

The Non-Operator's Guide to Wastewater Systems



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Introduction

Access to safe, reliable water depends on more than just the quality of a community's drinking water supply. It also depends on what happens after water is used. Every time residents flush the toilet, wash dishes, run a business, or operate a manufacturing process, they create wastewater. Managing that wastewater effectively is essential to protecting public health, preserving natural resources, and sustaining community growth.



Wastewater is simply used water that must be cleaned before it is returned to the environment. In many cases, the water we withdraw from rivers or aquifers has already been used upstream by another community and treated before being discharged. Water is reused repeatedly within the hydrologic cycle. Without proper treatment, however, wastewater can carry pathogens, nutrients, and other pollutants back into drinking water sources.

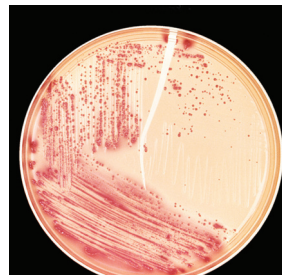
Contamination from human waste remains a global public health concern. Sanitation research frequently cited by organizations such as UNICEF notes that a single gram of feces can contain millions of viruses and bacteria, along with parasite eggs capable of transmitting disease [UNICEF (2000): *Sanitation for All: Promoting Dignity and Human Rights* (UNICEF, New York)].

Globally, unsafe water and sanitation continue to contribute to preventable illness and child mortality. Modern wastewater systems exist to prevent those outcomes by removing contaminants before water is reused or discharged. In the United States, most communities benefit from established wastewater infrastructure, yet reliable service does not happen automatically. Wastewater systems require sound governance, financial planning, regulatory compliance, asset

management, and a skilled workforce. For community leaders and policymakers, understanding the fundamentals of wastewater operations is critical - not to replace certified operators, but to support them through informed oversight and strategic decision-making.

This guide introduces wastewater operations in practical, non-technical terms. It explains how systems are organized, why treatment is required, how regulatory frameworks apply, and what leadership decisions most directly influence system sustainability. Its purpose is to equip elected officials, board members, managers, and community stakeholders with enough foundational knowledge to ask informed questions, evaluate risk, and plan responsibly for the future.

Why Wastewater Management Matters



Escherichia coli

Wastewater treatment serves three core public purposes: protecting human health, preserving environmental quality, and maintaining community standards.

First, untreated wastewater can contain bacteria, viruses, and parasites capable of causing serious disease. Effective treatment reduces these biological risks before water re-enters rivers, lakes, groundwater, or coastal areas.

Second, wastewater contains nutrients such as nitrogen and phosphorus. If discharged untreated, these nutrients can deplete oxygen in receiving waters, damage aquatic ecosystems, and contribute to harmful algal blooms. Proper management protects fisheries, recreation, and downstream drinking water supplies.

Third, wastewater affects quality of life. Odors,

visible pollution, and failing infrastructure undermine economic development and public confidence. Well-managed systems protect property values and community reputation.

Federal oversight of wastewater discharge is primarily governed by the Clean Water Act, which established national standards for water quality and created permitting requirements for facilities that discharge treated effluent to surface waters. Most centralized treatment plants operate under a National Pollutant Discharge Elimination System (NPDES) permit, typically administered by state environmental agencies. These permits define monitoring, reporting, and performance requirements. Noncompliance can result in enforcement actions, financial penalties, and reputational harm.

For leaders, regulatory compliance is not merely a technical matter; it is a governance responsibility. Ensuring adequate funding, staffing, and oversight directly influences whether a system meets its legal obligations.

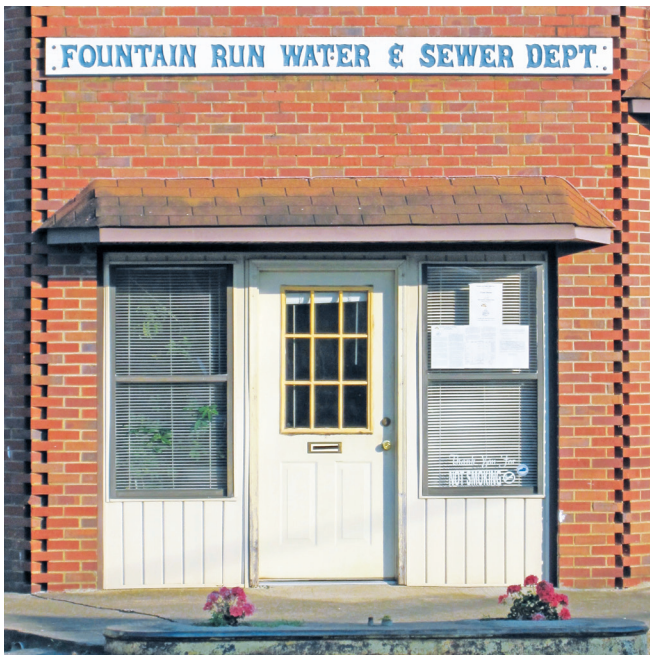
How Community Wastewater Systems Are Organized

While treatment technologies vary, community wastewater systems generally fall into two broad categories: centralized and decentralized.

Centralized systems are common in cities and towns where homes and businesses are connected to a network of underground sewer pipes. Wastewater flows through this collection system to a central treatment facility. There, solids are removed, organic material is reduced, and contaminants are treated before the cleaned water is discharged under permit conditions.

Decentralized systems are more common in rural or low-density areas where extending sewer infrastructure is not economically feasible. These systems treat wastewater near its source. The most familiar example is a septic system, which separates solids in a tank and disperses partially treated effluent into a soil absorption field for further treatment by natural processes. Some communities use small clustered systems that combine elements of both approaches.

The distinction between centralized and decentralized systems has practical implications for governance. Centralized systems typically require formal utility management, capital improvement planning, asset inventories, and certified operators. Decentralized systems often involve local health departments, homeowner responsibilities, and periodic inspection requirements. In some



cases, clustered systems may still require discharge permits and management similar to centralized facilities.

Regardless of configuration, every wastewater system must address the same fundamental objectives: safe collection, effective treatment, responsible discharge or reuse, and ongoing maintenance.

Leadership Responsibilities and Long-Term Resiliency

Wastewater infrastructure across the United States faces mounting pressures. Many systems were built decades ago and now require rehabilitation or replacement. Workforce challenges are emerging as experienced operators retire. Funding is often constrained, particularly in small or rural communities. Extreme weather events, population growth, and economic development can further strain existing facilities.

Resiliency encompasses financial sustainability, regulatory compliance, infrastructure reliability, and workforce continuity. Leaders influence resiliency through rate-setting decisions, capital investment planning, support for operator training, and transparent communication with the public.

Informed leadership does not require mastering treatment chemistry or engineering design. It does require understanding risk, recognizing regulatory obligations, planning for asset replacement, and ensuring that operational expertise is supported rather than sidelined.

By strengthening governance practices and maintaining a clear understanding of system fundamentals (such as those described in this guide), community leaders help safeguard public health, protect natural resources, and ensure that wastewater systems remain reliable for generations to come.

The Essential Role of the Wastewater Operator

Wastewater operators are the frontline guardians of public health and environmental protection. Every day, they are responsible for monitoring treatment performance, collecting and analyzing samples, adjusting chemical and biological processes, maintaining mechanical equipment, responding to alarms and emergencies, and ensuring compliance with discharge permits and reporting requirements. In many systems, the operator must be both scientist and mechanic—understanding treatment biology and chemistry while also maintaining pumps, controls, and infrastructure.

The position carries significant

legal and operational responsibility. When treatment processes fail, the risks include regulatory violations, environmental damage, and potential public health impacts. Skilled operators prevent these outcomes through constant oversight, preventive maintenance, and sound operational judgment.

For board members and elected officials, working effectively with your operator is a best management practice. This includes establishing clear communication channels, respecting professional expertise, involving operators in capital planning decisions, and ensuring they have the tools and staffing necessary to succeed. Operators should be

encouraged to provide candid assessments of system risks and infrastructure needs.

Although operator certification requirements are established at the state level rather than federally mandated nationwide, continuing education is essential in all jurisdictions. Treatment technologies evolve, regulations change, and new contaminants emerge. Funding operator training and professional development is a direct investment in regulatory compliance, system reliability, and the long-term protection of your community's health and water resources.

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How Wastewater is Regulated – and What Is Being Regulated

Modern wastewater regulation in the United States is rooted in the 1972 amendments to the Federal Water Pollution Control Act, now known as the Clean Water Act (CWA). Prior to that time, oversight was largely handled at the state level. The CWA significantly expanded the federal role and established the framework that still governs wastewater treatment today.

The 1972 amendments required secondary treatment—biological treatment following removal of settleable solids—for most municipal facilities. They also created the National Pollutant Discharge Elimination System (NPDES), a permitting program that requires any facility discharging wastewater from a

point source (such as a pipe or outfall) to surface waters to meet defined contaminant limits. States and Tribes may administer their own NPDES programs if they meet federal requirements; those jurisdictions are described as having “primacy.”

The CWA also established ambient water quality standards for rivers, lakes, and streams. Over time, additional regulations have strengthened this framework. The Sewage Sludge Regulations (40 CFR Part 503), adopted in 1993, set standards for the safe use and disposal of wastewater solids, including limits for heavy metals and pathogens. The Total Maximum Daily Load (TMDL) program, implemented in 2000, evaluates water quality

HOW WASTEWATER IS REGULATED –AND WHAT IS BEING REGULATED



Wastewater Treatment Plant (WWTP) Lab

on a watershed basis and sets the maximum amount of a pollutant a water body can receive while still meeting standards. TMDLs consider both point sources, such as treatment plants, and non-point sources, such as agricultural or stormwater runoff. Where water quality standards are exceeded, wastewater facilities may face tighter permit limits and may be required to add advanced treatment.

Understanding regulation requires understanding what, specifically, is being measured and controlled in wastewater.

One major measured category is **solids**, which includes materials that float, settle, remain suspended, or are dissolved. Treatment plants commonly measure total suspended solids (TSS)—particles captured on a fine filter—and total dissolved solids (TDS), which pass through the filter. Typical residential wastewater contains 150 to 300 milligrams per liter (mg/L) of TSS; after secondary treatment, concentrations are generally reduced to below 30 mg/L.

Biodegradable organic material is another category of what is being regulated. Organic matter serves as food for microorganisms, which consume it during treatment. If untreated wastewater was discharged directly to a stream, the decomposition process would consume dissolved oxygen in the receiving water, potentially killing fish and other aquatic life. The standard measure of organic strength is **biochemical oxygen demand (BOD)**, which quantifies the amount of oxygen consumed as microbes break down organic material. Residential wastewater typically has a BOD of 100 to 300 mg/L; after secondary treatment, BOD is generally reduced to below 30 mg/L.

Pathogens are also a primary concern. Raw wastewater contains bacteria, viruses, protozoans, and other microorganisms, some of which can cause disease. Because testing for every possible pathogen is impractical, permits rely on “indicator” organisms—most commonly *E. coli* or other coliform bacteria—to signal potential fecal contamination. NPDES permits typically include limits for these indicators to protect public health.

Finally, **nutrients** (particularly nitrogen and phosphorus) are closely regulated in many watersheds. While necessary for biological growth, excessive nutrient discharges can cause eutrophication, characterized by algal blooms and low oxygen conditions. Depending on the sensitivity of the receiving water body and applicable TMDL requirements, treatment plants may be required to meet specific effluent limits for total nitrogen (TN) and total phosphorus (TP).

For community leaders, the connection between regulation and treatment is direct. Permits regulate concentrations of solids, organic material, pathogens, and nutrients in treated effluent and residuals. Maintaining compliance requires technical expertise, consistent monitoring, and disciplined asset management. For many small systems, proactively upgrading technology ahead of new regulatory requirements is financially unrealistic. Instead, responsible planning often means budgeting for maintenance and replacement at the end of an asset’s useful life, closely tracking regulatory developments, and positioning the utility to pursue funding assistance when new requirements emerge.

Typical concentrations for untreated and treated residential wastewater.

WASTEWATER PARAMETER	UNTREATED WASTEWATER*	AFTER SECONDARY TREATMENT	AFTER ADVANCED TREATMENT
Biochemical oxygen demand	100 – 300 mg/L	<30 mg/L	<10 mg/L
Total suspended solids	150 – 300 mg/L	<30 mg/L	<10 mg/L
Total nitrogen	20 – 80 mg/L	10 – 15 mg/L	2 – 8 mg/L
Total phosphorus	6 – 15 mg/L	4 – 9 mg/L	<1 mg/L

**The ranges presented are for residential wastewater. The characteristics of a wastewater stream may be much different if the system receives significant contributions from industrial, commercial, or institutional sources.*

Additional Contaminants of Concern

Wastewater can contain a wide range of contaminants beyond solids, organic matter, nutrients, and pathogens. Depending on the users connected to a collection system,

wastewater may include industrial chemicals such as heavy metals and solvents, as well as agricultural pesticides. Some synthetic organic chemicals resist biological breakdown during treatment. These are known as **refractory compounds** and can include some types of detergents and pesticides that pass through conventional treatment processes largely unchanged.

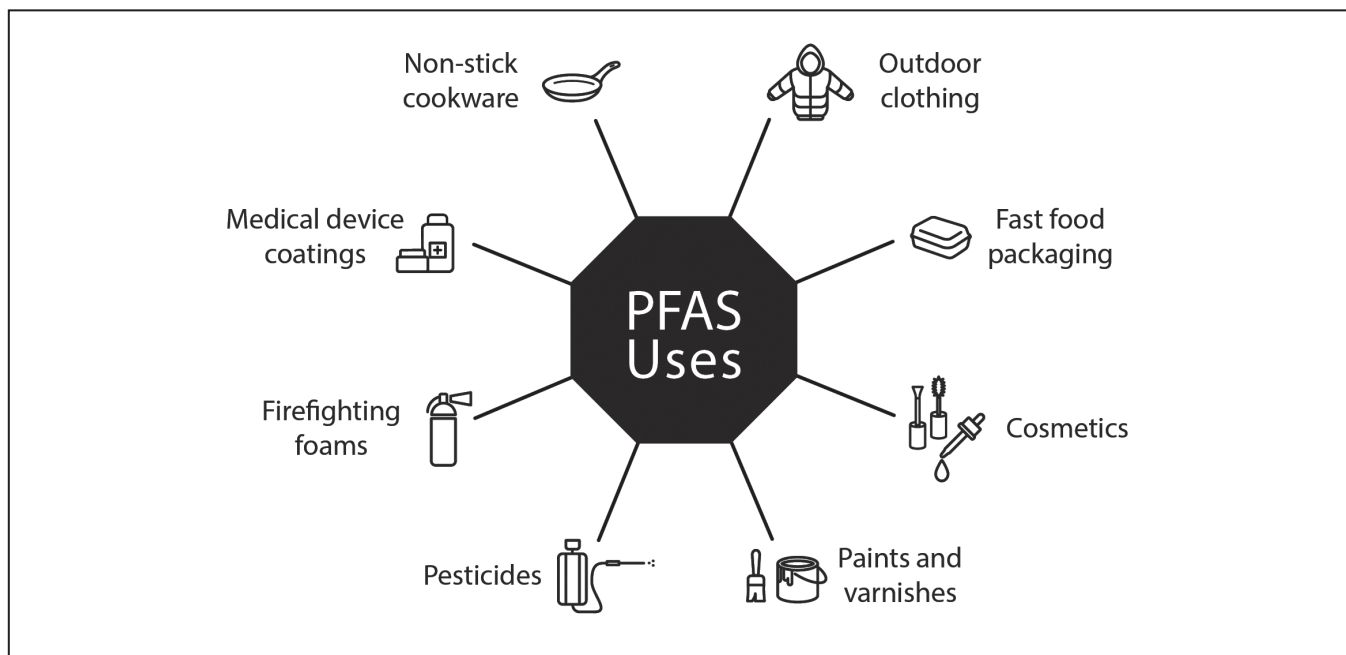
Pharmaceuticals and personal-care products have also drawn increasing attention. Although typically present at very low concentrations, some compounds from these products have been associated with endocrine disruption in humans and aquatic organisms. Wastewater treatment plants were not originally designed to remove these trace contaminants and, while concentrations are often reduced during treatment, complete removal is not always achieved.

In recent years, significant scientific and regulatory focus has centered on **per- and polyfluoroalkyl substances** (PFAS), including **perfluorooctanoic acid** (PFOA) and related “forever chemicals.” These compounds have been widely used in industrial processes, firefighting foams, nonstick coatings, and water-resistant consumer products. PFAS are highly persistent in the environment and resistant to

conventional biological treatment. As a result, they can pass through wastewater treatment plants and accumulate in surface waters or concentrate in wastewater solids (biosolids).

Growing research has linked certain PFAS compounds to potential health effects, prompting regulatory action at the federal and state levels. Recent drinking water standards established under the **Safe Drinking Water Act** (SDWA) set enforceable limits for several PFAS compounds in public water systems, and additional regulatory scrutiny is expected for wastewater discharges and biosolids management. While most wastewater facilities are not yet subject to specific numeric PFAS limits in their discharge permits, monitoring requirements are expanding, and future effluent or sludge regulations are possible.

For community leaders, the emergence of PFAS highlights a broader reality: wastewater systems are increasingly expected to manage contaminants they were never originally designed to treat. Addressing these challenges may require source control measures, industrial pretreatment programs, regional coordination, and, over time, significant capital investment. Staying informed about evolving science and regulation is essential to long-term planning and risk management.



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How is Wastewater Collected and Conveyed?

Before wastewater can be treated, it must first be collected and conveyed to a treatment or dispersal system. Collection infrastructure is one of the largest and least visible public investments a community makes. Because it is buried underground, it is often overlooked until a failure occurs. However, a community without an adequate collection system may find its opportunities for economic development are limited, regardless of the adequacy of its treatment plant.

From the Home to the Sewer

The wastewater treatment process begins inside homes and businesses. Wastewater from sinks, toilets, showers, and appliances flows through a household drainage system. These pipes rely on gravity to move wastewater away from the structure, while a vent system maintains proper air pressure and prevents sewer gases from entering the building.

Wastewater from individual fixtures drains into a central building pipe and exits through the building sewer (also called the service lateral). This pipe connects either to a community sewer network or to an on-site system such as a septic tank. Building sewers typically include capped cleanout ports—one near the building and one near the property line—to allow access in case of blockage. In most communities, property owners are responsible for the building sewer, while the utility maintains the public



sewer system. Proper maintenance at both levels is essential to prevent blockages, leaks, and backups.

Community Collection Systems

The network of underground pipes that carries wastewater to a treatment facility is known as the **collection system**. In this guide, we assume the system is designed as a **sanitary sewer**, intended to carry only wastewater. Older systems in some communities were built as **combined sewers**, carrying both wastewater and stormwater. During heavy rain, combined systems may overflow to nearby streams.

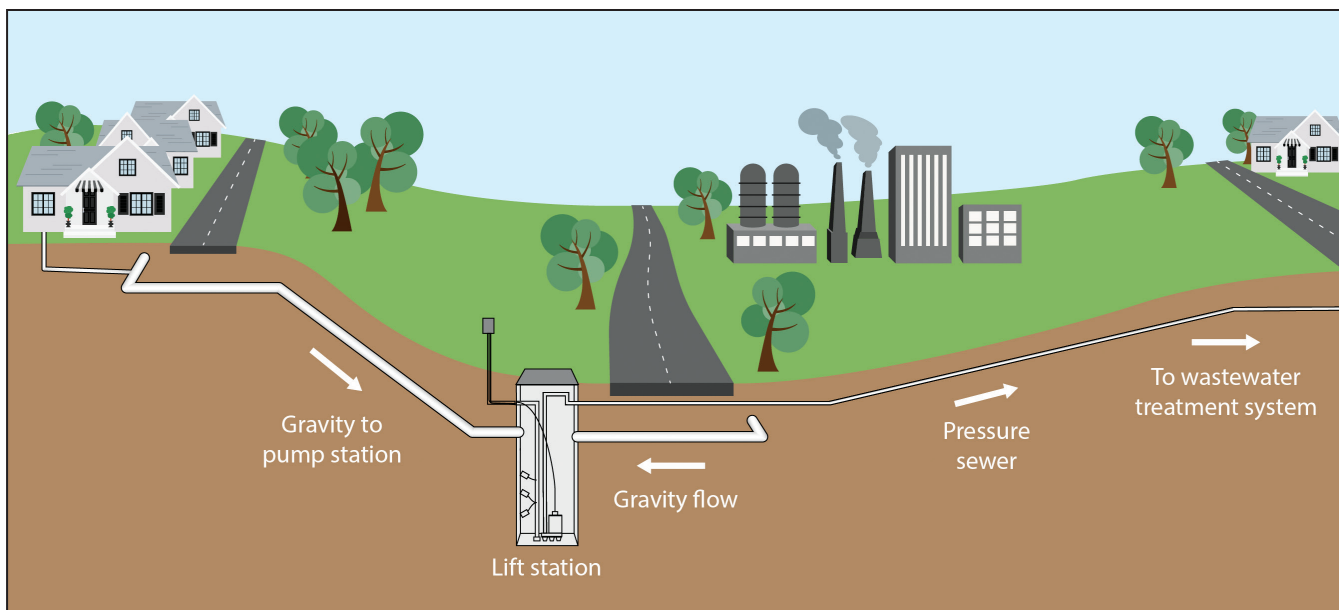
Even sanitary systems often receive unintended stormwater and groundwater through cracks, faulty joints, or illegal connections. This is known as **inflow and infiltration (I&I)**. Excess I&I can overload pipes and treatment facilities, leading to overflows or partially treated discharges.

Constructing a collection system frequently costs as much as (or more than) the treatment plant itself. Protecting that investment through proper operation, maintenance, and asset management is critical.

Conventional Gravity Collection Systems

Most traditional collection systems rely on gravity. Wastewater flows downhill through progressively larger pipes, much like branches merging into the trunk of a tree. An example flow process is listed below:

- Service laterals connect buildings to branch sewers.
- Branch (or lateral) sewers feed into main sewers.



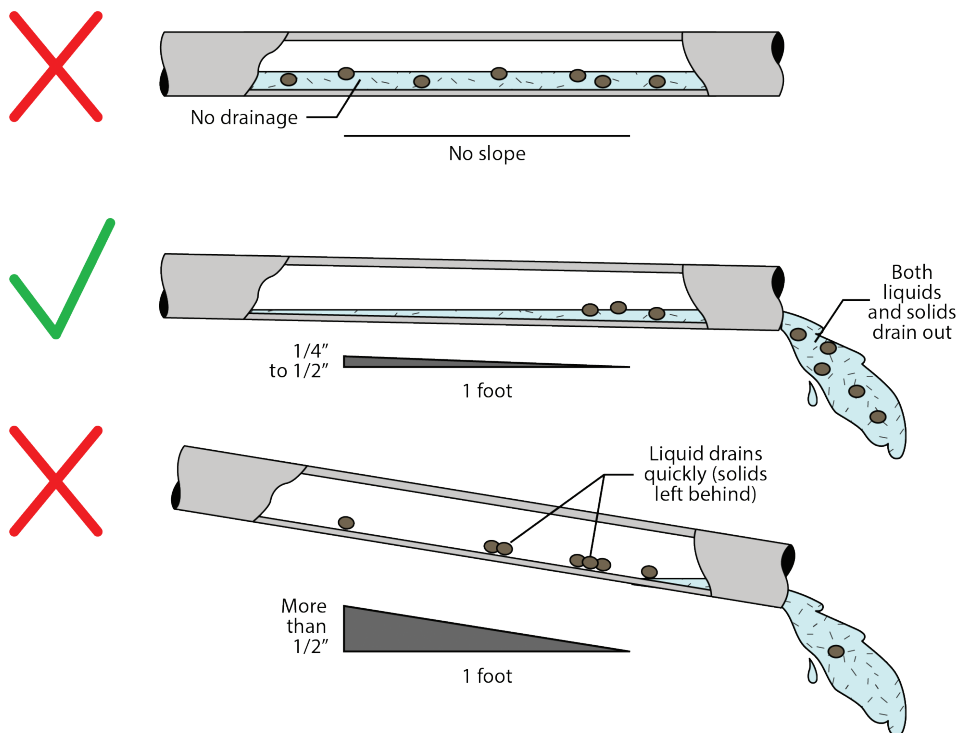
- Main sewers combine into trunk sewers.
- Interceptor sewers deliver wastewater to the treatment plant.

As flow increases downstream, pipe diameters increase and slopes can decrease while still maintaining adequate velocity.

Maintaining Proper Flow

Gravity systems must be carefully engineered to maintain sufficient velocity (known as **scouring velocity** or self-cleaning velocity) to prevent solids from settling in the pipe. Flow varies throughout the day, typically peaking in the morning and evening when water use

Too little or too much slope isn't good



is highest. Systems are designed so that adequate scouring occurs during average and peak flows.

Key Components (Appurtenances)

Collection systems include more than pipes. Important components include:

- **Manholes** provide access for inspection, cleaning, and maintenance. Manholes are installed at crucial points within the system, such as pipe junctions, changes in line direction or slope, and changes in pipe diameter.
- **Lift stations** pump wastewater to a higher elevation when gravity flow is not possible. A lift station typically includes a wet well, pumps, controls, alarms, ventilation, and sometimes odor control or screening equipment. Because they depend on electricity and require frequent maintenance, lift stations are used only when necessary, such as where maintaining the slope needed for gravity flow would require excavating to depths that would be expensive and impractical.

- **Force mains** carry wastewater under pressure from a lift station. These pipes must withstand pressure surges and potential corrosion.

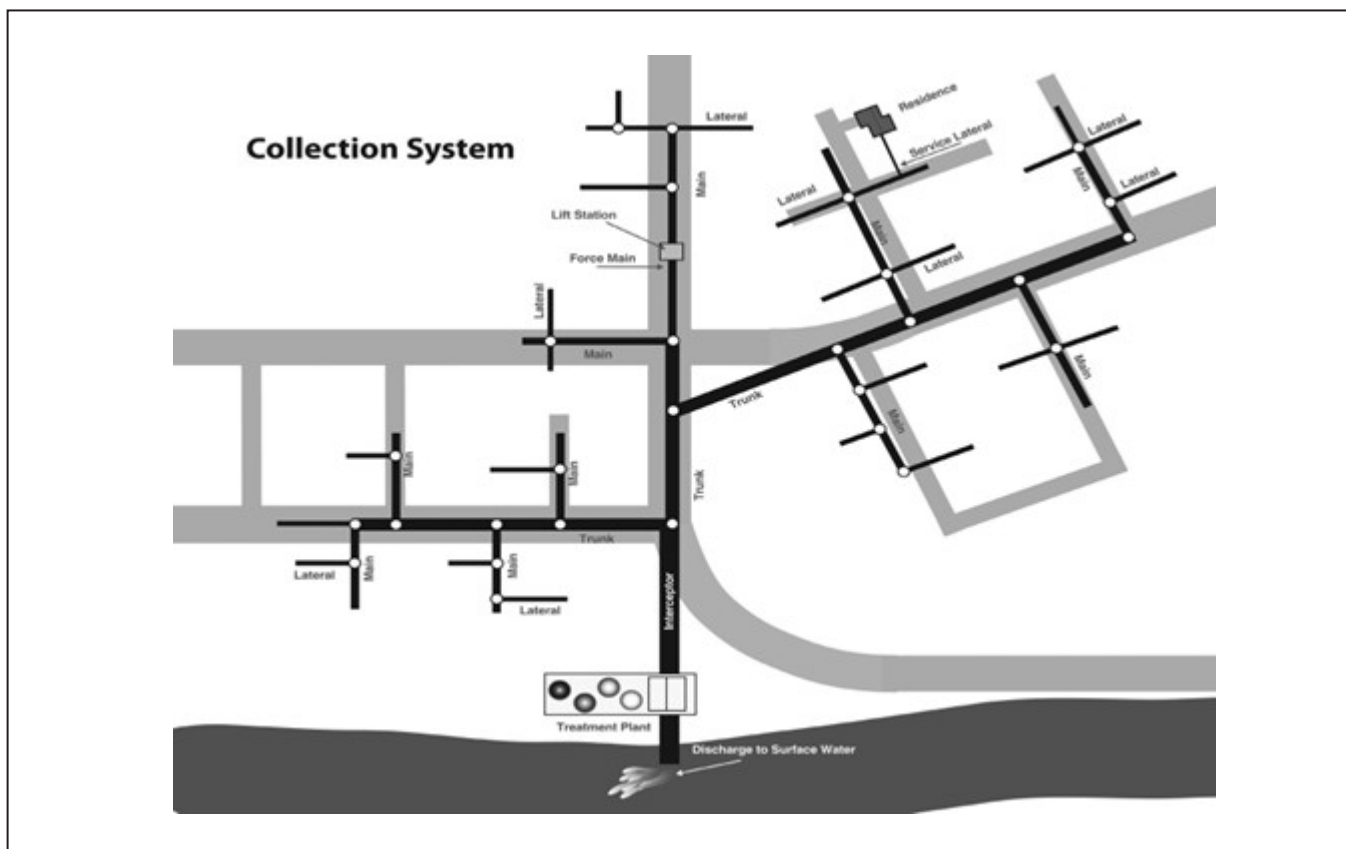
Pipes may be plastic (flexible and corrosion-resistant) or rigid materials such as concrete, clay, ductile iron, or steel, selected based on site conditions and performance needs.

Other common collection system appurtenances include backflow preventers, building sewers, and lateral branch cleanouts.

Alternative Collection Systems

In sparsely populated or challenging terrain (such as very flat land, steep hills, shallow bedrock, or high groundwater) conventional gravity systems may be prohibitively expensive. In response, several “alternative” collection technologies have been developed to reduce installation costs and excavation requirements.

Alternative systems typically use smaller-diameter pipes, shallow burial depths, and cleanouts instead of manholes. Many do not rely



entirely on gravity. These systems are often well suited for rural areas, communities replacing failing septic systems, or decentralized cluster developments.

Pressure Sewers

Pressure sewers transport wastewater under pressure through small-diameter plastic pipes. This gives them the advantage of being able to be installed at varying grades and more easily routed around obstructions or other utilities (e.g. water lines), storm sewers or streams. Pumps located at individual service connections move wastewater into the common main. Because the system is pressurized and watertight, inflow and infiltration are largely eliminated.

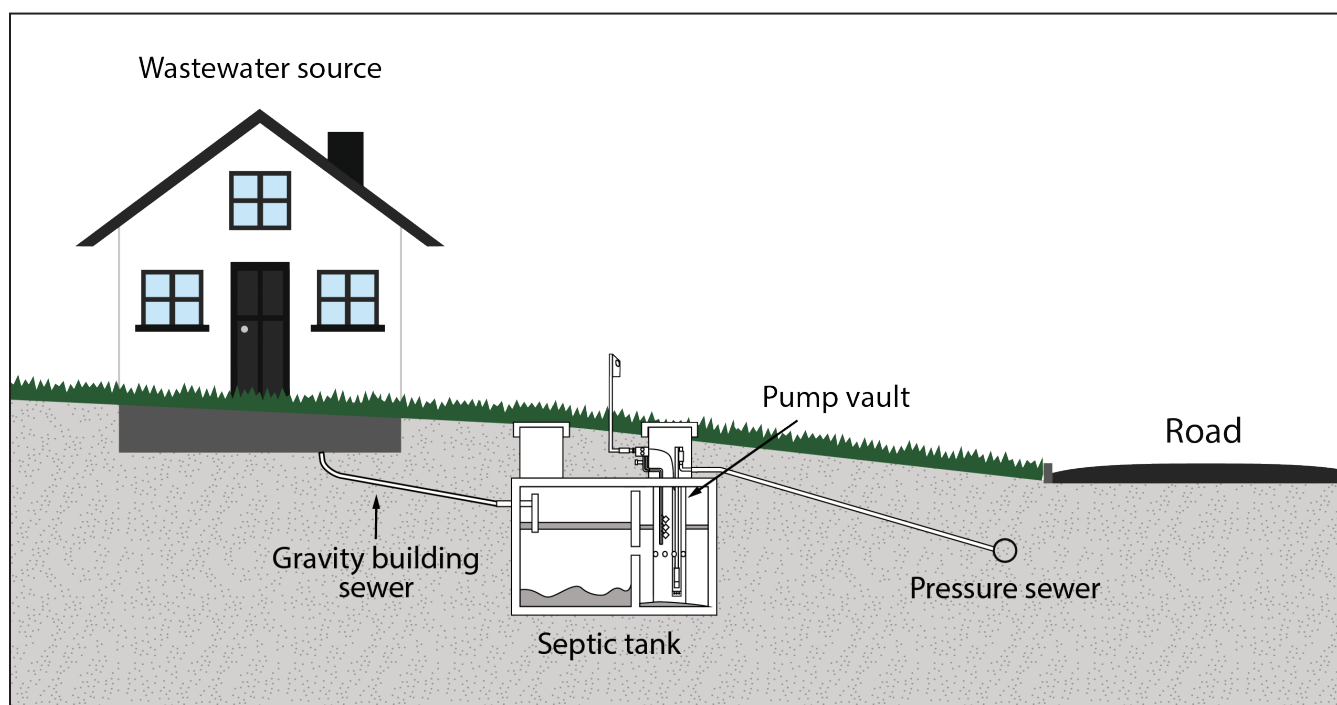
The pressure sewer system requires an integrated design that accounts for the number of connections (existing and projected) and site topography. Manufacturers of the pumps and associated pumping components typically make available to system design engineers their computer software and recommended design parameters and are a tremendous resource that should always be exploited. Identifying companies with a good track record in your region who have demonstrated on-going support is a critical part of the planning and selection process.

There are two primary types of pump systems (more details on each can be found in Appendix A):

- **Septic Tank Effluent Pump (STEP) systems** use a septic tank for primary treatment and a low-horsepower effluent pump to move clarified effluent to a pressure main. Solids settle and floatables rise in the tank, leaving partially treated liquid to be pumped. Because most solids are removed, small-diameter pipes (1.5–3 inches) can be used, reducing construction costs compared to conventional 8-inch gravity sewers. Watertight tank design is critical to prevent groundwater infiltration and unnecessary pumping.
- **Grinder Pump (GP) systems** do not use septic tanks. Instead, a grinder pump in a small watertight basin macerates solids and pumps all wastewater to the pressure main. Effluent quality is similar to raw sewage and



Sewer Pump Station



requires full downstream treatment. These systems avoid periodic septage pumping but may have shorter pump life and slightly higher power demand than STEP systems. Grinder systems require prompt response to malfunctions, as storage volume is limited.

Pressure Sewer Operation and Maintenance

Effective management of a pressure sewer system requires oversight of all components, including individual pump stations, septic tanks



Collection System Grinder Pump Basin

in STEP systems, service connections, and pressure mains. Electrical service is provided by each connected home or business, and although effluent and grinder pumps typically operate only a few minutes per day, prompt response to alarms is essential. Pump chambers in both STEP and grinder pump (GP) systems are equipped with high-level or malfunction alarms, and the responsible management entity (RME) must be prepared to respond quickly to prevent backups or overflows.

Communities should establish a formal maintenance program—whether through dedicated staff or contracted services—to ensure routine inspections, emergency response capability, and long-term asset tracking. Access easements must be secured for pretreatment components and service connections, and accurate as-built records and Geographic Information Systems (GIS) mapping should be maintained. STEP systems require periodic septic tank pumping to remove accumulated solids. Grinder pump systems, which lack septic tank storage, demand same-day emergency service because the wet well provides limited reserve capacity in the event of a malfunction.

Key Takeaways: Collection Systems

A collection system is the underground network of sewers that transport wastewater to treatment plants. Though often overlooked, it is a critical part of public infrastructure and requires significant investment.

Types of Sewers:

- Sanitary sewers carry only wastewater.
- Combined sewers (found in older systems) transport both wastewater and stormwater, which can lead to overflows.
- Inflow and Infiltration (I&I) occurs when stormwater or groundwater leaks into the collection system, potentially causing capacity issues.

Gravity Collection Systems: Wastewater typically moves through pipes using gravity. To prevent solids from settling, pipes must be engineered with a proper slope to maintain scouring velocity.

Collection System Components:

- Manholes provide access for inspection and maintenance.

- Lift stations pump wastewater uphill when gravity flow isn't possible. These require power and regular maintenance.
- Force mains carry pressurized wastewater from lift stations and must withstand additional pressure and potential corrosivity.

Alternative Collection Systems: Used in areas where conventional gravity sewers are too costly or impractical. These systems:

- Use narrower pipes, reducing installation costs.
- Can be installed at shallower depths, following the land's natural contours.
- Require pre-treatment (e.g., septic tanks, grinder pumps) to break down solids before wastewater enters the pipes.
- May require more maintenance due to decentralized treatment components.

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How is Wastewater Treated?

Wastewater Treatment Cycle

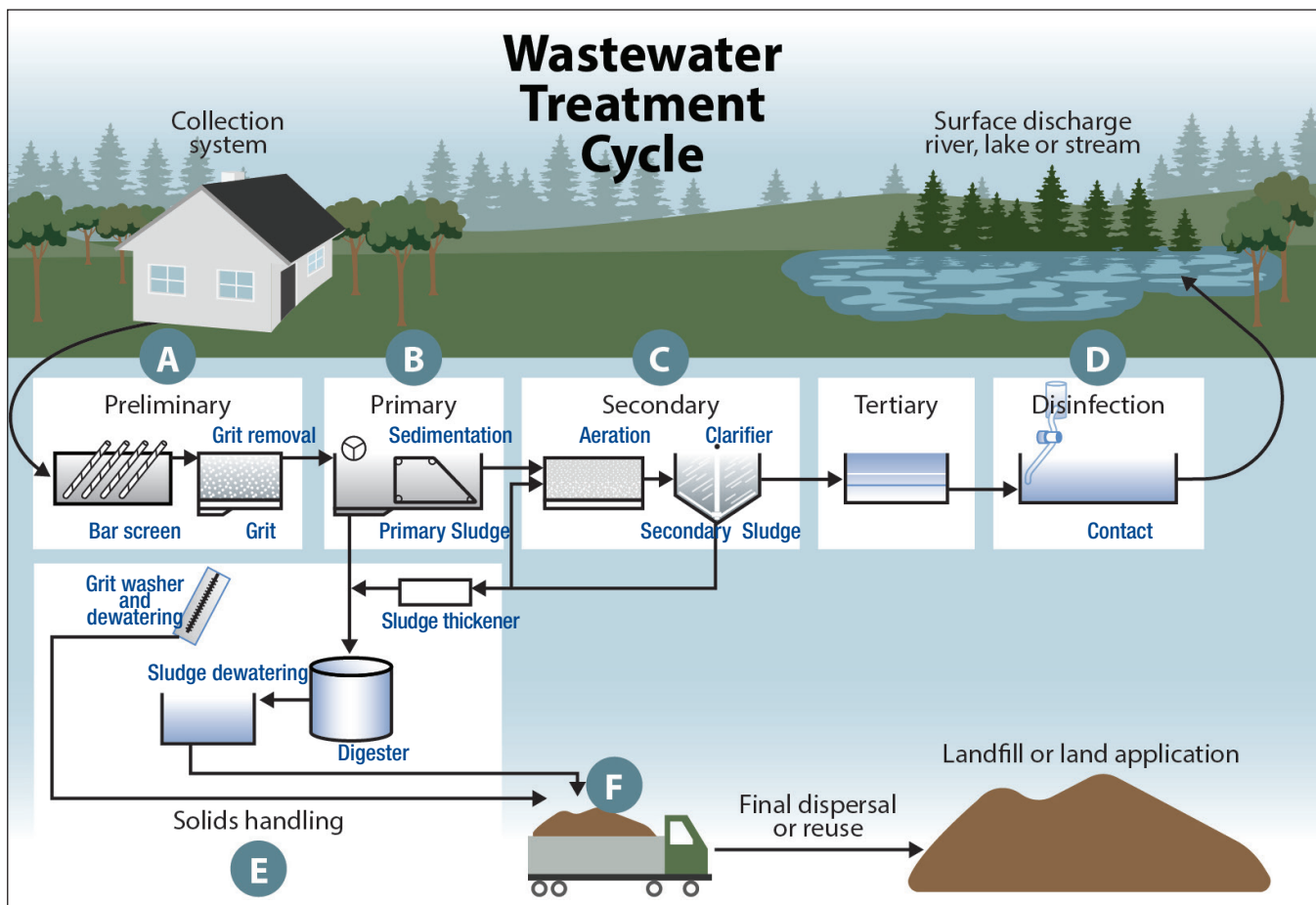
Wastewater treatment is a combination of physical, biological and chemical processes. In most wastewater treatment plants, there are also considerable structural and mechanical components in the form of tanks, pumps, aerators, and monitoring devices that accelerate and assist in these processes.

This section follows the wastewater treatment process through the various stages found in a mechanical plant. Not all communities will have a system that includes all the processes described in this guide. In fact, some communities rely on relatively non-mechanical wastewater treatment systems such as lagoons or septic systems that serve individual homes. However, most of the treatment principles described in this section also

apply to lagoons and septic systems, which will be discussed later.

The upstream end of a wastewater treatment plant is called the **headworks**. When the wastewater is brought to the plant's headworks, the process of treatment begins. Wastewater treatment is a sequence of processes with some feedback loops. These processes can be grouped into the following broad categories:

- Preliminary treatment
- Primary treatment
- Secondary treatment
- Advanced or tertiary treatment
- Disinfection
- Solids handling
- Final dispersal or reuse



Preliminary Treatment (Removing Large Debris and Grit)

THE STAGES OF TREATMENT AT A WASTEWATER PLANT
Preliminary treatment (A)
Primary treatment (B)
Secondary treatment (C)
Disinfection (D)
Solids handling (E)
Final dispersal or reuse (F)
Refer to the diagram showing these steps on page 21



Wastewater Treatment Plant

Preliminary treatment, often referred to as pre-treatment, involves removing coarse materials, such as tree branches, rags and plastic bags, by screening and removing smaller, mostly inorganic (non-decomposable) material, such as gravel, cinders and sand, by grit removal. Some plants grind the material into smaller particles rather than remove it. Preliminary treatment may also involve activities such as flow equalization, septage management, grease removal, and/or odor control.

Preliminary treatment may also be required of industrial or commercial users prior to entering the collection system.

The primary purpose of screening and grit removal is to eliminate materials that could affect downstream processes by damaging equipment, clogging pipes or pumps, or by making treatment processes less effective.

Screening and grit removal can also help control odors and protect the health and safety of plant operators.

Screening

Coarse screening strains larger materials, such as tree limbs, rocks, rags, cans, and wood, from the wastewater by passing it through vertically arranged parallel bars. The wastewater passes through the bars, and the bars hold back the larger pieces.

Screens need to be cleaned frequently because over-accumulation of materials will impede the flow of wastewater into the plant. At smaller plants, screens are sometimes cleaned manually



Small Influent Bar Screen

Trash that Wipe

Flushing wipes down the toilet can cause serious problems in the collection systems because most don't break down like toilet paper. Instead, they can clog pipes, damage pumps, and combine with grease to create blockages known as "fatbergs." These blockages can lead to sewer backups and costly repairs. Even wipes labeled as "flushable" may not dissolve quickly enough, so the best way to protect plumbing and the sewer system is to throw wipes in the trash instead of flushing them.

using a hand rake. For systems with combined sanitary and storm sewers, the volume of screened material can be much higher during heavy rain events than for systems that handle only sanitary wastewater. Larger plants typically use some form of mechanical cleaning.

The solids separated from the wastewater are either incinerated or sent to a landfill. The screenings may need to be pressed to remove excess water to comply with landfill regulations.



Influent Screw Conveyors

Grinding

Instead of screening coarse materials from the wastewater, some systems grind the material into smaller pieces that are then removed by downstream processes. Grinders are referred to as **comminutors**, macerators, or hammermills, depending on their mode of action. They use blades or teeth to reduce the size of coarse



Grinding-Influent Comminutors

material. When these devices are used in place of racks and screens, they may be preceded by a grit chamber to remove particles, such as gravel and sand, that would cause wear and tear on the grinders. Grinders are also sometimes used in lift stations to protect pumps from coarse materials, especially in areas with cold climates, where screened material could freeze to the rack or screen.

Grit Removal

Grit removal processes usually follow racks or screens. The goal is to remove inorganic particles, such as sand, cinders and gravel. These particles are small enough to pass through the bar screens but can cause problems to the downstream processes, such as abrasion of equipment, clogging of pipes, or accumulation in the solids-handling process, which is intended primarily for organic (decomposable) material. Some heavier organic materials, such as corn kernels, coffee grounds, eggs shells, and bone fragments, are also removed as grit.

Grit removal uses gravity, centrifugal force, or a combination of both. In the simplest type of grit chamber, the wastewater flows through a gently sloped chamber in which the velocity is controlled to maintain a speed of about one foot per second. This allows the heavier, mostly inorganic grit to settle out while lighter, organic material remains suspended in the wastewater flow. The deposited grit may be removed mechanically by scrapers or shoveled by hand in smaller wastewater treatment plants.

Aerated grit chambers use compressed air to create a spiral flow that assists in the separation of grit. Vortex-type grit chambers use either a turbine or the configuration of the unit to create a cyclonic flow pattern that uses gravity and centrifugal force to separate heavier, inorganic grit. In some plants, grit is further processed or washed to remove stray organic materials.

Flow Equalization

Flow equalization involves buffering the variations in the volume and contaminant

concentrations of incoming wastewater. Flow variations occur on a daily, periodic or seasonal basis. Recall that peak wastewater flow mirrors water usage, with one peak in the morning as people get ready for work and school and another peak in the evening as people prepare meals and get ready for bed. Variations also occur during wet weather, or seasonally such as in areas subject to seasonal tourism patterns.



Flow Equalization

Flow equalization benefits the system because a larger, costlier facility would be necessary to treat peak flows compared to the average flow. It also benefits the downstream treatment processes as it minimizes the effect of shock loads in which a slug of concentrated wastewater adversely affects the biological processes, and it makes the wastewater quality more uniform.

Flow equalization can be done on an in-line basis, in which the entire wastewater flow passes through an equalization basin. Peak flows are temporarily held in the basin, and a pumping station releases a controlled flow to the downstream treatment processes. This approach is most commonly used to address expected flow variations during the day in order to uniformly deliver the average daily flow received over a 24-hour period.

Seasonal or wet-weather variations are more

difficult to accommodate. These variations can be huge for systems with a lot of I&I and for those with combined sanitary and storm sewers. It is important to address inflow and infiltration through regular system evaluations and prompt repairs. Note that combined sewers are no longer being permitted but remain present in many communities with older infrastructure in place, which is difficult and quite costly to rectify.

To partially address seasonal and wet-weather flow variations, off-line arrangements may be devised to divert only overflow wastewater into the equalization basin, where it is held for slow release to the plant. Off-line basins are frequently used to capture the initial burst of wastewater during wet weather events in systems with combined sewers or those with considerable inflow. In combined sewer systems, this “first flush” often has a greater wastewater strength than the remainder of the wet-weather flow due to accumulated materials washed into storm sewers from streets and yards. Depending on their configuration, off-line basins may offer less ability to equalize daily flow variations.

Septage Management

Many treatment plants accept **septage**, which is the material pumped from the septic tanks of onsite wastewater system and grease traps. Treatment systems that accept septage have to be designed and have the capacity for it, in addition to a monitoring and control program to avoid systems upsets and/or discharge permit compliance problems. Septage and grease trap waste can have a significantly higher concentration of BOD, suspended solids, fats, oils, and grease compared to typical residential wastewater.

Some communities have ordinances that regulate septage, including where in the system it may be added, and requirements for sampling. Grease trap waste may not be allowed due to concentrated grease clogging pumps, filters, and other treatment processes. Preliminary treatment of septage may require aeration or other pre-

treatment if there is a significant volume of it relative to the total flow of the plant.

Odor Control

Odor control is a general plant issue but is especially relevant in the preliminary treatment processes. Odors can be particularly strong in the headworks area. Odors may also be generated from flow-equalization basins, especially if they receive any septage, and from the accumulation of material screened from racks. There are a variety of odor-control practices, including frequent removal of screenings, aeration, chemical oxidation, and the use of special odor-control units.

Commercial and Industrial Considerations

Industrial and commercial users are frequently asked or required to pretreat their wastewater discharge prior to entering the collection sewer system. The receiving treatment system may issue the industry a pretreatment permit specifying treatment components, pollutant discharge limits, and monitoring and reporting



Activated Sludge Aeration Tanks

requirements to be met in conjunction with their permit to discharge into the community's system. Where food service facilities are prevalent, grease control programs are (or should be) mandated, often regulating the location, size and design of grease interceptors, and frequency of servicing, and that establish ongoing inspection and enforcement protocols.

Key Takeaways: Preliminary Treatment

Preliminary treatment removes large debris, grit, and other materials that could damage equipment, clog pipes, or reduce treatment efficiency. It also helps control odors and protects plant operators. There are several types of preliminary treatment methods and considerations:

- **Screening:** Coarse screens remove large items like tree limbs, rags, and plastics. Regular cleaning is necessary to prevent blockages, and the collected debris is either put in a landfill or incinerated.
- **Grinding:** Some systems grind coarse materials into smaller pieces for easier downstream processing. This protects treatment infrastructure.
- **Grit Removal:** Inorganic particles like sand, gravel, and eggshells are removed to prevent equipment wear and system clogging. This process relies on gravity, centrifugal force, or aeration to separate heavier particles.
- **Flow Equalization:** Buffers fluctuations in wastewater flow, such as through an equalization basin, preventing system overloads due to peak flows or weather and ensuring steady treatment.
- **Septage Management:** Treatment plants may accept waste from septic systems and grease traps, but special handling and monitoring are required.
- **Odor Control:** Strategies like aeration, chemical oxidation, and frequent removal of screened materials help manage odors, especially in the headworks area.
- **Industrial & Commercial Pretreatment:** Businesses may be required to pretreat their wastewater before discharge to comply with local regulations, particularly for grease control in food service establishments.

Primary Treatment (Separating Out Solids)

THE STAGES OF TREATMENT AT A WASTEWATER PLANT

Preliminary treatment (A)

Primary treatment (B)

Secondary treatment (C)

Disinfection (D)

Solids handling (E)

Final dispersal or reuse (F)

Refer to the diagram showing these steps on page 21

Primary treatment focuses on separating solids from liquids. It involves letting the wastewater flow slowly through a tank or tanks that allow the settleable solids and floatable materials to separate from the wastewater. The tanks are referred to as primary clarifiers or primary sedimentation tanks. Usually, at least two tanks are available for use and are configured so that one tank can be taken out of operation for maintenance.

The tank is designed to allow for the stratification of materials—heavier, settleable solids sink to the bottom, and floatable materials rise to the top. The flow pattern and slower velocity are designed to improve the process. The settled solids are mechanically swept or scraped into a hopper for temporary storage and then pumped to a digester. The removed solids are referred to as primary **sludge**. The floating layer is removed by mechanical skimmers or sprayed water for further processing.



Primary Clarifier

The amount of solids separated during primary sedimentation varies depending on the holding time in the tank, the tank configuration, and the wastewater quality. Other factors include the freshness of the wastewater, its temperature, the density of the solid particles, and whether there are any industrial contributors to the wastewater. It is important to note that the use of chemicals for any solid-liquid separation will increase the quantity of solids or sludge to be generated. Removal rates of 50 to 70 percent of suspended solids and 20 to 40 percent of BOD can be achieved during primary treatment in plants that are well-designed and operated. Some plants may add chemicals to enhance the ability of small, suspended solids particles to coagulate into heavier, more settleable masses. In most plants, however, primary treatment relies totally on gravity.

Secondary Treatment (Treatment of Organic Contaminants)

THE STAGES OF TREATMENT AT A WASTEWATER PLANT

Preliminary treatment (A)

Primary treatment (B)

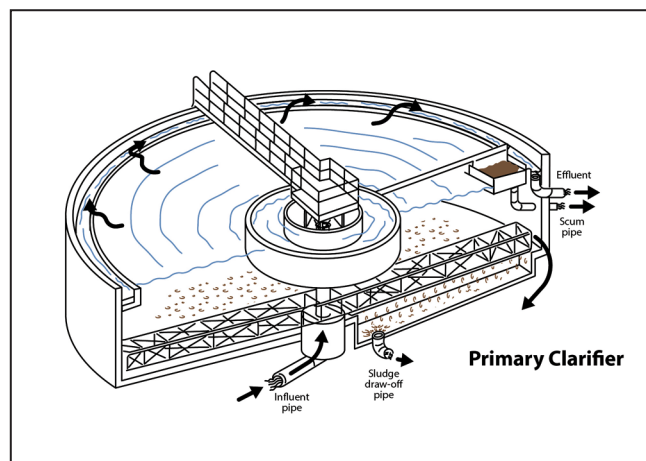
Secondary treatment (C)

Disinfection (D)

Solids handling (E)

Final dispersal or reuse (F)

Refer to the diagram showing these steps on page 21



Secondary treatment involves the biological treatment of organic contaminants. It reduces the amount of remaining organic solids, which are now mainly dissolved and colloidal (tiny particles that will not settle out by gravity), as well as the BOD associated with the solids. This step also results in the chemical transformation of some wastewater constituents, such as changing ammonia nitrogen to nitrate (**nitrification**).

Secondary treatment is a biological process that relies on microorganisms to decompose the remaining organic matter in the wastewater. The microorganisms are a mixture of bacteria, protozoans, fungi, rotifers, and nematodes, although the bulk of the work is done by bacteria. Wastewater serves as a food source for microorganisms. Most secondary treatment processes are **aerobic**, meaning they rely on microorganisms that use dissolved oxygen.

Secondary treatment needs to produce effluent that has an average BOD content of 30 mg/L, total suspended solids of 30 mg/L, and a pH between 6.0 and 9.0 at all times. Some plants may be required to meet more stringent standards.

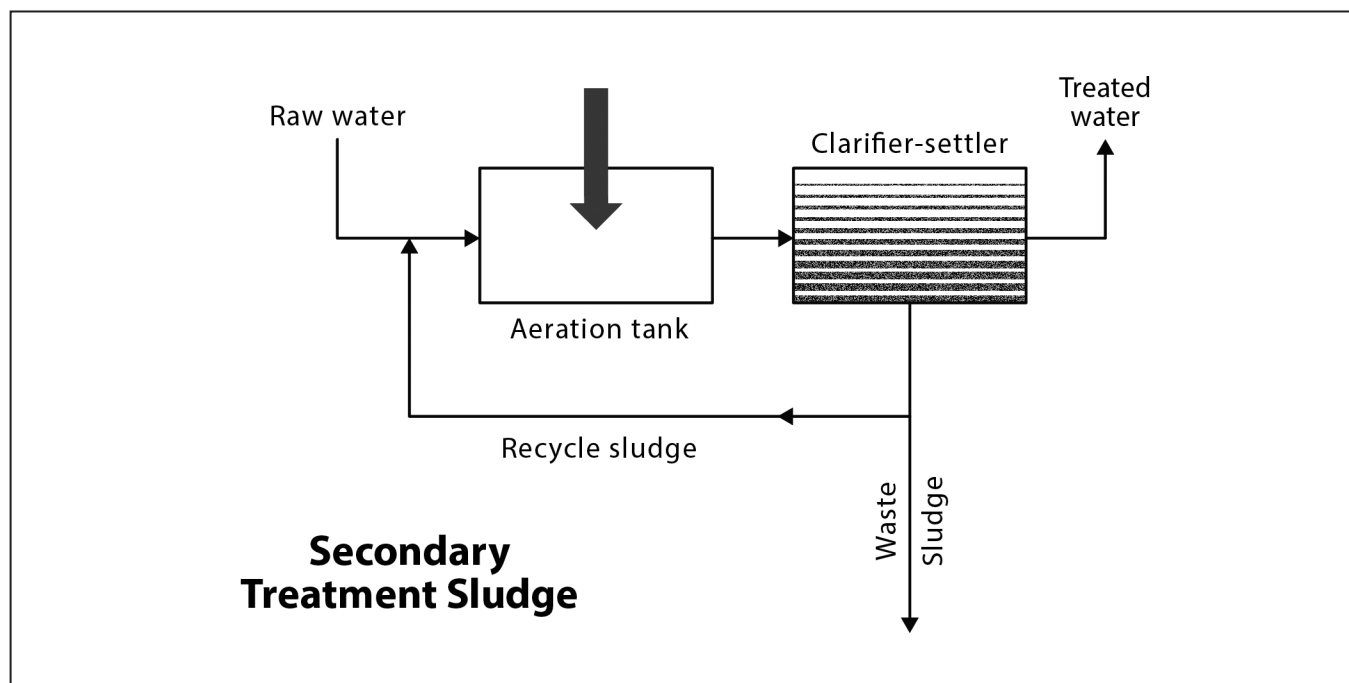
Secondary treatment processes are typically divided into two categories:

- In **suspended growth systems**, the microorganisms providing the treatment are mixed with wastewater. An activated sludge system is the most common type of suspended growth system. The microorganisms form a suspended, gelatinous **floc** (clumps of solids) material composed of microorganisms plus suspended, non-decomposable particles, which are referred to collectively as the **activated sludge**.
- In **attached growth, fixed-film systems**, the microorganisms, or biomass, grow on the surface of a medium. The wastewater is circulated over the biomass surface/medium, and the microorganisms consume and decompose the organic matter. Examples of attached growth systems include trickling filters and rotating biological contactors.

Increasingly, there are more systems that have characteristics of both attached and suspended growth systems. There are also many variations in both suspended and attached growth systems.

Suspended Growth Systems: Activated Sludge

The activated sludge process uses microorganisms to proportionally feed on



dissolved organic contaminants in wastewater, producing a high-quality effluent. A basic principle behind all activated sludge processes is that as microorganisms grow, they form particles that clump together. These particles (floc) are allowed to settle to the bottom of the tank, leaving a relatively clear liquid that is free of organic material and suspended solids.

In simple terms, wastewater from primary treatment—or untreated influent if no primary treatment is used—is mixed with microorganisms in an aeration tank. This tank acts as a biological reactor. The mixture, called **mixed liquor**, is continuously mixed and supplied with air to provide oxygen and keep the microorganisms suspended. After sufficient treatment time, the mixed liquor flows to a secondary clarifier, where the solids settle. Some of these solids are removed, and the partially treated water moves on to the next treatment step. The settled solids, known as **activated sludge**, are returned to the aeration tank to continue the process.



Activated Sludge Aeration Tank

Well-operated activated sludge plants are capable of producing high-quality effluent. Plus, due to their scalability, they can have relatively low construction costs and small land requirements, making them a suitable solution for a variety of communities and needs. The activated sludge process is widely used by large cities and communities where large volumes of wastewater must be treated economically. Small, activated sludge package plants are used frequently for isolated facilities, such as hospitals or hotels, cluster situations, subdivisions, and rural, small communities.

A basic activated sludge process consists of several interrelated components:

- an aeration tank where the biological reactions occur
- an aeration source that provides oxygen and mixing
- a tank, known as the secondary clarifier, where the solids settle and are separated from treated wastewater
- a means of collecting the solids either to return them to the aeration tank (return activated sludge) or to remove them from the process (waste activated sludge)



Extended Aeration Tank

Aerobic bacteria thrive as they travel through the aeration tank. They multiply rapidly with sufficient food and oxygen. By the time the waste reaches the end of the tank, the bacteria have consumed most of the organic matter to produce new cells.

The organisms settle to the bottom of the secondary clarifier tank, separating from the clearer water. This sludge is pumped back to the aeration tank, where it is mixed with the incoming wastewater or removed from the system as excess, a process called **wasting**. The relatively clear liquid above the sludge, called the **supernatant**, is sent on for further treatment as required.

Because activated sludge treatment is a biological process, monitoring the biological characteristics of the sludge provides important information to the operator on the state of the system. Efficient operation is ensured by

keeping accurate, up-to-date records, routinely evaluating operating and laboratory data, and anticipating problems before they become serious. A wide range of laboratory and visual and physical test methods are recommended. Principally, these include floc and settleability performance using a jar test, microscopic identification of the predominant types of bacteria, and analysis of various chemical parameters.

The treatment environment directly affects microorganisms. Changes in food, dissolved oxygen, temperature, pH, total dissolved solids, sludge age, presence of toxins, and other factors create a dynamic environment for the treatment organisms. The operator can change the environment (the process) to encourage or discourage the growth of specific microorganisms.

Chemical testing reveals sludge conditions and can warn of impending process problems. Compliance with the plant's NPDES permit requires specific chemical analyses. Alkalinity, solids (total, suspended and dissolved), biochemical oxygen demand (BOD), chemical oxygen demand, nitrogen, and phosphorus are some of the parameters that plant operators must monitor.

Variations of the Activated Sludge Technology

The activated sludge process can be incorporated into several configurations of a plant's design, including extended aeration, sequencing batch reactors (SBRs), and oxidation ditches.

Extended Aeration

Extended aeration is a modification of the activated sludge process in which wastewater is held in an aeration tank for an extended period—typically 18 hours or more. During this time, microorganisms remove organic waste under aerobic conditions. Air is supplied by mechanical or diffused aeration systems, which also provide mixing.

In most extended aeration package plants, wastewater flows directly from a lift station

or equalization basin into the aeration tank, without primary treatment. In the aeration tank, wastewater is mixed with microorganisms, and oxygen is added to support biological treatment.

After aeration, the mixed liquor flows to a secondary clarifier, where biological solids are allowed to settle. A portion of the settled solids, known as activated sludge, is returned to the aeration tank to maintain an active microbial population. Excess solids are wasted as needed to control the process. The clarified wastewater flows to a collection channel before being diverted to the disinfection system.

Extended aeration is the process used in many manufactured package plants serving schools, housing developments, and small communities. Because they operate at low food to microorganism ratios, they are considered among the most stable wastewater treatment processes.

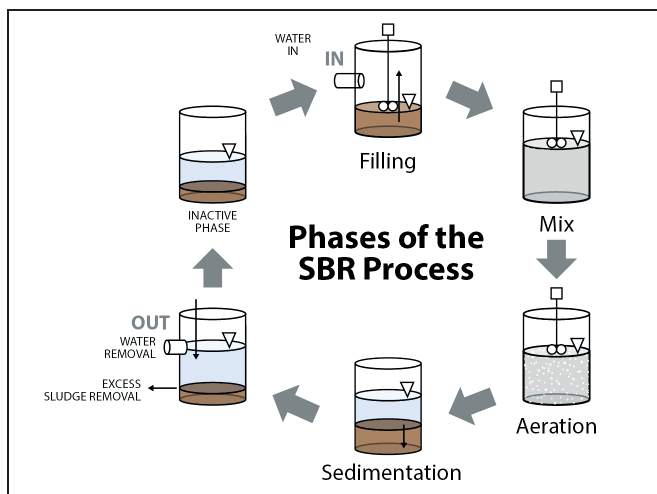
Extended aeration systems can accommodate periodic (intermittent) loadings without significant upset. They also produce similar or less waste sludge as other processes, although regular sludge wasting is still necessary to maintain proper control of the process.

Sequencing Batch Reactors

A **sequencing batch reactor (SBR)** uses one tank for the entire treatment process, unlike a conventional activated sludge system, which uses an aeration tank and a clarifier. SBR systems consist of five common steps carried out in sequence:

1. Fill
2. React (aeration)
3. Settle (sedimentation/clarification)
4. Draw (the effluent is decanted)
5. Idle

Sludge wasting usually occurs at the end of the settling phase. The SBR acts as an equalization basin when filling with wastewater, enabling the system to tolerate peak flows or loads. Adjusting cycles' total times is also used to handle flows or concentration variations in an SBR. If you receive large flows with low organic content, you reduce cycles times and, if you receive high



organic concentration in low flows, you increase cycles treatment times.

During this process, effluent enters a partially filled reactor. Once the reactor is full, it performs like a conventional activated sludge system but without a continuous influent or effluent flow. Aeration and mixing are discontinued after the biological reactions are complete, the solids are allowed to settle, and the treated effluent (supernatant) is removed. Excess solids are removed at any time during the cycle.



SBR Reactor - Empty

SBRs are typically used where flow rates are 5 million gallons per day or less. Due to their relatively small footprints, they are useful in areas where available land is limited. In addition, it is easy to modify cycles within the system for removal of nutrients, if necessary. SBRs are cost-effective if treatment beyond biological treatment, such as filtration, is required. SBRs also offer potential capital cost savings by eliminating the need for clarifiers. SBRs require sophisticated maintenance due to the timing

units and controls. Most are now computerized for simpler operations.

Oxidation Ditches

The **oxidation ditch** is another variation of the activated sludge process. It consists of a ring or oval-shaped channel equipped with mechanical aeration devices, such as brush rotors or disc aerators.



Oxidation Ditch

Oxidation ditches typically operate in an extended aeration mode with long solids retention times. Solids are maintained in suspension as the mixed liquor circulates around the channel. Secondary sedimentation tanks are used for most applications.

Oxidation ditch process plants can be designed to achieve specific objectives, including nitrification and/or removal of biological phosphorus. Due to the constant water level and continuous discharge, oxidation ditch technology does not cause an effluent surge that happens in some other biological processes, such as SBRs.

Attached Growth Systems

Attached growth or fixed film systems make use of organisms that are attached to a medium or substrate. The principle of treatment is otherwise similar to suspended growth systems: the microorganisms “eat” the remaining organic material in the wastewater while removing most of the remaining BOD. Attached growth systems can also be effective at nitrification (the conversion of ammonia to nitrate).

In all cases, attached growth filters act as secondary treatment devices following primary

treatment. Raw wastewater must be treated first to remove the larger solids and floating debris, because these solids can plug the media filter.

There are two basic designs of attached growth or fixed film systems: those that hold the media in place, allowing the wastewater to flow over the bed (such as trickling filters) and those where the medium is in motion relative to the wastewater (e.g., rotating biological disks). In most cases, drains under the media collect the effluent and send it either back through the unit or on to further treatment.

The main advantages of attached growth processes over the activated sludge process are lower energy requirements, simpler operation, less maintenance, and better recovery from shock loads. Attached growth processes in wastewater treatment are very effective for BOD removal and nitrification. Disadvantages include a larger land requirement, poor operation in cold weather, and potential odor problems.

Two types of attached growth systems that are frequently used at wastewater treatment plants are trickling filters and rotating biological contactors.

Trickling Filters

Trickling filters are by far the oldest attached growth process. This simple technology has been used for nearly 100 years to provide low-cost, low-maintenance, biological wastewater treatment.

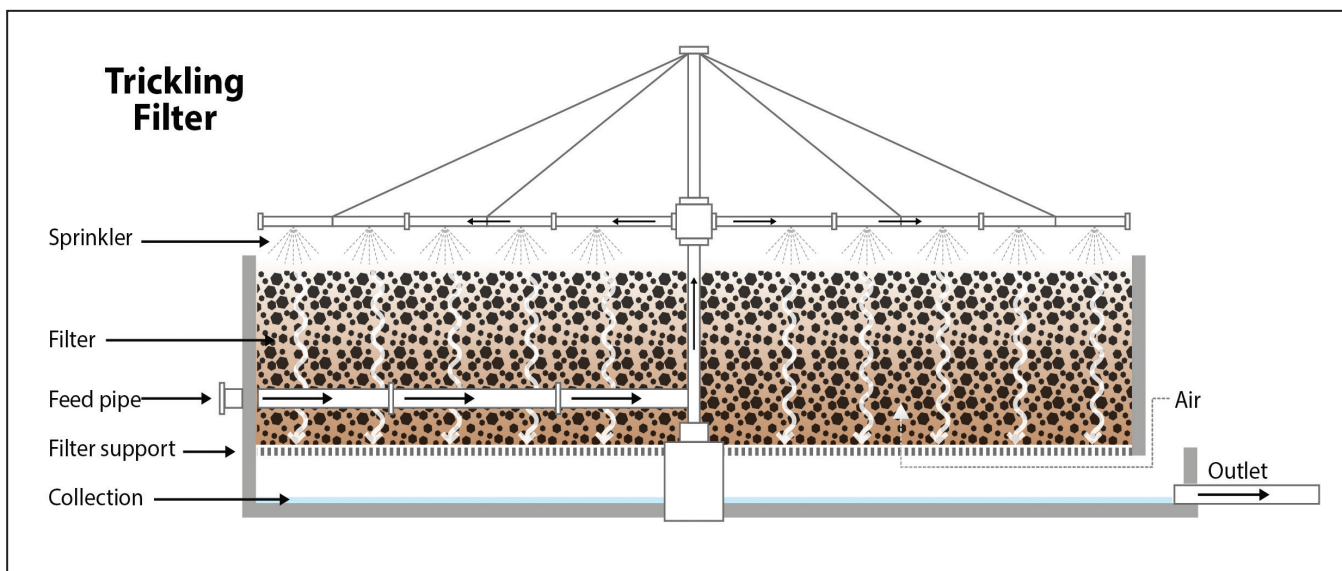
Although they are referred to as filters, they are not designed to provide actual physical filtration. The media are intended to serve only as an attachment site for the biological organisms that provide the treatment.

The most common design is the non-submerged trickling filter. The wastewater is applied to the surface of the filter, such as a bed of rocks, gravel or plastic. The wastewater percolates down through the bed to a drain, where it collects and discharges or is recycled for further treatment. The composition, size, uniformity, and depth of the medium all affect performance.

A jelly-like biological film forms on the gravel or plastic where the growing biomass breaks down the organic matter. The film becomes very thick and eventually chunks fall off the supporting surface and a new slime layer begins to grow in its place. This dropping off is called **sloughing** (pronounced “sluffing”) and should be a



Trickling Filter



continuous process if the system is managed properly. Without sloughing action, the medium would clog and develop anaerobic conditions.

The collected liquid is passed to a secondary sedimentation tank, where the solids are separated from the treated wastewater. The clumps of biomass that drop off must be treated as suspended solids.

Beds of conventional trickling filters are made up of pieces of crushed rock, slag or gravel that are 2 to 3 inches in diameter. The bed is commonly 6 to 10 feet deep, held in place by a reinforced concrete basin. When the medium is made up of plastic tubes, which are very light weight, the height can be much greater. These systems are sometimes called tower trickling filters or bio towers. Most modern trickling filters use plastic packing as the working medium.

Conventional trickling filters are round with rotating arms for distribution of the wastewater. Nozzles on the arms spray the wastewater evenly across the medium. Natural drafts are created by temperature differences between the outside air and air inside the filter. Deep tower filters sometimes require an additional air supply. The temperature of the wastewater is more important to the success of the process than the air temperature.

Trickling filters are highly reliable if operating conditions remain steady, and the wastewater temperature does not fall below 55° F for prolonged periods.

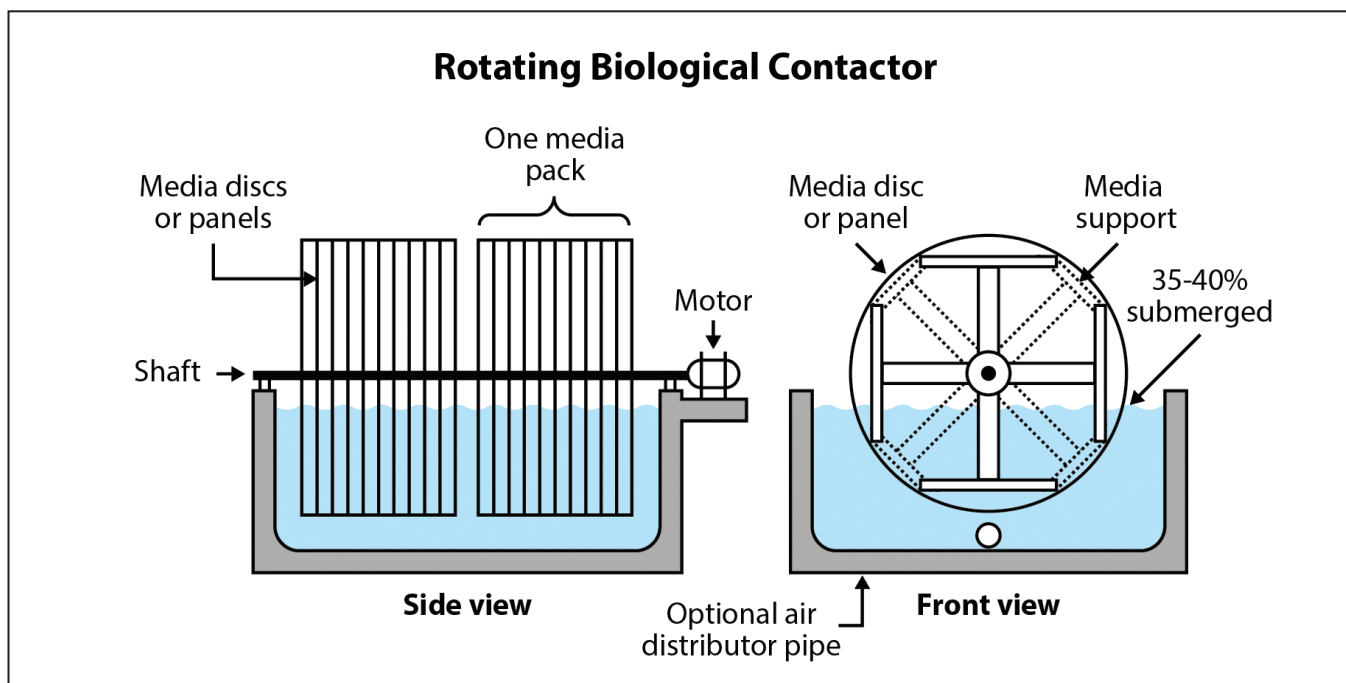
Sloughing tends to occur during seasonal temperature changes. Because the process is simple to operate, mechanical reliability is high. The trickling filter process is effective for removing suspended materials but is less effective for removing soluble organics.

Rotating Biological Contactors

Rotating biological contactors (RBCs) consist of a series of closely spaced, circular, plastic disks mounted on a shaft. The disks are partially submerged in wastewater and slowly rotate through it. The surface of the disks provides an attachment site for bacteria. Oxygen is provided as the disks move in and out of the water.

Solids are kept in suspension by the mixing action of the rotating medium. Excess slime on the disks sloughs off from time to time, just as in the trickling filter systems.

The disks are commonly made of high-density polyethylene or Styrofoam and are usually ridged, corrugated or lattice-like to increase the available surface area.



These systems must be designed carefully to avoid excessive biofilm growth and sloughing problems, which may lead to failure of mechanical parts in the treatment unit. RBCs can be arranged in a variety of ways, depending on specific effluent characteristics and the secondary clarifier design and can be designed specifically for BOD removal or nitrification.

RBCs are often covered with fiberglass housing to protect the disks from deterioration due to ultraviolet light, to protect the process from low temperatures, and to control the buildup of algae. This type of treatment does not perform well below 55° F.

Combined Attached Growth and Suspended Growth Systems

Some systems have paired attached growth and suspended growth units within their secondary treatment process. This usually involves a trickling filter followed by an aerated activated sludge basin and a clarifier. There are a number of possible configurations. The combination of the two takes advantage of the strengths of each type of treatment while overcoming some of their weaknesses.

For example, activated sludge systems are considered sensitive to shock loads of higher-strength wastewater, while trickling filters are



Final Clarifiers

considered shock-resistant. Having a trickling filter precede the activated sludge basin provides a level of protection. Activated sludge systems, however, allow for more operator control over the process than trickling filters.

Disinfection (Ensuring Safety Before Discharge)

THE STAGES OF TREATMENT AT A WASTEWATER PLANT

Preliminary treatment (A)
Primary treatment (B)
Secondary treatment (C)
Disinfection (D)
Solids handling (E)
Final dispersal or reuse (F)
Refer to the diagram showing these steps on page 21

Key Takeaways: Secondary Treatment

There are two main types of secondary treatment systems:

1. **Suspended Growth Systems** – Microorganisms remain suspended in the wastewater.

- **Activated Sludge Process:** The most common method, where microorganisms form flocs that settle out in a secondary clarifier. The settled sludge is either returned to the aeration tank or removed as waste.
- **Variations:** Extended aeration (longer retention time, stable for small communities), sequencing batch reactors (single-tank process with batch treatment), and oxidation ditches (continuous circulation of wastewater).

2. **Attached Growth Systems** – Microorganisms grow on a surface medium.

- **Trickling Filters:** Wastewater flows over a bed of rocks, gravel, or plastic where microorganisms degrade organic matter.
- **Rotating Biological Contactors (RBCs):** Disks rotate through wastewater, supporting microbial growth.

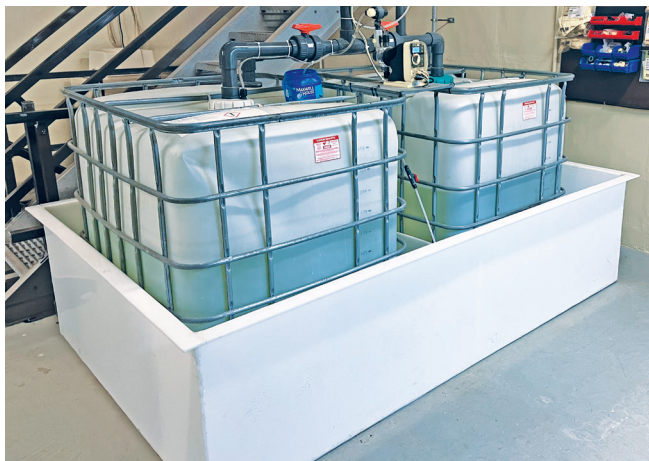
Each method has advantages, with attached growth systems requiring less maintenance but needing more space, while suspended growth systems like activated sludge are more efficient for large-scale treatment. Operators monitor microbial health and environmental factors to ensure effective treatment.

In many systems, after the wastewater has received secondary treatment, it is almost ready for discharge or dispersal. Some systems may first be required to provide advanced (or tertiary) treatment, which will be discussed later. For systems that are not required to provide advanced treatment, the final step before discharge is disinfection. Although as much as 95 to 98 percent of bacteria and other microbes have died off or been removed with the solids by the time secondary treatment is completed, wastewater must still be disinfected before it is discharged into the environment. This is because there are still enough remaining microbes that are potentially pathogenic to create a public health concern. Disinfection is also required by states to prevent the receiving stream from exceeding an established water quality standard for fecal or total coliforms. These standards vary from state to state and sometimes are seasonal as well.

- type of disinfectant
- concentration or intensity of the disinfectant
- contact time the disinfectant has with the target organisms
- temperature
- relative tolerance of the target organisms to the disinfectant
- characteristics of the wastewater, such as its turbidity, color, and suspended solids content, which can interfere with the disinfectant

Chlorination

Chlorination is the most used method of wastewater disinfection due to its low cost and its ability to disinfect wastewater at relatively low dosages. Chlorine is available in various forms, including liquefied chlorine gas in pressurized tanks and cylinders; sodium hypochlorite (liquid bleach); calcium



Hinsdale chemical tanks Sodium Hypochlorite WWTP

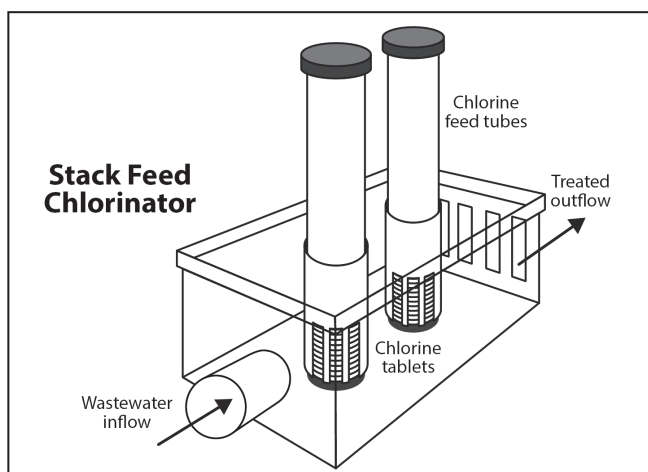


Chlorine Contact Tank

Although there are many ways to disinfect wastewater, there are three commonly used options:

- Chlorination
- Ozonation
- Ultraviolet light radiation

Disinfection kills or inactivates most of the remaining microbes. (However, disinfection does not result in the complete death of all microbes (sterilization). The effectiveness of these methods depends upon the:



hypochlorite, available as a liquid and as solid pellets or powder; and chlorine dioxide, a gas that is generated on-site.

Chlorine is a strong oxidant and kills microorganisms by damaging proteins, breaking down cell walls and deactivating enzymes.



Liquid Chlorine Disinfection

While chlorine in its various forms is an effective and economical disinfectant, it has a number of disadvantages. Chlorine gas is highly toxic, and the risk of accidental release presents a significant health and safety hazard for plant personnel and the public as liquefied gas tanks are commonly transported by rail and truck. Liquid bleach and sodium or calcium hypochlorite, which are more likely to be used at smaller plants, eliminate some, but not all, of the occupational risks.

Increasingly, chlorinated wastewater is required to be de-chlorinated before final discharge to the environment. This is because residual chlorine is toxic to aquatic life and because the chlorine reacts with organic material in the environment to form disinfection byproducts (DBPs) that are also considered to be damaging to aquatic life and carcinogenic to humans.

The most common method for de-chlorinating wastewater is by injecting pressurized sulfur dioxide gas, which requires specialized handling and safety systems. Smaller systems tend to use alternatives such as sodium metabisulfite or sodium bisulfate, which are easier to handle and operate at a smaller scale.

These chemicals can be dissolved in water and dosages given with a liquid chemical feed pump.

Disinfectant Safety and Handling

Chlorine, whether in gas, solution, or powdered form, is the most dangerous chemical used in most systems. Proper storage, use, transport, and personal protection can save lives. Exposure to chlorine can lead to:

- skin burns
- lung congestion
- pulmonary edema
- pneumonia
- pleurisy
- bronchitis
- death

Chlorine gas is greenish yellow in color. It is much heavier than air, which means it will sink to low spots—whether these are near the floor of a building or in a populated valley downhill from the treatment plant. Chlorine gas cylinders must be secured to floors or walls and labeled. Transport vehicles and the building where the chlorine is stored must be identified with signs. Plant staff working with chlorine gas must be equipped with a self-contained breathing apparatus (SCBA) with a mask that has been fitted to the user. Work with chlorine gas cylinders should be conducted only with a trained, SCBA-equipped partner standing by. In the event of a leak in the building where chlorine gas is stored or being worked with, staff in the building should keep their heads high and leave the building as soon as possible.

Sodium hypochlorite solution is pale yellow in color and is very corrosive and aggravating to skin and respiratory passages. Calcium hypochlorite powder (called HTH in the water industry) is also extremely reactive. Appropriate personal protective equipment (PPE) for liquid and powdered forms of chlorine includes:

- safety glasses or full-face shield
- long sleeves
- rubber gloves
- respirator (half or full-face)
- long pants
- steel-toed shoes

Plant managers should notify emergency personnel (police and firefighters) of the type and location of the disinfectant(s) used at the plant.

Ozonation

Ozone is an unstable oxygen compound (O_3). Like chlorine, it is a strong oxidant that has been successfully used for years as a disinfectant, although primarily in drinking water treatment plants. It is beginning to be used more in wastewater treatment plants for final disinfection as well as for odor control and advanced treatment. Ozone is generated on-site electrically. It is relatively expensive compared to chlorination, which has limited its use, especially for small systems.

Ultraviolet Radiation

Ultraviolet (UV) light is a relatively short wavelength and has an effective disinfecting capacity at 254 nanometers. UV light has been used for more than 100 years in various germicidal applications. Various types of UV lamps have been developed for use in water and



UV Radiation Hardin Ridge



UV Radiation

wastewater treatment plants. UV light penetrates and damages the genetic material of bacteria and viruses, making them unable to replicate. Unlike chlorine and ozone, UV light is a physical disinfectant, rather than a chemical disinfectant. It does not create any residual chemicals or result in any disinfection by-products.

The effectiveness of UV disinfection depends on the intensity of the light and the contact time, which is affected by the flow rate. Because wastewater systems generally have a wide variation in flow rates, a UV system is usually designed for the maximum flow rate.

UV disinfection, while does not come with the same risks as chlorination, does have safety concerns as it can cause eye damage and skin burns.

Historically, the use of UV light disinfection was limited by its relatively high cost. However, due to advances in UV technology and increasing requirements for de-chlorination, UV disinfection is becoming more economically feasible.

Advanced/Tertiary Treatment (If Nutrient Removal & Filtration Is Needed)

Although definitions vary, in this guide, advanced—or tertiary—treatment refers to any type of treatment beyond secondary treatment. Advanced treatment is not universally required, but it is becoming more common, especially for larger systems. Because most small community systems do not use advanced treatment, it is discussed only briefly here. However, as the need to protect drinking water sources and sensitive areas increases and emerging technologies become more affordable, advanced treatment will be more likely to be applied at smaller systems in the future.

There are several reasons that advanced treatment might be needed. In some cases, secondary treatment may not be sufficient to protect the quality of surface waters. This is especially true regarding nitrogen and phosphorus nutrients. In cases where water quality standards for surface waters are exceeded, point source facilities may be required by their state to reduce the amount

technology used, nutrient removal can result in concentrations of 2 to 8 mg/L of total nitrogen and less than 1 mg/L of total phosphorus. The efficacy of the nitrogen and/or phosphorous removal options will depend on the state and form in which the nutrients are found in the wastewater.

Some states have imposed NPDES limits as low as 3.0 mg/L for total nitrogen and 0.3 mg/L for total phosphorus for treatment plants that discharge to nutrient-impaired waters.

Advanced Treatment for Further Removal of Suspended Solids

Besides nutrients, wastewater that has received secondary treatment may still contain some suspended solids, dissolved organic matter, and other contaminants. This could include some toxic organic compounds that are resistant to biological degradation, trace amounts of pharmaceutical compounds, detergents, and dissolved inorganic matter.

There are several different methods that have been developed to provide further removal of suspended solids and other constituents. One common method is filtration through a granular medium,



Sand Filtration

such as **sand**. This process has been used for many years for treatment of drinking water but also applies to advanced wastewater treatment. Sand filtration treatment usually results in BOD and TSS concentrations of less than 10 mg/L.

Membrane filtration processes, such as microfiltration, ultrafiltration, nano-filtration, and reverse osmosis, are also being applied to wastewater treatment. Nano-filtration and reverse osmosis are able to remove particles as small as viruses and hardness ions. However, these processes require higher levels of pretreatment, operation and maintenance to prevent fouling of the membranes and sustainable performance. Rejected wastewater created during reverse osmosis process may be too concentrated to recycle back into the plant. Membrane filtration treatment can achieve BOD concentrations of less than 5 mg/L and TSS concentrations of less than 1 mg/L.

Membrane bioreactor systems (MBRs)

combine biological treatment such as activated sludge with membrane filtration, which can be more effective in removing solids, organics and pathogens than conventional treatment systems, and are increasingly being incorporated into systems designed to produce reuse-quality effluent. These also have the advantage of not requiring a separate secondary clarifier after the activated sludge treatment basin. However, this high level of treatment is typically associated with greater initial and ongoing operation and maintenance costs.

Handling of Solids

We have examined how wastewater is treated from the time it enters the plant to the time the treated liquid is discharged.



Aerobic Sludge Digester

However, at almost every step in the process, semi-solid residues are produced. For example, as much as one-third of the BOD load of the initial wastewater stream ends up in the primary sludge, the solids produced during primary treatment. Without proper management, these solids can create a major odor problem as the organic component decomposes. Primary and/or secondary sludge is usually stabilized in aerobic or anaerobic digesters to eliminate organic residue decomposition and odor problems, prior to dewatering and disposal.

Although we refer to these residues as solids, they are often more liquid or semi-liquid than solid. Because of their high-water content, these solids have a high volume. This makes them difficult to handle, store and transport.

Formerly, this residual material was referred to as sludge. The term sludge now generally refers only to solids that are still part of the treatment process at the plant, such as secondary sludge collected from the secondary treatment process. Once solids have been processed and have met the criteria for beneficial reuse, they are referred to as biosolids.

The nature of the solids is highly variable from system to system and even within the same system. Primary sludge has different characteristics than secondary sludge. The

solids produced from an activated sludge plant are different from the solids produced by a trickling filter. Some treatment processes work better for some types of solids than others.

Some of the different treatment processes for solids include thickening, dewatering, conditioning, stabilization and drying.

Thickening and dewatering reduce the volume of the solids. Conditioning helps make the dewatering process more effective. Stabilization and drying produce end products that are free of pathogens and will not further decay or produce foul odors.

Thickening

Thickening decreases the volume of the solids by removing some of the liquid. This can be achieved by gravity or by mechanical means.



Aerobic Sludge Thickener

Key Takeaways: Advanced/Tertiary

• Disinfection After Secondary Treatment:

- o Wastewater must be disinfected before discharge to eliminate remaining pathogens.
- o States require disinfection to meet water quality standards.

• Common Disinfection Methods:

- o **Chlorination:** Most common due to low cost but has toxicity risks and can require dechlorination.
- o **Ozonation:** Strong oxidant, used more in drinking water but gaining traction in wastewater treatment.
- o **Ultraviolet (UV) Radiation:** Physical method that avoids chemical byproducts but requires proper intensity and contact time.

• Advanced (Tertiary) Treatment:

- o Not always required but becoming more common, especially for nutrient removal.

o Nutrient Removal:

- Nitrogen is removed through biological processes like nitrification and denitrification or by chemical methods.
- Phosphorus is removed via coagulation with chemicals like alum or iron salts.

o Filtration Methods:

- Sand filtration reduces suspended solids and organic matter.
- Membrane filtration (e.g., reverse osmosis, MBRs) offers high-level purification but is costly.

Methods using gravity involve allowing the sludge to settle and compact in a tank similar to a primary clarifier. The compacted sludge is removed from the conical bottom of the tank. Mechanical means of thickening include the use of centrifuges, gravity-belt thickeners, and rotary drums. Chemical pre-conditioning is necessary for gravity-belt and rotary-drum thickening to be effective.

Although the volume of the sludge is greatly reduced, the thickened sludge is still semi-liquid and would need to be transported in a tank truck if it were to be moved to another facility for additional treatment.

Dewatering

Like thickening, dewatering reduces the liquid content of sludge, rendering it more solid and can be shoveled, moved by belt conveyors, and transported in dump trucks rather than tank trucks. Dewatering is usually necessary if the final solids are to be landfilled, composted or incinerated. Common dewatering methods use various types of centrifuges, belt-filter presses, drying beds and drying lagoons.

The most widely used dewatering method, especially for small and rural communities, is sludge drying beds. Sand drying beds involve spreading the sludge over a bed of sand that is 8 to 12 inches deep. Moisture is removed by drainage through the sand and by evaporation. An underdrain is necessary for removal of the separated water. The advantages of drying beds are that they have very low capital costs, low energy consumption, require little or no chemical conditioning, and require little in terms

of operator skill and attention. However, they take up a lot of space and can be affected by climatic conditions. They can be covered in areas where rain and snow are common.

Drying lagoons have sometimes been used for dewatering digested sludges and are used mostly in areas with high rates of evaporation.

Conditioning

Conditioning usually refers to the addition of chemicals to the sludge to assist with the dewatering process. Conditioning chemicals include synthetic organic polymers and inorganic chemicals, such as ferric chloride, alum and lime. The chemicals do not directly remove water from the sludge but rather alter the characteristics of the sludge so that dewatering processes that follow are more effective. The chemicals are usually applied in a liquid form rather than added dry. Because of the amount added, the inorganic chemicals can increase the final volume of the solids significantly.

Stabilization

Stabilization refers to processes used to produce a final product that has little or no potential to further decompose and create undesirable odors and that is free of pathogens. Some commonly used stabilization methods are alkaline stabilization, anaerobic digestion, aerobic digestion, and composting. Each of these methods has a number of variations.

Alkaline stabilization involves adding alkaline or basic material to the sludge, which raises the pH to a level that will eliminate microorganisms. Typically, either hydrated lime or quicklime is



Dewatering



Dewatered Sludge Bagging System



Sludge Drying Bed

used, although fly ash and cement kiln dust are sometimes used. Because some alkaline stabilization processes are exothermic (heat-releasing), they have the benefit of deactivating worm eggs in the sludge.

Anaerobic digestion involves the controlled decomposition of organic (and some inorganic) matter in the sludge in a closed, heated vessel with no oxygen. This fermentation process has been used for some time, resulting in continual improvements. The process produces significant amounts of methane gas along with carbon dioxide and small amounts of other gases. The amount of methane generated can be enough to make its collection worthwhile even in smaller plants. Some have generated enough heat and electrical power from digester gas to run their plants and even sell excess electricity. Anaerobic digestion, however, requires complex equipment and fairly skilled operation.

Aerobic digestion takes place in the presence of oxygen, usually in open containers. Similar to the activated sludge process, microorganisms are used to consume the biodegradable material in the sludge. Retention times are long enough that almost all biodegradable material is consumed. Advantages of aerobic digestion are that the capital costs of an aerobic digester are less than an anaerobic digester and the required skill level for operation is lower. Disadvantages are that aerobic digesters require significant energy to keep the solids mixed and oxygenated, and they do not produce methane that can be used to generate the power needed.

Stabilization by **composting** also involves the decomposition of organic matter by microorganisms. Composting can take place in either aerobic or anaerobic conditions, but aerobic conditions are almost always maintained as this process is faster. During part of the composting process, heat is generated, which helps to destroy potential pathogens. It is sometimes beneficial to add other materials, such as straw or leaves, to the solids to enhance the composting process. Wood chips are commonly added as a bulking agent to keep the composting material from becoming too compacted. The chips can be screened out later and reused. Composting results

in a material that is hummus-like in consistency that can be used agriculturally.

Regulation of Solids

The processing and final disposal of solids is addressed in the 1993 EPA regulations 40 CFR Part 503, commonly referred to as the “Part 503 rules.” They address how biosolids can be applied to land, how they can be disposed, how they must be stabilized to reduce the number of pathogens and make them less attractive to things that spread disease, like mosquitos, and the requirements for incinerators that burn wastewater biosolids.

THE STAGES OF TREATMENT AT A WASTEWATER PLANT

Preliminary treatment (A)

Primary treatment (B)

Secondary treatment (C)

Disinfection (D)

Solids handling (E)

Final dispersal or reuse (F)

Refer to the diagram showing these steps on page 21

The Part 503 rules establish two levels of quality for biosolids with regard to pathogens and vector attraction. Class A biosolids are safe for use by the general public and can be used for parks, gardens and golf courses. Class B biosolids do not meet all the established criteria for pathogen reduction and can be used for application to agricultural land or disposed of in landfills. Reducing the attraction of vectors involves stabilizing the solids so that there is less potential for disease to be spread by birds, insects or rodents. The Part 503 rules also address heavy metal content.

Sludge testing will also have to include the levels of Per- and Polyfluoroalkyl Substances (PFAS), including PFOA and PFOS contaminants, in the residuals being applied for agricultural use.

Final Dispersal of Effluent

After the wastewater is sufficiently treated, it can be discharged to the environment. There

are several options for final dispersal, including surface water discharge, effluent reuse, and land application.

THE STAGES OF TREATMENT AT A WASTEWATER PLANT

Preliminary treatment (A)
Primary treatment (B)
Secondary treatment (C)
Disinfection (D)
Solids handling (E)
Final dispersal or reuse (F)
Refer to the diagram showing these steps on page 21

Surface Water Discharge

Surface discharge is the direct discharge of wastewater effluent to a surface body of water. This is the most common form of effluent disposal. It is a viable option if an appropriate receiving stream is available and if regulatory agencies permit such a discharge. The required level of effluent treatment varies, but generally the effluent must meet the minimum secondary treatment standards and be disinfected. An NPDES permit or the state equivalent is necessary. Depending on site-specific conditions, more stringent discharge requirements, such as limitations on nutrients, may be applicable.



Surface Water Discharge

Effluent Reuse

Effluent-reuse systems use treated wastewater directly or indirectly as an alternative water

source. The minimum required treatment for reuse consists of primary and secondary treatment. Advanced treatment is required when high-quality reclaimed water is needed for sensitive areas, such as agricultural crops for human consumption. The factors that affect the feasibility of effluent reuse include treatment and transportation costs; availability and cost of potable water; reclamation potential of the wastewater; and water quality standards. Reuse is becoming increasingly more common.



Effluent Discharge Point (also known as "Outfall")

Land Application

Small systems may be permitted to apply waste-water effluent to land surfaces. Methods of surface disposal include spray irrigation, overland flow, and rapid infiltration. These methods combine additional treatment with final dispersal.

Spray irrigation systems apply treated effluent above ground to reclaim and disperse wastewater and is the most common land application. The area to be irrigated must be vegetated and landscaped to minimize runoff and erosion. The wastewater must be treated to a level high enough to protect public health and reduce odors. For this reason, the wastewater must be disinfected. After treatment and disinfection, a pump equipped with timers sends the wastewater under pressure through the mains and lines of the spray distribution system at preset times and rates.

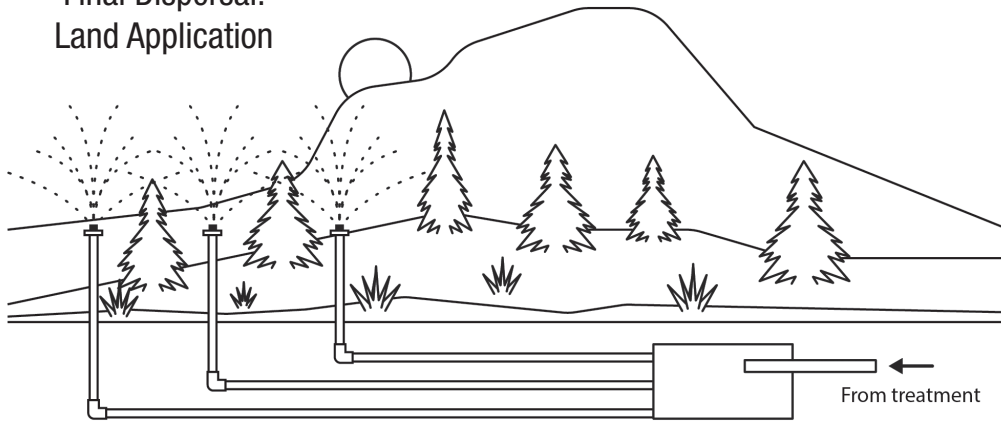
In **overland flow dispersal**, wastewater effluent is applied at the upper end of a treatment area, and it flows in a thin film over the site before it reaches a runoff collection ditch.

The ditch may then transport the remaining effluent to a reuse option or surface water discharge point. With this method, plants on the land may absorb the effluent and remove the nutrients, or the wastewater may evaporate. Although best suited to sites with impermeable soils, overland flow has been used successfully on moderately permeable soils.

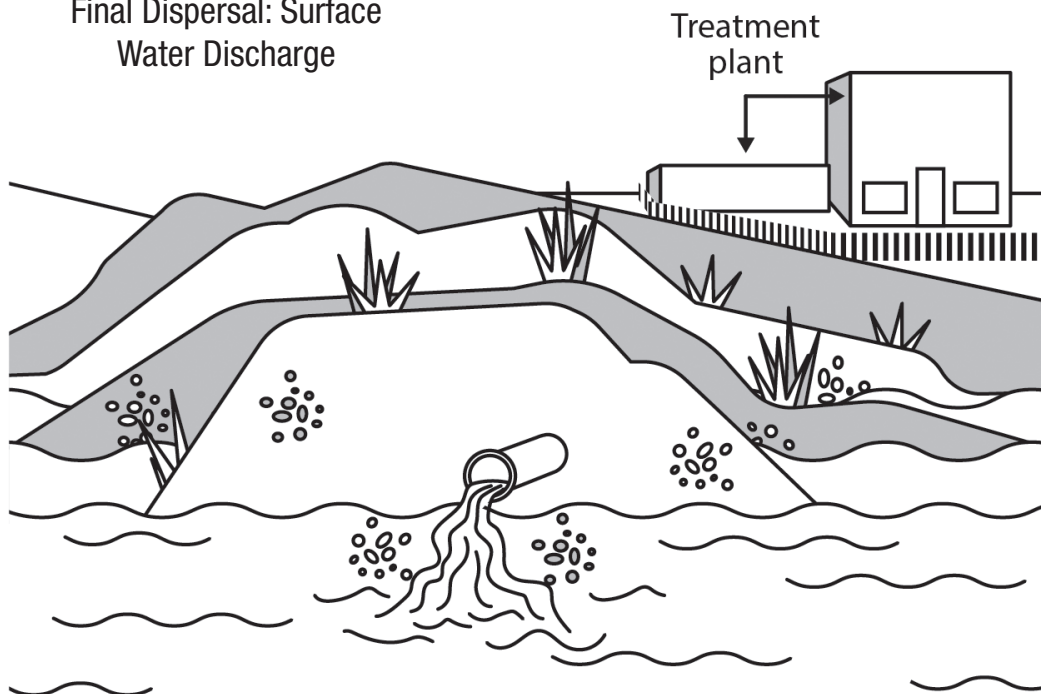
Rapid infiltration systems apply wastewater

effluent to highly permeable soils, such as sand and loamy soils, by spreading it in basins or by sprinkling it on ground surfaces. As the effluent moves through the soil, it undergoes additional treatment. A portion of the treated effluent may eventually reach the groundwater. Vegetation is optional, although a grass cover helps remove suspended organic and inorganic solids and nitrogen.

Final Dispersal:
Land Application



Final Dispersal: Surface
Water Discharge



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Lagoons for Wastewater Treatment

So far, this guide has focused on the treatment that takes place in mechanical treatment plants. However, as many as one-quarter of all community wastewater treatment systems, mostly in smaller communities, use lagoons and other natural systems such as marshes and constructed wetlands, to treat their wastewater. Lagoons, or stabilization ponds, in many ways function similarly to mechanical treatment plants. They are designed to provide primary and secondary treatment, although treatment occurs more slowly in lagoons than in mechanical plants. To compensate, the retention time in lagoons is much longer, usually several weeks or more.

The primary advantages of lagoons are that they are less expensive and simpler to construct, operate and maintain. Solids generally accumulate slowly and must be removed only every ten to twenty years.

Their primary disadvantages are that they do not work as well during times of low flow or under extreme winter conditions that can affect removal rates of some contaminants, especially ammonia, and they can take up more space than mechanical plants. The disadvantage of taking up more space, however, is not always a major issue in rural areas, where land is usually more readily available.

Most lagoon systems have a number of individual ponds or “cells” that are connected. The cells can be arranged in a series, parallel, or a combination of both. Lagoons in series are preferred for maximum removal rates. As the wastewater passes through a series of ponds, it is expected to improve in quality with each step. Final cells, which are usually lightly loaded, are referred to as “polishing cells.” In some cases, these may be constructed wetlands or marshes.



Left - Berm and Secondary Lagoon Treatment Cell. **Top Right** - Secondary Lagoon Treatment Cell **Bottom Right** - Retention Lagoon.

Lagoon Treatment Variations

Lagoons are classified as aerobic, anaerobic, or facultative, based on their oxygen content:

Aerobic lagoons have some dissolved oxygen distributed throughout most of the pond, except for the very bottom.

Anaerobic lagoons have no dissolved oxygen content.

Anaerobic ponds are typically the first cell in a series of ponds. Solids settle out on the bottom, providing primary treatment. Anaerobic bacteria convert organic material to simple compounds, such as methane and hydrogen sulfide. These are then oxidized to carbon dioxide, sulfate, and water in the following aerobic cell.

Facultative lagoons have an oxygenated aerobic layer and an anaerobic layer without oxygen. Facultative lagoons have both oxygenated aerobic and anaerobic zones without oxygen within the same cell. The anaerobic zones are mostly at the bottom of the pond at the inlet end, where solids enter and settle out to be digested by anaerobic bacteria. The aerobic zone is the upper layer. Facultative lagoons can be mechanically aerated.

Aerobic lagoons are further classified as aerated and non-aerated:

Aerated lagoons use mechanical aerators to maintain some oxygen in the water. The aerators are usually the only major mechanical component of a lagoon system. Aerated lagoons are 10 to 15 feet deep.

An aerobic lagoon does not necessarily require mechanical aeration, however. The oxygen needed by the beneficial bacteria that break down organic matter in the wastewater can often be supplied by the natural transfer of oxygen at the surface of the pond and by oxygen generated by algae in the pond during photosynthesis.

Non-aerated aerobic lagoons are usually 3 to 8 feet deep. Oxygen transfer is affected

by the amount of wind, the temperature of the water (more oxygen is dissolved at lower temperatures) and the depth of the lagoon.

Construction Considerations

Lagoons are constructed through a process of excavation, with the excavated material used to build an earthen dike perimeter. Generally, no earthen material needs to be brought in from offsite. Lagoons are typically lined with bentonite clays, and/or geotextile liners to prevent seepage.

Care should be taken to ensure that no biological or plant residue is incorporated into the sub-liner, as this may cause gas formation due to degradation of the materials. Gas formation may lift geotextile liners above the lagoon surface and cause the liner to degrade and perforate.

Lagoon systems can provide secondary treatment, effectively reducing the BOD and suspended solids load. However, because the microorganisms that provide biological treatment are less active in cold weather, treatment is less effective in winter, especially in northern areas. Lagoons located in colder areas are designed to accommodate a certain amount of storage ("freeboard") so that wastewater can be retained and discharged only when it meets permit conditions.

Lagoon Maintenance

Routine upkeep of wastewater lagoons is crucial for maintaining efficient treatment processes and mitigating potential environmental concerns. Regular mowing and vegetation management help control vegetation growth, prevent shading, and maintain access roads. Sludge removal and dredging are necessary to maintain treatment efficiency and prevent lagoon overflow. Water level management involves monitoring and adjusting water levels to maintain optimal treatment conditions and prevent overflow.

Aeration and mixing systems require maintenance to ensure effective treatment

performance and prevent equipment failure. Regular sampling and testing help monitor treatment efficiency, identify potential issues, and ensure compliance with regulatory requirements. When performing maintenance, inspect lagoon banks and fix any erosion

damage to prevent further erosion, this will ensure structural integrity of the lagoon. Pest and wildlife control measures prevent pest and wildlife issues that can have an impact on treatment efficiency and cause damage to lagoon dikes by burrowing.

Key Takeaways: Lagoons

Advantages of lagoons: generally lower capital cost, simpler and less expensive O&M, and less frequent need to remove solids.

Disadvantages of lagoons: Don't work as well during low flow or extreme weather, can have a relatively larger footprint; public concerns about land application of solids; possibility of need for mechanical upgrades to keep up with evolving anti-degradation rules/regulatory landscape.

- Aerobic lagoons have dissolved oxygen throughout the pond except at the bottom.
- Anaerobic lagoons have no dissolved oxygen.
- Facultative lagoons have an oxygenated aerobic layer and an anaerobic layer without oxygen.
- Lagoons are either aerated, to maintain oxygen levels in the pond, or non-aerated.

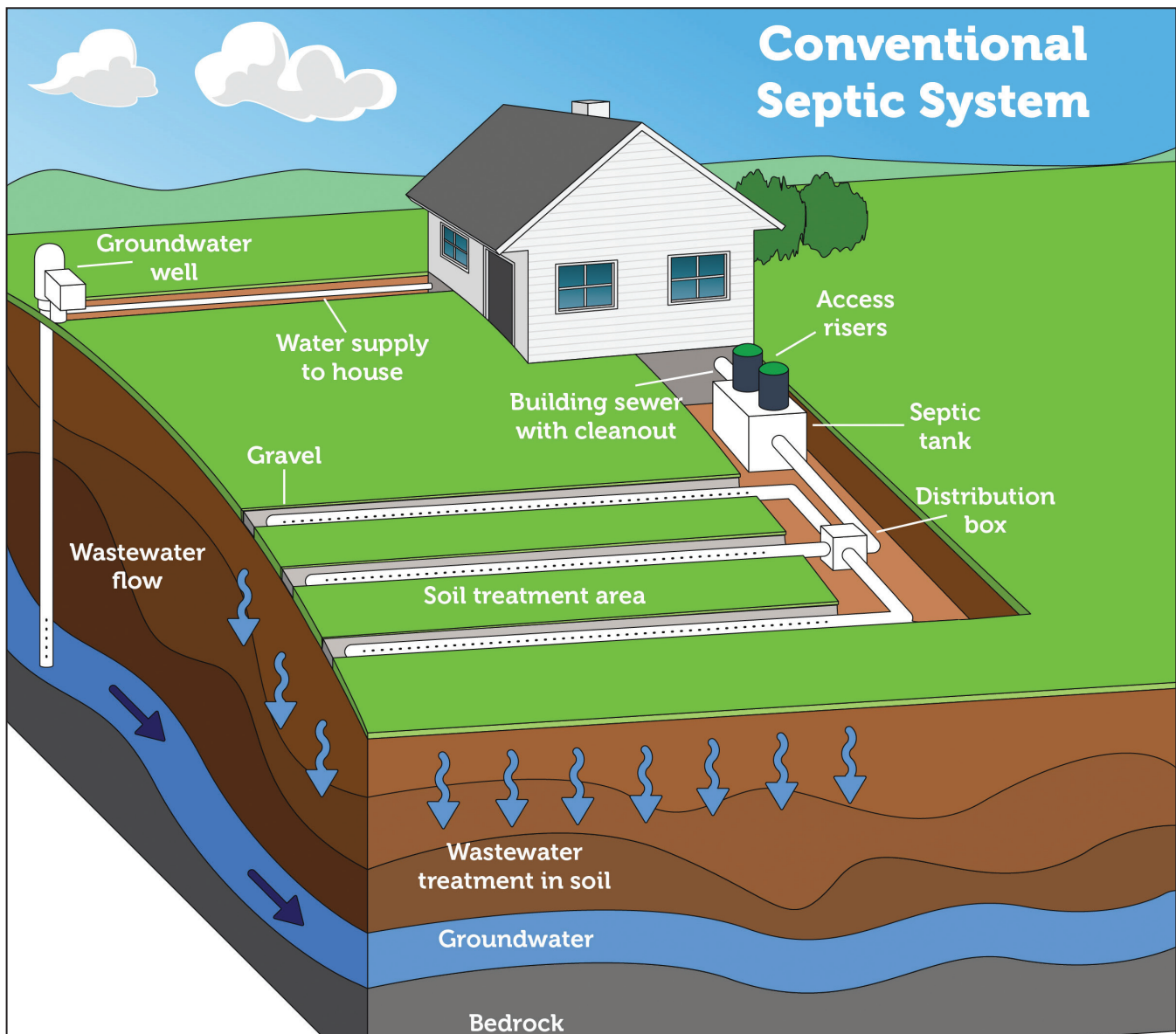
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What are Decentralized Wastewater Systems?

Decentralized wastewater treatment systems serve more than 20 percent of homes in the United States, and a much higher percentage in rural communities. These systems collect, treat, and disperse or reuse wastewater at or near the point of generation, serving individual homes, clusters of homes, small developments, or institutions. They are a practical alternative to extending centralized

sewer service long distances and are often used to replace aging or malfunctioning systems or support moderate growth.

Like centralized systems, decentralized systems must be properly sited, designed, installed, operated, and maintained to provide sustainable, long-term protection of public health and the environment. Regardless of scale, decentralized



systems rely on the same fundamental treatment principles as centralized plants:

- **Physical separation** of solids,
- **Biological treatment** by microorganisms, and
- **Filtration and polishing** through soil or engineered media.

Onsite Wastewater Treatment System (OWTS) Core Components:

There are several variations of OWTS in use today, varying from older legacy systems whose design criteria was simply to dispose of effluent into the environment, to modern advanced treatment systems producing water with near-complete removal of pathogens, highly reduced nutrient loads, and that may be suitable for safe non-potable indoor re-use or landscape irrigation. Design, installation and management are generally controlled by local and state rules, typically through a permit process. Design is based upon quantity and quality of wastewater generation, specific site and soil characteristics, intended end uses, and limiting factors posed by potentially impacted groundwater and surface water resources.

Septic systems are the most common type of OWTS, with pretreatment of sewage in a septic tank, and final treatment and dispersal of effluent in a soil treatment area (also called the “soil absorption area,” “drainfield,” or “leach field”).

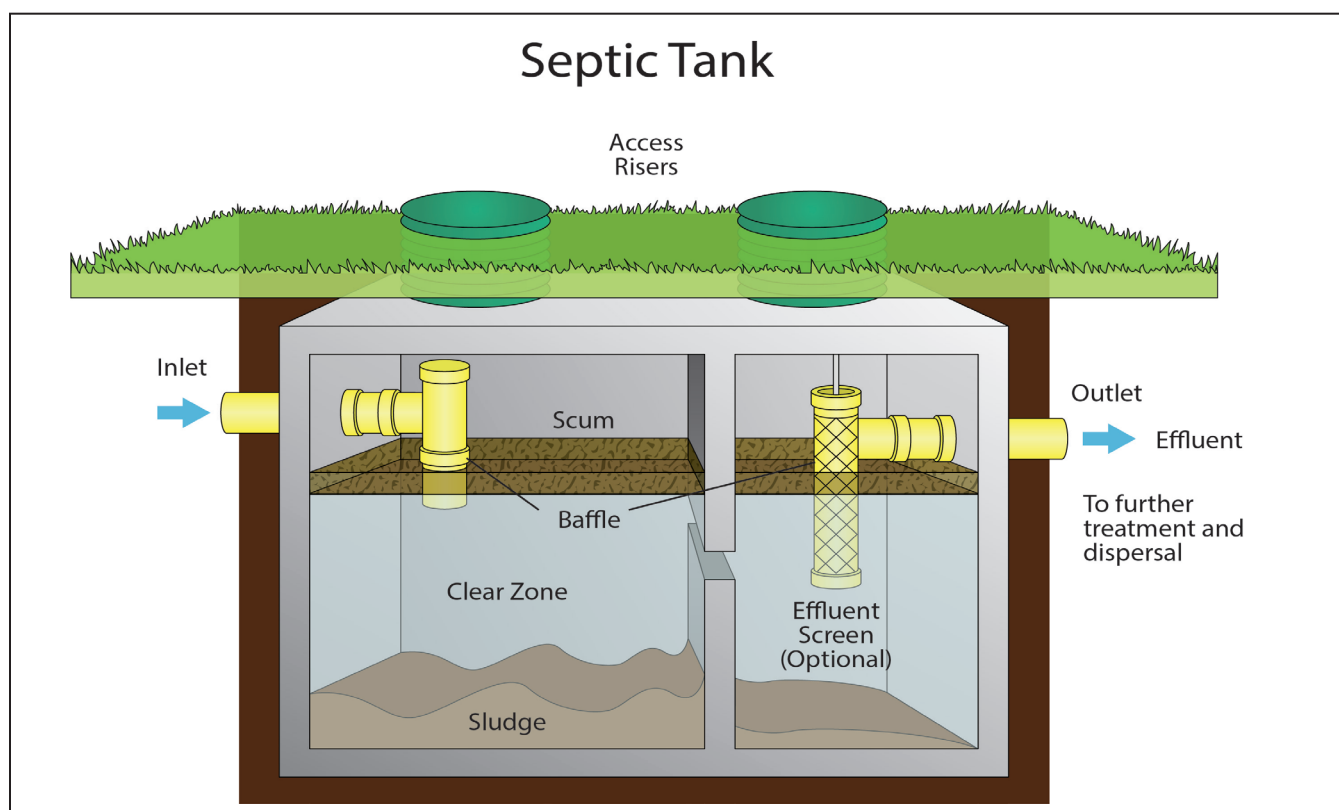
The Septic Tank

The **septic tank** is typically the first component of the septic system. It is a buried, watertight tank—typically 1,000 gallons or larger depending on home size and projected flow. It functions as a settling and digestion chamber.

Inside the tank:

- Heavy solids settle to the bottom, forming a **sludge layer**.
- Greases and lighter materials float to the top, forming a **scum layer**.
- Partially clarified liquid (effluent) remains in the middle zone.

Baffles or sanitary tees at the inlet and outlet slow incoming flow and prevent solids from leaving the tank. Many modern systems include



an **effluent screen or filter** at the outlet to capture remaining suspended solids.

Anaerobic (oxygen-limited) bacteria partially digest organic matter, reducing sludge volume. However, digestion is incomplete; solids accumulate and must be pumped periodically. If not pumped, solids can carry over into the drainfield, causing clogging and premature failure.

Watertight construction is essential to prevent groundwater from entering the tank or untreated sewage from leaking out. Access risers and secure lids are important for inspection, pumping, and public safety. Tanks must be inspected and pumped periodically; failure to do so commonly results in drainfield failure and costly replacement.

Soil Treatment Area

Final treatment occurs in the soil. Effluent is distributed through perforated pipe in gravel-filled trenches, chambers, or similar media. As wastewater moves through unsaturated soil, aerobic bacteria remove pathogens, organic material, and other pollutants before the water reaches groundwater.

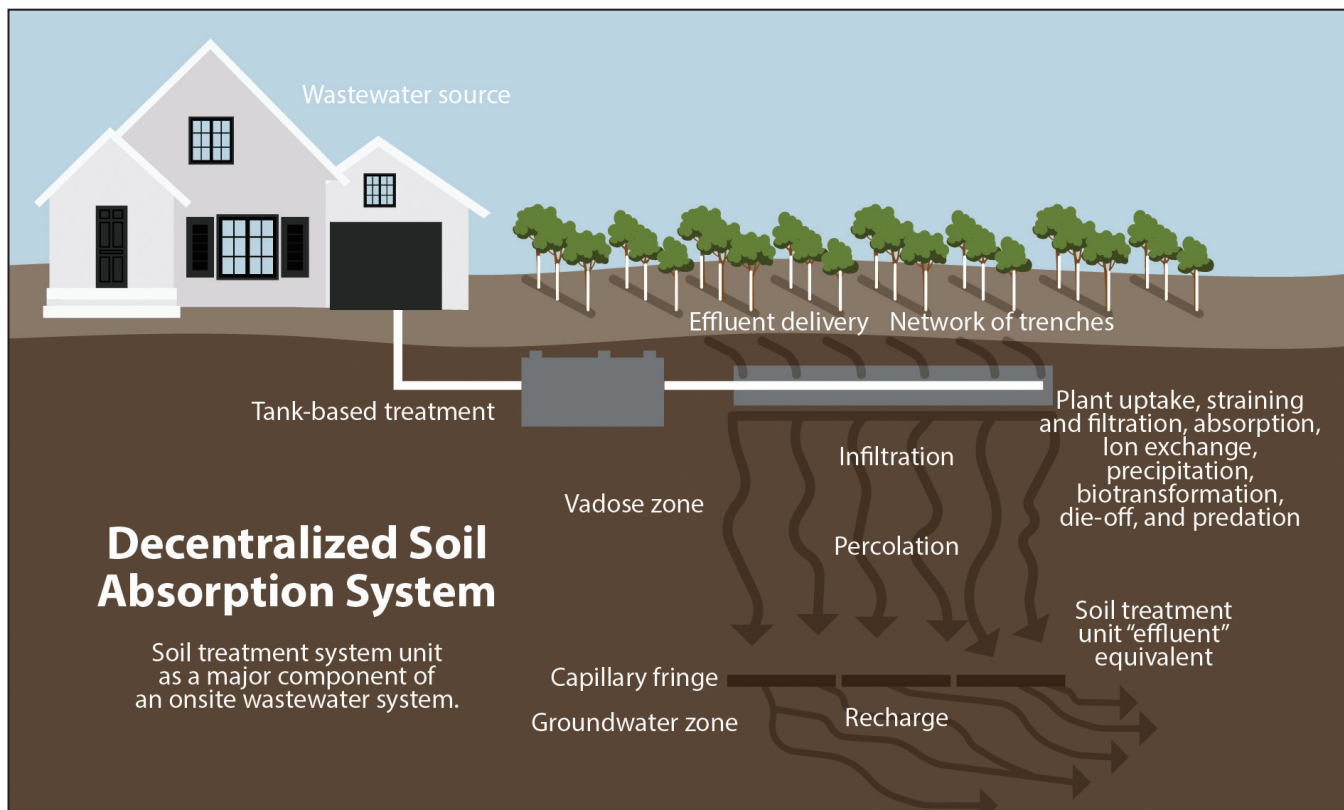
The drainfield provides most of the pollutant removal. Effluent flows into perforated distribution pipes placed in gravel trenches, chambers, or other porous media. From there, it infiltrates into unsaturated soil.

Treatment occurs through:

- **Filtration**, as solids are trapped in soil pores;
- **Aerobic microbial activity**, which removes pathogens and organic material;
- **Adsorption and chemical processes** that reduce nutrients and other contaminants.

A biologically active layer (sometimes called the biomat) forms at the infiltrative surface. When properly loaded, this layer enhances treatment. When overloaded, it can restrict flow and cause surfacing or backups.

Soil characteristics are the key design factor. Adequate depth to seasonal high groundwater, bedrock, or restrictive layers must be maintained. Setbacks from wells, surface waters, property lines, and buildings are required to protect water



resources and public health. Successful soil treatment requires:

- Unsaturated conditions (oxygen present),
- Adequate vertical separation to groundwater or bedrock,
- Soils with appropriate permeability (not too fast, not too slow).

When gravity flow is not possible, a pump tank may be used to lift effluent to the drainfield.

System size is based on projected wastewater flow and site-specific soil evaluation performed by trained professionals.

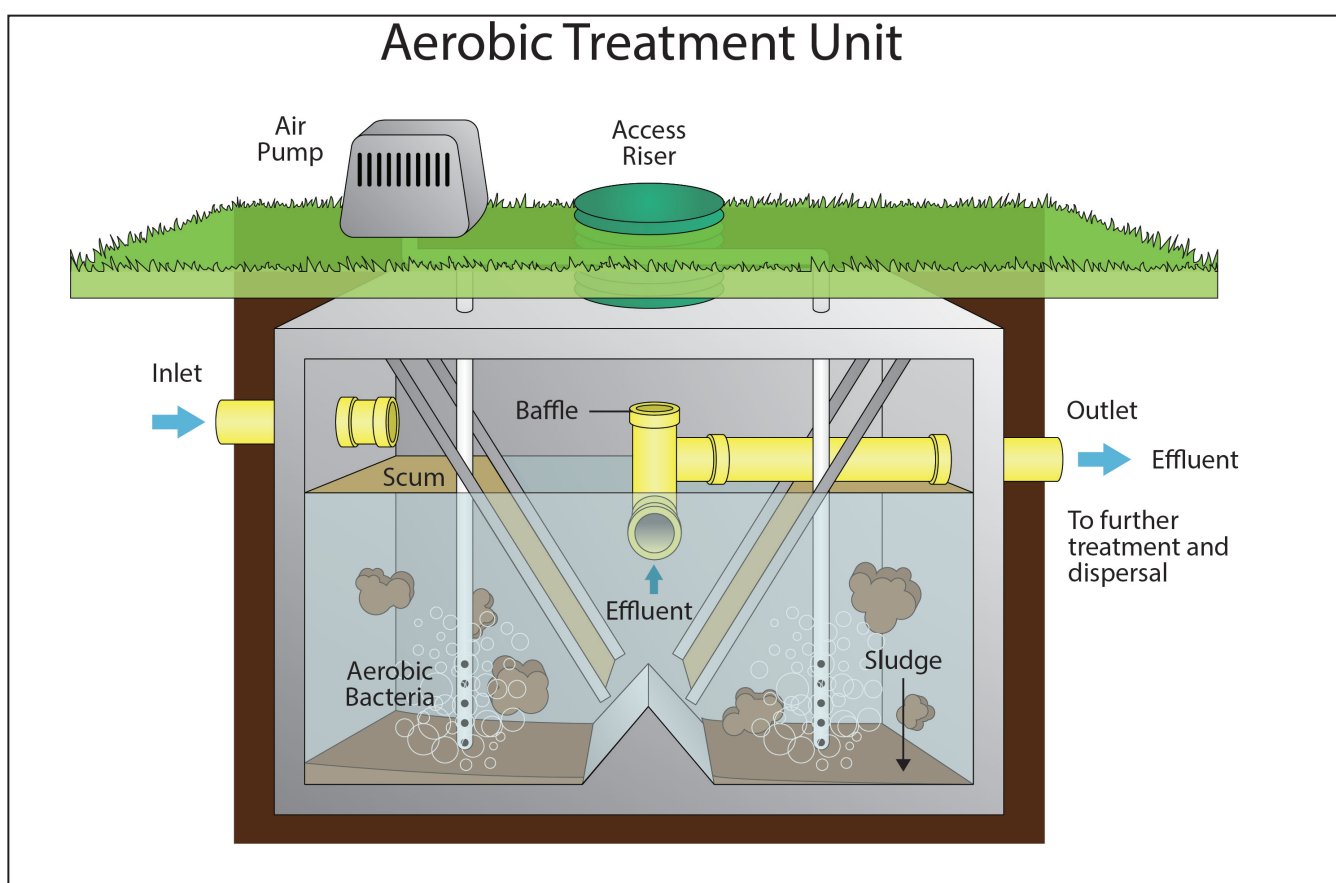
Advanced Pretreatment and Enhanced Dispersal

Many properties do not have favorable conditions for installing a conventional septic system with a septic tank and simple gravity-flow drainfield. A site may have poor soil conditions, a high water table, or it may be too



Aerobic Treatment Unit (ATU)

small to accommodate a conventional drainfield. In these cases, there are a wide variety of options, referred to as alternative systems. These other systems also provide treatment onsite. They usually involve providing additional treatment so that the water going



to the drainfield is of a higher quality or using some alternative form of final dispersal. Sometimes both are necessary.

In areas with limited soils and other site constraints, higher effluent quality may be required before discharge to the soil. Advanced pretreatment units (such as **aerobic treatment units [ATUs]**, **sand filters**, **peat filters**, or other media filters) can significantly reduce organic material, nutrients, and pathogens. These systems function similarly to small treatment plants and require reliable power, routine inspection, and professional maintenance:

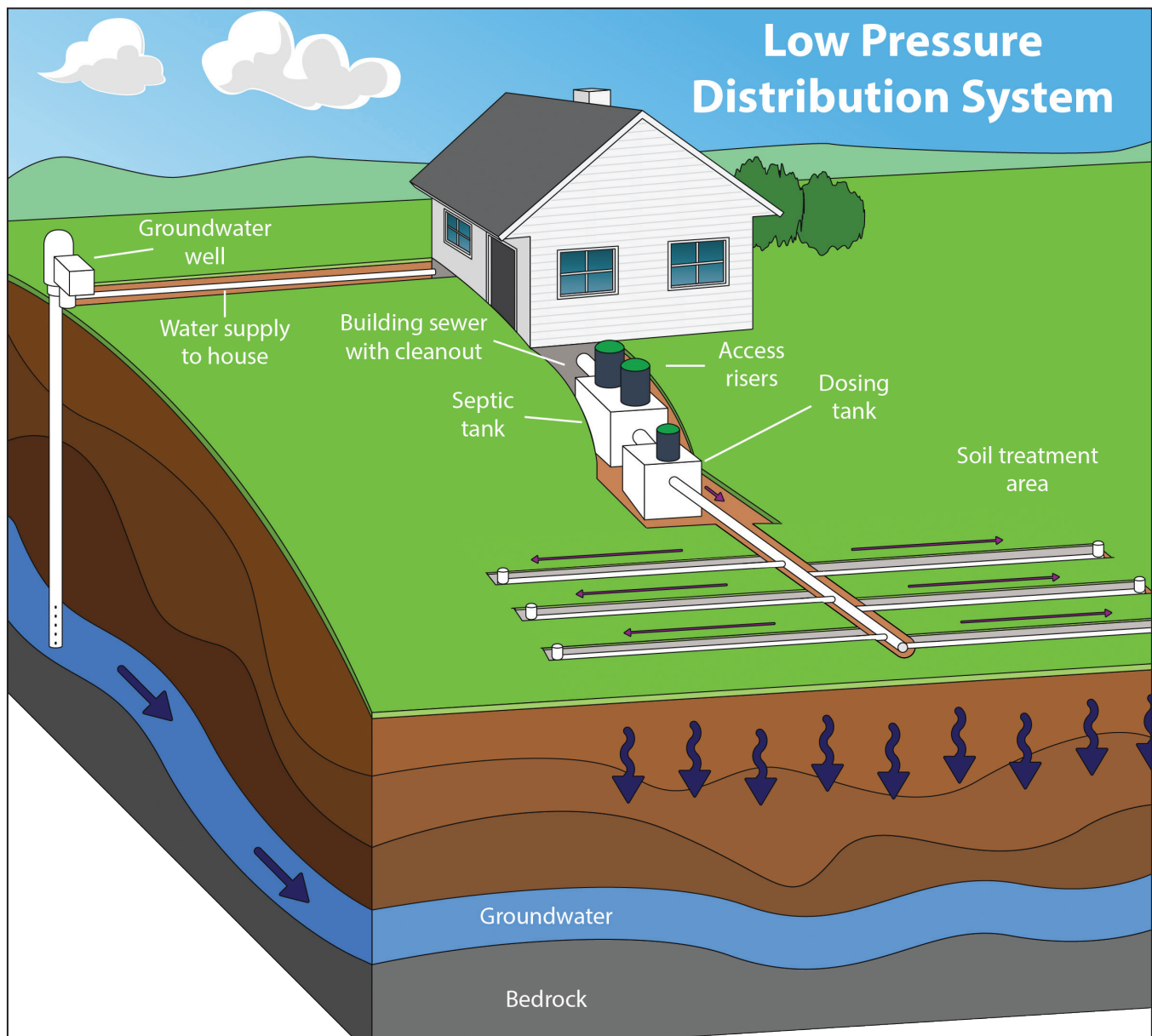
- Air is introduced into the treatment chamber using a blower or mechanical aerator.

- Aerobic bacteria break down organic matter more rapidly and completely than in septic tanks.
- Clarified effluent moves to settling and sometimes disinfection stages.

More information on decentralized pretreatment technologies can be found in Appendix D.

Enhanced dispersal methods improve how effluent is applied in difficult soils or high groundwater areas:

- **Low-pressure distribution (LPD)** systems evenly dose multiple trenches. Effluent is pumped under low pressure through



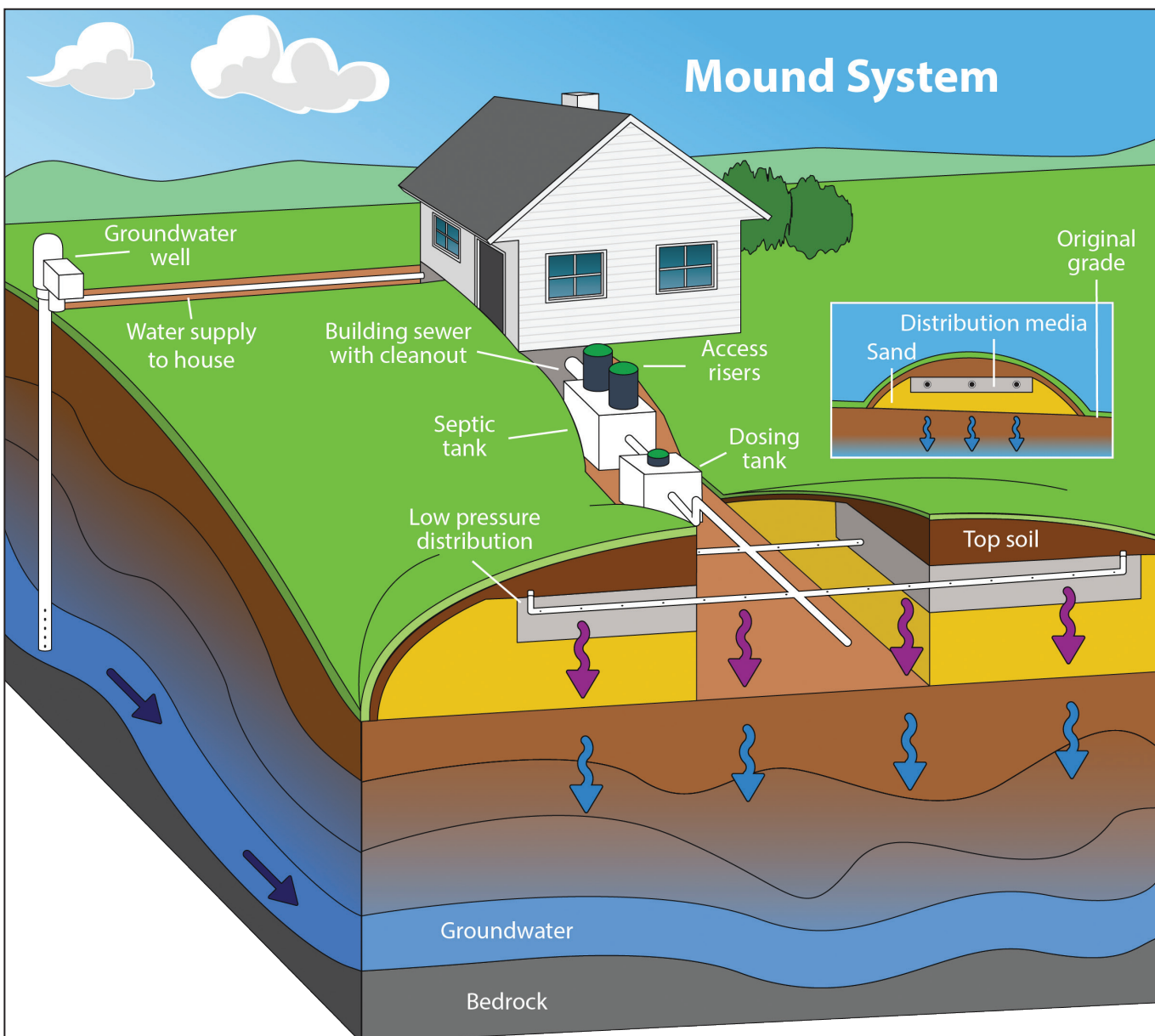
small-diameter pipes with closely spaced orifices. This ensures even distribution along the trench length, preventing localized overloading.

- **Drip dispersal systems** apply treated wastewater slowly and uniformly through shallow tubing near plant roots. Timed dosing allows soil to rest between applications, improving oxygen transfer and treatment efficiency.
- **Mound systems** elevate the drainfield using imported sand to provide additional separation from high groundwater or

shallow bedrock. Where vertical separation to groundwater or bedrock is insufficient, imported sand fill is placed above natural grade to create an elevated treatment area. Effluent is pumped into the mound and treated as it moves downward through the engineered sand and underlying soil.

As treatment performance increases, so do operational oversight and maintenance requirements.

Surface discharge or spray irrigation systems require advanced pretreatment and typically disinfection. Discharge to surface waters



requires a National Pollutant Discharge Elimination System (NPDES) permit and ongoing regulatory compliance.

Water reuse (such as for landscape irrigation or toilet flushing) may be considered in some applications but requires resilient design and active management to ensure public health protection.

Cluster Decentralized Systems

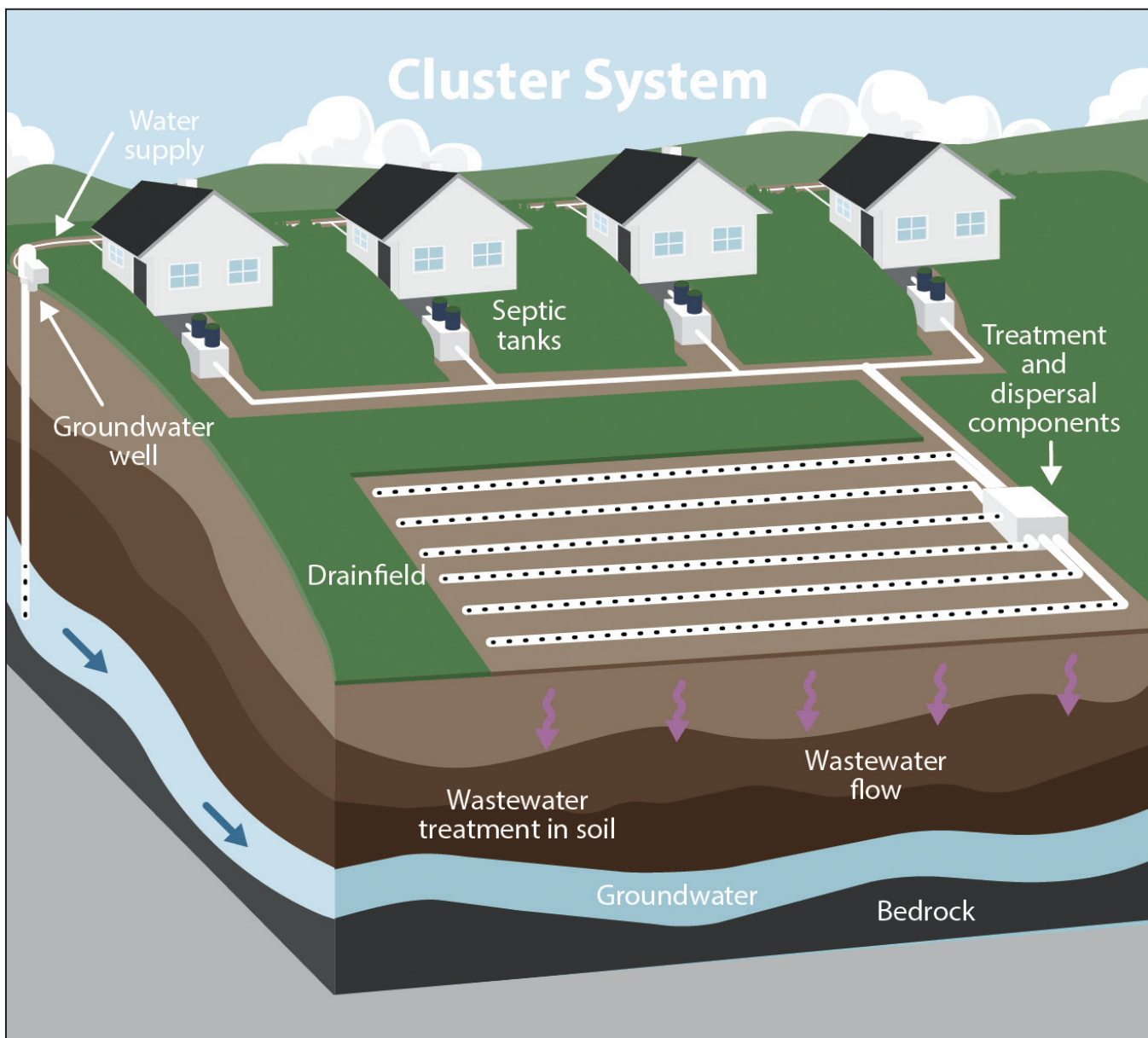
Cluster systems combine individual onsite pretreatment (often septic tanks at each home) with shared community treatment or

dispersal facilities. Instead of each property having its own drainfield, effluent is conveyed to a centralized soil treatment area or other treatment unit.

Cluster systems can be cost-effective where:

- Individual lots cannot support replacement drainfields;
- Lakefront or environmentally sensitive areas require improved treatment; or
- Extending centralized sewer service is financially prohibitive.

They often use alternative collection technologies such as STEP (Septic Tank Effluent



Pump) pressure sewers. Pretreatment at each property reduces solids loading to the shared dispersal area.

Because cluster systems function as small utilities, a legally authorized and adequately funded management entity must be established before operation begins. Governance, inspection authority, and stable funding are essential to long-term performance.

Operations, Management and Asset Planning in Decentralized/Onsite Systems

Decentralized systems are sometimes viewed as “low maintenance,” but sustainable performance requires structured oversight. Responsibilities may include:

- Maintaining a system inventory
- Establishing inspection and pumping schedules
- Tracking advanced system service contracts
- Educating homeowners
- Planning and funding repairs and replacements



OWTS Control Panel

As system complexity increases—such as with pumps, pressure dispersal, or advanced pretreatment—professional operation and maintenance become increasingly important (i.e. routine inspection/maintenance visits by a professional service provider).

Success entails a life-cycle management approach, with important complementary roles played by the homeowner, soil evaluator, system designer, installer, and regulatory agency acting in concert.

After the system is placed into service, ongoing performance that meets both the owner’s needs and remains protective of public health and the environment may require actions and collaborations between the system user, professional management entity and regulator.

Having the system owner understand what their system is, and its on-going management needs, are perhaps the most important to convey. An excellent available resource is the **Onsite Wastewater Treatment System Users Guide (RCAP, 2023)** (see link in Resources) and accompanying training modules.



OWTS Assessment RSOL

Another resource is EPA's "*Voluntary National Guidelines for Management of Onsite and Clustered Decentralized Wastewater Treatment Systems*," which describes five representative "*Model Programs*," with the level and intensity of management in each successive model increasing as the system complexity and environmental sensitivity of the area increase (EPA, 2003, 2005).

Communities should also plan for long-term repair and replacement. Even well-maintained systems eventually age and may be affected by flooding, sea-level rise, wildfire, or other natural disasters. Designated repair areas, financial assistance mechanisms, and reserve planning help prevent emergency failures and protect continued occupancy of served homes.

Key Takeaways: Decentralized Wastewater Treatment

- **Purpose & Role** – Decentralized systems serve homes and small communities at the source and rely on physical, biological, and soil treatment to protect public health.
- **Regulation & Design** – Governed by state/local permits; design is based on flow, soil/site conditions, environmental sensitivity, and intended use with required oversight.
- **Septic Systems** – Include a watertight septic tank for primary treatment and a soil treatment area for final treatment and dispersal; tanks require periodic pumping.
- **Soil Treatment Areas** – Effluent infiltrates unsaturated soil for filtration and biological treatment; adequate separation, permeability, and setbacks are essential.
- **Advanced Pretreatment** – Technologies like aerobic units and media filters improve effluent quality but require power, routine inspection, and professional maintenance.
- **Enhanced Dispersal & Discharge** – Low-pressure, drip, and mound systems improve distribution; surface discharge or reuse requires advanced treatment and permits.
- **Cluster Systems** – Combine onsite pretreatment with shared treatment/dispersal; require a formal, funded management entity before operation.
- **Operations & Asset Management** – Require system inventories, inspections, pumping schedules, service contracts, and planning for repair and replacement.
- **Governance & Collaboration** – Sustainable performance depends on coordination among owners, professionals, regulators, and responsible management entities.
- **Resilience & Long-Term Planning** – Proactive funding, repair areas, and management programs reduce risk from aging systems and natural disasters.

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System Troubleshooting: Inflow and Infiltration

The EPA defines **inflow** as water other than sanitary wastewater that enters a sewer system from sources such as roof leaders, cellar/foundation drains, yard drains, area drains, drains from springs and swampy areas, manhole covers, cross connections between storm sewers and sanitary sewers, and catch basins.

Infiltration: water other than sanitary wastewater that enters a sewer system from the ground through defective pipes, pipe joints, connections, or manholes.

Inflow and infiltration (I&I) are common problems that plague most wastewater systems. I&I can cause capacity issues in both the collection system and treatment plant if gone untreated. Some common problems associated with I&I include overflows, backups, and increased energy and chemical costs, as well as infrastructure damage.

With today's technology, there are several ways to inspect/monitor I&I, and some methods as simple as a visual inspection.

Manhole Inspection: It is a good practice to do manhole inspections after a rain event when possible. In a manhole with a brick chimney, this will allow you to see if rainwater or groundwater is entering the manhole between the bricks where the old grout weathered away over time. This will also allow you to look for leaks around seals on stacked precast concrete manholes, as well as around the ring and lid. Modern manholes have a rubber boot connector where the pipe enters the manhole, but that was not always the case with poured in place manholes or brick chimney manholes. In poured in place or brick chimney manholes, the grout surrounding the pipe entering the manhole wears away over time allowing infiltration to take place. This is another good place to check for manhole failure and I&I. Check to see if the manhole is above or

below grade when doing the inspection. Get GIS coordinates of the manhole if applicable to draw and update maps.

Smoke Testing: Smoke testing is done by forcing non-toxic smoke into the sewer system through different access points, which are typically manholes. The smoke enters all the pipes in the sewer system and will come out where there is a broken or cracked pipe, unsealed manholes, storm water cross connections as well as broken or open cleanouts to name a few. Communicate with the homeowners in the areas where smoke testing will take place and ask them to pour water into the drains of all the plumbing fixtures in the house to fill the traps under each sink. Although the smoke is non-toxic, this will cut back on the smoke entering homes. Also, coordinate with the local fire department and police department before doing a smoke test so they are prepared for any calls they may get. Some added benefits of smoke testing include finding manholes that have been covered up, illegal connections, and finding water leaks in the water distribution system that are inflowing into the sewer collection system.

CCTV: Closed Circuit TV cameras (CCTV) are a great way to inspect the inside of the sewer lines, where deficiencies were located during smoke testing. CCTV inspections can also help identify areas of grease buildup or root intrusion into the system as well as illegal taps. While CCTV inspections are generally more expensive than the other methods, it is a good trenchless method to see visually what is happening inside the collection line. It is worth noting that some municipal insurance providers offer small grants to the systems they cover to camera a pre-determined number of feet of sewer line per year.

Flow Monitoring Devices: Flow monitoring devices can be a valuable tool in troubleshooting

inflow and infiltration in the collection system. These devices provide instantaneous flow rate measurements of wastewater, providing valuable, up to the minute data to identify and locate I&I sources. There are several types of flow monitoring devices used in wastewater collection systems. This includes ultrasonic flow meters, magnetic flow meters, acoustic flow meters, and open channel flow meters.

Ultrasonic flow meters use high-frequency sound waves to measure flow rates, while magnetic flow meters use a magnetic field to measure the velocity of wastewater. Acoustic flow meters use sound waves to measure flow rates. There are multiple configurations in which you can install these types of meters. In pipe installation, insertion probe installation, and clamp on installation are a few of the more common configurations. Open channel flow meters are designed to measure flow rates in channels, streams and other open

flow applications, including manholes. They use techniques that include ultrasonic, radar, and acoustic sensors to measure flow rates. This provides accurate measurements in a range of collection system applications.

Flow monitoring devices are generally installed in strategic areas throughout the collection system. These areas include places where I&I is expected, areas where sanitary sewer overflows occur regularly and in areas with known high flow rates. These devices can determine if storm water is entering into the collection system through cracks, leaks, or other defects.

A rainfall/flow correlation analysis can be done by analyzing the relationship between rainfall intensity and corresponding changes in flow rates. The data can be used to provide insight into the impact of rainfall on the wastewater collection system and the magnitude and timing of inflow contributions.

A Strong Sewer Use Ordinance Protects Your System

A well-crafted Sewer Use Ordinance is one of the most important tools a community has to protect its wastewater infrastructure, treatment performance, and public health. An effective ordinance clearly defines prohibited discharges, restricts harmful commercial and industrial wastes, and authorizes inspections and enforcement. It should explicitly prohibit illegal connections—such as sump pumps, roof drains, and foundation (French) drains—that introduce excess inflow and infiltration, overload pump stations and treatment facilities, and drive up operating costs.

Equally important is controlling what enters the system from homes and businesses. “Flushable” wipes, grease, disposable hygiene products, and other debris clog pumps and damage equipment. Pharmaceuticals and personal care products (PPCPs)—including drugs, lotions, soaps, and cosmetics—are an increasing concern. Wastewater treatment was not designed to remove many of these compounds, and trace amounts can pass through to receiving waters.

Studies have linked PPCPs in waterways to endocrine disruption in aquatic life and the development of antibiotic-resistant bacteria. Although the long-term human health impacts remain under study, the potential risks warrant precaution.

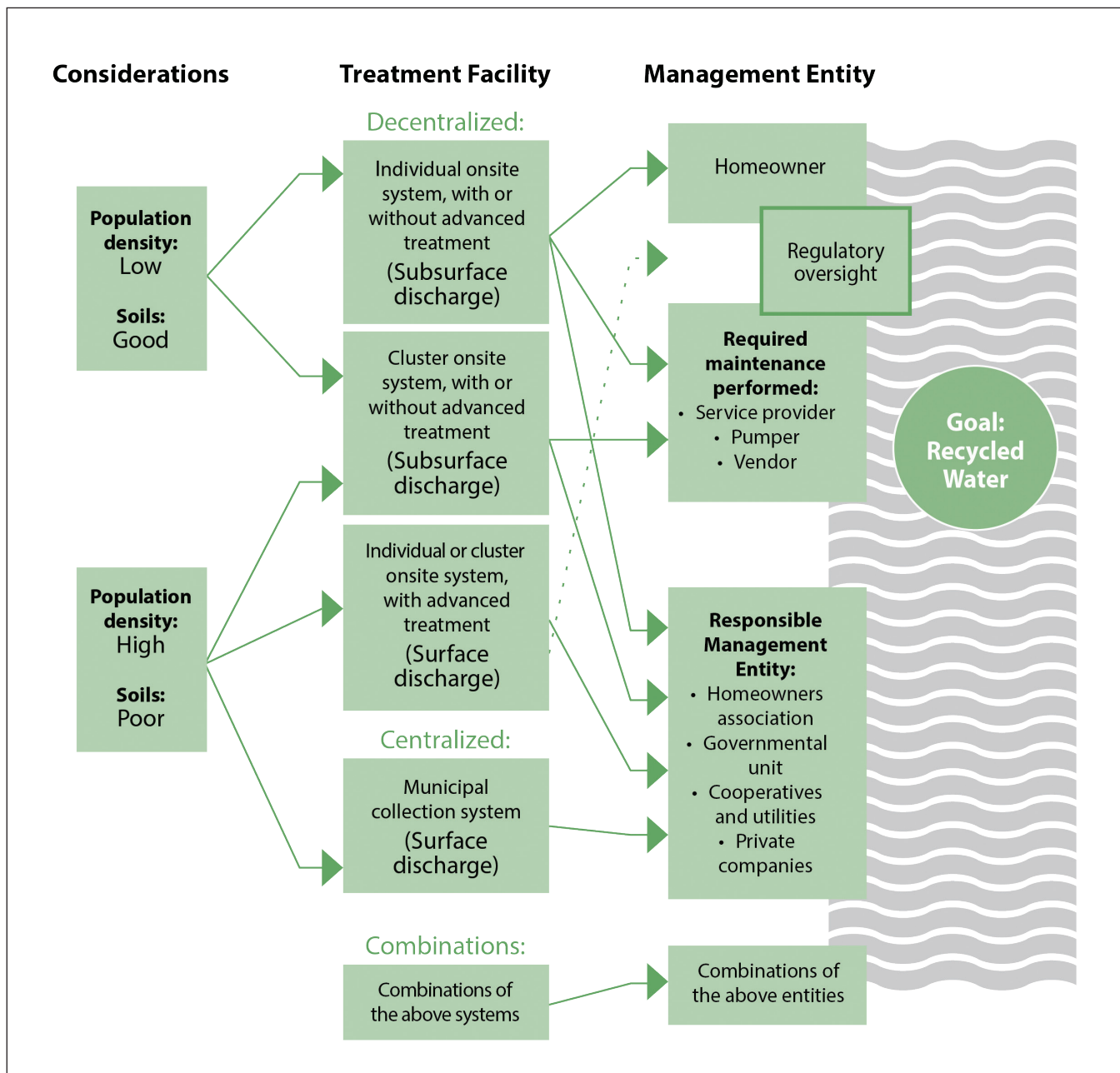
Board members and community leaders should pair a strong ordinance with active public education. Outreach campaigns, bill inserts, and take-back programs can reinforce that toilets are not trash cans. Residents should be encouraged not to flush medications and to return unused prescriptions to pharmacies or approved collection programs. When disposal in household trash is necessary, medications should be removed from original containers, mixed with an unpalatable material (such as used coffee grounds or kitty litter), and sealed in a leak-proof container. **Clear rules, consistent enforcement, and sustained public education protect system reliability, regulatory compliance, environmental quality, and ratepayer investments.**

How Do We Begin a Wastewater Improvement Project?

The previous sections gave you information and tools about wastewater so that you do not go into the process of acquiring a wastewater treatment system for your home, neighborhood or community with lack of knowledge. **This section provides you with an overview of the steps involved in**

upgrading or developing a sewer system. It does not cover setting up a legal management entity, nor does it cover how to manage a utility.

Specific needs and/or conditions might require a different approach or variations:



- Individual homeowners should not follow this process; instead, consult your county sanitarian or health department for locally specific guidance on appropriate/approved technologies based on soil conditions and ordinances. Individual systems require a less detailed process, but it should be performed by a certified professional such as a registered environmental health specialist or a certified installer/plumber, as applies in the project location.
- For new community utilities/facilities, be certain your organization has authority (by statute) to oversee wastewater management: to own and operate a facility, hire employees, borrow funds, etc. If not, you will need to form a legal entity or have the full support and authority of an entity that does. For example, a county Sewer Board could appoint your volunteer committee to provide them with professional or technology recommendations. A legal entity must be appointed or created to oversee the utility. Contact a TAP from your area for more information, as that is beyond the scope of this guide.

Engaging Qualified Professionals

Wastewater management and treatment are regulated by state and federal laws and regulations. Furthermore, many tasks in the process of acquiring, designing, selecting, construction, installation, operation and maintenance also require specific certifications or licenses. Regulatory agencies and the wastewater industry



promote development, use and compliance with product standards and certifications, as for example NSF International/ANSI Standards. Financing agencies also have their own requirements for procurement.

Understanding these requirements can be as complicated as understanding all the technical parts of wastewater treatment, therefore getting assistance from qualified and experienced professionals is a good choice.

Make sure that those assisting you in this process do not have any conflict of interest. For example, service or equipment providers usually have the required preparation and experience, and at one point in the project they will be of assistance and are very important, but their work objectives are to provide a service or sell equipment.

Communities and/or small utilities can get this assistance from “Technical Assistance Providers” (TAPs) from RCAP partner organizations. TAPs can be with you and assist you at all stages of your project at no cost to you.

Typical Project Process (Community Systems)

Defining the Problem

Work with your operator, if you have one, local health authorities, or watershed groups, and collect all available data available, such as watershed studies or monitoring and operation reports. Make sure that, in addition to the technical side of the problem, the community opinion and interests are considered. Later on, during the engineering study, your engineer will uncover more information; for now, do the best you can.

Procurement of Professional Services (RFPs/RFQs)

Wastewater treatment system design and evaluation should be performed by a professional engineer, or other certified wastewater professional, depending on state and/or local regulations. The use of these accredited professionals implies that their work will be certified, and they will be responsible for their work and the systems that they select in accordance with the laws and regulations where the license

or certification was issued. Therefore, requesting copies of certifications and licenses and checking they are up to date is important.

Your organization must follow procurement rules set by state regulations and funding agencies. Know what they are before you begin to avoid having to redo the process or have your decision challenged. Keep detailed records: most federal funding agencies will require information on your selection process as part of the evaluation of your fund's application.

For engineering services, it is recommended to use the Qualifications Based Selection (QBS) process, which evaluates based on experience and skills of the firms. The document sent to firms and advertised is a Request for Qualifications (RFQ). First, evaluate the firms' proposals, then interview a short list of finalists. Price is only discussed at the last step; if a price cannot be negotiated, the next best qualified is approached.

Other professionals, such as financial consultants, are typically procured using traditional Requests for Proposals (RFP), where price is specified and considered upfront.

Prepare a list of professionals with experience in similar projects. It is a good practice, and may be a requirement, to reach out to at least three (3); be aware of any regulations regarding minority/women's business enterprise engagement and public notice requirements.

Organize all the proposals received and make sure that all comply with the RFP/Q in terms of the information to be included. Late proposals that did not follow instructions or did not comply with RFP/Q should be discarded and not considered. If they cannot follow rules or provide a responsible and professional answer, it might be a flag to potential problems later in the project and/or with the service or products offered. Using a table to compare the proposals and the requirements is always useful, especially as part of the documentation for the funding agency.

Document the entire selection process. It is good administrative practice to have three or more people always involved. Obtain written opinions or include in meeting minutes any

recommendations from the wastewater qualified professionals providing assistance.

Engineering and Environmental Documents

The document typically required for funding applications is called a **Preliminary Engineering Report (PER)**. It is a feasibility study that is done to a higher level and must be signed off by a licensed engineer. A PER includes the evaluation and corresponding cost estimates for a minimum of three alternatives for a solution in the project. Their content is almost standard, but always check with funding agencies for specific requirements. The PER should evaluate the potential site, referencing the loading capability of the receiving stream (if any), and make a final recommendation for both collection and treatment processes. The PER should evaluate opportunities for regionalization/partnership with neighboring facilities. An analysis of life-cycle costs and costs per user should be included.

Federally funded projects also require some level of Environmental Report (ER) stating all the predicted impacts of the project on the area. This can be done by the engineer, although a qualified TAP or grant administrator can help with the groundwork and offset some of the costs.

Selecting the Appropriate Wastewater Treatment Technology

When considering which centralized treatment technologies are best for your community, there are many variables that need to be analyzed. When making these decisions you



Surface Aerator with Solar Panel

should engage numerous resources, such as your consulting engineer (and the information in the preliminary engineering report), regulatory and funder requirements, local health departments, financial and legal consultants, and technical assistance providers. Meeting regulatory requirements while maintaining affordability is often the goal for small systems with a limited customer base. The variables below will assist decision makers to determine and select the most appropriate treatment technology for their communities:

Effluent limits. This is often the driving variable for small systems needing to upgrade their wastewater treatment process. Many systems' current technologies are unable to meet the new effluent water quality regulations. These regulations are set by the state primacy agency and are correlated directly to where your system discharges effluent. Selecting a technology that will meet current or future regulatory requirements is important. Professional engineering services can provide valuable guidance in identifying the appropriate technology options.

Capital Costs. Generally, the more advanced the technology, the higher the initial construction costs. However, in many cases, the advanced technology can have lower costs in annual budget expense. For example, an ultraviolet (UV) disinfection system will cost considerably more than a traditional chlorine disinfection system, but you will eliminate ongoing chemical costs. Or adding a variable frequency drive (VFD) will save considerable costs in long term utility bills by allowing motors to run more efficiently.

Operation and Maintenance (O&M)

Costs. These costs are typically associated with the annual budget process. Like capital costs, O&M costs are generally higher with more advanced technology. This is a variable that should be carefully considered. This cost is often overshadowed by capital costs and regulatory requirements. Understanding this variable and its impact on overall costs to customers is essential.

Operational Complexity. Each state primacy office has criteria for determining the classification of a wastewater system. Knowing how a proposed technology may change the classification of the wastewater system could require operators to get high certifications, in turn increasing cost of labor. Furthermore, complexity may require additional operators to maintain due diligence of operational parameters, new skill sets, new vendor agreements, more instrumentation, etc.

Each one of these variables will have influences on your decision-making process. Capital costs are only part of the overall financial picture. Understanding how all the variables will impact the costs to customers will ensure rates that are more predictable, consistent, and hopefully affordable.

Seeking Funding for the Project

Once an option is selected and the PER formally adopted, the process of seeking funding for construction begins. It is highly recommended to work with a TAP and/or municipal/utility financial consultant to evaluate various funding scenarios and predict end user rates with a rate analysis.

Your consultants and TAPs should have information on possible funding sources, such as United States Department of Agriculture (USDA), USEPA, Community Development Block Grant programs (CDBG), etc., or other state or private organizations. They can help you consult with the different funding agencies to discuss your project, funding options and corresponding requirements.

To apply for low-interest loans and grants from federal and other sources, your project will likely be required to submit the PER, the ER, and financial information. Once funding is secured, engineered plans and a set of specifications for the work, equipment and materials will be developed. These specifications shall include recommended standards for the selected wastewater treatment system, such as those from NSF International/ANSI (if applicable). The specifications shall be part of any procurement process or request for proposal.

Why Skilled Wastewater Utility Management Matters

Although beyond the scope of this guide, it's important to note that the managing body of a wastewater utility is equally important as the technical operation of a treatment plant and should be in place long before operations begin.

Many wastewater systems have failed not because of the inability of the operators, but because of poor management. An effective system requires attention to a spectrum of issues that do not directly affect the treatment process, such as the health and safety of the employees, holding on to good staff and developing their skills, record-keeping, knowledge of regulations, and financial management.

Addressing these issues requires the system to generate sufficient revenue to pay for its operation and maintenance, to provide sufficient salaries and benefits that attract and retain operators whose skill levels match what the system requires, to pay for the planned replacement of critical components, and to make payments on any loans.

To ensure that customers are paying a fair share of the costs of operating the system, it is important to know how much wastewater they are generating. In most communities, wastewater rates are based on water usage because, apart from outdoor usage, water that comes into the house as potable water leaves as wastewater that must be treated. Some systems charge higher rates for businesses such as restaurants, laundromats and food processors that generate higher-strength wastewater.

With all of this, it is easy to see that skilled management is as important to the success of the system as skilled operators. A wastewater treatment system is a crucial—though typically underappreciated—community asset. As a critical piece of community infrastructure, the wastewater system needs to be maintained so that it continues to fulfill its function into the future.

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A Drop of Knowledge... but Need More?

Now that you have finished reading this guide, you hopefully have a better understanding of wastewater systems. If you have questions, the best person to turn to is most likely your system's operator. As the person who ensures that this system functions properly every day, your operator will be knowledgeable about the processes and issues that have been described in this guide. The additional resources that are listed starting on page 48 are other organizations and institutions that offer a wealth of technical assistance, publications, periodicals, and other types of help for small, rural communities.

Other RCAP Publications to Help with the Operation and Management of Wastewater Systems

The following publications can be accessed and downloaded for free (in PDF) on the RCAP website at <https://www.rcap.org/community-resources/>.

- Getting Your Project to Flow Smoothly
- Stormwater Program Finance & Management Guidebook

- The Basics of Financial Management for Small Community Systems
- A Resource for Small Utilities: The Role Mapping Serves for your Small, Rural, or Tribal Utility
- Formulate Great Rates: The Guide to Conducting a Rate Study for a Small System
- Homeowner Septic Guidebook
- Big Guide for Small Utility Boards

Free resources that can be sent to you regularly:

RCAP's electronic magazine, ***Rural Matters*** (quarterly), featuring practical, real-world stories from small communities highlighting how RCAP and its regional partners delivered targeted technical assistance helping local leaders and operators solve compliance challenges, stabilize operations, secure funding, and strengthen long-term system sustainability.

RCAP also produces a monthly electronic newsletter, **A Drop of Knowledge**. Each issue provides helpful tips, guides and resources on practical subjects.

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Appendix A: Comparison of Alternative Collection Systems

When evaluating alternatives, both capital and long-term operation and maintenance costs must be considered. While installation may be less expensive, alternative systems often require active management of distributed components such as septic tanks or pumps. Preliminary engineering reports or feasibility studies for your project should compare all costs. An engineering consultant and/or technical assistance provider, such as an RCAP staff member, would be able to assist with reviewing such a study.

STEP Systems

A STEP system consists of a septic tank to pretreat the wastewater and a submersible, low-horsepower effluent pump to push the wastewater into the pressure sewer main. All of the wastewater from each home or business enters the septic tank from the gravity sewer building drain leaving each building. In the septic tank, the wastewater separates into three layers. Greases and floatable materials rise to the top, solid materials settle to the bottom, and partially clarified liquid (“effluent”) remains in the middle. Effluent is pumped into the pressure sewers by the effluent pump located in a pumping chamber either within the second compartment of the septic tank or next to the tank. Because the effluent is relatively free of solids, sewers can be as small as 1.5 inches in diameter for the discharge pipes leading to the service connection and 2 or 3 inches for the mains – much smaller compared to conventional sewers, normally required to have a minimum diameter of 8 inches. Most STEP systems utilize new septic tanks, even when replacing existing septic systems. Special design and installation procedures are followed to assure long-term watertight conditions, to prevent groundwater and surface

water infiltration/inflow from being pumped into the pressure sewer (the pump will remove liquid entering the pump chamber regardless of its source).

Grinder Pump (GP) Systems

Grinder pump pressure sewer systems work somewhat differently than STEP systems. With this system, there is no septic tank. Preliminary treatment is done by a grinder pump, which sits in a watertight plastic chamber which has a capacity of about 70-120 gallons. The grinder pump is similar to a garbage disposal in that solid materials in the wastewater are cut up and ground into tiny pieces. All of the wastewater is then pumped into the pressurized service connection and into the pressure sewer main. Grinder pumps are usually one or more horsepower and turn on and off according to the levels in the pumping chamber. Pump chamber and controls are frequently provided as a package unit by the pump manufacturer. Other than reducing the size of wastewater solids, grinder pump effluent quality is similar to raw wastewater, requiring full treatment by the receiving treatment system, but has an advantage over a STEP system by not requiring periodic on-site septage removal. Pump life may be shorter, and power demand marginally greater compared to STEP system pumps. The additional solids removal and organics digestion provided with the STEP system may be preferred attributes in conjunction with final treatment and dispersal systems used with decentralized cluster systems.

Septic Tank Effluent Gravity Sewers

Septic tank effluent gravity (STEG) systems are a third alternative sewer technology for small communities to consider. STEG systems are also known by a variety of other names,

including small-diameter gravity sewers, variable-grade or minimum-grade effluent sewers. Like conventional sewers, STEG systems use gravity rather than pumps or pressure to collect and transport wastewater to the final treatment system or to a conventional sewer main. As with pressurized STEP sewer systems, STEG systems use septic tanks to provide primary treatment to the household wastewater to allow the bulk of the solid materials to settle out. Watertight tanks are likewise critical STEG system components. These sewers conveying fewer solids can be a smaller diameter than conventional sewers, but typically somewhat larger (3 to 4 inches) than those used for pressure sewers to accommodate any stray solids that may escape in the effluent of a septic tank that is malfunctioning or overloaded. Most STEG system designs call for the inclusion of an effluent screen or filter in the septic tank outlet (usually with 1/8-inch or smaller openings). Being gravity dependent, the point where the sewer system begins must always be higher than where it ends, and no part of the system can be higher than the starting point. However, STEG systems can be laid at variable grades. Effluent will back up at low spots until more pressure is created to push the wastewater over the “hump” in the pipe, a process called surcharging or siphoning. Any such “hump” along the sewer main must be well below the outlet of any connected septic tank. An experienced designer is essential, who fully accounts for the topography, number, elevations and relative locations of connections. With a septic tank at each connection, the operation and maintenance of STEG connections is similar to STEP and septic systems, including an annual inspection and tank pumping as needed. The STEG system laterals (the pipes going to each service connection) can be accessed and cleaned, if needed, through a series of cleanouts. It is not uncommon for STEG and STEP systems to be used in conjunction with each other.

Vacuum Sewers

Vacuum sewer systems are another alternative collection technology being used in some

communities in the United States. They rely on the suction of a vacuum, created by one or more central pumping stations, with relatively small-diameter vacuum mains connected to vacuum valve pits that collect raw wastewater from one to four adjoining connections. From the vacuum valve pits, wastewater is transported by vacuum in the sewer main to a collection tank at the vacuum pump stations for final conveyance to the treatment system. There are no electrical components at the individual connections to the system, nor are intermediate tanks or appurtenances needed between the connected facilities and the vacuum valve pits other than the standard building sewer and service line. From the collection tank, wastewater is then typically pumped by conventional lift station components to a nearby or remote location for treatment. The vacuum pumps are equipped with alarms that activate upon loss of vacuum, and an emergency backup generator in case a power outage or other problem develops. Small diameter plastic pipe can be used for these systems. Usually 3 or 4 inch diameter pipes from the service connection and 4 to 10 inch for the mains, depending on the flow and design of the system. The vacuum also keeps the lines very clean, so cleanout points are generally unnecessary. Like pressure sewers, vacuum sewers are relatively tight collection systems with little opportunity for extraneous infiltration or inflow into the system to overload the treatment plant. An integrated design is a prerequisite, as is a high level of support from the vacuum component manufacturer at the design, installation and on-going operation and maintenance phases. Specially trained operators must be readily available to respond rapidly to alarm conditions, such as loss of vacuum that renders wastewater removal from connected vacuum pits inoperable. This involves the ability to quickly identify the cause of the issue and implement the necessary repairs to restore service. The minimum number of connections for this option to be economically viable is therefore greater, compared with other alternative collection system options.

Collection Sewer Options and Comparative Features

Collection Sewer Options						
Type of System	Pipe Size	Pre-Treatment Required?	Variable Grade?	Direction Boring Feasible?	Requires Onsite O&M?	Service to Low-Density Areas?
Conventional (Gravity)	≥8"	No	No variation between Manholes	No	No	Less Cost Effective
Pressure Sewer	1-1/4-4"	Yes*^	Yes	Yes	Yes	Yes
STEP	1-1/4-4"	Yes^	Yes	Yes	Yes	Yes
GP	2"	No	Yes	Yes	Yes	Yes
STEG	3-4"	Yes*	Yes	Yes#	Yes	Yes
Vacuum	3-4"	No	Yes	Yes	No@	Less Cost Effective

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Appendix B: Comparison of Secondary Treatment Technologies

	Aerobic Treatment Processes		Anaerobic Treatment Processes
	Suspended Media/Activated Sludge	Fixed Film	
Modes or Variations	Extended Aeration, Step Aeration, Contact Stabilization, Conventional, Sequential Batch Reactors (SBR), Biological Nutrient Removal (BNR), Membrane Biological Reactors (MBR), Oxidation Ditch	Trickling Filters, Rotary Biological Contactors (RBC), Bio Towers	Upflow Reactor, Sludge Blanket Reactor, Filter Reactor, Continuous Stirred Tank, Anaerobic Contact Process.
Description	Aerobic biological treatment process in which microorganisms in suspension consume dissolved organic matter under conditions with dissolved oxygen.	Aerobic biological treatment process in which microorganisms on fixed film surfaces consume dissolved organic matter under conditions with dissolved oxygen.	Anaerobic biological treatment process in which microorganisms consume organic solids under conditions without dissolved oxygen. Three types of bacteria break organic solids into methane.
Process Control Capability	<u>HIGH</u> . Many process control methods for these processes and with significant accuracy. Some are food to mass ratio, mean cell retention time, and sludge age. Fully adjustable based on process control test results.	<u>MEDIUM</u> . Limited capability and usually reduced to making sure equipment functioning and minor adjustments, measurements and tests.	<u>HIGH</u> . Typically, anaerobic digester process control involves monitoring the feed-to-reactor volatile solids ratio, maintaining a stable pH and buffering capacity within the reactor, and tracking the volume of fatty acids to alkalinity ratio.
Operation Complexity	<u>HIGH</u> . Labor intensive operation. Most jurisdictions require certified operators. The number of required operators usually depends on state regulations which consider plant complexity, capacity and population served. Requires complex tests, laboratory work and calculations. Discharge permit requirement will influence operation.	<u>MEDIUM</u> . Operation focused on keeping equipment working with minor adjustments. Usually runs with one shift, but might vary depending on state regulations, plant complexity, capacity and population served. Limited to a few tests for process control, other than those required by discharge permits.	<u>HIGH</u> . Labor intensive operation. Most jurisdictions require certified operators. The number of required operators usually depends on state regulations which consider plant complexity, capacity and population served. Requires complex tests, laboratory work and calculations. Discharge permit requirement will influence operation.
Maintenance	<u>HIGH</u> . Most maintenance programs include preventive and corrective maintenance. Labor intensive.	<u>MEDIUM</u> . Most maintenance programs include preventive and corrective maintenance. Labor intensive.	<u>HIGH</u> . Most maintenance programs include preventive and corrective maintenance. Labor intensive.
Energy Consumption	HIGH	MEDIUM	HIGH
Capital Costs	HIGH	MEDIUM	HIGH
Operational and Maintenance Costs	HIGH	MEDIUM	HIGH

Please note: These treatment processes are not exclusive to centralized systems and can be found on a smaller scale as part of decentralized or onsite treatment systems. Centralized vs. Decentralized is related to the collection system arrangement and the number of residences included in the treatment system. This is further explained in this guide.

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Appendix C: Comparison of Activated Sludge Technologies

No.	Description	Extended Aeration	Sequencing Batch Reactors (SBR)	Oxidation Ditches
1.	Process Type and Mode	Aerobic biological treatment process, Suspended Media, Activated Sludge	Aerobic biological treatment process, Suspended Media, Activated Sludge	Aerobic biological treatment process, Suspended Media, Activated Sludge
2.	Process characteristics	Extended aeration treatment plants work with excess microorganisms to assure complete digestion of organic contaminants fed into the aeration tank.	A sequencing batch reactor (SBR) is a variation of the activated sludge process. As a fill and draw or batch process, SBR sequence of operations includes Mixed Fill, React Fill, React, Settling, and Decant.	An oxidation ditch, a modified form of the activated sludge process, is an aerated, long term, complete mix process. Many systems are designed to operate as extended aeration systems. Typical oxidation ditch treatment systems consist of a single or multi-channel configuration within a ring, oval, or horseshoe-shaped basin.
3.	Aeration	Air may be supplied by mechanical or diffused aeration to provide the oxygen required to sustain the aerobic biological process.	Air may be supplied by mechanical or diffused aeration to provide the oxygen required to sustain the aerobic biological process.	Mechanical surface aerators in a width arrangement.
4.	Mixing	Mixing must be provided by aeration or mechanical means to maintain the microbial organisms in contact with the dissolved organics.	Most SBRs use mechanical mixers.	Mechanical mixing and flow circulating in the tank.
5.	MLSS Range (mg/L)	1,500 to 5,000	2,000 to 5,000	1,500 to 5,000
6.	Sludge Retention Time (SRT), days	20 to 30	5 to 30	4 to 48
7.	Sludge Wasting Frequency	Wasting is usually done once every 12 to 18 months based on solid inventory and plant performance.	Once every cycle as per process control calculations.	Continuously or daily basis as per process control calculations.
8.	Food to Mass Ratio (F/M), lbs BOD per Day/lbs MLVSS	0.05 to 0.15	0.15 to 0.40	0.05 to 0.30
9.	Typical Size (MGD)	0.002 to 0.100	0.500 or less	0.010 to 0.500
10.	Return Activated Sludge/Wasting Activated Sludge System	Most extended aeration plants are small and the RAS and WAS system are "air lift" type, even though some systems use mechanical pumps.	Sludge return is internal within the reactor. Wasting use of a mechanical pump.	Oxidation ditches are suitable for facilities that require nutrient removal, have limitations due to the nature of the site, or want a biological system that saves energy with limited use of chemicals unless required for further treatment.
11.	Uses	Extended aeration package plants are typically used in small municipalities, suburban subdivisions, apartment complexes, highway rest areas, trailer parks, small institutions, and other sites where flow rates are below 0.1 MGD. Small footprint.	SBRs are suitable for areas with little land, stringent treatment requirements, and small wastewater flows. More specifically, SBRs are appropriate for RV parks or mobile homes, campgrounds, construction sites, rural schools, hotels, and other small applications. Small footprint. Process can be adjusted to increase nutrients removal, and/or cycles time to compensate for hydraulic or organic loads.	Oxidation ditches are particularly useful for schools, small industries, housing developments, and small communities. Ultimately, this technology is most applicable for places that have a large amount of land available.
12.	Disadvantages	Extended aeration plants do not achieve denitrification or phosphorus removal without additional unit processes. Systems require a larger amount of space and tankage than other "higher rate" processes, which have shorter aeration detention times.	High maintenance and energy consumption. Complex operation for small communities. Higher sludge generation, therefore more handling and disposal.	Oxidation ditches can be noisy due to mixer/aeration equipment and tend to produce odors when not operated correctly. Biological treatment is unable to treat highly toxic waste streams. Systems have a relatively large footprint.

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Appendix D: Comparison of Advanced Decentralized Pretreatment Technologies

Advanced pretreatment is typically intended to achieve enhanced reduction of organic matter, suspended solids, pathogens, and nutrients. Advanced pretreatment may help overcome a site's soil limitations, (e.g., low permeability, reduced vertical separation to groundwater, or to allow reduction in treatment area size or horizontal setbacks). Advanced pretreatment is likewise prerequisite for restaurants and other food service facilities that typically have a much higher organic load than domestic strength septic tank effluent prior to final soil treatment and dispersal. Nutrient reduction, especially of nitrogen, in many locales is also the major impetus for (and sometimes require) use of specially designed advanced pretreatment systems.

A wide-ranging variety of advanced pretreatment systems are available, with a wide variety of treatment methods, capabilities, costs, space needs, and operation and maintenance

requirements to assure ongoing sustainable performance. Some are generic, requiring site-specific design typically by a licensed professional engineer, and many are proprietary utilizing pre-manufactured models that have been developed by industry.

Adherence to state and local regulations should always be confirmed. Besides system cost, capabilities to achieve desired treatment standards, and regulatory compliance, other important considerations should go into system selection for use in home/small community decentralized systems. Are local designers/installers/operators familiar with the proposed system and available to support the system's use in the locale? Is there a good track record and demonstrated long-term "real-world" performance under expected local conditions and projected use? Due-diligent research is always recommended.

Advanced Decentralized Pretreatment System Options			
Type of System	Parameters Reduced*,^^	Generic	Proprietary
Media Filter (unsaturated)			
Single-Pass Sand Filter	BOD, TSS	X	
Recirculating Sand Filter	BOD, TSS, TN	X	
Polystyrene Beads	BOD, TSS, TN		X
Fixed Film	BOD, TSS, TN		X
Textile	BOD, TSS, TN		X
Peat	BOD, TSS		X
Coco-Fiber	BOD, TSS, TN		X
Gravel/Coarse Media	BOD, High-Strength	X	X
Aerobic Treatment Unit (ATU)			
Non-Recirculating	BOD, TSS		X
Recirculating	BOD, TSS, TN		X
ATU/Fixed Film	BOD, TSS, TN		X
Constructed Wetland	BOD, TSS, TN	X	X

*Nitrate/total nitrogen reduction typically requires recirculation and other specialized design, operation, maintenance and monitoring to consistently meet desired performance standards.

^^Significant pathogen reduction may be incorporated into the advanced pretreatment system design which require the addition of a disinfection component—typically a proprietary ultraviolet (UV) system or tablet chlorination system (and possibly dechlorination system when followed by a subsurface drain field). A high level of BOD and TSS reduction is also pre-requisite for optimal disinfection to occur.

Appendix E: Additional Resources

A number of other organizations and institutions work with small communities on their drinking water and wastewater needs. Here are some of them:

Rural Community Assistance Partnership (RCAP) (www.rcap.org)

The Rural Community Assistance Partnership (RCAP) is a national network of non-profit partners working to provide technical assistance, training, resources, and support to rural communities across every state, the U.S. territories, and Tribal lands. See the inside back cover of this guide for contact information for RCAP's six regional partners. These are the organizations that coordinate RCAP's work in your state and its communities. A toolbox of RCAP resources can be found here: <https://www.rcap.org/community-resources/>.

American Water Works Association (AWWA) (www.awwa.org)

Assists communities in providing safe drinking water and works to educate people on how to operate and manage drinking water systems. A resource for information about water resource development, water and wastewater treatment technology, water storage and distribution, and utility management and operations.

Other AWWA resources:

- [Small Systems Resource page](#)
- [Water-Wastewater Agency Response Network \(WARN\)](#) A network of utilities helping other utilities to respond to and recover from emergencies.

Water Professionals International (formerly Association of Boards of Certification) (<https://www.gowpi.org/>)

Includes almost 100 certifying authorities and represents 49 states. These boards certify water and wastewater operators, laboratory analysts, plant maintenance technologists, bio solids land

appliers, and backflow- prevention assembly testers.

National Environmental Health Association (NEHA) (www.neha.org)

A membership organization dedicated to advancing environmental health and protection professionals works to establish a standard of excellence for the professional and works to establish a standard of excellence for the profession.

Appalachian Community Technical Assistance and Training (ACTAT) Program (formerly National Environmental Services Center)

Assists small and rural communities with their drinking water, wastewater, environmental training, infrastructure resilience, and utility-management needs and helps them find solutions to problems they face. Provides toll-free technical assistance, training materials, publications, and free and low-cost products.

National Rural Water Association (NRWA) (www.nrwa.org)

A non-profit helping support wastewater and water professionals through training and technical assistance to both member and non-member systems across all 50 states.

National Water Resources Association (NWRA) (www.nwra.org)

Advocates federal policies, legislation and regulations promoting protection, management, development, and beneficial use of water resources that represent the interests of its members.

Water Environment Federation (WEF) (www.wef.org)

WEF is a technical organization that develops and promotes practices and policies that help members serve the public interest by providing

efficient and environmentally protective water quality and wastewater management services. WEF provides professionals with education, training, and business opportunities.

University of Illinois' Prairie Research Institute

Wateroperator.org and DecentralizedWastewater.org A collection of free resources for small water and wastewater system operators including a training calendar and resource library.

National Onsite Wastewater Recycling Association (NOWRA) (www.nowra.org)

NOWRA is the leading U.S. organization dedicated to advancing onsite and decentralized wastewater systems through education, advocacy, and professional support. Check out their resources for homeowners and operators:

- [Septic resources for homeowners](#)

Water Finance Assistance

(www.waterfinanceassistance.com/)

Offering technical assistance and training to improve the sustainability of utilities through a data driven approach.

Federal government resources

The primary agencies involved in small community water and wastewater issues are:

U.S. Department of Agriculture (USDA)

- [Rural Utilities Service \(RUS\)](#)
- [Water and Environmental Programs](#)

U.S. Environmental Protection Agency (EPA)

- [Office of Water](#)
- [Small Public Water Systems and Capacity Development](#)
- [Ground Water & Drinking Water](#)
- [Safe Drinking Water Hotline](#) (800) 426-4791
- [Septic Systems](#)
- [Lagoon toolbox](#)

U.S. Department of Health and Human Services

U.S. Geological Survey

Appendix F: Glossary

A

Activated sludge—sludge particles produced in wastewater by the growth of organisms in aeration tanks. The term activated comes from the fact that the particles teem with bacteria, fungi and protozoa. Activated sludge is different from primary sludge in that the sludge particles contain many organisms that feed on incoming wastewater.

Activated sludge process—a biological wastewater treatment process that speeds up waste decomposition. Activated sludge is added to wastewater, and the mixture is aerated and agitated. After some time, the activated sludge settles out through sedimentation and is disposed of or returned to the aeration tank to be reused.

Aerobic—a condition in which free oxygen is present.

Aerobic digestion—a biological sludge-stabilization process that takes place in an oxygenated environment. **Aerobic lagoon**—a wastewater treatment pond that has some dissolved oxygen present.

Aerobic treatment unit (ATU)—prefabricated units that provide wastewater treatment by injecting air into a tank, allowing aerobic bacteria to break down organic matter. Usually used for onsite or decentralized wastewater treatment.

Alkalinity—the capacity of water to neutralize acid. Alkalinity is not the same as pH because water does not have to be strongly basic (high pH) to have a high alkalinity.

Algae—aquatic plants that grow in sunlit water and release oxygen into the water.

Alternative system—a wastewater treatment or collection system that is used instead of a conventional system.

Anaerobic—a condition lacking free oxygen.

Anaerobic digestion—a sludge-stabilization process that takes place in an environment without oxygen.

Anaerobic lagoons—wastewater treatment ponds that have no dissolved oxygen content.

Anoxic—a condition without free oxygen but nitrate is present.

Attached growth process—a wastewater treatment process in which microorganisms providing treatment are attached to an inert surface, such as rock or plastic. It is also referred to as a fixed-film process.

B

Bacteria—single-celled organisms that help consume and decompose the organic components of wastewater.

Belt-filter press—a sludge de-watering device that uses two fabric belts to squeeze water from the sludge.

Biochemical oxygen demand (BOD)—a measure of organic matter in water based on the amount of oxygen consumed in biological processes that break down this organic matter.

Biomass—a microbial growth.

Biosolids—treated sewage sludge solids that have been stabilized to destroy pathogens and that meet rigorous standards that allow for safe reuse as an additive to soil.

Black water—domestic wastewater that carries human waste. Often synonymous with toilet water; however, some states include food waste (e.g., kitchen sink water) in this category.

C

Centralized wastewater treatment—treatment through which wastewater is transported by a network of sewers to a central treatment facility.

Chlorination—the process of adding chlorine gas or chlorine compounds to wastewater for disinfection.

Clarifier—removes solids from wastewater by gravity settling or by coagulation. Also referred to as a settling tank or sedimentation tank.

Class A biosolids—biosolids that meet the criteria of the Part 503 rules, allowing them to

be used in parks, gardens and golf courses.

Class B biosolids—biosolids that do not meet all the criteria for Class A biosolids. They may be applied to agricultural land or disposed of in landfills.

Clean Water Act—aims to restore and maintain the “chemical, physical, and biological integrity of the nation’s water.” It is the main federal law that serves to regulate facilities, including wastewater treatment plants that discharge wastewater into surface waters.

Cluster system—a wastewater treatment system that uses septic tanks at individual houses to remove solids and small-diameter sewers to transport the liquid effluent to a central area for additional treatment and/or dispersal. This is often achieved through a community soil-absorption system.

Coagulation—the clumping of solids to make them settle out of wastewater faster. Coagulation of solids is improved by the use of chemicals, such as lime, alum, iron salts or polymers.

Coliform bacteria—rod-shaped bacteria that live in the intestinal tracts of humans and other warm-blooded animals. Coliform bacteria are often used as indicators of fecal contamination and the potential presence of pathogenic microorganisms.

Colloidal—particles in suspension in wastewater that are too small to readily settle out during primary treatment.

Combined sewers—system of pipes that carries both sanitary sewage and storm water runoff.

Comminutor—a device to catch and shred heavy solid matter at the headworks of a wastewater treatment plant.

Composting—the natural biological decomposition of organic material in the presence of air to form a stabilized material that is humus-like in consistency.

Conditioning—the addition of chemicals to sludge to aid in the dewatering process. Conditioning chemicals include alum, lime, ferric chloride, and synthetic organic polymers.

Conventional septic system—a septic system with a standard septic tank and soil-absorption system in which the wastewater flow is moved by gravity.

D

Decentralized wastewater treatment—process in which wastewater treatment takes place close to where wastewater was generated. Often refers to some variation of a septic system that serves an individual home, business or small group of homes.

Denitrification—the reduction of nitrate to nitrogen gas that is carried out in wastewater treatment tanks by bacteria under anoxic conditions. The bacteria use nitrate for energy and, in the process, release nitrogen gas. Nitrogen gas, a major component of air, is released into the atmosphere.

Disinfection—the killing of microorganisms, including some disease-causing ones.

Disinfection By-Products (DBPs)—compounds that are formed during the disinfection process of water or wastewater by the chemical reaction of the disinfectants and organic matter. Many DBPs are considered to be harmful to aquatic life and human health.

Dissolved oxygen—the amount of free oxygen in solution in water or wastewater effluent. Adequate concentrations of dissolved oxygen are necessary for fish and other aquatic organisms to live and to prevent offensive odors.

Drainfield—the part of a septic system where clarified liquid effluent is dispersed into soil for final treatment and disposal. Also referred to as a soil-absorption system or leachfield.

Drip dispersal—a form of final dispersal of treated wastewater in which the effluent is applied to soil slowly and uniformly through a network of narrow, flexible tubes placed in the soil at shallow depths. Also referred to as drip irrigation.

E

Effluent—the liquid that comes out of a treatment plant after completion of the treatment process. Also refers to the liquid from

a particular unit, such as primary effluent (from the primary treatment process) or septic tank effluent, even though the effluent requires further treatment.

Eutrophication—the slow aging process by which a lake evolves into a bog or marsh, ultimately disappearing. During eutrophication, the lake becomes enriched with nutrients, especially nitrogen and phosphorus, which support the excess production of algae and other aquatic plant life.

Exothermic—a chemical reaction that releases energy in the form of heat.

Extended aeration—a variation of the activated sludge treatment process with a long detention time that results in heavy competition for food by the microorganisms and little production of sludge.

F

Facultative lagoons—a wastewater treatment pond that contains some areas where dissolved oxygen is present and others where oxygen is absent.

Fixed film system—a wastewater treatment process in which the microorganisms providing the treatment are attached to an inert surface or medium, such as rock or plastic. It is also referred to as attached growth process.

Floc—clumps of solids formed in sewage through biological or chemical action.

Flocculation—a chemical process by which clumps of solids in sewage are made to increase in size.

F:M—food to microbe ratio.

G

Gray water—domestic wastewater composed of wash water from sinks, showers and washing machines. It does not include toilet wastewater.

Grit chamber—a small detention basin designed to permit the settling of coarse, heavy inorganic solids, such as sand, while allowing the lighter, organic solids to pass through the chamber.

H

Headworks—the part of the wastewater treatment plant where the influent or raw sewage enters the plant.

Helminths—parasitic roundworms or flatworms.

I

Indicator organisms—microorganisms whose presence in a water sample indicate the presence of fecal contamination and possibly pathogenic microorganisms.

Infiltration—the penetration of water through the ground into underground soil or the passing of water from the soil into a pipe, such as a sewer.

Influent—water, wastewater or other liquid flowing into a reservoir, basin or treatment plant, or a unit of the treatment plant.

Inorganic—compounds that do not contain carbon from a plant or animal source or synthetic organic carbon.

Interceptors—large sewer lines that collect the flows from smaller main and trunk sewers and carry them to the treatment plant.

J

Jar test—a laboratory procedure that simulates on a small scale what is happening in the plant. It may be used to provide information about sludge settleability or to optimize chemical dosing or settling times.

L

Lagoon—a pond (usually constructed) in which algae and aerobic and anaerobic bacteria purify wastewater.

Lateral sewers—small underground pipes that transport sewage from homes and businesses to the larger sewer lines leading to a wastewater treatment plant.

Leachfield—the part of a septic system where clarified liquid effluent is dispersed into soil for final treatment and disposal. Also referred to as a drainfield or soil-absorption system.

Loading—the quantity of material added to a process at one time.

M

Membrane filtration—a water and wastewater treatment process, such as reverse osmosis, microfiltration, ultrafiltration or nano-filtration, which uses fine-pore membranes and pressure to remove small particles from the water.

Mixed liquor—activated sludge mixed with wastewater in an activated sludge treatment process.

Mixed liquor suspended solids (MLSS)—the suspended solids in the mixture of activated sludge and wastewater that undergoes aeration in an activated sludge treatment process.

Mound system—an effluent disposal system involving a mound of sand built on the original ground surface to which effluent is distributed.

N

National Pollutant Discharge Elimination System (NPDES)—a program established by the Clean Water Act that requires all wastewater discharges into U.S. waters to obtain a permit issued by the U.S. Environmental Protection Agency (EPA) or a state agency authorized by the EPA.

Nitrification—the biochemical oxidation of ammonium to nitrate.

Nutrients—elements or compounds essential as raw materials for plant and animal growth and development.

O

Organic matter—compounds that contain carbon. The term often refers to compounds in plants, animals and wastes; however, there are also manmade organic compounds.

Overland flow—land treatment of wastewater involving the controlled application of wastewater onto grass-covered gentle slopes with impermeable surface soils. As water flows over the grass-covered soil surface, contaminants are removed, and the water is collected at the bottom of the slope for reuse.

Oxidation ditch—a variation of the activated sludge treatment process that takes place in an oval channel with aeration provided by various types of

mechanical devices that move around the channel.

Ozonation—a disinfection process in which ozone is generated and added to wastewater effluent to kill pathogenic organisms.

P

Part 503 rules—federal rules established in 1993 by the U.S. Environmental Protection Agency that address how wastewater biosolids can be applied to land, how they can be disposed, how they must be stabilized, and what the requirements are for incinerators that burn biosolids.

Pathogens—disease-causing microorganisms, including certain bacteria, viruses, helminths and protozoans.

Peat filter—a type of alternative or advanced onsite wastewater treatment system. Peat filters involve the application of septic tank effluent to peat fibers housed in impermeable containers. As the effluent trickles through the peat, additional treatment is provided by microorganisms attached to the peat surface. The containers include an underdrain that collects the treated liquid, which is then dispersed, usually to a soil-absorption system.

Permeability—a measure of the ease with which water penetrates or passes through soil.

Pressure sewer—a system of pipes in which the wastewater is transported under pressure supplied by pumps.

Primary clarifier—a tank used in the primary treatment process that provides a non-turbulent environment allowing heavier solids to settle out and floatable materials to come to the surface where they may be separated. Also referred to as a primary sedimentation tank.

Primary sludge—sludge produced in the primary wastewater treatment process.

Primary treatment—the initial stage of wastewater treatment that removes floating material and material that easily settles out.

Protozoans—a group of one-celled microorganisms, generally larger than bacteria,

some of which feed on bacteria and some of which are pathogens.

R

Rapid infiltration—a method of final treatment and dispersal of wastewater effluent by spreading the effluent over highly permeable soils, such as sand and loam.

Receiving waters—water bodies, such as rivers, lakes and oceans, that receive discharges of treated or untreated wastewater.

Rotating biological contactor (RBC)—an attached growth wastewater treatment process involving large, closely spaced plastic discs mounted on a revolving horizontal shaft. The discs alternately move through the wastewater and the air, developing a biological growth on the surface of the discs that removes organic material in the wastewater.

S

Sand filter—a type of alternative or advanced onsite wastewater treatment unit. It involves the intermittent application of septic tank effluent to sand that is enclosed in a container, usually 2 or 3 feet in depth. The effluent receives further treatment as it trickles through the sand and is collected in an underdrain for further treatment or dispersal. Sand filters are classified as single-pass, in which the effluent is applied to the filter once, or recirculating, in which a portion of the liquid collected in the underdrain is recycled back to be applied to the filter again.

Sanitary sewers—the collection system for transporting domestic and industrial wastewater to municipal wastewater treatment facilities. Storm water is not directed into this system but is handled by a separate system.

Secondary clarifier—a clarifier following a secondary treatment process, designed for removal of suspended matter by gravity.

Secondary sludge—sludge produced during the secondary treatment process.

Secondary treatment—the stage in wastewater treatment in which bacteria consume the organic matter in wastewater.

Federal regulations define secondary treatment as meeting minimum removal standards for BOD, TSS and pH in the discharged effluents from municipal wastewater treatment facilities.

Septage—the residual solids in septic tanks or other onsite wastewater treatment systems that must be removed periodically for disposal.

Septic system—a wastewater system designed primarily for individual residences. It uses a septic tank to provide sedimentation, sludge digestion, and sludge storage, and a soil-absorption system or drainfield to provide final dispersal and treatment of the liquid effluent.

Septic tank—one of the primary components of a septic system in which heavier solids are allowed to settle out and lighter materials form a floating layer. An outlet is configured such that only relatively clarified liquid flows to the drainfield or soil-absorption system for final treatment and dispersal.

Septic tank effluent pump (STEP) sewer—a type of pressure sewer that uses a septic tank to eliminate most solids and a pump to push the liquid effluent through the sewers. Because there are very little solids in the sewage, very narrow pipes can be used.

Sequencing batch reactor (SBR)—a variation of the activated sludge process in which all treatment processes occur in one tank that is filled with wastewater and drawn down to discharge after treatment is complete.

Settleable solids—solids that are heavier than water and settle out of water by gravity.

Sludge—solids that settle out during a treatment process.

Sludge drying bed—a constructed bed of sand used to dewater sludge. An underdrain is used to collect the separated water.

Soil-absorption system (SAS)—the part of a septic system in which the clarified liquid effluent is dispersed into soil for final treatment and disposal. The SAS, also referred to as a drainfield or leachfield, is typically made up of a series of trenches or a bed lined with gravel or coarse sand. The effluent is dispersed through a

network of perforated pipes or drain tiles.

Solids retention time (SRT)— the average amount of time that sludge remains in an activated sludge treatment process. It is a critical part of the treatment process that an operator watches because it determines how well the process works.

Stabilization—any process used to produce a final biosolids product that has little or no potential to further decompose and create undesirable odors and that is free of pathogens.

Storm sewers—a separate system of pipes that carry rain and snow melt from buildings, streets and yards to surface waters.

Suspended growth process—a wastewater treatment process in which the microorganisms providing the treatment are maintained in suspension in the wastewater.

Suspended solids—the small particles suspended in water or wastewater.

T

Tertiary treatment—any physical, chemical or biological wastewater treatment process that is used to improve the quality of secondary effluent.

Thickening—any process to decrease the volume of sludge by removal of some of the liquid portion.

Total dissolved solids (TDS)—a measure of the dissolved matter in a sample of water or wastewater. It is obtained by passing the sample through a filter, evaporating the water and weighing the dried residue of the material that passed through the filter. TDS includes some colloidal matter that is small enough to pass through the filter.

Total suspended solids (TSS)—a measure of the suspended matter in a sample of water or wastewater. It is measured by passing the sample through a filter, evaporating the water, and weighing the dried residue that was retained on the surface of the filter. **Trickling filter**—an attached growth process that involves a tank, usually filled with a bed of rocks, stones, or synthetic media, to support bacterial growth used to treat wastewater.

U

Ultraviolet (UV) disinfection—a disinfection process in which wastewater is exposed to UV light to kill or deactivate potential microbial pathogens.

V

Vacuum sewer— an alternative sewer system that uses a vacuum (created by a central vacuum station and maintained in the lines) to draw and transport wastewater through the system to a final treatment unit.

Vector—an insect or any living carrier (birds, rats) that transmits an infectious agent.

Voluminous—large in volume or bulk.

W

Wasting—removal of excess microorganisms from a secondary treatment system.



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