing the system to lack of maintenance resulting in overgrown conditions preventing access to the land application area. TDEC did not identify the causes of noncompliance in the report, and they did not identify specific follow up actions for wastewater systems.

Contents

Summary and Findings: The Condition of and Best Practices for Tennessee Wastewater Systems

Tennessee's wastewater systems face several challenges, including aging infrastructure, complying with federal and state rules and regulations, meeting extra demand caused by population growth, and recruiting employees to replace retiring workers. Because of these and other concerns, County Executive and Tennessee Advisory Committee on Intergovernmental Relations (TACIR) commission member Jeff Huffman asked the commission to study the operations and financing of Tennessee's wastewater systems. He asked that the study examine

- the condition of Tennessee's wastewater systems,
- the number of wastewater systems that have enforcement letters from the Tennessee Department of Environment and Conservation (TDEC),
- the best practices for wastewater system management from other states,
- new technologies for wastewater system management that local governments could consider and would be permissible under TDEC rules,
- methods of wastewater system management that have not worked and should be avoided,
- the best methods for financing sewer lines and wastewater treatment plants, and
- the best methods to reduce the operating costs of wastewater systems.

Based on requests from other commission members, the scope of the study was expanded to include

- the governance structures of wastewater systems, including whether board members are compensated and whether the compensation includes benefits; and
- staffing issues at wastewater systems.

Tennessee's wastewater systems face several challenges, including aging infrastructure, meeting extra demand caused by population growth, and recruiting employees to replace retiring workers.

Tennessee has invested heavily in upgrading its wastewater infrastructure, but some systems are struggling to maintain their aging equipment while meeting growing service demands.

Tennessee has invested heavily in wastewater infrastructure in recent years—state administered awards from federal American Rescue Plan

(ARP) funds alone have totaled $467 million in noncompetitive grants and $44 million in competitive grants for wastewater projects since 2021. But still, most wastewater infrastructure construction and improvements are debt financed by local governments, and those governments are struggling to keep up with increased service demand and their systems' age. The *2022 Infrastructure Report Card* from the American Society of Civil Engineers graded Tennessee's wastewater infrastructure a C-. The report card states that over the past decade, efforts to expand capacity to support a growing population have resulted in neglected maintenance. The Tennessee section of the American Society of Civil Engineers noted that this was evidenced by the increased number of sewer overflows, which have at times resulted in sewer tap moratoriums—a temporary restriction on establishing new sewer connections or taps to existing infrastructure—essentially putting a pause on new development.

Wastewater systems in Tennessee will likely need to spend billions to pay for the repair, replacement, and expansion of their infrastructure.

Wastewater systems may also need to spend money to repair or replace their infrastructure to comply with their National Pollutant Discharge Elimination System (NPDES) permits or State Operating Permits (SOP). Wastewater systems planning to discharge into the state's surface waters must obtain a NPDES permit from TDEC. A State Operating Permit (SOP) issued by TDEC is required for wastewater systems that do not discharge into any surface or subsurface waters, like a wastewater system that discharges treated wastewater onto land. TDEC monitors compliance with the state's environmental laws, rules, and regulations, and it takes enforcement action when necessary.

Wastewater systems in the state will also likely need to expand their service in some areas as a result of the state's growing population. Tennessee's population is projected to reach 7,980,650 by 2042, marking a 13.8% increase from 2022, according to the University of Tennessee's Boyd Center for Business and Economic Research. West Tennessee will be one area that will see additional population growth because of the opening of Ford's BlueOval City, an expansive automobile manufacturing complex.

Wastewater systems in Tennessee will likely need to spend billions to pay for the repair, replacement, and expansion of their infrastructure. The state's 2018 report, *TN H2O: Tennessee's Roadmap to Securing the Future of Our Water Resources*, estimated it would cost approximately $8.9 billion to fund the repair and replacement of aging wastewater infrastructure and to extend the wastewater services to support the state's growing population from 2018 through 2040. However, local and state officials surveyed for the commission's infrastructure report said that $3.5 billion is needed to fund wastewater infrastructure projects that will be in some stage of development between fiscal year 2021-22 and fiscal year 2026-27.

There are 57 local governments that operate wastewater systems with active enforcement orders from TDEC and 36 with sewer moratoriums.

TDEC's enforcement actions range from informal notices of violation (NOV) to formal enforcement orders (EO) and moratoriums on new sewer connections. As of May 2024, 57 out of 278 public wastewater systems had active orders that were either final, signed, or appealed for permit violations from TDEC. There were also 13 other entities that operate wastewater systems with active EOs—seven of the 13 are privately operated, four are operated by schools, and two are operated by the state. Additionally, as of May 2024, there were 36 local governments that operated wastewater systems with sewer moratoriums.

As of May 2024, 57 of 278 public wastewater systems had active orders that were either final, signed, or appealed for permit violations from the Tennessee Department of Environment and Conservation.

There are 53 local governments with wastewater systems under financial oversight of the Tennessee Board of Utility Regulation.

State oversight is not limited to system operations; the Tennessee Comptroller of the Treasury identifies financially distressed systems based on audits and then refers the systems to the Tennessee Board of Utility Regulation (TBOUR), which oversees the financial integrity of wastewater systems. Distress is defined to include, but is not limited to, two consecutive years of negative change in net position (costs exceeding revenue), defaulting on debts, or overall liabilities exceeding assets. As of May 2024, 53 out of 278 public wastewater systems were under the board's oversight for being financially distressed. Thirteen of these systems were under distress specifically because of sewer service. Forty of these systems have a combined water and sewer fund, making it difficult to determine whether they were under distress because of water or sewer service or both.

Prudent management is essential to contain costs and reduce hazards.

Commission staff did not identify any valid management practices that should be avoided. Rather, research and interviews confirmed the risks of failing to properly manage equipment and assets. Neglecting regular equipment maintenance can lead to costly repairs and non-compliance with state regulations. Failing to implement an asset management plan can result in poor prioritization of infrastructure needs and inadequate funding for capital improvements. Ignoring energy efficiency measures can lead to unnecessary expenditures and higher operational costs. Improper dosing or monitoring of chemical disinfection can release harmful byproducts or fail to remove pathogens adequately, posing health risks. Additionally,

inadequate sludge treatment and disposal can contaminate soil, water, and air.

Asset management plans and use of the Effective Utility Management framework can help systems manage more efficiently.

An asset management plan helps systems prioritize critical infrastructure needs and direct spending efficiently.

An asset management plan helps systems prioritize critical infrastructure needs and direct spending efficiently. These plans can help ensure user rates are based on sound financial planning. According to TDEC's *Asset Management Plan Guide*, key components of an asset management plan include assessing the current state of infrastructure, creating a capital improvement plan that outlines the timing and costs of infrastructure rehabilitation or replacement, and developing a long-term funding strategy. A system like Downers Grove Sanitary District in Downers Grove, Illinois, demonstrates the benefits of incorporating computerized maintenance management systems and geographic information systems (GIS) into their asset management process to help improve their asset replacement needs and costs. Their GIS has information on the location and size of its sewers in addition to their installation dates and construction plans. The GIS is linked to their computerized maintenance management system that has information on the history of repairs and inspections of the sewers. The system also uses video cameras to help assess the condition of its pipes. This helps the system identify pipes that need to be replaced and repaired.

There are many management models that organizations can use to operate more efficiently and effectively. The US Environmental Protection Agency (EPA), along with water and wastewater industry organizations, developed an industry-specific approach to utility management called the Effective Utility Management (EUM) framework. This framework consists of five keys to management success. Systems like Austin Water in Texas and Columbus Water Works in Georgia have used the framework, which led to improved employee recruitment and customer satisfaction initiatives.

Wastewater treatment technologies are enabling efficient resource recovery and cost savings.

Wastewater treatment technologies are evolving to meet the demands of modern systems, with a strong focus on the renewable use of resources. Wastewater treatment systems, including a few in Tennessee, are using technologies and processes that help them to recover resources from wastewater like water for irrigation and nutrients for fertilizers. The Murfreesboro's wastewater system, for example, uses water from its water reuse system in its wastewater plant and provides non-potable water to golf courses and residential developments in the community to be used for irrigation. This means less water is discharged into local waterways.

With technologies like membrane bioreactors, systems can remove more contaminants from water, and they can process sludge more efficiently with thermal hydrolysis. The use of solar photovoltaic (PV) panels can also help systems save some money on electricity. For example, Chattanooga installed solar panels as its Moccasin Bend wastewater treatment plant, and those, along with other energy-saving measures, are helping it to save $1.4 million per year.

Efficient energy consumption is key to cutting costs.

To help cut operating costs, wastewater systems can focus on reducing energy consumption, which can constitute 25% to 40% of a system's annual operating budget. The EPA states that by incorporating energy efficient practices into their plants' operations, wastewater systems can reduce their costs by 15% to 30%. Implementing energy-efficient technologies and practices, such as idling or turning off non-essential equipment during periods of peak power demand and properly maintaining motors, can significantly contribute to these savings. Regular energy audits and continuous monitoring of energy usage also play crucial roles in identifying areas where further efficiencies can be achieved.

To help cut operating costs, wastewater systems can focus on reducing energy consumption, which can constitute 25% to 40% of a system's annual operating budget.

The best method for financing wastewater infrastructure projects will likely involve a combination of funding sources.

When it comes to financing wastewater infrastructure, systems may want to look at grant opportunities first, as grant money does not need to be repaid and can reduce the amount of money that needs to be borrowed, although many grant programs have matching requirements. Bonds may be a viable financing option for some systems but not others. For example, small systems in poor financial condition may struggle to attract bond buyers. Cities, counties, and metropolitan governments can issue general obligation bonds, which are backed by their taxing authority. Revenue bonds, which are backed by a system's revenues, can be issued by cities, counties, metropolitan governments, utility districts, water and wastewater authorities, and municipal energy authorities. The marketability of revenue bonds depends on the project and the system's ability to generate revenue. Because of this, revenue bonds may sometimes have higher interest rates than general obligation bonds. Loans from government or private sources may also be an option for systems that can't issue bonds. Systems that issue bonds could also use loans as another funding source for projects as could systems that didn't issue bonds.

Public wastewater systems in Tennessee are governed by various local entities whose compensation methods for those who serve on the governing bodies also vary.

Eighty-two percent of the public wastewater systems in Tennessee are operated by cities, and the cities' governing bodies oversee their systems. A few cities have separate utility boards that govern their systems. Thirteen percent of the wastewater systems in the state are overseen by the boards of utility districts, municipal energy authorities, or water and wastewater authorities. Three percent of the systems are operated by counties and metropolitan governments, and these are governed by the county or metropolitan government's governing board, a utility or public works department in the government, or a separate utility board. Two percent of the systems are operated by local governments working together jointly, and they are overseen by a board or committee.

Some of the wastewater systems in Tennessee face staffing challenges.

Compensation for the people who serve on the systems' governing bodies varies across the state. According to a survey of wastewater systems by commission staff, 65% (53 out of 82) of the survey respondents compensate their board members, with amounts ranging from $50 per month to $17,000 per year. Benefits also vary, with 32% (26 out of 82) of respondents offering health insurance, 22% (18 out of 82) providing vision insurance, and 20% (16 out of 82) offering dental insurance. Additionally, 9% (7 out of 82) of systems offer retirement benefits through the Tennessee Consolidated Retirement System (TCRS). Some systems also provide additional benefits, such as travel for board-related activities.

Retirement, retention, and recruitment are causing staffing challenges for some wastewater systems.

Some of the wastewater systems in Tennessee face staffing challenges. Seventeen percent (14 out of 82) of respondents to the commission staff survey said they had difficulty attracting and retaining certified wastewater operators. This is partly because more workers are eligible for retirement, and systems are having difficulty attracting new workers. Thirty-nine percent (32 out of 82) of the respondents reported they had at least one certified wastewater operator that would be retiring in the next 10 years. Sixteen percent (13 out of 82) of respondents reported that all (100%) of their certified operators would be retiring within 10 years.

In addition to retirement, retention is an issue for some systems that report operators are leaving for better-paying jobs at other systems. Seventeen percent (14 out of 82) of survey respondents said they have difficulty retaining certified wastewater operators. Survey respondents also said that operators will move onto larger systems that have more opportunity to advance. Some said they couldn't compete with surrounding communities when it comes to pay and benefits.

To help with recruiting new employees, the Tennessee Association of Utility Districts (TAUD) launched its first water and wastewater utility apprenticeship program in 2020. The program is designed to help fill the need for certified water and wastewater facility operators in rural Tennessee and raise awareness of careers in the industry. TAUD also partnered with Fayetteville Public Utilities (FPU) to create a pre-apprentice program for local high school students, teaching them about careers in the water industry. Systems in other states have instituted similar programs.

To help with recruiting new employees, the Tennessee Association of Utility Districts (TAUD) launched its first water and wastewater utility apprenticeship program in 2020.

Analysis: The Condition of and Best Practices for Tennessee Wastewater Systems

Wastewater can contain various substances that pose risks to human health, including pathogens such as protozoans, viruses, and bacteria, which can cause diseases like encephalitis, hepatitis A, salmonella, and typhoid fever.[1] Additionally, wastewater contains numerous chemicals.[2] While substances like shampoo and body soap are generally harmless, others like paint thinners and antifreeze can be harmful and pose significant risks to human health when present in untreated wastewater.[3] Per- and polyfluoroalkyl substances (PFAS) are another set of chemicals in that have been used in products since the 1940s.[4] PFAS are commonly found in wastewater and may pose potential risks to human health.[5] Scientific research has indicated that PFAS may result in decreased fertility, developmental delays in children, increased cholesterol levels, and increased risk of obesity and cancer in humans.[6]

Wastewater can contain various substances that pose risks to human health.

Chemicals, organic material, nitrogen, and phosphorus in wastewater can also affect aquatic life.[7] PFAS, for example, can affect the growth and development of fish.[8] Bacteria use oxygen to break down organic material and ammonia in wastewater,[9] taking oxygen away from the fish and other aquatic life that need it to survive.[10] An excess of nitrogen and phosphorus can feed growth in algae that consumes oxygen and blocks sunlight from reaching plants below the water's surface, which can kill them.[11] This can lead to the death of aquatic life—otherwise referred to as eutrophication.[12]

Beyond public health and environmental safety concerns, inefficient or failing wastewater systems could lead to costly repairs, civil penalties, or even lawsuits. With these health, safety, and efficiency concerns in mind, County Executive and Tennessee Advisory Committee on Intergovernmental Relations (TACIR) commission member Jeff Huffman asked the commission at its January 26, 2023, meeting to study the operations and financing of Tennessee's wastewater systems. He requested that the study examine

- the condition of Tennessee's wastewater systems,

[1] Indiana Department of Health "Diseases Involving Sewage"; and Olson et al. 2001.
[2] US Environmental Protection Agency 2004.
[3] Ibid.
[4] US Environmental Protection Agency "PFAS Explained."
[5] Thompson et al. 2022.
[6] US Environmental Protection Agency 2024h.
[7] US Environmental Protection Agency 2004; and US Geological Service 2018b.
[8] Jantzen, Annunziato, and Cooper 2016.
[9] US Environmental Protection Agency 2004.
[10] Ibid.
[11] US Environmental Protection Agency 2024b.
[12] Preisner, Neverova-Dziopak, and Kowalewski 2021.

- the number of wastewater systems that have enforcement letters from the Tennessee Department of Environment and Conservation (TDEC),
- the best practices for wastewater system management from other states,
- new technologies for wastewater system management that local governments could consider and would be permissible under TDEC rules,
- methods of wastewater system management that have not worked and should be avoided,
- the best methods for financing sewer lines and wastewater treatment plants, and
- the best methods to reduce the operating costs of wastewater systems.

Wastewater must be treated before it is discharged to reduce the amount of harmful substances in the water.

Based on requests from commissioners, the scope of the study was expanded to include

- the governance structures of wastewater systems, including whether board members are compensated and whether the compensation includes benefits; and
- staffing issues at wastewater systems.

Wastewater systems use treatment processes that combine physical, chemical, and biological methods to remove harmful substances from wastewater.

The environment may be able to handle small amounts of wastewater filled with substances like pathogens and chemicals.[13] But it cannot deal with the large amounts of wastewater that homes and businesses produce each day.[14] This is where wastewater treatment comes into play. Wastewater must be treated before it is discharged to reduce the amount of harmful substances in the water.[15] Wastewater from residences and businesses in Tennessee can be treated in either centralized or decentralized systems.[16]

Centralized Wastewater Systems

In centralized wastewater systems in Tennessee, wastewater is collected and delivered to a centrally located treatment plant to be processed.[17] The

[13] US Geological Service 2018b.
[14] Ibid.
[15] Water Environment Federation and Association of Boards of Certification 2018.
[16] US Environmental Protection Agency 2004.
[17] US Environmental Protection Agency 2024a.

plant may be far from where the wastewater was produced, and the treated wastewater is discharged to surface water or groundwater.[18]

Wastewater treatment in centralized systems follows a multistep process:

- Preliminary treatment—large solids that could interfere with wastewater treatment processes or cause wear and tear on equipment are removed.
- Primary treatment—remaining heavy solids are permitted to settle to the bottom as sludge, and lighter, floating solids are skimmed off the top.
- Secondary treatment—microorganisms such as bacteria, algae, and fungi are used to reduce the amount of organic matter such as proteins, carbohydrates, and fats in the wastewater.
- Tertiary treatment—may or may not be needed depending on where treated wastewater will be discharged or how it will be used. If discharging into a delicate ecosystem or planning to reuse for irrigation purposes, tertiary treatment processes may include nitrogen removal, phosphorus removal, carbon absorption, or additional filtration processes.
- Disinfection—pathogens are reduced using processes including chlorination, ultraviolent (UV) radiation, or ozonation to a level that will not cause disease.
- Solids handling—remaining sludge (e.g., heavy solids) is treated, so it can be disposed of in a landfill or incinerated.

For more information on treatment processes used in centralized wastewater systems, see appendix A.

Decentralized Wastewater Systems

Wastewater treatment systems not connected to a centralized wastewater plant are known as decentralized wastewater systems.[19] They treat small volumes of wastewater from homes and businesses largely in rural or suburban areas,[20] with treatment occurring close to where the wastewater is produced.[21] Most decentralized systems release treated wastewater in or on land through land applications like spray or drip dispersal technology, unlike centralized systems, which discharge into surface waters.[22] Decentralized systems include both onsite systems and cluster systems.[23]

Most decentralized systems release treated wastewater in or on land through land applications like spray or drip dispersal technology, unlike centralized systems, which discharge into surface waters.

[18] Jantrania and Gross 2006.
[19] US Environmental Protection Agency 2004.
[20] US Environmental Protection Agency 2023e.
[21] Jantrania and Gross 2006.
[22] Ibid.
[23] US Environmental Protection Agency 2004; and US Environmental Protection Agency 2012.

Onsite Systems

Onsite systems, also known as septic systems or subsurface sewage disposal systems, treat waste from only one home or business.[24] With an onsite system, the wastewater is piped from the building to a septic tank that is buried underground.[25] Solids, oil, and grease are separated from the wastewater.[26] Bacteria in the tank consume organic matter.[27] In a conventional system, the wastewater is discharged from the tank to a series of perforated pipes buried underground.[28] The pipes slowly release the water into the soil.[29] There are alternative systems that use pumps or gravity to help wastewater to filter through sand, organic matter or constructed wetlands.[30] Some also disinfect the water before discharging into the soil.[31]

Cluster Systems

Cluster systems, also referred to as community systems, serve one or more homes or businesses not connected to centralized wastewater systems.[32] There are 360 decentralized systems like this in use in the state.[33] In a cluster system, the wastewater is collected from the buildings and piped to a treatment unit where it is treated to remove organic material using microorganisms, similar to the secondary treatment processes used in centralized systems.[34] The treated wastewater will typically be discharged using spray or drip dispersal systems, but it can be discharged into surface waters or dispersed over land.[35]

The *2022 Infrastructure Report Card* from the Tennessee Section of the American Society of Civil Engineers gave Tennessee's wastewater infrastructure a grade of C-.

What is the condition of Tennessee's wastewater systems?

The *2022 Infrastructure Report Card* from the Tennessee Section of the American Society of Civil Engineers gave Tennessee's wastewater infrastructure a grade of C-.[36] In contrast, in the latest available nationwide report card from 2021, the American Society of Civil Engineers gave the nation's wastewater infrastructure a grade of D+.[37] The *2022 Infrastructure Report Card* from the Tennessee Section of the American Society of Civil Engineers said that over the past decade, Tennessee's wastewater

[24] US Environmental Protection Agency 2005.
[25] US Environmental Protection Agency 2023a.
[26] Ibid.
[27] US Environmental Protection Agency 2004.
[28] US Environmental Protection Agency 2024e.
[29] Ibid.
[30] US Environmental Protection Agency 2023a.
[31] Ibid.
[32] US Environmental Protection Agency 2005.
[33] Tennessee Department of Environment and Conservation 2024d.
[34] Lombardo 2004.
[35] Ibid.
[36] American Society of Civil Engineers 2022.
[37] American Society of Civil Engineers 2021.

infrastructure supported a 9% population increase.[38] But the focus on expanding system capacity has come at the expense of neglecting maintenance needs.[39] The report noted that this was evidenced by the increased number of sewer overflows, which have at times resulted in sewer tap moratoriums—a temporary restriction on establishing new sewer connections or taps to existing infrastructure—essentially putting a pause on new development.

Data both on enforcement actions taken by TDEC and the number of systems falling under financial oversight from the Tennessee Board of Utility Regulation (TBOUR) further indicate that some wastewater systems are having difficulty maintaining infrastructure and operations.

TDEC Oversight of Wastewater Systems and System Condition

TDEC oversees the engineering, design, and construction of wastewater treatment systems, including both centralized and decentralized systems. These wastewater systems are required to submit construction plans to TDEC for review prior to the start of a project. Additionally, state law mandates that any entity intending to treat wastewater must obtain a permit to do so.[40] The type of permit issued is contingent on the treatment activities the entity engages in.

Wastewater systems planning to discharge from point sources[41]—including but not limited to pipes, ditches, channels, tunnels, and conduits—into surface waters of the state must obtain a National Pollutant Discharge Elimination System (NPDES) permit from TDEC's Division of Water Resources (DWR).[42] The federal Clean Water Act prohibits the discharge of pollutants through a point source into any water of the United States without an NPDES permit.[43] These permits establish restrictions on the quantities, discharge rates, and concentrations of pollutants that discharged into receiving waters.[44] NPDES permits are typically held by centralized wastewater systems. A decentralized system that discharges into a waterway would be required to get this permit as well.

Wastewater systems planning to discharge from point sources into surface waters of the state must obtain a National Pollutant Discharge Elimination System permit from the Tennessee Department of Environment and Conservation Division of Water Resources.

[38] American Society of Civil Engineers 2022.
[39] American Society of Civil Engineers 2022; American Society of Civil Engineers 2021; and interview with Steve Wyatt, utility operations consultant, University of Tennessee Municipal Technical Advisory Service, August 16, 2023.
[40] Tennessee Code Annotated, Sections 69-3-101 et seq.; and Rules and Regulations of the State of Tennessee Chapters 0400-40-06 and 0400-40-10.
[41] A point source is defined in the Clean Water Act (33 United States Code, Section 1362) as any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel, conduit, discrete fissure, or container.
[42] Tennessee Department of Environment and Conservation "National Pollutant Discharge Elimination System (NPDES) Permit."
[43] US Environmental Protection Agency 2023d.
[44] 40 Code of Federal Regulations 122.2.

Wastewater systems that do not discharge into any surface or subsurface waters must obtain a State Operating Permit.

Wastewater systems that do not discharge into any surface or subsurface waters must obtain a State Operating Permit (SOP).[45] Decentralized systems that apply treated wastewater to land by spray or drip dispersal would need to obtain a SOP from TDEC's Division of Underground Storage Tanks.[46] The federal Safe Drinking Water Act applies to decentralized systems and regulates parameters like nitrate content through their SOP.[47]

Other permits that wastewater systems may need to obtain depending on their treatment techniques are a Biosolids State Operating Permit or an Aquatic Resources Alteration Permit (ARAP). Biosolids are organic materials produced during wastewater treatment and can be used to fertilize soil. A biosolids SOP authorizes applying these biosolids on land in Tennessee. There are approximately 73 wastewater treatment sites that also have a biosolids SOP.[48]

TDEC has taken a variety of enforcement actions against wastewater systems.

TDEC monitors compliance and, if needed, takes enforcement action. TDEC monitors permit compliance based in part on data reported monthly by wastewater systems. Wastewater systems' permits have effluent limits, and the systems must test whether they are meeting or exceeding those limits each month. They report the results of their tests to TDEC via an electronic reporting system known as the Network Discharge Monitoring Report (NetDMR).[49] TDEC also monitors compliance through required periodic inspections and has the authority to take enforcement actions against systems when necessary to ensure compliance with the law. Enforcement actions include notices of violation (NOV) and enforcement orders (EO). There are different types of EOs, which include director's orders, commissioner's orders, consent orders, and agreed orders. The type of EO which a system receives is determined by the severity of the violation, whether the order has been negotiated, and whether it has been appealed.[50] If a system is found to have the same type of permit violation in two consecutive quarters, they will be marked as being in significant noncompliance. When a system has a site or location that has more than

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[45] Tennessee Department of Environment and Conservation 2023c.

[46] Interview with April Grippo, deputy director, Division of Water Resources, Tennessee Department of Environment and Conservation, October 16, 2023; and interview with John Buchanan, director, Center for Decentralized Wastewater Management, University of Tennessee, March 27, 2024.

[47] 42 United States Code, Section 300f; and interview with John Buchanan, director, Center for Decentralized Wastewater Management, University of Tennessee, March 27, 2024.

[48] Commission staff analysis of Tennessee Department of Environment and Conservation "DWR Permits."

[49] Interview with Jessica Murphy, compliance and enforcement manager, Division of Water Resources, Tennessee Department of Environment and Conservation, March 27, 2024.

[50] Interview with Jessica Murphy, compliance and enforcement manager, Tom Moss, drinking water enforcement officer, and Sarah Elias, NPDES wastewater compliance manager, Division of Water Resources, Tennessee Department of Environment and Conservation, October 11, 2023.

five overflows during one year they must self-impose a moratorium on new sewer connections. See table 1 for descriptions of these terms.

Table 1. Enforcement Actions TDEC Can Take Against Wastewater Systems

Enforcement Action	Enforcement Agency	Action Type	Description and Penalty
Notice of Violations (NOV)	TDEC	Informal	No legal consequence. Corrective action requested.
Enforcement Order (EO)	TDEC	Formal	Civil penalty of up to $10,000 per violation, per day.
Director's Order	TDEC	Formal	Issued when fine amount is under $100,000. Can be appealed within 30 days.
Commissioner's Order	TDEC	Formal	Issued when fine amount is over $100,000. Can be appealed within 30 days.
Consent Order	TDEC	Formal	Issued when the initial order terms are negotiated and agreed upon up front.
Agreed Order	TDEC	Formal	Issued when initial order has been appealed and settled.
Significant Non-compliance (SNC)	Environmental Protection Agency (EPA) or TDEC	Formal	Issued when serious violations have occurred during two consecutive quarters (i.e., violating an EO).
Sewer Moratorium	TDEC or Self-Imposed	Formal	Self-imposed when one site or location has more than five overflows within one year. Can also be issued by TDEC through EO for chronic overflows or infiltration and inflow (I/I) related problems.

Source: Interview with Jessica Murphy, compliance and enforcement manager, Division of Water Resources, Tennessee Department of Environment and Conservation, March 27, 2024; Tennessee Code Annotated, Sections 69-3-107 et seq.; and US Environmental Protection Agency 1991.

NOVs are typically issued to wastewater systems after an investigation of a complaint or a routine compliance inspection for a number of different offenses ranging from failure to properly monitor or report permittees to violating their permit requirements.[51]

When TDEC issues an NOV, it indicates to the operators of the wastewater system that TDEC believes the wastewater system is violating its permit and needs to take corrective action or be prepared to defend its actions

[51] Email from Jessica Murphy, compliance and enforcement manager, Division of Water Resources, Tennessee Department of Environment and Conservation, March 19, 2024; and Tennessee Department of Environment and Conservation 2018b.

in subsequent enforcement. TDEC has recently issued NOVs for some wastewater systems:

- For wastewater systems with NPDES permits, 105 NOVs were issued in 2023—these systems are inspected annually by TDEC. Of those NOVs, 57 were issued to public wastewater systems operated by local governments.
- For wastewater systems with SOPs, 89 NOVs were issued from 2019 through 2024—these systems are inspected once every five years by TDEC.

TDEC can issue an EO if the violations indicated in the NOV are not resolved within the requested time frame. The most common reasons for wastewater systems violations are exceeding effluent limits—restrictions on the quantities, discharge rates, and concentrations of pollutants that are discharged into receiving waters—and excessive sewer overflows, which violates their NPDES permit.[52] When it comes to violations of SOPs, many of the NOV descriptions don't list the cause. Of those that do, the most common violations are from raw sewage seeping into the ground from failed drip fields and water ponding on the drip field from too much effluent being released into the ground.

As of May 2024, there were 75 active enforcement orders issued by the Tennessee Department of Environment and Conservation for wastewater systems in Tennessee.

As of May 2024, there were 75 active EOs issued by TDEC for wastewater systems in Tennessee. These orders were issued to 70 permittees, which are the entities that operate the wastewater systems. Fifty-seven of these permittees were local government entities.[53] Of the 13 other permittees with active EOs from TDEC, seven are operated by private entities, four are operated by schools, and two are operated by the state. See table 2 for a breakdown of the 75 active EOs issued by TDEC as of May 2024.

Additionally, the US Environmental Protection Agency (EPA) had three active EOs for wastewater systems in Tennessee as of May 2024—the City of Springfield, Knoxville Utilities Board, and Metro Water Services of Nashville. The EPA orders are federal consent decrees, an enforceable agreement that sets a schedule for the wastewater systems to remedy their non-compliance issues.[54]

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[52] Tennessee Department of Environment and Conservation "Report on DWR Documents"; and 40 Code of Federal Regulations 122.

[53] Commission staff analysis of Tennessee Department of Environment and Conservation "DWR Permits"; Tennessee Department of Environment and Conservation "Report on Sewer Moratoriums"; Tennessee Department of Environment and Conservation "Report on DWR Documents"; and Tennessee Department of Environment and Conservation "Enforcement Program Orders and Cases."

[54] Commission staff analysis of Tennessee Department of Environment and Conservation "DWR Permits"; Tennessee Department of Environment and Conservation "Report on Sewer Moratoriums"; Tennessee Department of Environment and Conservation "Report on DWR Documents"; and Tennessee Department of Environment and Conservation "Enforcement Program Orders and Cases."

Table 2. Active Enforcement Orders Issued by TDEC

Active Enforcement Orders	Number Issued to NPDES Wastewater Permittees	Number Issued to SOP Wastewater Permittees	Total Number Issued
Director's Order	33	2	**35**
Commissioner's Order	1	0	**1**
Consent Order	27	1	**28**
Agreed Order	7	4	**11**
Total Active Enforcement Orders	**68**	**7**	**75**

Source: Commission staff analysis of Tennessee Department of Environment and Conservation "DWR Permits"; Tennessee Department of Environment and Conservation "Report on Sewer Moratoriums"; Tennessee Department of Environment and Conservation "Report on DWR Documents"; and Tennessee Department of Environment and Conservation "Enforcement Program Orders and Cases" as of May 2024.

Infiltration and inflow are a significant challenge to many wastewater collection systems in Tennessee.

Significant increases in wastewater flow caused by wet weather conditions can pose operational challenges and affect treatment efficiency at a wastewater treatment facility.[55] Additionally, deferred maintenance and inadequate wastewater infrastructure can lead to sewer overflows or releases.[56] TDEC classifies any sanitary sewer overflows (SSO) or combined sewer overflows (CSO) as a permit violation and requires the self-reporting of these events.[57] SSOs and CSOs involve the release of untreated sewage from the sewer system before reaching a treatment facility. When sewer systems cannot contain all the sewage that flows into them it can lead to the discharge of untreated wastewater into waterbodies and possibly back up into people's homes.[58] The Tennessee Section of the American Society of Civil Engineers stated in the *2022 Report Card for Tennessee's Infrastructure* report that 82% of the state's municipal wastewater treatment facilities exceeded their hydraulic design capacity when receiving at least 3.4 inches of rainfall within a 24-hour period.[59]

The primary causes of wastewater overflows are infiltration and inflow (I/I)—the entry of excess water into a sewer system. Infiltration refers to stormwater or groundwater that enters a sewer system though defects

The primary causes of wastewater overflows are infiltration and inflow (I/I)—the entry of excess water into a sewer system.

[55] US Environmental Protection Agency 2024g.
[56] A "release" means the flow of sewage from any portion of the collection or transmission system owned or operated by a publicly owned treatment works (POTW) or a domestic wastewater treatment plant, other than through permitted outfalls, that does not reach waters. In addition, a "release" includes a backup into a building or private property caused by blockages, flow conditions, or other malfunctions originating in the collection or transmission system. Rules of the Tennessee Department of Environment and Conservation Chapter 0400-40-05; and American Society of Civil Engineers 2022.
[57] Tennessee Code Annotated, Section 69-3-114.
[58] US Environmental Protection Agency 2023b, 2024i, and 2024j.
[59] American Society of Civil Engineers 2022.

in the sewer like cracked or compromised sewer pipes or compromised manholes.[60] Inflow refers to rain or snowmelt that enters the sewer system through a direct connection like illicit ones from storm sewers, roof drains, or basement sump pumps.[61] For any non-compliance with wastewater rules and regulations that could endanger public drinking water, human health, or the environment, TDEC rules mandate giving notice to the Division of Water Resources within 24 hours and submitting a report no later than five days after the permittee becomes aware of the overflows.[62] When wastewater systems are reporting an excessive number of overflows from their collection systems, TDEC will take corrective action by imposing a moratorium.

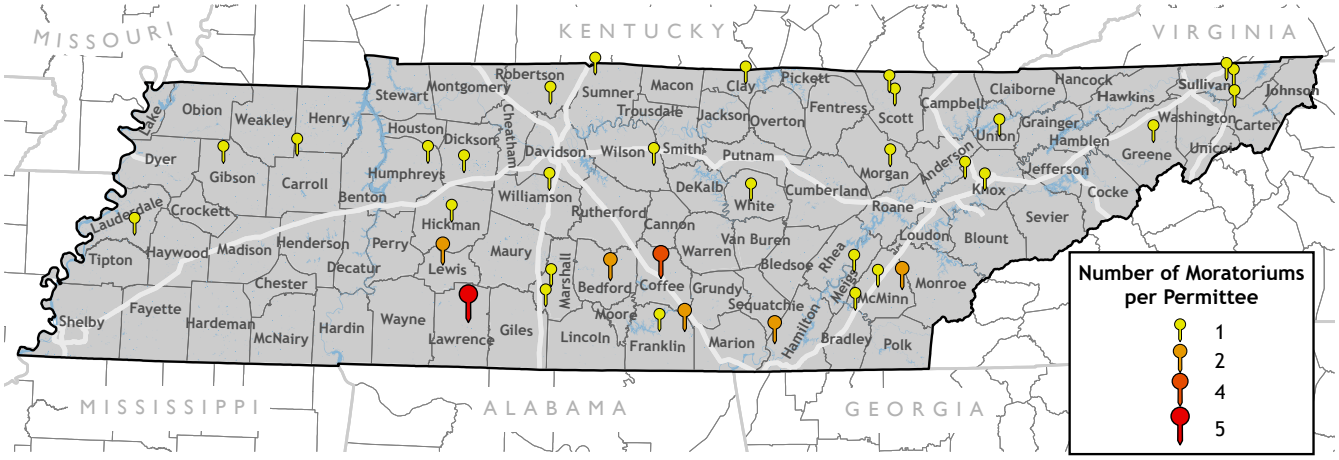
As of May 2024, there were 47 active sewer moratoriums affecting 36 permittees serving parts of 29 counties.

Sewer moratoriums can either be self-imposed—as required by the NPDES permit when one site or location has more than five sewer overflows within a year—or issued by TDEC through an EO for chronic sewer overflows or I/I related problems. A moratorium may be for a small portion of the collection system, or it may encompass the entire system depending on where the chronic overflow occurs.[63] When a wastewater system is under a moratorium, no new sewer connections can be added until TDEC determines that the issues resulting in the overflows are resolved. A moratorium on new sewer connections is cause for wastewater systems to redirect their funds toward system rehabilitation rather than expansion, indicating a failure to maintain or upgrade systems.[64]

The number of systems with moratoriums has increased in recent years. In 2019, there were 12 systems under sewer tap moratoriums.[65] As of May 2024, there were 47 active sewer moratoriums affecting 36 permittees serving parts of 29 counties.[66] See map 1.

[60] 40 Code of Federal Regulations Section 35.2005(b)(20).
[61] 40 Code of Federal Regulations Section 35.2005(b)(21).
[62] Rules of the Tennessee Department of Environment and Conservation 0400-40-05-.07(2)(l).
[63] Email from Jessica Murphy, compliance and enforcement manager, Division of Water Resources, Tennessee Department of Environment and Conservation, March 19, 2024.
[64] American Society of Civil Engineers 2022.
[65] American Society of Civil Engineers 2021b; and American Society of Civil Engineers 2022.
[66] Tennessee Department of Environment and Conservation "Report on Sewer Moratoriums."

Map 1. Active Moratoriums per Wastewater Permittee



Source: Commission staff analysis of Tennessee Department of Environment and Conservation "Report on Sewer Moratoriums."

Decentralized wastewater systems utilizing drip dispersal encounter challenges that centralized wastewater systems do not.

The land application of wastewater into soil is common among decentralized wastewater systems in Tennessee. DWR at TDEC undertook a statewide survey of all wastewater systems using drip dispersal in January and February of 2024. This was the first comprehensive attempt to assess the performance of all land application areas utilizing drip dispersal in the state. Over 370 decentralized wastewater systems in the state rely in some way on the land application of wastewater through drip dispersal; however, only 360 are currently operational according to TDEC's survey results, *Report on the Performance of Wastewater Systems Utilizing Drip Dispersal in Tennessee*.[67]

The purpose of the survey was to observe how the soil handled the water discharged by the systems and "report the results in a manner that may inform design engineers, operating entities, local governing bodies, and future standard development."[68] The most common and difficult challenge these systems face is the hydraulic overload of the soil profile—when incoming wastewater flow exceeds the system's design limiting the soil's ability to drain properly and the system's ability to adequately treat the effluent. The DWR observed and documented non-compliance in 51% of the surveyed systems. They noted the instances of non-compliance ranged from wastewater completely bypassing the system to lack of maintenance

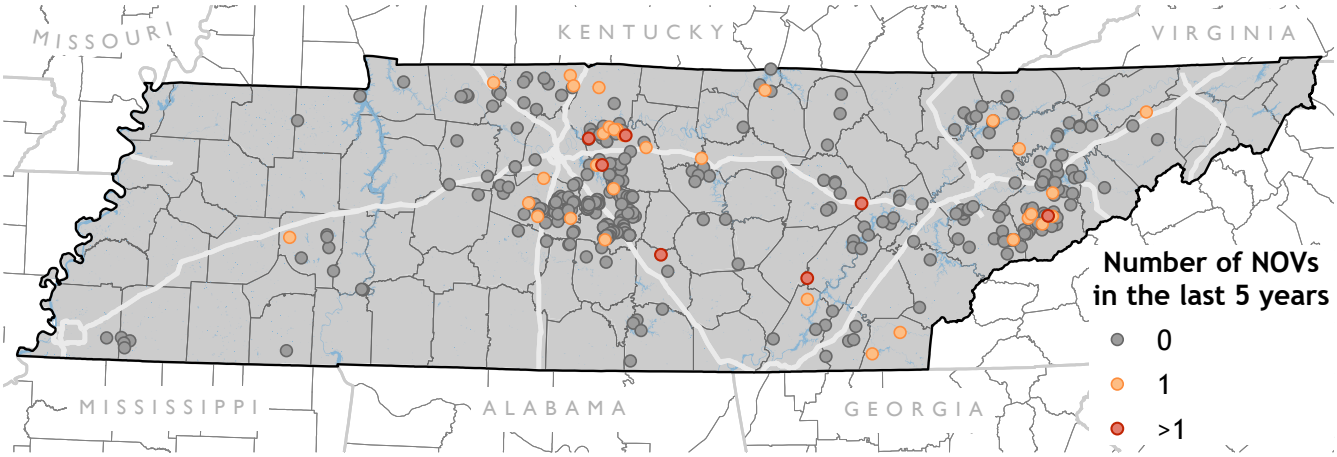
The Division of Water Resources at the Tennessee Department of Environment and Conservation observed and documented non-compliance in 51% of the surveyed systems.

[67] "This does not include subsurface sewage disposal systems subject to Tennessee Code Annotated, Section 68-221-401 et seq." Tennessee Department of Environment and Conservation 2024d.

[68] Tennessee Department of Environment and Conservation 2024d.

resulting in overgrown vegetation that prevented access to the land application area.[69] They did not identify the causes of noncompliance in the report, and they did not identify follow up actions for specific wastewater systems to take. The DWR's report emphasizes the need for routine inspections and maintenance to identify and resolve malfunctioning and overloaded capacity within wastewater systems that use drip dispersal. Where repairs or improved maintenance would not remedy the issue, the report suggests systems explore adding additional land application areas (e.g., adding more drip lines) or establishing a connection to discharge their effluent into nearby waterways under a NPDES permit. Of the systems surveyed by TDEC in the DWR's report, 39 have received NOVs in the last five years. See map 2.

Map 2. Decentralized Wastewater Treatment Systems Utilizing Drip Dispersal in Tennessee that Received Notices of Violation (NOVs), 2019-2024



Note: This map only shows the systems inspected by TDEC in 2024 for their Report on the Performance of Wastewater Systems Utilizing Drip Dispersal in Tennessee. See Tennessee Department of Environment and Conservation 2024d; and Tennessee Department of Environment and Conservation "Drip Investigation Survey Results" for more information.

Source: Email from Steve Owens, environmental consultant, Tennessee Department of Environment and Conservation, April 16, 2024; and commission staff analysis of Tennessee Department of Environment and Conservation "Report on DWR Documents."

Tennessee Board of Utility Regulation (TBOUR) Oversight for Wastewater Systems' Financial Health

TBOUR oversees public wastewater systems, ensuring their financial integrity. It can address customer complaints; approve new utility districts; investigate misconduct, mismanagement, and compliance issues; order corrective actions, including mergers or consolidations; and provide

[69] Tennessee Department of Environment and Conservation 2024d.

financial assistance to merging or consolidating systems.[70] The board administers a utility revitalization fund that provides money to systems that they ordered to merge or that voluntarily consolidated or merged.[71]

The Comptroller of the Treasury's office identifies financially distressed systems based on their audits and refers them to TBOUR. Findings that result in a system being identified as distressed include but are not limited to two consecutive years of negative net change (losses exceeding revenue), defaulting on debts, or overall liabilities exceeding assets.[72] The board can order corrective actions for distressed systems, typically including a rate study that would generally lead to a rate increase.[73]

As of May 2024, 53 out of 278 public wastewater systems are under the board's oversight for being financially distressed. Thirteen of these systems are under distress because of sewer service. Forty of these systems have a combined water and sewer fund, and it is difficult to determine whether they are under distress because of water or sewer service or both.[74]

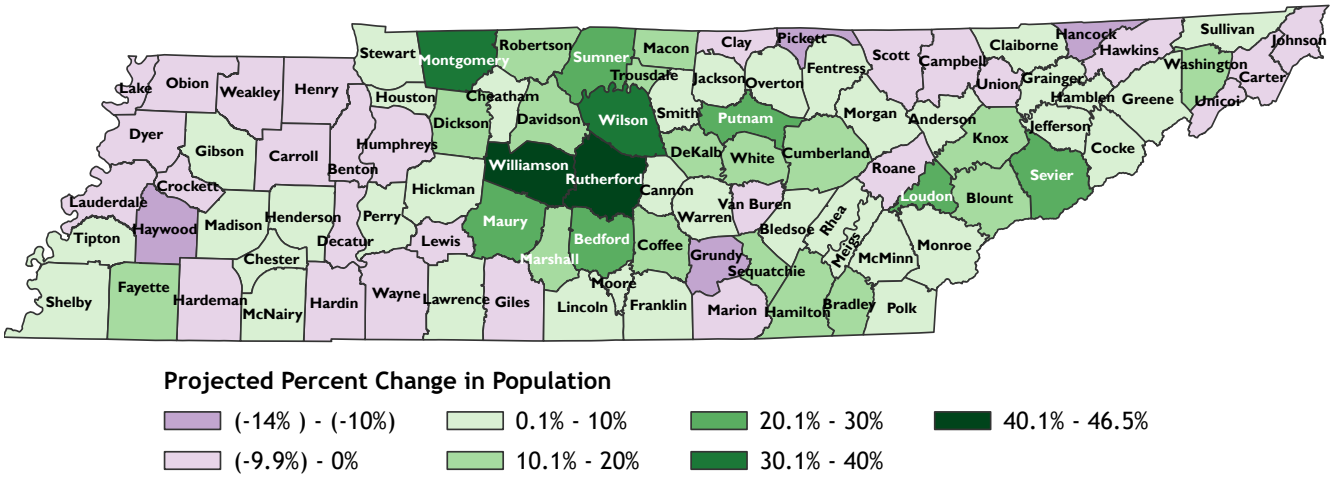
Resolving existing wastewater maintenance issues and keeping up with population growth could be costly.

Tennessee's wastewater systems will need billions of dollars in funding to expand, repair, or replace their infrastructure over the next 20 years.

Resolving existing wastewater maintenance issues and keeping up with population growth could be costly. Tennessee's population is projected to reach 7,980,650 by 2042, marking a 13.8% increase from the estimated 2022 population of 7,014,730, according to the latest projections from the University of Tennessee's Boyd Center for Business and Economic Research.[75] See map 3 for a breakdown of county growth projection estimates. These projections do not include projections of growth resulting from Ford's BlueOval City. The economic research and strategic communications firm Younger & Associates estimated that BlueOval City could bring in 176,341 people to 21 West Tennessee counties by 2045.[76]

[70] Interview with Ross Colona, assistant director, Jean Suh, contract audit review manager, and Lisa Bellar, senior contract audit review specialist, Tennessee Comptroller of the Treasury, August 28, 2023.
[71] Tennessee Code Annotated, Section 7-82-708.
[72] Spencer and Wyatt 2023; Tennessee Code Annotated, Section 7-82-703; and email from Nate Fontenot, financial analyst, Tennessee Comptroller of the Treasury, May 7, 2024.
[73] Interview with Ross Colona, assistant director, Jean Suh, contract audit review manager, and Lisa Bellar, senior contract audit review specialist, Tennessee Comptroller of the Treasury, August 28, 2023.
[74] Email from Nate Fontenot, financial analyst, Tennessee Comptroller of the Treasury, May 7, 2024.
[75] Boyd Center for Business and Economic Research 2024.
[76] West TN Planning 2024.

Map 3. Projected Percent Change in Population from 2022 to 2042 in Tennessee's Counties



Note: Projections don't include growth resulting from BlueOval City.

Source: Boyd Center for Business and Economic Research 2024.

Stakeholders interviewed for this report said that the state's wastewater infrastructure needs upgrades. Wastewater system pipes are designed to last only 40 to 50 years, and they are starting to get old and fail. Their deterioration has led to problems like water loss and inflow infiltration.[77]

With the projected population growth in the coming years, Tennessee's wastewater systems will need to spend a significant amount of money to repair and expand their infrastructure. The state's 2018 report, *TN H2O: Tennessee's Roadmap to Securing the Future of Our Water Resources,* estimated it would cost approximately $8.9 billion to fund the repair and replacement of aging wastewater infrastructure and to extend the wastewater services to support the state's growing population from 2018 through 2040, with Middle Tennessee and rural areas of East Tennessee facing the greatest need for increased wastewater capacity in 2040.[78]

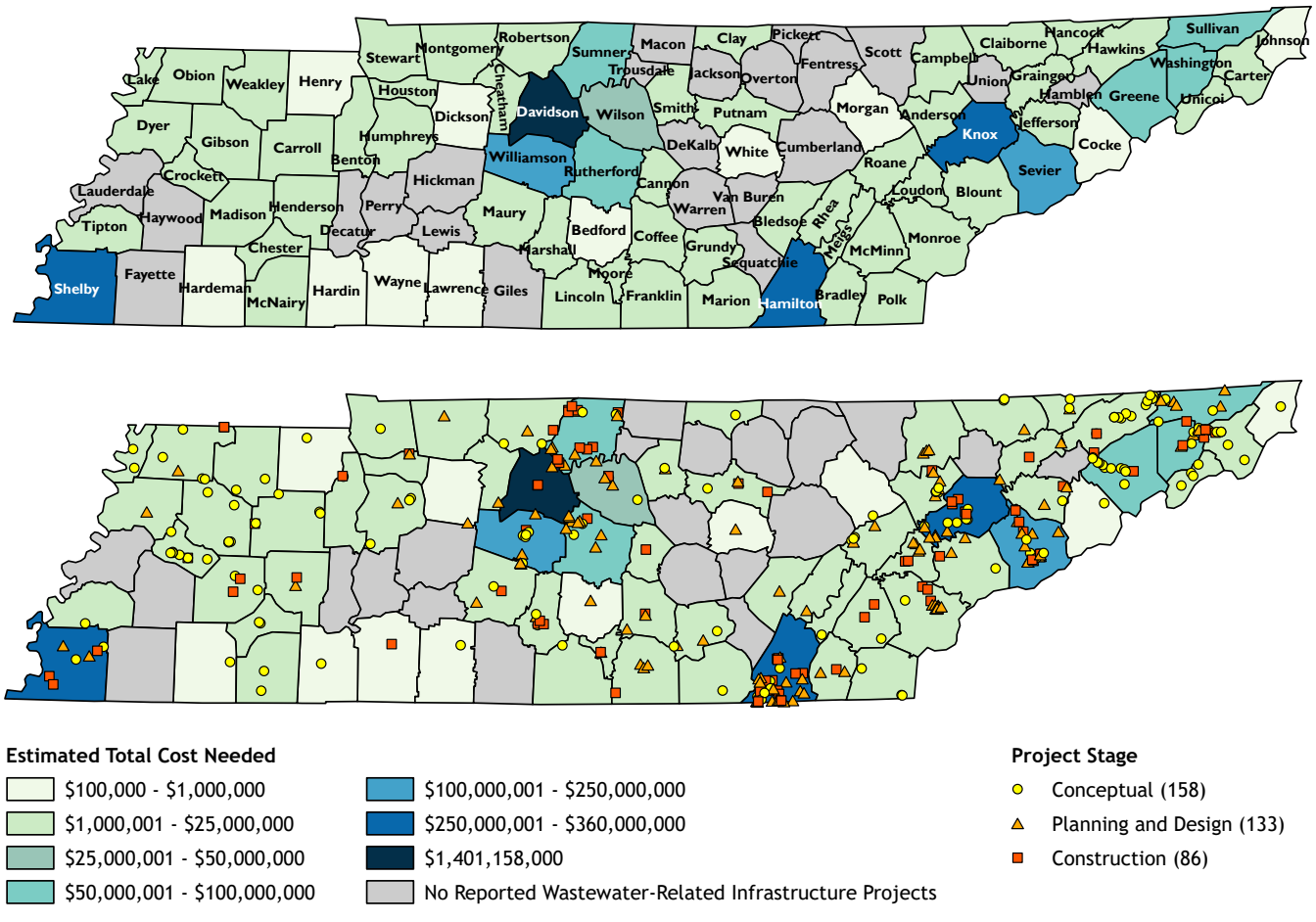
Local and state officials surveyed for the commission's annual infrastructure survey said that $3.5 billion is needed to fund wastewater infrastructure from fiscal year 2021-22 through fiscal year 2026-27. This was a $1.1 billion increase from the previous year, primarily driven by a single Nashville project that increased by $506 million because of updated cost estimates.[79] The project, enforced by a federal consent decree from the EPA for violations of the Clean Water Act, includes extensive upgrades and

[77] Interview with Ross Colona, assistant director, Jean Suh, contract audit review manager, and Lisa Bellar, senior contract audit review specialist, Tennessee Comptroller of the Treasury, August 28, 2023.
[78] Tennessee Department of Environment and Conservation 2018b.
[79] Tennessee Advisory Commission on Intergovernmental Relations 2024; and Tennessee Advisory Commission on Intergovernmental Relations "Public Infrastructure Needs Inventory Database."

rehabilitation to the city's sewer system to reduce the amount of overflow events and improve capacity.[80]

The commission's infrastructure needs report, which collects and analyzes information sourced from the state's nine development districts, lists 377 ongoing projects in various stages. Of the 377 ongoing projects, 158 are in the conceptual stage, which means the project has an estimated cost but is not in planning and design yet; 133 are in the planning and design stage; and 86 are under construction. Hamilton County has the most wastewater-related infrastructure projects at a total of 43. See map 4. For a comprehensive list of the state's estimated needs by county, see appendix B. Wastewater projects were reported in 73 counties. There were only 22 counties that did not report any wastewater-related infrastructure needs.

Map 4. The Estimated Cost Reported for Wastewater-Related Infrastructure Projects in Tennessee for July 2022 through June 2027



Source: Commission staff analysis based on Tennessee Advisory Commission on Intergovernmental Relations "Public Infrastructure Needs Inventory Database."

[80] Metro Water Services 2022.

What are the best methods for financing sewer lines and wastewater treatment plants?

Choosing the best option to finance wastewater infrastructure requires careful analysis of project size, local needs, and long-term financial health. By strategically analyzing these available financing options, communities can ensure their systems remain in working condition. Wastewater treatment requires significant investment. In the past, the federal government shouldered a large portion of this burden through grants.[81]

Historically, there was a significant amount of federal grant funding available for wastewater projects. The EPA's Construction Grants program provided more than $60 billion of funding for wastewater treatment projects in the 1970s and 1980s nationwide.[82] The federal government's share of project costs was originally 75% but by 1981, was reduced to 55%.[83] The grants program ended in 1990 and was replaced with the Clean Water State Revolving Fund (CWSRF) program.[84] Under this program federal funds are provided to states who use the money to fund loans to systems who then repay the loans to the state.[85] As money is paid back to the state's revolving loan fund, the state makes new loans.[86]

According to data from the commission's infrastructure survey, of the wastewater projects completed from 2007 to 2022, 83% of the funding came from the wastewater systems, 11% came from federal funding sources, 4% came from the state, and 2% came from other sources.

Today, the federal government directly funds a small portion of wastewater projects.[87] Local governments provide most of the funding for capital projects.[88] According to data from the commission's infrastructure survey, of the wastewater projects completed from 2007 to 2022, 83% of the funding came from the wastewater systems, 11% came from federal funding sources, 4% came from the state, and 2% came from other sources. These days, most wastewater projects are debt-financed.[89]

Overview of Funding Sources

When considering potential sources of funding for capital projects, a utility could evaluate the advantages and disadvantages of each form of financing available.[90] They may also want to consider how the funding alternative will affect their financial capacity and how it fits in their utility's long-term financial plans.[91] There are several different types of funding opportunities that systems can use.

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[81] US Environmental Protection Agency 2023c.
[82] Ibid.
[83] Ramseur and Tiemann 2019.
[84] Ramseur 2018.
[85] Ramseur and Tiemann 2019.
[86] Raftelis 2015.
[87] Ramseur 2018.
[88] Ibid.
[89] Ibid.
[90] Fedder, Hofield, and Mastracchio 2014.
[91] American Water Works Association 2014.

Internal Funding

Revenues or cash reserves generated from user rates, fees, and charges could be used to fund capital projects.[92] It is a convenient way of financing low-cost, short-term capital projects.[93] The public will likely find this form of financing easy to understand and politically acceptable.[94] There may be an equity issue with this type of financing because current ratepayers could be funding projects that will be used by new ratepayers in the future.[95]

Grants

Grants can help systems reduce the total costs of capital projects because they don't have to be paid back.[96] Most grant programs require grant applicants to provide matching funds in addition to the grant funds.[97] There are grant programs that can be tapped for wastewater projects. For example, there is the Community Development Block Grant (CDBG) program, and there are a few grants available through the US Department of Agriculture that can be used to finance wastewater projects.[98] The state of Tennessee offers grants as well, including Site Development Grants that can be used for utility line construction and relocation to improve Select Tennessee Certified Sites and prepare other sites to achieve this certification. The Select Tennessee Certified Sites are certified by the Tennessee Department of Economic and Community Development, and the sites are marketed to site selection consultants and businesses for development.[99] The sites must have utilities available at the site, or there must be plans to extend utility service to the site.

There are grant programs that can be tapped for wastewater projects.

Some of these grants may apply only to specific types of projects. The CDBG Entitlement Program grants, for example, can only be used for projects in the principal cities of Metropolitan Statistical Areas (MSA) and other cities with populations over 50,000.[100] Depending on the grant

[92] Financing and Charges for Wastewater Systems Task Force 2018.
[93] Grigg 2012.
[94] Ibid.
[95] Raftelis 2015.
[96] Ibid.
[97] Appalachian Regional Commission 2020; Delta Regional Authority 2024; Tennessee Department of Economic and Community Development "Infrastructure Planning Grant" and "Site Development Grant"; Tennessee Department of Environment and Conservation 2024a; US Department of Agriculture "Community Facilities Direct Loan & Grant Program in Tennessee", "SEARCH—Special Evaluation Assistance for Rural Communities and Households in Tennessee", and "Water & Waste Disposal Predevelopment Planning Grants in Tennessee"; and US Economic Development Administration "Economic Adjustment Assistance Frequently Asked Questions."
[98] US Department of Agriculture "Community Facilities Direct Loan & Grant Program in Tennessee", "Water & Waste Disposal Loan & Grant Program in Tennessee", and "Water & Waste Disposal Predevelopment Planning Grants in Tennessee"; and Tennessee Department of Environment and Conservation "About CDBG."
[99] Tennessee Department of Environment and Conservation "Become a Tennessee Certified Site."
[100] US Department of Housing and Urban Development 2024.

requirements, they may be competitive, and it may be difficult to qualify for them.[101]

Bonds

Bonds are frequently issued to finance projects because they can provide large sums of money to fund the projects and can be repaid at a uniform level over a set period of time.[102] The interest rates are based on the creditworthiness of the systems; small utilities, for example, that are in poor financial condition may have difficulty attracting bond buyers.[103] General obligation bonds and revenue bonds are two common types of bonds issued to finance wastewater projects.

Bonds are frequently issued to finance projects because they can provide large sums of money to fund the projects and can be repaid at a uniform level over a set period of time.

General obligation bonds are backed by the bond issuer's full faith and credit.[104] These bonds can only be issued by governments that have taxing authority.[105] They are one of the lowest-cost sources available to finance projects.[106] Cities, counties, and metropolitan governments that operate wastewater systems are authorized to issue general obligation bonds in Tennessee.[107] These have had widespread use because of low borrowing costs and the ease of issuing them.[108] This can make them a good choice for a start-up utility.[109] One disadvantage of these bonds is that they become part of the local government's debt and will be included in determining the bonding capacity of the local government.[110] This may make it more difficult for local governments to use debt to fund other projects.[111] In some cases, a bond issue may also have to be approved by voters.[112]

Revenue bonds are backed by a system's revenues,[113] and funds have to be allocated from revenues to pay off the bonds.[114] These bonds are available to systems that don't have taxing authority.[115] Cities, counties, metropolitan governments, utility districts, water and wastewater authorities, and municipal energy authorities are authorized to issue revenue bonds for

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[101] Fedder, Hofield, and Mastracchio 2014.
[102] Bloetscher 2009.
[103] Ibid.
[104] Financing and Charges for Wastewater Systems Task Force 2018.
[105] Wastewater Collection System Management Task Force 2021.
[106] Financing and Charges for Wastewater Systems Task Force 2018.
[107] Tennessee Code Annotated, Sections 9-21-107, 5-16-106(c), and 7-34-101 et seq; and Tennessee Comptroller of the Treasury 2023c.
[108] Financing and Charges for Wastewater Systems Task Force 2018.
[109] Fedder, Hofield, and Mastracchio 2014.
[110] Bloetscher 2009.
[111] Financing and Charges for Wastewater Systems Task Force 2018.
[112] Bloetscher 2009. Tennessee Code Annotated, Section 9-21-206, states that if registered voters present a petition signed by 10% of voters, a referendum must be held on the bond issue, and the bonds can't be issued unless approved by a majority of voters.
[113] Wastewater Collection System Management Task Force 2021.
[114] Bloetscher 2009.
[115] Fedder, Hofield, and Mastracchio 2014.

projects.[116] The marketability of the bonds will depend on the project and the ability of the system to generate revenue.[117] Because of this, revenue bonds may sometimes have higher interest rates than general obligation bonds.[118]

Double barrel bonds are a hybrid of revenue and general obligation bonds.[119] The double barrel bonds are secured first by revenues and secondarily secured by the taxing authority of the local government.[120] They are likely to have interest rates similar to that of a general obligation bond.[121]

Loans

Loans are available from federal and state agencies to finance wastewater projects.[122] There are programs such as the federal Water Infrastructure Finance and Innovation Authority program that makes loans for large capital projects of at least $5 million.[123] Government loan programs offer rates that typically are competitive with market rates.[124] For example, the Clean Water State Revolving Fund program provides loans for capital projects that are at or below market rates.[125] The specifics of any government loan programs could be assessed to determine their suitability for financing projects.[126]

Loans are available from federal and state agencies to finance wastewater projects.

Bank loans can also be a source of funding, especially on a short-term basis.[127] The process of obtaining a bank loan is more streamlined than the bond issuance process, and a system may be able to get funding more quickly if they apply for a loan.[128] One drawback to these loans is that the interest rate could be higher than it would be on a government loan.[129]

Notes

Notes function much like bonds and loans, serving as short-term debt where the issuer commits to repaying the borrowed amount along with interest.[130] In Tennessee, local governments are authorized to issue several types of notes. Cities, counties, and metropolitan governments,

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[116] Tennessee Code Annotated, Sections 7-82-501, 68-221-611, and 7-36-113; and Tennessee Comptroller of the Treasury 2023d.
[117] Financing and Charges for Wastewater Systems Task Force 2018.
[118] Ibid.
[119] Raftelis 2015.
[120] Financing and Charges for Wastewater Systems Task Force 2018.
[121] Raftelis 2015.
[122] Wastewater Collection System Management Task Force 2021.
[123] US Environmental Protection Agency 2023f.
[124] Wastewater Collection System Management Task Force 2021.
[125] Tennessee Department of Environment and Conservation 2024b.
[126] Wastewater Collection System Management Task Force 2021.
[127] Raftelis 2015.
[128] Financing and Charges for Wastewater Systems Task Force 2018.
[129] Ibid.
[130] Tennessee Comptroller of the Treasury 2023d.

for instance, can issue bond and grant anticipation notes.[131] These notes serve as a means for financing expenditures until bonds are issued or grant funds are received.[132] Additionally, they have the authority to issue capital outlay notes, which are primarily utilized for financing short-term capital assets such as vehicles.[133] Moreover, these governments along with energy authorities and utility districts can issue revenue anticipation notes, which can provide necessary funds for operations until revenue collection is possible.[134]

Contributions

Developers may be required to construct components of a wastewater system for a new development and give the infrastructure to a system.[135] These are known as contributions from developers.[136] They are one-way systems that fulfill their infrastructure needs in areas where new growth is occurring.[137] It enables systems to reduce the amount they spend on capital projects.[138] Developers may voice opposition to these requirements.

For additional information on private funding sources and government loans and grants that are available to fund wastewater projects, see appendix C.

The decentralized systems treat wastewater close to its source, reducing the need for extensive sewer networks and large treatment plants, which lowers capital investment and maintenance costs.

Decentralized Systems as a Cost-Effective Alternative to Centralized Systems

Decentralized wastewater treatment systems can be a cost-effective alternative to traditional centralized systems. The decentralized systems treat wastewater close to its source, reducing the need for extensive sewer networks and large treatment plants, which lowers capital investment and maintenance costs.[139] Decentralized systems typically involve smaller initial investments and can be built incrementally to meet local demands, allowing communities to expand their wastewater treatment capacity in phases as needed.[140] This incremental approach helps avoid the large upfront costs associated with centralized systems and enables the use of the latest cost-saving technologies that may exist at the time.

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131 Tennessee Code Annotated, Sections 9-21-501 et seq. and 9-21-701.
132 Fedder, Hofield, and Mastracchio 2014; and Tennessee Comptroller of the Treasury 2023d.
133 Tennessee Code Annotated, Sections 9-21-601 et seq.; and Tennessee Comptroller of the Treasury 2023d.
134 Tennessee Code Annotated, Sections 9-21-801 et seq., 7-34-111, 7-36-113, and 7-82-501; and Tennessee Comptroller of the Treasury 2023d.
135 Fedder, Hofield, and Mastracchio 2014.
136 Financing and Charges for Wastewater Systems Task Force 2018.
137 Ibid.
138 Fedder, Hofield, and Mastracchio 2014.
139 US Environmental Protection Agency 2015b.
140 US Environmental Protection Agency 2015a.

In rural communities, decentralized systems are particularly effective because of financial and geographical constraints that may make large-scale centralized facilities impractical.[141] These communities may lack the financial resources and personnel to manage and operate large systems.[142] Decentralized systems can provide tailored solutions that address specific site conditions, such as challenging terrain issues, and can be implemented to meet local needs efficiently.[143] Decentralized systems can be integrated into existing urban infrastructure to supplement centralized systems, providing flexibility and scalability.[144] Sometimes connecting new developments to centralized treatment plants is not feasible because of financial costs.[145]

In the *Small Community Wastewater Cluster Systems* report from the Purdue University Cooperative Extension Service, it was noted that a disadvantage of these systems could be the operation and maintenance needed.[146] The decentralized systems are located on sites that maintenance staff will have to travel to.[147] There may be disruptions in service because of breakdowns.[148]

Decentralized systems can provide tailored solutions that address specific site conditions, such as challenging terrain issues, and can be implemented to meet local needs efficiently.

Consolidated Utility District in Rutherford County is one system that has been recognized for how successful it's been in providing sewer services to its customers using decentralized systems.[149] Developers who build within the district's jurisdiction are required to build the systems according to the district's requirements.[150] After they're built, the district takes ownership of the decentralized systems and is responsible for maintaining them.[151] They have on-call maintenance staff to deal with issues that may arise, and their staff regularly visits the sites where the systems are located.[152]

What are the best practices for wastewater system management from other states and the best methods to reduce the operating costs of wastewater systems?

Wastewater systems can improve management of their organizations and reduce their energy costs in several ways. In particular, systems can identify and prioritize areas of their operations for improvement by using

[141] Water Environment Foundation and Water Research Foundation 2019.
[142] Ibid.
[143] Ibid.
[144] US Environmental Protection Agency 2015b.
[145] Water Environment Foundation and Water Research Foundation 2019.
[146] Jones et al. 2001.
[147] Ibid.
[148] Ibid.
[149] US Environmental Protection Agency 2015b; and interview with John Buchanan, director, Center for Decentralized Wastewater Management, University of Tennessee, March 27, 2024.
[150] Interview with Bryant Bradley, director of operations, Consolidated Utility District, May 1, 2024.
[151] Ibid.
[152] Ibid.

the Effective Utility Management (EUM) framework developed by the EPA with help from water and wastewater organizations. They can also develop asset management plans and engage in practices that can help them operate more energy efficiently.

The EPA's Effective Utility Management Framework

The EPA along with water and wastewater industry organizations developed an industry-specific approach to utility management.[153] These organizations worked together to create an EUM framework that water and wastewater systems can use to help improve performance. The group developed five keys to management success and related guiding principles.

The Environmental Protection Agency along with water and wastewater industry organizations developed an industry-specific approach to utility management. These organizations worked together to create an EUM framework that water and wastewater systems can use to help improve performance.

Key 1 - Leadership

Effective leadership encompasses both individuals and teams, guiding long-term vision within the organization, while also engaging stakeholders and promoting collaboration with external partners. Leaders should foster an organizational culture that embraces positive change and supports emerging leaders. They should also be committed to continual improvement within the system and plan for seamless leadership transitions.

Key 2 - Strategic Business Planning

A strategic business plan provides a framework for decision-making in the future. It involves assessing current conditions; forecasting potential future events; analyzing their causes and effects; and establishing objectives, strategies, and organizational values as well as a clear vision for the system. Preparation of the plan requires a long-term perspective, aligning system goals with community values and interests. Regular review and revision of the plan is essential for maintaining its relevance and effectiveness.

Key 3 - Knowledge Management

Ensuring thorough documentation of processes by recording standard operating procedures and fostering shared knowledge among employees enables systems to effectively address knowledge loss resulting from employee turnover or absences. Data management systems can help improve the ability of systems to track and manage system performance.

Key 4 - Measurement

The groups that developed the EUM framework also identified 10 attributes of effectively managed systems that can serve as goals for systems to help them improve their performance. See appendix D. These attributes can serve as a starting point and are one example of a framework for how goals can be developed. By identifying areas for improvement and setting goals

[153] US Environmental Protection Agency 2017.

for improvement, systems can enhance overall performance. Establishing a tracking or measurement system to monitor progress towards these goals can help systems continually improve over time.

Key 5 - Continual Improvement Management

The last key is instituting a culture of continuous improvement. Continual improvement plays a central role in effective system management. Some organizations adopt formal programs to help achieve this goal. One way this culture can be fostered is through a framework known as "Plan-Do-Check-Act."[154]

- Plan – Plan a change.
- Do – Implement the change.
- Check – Evaluate the results of implementing the change.
- Act – Revise plans as needed.

Continual improvement plays a central role in effective system management. Some organizations adopt formal programs to help achieve this goal.

EUM Case Studies

The EPA prepared case studies of several water and wastewater systems to highlight how they had used the EUM system in their everyday operations and their results after using it. The EPA's case study of Austin Water in Austin, Texas, found that one of the attributes the system chose to work on was employee and leadership development.[155] To help reduce its vacancy rate, the system widened its recruitment efforts. Staff attended job fairs and focused on recruiting not only trade school graduates but also veterans, at-risk youth, and people who had previously been incarcerated. The system also provided training for its previously incarcerated employees to help enhance their skills.

Columbus Water Works in Columbus, Georgia, was another system that the EPA studied.[156] Enhancing customer satisfaction was one attribute the system chose to focus on. In surveys, customers indicated that they wanted to know when employees performed services at their residences. In response, the system implemented a door hanger program. Paper door hangers were left on customers' doors after service calls to let them know the services that had been performed. The hanger also included a survey form that customers could send in. The system also chose to work on the employee and leadership development attribute. As a result, it developed partnerships with outside agencies like the Columbus State University Leadership Institute to provide learning opportunities for employees.

[154] American Society for Quality "What is the Plan-Do-Check-Act (PDCA) Cycle?"; and Raftelis 2015.
[155] US Environmental Protection Agency 2020.
[156] US Environmental Protection Agency 2018.

Asset management plans can help wastewater systems manage their infrastructure and ensure there is enough money to repair and replace them.

Determining the best time to repair or replace infrastructure may at times be a challenge for systems.[157] An asset management plan can help systems identify what infrastructure is most critical for them to repair or replace.[158] This enables systems to direct their spending to where it is most needed and better meet their regulatory requirements and customers' expectations.[159] Asset management plans can also help ensure that user rates are based on sound financial planning.[160] And in Tennessee, asset management plans are required for utilities receiving state revolving fund loans.[161] According to TDEC's *Asset Management Plan Guide*, an asset management plan has several key components:

An asset management plan can help systems identify what infrastructure is most critical for them to repair or replace.

- Current State of Assets – The system identifies what assets it owns, where they are located, and what condition they are in.[162]
- Level of Service - At this stage of the planning process, a system will define the level of service that customers demand and that the law requires and compare that to the level of service being provided.[163]
- Critical Assets - A system will rank how critical each asset is.[164]
- Capital Improvement Plan - The system completes a capital improvement plan that includes the timing and costs of infrastructure that needs to be rehabilitated or replaced as well as any new infrastructure requirements. The capital improvement plan will also include funding sources.[165]
- Long Term Funding Plan – This step involves the system looking at its long-term funding strategy and considering whether the user rates are sufficient to cover their costs.[166]

To assist the state's systems in developing asset management plans, TDEC offers asset management plan grants.[167] It also has an asset management guide and templates on its website.

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[157] US Environmental Protection Agency 2008.
[158] Interview with Vena Jones, state revolving fund & water infrastructure grants manager, Tennessee Department of Environment and Conservation, September 6, 2023.
[159] Tennessee Department of Environment and Conservation 2023a; and US Environmental Protection Agency 2008.
[160] US Environmental Protection Agency 2008.
[161] Tennessee Department of Environment and Conservation 2023a.
[162] Tennessee Department of Environment and Conservation 2023b.
[163] Tennessee Department of Environment and Conservation 2023b; and US Environmental Protection Agency 2008.
[164] Ibid.
[165] Ibid.
[166] Ibid.
[167] Tennessee Department of Environment and Conservation 2024a.

The American Water Works Association compiled case studies showcasing some of the leading business practices in asset management used by utilities around the country. One of the basic components of asset management is identifying what assets the system owns and their location and condition. Downers Grove Sanitary District in Downers Grove, Illinois, uses a geographic information system (GIS) that has information on the location and size of its sewers in addition to their installation dates and construction plans.[168] The GIS is linked to a computerized maintenance management system (CMMS) that has information on the history of repairs and inspections of the sewers. The system also uses video cameras to help assess the condition of its pipes. This helps the system identify pipes that need to be repaired or replaced. Downers Grove Sanitary District used to rely on staff's knowledge of the physical assets, but now the district's leadership says it is better equipped to deal with regulators because of the systems and data it has.

The American Water Works Association compiled case studies showcasing some of the leading business practices in asset management used by utilities around the country.

The Livingstone County Water and Sewer Authority in Lakeville, New York, also uses a CMMS to help it track the maintenance history of its assets.[169] The system monitors pump stations and tanks daily using information from a supervisory control and data acquisition (SCADA) system. Maintenance questionnaires are sent to maintenance staff on a weekly, monthly, semiannual, and annual basis. The questionnaires consist of a list of detailed questions, and if an issue is identified, the director of operations is notified. The director will determine whether repairs need to be made. These systems help ensure that maintenance is completed in a timely and efficient manner.

In Mount Pleasant, South Carolina, the Mount Pleasant Waterworks initiated its asset management planning program in 2004.[170] The system used asset and maintenance information from its CMMS in the development of its asset management plan. It ranked how critical each asset was and its condition and calculated the current value of its assets and the replacement cost. It was able to use this information to develop a detailed plan for the management of its assets and current and long-term funding strategies. It also hired a full-time asset management coordinator to oversee the program. As a result of its planning capabilities, the system received a bond upgrade.

Wastewater systems may help to decrease their operating costs by improving their energy efficiency.

Providing wastewater service is energy intensive.[171] By focusing on energy efficiency, systems can cut down on costs. According to the US

[168] Stillman and Jones 2017.
[169] Ibid.
[170] Ibid.
[171] Drinan and Spellman 2013.

Department of Energy's *Energy Data Management Manual for the Wastewater Treatment Sector*, it's possible for electricity to "constitute 25% to 40% of a wastewater treatment plant's annual operating budget."[172] Electricity represents the largest controllable cost of providing wastewater services.[173] Reducing energy consumption can lead to a reduction in operation costs.[174] A wastewater system that incorporates energy efficiency practices may be able to reduce their costs by 15% to 30%.[175]

A wastewater system that incorporates energy efficiency practices may be able to reduce their costs by 15% to 30%.

In its guide *Evaluation of Energy Conservation Measures for Wastewater Treatment Facilities*,[176] the EPA outlines a nine-step process for energy management:

- Create an energy sustainability team to implement energy saving measures.
- Gather data on energy use at the system.
- Create a baseline of energy performance that you can use to measure improvements over time.
- Conduct an energy audit and determine the energy use of various processes and identify opportunities for areas where you can reduce energy use.
- Identify energy improvement goals.
- Identify energy saving measures and develop a plan for implementing them.
- Implement improvements.
- Track performance and review progress towards energy saving goals.
- Communicate your energy savings successes to employees, management, and the community.

Tennessee's Plant Optimization Program (POP) is a free, voluntary program that wastewater systems can participate in to help them reduce energy consumption and improve removal of nitrogen and phosphorus from treated wastewater at their facilities.[177] The program's staff helps facilities implement low and no-cost measures to reduce their energy use.[178] Wastewater systems that implemented the measures reduced their annual

[172] Lemar and de Fontaine 2017.
[173] US Environmental Protection Agency 2024d.
[174] Drinan and Spellman 2013.
[175] US Environmental Protection Agency 2024d.
[176] Cadmus Group 2010.
[177] Interview with Karina Bynum, water quality environmental fellow, Tennessee Department of Environment and Conservation, October 13, 2023; and Tennessee Department of Environment and Conservation "Tennessee Plant Optimization Program (TNPOP)."
[178] Tennessee Department of Environment and Conservation "Tennessee Plant Optimization Program (TNPOP)."

energy costs an average of 19%.[179] There has been $390,468 in annual cost savings since 2016.

TDEC conducted case studies of some of the systems it had helped through the program. One city that participated in the program, Carthage, bought timers with the money it saved that enabled it to automate the operation of its aerators and save additional money.[180] Fayetteville used its energy savings to invest in probes which gave it the ability to do real-time monitoring of its system's oxygen levels and gave it better control of its aerators and blowers.[181]

There are many ways wastewater systems can reduce their energy consumption. To help systems identify potential options to conserve energy, the New York State Energy Research and Development Authority and the Wisconsin Public Service Commission's Focus on Energy program both published guides detailing best practices for energy conservation for wastewater systems: the *Wastewater Energy Management Best Practices Handbook* and the *Water and Wastewater Energy Best Practices Guide*, respectively.[182] A condensed list of practices from these guides is in appendix E.

There are many ways wastewater systems can reduce their energy consumption.

What are methods of wastewater system management that have not worked and should be avoided?

Commission staff did not identify any valid management practices that should be avoided. Rather, research and interviews confirmed the risks of failing to properly manage equipment and assets. Some wastewater system management practices may lead to decreased efficiency or cause environmental harm. Skipping routine maintenance or lacking long-term plans like an asset management plan can lead to higher costs, environmental compliance issues, or even the inability to address future needs. Neglecting energy-saving tactics, using chemicals inefficiently, or inadequately handling sludge and biosolids treatments can have negative effects on the wastewater system. Avoiding these pitfalls helps to ensure that a wastewater system operates efficiently.

Failure to regularly maintain wastewater facility equipment and infrastructure are the leading factors in non-compliance for Tennessee

[179] Tennessee Department of Environment and Conservation "TNPOP Case Studies."
[180] Tennessee Department of Environment and Conservation 2018a.
[181] Tennessee Department of Environment and Conservation 2015.
[182] New York State Energy Research and Development Authority 2019; and Wisconsin Focus on Energy 2020.

wastewater systems.[183] Stakeholders said when maintenance is continuously deferred, it can become costly.[184] Asset management plans are critical-for effectively managing wastewater systems and infrastructure.[185] Without a proper plan, wastewater systems may struggle to maintain compliance with state rules and regulations, secure adequate funding for capital improvements, and address customer needs. Tennessee's *TN H2O* plan found that a significant number of water and wastewater systems didn't seem to have a comprehensive long-range plan and capital budget.[186] Stakeholders also mentioned that the lack of long-range planning at wastewater facilities was a cause of concern.[187]

Wastewater operations are typically the largest energy expense in a community.[188] According to the US EPA, "For many municipal governments, drinking water and wastewater plants typically are the largest energy consumers, often accounting for 30% to 40% of total energy consumed."[189] Neglecting to implement energy-saving measures in the system can lead to unnecessary expenditures.

"For many municipal governments, drinking water and wastewater plants typically are the largest energy consumers, often accounting for 30% to 40% of total energy consumed."

US Environmental Protection Agency

Another issue can be chemical disinfection. It can effectively kill pathogens in wastewater. However, improper dosing or monitoring can result in the release of harmful byproducts or inadequate pathogen removal.

Stakeholders also said that all wastewater systems struggle with improving solids handling, especially during the wet season.[190] Sludge treatment and disposal are integral parts of wastewater treatment, and failure to take this into account will affect the overall environmental sustainability of the system.[191] Sludge generated during wastewater treatment can contain concentrated pollutants and pathogens, and improper disposal or management of sludge can contaminate the soil, water, and air.[192]

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[183] Interview with Jessica Murphy, compliance and enforcement manager, Tom Moss, drinking water enforcement officer, and Sarah Elias, NPDES wastewater compliance manager, Division of Water Resources, Tennessee Department of Environment and Conservation, October 11, 2023; and interview with Vena Jones, manager, State Revolving Funds and Water Infrastructure Grants, and Eliana Blash, administrative assistant, Tennessee Department of Environment and Conservation, September 6, 2023.
[184] Interview with Steve Wyatt, utility operations consultant, University of Tennessee Municipal Technical Advisory Service, August 8, 2023.
[185] Tennessee Department of Environment and Conservation 2023a.
[186] Tennessee Department of Environment and Conservation 2018b.
[187] Interview with Karina Bynum, water quality environmental fellow, Division of Water Resources, Tennessee Department of Environment and Conservation, October 13, 2023.
[188] US Environmental Protection Agency 2024d.
[189] Ibid.
[190] Interview with Karina Bynum, water quality environmental fellow, Division of Water Resources, Tennessee Department of Environment and Conservation, October 13, 2023.
[191] Krishna, Sachan, and Jatav 2022.
[192] Un 2024; and Li et al. 2021.

What are new technologies for wastewater system management that local governments could consider and would be permissible under TDEC rules?

Wastewater treatment technologies are evolving to meet the demands of modern systems, with a strong focus on the renewable use of resources. Innovations in this field are enhancing the effectiveness of wastewater treatment while improving energy savings and resource recovery. This section explores some newer technologies and processes being used by systems today.

Water Reuse

Water reuse involves treating wastewater and reusing it for beneficial purposes such as drinking, industrial uses, or irrigation.[193] In Tennessee, unrestricted non-potable reuse of wastewater is permitted if the water is properly treated and disinfected.[194] Wastewater treatment facilities must submit a permit application to TDEC to implement a water reuse system, along with a reclaimed wastewater management plan and proposed service agreements between the provider and purchaser of reclaimed wastewater.[195] Permit applicants for new or expanded wastewater discharges into surface waters must include in their application a consideration of beneficial reuse of wastewater as an alternative to discharging into surface waters.[196]

Wastewater treatment technologies are evolving to meet the demands of modern systems, with a strong focus on the renewable use of resources.

In 1992, the city of Franklin was the first community in the state to operate a water reuse system.[197] However, water reuse is not a practice that has been widely adopted statewide. Murfreesboro, Franklin, Pigeon Forge, Spring Hill, Smyrna, and the Water and Wastewater Authority of Wilson County wastewater systems in Tennessee are permitted for unrestricted non-potable reuse.[198] The reclaimed water is primarily used for irrigation of golf courses and residential landscaping.[199] The city of Murfreesboro's wastewater system, for example, uses water from its water reuse system in its wastewater plant and provides non-potable water to golf courses and residential developments in the community to be used for irrigation.[200] This means less water is discharged into local waterways.[201]

[193] US Environmental Protection Agency 2024b.
[194] Rules and Regulations of the State of Tennessee 0400-40-06-.10.
[195] Ibid.
[196] Tennessee Code Annotated, Section 69-3-108.
[197] Butler and Hilty 2008.
[198] Tennessee Department of Environment and Conservation 2018b.
[199] Ibid.
[200] Murfreesboro Water Resources "Reclaimed Water."
[201] Tennessee Department of Environment and Conservation 2018b.

Nutrient Recovery

Water isn't the only resource that can be recovered from wastewater. Nitrogen and phosphorus are two resources that can be extracted from wastewater and applied to crops as fertilizer or soil amendment.[202] Chattanooga, Knoxville, and Nashville produce fertilizer at their wastewater treatment plants.[203] Nashville's fertilizer is sold under the name Music City Gold.[204] Chattanooga works through a third-party contractor that transports their fertilizer to farmers free of charge,[205] and Knoxville provides fertilizer to farmers near the city for free.[206]

Biogas as Fuel

Nitrogen and phosphorus are two resources that can be extracted from wastewater and applied to crops as fertilizer or soil amendment.

Biogas generated by anaerobic digesters during the wastewater treatment process can be used as an energy source at the wastewater treatment facility.[207] If the biogas is processed further to remove impurities, the resulting methane can be used as fuel.[208] Chattanooga announced it will move forward with plans to install a system at its Moccasin Bend wastewater treatment plant that will convert solids in the wastewater into biogas that can be used as power at the plant or sold as a natural gas substitute after being further processed.[209] The project is expected to cost between $130 million and $150 million.[210]

Thermal Hydrolysis

Thermal hydrolysis is a method used to treat sewage sludge, making it easier to process through anaerobic digestion.[211] It uses high heat and pressure to break down sludge and destroy pathogens.[212] The city of Franklin uses thermal hydrolysis in its wastewater treatment system.[213]

Membrane Bioreactors

Membrane bioreactors are used in wastewater treatment to remove a wide range of dissolved contaminants.[214] These systems combine conventional biological treatment with membrane filtration, offering a high level

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[202] Theregowda et al. 2018.
[203] City of Chattanooga 2023; Knoxville Utilities Board "KUB's Biosolids Beneficial Reuse Program"; and Metropolitan Government of Nashville and Davidson "Wastewater treatment."
[204] Tycowa "Music City Gold."
[205] Interview with Mark Heinzer, administrator of wastewater division, Tony Kinder, director of engineering, Steve Sanders, director of maintenance, and Justin Steinman, director of administration, Moccasin Bend, Chattanooga, September 11, 2024.
[206] Knoxville Utilities Board 2023.
[207] New York State Energy Research and Development Authority 2019.
[208] Ibid.
[209] Walton 2023.
[210] Ibid.
[211] US Environmental Protection Agency 2006.
[212] Ibid.
[213] City of Franklin, TN "Water Reclamation Facility Project Updates."
[214] US Environmental Protection Agency 2007.

of contaminant removal, including pathogens, suspended solids, and organic matter.[215] They can be very effective in treating water for reuse in irrigation.[216]

Solar Photovoltaic

Solar photovoltaic (PV) technology is being integrated into wastewater treatment plants. A PV system can provide a source of renewable power for wastewater systems.[217] Chattanooga installed solar panels at its Moccasin Bend wastewater treatment plant, and those along with other energy-saving measures are helping it to save $1.4 million per year.[218] The cities of Franklin, Lebanon, and Nashville have solar panels installed at their wastewater systems as well.[219]

What are the governance structures of wastewater systems in Tennessee?

Public wastewater systems are governed by several different entities in the state.

Public wastewater systems are governed by several different entities in the state.[220] Eighty-two percent (230 out of 278) of public wastewater systems are operated by cities.[221] In most of these cities, the wastewater rates are set by the city's local governing body.[222] In a few cities, including Bulls Gap,[223] Clinton,[224] and Harriman,[225] the rates are set by utility boards and not the city's governing body.[226]

Nine percent (24 out of 278) of public wastewater systems are run by utility districts. These districts can be created by filing a petition with the Tennessee Board of Utility Regulation (TBOUR).[227] A petition must be signed by at least 25 real property owners who live within the proposed district's boundaries. TBOUR has the authority to approve the creation of the district. These districts are governed by boards of commissioners.[228] In single-county utility districts, the commissioners are appointed by the

[215] Ibid.
[216] Ibid.
[217] New York State Energy Research and Development Authority 2019.
[218] US Department of Energy 2022.
[219] City of Franklin, TN 2012; Lamb 2023; and Smith 2018.
[220] A list of public wastewater utilities was provided to commission staff by the Tennessee Board of Utility Regulation. See email from Nate Fontenot, financial analyst, Tennessee Comptroller of the Treasury, May 13, 2024.
[221] Tennessee Code Annotated, Sections 6-2-201(11), 6-19-101(11), 6-33-101, 7-3-302, and 7-35-401 through 7-35-432.
[222] Commission staff review of municipal codes of cities with wastewater utilities.
[223] Bulls Gap Municipal Code 18-106.
[224] Clinton Municipal Code 18-105(4).
[225] Harriman Municipal Code 18-101.
[226] Cleveland Utilities is in the process of forming an Energy Authority so it can provide broadband service. See Cleveland Utilities "Cleveland Utilities Receives Green Light to Provide Broadband Services in Conjunction with Transitioning to an Energy Authority."
[227] Tennessee Code Annotated, Section 7-82-201.
[228] Tennessee Code Annotated, Section 7-82-307. There are exceptions for certain districts in Tennessee Code Annotated, Section 7-82-307.

county mayor.[229] In multi-county districts, the commissioners are elected by customers.[230]

Two percent (6 out 278) of public wastewater systems are governed by the boards of commissioners of water and wastewater treatment authorities.[231] A city, county or metropolitan government can file a petition with TBOUR to create an authority.[232] Each authority is governed by a board of commissioners.[233] These commissioners are appointed by the executive officer of the government that petitioned for the creation of the authority, and the commissioners must be approved by that entity's governing body.

Municipal energy authorities operate 2% (5 out of 278) of public wastewater systems in the state.

Municipal energy authorities operate 2% (5 out of 278) of public wastewater systems in the state. A municipal energy authority can be formed by a resolution approved by a two-thirds vote of the county or city's governing body.[234] An authority is governed by a board of directors.[235] The board's directors fill any vacancies on the board subject to the approval of the county or municipal governing body that approved the formation of the authority.[236]

Two percent (5 out of 278) of public wastewater systems are operated by counties. The governing body of the system can be selected by the county governing body by resolution.[237] The governing board can also be an existing county agency, a public works department, or a board of public systems.

Metropolitan governments also provide wastewater service in the state. These governments operate 1% (3 out of 278) of Tennessee's public wastewater systems. In the Metropolitan Government of Nashville and Davidson County, the Metropolitan Council sets the rates for wastewater service.[238] A seven-member water and sewer board sets wastewater rates in the Metropolitan Government of Hartsville and Trousdale County.[239] The metropolitan water and sewer department of the Metropolitan Government of Lynchburg and Moore County provides wastewater service. It is governed by a five-member board appointed by the metropolitan government executive.[240]

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[229] Ibid.
[230] Ibid.
[231] Tennessee Code Annotated, Section 68-221-605. There is also a law that authorizes the creation of regional water and wastewater authorities in Tennessee Code Annotated, Sections 68-221-1301 through 68-221-1309.
[232] Tennessee Code Annotated, Section 68-221-604.
[233] Tennessee Code Annotated, Section 68-221-605.
[234] Tennessee Code Annotated, Section 7-36-103.
[235] Tennessee Code Annotated, Section 7-36-109.
[236] Tennessee Code Annotated, Section 7-36-110.
[237] Tennessee Code Annotated, Section 5-16-102.
[238] Code of the Metropolitan Government of Nashville and Davidson County, Chapter 15.44.
[239] Metropolitan Government of Hartsville/Trousdale County Ordinance No. 119-2015-10 c; and Tennessee Comptroller of the Treasury 2023b.
[240] Winnett Associates 2023.

A few local governments jointly work together to provide wastewater services. They operate 2% (5 out of 278) of the public wastewater systems in the state. Tennessee's Interlocal Cooperation Act authorizes local governments to enter into agreements to exercise powers and authority jointly with other local governments that have the same powers and authority.[241] The cities of Caryville and Jacksboro jointly operate the Caryville-Jacksboro Utilities Commission that provides water and wastewater service.[242] It is governed by a board of commissioners.[243] Each city appoints a member to the board, and these two members appoint a third member.[244] Benton and Decatur counties entered into an agreement to form the Benton-Decatur Special Sewer District.[245] It is governed by a six-member board.[246] The mayor of Benton County and mayor of Decatur County each appoint three board members.[247] The city of Bristol, Tennessee, jointly owns a wastewater treatment plant with the BVU Authority of Bristol, Virginia.[248] Each city appoints three members to sit on a six-member committee that oversees the system.[249]

Tellico Area Services System is a water and wastewater system co-owned by Monroe and Loudon counties.[250] It is governed by a six-member board of commissioners.[251] The Tellico Reservoir Development Agency entered into an agreement with the Tellico Area Services System to construct a sewer line and pump stations for the system.[252] Under the agreement, Tellico Area Services System will pay the Tellico Reservoir Development Agency $1,500 for each customer that taps onto the sewer line until the Agency is reimbursed for the construction costs.[253]

Private, Investor-Owned Wastewater Systems and Wastewater Cooperatives

There are 13 private, investor-owned, wastewater systems that are under the oversight of the Tennessee Public Utilities Commission (TPUC).* The majority of the systems TPUC regulates are decentralized. It approves the creation of the wastewater systems, which are required to submit annual reports that allow TPUC to gauge how the systems are performing. Cases can be made to TPUC about the need for a rate change, and ultimately, TPUC makes the decision about the rates. TPUC also handles customer complaints. The systems are required to get NPDES or SOP permits from TDEC depending on where they discharge.

TPUC staff note that they are seeing a rise in big companies acquiring smaller systems across the state and country because they do not have the resources to maintain the facilities and systems under them. There are acquisition rules in place that regulate this process. Following these types of acquisitions, rates generally stay the same, but might increase when necessary repairs or changes to update the systems are made.

Water cooperatives are nonprofit corporations that are member owned.† They are not under the oversight of TBOUR or TPUC. As is the case for other wastewater systems, they are required to get NPDES or SOP permits from TDEC depending on where they discharge.

241 Tennessee Code Annotated, Section 12-9-104.
242 Mitchell, Emert, and Hill 2023.
243 Caryville Municipal Code 18-207(5); and Jacksboro Municipal Code 18-207(5).
244 Mitchell, Emert, and Hill 2023.
245 Tennessee Comptroller of the Treasury 2023a.
246 Ibid.
247 Tennessee Comptroller of the Treasury 2023a.
248 Brown Edwards 2023.
249 City of Bristol Finance Department 2023.
250 Tellico Area Services System "Our Story."
251 WarrenJackson 2022.
252 Rodefer Moss 2023.
253 Ibid.

* Interview with David Foster, director of utilities, and Joe Shirley, director, utility audit and compliance, Tennessee Public Utility Commission, December 14, 2023.

† Tennessee Department of Environment and Conservation 2018b.

What is the compensation for wastewater utility board members and does this include benefits?

Much like the governance structure of public wastewater systems, the compensation and benefits made available to board members vary greatly across the state.

Much like the governance structure of public wastewater systems, the compensation and benefits made available to board members vary greatly across the state. Commission staff conducted a survey of the 278 public wastewater systems overseen by TBOUR to learn more about the compensation rates and benefits provided to board members. Respondents from 82 systems reported information about their board and staff, insurance and benefits options, and system debt levels. See appendix F for additional information about the survey results.

Sixty-five percent (53 out of 82) of respondents reported that they pay their governing board members, although the amount and frequency of compensation vary widely. Some boards are paid a standard amount for the year while others are paid per meeting. Other board members' compensation is grouped with their services for additional systems, like energy or water. The survey results show that board member compensation can range from $50 per month to $17,000 a year depending on the board they serve on.

Benefit packages vary as well, with 32% (26 out of 82) of respondents reporting that their system offers health insurance to board members. Of those systems providing health insurance, 88% (23 out of 26) pay a portion of the health insurance premium. Fewer systems, 22% (18 out of 82), report offering vision insurance, and 20% (# out of #) of survey respondents said they offer dental insurance. Respondents reported that life insurance is made available by 15% (12 out of 82) of systems.

Retirement benefits are offered by just 9% (7 out of 82) of the systems that participated in the survey. They report that they all offer retirement benefits through the Tennessee Consolidated Retirement System (TCRS). Board members enrolled in TCRS can access a defined benefit plan that provides lifetime retirement, survivor, and disability benefits for employees and eligible beneficiaries[254] and includes 401K and 457b or deferred compensation plan options. Retirement benefits are not always offered to all members of a board and, instead, are often reserved for chairmen of the boards. This is the case for the Lenoir City Utility Board, where a defined benefit pension plan plus 3% to a 457b deferred compensation plan is available only for the chairman of the board.

Beyond the more standard benefits offered, like health insurance, some systems provide board members with additional benefit options. Webb Creek Utility District offers members of its governing body a health reimbursement card up to $2,000 a month, in addition to the health insurance

[254] Tennessee Department of Treasury "Retirement."

that it offers. The Ripley Gas, Water, and Wastewater department offers a similar benefit in the form of a flexible benefit card. Other additional benefits reported in the survey include paid travel for board-related activities and training opportunities.

What are the staffing issues at wastewater systems in Tennessee?

In the 2023 American Water Works Association (AWWA) *State of the Water Industry* nationwide survey, talent attraction and retention were listed as the 12th most challenging issues for water and wastewater systems.[255] This is partly because of the aging wastewater workforce and the difficulty in recruiting younger workers to take their place.[256] Some wastewater systems are having trouble retaining their staff because they can leave for better paying jobs elsewhere.[257] Seventeen percent of respondents (14 out of 82) to the commission staff survey of wastewater systems said they had difficulty attracting and retaining certified wastewater operators. Fifty-nine percent of respondents (48 out of 82) said they didn't have difficulty attracting and retaining operators.

Thirty-nine percent (32 out of 82) of the respondents to the commission staff survey reported they had at least one certified wastewater operator that would be retiring in the next 10 years.

The need for certified wastewater operators is rising as operators retire.

One of the reasons for the difficulty in retaining workers is the rising number of operators in the wastewater industry that are retiring. This has been identified as one area of concern among systems and was listed as the 6th most challenging issue for water systems in the AWWA *State of the Water Industry* survey.[258] According to US Bureau of Labor Statistics data, 34% of water and wastewater operators nationwide are under the age of 35, and 66% are over the age of 35. Forty-two percent are over the age of 45. Certified wastewater operators tend to skew older in Tennessee as well. The *TN H2O* plan reported that the average age of wastewater certification holders ranged from the upper forties to the mid-fifties depending on the type of certification.[259] This suggests that a number of the certified wastewater operators in the state are nearing retirement age.

Thirty-nine percent (32 out of 82) of the respondents to the commission staff survey reported they had at least one certified wastewater operator that would be retiring in the next 10 years. Sixteen percent (13 out of 82) of the survey respondents reported that all (100%) of their certified operators would be retiring in 10 years. Twelve percent (10 out of 82) replied that

[255] American Water Works Association 2023.
[256] Interview with John Lawrence, director, Fleming Training Center, November 20, 2023; and Kane and Tomer 2018.
[257] Interview with John Lawrence, director, Fleming Training Center, November 20, 2023.
[258] American Water Works Association 2023.
[259] Tennessee Department of Environment and Conservation 2018b.

50% to 99% of their certified operators would be retiring within 10 years, while 35% (29 out of 82) said that less than 50% would be retiring in that time period. Twenty-four percent (20 out of 82) said they did not have any certified operators retiring in the next 10 years, and 30% (25 out of 82) of respondents did not answer the question.

Efforts are being made to recruit new people to the field.

Systems are having trouble recruiting new people to replace the retiring operators.[260] Potential applicants may not be aware of the jobs available in the wastewater industry.[261] Wastewater systems must have at least one operator in charge who is certified.[262] It is skilled and technical work that requires operators to perform duties such as inspecting, maintaining and operating wastewater plant equipment, monitoring meters and gauges, testing wastewater samples, and reporting results to regulatory agencies.[263]

Twenty-four percent (20 out of 82) of survey respondents said they did not have any certified operators retiring in the next 10 years.

It can be difficult to pass the exams necessary to become a certified wastewater operator.[264] This can make it harder to find people who are certified to work as wastewater operators. There are four different levels, also known as grades, of wastewater treatment certification.[265] In addition to these four levels of certification, there is a certification for biological/natural systems that use natural biological treatment as the predominant form of treatment.[266] There are also two grades of certification for wastewater collection system operators; collection systems are the collection of pipes and equipment that convey the wastewater to the treatment plant.[267] To sit for an exam, applicants are required to have at least a high school diploma or general educational development (GED) degree. They must also have a certain amount of experience working at wastewater treatment plants or collection systems depending on which grade they want to be certified. Applicants must score at least 70% to pass the exam.

There are two schools in Tennessee that help applicants prepare for the certification exam. The Fleming Training Center in Murfreesboro provides courses to help people prepare for the exam,[268] and it offers continuing education training for certified operators. Pellissippi State Community College in Knoxville offers an Associate of Applied Science (AAS) Degree

[260] Interview with John Lawrence, director, Fleming Training Center, November 20, 2023; and interview with Steve Wyatt, utility operations consultant, University of Tennessee Municipal Technical Advisory Service, August 16, 2023.
[261] Kane and Tomer 2018; and Smith 2021.
[262] Tennessee Code Annotated, Section 68-221-904.
[263] US Bureau of Labor Statistics 2024.
[264] Interview with Steve Wyatt, utility operations consultant, University of Tennessee Municipal Technical Advisory Service, August 16, 2023; and Tennessee Department of Environment and Conservation 2018b.
[265] Rules and Regulations of the State of Tennessee Chapter 0400-49-01.
[266] Ibid.
[267] Rules and Regulations of the State of Tennessee Chapter 0400-49-01; and American Water Works Association "Wastewater Collection Systems."
[268] Tennessee Department of Environment and Conservation 2024c.

in Water Quality Technology.[269] The program trains students for careers in water and wastewater treatment operations, and graduates are prepared in the program to sit for certification exams.

To help with recruiting new workers, the Tennessee Association of Utility Districts (TAUD) launched its first water and wastewater utility apprenticeship program in 2020.[270] The apprenticeship program was designed to help fill the need for certified water and wastewater operators in rural Tennessee.[271] The two-year apprenticeship program prepares apprentices for certification as a water or wastewater systems operator.[272] TAUD recruits by word of mouth[273]—systems reach out to TAUD to recommend candidates for the program.[274] These are typically people that may not have any experience working at a wastewater plant.[275] The program combines on-the-job training with training at the Fleming Training Center in Murfreesboro.[276]

Systems in other states have started programs to help students learn more about careers in the industry and possibly recruit new workers to the industry. The Metropolitan District of Hartford, Connecticut (MDC), is a water and wastewater system that offers a month-long Learn and Earn program for high school students each summer.[277] The students are paid to learn about water conservation and wastewater treatment and work at one of the system's departments. MDC also offers a work-based internship program where students as young as 16 get paid to work up to 20 hours per week at the system. Six water and wastewater systems in Pennsylvania offer nine-week, paid summer internships to high school graduates and other adults interested in exploring careers in the field.[278] Interns rotate through all six organizations gaining exposure to a variety of job opportunities in water and wastewater operations.

Systems in other states have started programs to help students learn more about careers in the industry and possibly recruit new workers to the industry.

In addition to apprenticeship and internship opportunities, systems can reach out to K-12 students to help increase their awareness of the industry. For example, Metropolitan Nashville and Davidson County's water services department offers information to middle and high school students about wastewater treatment and careers on its website.[279] It also offers teachers

[269] Pellissippi State Community College "Water Quality Technology (A.A.S.)."
[270] National Rural Water Association 2020.
[271] Ibid.
[272] Interview with John Greer, former program manager, Tennessee Association of Utility Districts, October 16, 2023.
[273] Ibid.
[274] Interview with John Lawrence, director, Fleming Training Center, November 20, 2023.
[275] Ibid.
[276] Interview with John Lawrence, director, Fleming Training Center, November 20, 2023; and National Rural Water Association 2020.
[277] Metropolitan District Hartford Connecticut "Learning Opportunities."
[278] Water and Wastewater Internship Program "WWIP—Water and Wastewater Internship Program."
[279] Metropolitan Government of Nashville and Davidson County "Waste and Water School and Group Education Programs."

the opportunity to request tours and speakers on its website. Systems in other states have enacted more unique programs to educate students about wastewater treatment. The Los Angeles County Sanitation Districts offer a Sewer Science program, which is a week-long laboratory for high school science students that shows them how wastewater is treated.[280] The San Antonio, Texas, water system offers an Academy of Water Influencers that is a virtual institute for high schoolers where they can learn about the value of water and career paths in the water industry.[281] They complete a series of learning modules online.

To help fill vacant wastewater operator positions in its state, the Texas state legislature passed a law in 2023 to allow high school students to work toward becoming a water or wastewater operator while still in high school.[282] The law authorizes individuals without high school diplomas to act as a provisional wastewater operator if they have completed training, passed required exams, and work under the supervision of a certified operator.[283] The provisional Wastewater Class D license is valid for two years. At the end of that time period, they must upgrade the license to a nonprovisional license if they want to continue to work as a licensed wastewater operator.[284]

In the commission staff survey of the state's wastewater systems, 17% (14 out of 82) of respondents replied they were having difficulty retaining certified wastewater operators.

Some systems are having trouble retaining operators.

In the commission staff survey of the state's wastewater systems, 17% (14 out of 82) of respondents replied they were having difficulty retaining certified wastewater operators. Survey respondents said that operators will move onto larger systems that have more opportunity to advance. Some said they couldn't compete with surrounding communities when it comes to pay and benefits.

There is variation in what wastewater operators are being paid statewide. Survey respondents reported that they paid annual salaries between $3,000 and $138,000 to their certified wastewater operators. Some of the survey respondents noted that they employ operators on a part-time basis. Other survey respondents reported paying their operators between $20.52 and $37.45 per hour. US Bureau of Labor Statistics data show salary differences by geographic location. The median hourly wage for water and wastewater operators in the north central part of Tennessee, for example, is $19.46, while the median hourly wage for water and wastewater operators in the Knoxville area is $25.19 (see map 5). Interestingly, the median hourly wage for water and wastewater operators in Tennessee is higher than several of the other surrounding southern states (see map 6).

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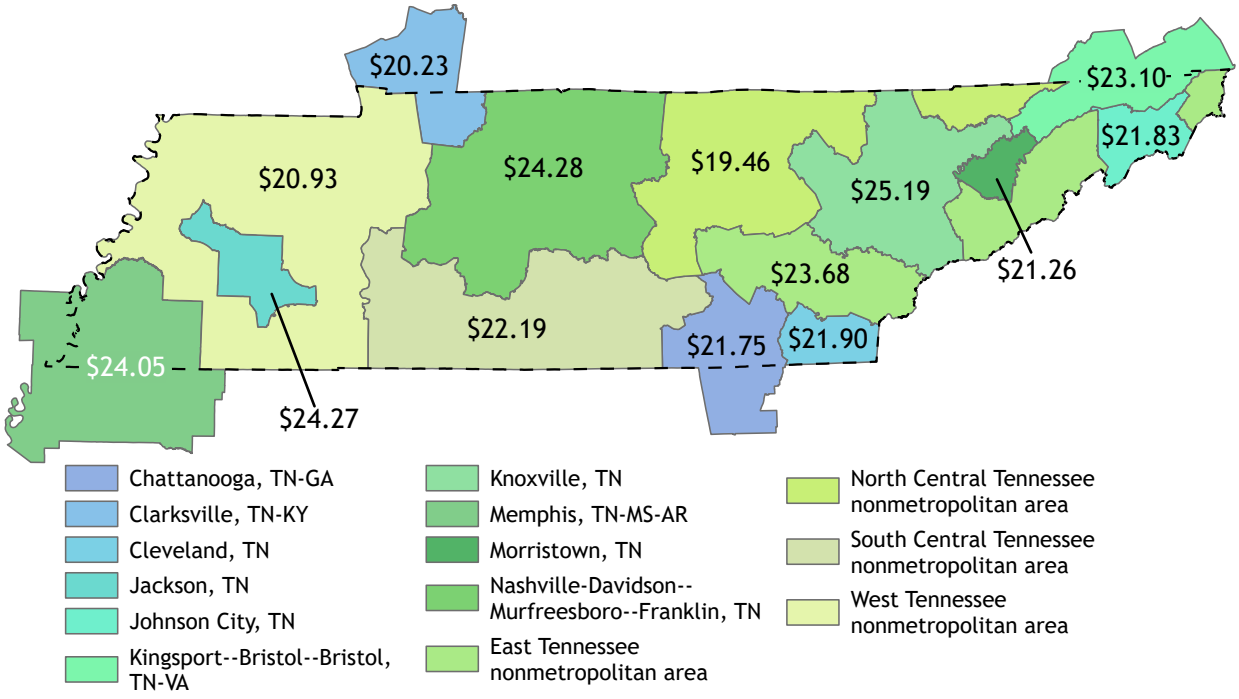
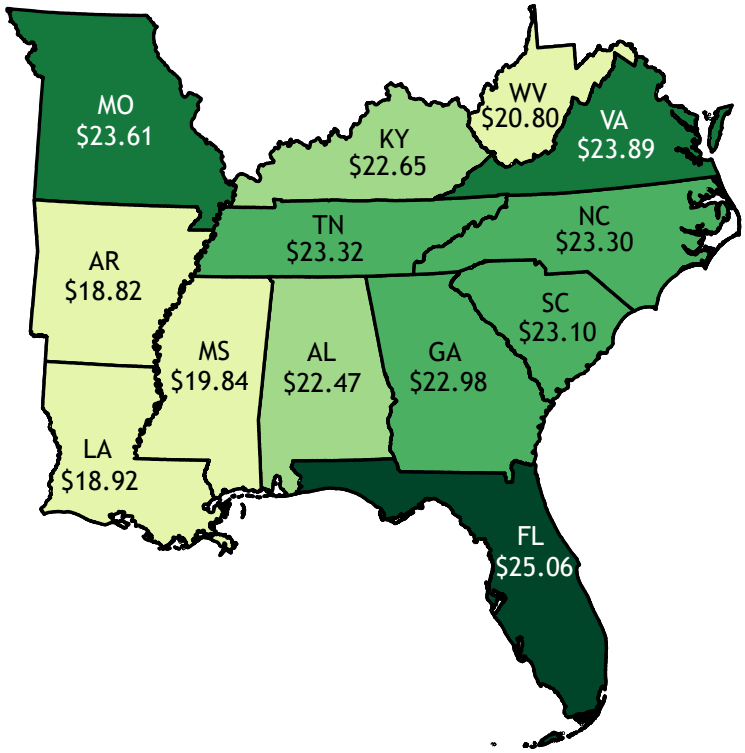
[280] Los Angeles County Sanitation Districts "Sewer Science: How Sewage and Drinking Water are Cleaned."
[281] San Antonio Water System 2024.
[282] Salhotra and Carver 2023.
[283] Texas Water Code, Section 37.0045 (2023 Texas House Bill 1845).
[284] Texas Commission on Environmental Quality "Occupational Licenses: Wastewater Treatment Plant and Collection System Operators."

Map 5. Tennessee Water and Wastewater Treatment Plant and System Operators Hourly Median Wages for Metropolitan and Nonmetropolitan Areas, 2023



Source: US Bureau of Labor Statistics "Occupational Employment and Wage Statistics Query System."

Map 6. Water and Wastewater Treatment Plant and System Operators Hourly Median Wages in the Southeastern US, 2023



Source: US Bureau of Labor Statistics "Occupational Employment and Wage Statistics Query System."

This problem is not unique to Tennessee. In 2022, to learn about workforce issues, researchers at the Kentucky Water Resources Research Institute at the University of Kentucky undertook a Water Workforce Survey of operators and managers at the state's water and wastewater systems.[285] Thirty-nine percent of operators who responded to the survey said they were extremely or somewhat dissatisfied with their wages; only 49% thought they were being paid a fair wage.[286] Despite their dissatisfaction with their pay, 65% were somewhat or extremely happy with their jobs, and 76% liked doing their assigned tasks.[287]

In 2022, a Kentucky Water Workforce Survey administered by the Kentucky Water Resources Research Institute at the University of Kentucky found that 39% of operators at Kentucky's water and wastewater systems were extremely or somewhat dissatisfied with their wages.

Based on the survey responses, the Kentucky researchers developed a set of recommendations to help with retaining and recruiting operators. To help with retaining employees, they recommended that system management and decision makers might want to consider several ideas:

- Educate system decision makers about the magnitude and nature of the problem.
- Increase pay.
- Increase benefits.
- Demonstrate a greater appreciation of employees.
- Develop succession plans for both operators and managers.
- Provide tools and support to management to help address retention issues.

To help with recruiting new operators, they recommended that system management and decision makers might want to consider several ideas:

- Evaluate system financials and explore avenues to increase operator salary scales.
- Develop and implement an effective trainee internship and/or apprentice program.
- Develop more effective marketing strategies and techniques to advertise new positions.
- Evaluate benefit packages to ensure they are commensurate or competitive with other industries or even other systems.
- Improve communication and interaction with staff.

[285] Koyagi et al. 2022.
[286] Ibid.
[287] Koyagi et al. 2022.

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Appendix A: Treatment Processes used in Centralized Wastewater Treatment Systems

Wastewater is collected and treated at a centrally located treatment plant to be processed in centralized wastewater systems.[288] The wastewater is treated in a multistep process.

Preliminary Treatment

Wastewater might have large solids in it that could interfere with the wastewater treatment processes or cause wear and tear on the equipment.[289] Many of these solids can be removed during preliminary treatment. The process may include a number of steps such as screening, grinding, and grit removal.[290]

During screening, large solids such as rocks and branches are removed with screens.[291] They will vary from coarse screens to very fine ones.[292] With shredding, solids are ground down to a size that can enter the treatment facility without damaging the equipment.[293] Some plants might use comminutors or grinders to grind the solids to a smaller size.[294] After being screened, the wastewater may flow into a grit chamber where grit and small stones settle to the bottom of the chamber.[295] The solids collected during the preliminary treatment phase are incinerated or shipped to a landfill.[296]

Primary Treatment

After pretreatment, there will still be solids in the wastewater. Remaining solids can be removed using primary clarifiers.[297] The heavier solids settle to the bottom.[298] These solids are called sludge.[299] The lighter weight solids float to the top and are then skimmed off.[300] A dissolved air flotation thickener is another primary treatment process that uses compressed air to get the solids to float so they can be removed.[301] The remaining liquid is then sent onto the secondary phase of treatment.

Secondary Treatment

During secondary treatment, microorganisms reduce the amount of organic matter such as proteins, carbohydrates, and fats that are in the wastewater.[302] Most secondary treatment involves either attached growth processes or suspended growth processes.

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[288] US Environmental Protection Agency 2024a.
[289] Water Environment Federation and Association of Boards of Certification 2018.
[290] Drinan and Spellman 2013; and Tennessee Department of Environment and Conservation 2020, Chapter 4.
[291] Drinan and Spellman 2013.
[292] US Environmental Protection Agency 2004.
[293] Ibid.
[294] Water Environment Federation and Association of Boards of Certification 2018.
[295] US Environmental Protection Agency 2004.
[296] Ibid.
[297] Water Environment Federation and Association of Boards of Certification 2018.
[298] Drinan and Spellman 2013.
[299] US Environmental Protection Agency 2004.
[300] Water Environment Federation and Association of Boards of Certification 2018.
[301] Ibid.
[302] Metcalf & Eddy, Inc. 2014; and US Environmental Protection Agency 2004.

Attached growth or fixed film processes include trickling filters and rotating biological contractors.[303] They are effective at removing organic material from wastewater.[304] Microorganisms like bacteria, algae, and fungi grow on a filter and form a slime—also known as biomass—layer on the filter.[305] When the organic material in the wastewater comes into contact with the microorganisms that are attached to a filter, the microorganisms consume the oxygen-demanding substances.[306]

Suspended growth processes are secondary treatment processes where the microorganisms mix with the wastewater.[307] These types of secondary treatment processes include activated sludge, oxidation ditches, or sequencing batch reactors.[308] In these methods, the wastewater is mixed with microorganisms and air and the microorganisms break down the organic material in the wastewater.[309]

Tertiary Treatment

Advanced or tertiary treatment of wastewater may be needed, for instance, if you are discharging into a delicate ecosystem or plan to reuse the water for irrigation purposes.[310] Some examples of advanced or tertiary treatment processes include nitrogen removal, phosphorus removal, carbon absorption, and additional filtration processes.[311]

Nitrogen removal may be needed in some cases. Too much nitrogen in water may encourage excessive growth of algae and other plants, and when the plants decompose they may use oxygen that is needed by fish and other aquatic life.[312] Nitrogen can be removed using biological processes known as nitrification and denitrification.[313] In the nitrification process, the water enters a tank where microorganisms thrive and convert ammonia in the wastewater via nitrite to nitrate.[314] There is an additional denitrification process that can convert the nitrate nitrogen into nitrate gas.[315] Ammonia stripping is another method that can be used to reduce the level of nitrogen in wastewater before releasing it.[316] In this method, the pH level in the wastewater is raised by adding lime, and dissolved ammonia gas is formed which is then removed from the wastewater.[317]

Like nitrogen, excess phosphorus in water can encourage the excessive growth of algae.[318] Phosphorus can be removed using chemical means. Lime, alum, or ferric chloride is added to the wastewater.[319] The addition of one of these chemicals will cause phosphorus particles to clump together into masses.[320] The clumps can then be removed from the wastewater.[321] Phosphorus can also be removed using biological means by using

[303] US Environmental Protection Agency 2004; and Water Environment Federation and Association of Boards of Certification 2018.
[304] US Environmental Protection Agency 2000c.
[305] US Environmental Protection Agency 2004.
[306] Ibid.
[307] Drinan and Spellman 2013.
[308] Tennessee Department of Environment and Conservation 2020, Chapter 7.
[309] US Environmental Protection Agency 2004.
[310] Ibid.
[311] Drinan and Spellman 2013; and Water Environment Federation and Water Professionals International 2022.
[312] US Geological Service 2018a.
[313] Drinan and Spellman 2013.
[314] Water Environment Federation and Water Professionals International 2022.
[315] US Environmental Protection Agency 2004.
[316] US Environmental Protection Agency 2000a.
[317] Drinan and Spellman 2013.
[318] US Environmental Protection Agency 2024f.
[319] Mackenzie and Cornwell 2023.
[320] Drinan and Spellman 2013.
[321] Ibid.

microorganisms that will consume the phosphorus.[322] Additional organic materials can be removed using carbon absorption technology.[323] During this process, the wastewater flows through activated carbon granules or powder.[324] Any trace organic substances that remain in the wastewater will be captured by the carbon.[325] Any suspended solids remaining in the wastewater can be removed using filtration processes. One example is reverse osmosis membranes.[326] These filters can filter out substances like sodium.[327]

Disinfection

After the wastewater has completed the secondary treatment process or the advanced or tertiary process if that is required, it will be disinfected. This will reduce the level of pathogens to a level that they will not cause disease if discharged into receiving waters.[328] The most commonly used methods include chlorination, ultraviolent (UV) radiation, and ozonation. With chlorination, chlorine or chlorine substitutes like hypochlorite are added to the water to disinfect it. To disinfect wastewater using UV radiation, the water is exposed to UV light of a specific wavelength and intensity for a period of time. Ozonation is a disinfection method where a gas—ozone—is used to disinfect the wastewater.

Solids Handling

There will be solids leftover after the treatment. These are referred to as sludge.[329] It has to be treated before being disposed of through a process involving thickening the sludge and stabilizing it using chemical methods or aerobic or anaerobic digestion. It is also conditioned using chemical or heat treatment and dewatered before it can be disposed of.[330] After being treated, it can be disposed of in a landfill or incinerated.[331]

[322] Oehmen et al. 2007.
[323] US Environmental Protection Agency 2000b.
[324] US Environmental Protection Agency 2004.
[325] Ibid.
[326] Water Environment Federation and Water Professionals International 2022.
[327] Ibid.
[328] Drinan and Spellman 2013.
[329] Drinan and Spellman 2013; and US Environmental Protection Agency 2004.
[330] Drinan and Spellman 2013.
[331] Drinan and Spellman 2013; and Rules and Regulations of the State of Tennessee Section 1200-03-16-.15.

Appendix B: Estimated Cost Reported for Wastewater-Related Infrastructure Projects

	Number of Projects	Estimated Cost Needed	Percent of State Total Cost
Tennessee	377	$3,509,582,262	100%
Anderson	11	23,450,000	0.67%
Bedford	1	514,000	0.01%
Benton	2	1,501,000	0.04%
Bledsoe	1	8,382,400	0.24%
Blount	4	11,367,000	0.32%
Bradley	3	5,700,000	0.16%
Campbell	3	3,361,000	0.10%
Cannon	1	2,100,000	0.06%
Carroll	6	2,534,900	0.07%
Carter	7	10,550,000	0.30%
Cheatham	1	2,500,000	0.07%
Chester	2	3,900,000	0.11%
Claiborne	3	10,057,682	0.29%
Clay	1	3,000,000	0.09%
Cocke	1	543,000	0.02%
Coffee	3	11,000,000	0.31%
Crockett	9	4,239,000	0.12%
Davidson	3	1,401,158,000	39.92%
Dickson	1	500,000	0.01%
Dyer	1	9,000,000	0.26%
Franklin	4	16,160,000	0.46%
Gibson	5	1,665,000	0.05%
Grainger	3	4,025,850	0.11%
Greene	10	57,682,000	1.64%
Grundy	4	9,875,000	0.28%
Hamilton	43	319,956,057	9.12%
Hancock	3	3,042,988	0.09%
Hardeman	1	750,000	0.02%
Hardin	1	605,000	0.02%
Hawkins	17	20,167,617	0.57%
Henderson	2	1,409,650	0.04%
Henry	1	200,000	0.01%
Houston	2	10,500,000	0.30%
Humphreys	4	6,675,000	0.19%
Jefferson	4	7,801,962	0.22%

	Number of Projects	Estimated Cost Needed	Percent of State Total Cost
Johnson	1	430,619	0.01%
Knox	17	355,490,408	10.13%
Lake	2	1,500,000	0.04%
Lawrence	1	1,000,000	0.03%
Lincoln	1	3,000,000	0.09%
Loudon	19	23,151,558	0.66%
Madison	4	24,377,533	0.69%
Marion	1	1,200,000	0.03%
Marshall	7	6,890,378	0.20%
Maury	3	17,725,000	0.51%
McMinn	3	5,646,925	0.16%
McNairy	2	5,470,000	0.16%
Meigs	1	3,200,000	0.09%
Monroe	3	1,876,000	0.05%
Montgomery	1	5,650,000	0.16%
Moore	2	16,200,000	0.46%
Morgan	1	100,000	0.00%
Obion	7	5,124,000	0.15%
Polk	3	7,950,000	0.23%
Putnam	4	5,461,000	0.16%
Rhea	1	23,800,000	0.68%
Roane	5	8,195,990	0.23%
Robertson	4	24,200,000	0.69%
Rutherford	11	53,246,082	1.52%
Sevier	27	105,862,648	3.02%
Shelby	7	309,650,000	8.82%
Smith	2	7,300,000	0.21%
Stewart	1	15,000,000	0.43%
Sullivan	8	63,330,972	1.80%
Sumner	19	84,900,000	2.42%
Tipton	1	12,000,000	0.34%
Unicoi	4	4,413,189	0.13%
Washington	14	$69,390,000	1.98%
Wayne	1	$1,000,000	0.03%
Weakley	2	$1,500,000	0.04%
White	1	$600,000	0.02%
Williamson	13	$228,863,558	6.52%
Wilson	5	$29,012,296	0.83%

Source: Commission staff analysis based on Tennessee Advisory Commission on Intergovernmental Relations "Public Infrastructure Needs Inventory Database."

Appendix C: Funding Sources for Wastewater Projects

Federal Funding Sources

The federal government offers several funding sources for wastewater systems. There are both grants and loans available for wastewater systems. The Environmental Protection Agency, Department of Agriculture, Department of Commerce, and Army Corps of Engineers offer federal funding for these types of projects.

US Environmental Protection Agency

The Water Infrastructure Finance and Innovation Act (WIFIA), a federal credit program administered by the US Environmental Protection Agency (EPA), offered loans for eligible water and wastewater infrastructure projects. Because this is a federal credit reform program, when the loans are repaid, they are returned to the US Treasury. The application process consists of two steps.[332] First, a letter of interest form must be submitted. In the form, the applicant provides information about their project's eligibility and feasibility and their credit worthiness. The applicant is then invited to apply for a loan if the EPA thinks there is a reasonable expectation they will be able to close on the loan. WIFIA appropriation levels for the program remain consistent year to year with approximately $6 billion to $7 billion available to lend.[333] In general, the federal government can provide a maximum of 49% of project costs, but small communities are eligible for a maximum of 80% of project costs.[334] Tennessee has received a total of $342 million in loans for two projects in 2020 and 2022 for the cities of Memphis and Chattanooga, respectively.[335]

US Department of Agriculture

The US Department of Agriculture (USDA) offers various grant and loan programs for wastewater infrastructure projects. The Wastewater Disposal Direct Loan and Grant Program provides infrastructure for rural areas and towns with populations of up to 10,000. Eligible entities include most state and local government entities, private nonprofit organizations, and federally recognized tribes. Available funds may be used to build, repair, or improve public water systems, waste collection, and treatment systems. Funding consists of long-term, low-interest loans, but if funds are available, a grant may be combined with a loan to keep user costs reasonable. The repayment period for this program is a maximum of 40 years.[336]

The Water and Waste Disposal Loan Guarantees administered by the USDA help private lenders provide affordable loans to borrowers to construct, improve, and repair water supply and distribution systems and waste collection and treatment systems in rural areas.[337] The federal government will guarantee up to 90% of the loan amount for projects that serve rural areas with populations of 10,000 or less.[338] The USDA has an online map that shows the areas that are eligible for these guarantees.[339] The guarantees are available for loans being made to state and local governments, federally recognized tribes, and nonprofit organizations.[340]

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[332] US Environmental Protection Agency 2024l.
[333] Interview with Karen Fligger, deputy director, Office of Wastewater Management, US Environmental Protection Agency, November 6, 2023.
[334] Ibid.
[335] US Environmental Protection Agency 2023g; and US Environmental Protection Agency 2024m.
[336] US Department of Agriculture "Water & Waste Disposal Loan & Grant Program in Tennessee"; and interview with Chris Hampton, program manager, Rural Utilities Service & Community Facilities, US Department of Agriculture, October 16, 2023.
[337] Ibid.
[338] US Department of Agriculture "Water & Waste Disposal Loan Guarantees in Tennessee".
[339] US Department of Agriculture "Eligibility."
[340] US Department of Agriculture 2017.

USDA also offers the Water and Waste Disposal Predevelopment Planning Grants which help eligible low-income communities plan and develop applications for proposed USDA Rural Development water or waste disposal projects. Eligible entities include most state and local governments, nonprofit organizations, and federally recognized tribes. This program is for low-income communities with initial planning and development of an application for USDA Rural Development Water and Waste Disposal direct loan or grant and loan guarantee programs. Communities include rural areas and towns with populations of 10,000 or less and must have a median household income below the poverty line or less than 80% of the statewide nonmetropolitan median household income. Partnerships with other federal, state, and local entities are encouraged, but grants are awarded only when the applicant cannot afford to borrow the needed funds. The maximum grant amount is $60,000 or 75% of the predevelopment planning costs, and funds cannot be used to pay for work already completed. These predevelopment planning grants do not have to be paid back if the application for the USDA direct loan or loan and grant combination is not awarded.[341]

The Special Evaluation Assistance for Rural Communities and Households (SEARCH) program covers predevelopment planning costs: feasibility studies to support applications for funding water or waste disposal projects, preliminary design and engineering analysis, and technical assistance for the development of an application for financial assistance.[342] Predevelopment planning costs must be related to the project. Most state and local government entities, nonprofit organizations, and federally recognized tribes can apply for the grant. The projects must serve areas that are rural and financially distressed. The areas must have a population of 2,500 or less, and the median household income for the area served must be below the poverty line or less than 80% of the median household income.[343]

The Communities Facilities Direct Loan and Grant is a loan and grant program that offers funds to purchase, construct, or improve essential community facilities or purchase equipment and pay related project expenses. Eligible communities include rural areas including cities, villages, townships, and towns including Federally Recognized Tribal Lands with no more than 20,000 residents according to the latest US Census Data. Eligible entities are placed on a priority point system based on population and median household income, but higher priority is given to small communities with a population of 5,500 or less or low-income communities having a median household income below 80% of the state nonmetropolitan median household income. The grant maximum depends on the project criteria and ranges from 15% to 75% of project costs.[344]

US Department of Commerce

The Economic Development Administration Public Works Program provides funding for infrastructure projects in distressed communities.[345] There is approximately $40 million available for the Southeastern region, which includes eight states. Each project is usually awarded from $1 million to $2.5 million, but funding is competitive. Tennessee is usually awarded funds for two to four projects each year, depending on how many applications are submitted.[346]

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[341] US Department of Agriculture "Water & Waste Disposal Predevelopment Planning Grants in Tennessee."
[342] US Environmental Protection Agency 2024k.
[343] Environmental Finance Center Network 2022; US Department of Agriculture "SEARCH – Special Evaluation Assistance for Rural communities and Households in Tennessee"; and 7 Code of Federal Regulations, Subtitle B, Chapter XVII, Part 1774.
[344] US Department of Agriculture "Community Facilities Direct Loan & Grant Program in Tennessee."
[345] US Economic Development Administration "Public Works."
[346] Telephone call with Lucas Blankenship, economic development representative, Economic Development Administration, March 8, 2024.

US Army Corps of Engineers

The US Army Corps of Engineers provides the Environmental Infrastructure Assistance program, available to specified cities, counties, and states for water distribution works, stormwater collection, surface water protection projects, and environmental restoration. Cost sharing is required to receive assistance—65% federal and 35% nonfederal.[347]

State Funding Sources

Like the federal government, the state offers funding opportunities for wastewater systems. The Tennessee Department of Environment and Conservation, Tennessee Department of Economic Development, and the Comptroller of the Treasury offer funding for wastewater systems. Some of these programs are state-administered programs in which the federal government allocates funds to the states, and the states are responsible for distributing the money to systems.

Tennessee Department of Economic and Community Development (ECD)

The US Department of Housing and Urban Development's (HUD) Community Development Block Grants (CDBG) provide funds for a range of community issues including water and wastewater infrastructure and improvements. City and county governments are eligible for this grant except those in entitlement communities—communities that receive direct CDBG funds from HUD. Utility districts and authorities are not eligible to apply. The level of funding is determined based on Congressional appropriations each year. In recent years, Tennessee has received approximately $25 million per year, and 30% to 35% of funds are appropriated for water and wastewater projects.[348] Between 2022 and 2024, 34 wastewater projects were funded for a little over $16.3 million.[349]

CDBG projects are evaluated based on scoring, depending on the category of project type. Sewer projects are scored based on the following criteria: community need (per capita income of the area based on the most recent American Community Survey or Census data, poverty rate, three years of unemployment data for the county, and per capita income if it's based on income survey), project impact (cost per person, grant cost per low- and moderate-income person, and rate factor that takes into account the rates customers pay), project need (technical score based on level of infiltration and inflow, capacity, and age of system), and rate factor (sewer or water rate for 5,000 gallons divided by the Census per capita income for the area).[350] There is also an economic development bonus if the proposed project directly aids economic development.[351] Each scoring criteria is based on a 100-point scale, with the exception of the economic development bonus that has a maximum of 10 points. The maximum score an application can receive is 310 points.[352]

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[347] Congressional Research Service 2022.

[348] Interview with Kent Archer, director of community infrastructure, Tennessee Economic and Community Development, October 25, 2023; interview with Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, December 20, 2023; presentation by Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, Tennessee Advisory Commission on Intergovernmental Relations meeting, January 25, 2024; and Environmental Finance Center Network 2022.

[349] Commission staff analysis of data received in emails from Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, March 20, 2024, March 21, 2024, and March 22, 2024.

[350] Interview with Kent Archer, director of community infrastructure, Tennessee Economic and Community Development, October 25, 2023; and Tennessee State CDBG Program 2024 Application Notices.

[351] Interview with Kent Archer, director of community infrastructure, Tennessee Economic and Community Development, October 25, 2023; and interview with Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, December 20, 2023.

[352] Email from Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, May 30, 2024.

The Appalachian Regional Commission (ARC) is an economic development partnership between the federal government and 13 state governments focusing on counties across the Appalachian region. ARC provides federal funding support in the form of grants to counties in Middle and East Tennessee for public infrastructure projects. The amount of funding available each year fluctuates, but most recently, the ARC had $9 million dollars to offer for eligible projects. Applicants for an ARC grant are required to submit a pre-application in December. If a pre-applicant is moved on to the full application process, they are likely to be approved for a grant. ECD assesses several factors, including community need, project need, and county designation. Each grantee can expect to receive up to $1 million for construction projects and $500,000 for non-construction projects.[353] Between 2022 and 2024, five wastewater projects were funded for a little over $3.1 million in Tennessee.[354]

The Delta Regional Authority (DRA) is a regional economic development agency serving local communities in eight states including Tennessee. It provides federal funding to projects in West Tennessee that have an economic development component.[355] In 2023, Stanton, Tennessee, received a $3.5 million DRA grant for water and sewer facilities in preparation for Ford's BlueOval City—this grant was accompanied by an $8.1 million award from the USDA.[356]

ECD's Infrastructure Planning Grant is state funded and available to assist financially distressed counties and utility districts with community-wide planning for water and sewer infrastructure. The grant is available to those systems that serve distressed counties and rural communities that have been on the list of financially distressed utility systems provided by the Comptroller at any point over the last three years.[357] Grant funds can be used for up to three of the following categories: water system mapping and modeling, water system analysis, sewer system mapping and modeling, sewer system analysis, asset management-related activities, and regionalization studies. Grantees are eligible for up to $500,000.[358] Between 2022 and 2024, 31 wastewater projects were funded for a little over $5.5 million; there were no awarded projects in 2023.[359]

ECD's Site Development Grant is state funded and can be used to improve Select Tennessee certified sites and prepare other sites to achieve certification. The Select Tennessee Certified Sites Program markets the sites to a targeted group of site selection consultants and business leaders. To be eligible for a grant, the application must be from a government entity with a site that is publicly owned, at least 20 acres, and has undergone a site visit for the Select Tennessee suite of programs. Scoring is based on public benefit, performance measures,

[353] Interview with Kent Archer, director of community infrastructure, Tennessee Economic and Community Development, October 25, 2023; interview with Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, December 20, 2023; and Tennessee Department of Economic and Community Development "Appalachian Regional Commission—Application."
[354] Commission staff analysis of data received in emails from Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, March 20, 2024, March 21, 2024, and March 22, 2024.
[355] Interview with Kent Archer, director of community infrastructure, Tennessee Economic and Community Development, October 25, 2023.
[356] Interview with Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, December 20, 2023; and email from Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, March 21, 2024.
[357] Tennessee Economic and Community Development "Infrastructure Planning Grant."
[358] Interview with Kent Archer, director of community infrastructure, Tennessee Economic and Community Development, October 25, 2023; and interview with Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, December 20, 2023.
[359] Commission staff analysis of data received in emails from Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, March 20, 2024, March 21, 2024, and March 22, 2024.

and project timeline, but priority is given to projects that can be completed quickly.[360] Between 2022 and 2024, three wastewater projects were funded for a little over $3.5 million.[361]

Tennessee Department of Environment and Conservation (TDEC)

Before TDEC applies for capitalization grants—money received from the EPA—projects are placed on a priority ranking list, and an annual intended use plan is created. They are then ranked based on criteria and procedures outlined in the Clean Water State Revolving Fund's (CWSRF) Priority Ranking System Rules. This ranking system forms the basis for eligibility determinations and the allocation of CWSRF loans from the State Revolving Fund Loan Program.[362] Projects can be moved up on the priority list depending on matter of importance deemed by TDEC—for example, significant non-compliance issues, economic stability of the community, the effect the project may have to water quality, and level of service to the customers—only if they are in compliance with the Comptroller of the Treasury.[363]

The CWSRF, commonly known as the State Revolving Fund Program (SRF), has been funded through the EPA by congressional allocation every year since 1987. States are required to contribute an additional 20% to match the federal grants. SRF loans offer discounted rates as opposed to market rate loans; a reduced interest rate or additional subsidization or principal forgiveness can be given to disadvantaged communities based on their ability to pay index (ATPI) rating, which is required by the federal government. There is currently approximately $26 million in funds available for wastewater projects—a decrease in prospective funding because of earmarked funds proposed by Congress. In 2009, Congress authorized these state funds to provide further financial assistance through additional methods such as grants and principal forgiveness.[364]

The State Water Infrastructure Grants (SWIG) funds are administered and allocated funds from the 2021 American Rescue Plan (ARP) Act by TDEC for water, wastewater, and stormwater infrastructure. ARP funds must be obligated by 2024 and spent by 2026. Eligible communities include counties and cities that own or operate a wastewater system, and they must submit their audited financials to the Comptroller of the Treasury. Online training is available to help complete the application process.[365] Approximately $467 million in noncompetitive grants and $44 million in competitive grants has been available for wastewater projects,[366] totaling 437 wastewater projects executed through ARP grants. The SWIG program also offers Asset Management Plan Grants—financed using funds from SRF—that can be used by systems to help them complete their asset management plans.[367]

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[360] Interview with Kent Archer, director of community infrastructure, Tennessee Economic and Community Development, October 25, 2023; and interview with Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, December 20, 2023.
[361] Commission staff analysis of data received in emails from Brooxie Carlton, assistant commissioner of community and rural development, Tennessee Economic and Community Development, March 20, 2024, March 21, 2024, and March 22, 2024.
[362] Rules and Regulations of the State of Tennessee Chapter 0400-46-01.
[363] Interview with Vena Jones, manager state revolving fund and water infrastructure grants, Tennessee Department of Environment and Conservation, September 6, 2023.
[364] Ibid.
[365] Interview with Vena Jones, manager state revolving fund and water infrastructure grants, Tennessee Department of Environment and Conservation, September 6, 2023.
[366] Commission staff analysis of data received in an email from Vena Jones, manager state revolving fund and water infrastructure grants, Tennessee Department of Environment and Conservation, March 11, 2024.
[367] Interview with Vena Jones, manager state revolving fund and water infrastructure grants, Tennessee Department of Environment and Conservation, September 6, 2023.

Tennessee Comptroller of the Treasury

The Tennessee Board of Utility Regulation (TBOUR) administers a utility revitalization fund to provide money to systems that they order to merge. Systems that voluntarily merge may apply to the TBOUR for grants from the fund. TBOUR has the discretion to grant money if they find the merger is in the best interest of at least one system, does not harm another system, and the grant is necessary to achieve the merger.[368] As of May 2024, only one grant has been awarded for a total of $500,000 to the Plateau Utility District for a consolidation with the City of Wartburg's system to pay off some of Wartburg's debt on its sewer system.[369]

Private Funding Sources

There are private entities and nonprofit organizations that offer funding opportunities for wastewater systems in Tennessee. This is not an exhaustive list of opportunities. Rather, it is an example of what is available to communities from sources other than the state and federal government. There may be funding available from sources, such as banks, other than the ones mentioned below.

Communities Unlimited provides loans up to $750,000 for wastewater projects to communities of 10,000 or less but can also offer loans to larger communities. Most of the systems that are offered loans are recommended by the Communities Unlimited technical staff or USDA. To receive a loan, systems must first prove that repayment is possible.[370]

CoBank is a bank that provides loans, leases, and other financial services to agribusiness and rural infrastructure customers nationwide. It offers bonds, short-term revolving credit, and loans with a fixed rate. CoBank also leases equipment to systems for their projects.[371]

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[368] Interview with Ross Colona, assistant director, Jean Suh, contract audit review manager, and Lisa Bellar, senior contract audit review specialist, Tennessee Comptroller of the Treasury, August 28, 2023.
[369] Email from Ross Colona, assistant director, Tennessee Comptroller of the Treasury, March 11, 2024.
[370] Interview with Annie Chiodo, Tennessee environmental state coordinator, and Bryn Bagwell, director of lending, Communities Unlimited, November 6, 2023.
[371] Interview with Michael Griffiths, vice president, CoBank, December 14, 2023.

Appendix D: Attributes of Effectively Managed Systems

Attribute	Characteristics of Attribute from *Rural and Small Systems Guidebook to Sustainable Utility Management*	Characteristics of Attribute from *Effective Utility Management A Primer for Water and Wastewater Utilities*
Product Quality	The system is in compliance with permit requirements and other regulatory or reliability requirements. It meets its community's expectations for the potable water or treated effluent and process residuals that it produces. The system reliably meets customer, public health, and ecological needs.	• Meets or exceeds regulatory and reliability requirements. • Operates consistent with customer, public health, economic, and ecological needs.
Customer Sustainability	The system is active in its community and is aware of the impacts that its decisions have on current and long-term future community health and welfare. It seeks to support overall watershed, source water protection, and community economic goals, where feasible. It is aware of, and participates in, local community and economic development plans.	• Ensures water availability through long-term resource supply and demand analysis, conservation, fit for purpose water reuse, integrated water resource management, watershed management and protection, and public education initiatives. • Manages operations to provide for long-term aquifer and surface water sustainability and replenishment. • Understands and plans for future water resource variability (e.g., changing weather patterns, including extreme events, such as drought and flooding).
Employee and Leadership Development	The system recruits and retains a workforce that is competent, motivated, and safe-working. Opportunities exist for employee skill development and career enhancement, and training programs are in place, or are available, to retain and improve their technical and other knowledge. Job descriptions and performance expectations are clearly established (in writing), and a code of conduct is in place and accepted by all employees.	• Recruits, develops, and retains a competent, safety-focused workforce. • Is a collaborative organization dedicated to continual learning, improvement, and adaptation. • Implements procedures for institutional knowledge retention, workplace safety, and continual learning (e.g., standard operating procedures). • Invests in/provides opportunities for professional and leadership development. • Supports an integrated and well-coordinated senior leadership team.

Attribute	Characteristics of Attribute from *Rural and Small Systems Guidebook to Sustainable Utility Management*	Characteristics of Attribute from *Effective Utility Management A Primer for Water and Wastewater Utilities*
Financial Viability	The system establishes and maintains an effective balance between long-term debt, asset values, operations and maintenance expenditures, and operating revenues. Rates are adequate to pay its bills, put some funds away for both future capital expenditures and unanticipated issues, and maintain, repair, and replace its equipment and infrastructure as needed. The system discusses rate requirements with its customers, decision making authorities, and other key stakeholders.	• Understands and plans for full life-cycle cost of utility. • Effectively balances long-term debt, asset values, operations and maintenance expenditures, and operating revenues. • Sets predictable and adequate rates to support utility current needs and plans to invest in future needs, taking into account affordability and the needs of disadvantaged households when setting rates. • Understands opportunities for diversifying revenue and raising capital.
Operational Resiliency	The system ensures that its leadership and staff members work together to anticipate and avoid problems. It proactively identifies legal, financial, non-compliance, environmental, safety, security, and natural threats to the system. It has conducted a vulnerability assessment for safety, natural disasters, and other environmental threats, and has prepared an emergency response plan for these hazards.	• Works together with staff internally and coordinate with external partners to anticipate and avoid problems. • Proactively establishes tolerance levels and effectively manages risks (including legal, regulatory, financial, environmental, safety, security, cyber, knowledge-loss, talent, and natural disaster-related). • Plans for and actively manages to maintain business continuity.
Water Resource Adequacy/Water Resource Sustainability	The system ensures that water availability is consistent with current and future customer needs. It understands its role in water availability, and manages its operations to provide for long-term aquifer and surface water sustainability and replenishment. It has performed a long-term water supply and demand analysis, and is able to meet the water and sanitation needs of its customers now and for the reasonable future	• Ensures water availability through long-term resource supply and demand analysis, conservation, fit for purpose water reuse, integrated water resource management, watershed management and protection, and public education initiatives. • Manages operations to provide for long-term aquifer and surface water sustainability and replenishment. • Understands and plans for future water resource variability (e.g., changing weather patterns, including extreme events, such as drought and flooding).

Attribute	Characteristics of Attribute from *Rural and Small Systems Guidebook to Sustainable Utility Management*	Characteristics of Attribute from *Effective Utility Management A Primer for Water and Wastewater Utilities*
Operational Optimization	The system ensures that its leadership and staff members work together to anticipate and avoid problems. It proactively identifies legal, financial, non-compliance, environmental, safety, security, and natural threats to the system. It has conducted a vulnerability assessment for safety, natural disasters, and otherenvironmental threats, and has prepared an emergency response plan for these hazards.	• Conducts ongoing performance improvements informed by performance monitoring. • Minimizes resource use and loss from day-to-day operations. • Is aware of and adopts in a timely manner operational and technology improvements, including operational technology and information technology. • Manages and utilizes data from automated and smart systems.
Infrastructure Stability/Infrastructure Strategy and Performance	The system understands the condition and costs associated with its critical infrastructure assets. It has inventoried its system components, conditions, and costs, and has a plan in place to repair and replace these components. It maintains and enhances the condition of all assets over the long-term at the lowest possible life-cycle cost and acceptable level of risk.	• Understands the condition of and costs associated with critical infrastructure assets. • Maintains and enhances assets over the long-term at the lowest possible life-cycle cost and acceptable risk. • Coordinates repair efforts within the community to minimize disruptions. • Plans infrastructure investments consistent with community needs, anticipated growth, system reliability goals, and with a robust set of adaptation strategies.
Customer Sustainability	The system is active in its community and is aware of the impacts that its decisions have on current and long-term future community health and welfare. It seeks to support overall watershed, source water protection, and community economic goals, where feasible. It is aware of, and participates in, local community and economic development plans.	• Ensures water availability through long-term resource supply and demand analysis, conservation, fit for purpose water reuse, integrated water resource management, watershed management and protection, and public education initiatives. • Manages operations to provide for long-term aquifer and surface water sustainability and replenishment. • Understands and plans for future water resource variability (e.g., changing weather patterns, including extreme events, such as drought and flooding).

Attribute	Characteristics of Attribute from *Rural and Small Systems Guidebook to Sustainable Utility Management*	Characteristics of Attribute from *Effective Utility Management A Primer for Water and Wastewater Utilities*
Stakeholder Understanding and Support	The system actively seeks understanding and support from decision making bodies, community members, and regulatory bodies related to service levels, operating budgets, capital improvement programs, and risk management decisions. It takes appropriate steps with these stakeholders to build support for its performance goals, resources, and the value of the services that it provides. The system performs active outreach and education to understand concerns and promote the value of clean, safe water and the services the utility provides, consistent with available resources.	• Engenders understanding and support from oversight bodies, community and watershed interests, and regulatory bodies for service levels, rate structures, operating budgets, capital improvement programs, and risk management decisions. • Actively engages in partnerships and involves stakeholders in the decisions that will affect them. • Actively promotes an appreciation of the true value of water and water services, and water's role in the social, economic, public and environmental health of the community.

Source: US Department of Agriculture and US Environmental Protection Agency 2016; and US Environmental Protection Agency 2017.

Appendix E: Best Practices in Energy Efficiency for Wastewater Systems

The New York State Energy Research and Development Authority published a list of best practices in energy efficiency for wastewater systems in its *Wastewater Energy Management Best Practices Handbook* as did Wisconsin's Focus on Energy program of the Wisconsin Public Service Commission in its *Water and Wastewater Energy Best Practices Guide.* A summary of the best practices from these guides is below.

Energy Efficiency Practices - Organizational Management

Wastewater systems may want to consider

- appointing an energy manager with authority and a budget for improving energy efficiency;
- monitoring and recording facility data so it can be used as a tool in managing operations and energy usage of a wastewater system;
- reviewing their overall energy usage;
- including energy efficiency in capital-improvement and operations plans;
- including the projected payback period, based on energy savings, when calculating the financial effect of an energy efficiency project;
- utilizing lifecycle cost analysis when purchasing equipment rather than lowest upfront cost;
- ensuring that when designing and expanding a system that it has the flexibility to serve both current and future needs;
- administering an annual energy survey to help identify opportunities for improving energy efficiency; and
- making sure that employees understand the relationship between energy usage and facility operations.

Energy Efficiency Practices - Treatment Process

Wastewater systems may want to consider

- minimizing pumping and specific treatment processes during peak demand periods;
- administering an energy efficiency assessment of their pump stations since many would benefit from a variable speed drive or new or additional pump;
- using an energy monitoring system that can help staff develop an energy baseline that can be used to help staff set energy reduction goals and monitor results;
- using a supervisory control and data monitoring system (SCADA) that allows operators to remotely monitor equipment operation and adjust their operation;
- shifting backwash cycles to off-peak periods to reduce the energy peak demand;
- idling or turning off non-essential equipment during periods of peak power demand when feasible;
- maintain motors since it can increase motor efficiency and prolong service life;
- minimizing the operation of idling or lightly loaded motors by replacing inefficient motors with energy-efficient motors;

- replacing oversized motors with correctly sized, high-efficiency, or premium-efficiency motors;
- replacing existing motors with new premium-efficiency motors;
- matching motor-output speeds to the specific load and avoid running at constant full power, thereby reducing energy usage;
- optimizing their grit removal system since different systems consume different levels of energy;
- automating monitoring and control of dissolved oxygen, pressure, and flow rate;
- optimizing pump system efficiency by selecting the pump or combination of pumps that provide peak efficiency;
- comparing facility's design flow rate with current flow rate and see whether pumping rates can be reduced;
- taking actions to reduce total head losses;
- modifying the operation of a pumping system to eliminate the use of discharge valve throttling to control the flow rate from pumps;
- looking at ultraviolet (UV) disinfection system design or redesign options to reduce the number of lights, change bulb orientation and type, and adjust the turndown ratio;
- installing dose pacing if using UV disinfection where UV doses can be varied based on the flow rate;
- incorporating energy efficiency in membrane-treatment systems by selecting the best flux-rate membrane for their application;
- identifying, planning, and designing the most energy-efficient and effective ways to operate the system;
- when planning improvements, staging construction using smaller-sized modular equipment so new units can be brought on as needed to allow a system to better manage energy costs;
- managing the system so it operates energy efficiently during seasonal and tourist peaks perhaps idling equipment during off-season;
- using smaller basins initially and adding basins sequentially as loads increase until design capacity is reached;
- covering basins to reduce the volume of fresh air required for the maintenance of good indoor air quality and dehumidification requirements;
- reducing the consumption of potable water through the recycling and utilization of the final effluent in process applications or washdown of tanks may reduce the volume of potable water treated and/or pumped fresh water consumption through final effluent recycling;
- assessing the aeration system to determine whether it is operating as efficiently as possible and consider the costs of improvements like fine bubble aeration, dissolved oxygen control, and variable airflow-rate blowers;
- assessing the feasibility of fine-bubble aeration, which can result in more energy efficient treatment of wastewater;
- requiring that the aeration system and the aerobic-digester blowers have variable air-supply rate capabilities;

- using automatic dissolved oxygen (DO) control technology to maintain the DO level in the aeration and post-aeration at preset control point;
- installing a cascade aeration system since it provides re-aeration by increasing the water turbulence as it flows over the steps without a need for electricity;
- assessing the operation of its aerobic digester to determine whether better control could be achieved through a separate smaller blower or using flexible membrane digesters with surface diffusers with adjustable airflow rates;
- researching, assessing, and using the most energy-efficient blower technology that they can;
- assessing the aeration system to determine whether the blowers are supplying air flow to aeration tanks or to aeration tanks and other equipment including aerobic digesters and assessing whether each piece of equipment that needs airflow from the blowers could be fit with an individual blower for its specific requirements;
- optimizing the air-to-solids ratio in a dissolved air flotation (DAF) system by adjusting the supply air or by feeding the highest possible solids content;
- evaluating replacing a centrifuge with a screw press;
- evaluating replacing a centrifuge with a gravity belt thickener;
- assessing the energy and production effects of various biosolids processing options when planning new facilities or expansion of existing ones;
- evaluating the cost of mixing options in aerobic digesters since aeration may not always be the most energy-efficient option for mixing in a digester;
- evaluating the costs of different mixing options in anaerobic digesters;
- evaluating the use of mechanical mixing rather than using the existing aeration-system blower to mix the anoxic zones when a system incorporates anoxic zones;
- using biotowers or trickling filters that could provide energy-efficient treatment of waste;
- optimizing anaerobic digester performance through methods like biosolids pretreatment or changing the temperature from mesophilic (85-105°F) to thermophilic (125-140°F) increases the rate of destruction of the solids in the biosolids;
- assessing the use of biogas that can be used as a source of energy to fuel the facility's boilers, fuel an engine, drive a piece of an equipment, or generate electricity; and
- using a solar photovoltaic generation system that converts sunlight into electricity.

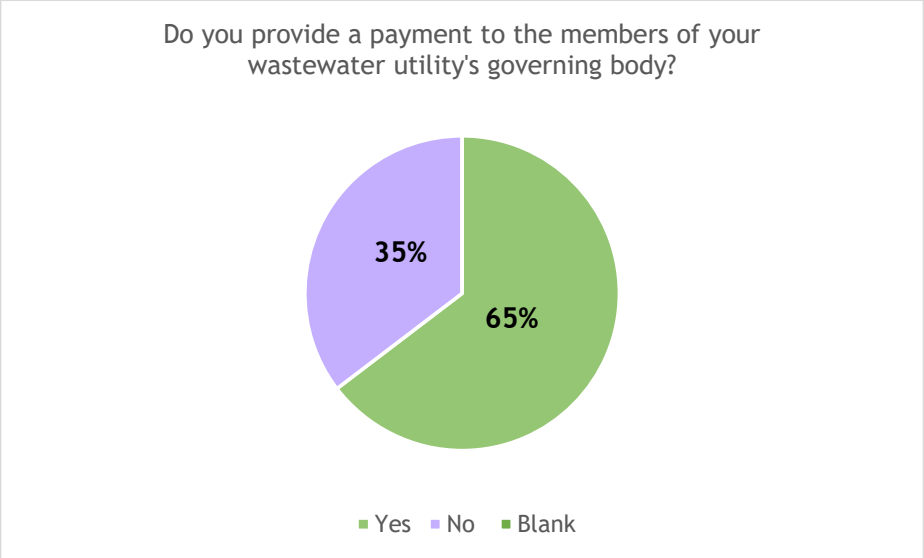
Energy Efficient Practices – Buildings

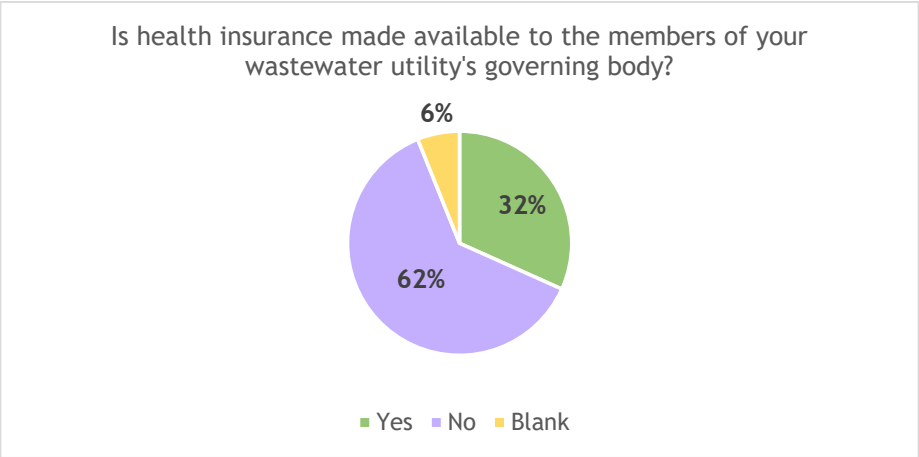
Wastewater systems may want to consider

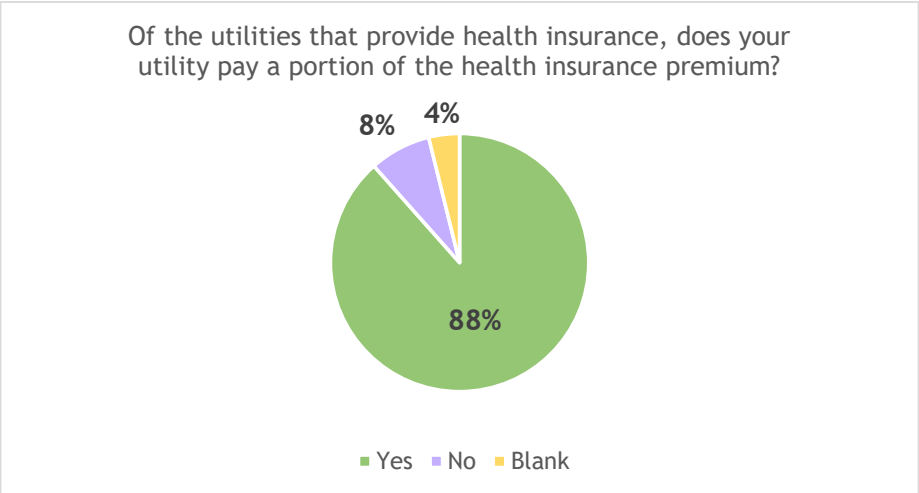
- shutting off lights manually or using occupancy sensors to save money;
- cleaning lighting since this can prevent the accumulation of dirt on the lights that can decrease light output;
- checking outside air ventilation devices and ventilation supply fans regularly and performing routine maintenance as needed to ensure system efficiency and optimal performance;
- replacing ventilation air filters since this will help improve the system's energy efficiency;

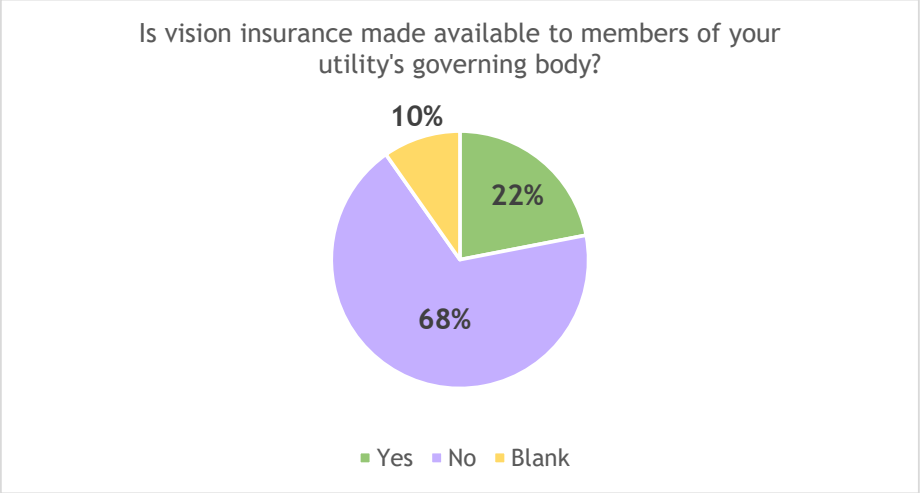
- installing variable frequency drive (VFD) control on rotary-screw air compressors in place of inlet modulation with unloading;
- installing high-efficiency lamps and advanced controls that can increase energy efficiency of the entire lighting system;
- evaluating existing heating, ventilation and air conditioning (HVAC) systems regularly to see whether they should be re-commissioned or replaced with more energy-efficient systems; and
- looking at the standards set forth by Leadership in Energy and Environmental Design (LEED) in the design of new construction or major renovation projects.

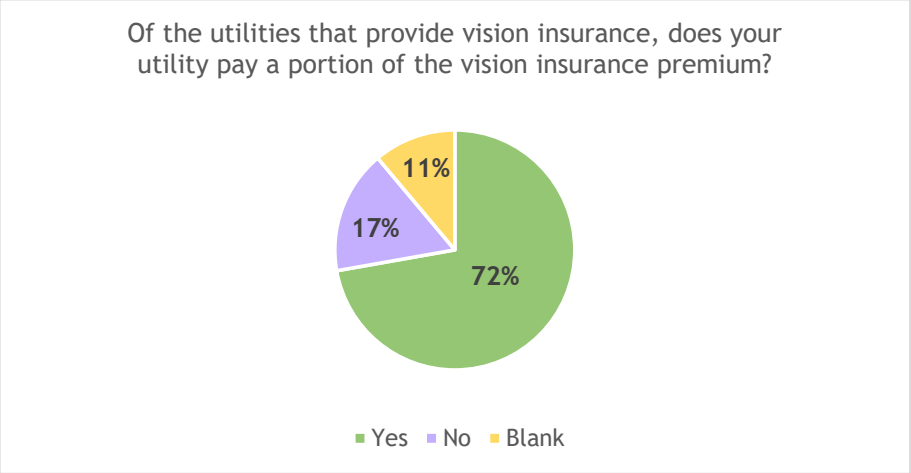
Appendix F: Commission Staff Survey Results

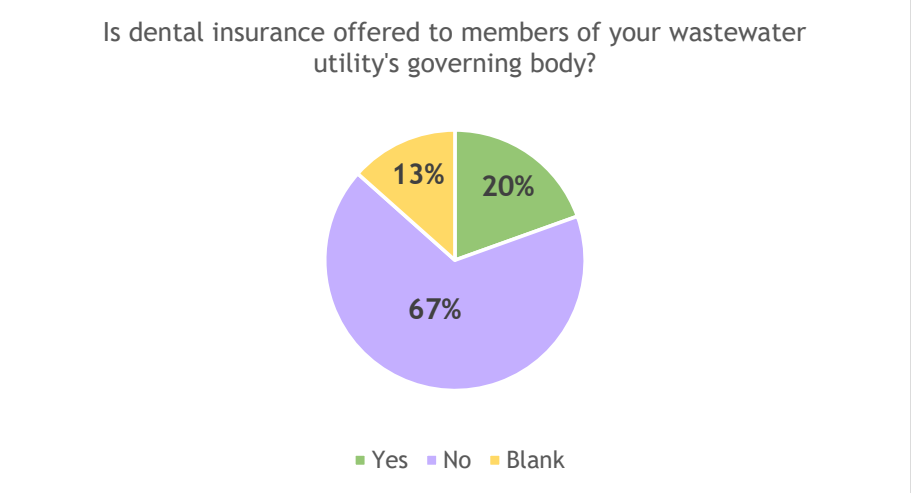


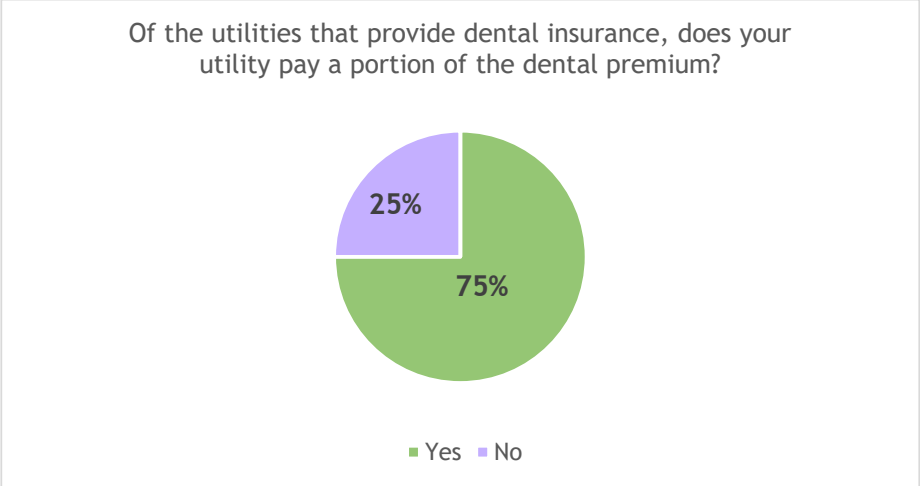


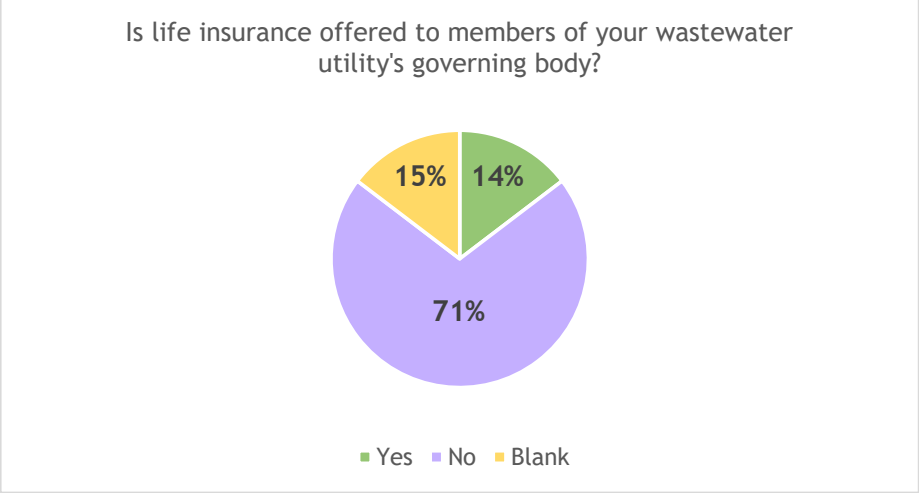


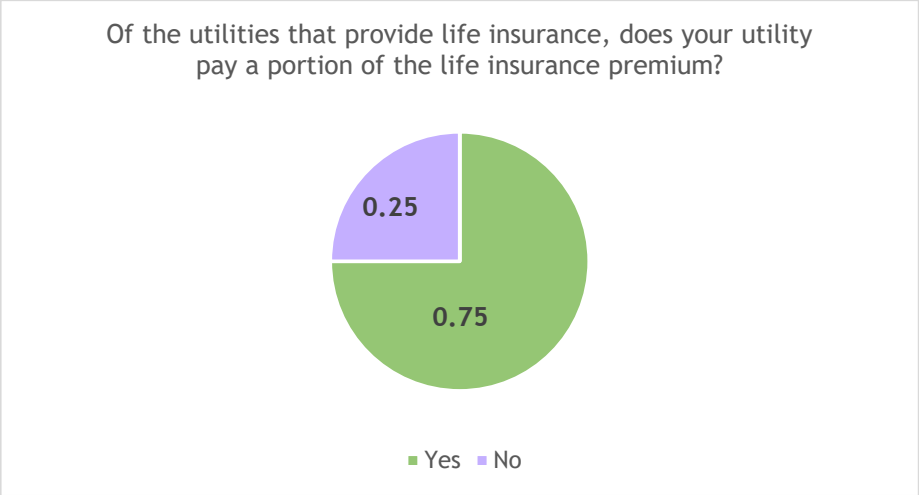

Is vision insurance made available to members of your utility's governing body?
10%
22%
68%
Yes
No
Blank

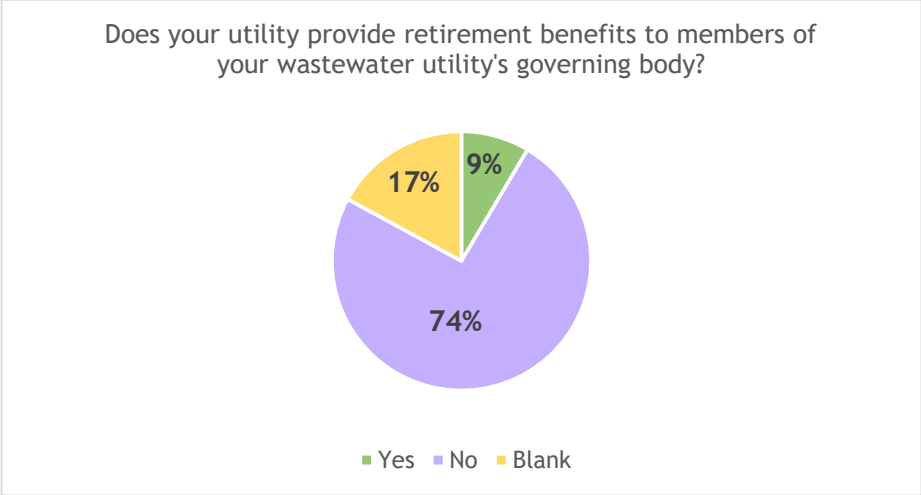

Of the utilities that provide vision insurance, does your utility pay a portion of the vision insurance premium?
11%
17%
72%
Yes
No
Blank

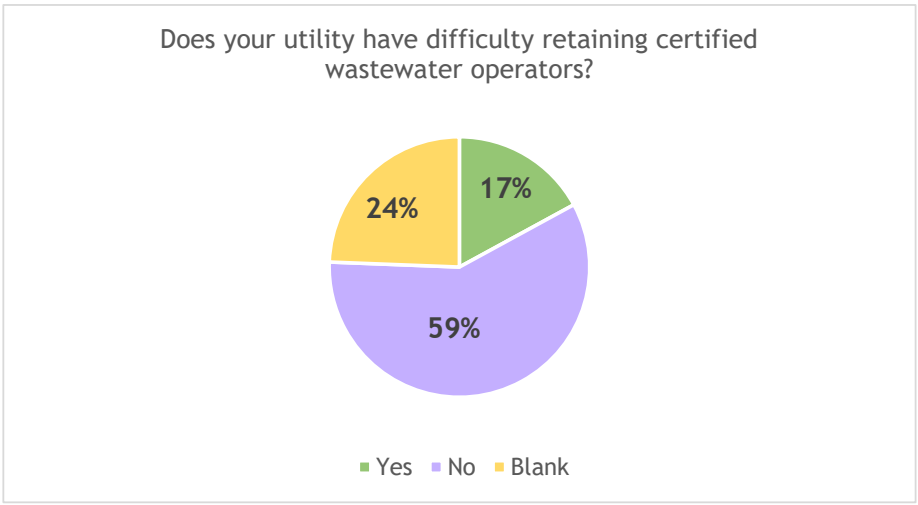

Is dental insurance offered to members of your wastewater utility's governing body?
13%
20%
67%
Yes
No
Blank

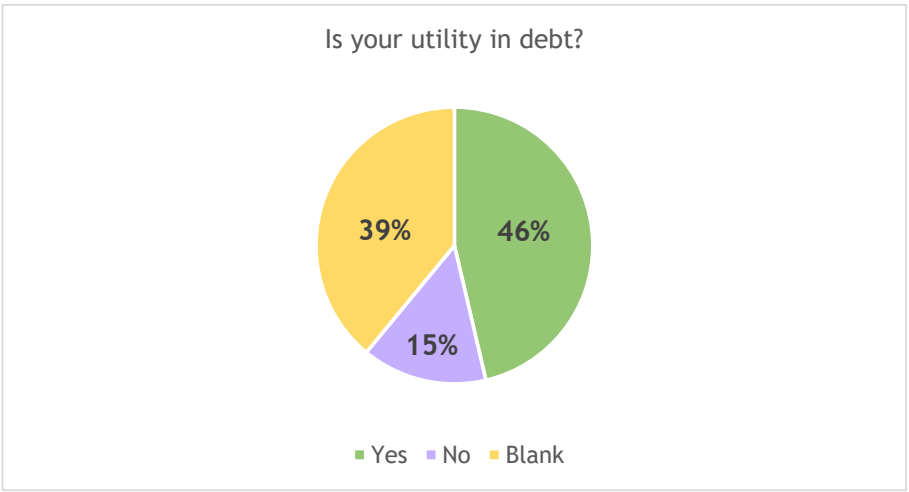

Of the utilities that provide dental insurance, does your utility pay a portion of the dental premium?
25%
75%
Yes
No

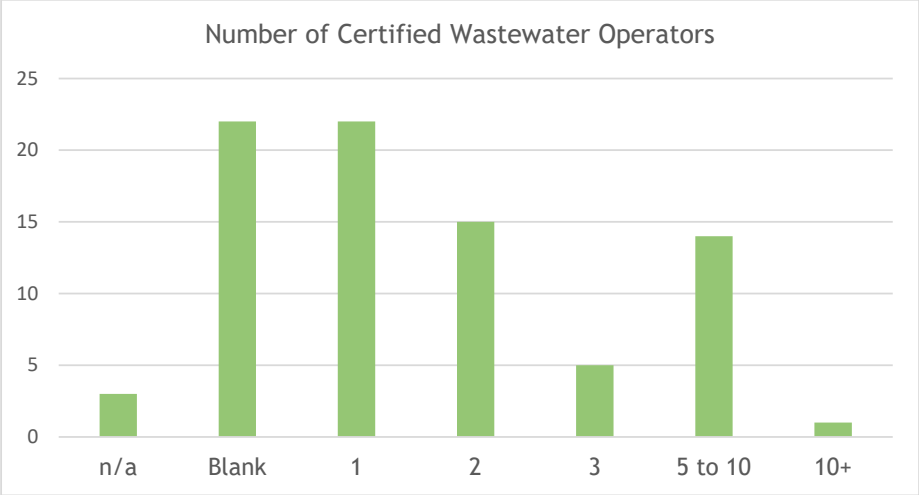

Is life insurance offered to members of your wastewater utility's governing body?
15%
14%
71%
Yes
No
Blank

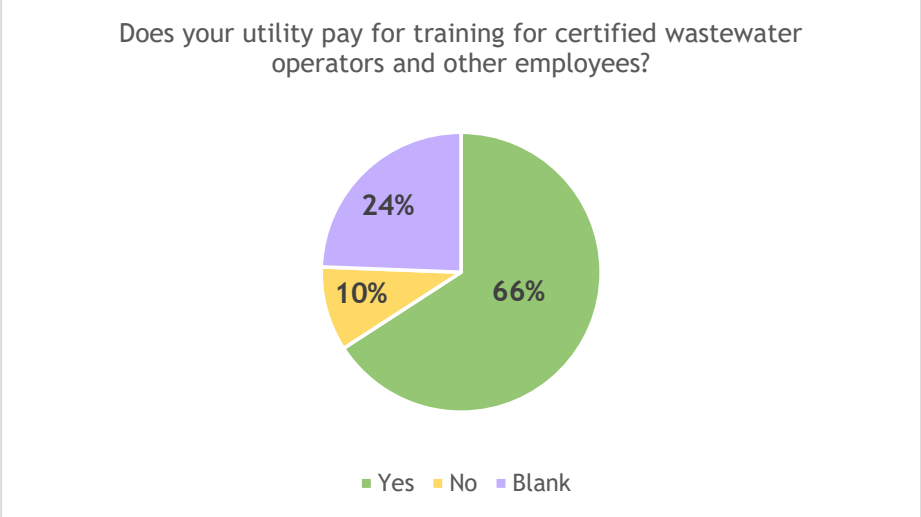

Of the utilities that provide life insurance, does your utility pay a portion of the life insurance premium?
0.25
0.75
Yes
No

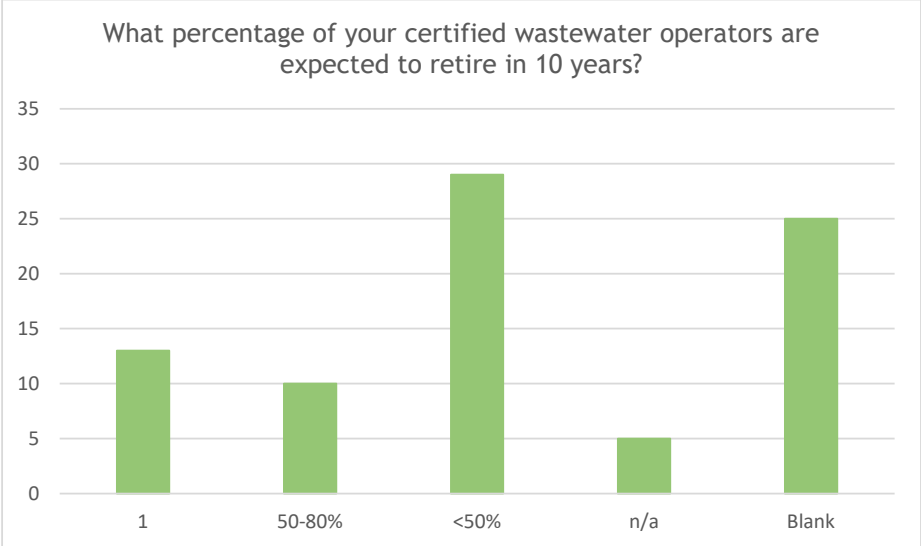

Does your utility provide retirement benefits to members of your wastewater utility's governing body?
9%
74%
17%
Yes
No
Blank


Does your utility have difficulty retaining certified wastewater operators?
17%
59%
24%
Yes
No
Blank


Is your utility in debt?
46%
15%
39%
Yes
No
Blank


Number of Certified Wastewater Operators
25
20
15
10
5
0
n/a
Blank
1
2
3
5 to 10
10+


Does your utility pay for training for certified wastewater operators and other employees?
24%
10%
66%
Yes
No
Blank


What percentage of your certified wastewater operators are expected to retire in 10 years?
35
30
25
20
15
10
5
0
1
50-80%
<50%
n/a
Blank