Residential Onsite Wastewater Treatment Systems:

An Operation and Maintenance Service Provider Program

Photo: Canadian Septic

Third Edition

National Onsite Wastewater Recycling Association

October 2025

Inside Front Cover

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Residential Onsite Wastewater Treatment Systems: An Operation and Maintenance Service Provider Program
Third Edition

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1 Introduction to the Operation and Maintenance Service Provider Program

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the role of service providers.
2. Define key terms describing onsite wastewater treatment systems.
3. Describe the benefits of performing regular operation and maintenance for onsite wastewater treatment systems.
4. Explain how relative risk determines the nature and frequency of operation and maintenance activities.

Overview

This chapter provides an overview of the relationship between protecting public health, environmental issues, and the growing importance of operation and maintenance (O&M) applications for an expanding decentralized wastewater treatment industry. It will:

- Provide a general description of onsite wastewater treatment systems
- Outline program goals, scope and implementation.
- Discuss wastewater characteristics.
- Define inspection procedures.
- Introduce operational checklists for use in documenting essential information about system performance and identifying key maintenance issues.

Onsite Wastewater Treatment Systems

Residential onsite wastewater treatment systems collect, treat, and disperse wastewater generated at a single-family residence (Figure 1-1). These systems are located at or near the home. An onsite wastewater treatment system may include a combination of any of the following components:

- Wastewater source (user, facility, or owner)
- Collection and storage
    - Plumbing from facility to treatment components
    - Holding tanks
    - Incinerating and composting toilets
- Treatment components
    - Septic tanks
    - Trash tanks
    - Processing tanks
    - Aerobic treatment units
    - Media filters
    - Constructed wetlands
    - Lagoons
    - Disinfection components
- Final treatment and dispersal components
    - Gravity distribution to trench or bed STA
    - Evapotranspiration beds
    - Low pressure distribution STA
    - Integrated treatment and dispersal
    - Drip distribution STA
    - Spray distribution STA
    - Outfalls

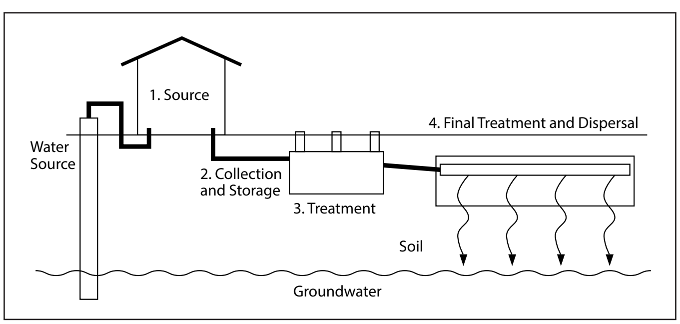

Figure 1-1. An example of an onsite wastewater treatment system illustrating the four parts of a basic treatment train (After: Bouma, 1979).

This manual does not promote any specific technology. Those included are representative of the more commonly used technologies. All systems, regardless of complexity, require regular operation and maintenance on some level. Each component of a system must be evaluated to determine overall system performance. O&M service providers should always use caution and be familiar with manufacturer-specific requirements.

Program Goals, Scope and Implementation

The O&M Service Provider Program is designed to establish best practice standards for service visits to onsite wastewater treatment systems described in the next section. The focus of these materials is single-family residential systems. The United States Environmental Protection Agency (U.S. EPA), and state and local government entities all recognize the importance of onsite and decentralized wastewater treatment systems as an essential component of the wastewater infrastructure. Through routine service visits and proper maintenance, onsite wastewater treatment systems can be a permanent and effective part of the wastewater infrastructure. As licensing and certification programs develop, these materials can provide educational resources to support training for practitioners seeking licensing and/or certification. This manual is only a training manual. It does not take the place of a certification program but can be a valuable resource to support such efforts.

The primary goal of this program is to provide a complete set of reference materials and forms for both training and field use by personnel who service residential systems. The forms may be useful for evaluating commercial or industrial systems; however, additional operational checklists may be needed to thoroughly evaluate systems other than those serving single-family residences.

This program will cover key aspects of O&M inspection procedures, data collection, and the use of operational checklist forms. These procedures and documents can be integrated into the O&M professional's business model and used to analyze, track and report on system status and performance. With this information, the O&M professional can confidently and effectively address and communicate the O&M issues of onsite wastewater treatment systems based upon accepted industry standards of practice.

Wastewater Characterization and Quantification

Wastewater sources and common constituents

Three broad categories of wastewater are domestic/residential, commercial, and industrial.

- **Domestic wastewater** is normally discharged from plumbing fixtures, appliances, and devices such as toilets, bath, laundry, and dishwashers coming from a household or residence.
- **Commercial wastewater** includes wastes resulting from office buildings, restaurants, or food processing and production enterprises and the characteristics are likely quite different from domestic wastewater.
- **Industrial wastewater** is the water or liquid-carried waste from an industrial or manufacturing process and the characteristics of these waste streams vary widely depending upon specifics. The details of O&M for systems serving industrial sources are not specifically included in these materials.

The focus of these service provider materials is domestic wastewater generated by single-family residences. This wastewater is composed primarily (99.9 percent) of water. The constituents in wastewater are typically described by the mass of the constituent dispersed into the liquid volume. The term parts per million (ppm) expresses a concentration defined by a relative mass of the constituent present in a mass of liquid. Because we are working with water, the common expression of concentration is mass per liquid volume in milligrams per liter (mg/L). Thus, in this instance, the terms ppm and mg/L are identical.

Although the constituents and strength of domestic wastewater can vary from residence to residence or even day to day, there are certain constituents that are generally present. These include the following:

- Organic materials
- Inorganic materials
- Solids
- Pathogenic organisms
- Nutrients
- Metals
- Persistent organic compounds
- Fats, oils, and grease (FOG)
- Other chemicals

Organic materials are carbon-based constituents that come from plant or animal sources and may be solid or liquid. These materials may be part of living organisms in the wastewater, or they can be non-living materials carried by or dissolved in water. Most organic materials can be broken down and consumed by microbes. Biochemical oxygen demand (BOD) is the typical measurement used to gauge the organic content of wastewater.

Inorganic materials in domestic wastewater include minerals, metals, dissolved salts, sand, and silt which are relatively stable compounds not easily broken down by microorganisms.

Solids in wastewater may be organic or inorganic and removing them is one of the major goals of wastewater treatment. Solids in residential wastewater may be ***dissolved*** in the liquid or ***suspended***. Some of the suspended solids may settle out before leaving the septic tank. These are called ***settleable*** solids.

Pathogenic organisms are disease-causing microorganisms and include helminths (worms), protozoa, bacteria, and viruses. These organisms live comfortably in the human digestive system but have difficulty surviving in other (aerobic) environments.

Nutrients are essential elements for the growth of living organisms. Because humans do not metabolize all the nutrients they consume, waste carries significant quantities of residual nutrients in both organic and inorganic forms. Excess nutrients are a potential contaminant if they overfertilize natural ecosystems in the receiving environment. Of particular concern are nitrogen and phosphorous.

Nitrogen is found in several forms in wastewater. **Organic nitrogen** is found in cells of all living organisms as part of proteins and amino acids as well as genetic material and is the principal compound in urine. Organic forms of nitrogen are unavailable to plants until converted to inorganic forms of nitrogen (ammonium [NH_4^+] and nitrate [NO_3^-]). Many microbes can convert organic nitrogen into inorganic forms.

Ammonium nitrogen is the main form of nitrogen in septic tank effluent. It is available for plant uptake when it reaches the soil, and its positive electrical charge allows it to bind to soil particles or specific materials or minerals in some treatment technologies. Under aerobic soil conditions, specialized microbes convert ammonium nitrogen to the nitrate form.

Nitrate nitrogen is a negatively charged ion that stays dissolved in water. Nitrate formation requires the presence of oxygen and specific bacteria, conditions which are typically absent in the septic tank environment. Nitrate typically forms in oxygenated treatment components or in the soil treatment or dispersal area. Because of its negative charge, nitrate is not strongly held by the soil and can leach into the groundwater. High concentrations in groundwater present a potential human health risk. Nitrate may be converted to nitrogen gas (N_2) under anoxic conditions through the microbiologically mediated process of denitrification.

Phosphorus is another key nutrient found in the cells of all living organisms: it primarily helps make up cells' genetic information, signaling molecules and is an essential component of cell membranes. Phosphorus enters our wastewater in body wastes, food residues, and detergents. Phosphorus moves with the soil absorption plume but at a retarded rate. Phosphorus retention in the soil treatment area (STA) depends upon sorption and precipitation reactions on the surface of soil particles. Soil erosion episodes result in transport of phosphorus on soil particles suspended in surface water or in groundwater. Phosphorus remains in mineral (solid) form and cannot be converted to a gas for removal as is the case with nitrogen.

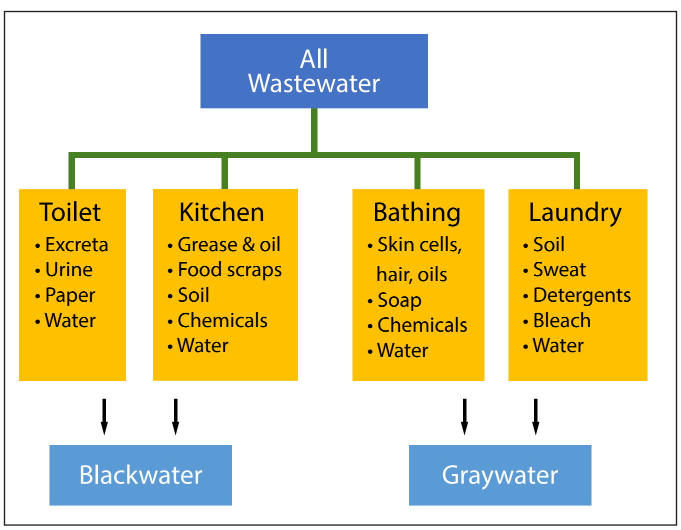

Figure 1-2. Household sources that generate blackwater and graywater.

Metals are inorganic chemical compounds that are stable and resistant to decomposition. While primarily a concern in industrial discharges, they can be present in residential wastewater when strong chemicals and/or vitamins are used in the home. Some drinking water sources can also have high dissolved metal content, depending on the geology and mineral composition of the aquifer. While some metals are essential for animal and plant nutrition, at higher levels they may be toxic. In soil, metals generally become more soluble as pH decreases.

Persistent organic compounds are stable compounds that decompose slowly and can persist in soil and groundwater for years. Like metals, they are primarily a concern in industrial wastewater, but can be found in household solvents, cleansers, paint, pesticides, herbicides and medical products.

Fats, oils, and grease (FOG) in domestic wastewater generally originate in the kitchen or bathroom. Kitchen FOG usually comes from disposing of animal- or vegetable-based food scraps or residue down the sink and into the system. Wastewater from households using garbage disposal devices typically contains 30 to 40 percent more FOG than households not using garbage disposals. Bath oils, suntan lotions, and moisturizing creams are bathroom sources of FOG that may enter the wastewater stream. Excess use of fabric softening laundry products may also be a source.

Other chemicals, including medicines, medicine metabolites, endocrine disruptors, antibiotics, disinfectants, and chemotherapy drugs, can seriously alter the performance of a system through their effect on the biological activity of organisms.

Collection and storage components

Collection components of residential systems are generally limited to a solid, rigid pipe known as a building sewer that collects wastewater from plumbing fixtures and appliances. The building sewer is laid on a 1 to 2 percent downward slope (1/8- to 1/4-inch per foot), exits the structure, and extends to the pretreatment component. A cleanout should be installed in the piping before the first pretreatment component. Depending on sampling needs and requirements, adequate sampling ports should be located between components. Some sites may have elaborate collection systems with multiple building sewers and treatment components. Some have dosing tanks that collect the wastewater and supply lines to transport it to the subsequent components. Holding tanks receive wastewater but have no outlet. They are considered storage devices because they store sewage until it is collected and transported to a different location for treatment and dispersal.

Wastewater consists of blackwater (wastewater from toilets and food preparation areas) and graywater (wastewater from all other plumbing fixtures). Blackwater contains higher concentrations of nitrogen and human pathogens and decomposes more slowly than graywater. Traditionally, systems have combined blackwater and graywater for treatment, but occasionally they are treated separately. Where permitted by local regulation, blackwater and graywater may be split using appropriate plumbing configurations. A urine diversion system incorporating a separate holding tank is one example.

The elimination of graywater reduces hydraulic and organic loading but does not eliminate the need to treat graywater. Although residential graywater has fewer large solids than blackwater, it still contains pathogens. When properly treated, graywater can be reused for irrigation, toilet flushing, or other uses in some jurisdictions.

There are two main types of non-discharging toilets that treat non-water-carried toilet waste: incinerating and composting. An incinerating toilet is a toilet that reduces human excreta and urine to a sterile ash and vapor by incineration. It is a self-contained waterless system that is powered by electricity or fueled by natural or propane gas. Exhaust gases must be properly vented, and residual ash must be removed every other incineration cycle. The toilet can be used 40 to 60 times between incineration cycles. Incineration itself requires about 4.5 hours.

A composting toilet is a toilet that receives non-water-carried waste, such as human excreta, urine, and some organic kitchen waste, and transmits it to a composting chamber. The waste undergoes drying and varying degrees of decomposition. The toilet can contain mechanical agitators, thermostats, humidistats, heaters, and fans to ensure that proper moisture content and temperatures are maintained. Direct homeowner involvement is required to monitor moisture and temperature levels. The key maintenance activity is periodic removal of the composted waste.

Treatment components

Treatment components remove many of the contaminants from the wastewater to prepare the effluent for final treatment and dispersal into the environment. Many options exist and the level of treatment is selected to match the receiving environment and the intended use. The most used treatment component is the septic tank and this is discussed in Chapter 5 along with trash tanks. Advanced treatment components are discussed in Chapter 7.

Final treatment and dispersal components

Final treatment and dispersal components provide the final removal of contaminants and distribute the effluent for dispersal back into the environment. Several options exist for meeting the treatment and dispersal requirements and these are covered in Chapter 8 of this manual. Some processes require aerobic conditions, where free oxygen is available to microbes to complete metabolic processes. Other processes require anaerobic conditions, where free oxygen is unavailable to microbes.

Treatment Processes

Wastewater treatment processes are categorized as:

- Physical
    - Filtration
    - Dispersion
    - Settling
    - Dilution
- Chemical
    - Cation exchange
    - Adsorption
    - Precipitation
- Biological
    - Natural die-off
    - Predation
    - Mineralization
    - Liquefaction
    - Biochemical oxidation and reduction
    - Anaerobic digestion

Physical processes

Filtration works by moving wastewater through pore spaces in various media to trap and remove large particles, pathogens, and suspended solids. The smaller the pore space size, the smaller the size particle or microorganism that can be physically trapped. *Settling* is the process by which solids fall out of suspension in the wastewater. *Dispersion* dilutes the remaining contaminants but does not remove them.

Chemical processes

Cation exchange and adsorption allow contaminants in wastewater to bond with media or soil particles, slowing the rate of movement and allowing uptake of nutrients by plants and microorganisms in the media or soil. *Precipitation* occurs when constituents chemically combine to form a new compound and bind to soil surfaces or become heavy enough to physically settle out of the effluent. Precipitation is important for phosphorus removal.

Biological processes

Natural die-off occurs when pathogens accustomed to anaerobic, high nutrient conditions in the human gut are held in aerobic, nutrient-poor conditions. *Predation* occurs when microorganisms attack and destroy pathogenic bacteria and viruses. *Mineralization* is the biological transformation of organic nitrogen into other inorganic forms that can become part of additional biologically driven treatment processes. *Liquefaction* is the biological transformation of suspended volatile organic carbon into dissolved compounds available for oxidation. *Biological oxidation* occurs when aerobic bacteria break down organic matter into water and carbon dioxide (CO_2), reducing BOD and removing pathogens under aerobic conditions. Anaerobic conditions favor anaerobic bacteria which can digest certain constituents, such as in a septic tank. The last two categories underscore the importance of oxygen state. The term "anoxic" describes a condition of low dissolved molecular oxygen (anaerobic) with presence of bound oxygen in nitrate form. Another category of bacteria which can be supported in aerobic or anaerobic conditions is referred to as facultative. These organisms adjust their metabolic activity based upon the oxygen state.

Analyzing Constituents of Concern

Processes employed to treat a given wastewater stream depend on the constituents present in the effluent and the level of treatment desired. We can test wastewater to determine the strength (or concentration) of constituents of concern, including:

- Solids analysis
- Turbidity
- Biochemical oxygen demand (BOD)
- Chemical oxygen demand (COD)
- Dissolved oxygen (DO)
- Fecal coliform bacteria (FC)
- pH
- Alkalinity
- Total nitrogen (TN)
- Total Kjeldahl nitrogen (TKN)
- Total phosphorus (TP)

Solids analysis measures the mass of solids in wastewater. Typical analyses include total suspended solids (TSS), total dissolved solids (TDS), total volatile solids (TVS), or total solids.

Turbidity is the physical clarity of wastewater and is an indicator for the presence of suspended matter.

Biochemical Oxygen Demand (BOD*)* is the amount of oxygen consumed by microbes during the oxidation of organic matter (both carbon and nitrogen compounds). It is an indicator of overall wastewater strength and typical laboratory tests are performed over a five-day period.

Chemical Oxygen Demand (COD*)* is a measure of the amount of organic matter oxidized by a strong chemical oxidant.

Carbonaceous Biochemical Oxygen Demand (CBOD*)* is the amount of oxygen consumed by microbes during the oxidation of organic carbon component of organic matter not including the nitrogen compounds that are measured as part of BOD. It is an indicator of organic carbon content of a sample.

Dissolved Oxygen (DO) is the concentration of oxygen dissolved in a liquid.

Fecal coliform bacteria (FC) are indicator microorganisms that live in the digestive system of humans and animals but are not necessarily pathogenic. FC can be cultured in standard tests. Positive results indicate contamination from fecal matter and thus, the likely presence of pathogens.

pH measures the acid or base quality of wastewater. It is measured on a scale from 0 to 14, with 0 being the most acidic (e.g., battery acid), 14 the most basic (e.g., drain cleaner), and 7 neutral (e.g., distilled water).

Alkalinity refers to the relative chemical capacity to neutralize acids and buffer variations in pH.

Total Nitrogen (TN) is the sum of organic nitrogen, ammonia nitrogen and nitrate-nitrogen.

Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen and ammonia nitrogen.

Total Phosphorus (TP) is a measure of all the forms of phosphorus, dissolved or particulate.

Importance of O&M Service

Operation and maintenance are essential to the long-term performance of onsite wastewater treatment technologies. All system components require maintenance. O&M

service visits can provide early detection of problems that could result in malfunction of onsite wastewater treatment systems if left uncorrected. Early detection makes it possible to take remedial action before a system becomes a public health hazard, a detriment to the environment, or a liability for the homeowner.

Public health

Wastewater is a public health concern because sewage can contain pathogenic organisms.

The pathogens must be removed from the wastewater before it reaches surface water or groundwater resources. Soil-based treatment systems require an unsaturated zone for pathogen removal. This treatment is obtained by physical (filtration), chemical (adsorption and transformation), and biological (degradation and predation) processes with subsequent die-off or inactivation of the pathogens. Onsite wastewater treatment systems may include treatment components to remove nutrients or additional pathogens before distribution and dispersal to the soil. These systems must be operational to achieve the desired levels of treatment and meet performance requirements.

Public safety

Wastewater treatment systems may be a public safety risk. Access for operation and maintenance activities means reasonable access to tanks. Open tanks pose a potential entrapment and drowning risk. Tank access (typically via risers) must be secure to limit the risk of unauthorized or accidental entry. Secondary restraint systems serve as a backup restriction to tank access and strict adherence to manufacturer guidance for securing the risers and secondary restraint systems are critical. Inoperable components like unsecured riser lids, or structurally unsound risers or tanks must be replaced to maintain system security.

Environmental protection

Environmental regulations are a major driving force in the management of onsite wastewater treatment systems. Until the late 20th century, it was assumed that proper management of wastewater was achieved when sewage effluent did not back up into the house or surface in the yard. Now, a higher level of treatment is required so that constituents of concern are removed before effluent reaches surface water or groundwater resources.

The EPA has implemented many watershed protection programs that affect the onsite wastewater treatment industry. Examples include the regulations for Total Maximum Daily Load (TMDL) of potential pollutants allocated to stream segments and the Coastal Zone Management Program (CZMP) that applies to coastal water resources. Because onsite wastewater treatment systems are non-point sources of contaminants and a possible source of pollution in watersheds, these EPA watershed programs influence how onsite wastewater treatment systems are managed to achieve system performance. The EPA has national guidelines for the management of onsite and clustered (decentralized) wastewater treatment systems. The guidelines can be found at: http://cfpub.epa.gov/owm/septic/home.cfm

System reliability

System reliability describes the life-cycle performance of onsite wastewater treatment systems based upon their engineering, design, installation, use and maintenance. All system components from the source to the final dispersal system must be functional within expectations. Advanced treatment systems have several additional components that must be functional to achieve appropriate levels of wastewater treatment. These components each have operating limits and maintenance activities that must be performed to keep the entire system operating. Servicing or maintaining components should extend their operational life and improve system reliability.

Customer satisfaction

A properly performing system is key to customer satisfaction. If the unit has problems that result in loss of property use or value, the customer will naturally be unhappy and vent their frustration to the maintenance provider, the permitting authority, and anyone else who will listen. Unpleasant experiences resulting in customer dissatisfaction negatively affect the entire onsite wastewater industry.

Evaluating risk

System complexity and the risk to public health and environment are directly related. As system complexity increases, environmental consequences of improper wastewater treatment increase. Generally, the site is assessed for its ability to provide effective wastewater treatment in the soil. Sites with deep, well-drained soils can use a septic tank for pretreatment and a trench distribution system for final treatment and dispersal. The soil provides most of the treatment, and system operation is relatively simple. As the depth of available treatment soil on the site decreases, or the density of development increases, the system requires either additional treatment components to reduce the contaminants in the effluent prior to dispersal or a different type of distribution technology. As the depth of well-drained soil decreases, the required treatment and distribution technologies increases in complexity. Densely developed areas with many systems that could negatively impact groundwater resources often also require additional treatment components that improve wastewater treatment prior to dispersal to the environment. However, in both these cases, wastewater is treated to a high degree and kept below ground, minimizing opportunities for direct contact with effluent.

A system discharging wastewater via an outfall (i.e. a pipe leading to a surface water body) poses the greatest risk. Even though disinfection is generally required, most of the treatment occurs in the treatment components. The effluent then leaves the system via saturated flow directly to the surface, without additional treatment in the soil. The second highest level of risk is associated with surface application of effluent. The potential for human contact significantly increases. Dispersal of wastewater and nutrient uptake still occurs in the soil, thus providing some treatment of the effluent as it infiltrates. Subsurface distribution is preferable to surface applications or outfalls because it limits human contact with wastewater and provides additional polishing and treatment.

Development density is another parameter used to establish the relative risk for a site. A site of one acre or less in a subdivision where all facilities are served by onsite wastewater treatment systems has a greater risk than one facility on several hundred acres of land. The potential for contaminant loading is greater for the subdivision of small lots compared to single facilities on large tracts of land. The increase in risk of human exposure to wastewater and environmental risks caused by developmental density warrants an increase in O&M frequency.

The frequency required for both monitoring of system performance (degree of contaminant removal) and maintenance is related to the complexity of the treatment process, system reliability, and the quality and quantity of wastewater loading.

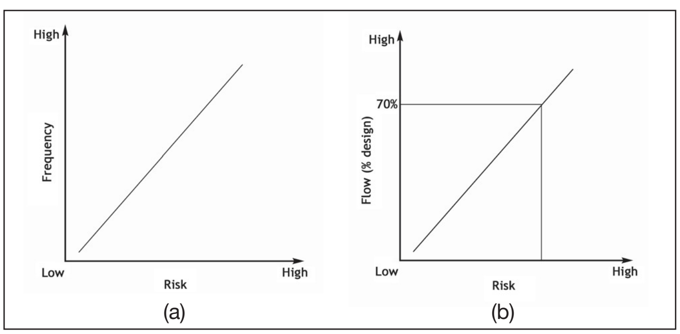

Figure 1-3. Relationships between relative risk, maintenance frequency and actual flow rate as a percentage of design. 1-3 (a): As risks associated with malfunction on a site increase, O&M frequency should also increase. 1-3 (b): As the flow rate increases relative to design capacity, the risk of system malfunction increases.

However, monitoring frequency is also determined based on public and environmental risk. Maintenance frequency is determined by the relative risk posed by malfunction, as well as by performance requirements. Monitoring frequency is often mandated by code or regulation. A system constructed on a site with shallow groundwater, for example, would typically require more frequent visits than a system on a site with greater vertical separation to the groundwater table. Local regulations or the operating permit sometimes require the homeowner to maintain a service agreement with a local O&M service provider. Figure 1-3 (a) illustrates the concept that as the implications of malfunction increase, maintenance frequency should necessarily increase.

System performance is directly affected by the quantity of wastewater being treated relative to the design capacity of the system. Systems perform best (and the risk of malfunction is minimized) if the actual average daily flow is less than 70% of the design capacity as shown in Figure 1-3 (b). At average flows greater than 70% of design flow, peak flows likely exceed system capacity to meet treatment goals and greater attention is thus warranted.

The effects of high average daily flow may be mitigated using a flow equalization tank and a time dosed system. These additions attenuate flow and limit the risk of hydraulic overload in subsequent components. Note that treatment components used prior to a flow equalization tank must still be adequately sized to accept and treat peak (surge) flows.

Management Concepts

To promote clear discussion, it is important to use specific terminology regarding different aspects of management. Management is a term that is generally used to describe different activities and these are described below.

Program management is the overarching framework for providing long-term, successful, and sustainable function of onsite wastewater treatment systems as a component of our wastewater infrastructure. This includes the organizational management necessary to carry out all aspects of the program.

Personnel management describes the operation of a business and the people performing the operational evaluation of the system components.

System management involves operating the individual system. These training materials focus on activities associated with system management or performance of O&M activities on all components of residential onsite wastewater treatment systems. This promotes proper system function and ensures that water quality treatment standards are met. O&M activities may range from relatively simple (gravity) to complex when advanced technologies are required and can include operation, maintenance, monitoring and compensation.

Operation: assessing the functionality of each component of the system.

Maintenance: routine or periodic action or preventative proactive measures taken to ensure proper system performance and extend system longevity.

Monitoring: verifying component or system status relative to specific operational, performance or compliance standards.

Inspection: evaluation of and reporting on the status of an onsite wastewater treatment system.

Reporting: submitting an account of inspection, monitoring or operation and maintenance activities performed on a wastewater treatment system.

Performance standards: minimum criteria for component or system treatment performance (e.g., presence or concentration of a contaminant in effluent) typically established by a proprietary source or regulatory authority to ensure compliance with public health and environmental goals of the state or community.

Acceptable: a condition in which a component is performing its intended purpose and is in an operable state.

Unacceptable: condition in which a component is not operating as intended, indicating the need for maintenance, upgrades, repairs, or further investigation.

Malfunction: a condition in which a component or system does not perform as designed and installed.

Hard malfunction: component malfunction that disrupts the overall system performance and constitutes an immediate public and environmental health and safety risk.

Soft malfunction: component malfunction that does not disrupt overall system performance and can typically be corrected via maintenance or operational activities.

Troubleshooting: identifying and correcting causes of system malfunction.

Mitigation: correcting system malfunction accomplished through an operational evaluation of all components (source, collection and storage, treatment, final treatment, and dispersal) to determine the reason for the malfunction.

Repair: fixing or replacing substandard or damaged components. These may be required repairs, recommended repairs, or upgrades and may require a permit from the local regulatory authority.

Replacement: exchanging a component with an equivalent component.

Upgrade: improving a system by adding a device or component or by replacing a given device or component with one of higher quality to increase the system's effectiveness, treatment capability or to facilitate operation and maintenance.

Compensation: fair payment for services rendered.

Service: performing one or more activities related to wastewater treatment systems, including installation, inspection, operation, maintenance, assessment, and mitigation.

Promoting Professionalism

An onsite wastewater treatment system O&M service provider is a professional trained in the operation and maintenance of onsite wastewater treatment technologies. A profession has specific criteria which are centered around:

- A defined body of knowledge
- Standards for admission
- Standards for retention
- Criteria for expulsion

These training materials are intended to define and standardize the **body of knowledge** needed to perform O&M for onsite wastewater treatment systems. **Standards for admission** to the profession as a service provider are defined as the level of experience and expertise required to effectively perform O&M. A person's abilities may be measured by a certification exam or an evaluation or demonstration of relevant knowledge and skills administered by an organization or entity qualified to certify an applicant's familiarity with the defined body of knowledge.

Standards for retention are actions the person must take to maintain professional certification. Participation in continuing education activities such as short courses, conferences, self-study, and lectures are common best practices in any profession, and may be required to remain licensed or a member of the profession. Generally, continued certification requires that the professional earns a minimum number of continuing education units (CEUs) during a specific period (for example, eight contact hours per year). Learn and observe local requirements for these parameters.

Because professionals are expected to conduct themselves in a certain manner, professions also have **criteria for expulsion**. For example, there are specific activities that should be performed during any service visit. Documentation that a service provider does not consistently perform the minimum required activities can result in a loss of certification. Failing to effectively evaluate systems while determining operational status or reporting inaccurate information are additional examples of criteria for expulsion.

The O&M professional may perform a variety of services for the end user (system owner) that include:

- Assessing the onsite wastewater treatment system to determine operational status.
- Performing routine maintenance activities to keep the system operational.
- Performing proactive maintenance to extend component life and limit risk of component and system malfunction.
- Responding to emergencies in a timely manner.
- Collecting and recording information regarding operational status of treatment components and recommending timely maintenance, replacement, or pumping of components as required.
- Monitoring system performance through collection and analysis of effluent samples when appropriate.
- Recognizing conditions that require troubleshooting to diagnose causes of system malfunctions.
- Reporting system operational status to the owner, regulatory community, and others.
- Serving as an informational resource for the owner.

Troubleshooting of onsite wastewater treatment systems requires advanced knowledge and is not considered a function of the entry level O&M service provider.

Opportunities for Service Providers

The expansion of the onsite wastewater treatment industry combined with the integration of management has created an opportunity for professionals to enter the market. Expanded services are needed due to the increasing use of systems that require routine O&M service visits, increased system density, and more stringent performance requirements set by regulatory authorities. The demand for services has resulted in a greater number of people entering the profession and a need to standardize the services offered.

Standardization of services helps consumers understand their systems' service requirements and encourages consistent O&M. People seeking services from an O&M service provider deserve proper service for a fair price. The industry must define what it considers to be the appropriate standards.

A series of operational checklists were developed to assist the industry in meeting this challenge. The forms provide a uniform approach to evaluate technologies. However, they may not capture all the maintenance activities recommended by system manufacturers. The purpose of these forms is to identify and record the critical factors necessary to determine system performance, and to develop a tracking mechanism for later troubleshooting and repair of the system if needed. Service providers may need additional training and certification for specific technologies they intend to service in their areas. Follow manufacturer-specified guidance so as not to void system warranties.

Summary

These materials will equip service providers with the broad base of information needed to effectively perform service on onsite wastewater treatment systems. They can be customized for a given company or a given set of systems or technologies. Supporting information on developing a business model using these materials is included in Chapter 3.

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Explain the meaning of safety management.
2. Describe the causes of accidents and give examples of each.
3. Identify the hazards associated with wastewater and wastewater systems and name strategies to mitigate these risks.
4. List practices that demonstrate good personal hygiene.
5. Identify safety equipment and demonstrate safe work habits required to prevent injuries.

Overview

This chapter will discuss key points on **safety management.** It will then focus on specific hazards present in the O&M profession and how to mitigate the associated risk. The chapter concludes with a few tips on first aid.

Managing Safety

An effective safety culture is created in a company through clear commitment to safety by top management. Company leaders must commit themselves to safety guidelines, follow them and support their employees and colleagues in following them as well. A safety-oriented culture includes providing adequate resources (money, training, and people) that ensure safety is of the highest importance. A company's safety, health, and environmental (SH&E) management is based on identification of hazards and control of risks by both staff and management. Responsibility for SH&E management in any company involves everyone. Throughout the organization, employees must know their level of responsibility, what they control, and what they don't control. In larger companies, there may be someone directly responsible for development and management of SH&E issues. Because most companies in the onsite wastewater treatment industry are small businesses with fewer than 10 employees, safety programs typically require more involvement by all personnel. All safety topics are equally important. Components of a safety plan include:

- Observation of sound engineering and maintenance standards.
- Development of comprehensive SH&E procedures and operating instructions.
- Clear documentation of safety-related expectations and objectives for managers and employees.
- Use of programs to help employees anticipate potential injuries and incidents.
- Incentives for personnel to minimize behaviors that could result in preventable injury or invite other risks.

Many people consider the process of safety management a burden. However, people make hundreds of safety decisions every hour every day. Here are a few examples:

- When you start your car in the morning, do you look behind as you back out of the driveway?
- When you drive to work, do you wear your seatbelt?
- Do you signal before you change lanes in traffic?
- Do you slow down when driving in heavy rain?
- Do you turn your headlights on at dusk?
- Do you wash your hands before you prepare food?

Companies performing onsite wastewater treatment O&M can translate these examples into actions that encourage worker safety.

Few accidents occur randomly, especially in the workplace. Generally, the root cause of accidents can be placed into one of four categories:

1. Rushing: Hurrying to get the job done for any reason.
2. Eyes not on path: Often the cause of most slips, trips, and falls.
3. Eyes not on task: Contributes to most impact, penetration, or splash injuries.
4. Line of fire: Wrong place, wrong time. May be in combination with 1-3 above.

Creating an SH&E Policy

A company's commitment to SH&E management comes from its vision and values (Figure 2-1). Each company should create and adopt a safety policy that is uniquely aligned to their needs and daily practices. A policy of "no injuries to anyone, ever" has its basis in the belief that accidents can be controlled and injuries prevented. The SH&E policy expresses the company's commitment to this principle (see Example 2-1). The SH&E policy is supported by company standards and safe procedures that allow management of the safety process. Other elements include various operating instructions or procedures, hazard-specific training, and keeping records of pertinent events. Developing and maintaining compliance with regulatory requirements and the company's management system are further supported through a series of reviews. The following list is an example of standards for an SH&E management program and includes steps to establish its SH&E policy.

1. SH&E management

A company's SH&E policy applies throughout its operations. The company identifies policies and standards necessary to comply with local laws and with the company's SH&E management program. The company's SH&E policy and standards are put in place, and resources needed for implementation are established. The conduct and accountability expected from employees for SH&E performance are defined.

2. Management and resources

Management personnel lead the implementation of the company's SH&E policy and establish and monitor programs aimed at the continuous improvement of performance toward defined goals. The responsibility and authority of personnel charged with implementation of these standards are described.

3. Communication

Relevant information is provided to employees, contractors, customers, suppliers, and the public concerning the potential effects of the company's materials, products, and activities on the safety and health of people and the environment. Information and procedures are updated and communicated regularly, as needed.

4. Training

Competence and expertise in SH&E protection are considered in selecting and placing employees. Training needs are identified and satisfied to ensure that all employees have the necessary skills and proper regard for the safety and health of themselves and others as well as for environmental protection. Training and validation are regularly reviewed and updated as needed.

5. Material hazards

A complete and current inventory is available of all materials and products present in the workplace. Their associated hazards are identified, and risks to people and the environment assessed. Appropriate information is maintained to properly handle, store, transport, use, and dispose of materials. Appropriate limits for workplace and environmental exposure to all relevant materials and physical agents are established, and that information is disseminated. Personal protective equipment (PPE) required while in contact with the material is identified, provided, and used.

6. SH&E quality assurance

All facilities are equipped and maintained to ensure continued safe operation, the health of people, and minimum adverse impact to the environment. There are periodic reviews of hazards to identify opportunities for reduction or elimination. There are also routine inspections of worksites, equipment, and PPE.

7. Work procedures

Work procedures are written and maintained (and periodically updated) to ensure the safety and health of people and the protection of the environment. Hazards are eliminated or consequent risks reduced as far as is reasonably practicable. Control measures are implemented, and monitoring programs are arranged to demonstrate safe and healthy working conditions, safe behavior, and effective protection of the environment and assets.

8. Emergency plans

The nature and scale of all reasonably foreseeable emergencies (including transport emergencies) are identified. Adequate arrangements are established to deal with these emergencies. The arrangements are made in association with public emergency services. Plans are communicated and reviewed.

9. Contractors and suppliers

The SH&E implications of all aspects of work carried out by others on behalf of the company are considered. Competent contractors are selected and monitored. The contractor is required to provide sufficient information to ensure that the safety and health of company employees or others are not put at risk and that company environmental standards are not compromised by the contractor's activities.

10. Soil and water protection

Policies and procedures are designed to prevent contamination of land, groundwater and surface waters arising from company activities.

11. SH&E management performance and reporting

SH&E performance and records are maintained as required.

Figure 2-1. Program development pyramid: Building a solid foundation.

Example 2-1. Sample SH&E Policy.

Safety, Health, and Environment Policy

We believe that all work-related injuries, illnesses, and environmental incidents are preventable.
We will manage all our activities with concern for people and the environment and will conduct our business without compromising these values and vision.
We will:

- Strive to ensure our facilities operate to the highest standards to protect our employees, contractors, neighbors, and the environment.
- Sell only those products or services that can be completed, transported, stored, used, and disposed of safely.
- Provide appropriate information and/or training on the safe use and disposal of our products to our customers and consumers.
- Require every employee and contractor working for us to comply with relevant legislation and with this policy and provide them with the necessary training.
- Communicate openly about our activities and report progress on our safety, health, and environmental performance

We make this commitment to our employees, contractors, customers, and the community as we work towards our vision of

"No Injuries to Anyone, Ever"

Implementing the standards

Each company is a little different, but all build their safety program by choosing from the standards listed. Some require minimum effort to implement. Others may require more effort, depending on the activities of the company. Generally, most of the standards can be organized into one of three areas: attitude, skills and knowledge.

Attitude

A person's attitude during the workday is not static and is based on some behavioral characteristics. The list of safety decisions listed at the beginning of this chapter is really a list of safe behaviors that we choose to exhibit. An important part of understanding behaviors is understanding the different perspectives associated with a person's attitudes toward risk. So, let's look at the previous examples from a different perspective:

- When you use the garbage disposal, are you careful not to put your fingers in the unit? When you use a tool other than your fingers to clear a jammed garbage disposal, you put yourself in the **line of fire (the predictable path of a hazard)**.
- When you start your car in the morning, do you look behind as you back out of the driveway? It is easier to keep your **eyes on the path** if the car is backed into the driveway and you have a clear view of the street ahead of you.
- When you drive to work, do you wear your seatbelt? Failing to wear a seatbelt is commonly a **rushing** issue and thus puts you in the **line of fire** if you have an accident.
- Do you signal before you change lanes in traffic? Accidents often occur when drivers fail to signal; because they are **rushing**, they are distracted and don't have eyes **on the path**, or they are not driving defensively to avoid the **line of fire**.
- Do you slow down when it is raining hard? The choice not to **rush** helps drivers stay safe in the rain.
- Do you turn your lights on at dusk? Turning your lights on at dusk enables you to keep your **eyes on the path**.

This last discussion was designed to help understand the motivations for behavior. Behaviors are changed by a conditioned response that works both positively and negatively. If your phone rings and you answer it, and no one is on the line, you will hang up. If this continues you may become less likely to answer the phone each time. If you eat your lunch without washing your hands and don't get sick, you tend not to wash your hands when running late from one job to the next. If you scrape your knuckles on a concrete lid and don't get sick shortly after being exposed to raw sewage through the wound, you are not motivated to wear your gloves. However, if you hurt your back by lifting a heavy concrete tank lid and that causes you to be off work for two weeks and lose pay or customers, you start lifting in a way that protects your back.

Regular reinforcement of safe behaviors is critical to ensuring that complacency does not result in compromised practices. Documenting near misses and identifying unsafe practices facilitates and reinforces adoption and implementation of safe work practices.

Key safety point:

Your feedback from positive and negative behaviors should be the same if nothing happens. Don't gamble with your health and ability to work.

Skills and knowledge

Employees come into this industry with a variety of skill sets and a range of knowledge based on prior experience or work history. Even those new to the industry or workplace may have a common skill that is easily transferred to similar work tasks or work environment. It is important to understand everyone's skills and evaluate them relative to their new workplace environment. This is the employer's responsibility.

A company's safety or integrated work procedure is developed to assist people in controlling risks in the workplace. Therefore, a high degree of compliance is required. Procedures are divided into two main categories to assist in prioritizing the standards to meet local requirements and company policy: critical and regular.

- **Critical procedures** are those that carry significant risk, involve several people, and/or require a high degree of attention to ensure the required level of compliance is maintained. Widespread training is required, and in-depth procedures are needed to ensure that compliance continues. Confined space entry is a perfect example.
- **Regular procedures** are those that involve few people, normal risks, and require lower levels of attention. Training is limited to those people who are directly affected. Examples include checking sludge and scum levels, activating alarms and pumps to confirm operation.

Safety Hazards

In this section, we will review:

- Specific safety hazards
- Points of entry and mitigation
- Engineering controls to minimize risk of exposure by use of PPE

O&M professionals working on onsite wastewater treatment systems must understand the possible safety hazards they may encounter. They must also practice good personal hygiene, avoid personal injury, know the basics of first aid, and understand proper safety procedures for working in confined spaces. Additionally, the service provider must also plan to properly deal with any surface discharge of effluent. Common safety hazards associated with onsite wastewater treatment systems include pathogens, poisonous or explosive gases, electrical hazards, and others.

Biological hazards (pathogens)

Working with onsite wastewater treatment systems creates the possibility that homeowners and O&M service providers may contact **pathogenic parasites, bacteria and viruses** in sewage effluent. Pathogenic bacteria have the potential to cause diseases such as salmonella, shigellosis, typhoid fever, cholera, paratyphoid, bacillary dysentery, and anthrax. Viruses can cause polio and infectious hepatitis. Internal parasites can cause amoebic dysentery, ascaris (giant ringworm), and giardiasis.

Point of entry: (Line of fire exposure)

This exposure is the most common through direct contact with raw sewage or partially treated effluent in any portion of the wastewater stream. Exposure can occur through the skin, eyes, or mouth; through open cuts or scrapes; or with contact from splashing or back splashing of liquid from any of the open elements of a tank or treatment component. This can occur during procedures from initial inspection to testing of system pressure and volume flows (squirt heights). Some pathogenic organisms can live on surfaces for extended periods of time, so contact with a contaminated tool hours after using it could expose a service provider to harm.

Personal protective equipment

- **Hands/arms**

A high-quality nitrile glove is a critical piece of PPE for minimizing this type of exposure. Ensure that the type of glove used is suitable for protection against exposure to raw sewage or effluent. Gauntleted over-gloves provide additional protection. Ensure that when taking this equipment off and on, careful procedures are used to ensure that no cross-contamination of clothing or equipment occurs. If there is a possibility that cross-contamination has occurred, wipe down affected surfaces (steering wheels, gearshifts, door handles, or hand tools) with a disinfectant and wash or sanitize hands thoroughly.

- **Eyes/mouth**

Eye protection such as glasses (with side shields) or goggles should be worn. Safety glasses designed for protection from flying debris and penetrating objects may not be necessary, but a face shield or facemask may be worn for an additional level of splash protection, particularly for the mouth.

Good personal hygiene

Practicing good personal hygiene is important for the operator because all wastewater must be assumed to be infectious. O&M professionals should observe the following practices to avoid infection:

- Keep hands and fingers away from eyes, ears, nose, and mouth.
- Wear nitrile gloves that have been evaluated and deemed "fit for use."
- Wash hands after handling potentially contaminated equipment, tools or surfaces, and before eating or smoking.
- Do not store or wash personal clothing with potentially contaminated work clothing.
- Give cuts and scratches first aid immediately.
- Take a shower after work.
- Receive appropriate immunizations against illness including but not limited to Typhoid fever, tetanus, paratyphoid, polio, and hepatitis A and B. Consult with your local physician and/ or health care professionals for appropriate immunizations and other appropriate preventative health measures.
- If access to running water and soap is limited, provide and use waterless hand cleaners and ensure that they are effective against viruses.

Key safety point:

If your safety gloves have ANY holes or minute perforations, contamination is a real possibility. For comparison, a virus moving through a pinhole in a glove is like a garden snake swimming through a 3-foot culvert.

Gloves should be hospital quality and fit for use. You may not be able to tell if there is a minute hole or tear, so gloves should be changed after each job or more frequently if the barrier protection is compromised.

Underground system components and confined space

There are hazards associated with under-ground or confined spaces. The definition of a confined space is that it has limited entry and exit; it contains known or potential hazards; it has poor natural ventilation; and it is not designed for continuous human occupancy. There are two categories of confined spaces: open-top enclosures with depths that restrict the flow of air, and enclosures with extremely small openings for entry and exit. Wastewater treatment tanks and components typically fall into the latter category. All O&M professionals should have designated training and equipment regarding confined spaces. Seek Occupational Safety and Health Administration (OSHA) guidance and training, applicable certifications.

The nature of confined spaces makes them dangerous. If one does not know the dangers involved and is not properly trained in rescue procedures, death can occur. One-half of fatalities in confined spaces occur among rescuers who are improperly trained and who succumb to danger, because they respond impulsively in an emergency. Confined Space Training should include:

- Safe entry and exit procedures
- Use of respiratory equipment
- Knowledge of first aid techniques
- Isolation techniques: blanking and blocking
- Procedures for monitoring the atmosphere
- Lockout/tag out
- Safe practices
- Confined space rescue

Ventilation is often a problem in confined or underground spaces. Use appropriate measurement devices and technology to test air quality for oxygen concentration and the presence of dangerous gases. A clean air supply should be provided, and the space should be ventilated if any of the following are present:

- Sources of combustible vapor or gases
- Toxins and other contaminants above permissible levels
- Oxygen levels of concern*
- Potential hazards of flammability
- Toxic gases or vapors
- Disturbed particulate matter

*Normal atmospheric oxygen level is 20.9 percent, deficient is less than 19.5 percent, and excess (which can lead to explosion) is more than 23 percent. The normal oxygen level in septic tanks is 19 percent, so care should be taken when accessing a septic tank.

Poisonous and explosive gases

Another hazard associated with onsite wastewater treatment systems is the potential for the buildup of **poisonous or explosive gases** commonly produced as a natural byproduct of wastewater treatment. To prevent problems with the accumulation of hazardous gases, check for oxygen levels and toxic gases with the appropriate equipment, and use appropriate gas masks or air supply packs.

Point of entry: Inhalation (line of fire exposure) and personal protective equipment

This exposure may also be associated with confined space entry. Tanks containing sewage or partially treated wastewater are confined spaces. Entry of such spaces is an OSHA regulated activity. Commercial air quality testers are available for testing the space for oxygen and various types of contaminants. PPE for this exposure ranges from partial facemasks with specialized canisters that capture and remove the poison gas to air-supplied breathing apparatuses. **Do not enter tanks unless trained and equipped to do so.**

Engineering controls for managing gases

Another means of controlling this hazardous environment is using engineering controls. Written procedures, task-specific training, testing equipment, and confined space entry procedures are among these controls. The space may be flooded with a volume of fresh air to purge any poisonous gases, but continual air quality testing is required by a trained person.

Key safety point:

Some gases are poisonous; others are poisonous AND explosive. Air testing devices that test for explosive environments typically test ONLY for the percentage (level) of oxygen that renders it explosive/ flammable. The equipment may or may not indicate if it is poisonous. Make sure the device is capable of testing what is needed (fit for use).

- **Hydrogen sulfide**

Hydrogen sulfide (H_2S) is formed during anaerobic decomposition in the septic tank. Hydrogen sulfide smells like rotten eggs at low concentrations, erodes concrete and metals, discolors and removes paint, and can paralyze the human respiratory system. When mixed with oxygen it forms **sulfuric acid** (H_2SO_4). It causes dizziness, irritation, and headaches at as low as 50 ppm, and is toxic or fatal at 600 ppm. It also causes olfactory fatigue, and, after a few minutes, the smell is no longer noticeable to a human in the area, which may make them forget about the danger.

- **Chlorine gas**

Chlorine (Cl_2) is another gas that can accumulate in the tank. Chlorine gas is heavier than air, is irritating to the nose and mouth, and forms **hydrochloric acid** (HCl) in the lungs. In addition, because chlorine displaces air, it can cause suffocation. Most gas masks are useless against chlorine, so air supply packs are needed for protection. The safety limit for chlorine gas is 1 ppm. Chlorine products are used in disinfection of wastewater. Generally, chlorine gas is not used in small systems. However, chlorine tablets and liquid chlorine bleach may release chlorine.

- **CO(x) gases**

Carbon dioxide (CO_2) and **carbon monoxide** (CO) are other gases that pose hazards to O&M service providers. Carbon dioxide is an odorless, tasteless gas that is produced by gas-forming bacteria that digest organic substances in treatment components of onsite wastewater treatment systems. The exposure limit for carbon dioxide is 5000 ppm. Carbon monoxide can become a problem when there is a lack of oxygen. Carbon monoxide is colorless, odorless, explosive, and causes suffocation. The exposure limit for carbon monoxide is 50 ppm.

- **Methane**

Methane (CH_4), which is produced by gas-forming bacteria that digest organics in septic tanks, is odorless and is explosive when mixed with air.

Lockouts and tag outs

Be aware of standard lockout and tag out procedures that protect people from electrical hazards by deenergizing circuits, releasing pressure in piping and ensuring that they cannot be reenergized or repressurized without appropriate authority. Safe work practices should always be required and be consistent with the nature and extent of the associated hazard. Live components that have been de-energized but not locked out must be treated as energized, and de-energized circuits should be locked out and tagged. Written procedures shall be kept and made available for inspection. A copy of paragraph (b) of General Industry Standards of Occupational Safety and Health, set by the U.S. Department of Labor, 1910.353, fulfills the requirement for written procedures. This can be found at: http://www.osha.gov.

Lockout and tag out procedures state that the locks and tags must be in place before equipment may be de-energized. Live parts must be disconnected from all electrical sources, and stored electrical energy must be released. This includes depressurizing a system prior to servicing. The general provisions for lockout and tag out are that live parts must be deenergized unless it is impossible to do so. If de-energizing is impossible, and if safe work practices for working on live parts are mandated.

Locks and tags must be placed together unless the lock cannot be applied. If only a tag is used, an additional safety measure must be used as well. A lock may only be used without a tag if only one item is de-energized, if the lockout period does not extend past the must check to see if the equipment is de-energized and verify that equipment is safe to energize. Only the person placing the lock should remove it unless that person is not in the workplace and the employer takes certain precautions. Only qualified people are allowed to work on live, exposed parts.

Electrical shock

Electrical shock is another potential hazard to onsite wastewater treatment system O&M professionals. Because electrical shock can cause serious injury or death, O&M professionals should not attempt to repair electrical equipment unless they are experienced with electrical systems. In all states, O&M professionals must be qualified and authorized to work on electrical equipment before attempting to make any repairs or troubleshoot.

Ordinary 120-volt electricity can be fatal; 12 volts may also cause injury. Depending on the systems, service providers may also see 240-volt systems.

Point of entry: Direct contact with energy to ground (line of fire exposure) and personal protective equipment

This exposure may also be associated with a confined space entry and in some cases can be the cause of the resulting reaction of flammable/ explosive gases. Depending on the task at hand, the best control is the use of established lockout/tag out procedures. "Hot wiring" is generally not a recommended practice on live electrical components but is allowed in some cases. The electrical license holder may need additional certification to do this.

Engineering controls for electrical hazards

Another means of controlling this hazardous environment is by engineering controls. Engineering controls are those measures that help control the working environment by some physical means. Written procedures, task-specific training, and following proper lockout/tag out procedures will ensure safety. These procedures must be documented, and specific training must be provided for employees exposed to electrical hazards.

Key safety point:

Use the right tool for the job. Hand tools and some specialized tools are designed specifically for use in electrical environments.

If you are using a lockout/tag out procedure, check to make sure you are following a permit-to-work procedure as well. This is occasionally used as another level of engineering control.

Any electrical system should be considered dangerous unless the service provider knows that it is de-energized. Remember these basic safety rules when working around electrical equipment:

- Always keep your mind on the potential hazard.
- Don't use metal ladders.
- Never override any electrical safety device.
- Inspect extension cords for abrasion and insulation failure.
- Use only grounded or insulated (Under writer Laboratory (UL) approved) electrical equipment.
- Take care not to ground yourself when in contact with electrical equipment or wiring.

Only trained and qualified individuals should be allowed to service, repair, or troubleshoot electrical equipment and systems.

Utility lines

Utility lines are a potential hazard located on every property. The O&M professional should identify the location of utility lines when entering the property. Overhead utility lines are well within the reach of a liquid vacuum tank or backhoe. Look up and around you when you scope the site for other dangers. Underground utility lines are also a danger when digging on a site. Before digging at a site, locate underground utility lines. A free service available to everyone in the United States is the Underground Service Alert (USA). The number to call is: **1(800) 227-2600.** Please remember that some electrical and gas lines may not be marked by the locator service because they are local lines. These local lines may be going to the onsite wastewater treatment system or other units requiring electricity on the property. Always exhibit care when digging with a backhoe or hand tools around an onsite wastewater treatment system.

Other common hazards

Other hazards for the O&M professional include the following (NOTE: This list is not complete). Every region has specific hazards of which service providers should be aware:

- Stinging insects
  - Scorpions
  - Wasps
  - Bees
- Biting insects
  - Black widow spiders
  - Brown recluse spiders
  - Mosquitoes
  - Biting flies
  - Fire ants
- Dogs
- Venomous snakes
- Poisonous or thorny vegetation
  - Poison ivy
  - Poison oak
  - Rose bushes
  - Berry bushes, thistle, devil's club, etc.
- Open excavations
  - Slopes, ditches, shore-up sides
  - Pits
  - Open tank access risers

Ergonomics and Lifting Injury Prevention

O&M professionals should be aware of activities that could cause injury such as when lifting heavy or awkward items. The following steps should be taken to avoid personal injury:

- Do not lift more than can be handled comfortably.
- Establish a solid footing and good balance before lifting.
- Get as close to the load as possible when lifting or carrying.
- Make sure both feet are pointing at the load.
- Keep the back straight, while gripping the object firmly and using the legs to provide lift.
- Never carry a load that is too large to see over or around.

Key safety point:

Use the buddy system. Working alone is always a great risk itself.

Surface Discharge of Sewage and Effluent

In addition to personal safety, the operator should have an emergency plan for dealing with sanitation problems because of surface discharges of effluent or sludge. Because any discharge of effluent should be considered potentially infectious, surfaces that have been contaminated with wastewater need to be dealt with in a manner that minimizes human contact with or exposure to the area. One approach is to physically block off any area where discharge occurs and then treat it with lime if necessary. Fence in tank areas and put lockable lids on tanks to prevent children from gaining access. Removal of residuals (pumping) should be performed by an authorized handler, and sludge should be transported to an authorized facility. Any bypasses must be reported to an appropriate regulatory agency in a timely manner.

First Aid

Because of the possibility of accidents, injury, and exposure to hazardous material, always keep a well-stocked first aid kit on hand, preferably in the vehicle or toolbox from which you are working. Clean water for handwashing should be available, but at a minimum, waterless hand cleaner and towels should be available at the job site. Knowledge of CPR is mandated in some jurisdictions depending on the crew size. With the use of cell phones and two-way remotes, it is unlikely that you will need to make other arrangements, but if you are in an area without service, contingency plans should be developed. All those present on the site must be aware of the location of the nearest hospital or urgent care facility in case of an emergency.

For more complete information about first aid, contact the American Red Cross (www.redcross.org) for training information and publications.

Emergency Contacts

It is a good company policy to require that specific emergency contact information always be available on the work site.

- 911 for EMS units or fire trucks
- Verified 911 address for the site
- Telephone number of the nearest hospital or medical treatment facility
- Directions on how to get there
- Notify others of your schedule if working alone

Summary

Whether we are aware of it or not, we make decisions about safety continuously. It defines our risk tolerance and determines the choices we make as we go forward. We hope that this discussion has raised your awareness of key safety issues for O&M service providers. If you are going to take risks, do it with full knowledge of the potential consequences. Then you can make reasonable choices based on your experience and knowledge as to how much and what level of protection you require.

You can obtain additional information on safety and safety management through various sources including the local regulatory agency responsible for worker and workplace safety in your state.

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the importance of ethics in formulating a business plan that provides value to the customer.
2. Identify the characteristics that contribute to credibility, respect and admiration for a professional or a business.
3. List the keys to establishing a successful business.
4. Describe how the O&M checklists can be used to establish standards of practice.

Overview

The decentralized wastewater infrastructure requires professional Service Providers to perform system management. This industry is growing as a greater percentage of installations include advanced technologies that require a higher degree routine maintenance for optimal performance. Additionally, land development is occurring in areas with significant soil and siting constraints. In areas needing to reduce the water footprint, this industry is vital as we develop strategies to incorporate water reuse features. The successful expansion of the decentralized wastewater industry depends on having capable and responsible business professionals providing critical services to support the infrastructure.

Business Ethics

The O&M Service Provider Program is designed to support the development of a positive relationship between the service provider and the clientele. This discussion is designed to assist individuals and businesses in developing a philosophy for conducting O&M on onsite wastewater treatment systems. All entrepreneurs face questions of ethics and can build credibility, respect, and admiration. Society places a high value on these.

The path to earning credibility, respect and admiration is **ethics**. Ethics addresses the moral duties and obligations that we have within our society. Acceptable behavior (that is, what is right and wrong) is defined within ethics with the goal of achieving maximum good for all people. Ethical questions affect our daily lives. We make ethical or unethical decisions every day that build or weaken our credibility, personal respect, and admiration from others.

Ethics and law

Generally, ethical questions that are the most important evolve into laws. These laws include punishments for offenders as part of the judicial process. The area of personal ethics usually does not include an objective review of one's actions or a structured punishment procedure. Instead, the "rules" are much less specific and are handed down by word and example rather than by written documentation. This is because many of these stated or unstated norms are based on emotion, religious beliefs, and subjective personal perceptions. Thus, the differences between ethics and laws include structure, formality, and objectivity. Even though ethics are vaguer, they influence our lives as much or perhaps more than any law.

Earning customer loyalty

Credibility that is built up within the minds of our peers and customers includes believability and dependability. When one demonstrates a level of integrity, honesty, and consistency in one's dealings with others, society acknowledges the pattern. When people with credibility speak, their words carry weight in the minds of listeners. Their words are believed to be true, simply based upon the source.

The second element of credibility relates to being dependable. People in positions of leadership have developed a history of being believable. Their peers believe what they say and have come to depend upon their input before making decisions. People accept the information being presented by an authority figure, because he or she is dependable. As a service provider, people will accept what you say because of your dependability.

Thus, the value of credibility becomes clear. People seek to continue a relationship with creditable professionals, which makes the professional valuable. As your credibility increases, your value increases.

Respect is directed at people in a position of public respect or at those who have earned personal respect. Positional respect is a result of the position itself, rather than the character of the person holding that position. For example, a police officer guiding traffic in an intersection holds positional respect. You, as a driver approaching the corner, have never met the police office. Yet, you carefully follow instructions because of the police officer's position of respect. This type of respect is necessary for the proper and efficient functioning of our society, but it is not the valued type of respect we are speaking of today.

Personal respect, rather than positional, is the goal of an ethical person. The significant difference between the two is that personal respect must be demonstrated and earned. Our peers are keeping mental notes of our actions, noticing either breeches of ethics or advances that we demonstrate every day. Because personal respect must be earned and is an individual trait arising from our personal relationships, it is far more valuable than positional respect.

For example, regulatory inspectors in our industry have an automatic positional respect. But, like all of us, they also seek and value personal respect. They must be willing to make ethical decisions to earn respect from each person with whom they interact.

The final aspect of ethics that we will address deals with the responsibility we have as professionals to guide and influence the onsite wastewater treatment industry. Part of being a professional is active membership in local, state, and national professional associations.

Participating in these organizations provides the opportunity to both gain (information, continuing education units, etc.) and give back to the industry (modeling best practices, mentoring others).

Giving back also involves developing admiration from our peers through ethical conduct that allows us to guide the industry toward betterment for all. Like personal respect, this benefit from living an ethical life is difficult and time consuming to build but is easily destroyed.

Gaining this admiration is not for the benefit of our personal egos. It is instead our responsibility to provide the necessary leadership for the entire industry.

Ethics from a viewpoint of personal, public, and peer group perceptions

Service providers must function as professionals. This includes knowing the applicable local, state/provincial and national statutes, codes, laws, and regulations applicable to the industry. If facility owners receive conflicting answers to the same question from different service providers, they will become suspicious of the whole industry. You as a professional must know the correct answer to general questions, or you and the industry will lose credibility.

Service providers should compete honestly and lawfully, building their businesses through their own skills and merits. How can this be implemented? Use straight forward contracts showing what services you will provide. These contracts educate homeowners so they can compare bids and ask competitors appropriate questions.

O&M service providers should also avoid any act that might promote their individual interests at the expense of the integrity of the industry and avoid conduct that might discredit the industry. If the onsite wastewater treatment industry gets a "black eye," then it is harder to maintain this industry in the eye of the public. Instead, service providers should seek to enhance the reputation of the industry with others by the way they communicate and interact. You are the representative of the industry to the client, and this will reflect on the industry.

Business ethics summary

We should always be aware of ethics. Doing so allows each of us to gain personal respect, credibility among our peers, and even admiration from those whom we influence. Your credibility is established through being knowledgeable and dependable while demonstrating a level of integrity, honesty, and consistency in business dealings with your customers and this, in turn, establishes your company's value. Standards of Practice provide the framework within which business planning should be approached.

EPA Management Models

The EPA developed a document describing the voluntary approach to management of onsite wastewater treatment systems (U.S. EPA, 2003). These management guidelines included five models with the intention of improving protection of public health through implementing management of onsite wastewater treatment systems. The guidelines presented five different models with an increasing level of management oversight in response to an increasing risk to public health and the receiving environment if the onsite wastewater treatment system malfunctions. The five EPA management models include:

a. Model 1 - Homeowner awareness
b. Model 2 – Maintenance contracts
c. Model 3 – Operating permits
d. Model 4 – Responsible Management Entity operation and maintenance
e. Model 5 – Responsible Management Entity ownership

These management models serve as guidance for local communities to identify and implement an appropriate level of management in their area. The programs are adapted and tailored to fit the unique characteristics of the area. Those considering developing businesses in the decentralized wastewater treatment industry should bear these programs in mind from the perspective of providing necessary services to support implementation of one or more of these Models.

Model 1 - The homeowner awareness model

EPA recommends Model 1 - The Homeowner Awareness Model as the minimum level of management. This program specifies appropriate management practices where treatment systems are owned and operated by individual property owners in areas of low environmental sensitivity, i.e., no restricting site or soil conditions such as shallow water tables or drinking water wells within locally determined horizontal setback distances. This model is applicable where treatment technologies are limited to conventional systems, which are passive and robust treatment systems that can provide acceptable treatment under suitable site conditions despite a lack of attention by the owner. Malfunctions that might occur and continue undetected will pose a relatively low level of risk to public health and water resources. The objectives of this management model are to ensure that all systems are sited, designed, and constructed in compliance with sound, prevailing rules; all systems are documented and inventoried by the regulatory authority; and system owners are informed of the maintenance needs of their systems through timely reminders. The model is intended to provide accurate records of the types and location of installed systems, to raise homeowners' awareness of basic system maintenance requirements, and to better ensure that the homeowners attend to those deficiencies that overtly threaten public health. This model, like all management programs described in this guidance, suggests the use of only trained and licensed/certified service providers. This model is a starting point for enhancing management programs because it provides communities with a good database of systems and their application for determining whether increased management practices are necessary.

Model 2 - The maintenance contract model

EPA recommends Model 2 - The Maintenance Contract Model where more complex system designs are employed to enhance the capacity of conventional systems to accept and treat wastewater or where small clusters are used. For example, treating wastewater to remove nonbiodegradable materials and particulate matter that typically pass through a septic tank may enhance subsurface infiltration system performance on marginally suitable sites (sites with limited area, slowly permeable soils, or shallow water tables). However, such treatment units can have mechanical components and sensitive treatment processes, which require routine observation and maintenance if they are to perform satisfactorily. Maintenance of these more complex systems is critical to sustaining acceptable protection in these areas of greater environmental sensitivity. Therefore, these systems should be allowed only where trained operators are under contract to perform timely operation and maintenance. The objectives of this model build on the Homeowner Awareness Model by ensuring that property owners maintain maintenance contracts with trained operators.

Model 3 -The operating permit model

EPA recommends Model 3 - The Operating Permit Model where sustained performance of onsite wastewater treatment systems is critical to protect public health and water quality. Examples of locations where this program might be appropriate include areas adjacent to estuaries or lakes where excessive nutrient concentrations may be a concern or situations where a source water assessment has identified onsite systems as potential threats to drinking water supplies. EPA strongly recommends that this be the minimum model used where large-capacity systems or systems treating high-strength wastewater is present. Onsite wastewater treatment systems are classified as Class V injection wells under the Underground Injection Control program (UIC). The implementation of these Management Guidelines is deemed to provide adequate protection of public health and the environment. The principal objective of this management program is to ensure that the onsite wastewater treatment systems continuously meet their performance criteria. Limited-term operating permits are issued to the property owner and are renewable for another term if the owner demonstrates that the system complies with the terms and conditions of the permit. In subareas where it is appropriate to use conventional onsite wastewater treatment system designs, the operating permit may contain only a requirement that routine maintenance be performed in a timely manner and the condition of the system be inspected periodically. With complex systems, the treatment process will require more frequent inspections and adjustments, so process monitoring may be required. An advantage to implementing the program elements and activities of this management program is that the design of treatment systems is based on performance criteria that are less dependent upon site characteristics and conditions. Therefore, systems can be used safely in more sensitive environments if their performance meets those requirements reliably and consistently. The operating permit provides a mechanism for continuous oversight of system performance and negotiating timely corrective actions or levying penalties if compliance with the permit is not maintained. To comply with these performance standards, the property owner should be encouraged to hire a licensed maintenance provider or operator.

Model 4 - The responsible management entity (RME) operation and maintenance model

EPA recommends Model 4 - The Responsible Management Entity (RME) Operation and Maintenance Model where large numbers of onsite and clustered systems must meet specific water quality requirements because the sensitivity of the environment is high, e.g., wellhead protection areas or shellfish waters. Frequent and highly reliable operation and maintenance is required to ensure water resource protection. Issuing the operating permit to an RME instead of the property owner provides greater assurance of control over performance compliance. This allows the use of performance-based systems in more sensitive environments than the Operating Permit Model. For a service fee, an RME takes responsibility for the operation and maintenance. This approach can reduce the number of permits and the administration functions performed by the regulatory authority. System malfunctions are also reduced through routine and preventive maintenance. The operating permit system is identical to that of the Operating Permit Model except that the permittee is a public or private RME. States may need to establish (and some already have) a regulatory structure to oversee the rate structures that RMEs establish and any other measures that a public services commission would normally undertake to manage private entities in noncompetitive situations.

Model 5 - The responsible management entity (RME) ownership model

Model 5 - The Responsible Management Entity (RME) Ownership Model is a variation of the RME operation and maintenance concept in the RME Operation and Maintenance Model, with the exception that ownership of the system is no longer with the property owner. The designated management entity owns, operates, and manages the decentralized wastewater treatment systems in a manner analogous to central sewer. Under this approach, the RME maintains control of planning and management, as well as operation and maintenance. This management model is appropriate for environmental or public health conditions like those for the RME Operation and Maintenance Model, but Model 5 provides a higher level of control of system performance. It also reduces the likelihood of disputes that can occur between the RME and the property owner in the RME Operation and Maintenance Model when the property owner fails to fully cooperate with the RME. The RME can also more readily replace existing systems with higher-performance units or clustered systems when necessary. EPA recommends implementation of the management practices detailed in the RME Ownership Model in cases such as where new, high-density development is proposed in the vicinity of sensitive receiving waters. States might need to establish a regulatory structure to oversee the rate structures that RMEs establish and any other measures that a public services commission would normally undertake to manage entities in noncompetitive situations.

The O&M service provider must be aware of the management program being implemented in their service area. Local regulatory entities may implement multiple program levels within their jurisdiction in response to site conditions requiring a greater level of oversight to limit the risk of malfunctioning systems in their area. Due to site specific regulatory approaches and requirements, a service provider may be self-employed or employed by an O&M service company or Responsible Management Entity (RME).

Business Planning

A new business interested in serving the decentralized wastewater industry must consider what business model is optimal to serve their target customers. If you are new to business (or new to THIS business), professional and industry organizations can be a source of helpful information in how to establish a successful business model serving this industry.

A **business model** is a framework for creating economic, social, and/or other forms of value. The term business model is thus used for a broad range of informal and formal descriptions to represent core aspects of a business, including purpose, offerings, strategies, infrastructure, organizational structures, trading practices, and operational processes and policies. For this discussion, we will focus on the services you could offer as a professional in the onsite industry.

In the onsite wastewater treatment industry, particularly when it comes to operation and maintenance, there are many philosophies that professionals may incorporate into their business model. Although individuals must develop a model that is best suited to them, the philosophy that serves as the foundation of any business model will be influenced by regulatory framework, wastewater treatment system management parameters, and professional qualifications associated with operation and maintenance activities.

Creating a strategic plan for your business

Strategic planning is a management tool that guides your business to better performance and long-term success. This training program presents introductory concepts for building a strategic plan for your business. Additional resources and guidance from experts in the process should be sought in developing a successful plan.

Working with a plan will focus your efforts, unify your team in a single direction, and help guide you through tough business decisions. A strategic plan requires you to define your goals, and in defining them, move toward achieving them, which is a huge competitive advantage.

1. Define your company vision

   Your company vision must define your company goals in 100 words or less. This statement must be written and publicly available to both employees and customers.

   This statement should answer the key questions that drive your business: Where is your company headed? What do you want your company to be? What does your business provide to improve your customer's life? What does your business provide to improve your employee's life? A well-defined company vision must communicate how everyone achieves success through being a partner with this business.

2. Define your personal vision

While your personal vision is just as important to your strategic plan, it does not need to be shared with your team and customers. Your personal vision must define your personal goals in 100 words or less. Your personal vision should incorporate what you want your business to bring to your life, whether that's enormous growth, early retirement, or simply more time to spend with family and friends.

Aligning your personal vision with your company vision is key to achieving your personal and professional goals. Know your personal vision statement inside and out and keep it at the forefront of your decision making.

3. Know your business

Conduct a SWOT (strengths, weaknesses, opportunities and threats) analysis. By knowing where your business is now, you can make more informed predictions for how it can grow.

A decentralized wastewater treatment business assists in implementing an effective wastewater infrastructure for customers. An effective infrastructure protects public health, public safety, environmental health, environmental safety and ultimately our water resources. A decentralized infrastructure requires site evaluation, design, installation, operational checks, operation, routine maintenance, maintenance, component replacement, repairs, monitoring, troubleshooting, mitigation, pumping, biosolids management, process monitoring, record keeping, component manufacturing, and property transfer inspections. These services must be available for implementation of a decentralized infrastructure. The level of service provided by your company must match your strengths, knowledge and skills to perform the services effectively and efficiently.

System management is evolving from reactive maintenance to proactive maintenance. Reactive maintenance describes a business model of responding to alarm conditions indicating a component has malfunctioned. Proactive maintenance describes a business model of conducting routine maintenance activities and analyzing operational data to identify and predict the need for system maintenance. As the risk of system malfunctions that may endanger the public increases, proactive maintenance becomes the preferred management approach. Process monitoring is another tool assisting companies implement a proactive business model. Process monitoring provides a computational system evaluating component operating conditions and identifies deviations from normal operation. Therefore, process monitoring identifies component issues before the component causes a deviation from normal treatment performance. Remote continuous process monitoring facilitates remote analysis of component operation data, identification of deviations from normal operational patterns and notification of the relevant parties (service provider, owner and permitting authority) of the component operational deviation. Therefore, remote continuous process monitoring significantly reduces the risk of a system deviating from the desired performance goal. These types of changes offer both opportunities and threats. The business owner must be aware of changing expectations for service, identify any threats these changes have to their current business processes, and recognize opportunities for capitalizing on a changing industry based upon the business strengths.

Water reuse along with its unique service requirements is another example of a disruption in the standard approach to providing wastewater services. Water reuse is a critical component of our long-term water resource solution. Water reuse technologies are available for implementation at single family residences. Because of the inherent risk to public health with direct reuse systems, a multiple barrier approach is implemented in the treatment train to incorporate redundancy of critical processes and achieve log reduction values for target contaminants. A malfunctioning component will have a direct impact on the ability of downstream processes to achieve their water quality goal. Therefore, implementation of remote continuous process monitoring assists in identification of anomalies in component operation and can notify the relevant party about the anomaly. The service provider can act upon the condition, thus lowering the risk of a component malfunction resulting in a deviation from the desired effluent quality. Because of the increased risk to public health, business owners need to assess whether this changing condition is an opportunity or a threat and adjust their business processes accordingly.

Questions such as "Why is this business important?" and "What does this business do best?" are a great place to start. A SWOT analysis can also help you plan for making improvements.

Questions such as "What needs improvement?" and "What more could the business be doing?" can help guide your strategic plan in a way that closes gaps and presents opportunities.

4. Establish short-term goals

   Short-term goals should include everything you (realistically) want to achieve over the next 36 months.

   Goals should be "S.M.A.R.T." (specific, measurable, actionable, reasonable, and timely).

   An example of S.M.A.R.T. goals include "building out a new product or service within the next year" or "increasing net profit by 2 percent in ten months." If you've already conducted a SWOT analysis, you should have an idea of what your business can reasonably achieve over a specified period.

5. Outline strategies

   Strategies are the steps to implement to meet your short-term goals. If the short-term goal is "build out a new product or service," the strategies might be:

   - Researching competitor offerings,
   - Getting in touch with vendors and suppliers,
   - Formulating a development plan, and
   - Outlining a marketing and sales plan for the new offering.

   Strategies must be researched, based upon your strengths, and well defined to become achievable.

6. Create an action plan

   An action plan is an essential part of the business planning and strategy development process. The best analysis, in-depth market research, and creative strategizing are pointless unless they lead to action.

   An action plan needs to be a working document; it must be easy to change and update, but must also be specific about what you're doing, when you will do it, who will be accountable, what resources will be needed, and how that action will be measured.

   Action plans put a process into your strategies. Using the previous example, an action plan might be: "Owner develops competitor research packet for new offerings by 9/1. Review packet with the executive team by 9/15."

   A defined action plan will assist in keeping your strategy implementation on track as other routine tasks compete for your time. The action plan will also communicate with others about the tasks being implemented and the target timeframe for implementation.

7. Foster strategic communication

   To align your team, you must communicate strategically. Results-driven communication focuses conversations and cuts out excessive meetings. Every communication should be rooted in a specific goal.

   Include the how, where, when, and (most importantly) why every time you deliver instructions, feedback, updates, and so on.

   As your team becomes knowledgeable about your business, their interactive communication and actions will instill the company vision and core goals without management directives. Ultimately, a service company must impart value to their customers to be successful. Employees should understand how their communication and actions affect the customer's perception of value and how that action supports the business and their jobs. Their actions must reflect these value propositions to retain and expand the customer base.

8. Review and modify regularly

   Check in regularly to make sure you're progressing toward your goals. A weekly review of your goals, strategies, and action plans can help you see if you need to make any modifications.

   Schedule time in your calendar for this. Weekly check-ins allow you to reassess your plan considering any progress, setbacks, or changes.

9. Hold yourself accountable

   A business coach or mentor is great for holding yourself accountable. If you have a hard time sticking to your plans, you'll have an equally hard time meeting your goals. The number one reason you would choose to work with mentors is accountability. A business coach or mentor should be familiar with your business but not too close to limit the risk of having a perspective too like your own. As the coach or mentor becomes familiar with your team, product, and business, they can assist in working through all kinds of challenges. Because a coach is independent of the day-to-day obstacles to progressing the business, they are independent of the pressures to accept mediocre results. They can revive the resolve and ambition of the leader, resulting in continuation of focus on business growth. A coach can build accountability in the leader through questioning what is working, keeping everything on track, identifying areas of underperformance and asking for corrective action strategies.

10. Be adaptable

    A plan is great, but you can't plan for everything. Challenges will arise. So too will opportunities, and you must be ready at a moment's notice to amend your plan. Weekly reviews will help enormously with this. A strategic plan must remain fluid to allow revision as goals are achieved early and a plan rewrite is required to remain current. The main constant is change. Therefore, it is important to remain agile and seize opportunities that were unforeseen and adjust accordingly. Agility and continuous improvement mindset are critical to being able to exceed plan goals.

11. Create a strategic planning team

    As a business owner, you should never feel like you must do everything alone. A strategic planning team can help with every phase of the process, from creating a company vision to adapting your strategy week-to-week. Compile your team of key management staff and employees—some visionaries and some executors.

A business owner must understand the critical role of good business planning within a successful business. If a business thinks they are too busy to start strategic planning, then the business needs strategic planning more than they know. A focused strategic plan assists in focusing the team's energies on business growth, rather than just doing the same thing each day, or simply reacting or responding to short-term challenges while in business. As a business owner, it is your responsibility to steer the ship, not put out day-to-day fires.

Strategic plan development is challenging and time consuming, but the efficiency gained through implementation and good communication is rewarding. As the team understands their role in implementing the company vision, their normal actions will support the company growth without extra effort. The company will achieve the long-term goals because individual decision making supports the goals. Employees will reduce the number of incorrect decisions which do not support the achievement of long-term goals and drain energy from the company. A good long-term strategic plan will streamline business processes and increase your company's efficiency.

Implementing your business model

System management requires business providing essential services required for a functioning decentralized wastewater infrastructure. A company's business model must outline their services and build the business processes to efficiently deliver those services. Employees are necessary to provide these services. As the knowledge, skills, and abilities of employees increase, the value provided to system owners increases. The Operation and Maintenance Service Provider training program was developed to support employee development and guide uniform and consistent evaluation of treatment systems. The O&M checklists are critical to uniformly determining the operational status of treatment systems, identifying inoperative components and communicating the status of treatment system to the owner. Good communication is essential in business, and everyone must be on the same page when implementing business processes. Having a common knowledge base that specifies activities and tasks can improve efficiency and facilitate long term growth potential through delivery of valuable services.

The service contract is a document that must clearly specify and communicate to the customer the services to be provided, response time to requests for service, authorization to perform defined activities, what is offered for an extra charge, owner responsibilities, and conditions for termination of the contract by either party. Many companies offer multiple levels of contract to foster greater education of the customer on the services offered. An example program could implement a four-tier model with bronze, silver, gold and platinum contracts. The bronze contract is the lowest level of service with periodic assessment of system operational status. The silver contract services are expanded to include replacement of items requiring routine replacement. For example, owner activities tend to damage riser lids, therefore, the contract terms include replacement of one lid per year, while additional damaged lids are authorized to be replaced at the time of service. The gold contract adds additional features such as discounted rate structures and an expanded list of less frequent replacement items included as a one-per-contract year basis. The platinum contract is essentially an inclusive contract of all services including replacement of listed system components and pumping of tank contents. As the customer evaluates the services identified in each contract, the customer increases their knowledge of the variety of services required to keep their treatment system operational. Additionally, the customer should gain a perspective that as the level of service increases, their responsibility to perform routine activities to keep the system operational decreases. Therefore, many knowledgeable customers will choose an inclusive service option.

The service contract must communicate its value to the customer. A well-written contract will demonstrate the level of service provided at a fair expense. Well written contracts allow owners to compare costs with a full understanding of the services to be provided. A good contract communicates value for a fair price. The expense associated with the contract becomes less important as the value to the customer increases. The goal as a company is to be known as extremely valuable, not cheap.

A business model must specify the services to be provided. Available services must impart value to the client (system owner). A well-defined business model implemented by knowledgeable people improves the ability to identify and retain customers. The O&M checklists provide thorough and consistent guidance for evaluation of treatment systems and foster clear communication of system operational status to the owner.

Use of O&M Checklists in Business Implementation

The goal of any business is efficient delivery of services for a fair price. A series of forms and operational checklists are presented and used throughout this program that can facilitate business establishment and growth through standardizing services. The forms are presented in a logical sequence that reflects the different stages of a service visit. A business can adopt these forms to define business processes for conducting service visits. The following is a standard procedure that can serve as a guideline for the use of the checklists in a service program.

Step 1: Client contact

When a client contacts the company to request an estimate for a service contract or when a new client is solicited, establish a file in the client's name. Collect necessary information to develop a reasonable estimate for the contract.

Complete Section A (Client Contact Information) of **Form 3-1. System description (SD)** with:

- Owner's contact information: Name, address, phone numbers.
- A system reference number for the filing system and for use on all checklists associated with this system.
- Property identification number as appropriate.
- Directions to the site.

Step 2: Gather system information

A careful assessment of the system at this point allows the service provider to closely estimate the time needed for an initial system inspection and subsequent service visits, and thus provide an accurate, itemized cost estimate to the homeowner. The provider can determine what, if any, improvements or upgrades will facilitate system maintenance activities. Be prepared to explain that spending money up front on (for example) improving access to components may save dollars in the long run.

The amount of documented system information available will vary. Ask the homeowner for any information they might have. Consult the local permitting authority and request copies of all permit records, including:

- System design
- As-built plans
- Reports on previous service, if applicable
- Local O&M frequency requirements
- Monitoring requirements

Using available information, complete Section B (System Documentation Available) of **Form 3-1. System description (SD)** with information regarding design and installation of the system. Include contact information for the designer and installer if it is available. Note the design flow assigned to the system.

In Section C of **Form 3-1. System description (SD)** (Operational Checklists) indicate which Operational Checklists are needed based on the components included in the system. If documentation is unavailable complete Section D (No System Documentation Available) with facility and system details. This will require a system inspection to thoroughly document the nature of the system components and determine what upgrades or improvements are needed to facilitate system maintenance.

The service provider may choose to evaluate and characterize wastewater source using **Form 9-3. Residential Survey (RS)**. This survey provides valuable information that may influence system performance and therefore the estimate of costs.

Step 3: Develop a cost estimate

Using the information gathered, determine the type and frequency of O&M activities required for the system. Include and specify monitoring and maintenance requirements mandated by the regulatory authority, designer, and/or manufacturers. Develop an itemized cost estimate for an O&M service agreement, taking into consideration travel, personnel, and administrative overhead.

Step 4: Finalize the service contract

Negotiate a service agreement with the client. Be sure to specify:

- Services included in the contract price.
- What activities require additional fees.
- Terms for compensation.
- Upgrades or improvements that will facilitate maintenance and how this affects cost.
- Owner responsibilities, including:
    - Maintaining reasonable water use in the home.
    - Excluding chemicals and other problematic inputs from the system.
    - Managing access by children and confining pets during system inspections.
- Authorization to safely access the site to perform service activities, and
- Terms for termination of contract.

Contracts should be executed in writing for clear communication and the protection of all parties. Each party should receive an original signed copy of the agreement. The permitting authority may also require a copy.

Step 5: Prepare to conduct a service visit

Transfer information from **Form 3-1. System description (SD)** to **Form 3-2. System evaluation (SE)**. Print out or copy the required Operational Checklists listed in Section C on **Form 3-2. System evaluation (SE)**. Collect additional information and items required for locating and completing the O&M service such as:

- Files containing System Description, permit documents, or as-built drawings identifying the components and their location.
- Copies of any previous system inspections.
- Necessary tools for conducting operation and maintenance (See Appendix C for a list of Suggested Tools).
- Locator map identifying the site location.
- Item to document your presence at the site (e.g., business card, copy of documents, summary note, or door hanger).

Step 6: Conduct a service visit using Form 3-2. System evaluation (SE), Section D

Item 1: Record the date and time of the O&M service visit.

Item 2: Assess the site (on lot and in neighborhood).

NOTE: During the first O&M service visit, use **Form 4-1. Site assessment (SA)** to thoroughly assess the site. During subsequent service visits, evaluate the site and note any changes in Item 2. Changes may indicate the need to reassess the entire site using Form 4-1.

2.a: Evaluate the presence and source of any odor within 10 feet of the system perimeter.

2.b: Evaluate the site for surfacing wastewater or breakouts from the system components.

2.c: Evaluate the site and neighborhood for construction, utility work, or changes to drainage patterns. These items may lead to changes in surface and subsurface water movement that could affect the system.

2.d: Verify that all system components are present and have not been modified. (NOTE: If components have been replaced, removed, or upgraded, note these modifications on Form 3-1. System description (SD) or on the as-built drawings.)

2.e: Verify that lids to system components (at grade or on risers) are present and secure.

2.f: Verify that a secondary restraint safety feature is present and secure.

2.g: Document any evidence of vehicular traffic on the onsite wastewater treatment system.

Item 3: Assess flow passing through the system. Average daily flow will be compared to the design flow.

3.a: Indicate which method is used to estimate flow through the system.

- A water meter on the potable water line to the house may provide this information. However, water used for activities external to the house (filling swimming pools, watering lawns, and/or washing cars) will add extra flow that may not reach the system. Water meter readings can be compared on subsequent visits to determine the flow through the system. The average gallons per day through the system can be determined by dividing the difference between readings by the number of days since the last reading.
- If the system includes a dosing tank and controls, use the information recorded from elapsed time meters and/or cycle counters to calculate the flow. Indicate if it is from Form 6-2. Pump: Demand Dosed (PDD) or Form 6-3. Pump: Time Dosed (PTD).
- If a flow meter is included in the discharge line, total flow through the pump tank can be used to estimate average daily flow. This is not typically found in most systems.

- As a last resort, flow can be estimated based on 50 to 70 gallons generated per day per person living in the residence.

Item 4: Complete the operational checklists associated with pretreatment tanks, dosing systems and controls (Chapters 5 and 6).

Item 5: Complete the operational checklists associated with advanced treatment components (Chapter 7). Observe their condition and record their status.

Item 6: Complete operational checklists for final treatment and dispersal components (forms discussed in Chapter 8). This includes any field observations or records of conditions in trenches.

Item 7: List any changes in components or modifications to the system that were noted during the evaluation. This allows detailed updates to **Form 3-1 System description (SD)** to be made in the office.

Item 8: Confirm site status at the conclusion of the O&M service visit.

- Verify that controls are set in the appropriate mode (automatic or continuous run) as appropriate for normal operation.
- Ensure power is available to all necessary components.
- Revisit all components to verify the lids are on and properly secured.
- Gather tools and stow them for use at the next site.
- Verify that no sewage is on the ground surface.
- Provide documentation of the visit for the facility owner (e.g., business card, copy of documents, summary note, or door hanger).

Item 9: Record any additional comments or summary considerations on the system evaluation form.

Item 10: Note the overall system condition. The system is either acceptable or unacceptable. Acceptable means that a component or system is performing its intended purpose and is in an operable state. Unacceptable means that a component or system is not operating as intended, indicating a need to implement maintenance, upgrades, repairs, or further investigation. Note whether maintenance is needed, was performed, or if mitigation is required.

Step 7: Reporting

File forms with appropriate entities. Aside from the homeowner, this may include the permitting authority or any other group that requires a copy of the information.

Form 3-2. System evaluation (SE) will typically provide the required information to permitting authorities, but some entities require a copy of all materials generated during the service visit.

Summary

Successful businesses are required for effective management of decentralized wastewater treatment systems. Business models demonstrating value to all parties are valuable to everyone associated with the business. Defined business processes assist in delivering consistent services efficiently. Knowledgeable, trained, ethical employees demonstrate the value proposition of the business to customers. Customers with a clear recognition of the value received are retained and serve as effective advertising to your prospective future customers. The Operation and Maintenance Service Provider program provides a framework for consistent, effective delivery of services.

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Form 3-1 Operational Checklist: System Description (SD)

(This form is used for the initial system evaluation for the facility and the site. It should be kept on file, and a copy should accompany the service provider at each O&M service visit. Any changes to the system facility should be recorded on the form, along with the date the change was noted.)

A. Client Contact Information

Name of owner:________________________________ Reference #:____________

Phone:________________________________ T:___R:___Sec:___No.:____

Cell:________________________ E-mail:________________________

Site address/County:____

____

Mailing address/County (if different):________________________________

____

Directions to site:____

B. System Documentation Available (If no documentation, complete Section D.)

Date installed:________________________

Installer:________________________________ License #:____________

Phone:____________ Cell:________________ Fax:____________

E-mail:________________________________

Designer:________________________________ License #:____________

Phone:____________ Cell:________________ Fax:____________

E-mail:________________________________

Previous service provider:________________________ License #:____________

Phone:____________ Cell:________________ Fax:____________

E-mail:________________________________

Design flow: ____________Gal per day

C. Operational Checklists

Identify operational checklists for components included in system.

Form 4-1 Site Assessment on File. ☐ Yes ☐ No

Treatment Tanks and Dosing Systems and Controls (Chapters 5 and 6):

☐ Holding tank: ______________ ☐ Septic/trash/processing (tank): ______

☐ Grease interceptor: ___________ ☐ Dosing tank: __________________

☐ Pump: Demand dose system:_____ ☐ Pump: Time dose system: __________

Advanced Treatment Components (Chapter 7):

☐ Media filter: ______________ ☐ Aerobic treatment unit:____________

☐ Constructed wetland: ________ ☐ Lagoon: ____________________

Reference #:____________________

☐ Disinfection unit–chlorine: ______ ☐ Disinfection unit–ultraviolet light: _____
☐ Disinfection unit–ozone: ________

Final Treatment and Dispersal Components (Chapter 8):

☐ Gravity distribution STA:___________ ☐ Low pressure distribution STA: _____
☐ Drip distribution STA: _____________ ☐ Spray distribution STA: ____________
☐ Evapotranspiration bed: ___________ ☐ Free access media filter: ___________
☐ Buried treatment/dispersal:_________ ☐ Outfall: ________________________

D. No Permit or Other Paperwork

Complete the section on Facility Details with any available information on the source. The section on System Details allows the service provider to capture as many specifications as possible and requires a visit to the system.

Facility Details

1. Number of bedrooms: ____________
2. Square footage of facility: ________sq ft
3. Number of current occupants: ____________
4. Design flow: ________gpd
5. Design strength: _______BOD_5 (mg/L) ______TSS (mg/L) _______FOG (mg/L)
6. Water supply:
   - ☐ Private water supply
   - ☐ Public water supply
7. Water source (if private supply): Lateral distance to water supply
   - ☐ Groundwater well: _________ ft
   - ☐ Spring: _________ ft
   - ☐ Surface water (i.e. creek, lake, etc.): _________ ft
8. Garbage disposal present: ☐ Yes ☐ No
9. Water softener or water treatment chemicals used: ☐ Yes ☐ No
   - ☐ Softener backwash drains to system: ☐ Yes ☐ No
10. Facility has NOT been remodeled since original construction: ☐ Yes ☐ No

System Details

1. Site
   a. Landscape position: ______________________________________
   b. Drainage: ☐ None ☐ Surface/gravity ☐ Subsurface/gravity ☐ Subsurface/pump
   c. Monitoring well present. ☐ Yes ☐ No
2. Pretreatment components - Tanks
   a. Holding tank
      1) Capacity:____gal
      2) Material: ☐ Concrete ☐ Fiberglass ☐ Plastic ☐ Other _____________
         i) Manufacturer:________________________
      3) Access to surface. ☐ Yes ☐ No

Reference #:______________

4) Location (GIS): ______/_____

b. Septic tank /Trash tank

1) Capacity (total): __________gal

i) Compartmented. ☐ Yes ☐ No

ii) Capacities for compartmented system: 1)_____gal 2)____gal

2) Material: ☐ Concrete ☐ Fiberglass ☐ Plastic ☐ Other

i) Manufacturer:________________________________

3) Access to surface. ☐ Yes ☐ No

4) Location (GIS): ______/_____

5) Effluent screen. ☐ Yes ☐ No

i) Manufacturer:____________________ Model: ________________

c. Flow equalization tank (surge, etc.)

1) Capacity: ________gal/in

2) Material: ☐Concrete ☐ Fiberglass ☐ Plastic ☐ Other

3) Access to surface. ☐ Yes ☐ No

4) Location (GIS): ______/_____

5) Dosing tank: ☐ NA

i) Manufacturer:____

6) Pump: ☐ NA

i) Manufacturer:____________________ Model:_________ HP:___

7) Pump operating condition

i) Discharge Rate: ________gal/in

ii) Operating Pressure: ___________ft

8) Control method

i) Sensors: ☐ Floats ☐ Pressure transducer ☐ Ultrasonic ☐ Other

ii) Description:____

9) Pump dose settings

i) Frequency _____ doses/day

ii) Interval _____sec/dose

iii) Volume _____ gal/dose

10) Control panel

i) Manufacturer:____________________ Model:________________

11) Electrical

i) Separate circuits (pump, alarm). ☐ Yes ☐ No

ii) Breaker size: ____________

12) Alarm

i) Manufacturer: ____

ii) Sensors: ☐ Floats ☐ Pressure transducer ☐ Ultrasonic ☐ Other

iii) Description:____

Reference #:______________

d. Dosing tank
   1) Capacity: ______ gal/in
   2) Material: ☐ Concrete ☐ Fiberglass ☐ Plastic
   3) Access to surface. ☐ Yes ☐ No
   4) Location (GIS): ______/_____
   5) Dosing tank: ☐ NA
      i) Manufacturer:______________________________
   6) Pump: ☐ NA
      i) Manufacturer:____________________ Model:_________ HP:___
   7) Pump operating condition
      i) Discharge Rate: _____ gal/min
      ii) Head: __________ft
   8) Control method
      i) Sensors: ☐ Floats ☐ Pressure transducer ☐ Ultrasonic ☐ Other
      ii) Description:______________________________
   9) Pump dose settings
      i) Frequency: _____doses/day
      ii) Interval: _____sec/dose
      iii) Volume: _____gal/dose
   10) Panel for sensors
      i) Manufacturer:____________________ Model:________________
   11) Electrical
      i) Separate circuits (pump, alarm). ☐ Yes ☐ No
      ii) Breaker size: ____________
   12) Alarm
      i) Manufacturer:______________________________
      ii) Sensors: ☐ Floats ☐ Pressure transducer ☐ Ultrasonic ☐ Other
      iii) Description:______________________________

3. Advanced Treatment Components
   a. Aerobic treatment unit (ATU)
      1) Treatment method:
      ☐ Suspended growth ☐ Sequencing batch reactor ☐ Membrane bioreactor
      ☐ Attached growth ☐ Rotating biological contactor ☐ Integrated fixed/activated sludge
      ☐ Moving bed bioreactor ☐ Other: ________________________
      2) Capacity: _________gpd
      3) Material: ☐ Concrete ☐ Fiberglass ☐ Plastic
         i) Manufacturer:____________________ Model #:______________
         ii) Product serial #:______________________________
      4) Access to surface. ☐ Yes ☐ No
      5) Location (GIS): ______/_____

Reference #:______________

6) Effluent screen / Tertiary filter ☐ NA
   i) Manufacturer:____
7) Air supply
   i) Air supply method: ☐ Aspirator ☐ Compressor ☐ Blower ☐ Free Air
   ii) Manufacturer:______________________ Model #:______________
8) Sludge return method: ____

b. Single pass filter
1) Media: ☐ Sand ☐ Glass ☐ Foam ☐ Peat/Coir ☐ Other: ____________
   i) Media depth: ___________in
   ii) Liner material:____
2) Filter size: _________sq ft
   i) Dimensions: _____ft x __ft
   ii) Accessibility: ☐ Buried ☐ Free Access ☐ Covered
   iii) Cover material:____
   iv) Lid insulated. ☐ Yes ☐ No
3) Distribution method: ☐ Pressure ☐ Gravity
   i) Pipe diameter: ___________in
   ii) Flow control: ☐ Orifice ☐ Spray nozzle ☐ Other: _______________
   Orifice orientation: ______________________________
   iii) Flow control diameter: ___________in
   iv) Number of flow controls (orifices, nozzles, etc.): _____________
   v) Squirt height/Operating Pressure: ___________in
   vi) Clean outs/Inspection ports: Number_____ ☐ Yes ☐ No
   vii) Clean out access to surface. ☐ Yes ☐ No
4) Filtrate collection system: ______

c. Recirculating Filter
1) Media: ☐ Sand ☐ Gravel ☐ Polystyrene ☐ Peat/Coir ☐ Foam ☐ Textile
   ☐ Other:____
   i) Media depth: ___________in
   ii) Liner material: _____________
   iii) Recirculation method: _____________
2) Filter size: _________sq ft
   i) Dimensions: _____ft x __ft
   ii) Accessibility: ☐ Buried ☐ Free Access
   iii) Cover material:____
   iv) Lid insulated. ☐ Yes ☐ No
3) Distribution method
   i) Pipe diameter: ___________in
   ii) Flow control: ☐ Orifice ☐ Spray nozzle ☐ Other: _______________
   Orifice position: ________________________________

Reference #:________________

iii) Flow control diameter: ____________in

iv) Number of flow controls (orifices, nozzles, etc.): ______________

v) Squirt height/Operating head: ____________in

vi) Clean outs/Inspection ports: Number______ ☐ Yes ☐ No

vii) Clean out access to surface. ☐ Yes ☐ No

4) Filtrate collection system: ______________

5) Forced aeration: ☐ NA

i) Description:____

d. Trickling filter

1) Media: ☐ Gravel ☐ Foam ☐ Textile ☐ Plastic ☐ Other:________________

i) Media depth: ____________in

ii) Liner material: ______________

2) Filter size: __________sq ft

i) Dimensions: ______ft x ___ft

3) Distribution method

i) Pipe diameter: ____________in

ii) Flow control: ☐ Orifice ☐ Spray nozzle ☐ Other: ________________

Orifice position: ___________________________________

iii) Flow control diameter: ____________in

iv) Number of flow controls (orifices, nozzles, etc.): ______________

v) Squirt height/Operating Pressure: ____________in

vi) Clean outs/Inspection ports: Number______ ☐ Yes ☐ No

vii) Clean out access to surface. ☐ Yes ☐ No

4) Filtrate collection system: ______________

5) Forced aeration: ☐ NA

i) Description: ____

e. Constructed wetland

1) Bed media: ☐ None ☐ Gravel ☐ Other:_______________________________

i) Number of cells: ______________

ii) Media depth: ____________in

iii) Water depth: ____________in

iv) Liner material: ______________

v) Border material: ______________

2) Size: __________sqft

i) Dimensions: ______ft x ___ft

ii) Length to width ratio: _______ : ______

3) Distribution method

i) Pipe diameter: ____________in

ii) Flow control: ☐ Orifice ☐ Spray nozzle ☐ Other: _______________

Orifice position: ___________________________________

iii) Flow control diameter: ____________in

iv) Number of flow controls (orifices, nozzles, etc.): ______________

Reference #:________________

v) Squirt height/Operating Pressure: ___________in
vi) Clean outs/Inspection ports: Number______Yes____No____
vii) Clean out access to surface. Yes____No____
4) Surface loading rate: ____________________________gpd/sq ft
5) Filtrate collection system:____
6) Monitoring location: ____
7) Vegetation: ☐ NA
i) Description:____
8) Water level control: ☐ NA
i) Description:____

f. Lagoon system
1) Type: ☐ Aerobic ☐ Facultative ☐ Partial-mixed aerated ☐ Anaerobic
i) Water depth_________________ft
ii) Liner material: __________________________________
2) Lagoon size: _________sq ft
i) Dimensions: _____ft x __ft
ii) Length to width ratio: _____ : ______
3) Inlet to lagoon
i) Pipe description:____
ii) Pipe diameter: ___________in
iii) Clean outs. ☐ Yes ☐ No
4) Surface loading rate: ______________________________________gpd/sq ft
5) Monitoring location: ____
6) Vegetation: ☐ NA
i) Description:____
7) Water level control: ☐ NA
i) Description:____

g. Disinfection unit
1) Chlorine – tablet
i) Manufacturer:______________________ Model:_________________
2) Chorine – liquid
i) Manufacturer:______________________ Model:_________________
3) Ultraviolet light
i) Manufacturer:______________________ Model:_________________
4) Ozone
i) Manufacturer:______________________ Model:_________________
5) Other:____
6) Disinfection monitoring location:_____________________________________
7) Dechlorination
i) Type: ____
ii) Manufacturer:______________________ Model:_________________
8) Dechlorination monitoring location: __________________________________

Reference #:______________

4. Final treatment and dispersal
   a. Gravity
      1) Type: ☐ Trench ☐ Bed ☐ ET bed
         i) If lined ET bed, describe liner material:__________________________
      2) Distribution: ☐ Gravity ☐ Pressure-dosed gravity ☐ Siphon-dosed gravity
      3) Configuration: ☐ Parallel ☐ Serial ☐ Sequential
      4) Distribution approach: ☐ Distribution box ☐ Header ☐ Drop box ☐ Stepdown
      5) Distribution media
         i) Material: ☐ Gravelless ☐ Multi-pipe ☐ Chamber
            ☐ Washed rock ☐ Polystyrene ☐ Other:______________________
            ☐ Combined treatment and dispersal:__________________________
   b. Pressure
      1) Low pressure distribution
         i) Level ☐ Yes ☐ No
         ii) Number of zones: ____________
         iii) Switching method: ☐ NA ☐ Hydraulic valves ☐ Separate pumps
              ☐ Other:______________________________
         iii) Distribution method
              a) Pipe diameter: __________in
              b) Orifice diameter: __________in
              c) Orifice orientation: ____________
              d) Number of orifices: ____________
              e) Squirt height/Operating head: __________in
              f) Clean outs/Inspection ports: Number_____ ☐ Yes ☐ No
              g) Clean out access to surface. ☐ Yes ☐ No
         iv) Number of trenches/beds: ____________
         v) Dimensions of trenches/beds: _____ft x __ft
      2) Drip distribution STA
         i) Distribution field: ☐ Surface ☐ Subsurface
         ii) Drip tubing manufacturer:____________ Model:_________________
         iii) Filtration: ☐ Screen ☐ Disk ☐ Sand
              Manufacturer:______________________ Model:_________________
         iv) Filter cleaning: ☐ Automated ☐ Manual/Continuous flush
         v) Number of zones: ____________
              a) If multiple, switching device: ____________
              b) Zone area(s): _____sq ft ___ sq ft _____sq ft
         vi) Field flushing: ☐ Automated ☐ Continuous ☐ Manual
         vii) Air release/Vacuum breaker: ☐ NA
              a) Manufacturer:_______________ Model:_________________
         viii) Inspection ports. ☐ Yes ☐ No
              a) Locations:____

Reference #:_______________

3) Spray distribution STA
   i) Number of zones: _____________
      a) If multiple, switching device:______________________________
   ii) Sprinkler heads per zone: _____________
      a) Manufacturer:________________ Model(s):________________
      b) Pattern(s):____
   iii) In-line filtration: ☐ None ☐ Screen ☐ Disc ☐ Sand
      a) Manufacturer:________________ Model:__________________
   iv) Total area of spray distribution fields: _________sq ft
   v) Gauging device:____

c. Surface discharge (outfall)
   1) Permit number:____
   2) Permit requirements:____
   3) Location:____
   4) Monitoring location:____

Reference #:_______________

E. Sketch of system

Scale 1 in = _______ ft

Form 3-2 Operational Checklist: System Evaluation (SE)

This form is used to determine system design flow, gather the operational checklists needed to conduct an O&M service visit, and provides a template on which to summarize overall system status to the owner or others.

A. Client Contact Information

Name of owner:______________________________ Reference #____________

Site address/County:____

____

Date of last service:____________________________

B. System Documentation (*See Form 3-1 System Description (SD) for complete documentation)*

Design flow: ________Gal per day

C. Operational Checklists *(from Form 3-1 System Description (SD) Section C)*

Form 4-1 Site Assessment on File. ☐ Yes ☐ No

Treatment Tanks and Dosing Systems and Controls (Chapters 5 and 6):

☐ Holding tank: ________________ ☐ Septic/trash/processing (tank): _____

☐ Dosing tank: ________________ ☐ Pump: Demand dosed system: _____

☐ Pump: Time dosed system: _____

Advanced Treatment Components (Chapter 7):

☐ Media filter: ___________________ ☐ Aerobic treatment unit: ________

☐ Constructed wetland: ____________ ☐ Lagoon: ____________________

☐ Disinfection unit–chlorine: ___ ☐ Disinfection unit–ultraviolet light: ________

☐ Disinfection unit–ozone: ________

Final Treatment and Dispersal Components (Chapter 8):

☐ Gravity distribution STA: _______ ☐ Low pressure distribution STA:_________

☐ Drip distribution STA: __________ ☐ Spray distribution STA: ______________

☐ Evapotranspiration bed: ________ ☐ Free access media filter: ______________

☐ Buried treatment/dispersal: _____ ☐ Outfall: ____________________________

D. System Evaluation

1. O&M service provided on: Date:_______________________ Time:______________

2. Observation and assessment of the site (on lot and in neighborhood)

   a. Evaluate presence of odor within 10 ft of perimeter of system:

      ☐ None ☐ Mild ☐ Strong

      i) Source of odor, if present: ______________________________

   b. Surfacing or breakouts. ☐ Yes ☐ No

   c. Construction, utility work, or changes in drainage patterns. ☐ Yes ☐ No

   d. All components present and not modified. ☐ Yes ☐ No

Reference #:______________

e. Access lid at grade and secure. ☐ Yes ☐ No

f. Secondary restraint safety feature present and secure. ☐ Yes ☐ No

g. Traffic on onsite wastewater system. ☐ Yes ☐ No

3. Estimated system flow: ___________ gallons per day

Indicate method used for estimate:

☐ Source water meter reading:

This time: __________(gal) - Last time: ________(gal) = ______gal

___________________(gal) / __________________days = ___________GPD

☐ Dosing tank control panel meter readings (indicate form used):

☐ PDD ☐ PTD

☐ Discharge line meter ____________GPD

☐ Estimate based on number of occupants: _________People

4. Complete operational checklists for pretreatment tanks, dosing systems and controls (Chapters 5 and 6).
5. Complete operational checklists for advanced treatment components (Chapter 7).
6. Complete operational checklists for final treatment and dispersal components (Chapter 8).
7. Updates required on **Form 3-1 System Description**:

____

____

____

8. Site status at conclusion of O&M service visit:

☐ Verify controls are set in the appropriate mode.

☐ Verify power is on to all components.

☐ Revisit all components to verify lids are secure.

☐ Gather all tools for removal from the site.

☐ Verify no sewage is on the ground surface.

☐ Leave service notification for owner.

9. Comments:

____

____

____

10. Overall system condition:

☐ Acceptable ☐ Maintenance needed

☐ Unacceptable ☐ Maintenance performed

☐ Mitigation required

Reference #:______________

Company name: ____

____

____

Agreement period from: ____________________________to ______________________

This report indicates the condition of the above onsite wastewater treatment system at the time of the O&M service visit. It does not guarantee that it will continue to function satisfactorily.

Signature of service provider:___________________________________Date:________________

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Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the influence of topography and landscape position on system performance.
2. Identify vegetative growth patterns that indicate potential malfunctions.
3. List potential causes and effects of erosion.
4. List the benefits of vegetative cover in the soil treatment area.
5. Describe the importance of avoiding encroachments on system.
6. Identify proper grading and subsurface water management procedures.
7. Accurately complete Form 4-1 Site Assessment (SA).

Overview

The site is essentially a system "component" that must be managed as much as any other individual component. By careful initial assessment of the site, the service provider can track any changes that may occur over time because of system location in the landscape as well as from human activities.

The purpose of this exercise is to identify surface and subsurface features used to manage water on the site since this significantly affects performance of soil-based systems. Complete **Form 4-1 Site Assessment** upon securing an agreement to provide O&M for a system and retain the information for reference. During subsequent visits, Form 4-1 is needed only if conditions on the site have changed. For some of the activities, the service provider will determine whether certain critical points are in acceptable or unacceptable condition. Unacceptable conditions indicate the need for maintenance, upgrade, repair, or further investigation.

Certain tools and equipment are helpful for O&M service providers. A list of suggested tools is included in "Appendix C."

Using Form 4-1: Site Assessment Operation and Maintenance

Careful and continued assessment of the site can be accomplished by using **Form 4-1 Site assessment (SA)**. Protecting the site and the soil treatment area (STA) is fundamental to optimal performance. Ensuring proper stormwater drainage, managing vegetation and preventing encroachment are part of providing complete service. The service provider will determine whether certain critical inspection points are found to be in acceptable or unacceptable condition. Unacceptable conditions indicate the need for maintenance, upgrade, repair, or further investigation.

1. Odors

Evaluate the presence of odor as you approach the system and walk around the property. There should be no strong odors near the filter if the venting system is operating properly and there are no breakouts. If odors are detected, determine the source by checking for missing caps on inspection ports or damaged lids or risers. Check for any indication of leaks around or above the system. Also check the roof vent location, prevailing winds, and atmospheric pressure, as these factors can contribute to odor issues. Note whether odors are mild or strong.

2. Surface water management

Topography and landscape position are the connection between the hydrologic cycle and onsite system site assessment. Excess water, including precipitation and/or stormwater can overwhelm any onsite system's treatment capabilities, and so should be managed carefully and diverted away from system components. The upslope areas of a site have good drainage as water flows away from these zones relatively quickly. The lower portions of the landscape have poor drainage as water flows into these zones or moves away from them slowly. Note the location of the site relative to surrounding properties. If the lot is located at a low elevation, surface water and/or groundwater may flow toward and across it. If a stormwater drainage channel that serves several adjacent properties or an entire subdivision is discharging onto or near the site, there are serious implications for system performance during wet seasons.

Surface water should be diverted away from tanks, the soil treatment area (STA), and any other system components. Diversion berms and swales can be used to collect surface water moving across the site and channel it around the system. If required, these should be intact and operating effectively. Stormwater running off buildings or other structures can infiltrate into the components of onsite wastewater treatment systems. Stormwater from roofs, driveways, or patios should be diverted around or away from the system with the use of gutters, drainage trenches, and/or berms.

Proper grade over system components including tanks and STAs is essential to good surface water management. Final grade should be relatively even and sloped to allow surface water to drain away from system components. However, excessively steep slopes will encourage erosion (soil being carried away during precipitation events). Side slopes of mounded soil treatment areas are prone to erosion if they are excessively steep. Sewage odors and/or surfacing effluent could indicate problems, whether on this site or in the neighborhood. The type of odor and the possible source should be recorded.

Surface settling (uneven low-lying areas in a landscape) indicates soil shifting below the land surface. Settling around tanks or other buried components is a sign of problems: settling can be the result of poor installation practices (settling of backfill), soil infiltration into the tank through open joints or cracks, broken pipes, or structural failure of the tank. Surface settling in the soil treatment area may occur as new fill material used in installation settles. Alternately, soil may be infiltrating into the distribution system or subsurface components may have structurally failed.

Erosion around system components can occur because of settling, improper grading, or inadequate/improper vegetation. The system area should remain free of any eroded areas or any excavations.

3. Subsurface water management

Some sites may have structures below the ground surface to manage water (e.g. near a foundation, or if gutters discharge below-ground). Subsurface water management (diverting water away from system components) can be achieved using interceptor drains to collect water moving onto the site and diverting it around and away from the system. If interceptor drains are present, they must have an effective outlet. That is, the outlet must be capable of conveying collected water away from the site. Some interceptor drains will collect both surface- and groundwater by design: the gravel backfill is brought all the way to the ground surface in a trench excavated to the appropriate elevation. In this case, it is critical that the gravel at the surface be kept open so that the drain remains effective. Outlets should be free flowing, stabilized, and protected with a rodent guard. If a pumped drainage system is used, this introduces another component that must be inspected and maintained. In this situation, additional check lists for the dosing tank, pump, and controls must be completed. Ensure that the pump drainage is operating properly, and the discharge outlet is stabilized.

4. System encroachment

Placing manmade structures too close to system components will affect performance and is probably regulated by local code. Driveways and utility easements should not compromise the system. Patios, decks, or other structures should not be located on top of any system component because they restrict air flow, prohibit proper vegetative growth, restrict access, and encourage stormwater-driven erosion. Likewise, grazing livestock or keeping family pets over the system should be discouraged because this will also cause compaction and erosion, and above-ground components may be damaged. Vegetable gardening and child play areas over system components should be discouraged as these could become contaminated with wastewater if there was a problem with the system. Make a note if any such activities are occurring over or near system components.

Construction or utility installation in the area should be noted during any inspection. Problems associated with such activities may not be readily apparent. It is also important to note if activities on adjacent properties may affect flow or damage the system. Ideally, the system should be protected from traffic either by being in an inaccessible location or by the erection of barriers.

If the design specifies a reserve area for replacement of the initial system, this should also be free of any system encroachment. Any activities that would encourage compaction or erosion should be avoided. Vegetable gardening, however, would be considered an appropriate use of the replacement area.

5. Vegetation and soils

The right type of vegetation on and around system components serves several purposes. Properly maintained vegetation stabilizes the soil and prevents erosion. In the soil treatment area (STA), appropriate vegetation removes water and nutrients and assists in treatment and assimilation of waste. Additionally, vegetation provides food and habitat for soil organisms that break down waste constituents. Vegetation can also be used as an indicator of site characteristics and system function. If wetland plants are present, they could be an indicator of a shallow water table. Dead vegetation near components can sometimes indicate the presence of toxic constituents in the wastewater. In dry regions, dead vegetation over a tank or lateral may simply be due to insufficient moisture to maintain vegetation during dry periods. Excessive vegetation adjacent to dead vegetation (bullseye pattern) can indicate surfacing wastewater. Sometimes vegetation problems have nothing to do with a system. Testing soil fertility and salinity is essential to identify and solve problems with vegetation.

Inappropriate vegetative cover near system components can cause problems for systems. Woody shrubs and trees have extensive root systems that can extend much farther than the leaf canopy visible above ground. Certain trees and shrubs may compromise system components through the infiltration of roots. Additionally, the upheaval of large trees during storm events may disturb or unearth system components. Large trees and shrubs, especially water-loving varieties, should be kept as far from the system as possible. The often cited 10-foot minimum setback may be insufficient for large shrubs and trees; if the branches and leaves extend over the system, chances are the roots will grow toward and/or into the system as well.

6. Groundwater monitoring wells

If groundwater monitoring wells are required for a system, they must be accessible, properly constructed, labeled, and protected. Monitoring well construction, maintenance, and sampling procedures should follow local codes or EPA guidelines if no local codes exist. Indicate if any testing is done and any recommendations are made as a result. If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to an authorized laboratory. Retain a signed COC from the laboratory to complete the system file. Report the information to the proper entities.

7. Additional comments and photographs

Photos of initial site conditions serve as a good baseline for identifying changes in site conditions. Any other site conditions that could affect system performance should be noted (e.g., recent tree removal, flooding, filling in of holes, or grading).

Form 4-1 Operational Checklist: Site Assessment (SA)

Complete this form during an initial site assessment and use as a reference for all other O&M service visits.

Service provided on: Date________________Time: ________Reference:_____________

Service provided by: Company: ________________ Employee:___________________

Date of last service: ____________________________ By: ☐ You ☐ Other:__________

Date of last inspection: _________________________

1. Odor within 10 ft of perimeter of the system:
   a. Evaluate presence of odor:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: _______________________________
2. Surface water management
   a. Surface water effectively diverted from site ☐ Yes ☐ No
   b. Surface water diverted from system ☐ Yes ☐ No
   c. System components free from settling/erosion ☐ Yes ☐ No
3. Subsurface water management
   a. Type: ☐ Gravity ☐ Pump ☐ NA
   b. Outlet open to drainage. ☐ Yes ☐ No
   c. Rodent guard on outlet. ☐ Yes ☐ No
   d. Pumped drainage operational ☐ NA ☐ Yes ☐ No
   e. Stabilized drainage outlet ☐ NA ☐ Yes ☐ No
4. System encroachment *(If yes, indicate all that apply.)* ☐ Yes ☐ No
   ☐ Driveway ☐ Utility easement ☐ Patio ☐ Deck ☐ Gardening
   ☐ Vehicular traffic ☐ Construction ☐ Pets /Livestock
   ☐ Other: _______________________________
5. Vegetation and soils
   a. Trees in soil treatment area ☐ Yes ☐ No
      Species: ______________________________
      Location: ______________________________
   b. Excessive vegetation ☐ Yes ☐ No
      Location: ______________________________
   c. Uneven vegetation ☐ Yes ☐ No
      Location: ______________________________
   d. Poor vegetation ☐ Yes ☐ No
      Location: ______________________________
   e. Soil fertility and salinity sampling (if required) ☐ Yes ☐ No
6. Groundwater monitoring wells NA_________________
   a. Present ☐ Yes ☐ No
   b. Accessible ☐ Yes ☐ No
   c. Intact ☐ Yes ☐ No
   d. Protected ☐ Yes ☐ No
   e. Labels and tags in place ☐ Yes ☐ No

Notes

1. ☐ Acceptable ☐ Unacceptable

3. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

5. ☐ Acceptable ☐ Unacceptable

6. ☐ Acceptable ☐ Unacceptable

Reference # :_____________

f. Groundwater sampling (if required) ☐ Yes ☐ No

7. Additional comments:

____
____
____

Attach any photographs.

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe various types of pretreatment tanks.
2. Evaluate baffles & effluent screens within a tank.
3. Measure sludge & scum accumulation and identify if the tank needs pumping.
4. Identify unacceptable conditions in a tank.
5. Accurately complete Operational Checklists 5-1 Holding tank (HT) and 5-2 Septic, trash and processing tanks (STPT).

Overview

This section describes tanks that are used to separate, decompose, and store solids that are part of the stream of wastewater, including holding tanks, septic tanks, trash tanks, and processing tanks. These tanks are the first component in any treatment train and can serve multiple purposes. Holding tanks, which are tanks with no outlet, are only designed to hold wastewater until it is transported off the site for treatment and dispersal. Septic, trash and processing tanks allow wastewater to move onto subsequent components of the treatment train.

Holding Tanks

Use of a holding tank in an onsite wastewater treatment system incorporates the services of a sewage pumper/ hauler and off-site treatment for the sewage generated. The tank is a watertight device capable of storing several days of wastewater generated in the residence (Figure 5-1). Use of holding tanks is often prohibited except under extenuating circumstances and their use is often temporary while other options are being explored. In some cases, a holding tank captures commercial or industrial flow which cannot be treated in the onsite wastewater treatment system which may include advanced treatment components that cannot tolerate chemical additions.

Holding tanks are generally considered a collection and storage device. Treatment is provided at a different location. Settling of the solids may occur during storage. However, all material in the holding tank is removed during pumping.

Using Form 5-1: Holding Tanks Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Holding Tanks. The form for documenting inspection points follows the text.

1. Conditions at the holding tank

Check for odors near the tank. There should be no strong odors if the house vent stack is operating properly. If odors are detected, determine the source by checking for missing caps on inspection ports, damaged lids/risers, or surfacing effluent. Also check the roof vent location, prevailing winds, and atmospheric pressure. Note whether the odor is mild or strong.

2. Tank description

Record the material used for tank construction. Tanks may be made of concrete, plastic or fiberglass. Note any flex or deformation detected in non-concrete tanks because their strength is dependent upon the integrity of their shape. With the availability of newer materials, metal tanks are uncommon. Metal tanks typically have significant problems with watertightness because of corrosion. Record the capacity of the tank. This should be included in the permit, but if it is not available, it can be calculated by first calculating the volume in cubic feet based on tank dimensions and then using a conversion factor to convert cubic feet to gallons. These calculations are discussed in Appendix A.

3. Holding tank access

Note where the access is located on the tank (inlet or center). If the tank access is farther than 6 to 7 feet from any tank wall, it may limit access for maintenance in those areas, especially during pumping services.

Tank access must be adequate for inspection, servicing and pumping the tank. Holding tank access should always come to grade. Check the seams where risers join tanks for stains or root intrusion that may indicate infiltration of groundwater or surface water. If access is buried, note how much cover is on the tank after excavation, and note swing tie measurements from nearby fixed landmarks to the cover. Include time for excavation in your ongoing costs or convince the owner to modify the access.

The lid on the tank or riser should be securely fastened with safety screws (screws or bolts that require a non-standard tool) or other means (e.g., a concrete lid weighing more than 60 pounds). The lids must be operable as designed, and there should be no obstacle placed near or on top that makes them inoperable. The lids must not be so heavy as to make them inoperable. ***Secondary restraint safety features (secondary lids) are critical, and all holding tanks should be retrofitted if they are not present.*** If the tank was uncovered by the owner, note that on the checklist.

4. Alarms

An alarm is used to monitor the level in the holding tank. Figure 5-1 illustrates a holding tank with a float in an alarm condition. Note whether this is audibly and visibly operational. Some systems may include an event counter to track alarm events. Compare the present reading to previous readings to calculate the number of alarm events. If the system includes a battery backup, verify that the battery operates the alarm as designed.

Telemetry is also an option for remote notification of alarms. If the system includes telemetry, verify the electronic connection between the control panel and the receiving entity. One way to do this is to trigger an alarm and log into the website or make a phone call to verify that the system logged the alarm event.

5. Current tank operating conditions

The maximum liquid level for a holding tank is measured from the bottom of the tank to the invert of the inlet pipe. Measure the current level in the tank with respect to the inlet. Measure the alarm activation level from the invert of the inlet pipe. Use of multiple sensors increases accuracy of water levels. Examples include three alarm sensors set at 50, 75, and 100 percent capacity or two alarm sensors set at 75 percent and 90 percent capacity. The alarm level is specified based on how fast a pumper can respond to a service call. Note whether levels have exceeded the maximum or if the level has dropped without the tank being pumped out (an indication of a possible leak). Check the inlet for sewage flow into the tank. Flows often vary. Continuous flow may indicate a leak. Note the date the tank was last pumped.

6. Tank structural integrity

If the tank is pumped, evaluate structural conditions. ***Do not enter the tank under any circumstances to evaluate integrity.*** Check the integrity of the tank top, sides, and bottom as well as possible from above using either a hand mirror to cast light into the tank or (even better) using a remote camera. The inside of the tank should show no signs of structural failure such as cracks, exposed rebar or rust stains from the rebar in a concrete tank. Spalling (physical degradation of a concrete structure that exposes aggregate and/or structural reinforcement materials) is an indication of possible structural failure and should be noted. A plastic or fiberglass tank that has cracks, punctures or is deformed has lost a significant amount of its structural integrity and is likely no longer watertight.

Because the tank lid is above the liquid level, it is particularly prone to corrosion if constructed of concrete. Inspect the inside of the tank (particularly at the riser/tank seam) to make sure there is no root intrusion that would suggest leakage or infiltration.

7. Holding tank pumping

Check required pumping frequency. Local regulations may dictate the frequency, but holding tanks are generally required to be pumped well in advance of reaching capacity.

8. Contractor

Note contractor responsible for pumping. Note the date and the gallons removed.

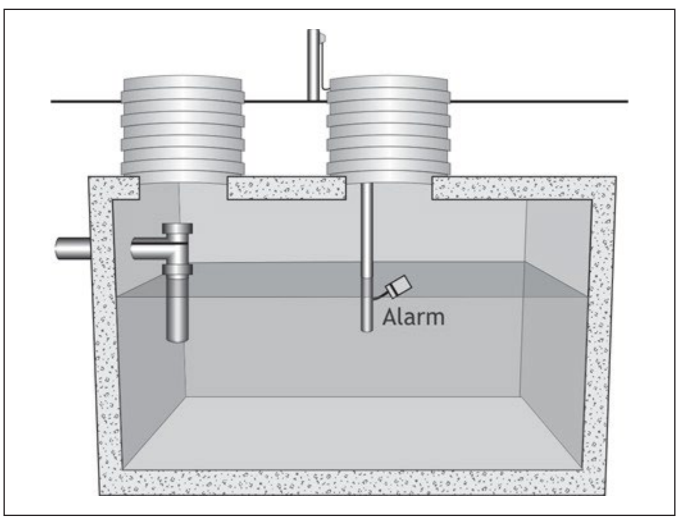

Figure 5-1. Holding tank with the liquid level in alarm condition.

Form 5-1 Operational Checklist: Holding Tank (HT)

Service provided on: Date:________________Time:_____Reference #:_______________
Service provided by: Company: _________________ Employee:____________________
Date of last service: ____________________________ By: ☐ You ☐ Other:__________
Date of last inspection: _________________________

1. Conditions at the holding tank
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ________________________________
2. Tank description
   a. Material: ☐ Concrete ☐ Fiberglass ☐ Plastic
   b. Capacity: __________gal
3. Tank access
   a. Access location: ☐ Inlet ☐ Center
   b. Located at grade. ☐ Yes ☐ No
   c. If 'No', how deep is lid buried. _____________
   d. Risers on tank. ☐ Yes ☐ No
   e. Evidence of infiltration in risers. ☐ Yes ☐ No
   f. Lids securely fastened. ☐ Yes ☐ No
   g. Lid in operable condition. ☐ Yes ☐ No
   h. Secondary restraint safety feature secure ☐ NA ☐ Yes ☐ No
4. Alarm(s)
   a. Alarm(s) present. ☐ Yes ☐ No
   b. Audible alarm operational. ☐ NA ☐ Yes ☐ No
   c. Visible alarm operational. ☐ NA ☐ Yes ☐ No
   d. Telemetry operational. ☐ NA ☐ Yes ☐ No
5. Current tank operating conditions
   a. Liquid level relative to inlet invert: __________ in
      ☐ At ☐ Above ☐ Below
   b. Maximum liquid level of tank (invert of inlet pipe):________in
   c. Height at which alarm is activated as measured from invert of inlet: ______in
   d. Evidence liquid level has been higher. ☐ Yes ☐ No
   e. Evidence liquid level dropped without pumping. ☐ Yes ☐ No
   f. Evidence of continuous inflow. ☐ Yes ☐ No
   g. Date of last pump out: ___________________________________
6. Tank structural condition (evaluate if tank pumped): ☐ NA
   a. Watertight (no visible leaks). ☐ Yes ☐ No
   b. Rebar exposed. ☐ Yes ☐ No
   c. Corrosion present. ☐ Yes ☐ No
   d. Spalling present. ☐ Yes ☐ No

Notes

1. ☐ Acceptable ☐ Unacceptable

3. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

5. ☐ Acceptable ☐ Unacceptable

6. ☐ Acceptable ☐ Unacceptable

Reference #: ____________________

e. Cracks present. ☐ Yes ☐ No
f. Root intrusion. ☐ Yes ☐ No
g. Deflection in plastic tanks. ☐ NA ☐ Yes ☐ No

7. Holding tank pumping recommended. ☐ Yes ☐ No
8. Contractor responsible for pumping:_________________________________
   a. Gal removed: ____________________Date: _____________________

Septic Tanks, Trash Tanks and Processing Tanks

A septic tank, trash tank, or a processing tank is an enclosed watertight container made of concrete, polyethylene, or fiberglass that receives sewage from the source and provides provides primary treatment by separating solids from wastewater (Figure 5-2). Because the liquid level in the tank remains relatively constant, the rate of flow through the tank is slowed, promoting solids separation. Settleable solids fall to the bottom of the tank as sludge, while floatable solids (fats, oils and grease or FOG) rise to the top as scum. The clarified liquid (effluent) in the clear zone moves out of the outlet pipe to the next system component.

Effective solids separation is dependent upon amount of time effluent remains in the septic tank. Detention time is a measure of the time effluent remains in a tank and is calculated by dividing the tank volume by the daily flow (see Appendix A). Inclusion and configuration of inlet deflection devices such as baffles and compartment walls result in a less direct flow path for the effluent to allow for further separation in the tank.

Inflow, infiltration and exfiltration

Inflow (extraneous water directly entering a component, such as via a sump pump, downspout, foundation drain, or condensate line) or infiltration (entry of surface water through a leaking pipe, pipe penetration or access riser/ tank seam) increases flow beyond design capacity and reduces detention time. This results in solids carrying over that can clog the distribution pipes, and excess hydraulic loading that can saturate the soil treatment area and cause the system to malfunction.

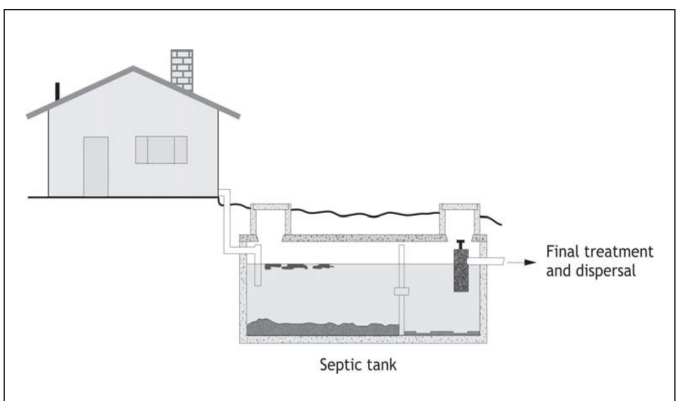

Figure 5-2. Two compartment septic tank system (profile view).

Exfiltration occurs when structural integrity is compromised in the form of leaking pipe penetrations or cracks. Effluent leaking from the tank can contaminate groundwater. If effluent surfaces, it poses a risk to the surface water resources and public health.

All tanks must be watertight to prevent water from entering or leaving the system through openings other than designated inlet and outlet piping.

Septic tanks

Used properly, the septic tank provides primary treatment of wastewater. The fundamental function of the septic tank is to remove solids from raw wastewater, which is called primary treatment. Primary treatment generally refers to allowing solids to settle to the bottom, and oils, grease, and other floatables to migrate to the surface. Primary treatment reduces two commonly used measures of contaminant concentration: five-day biochemical oxygen demand (BOD_5) which is reduced by 31 to 54 percent or more, and total suspended solids (TSS) which is reduced by 60 to 80 percent. Oil and grease are typically reduced by 79 percent.

Of the solids removed from the wastewater, some are digested, and some are stored in the tank. Up to 50 percent of the solids retained in the tank decompose; the rest accumulate as sludge and scum and must be removed periodically. Pumping the tank is performed by a professional, as residual solids (septage) must be handled and disposed of according to accepted practices and regulatory parameters.

The septic tank is a facultative or anaerobic treatment system. An anaerobic system does not have free oxygen and the microbes breaking down the waste must be able to live on the organic material in the septic tank. They are thus referred to as anaerobic microbes. Facultative microbes can thrive with or without free oxygen and are also present in septic tanks.

Anaerobic bacteria do not thrive in environments with free oxygen. Wastewater entering the septic tank has dissolved free oxygen, and this is quickly removed because of the oxygen requirements of the wastewater treatment processes. As the system matures, the anaerobic bacteria become more efficient, because the oxygen demand in the system rapidly removes free oxygen entering with the influent and maintains the anaerobic environment. Greater removal rates of BOD_5 and TSS are achieved under this fully anaerobic environment.

An effluent screen should be placed in the outlet of the septic tank for additional filtration (Figure 5-3). Effluent screens remove solids that could instead be carried out of the tank and potentially clog downstream treatment devices. Processing tanks usually have an effluent screen within the pump vaults.

Trash tanks

A trash tank is generally used before advanced treatment units (Figure 5-4). These tanks can be as small as one-half of the daily design flow volume. The size is generally specified by the manufacturer of the advanced treatment unit. Trash tanks can serve as an anaerobic/facultative treatment device but mainly serve to remove plastic and other non-degradable items from the wastewater stream. Trash tanks are not designed for recirculation.

Processing tanks

This is a special use of an anaerobic treatment tank used to increase nitrogen removal. Processing tanks are used in conjunction with some advanced treatment units that will be covered in Chapter 7. The processing tank is a combination septic tank, surge tank, pump tank, and recirculating tank. As illustrated in Figure 5-5, anaerobic effluent from the processing tank is pumped to an advanced treatment unit where ammonium nitrogen (NH_4^+) is converted to nitrate nitrogen (NO_3^-) by the aerobic processes that occur there. The effluent is then recirculated to the processing tank where denitrifying bacteria convert the NO_3^- to nitrogen gas (N_2) through a process called denitrification. The anoxic conditions in the processing tank are ideal for these organisms.

If there is too much circulation, the processing tank can turn aerobic, thus inhibiting the conversion of nitrate to nitrogen gas. If insufficient circulation takes place, the amount of ammonium that is converted to nitrate might not be sufficient, and the effluent treatment in terms of BOD_5 and TSS removal might be compromised. The O&M for this component is like the other anaerobic treatment tank with the additional step of setting and adjusting the circulation ratio. This is introduced in Advanced Treatment (Chapter 7) and in Troubleshooting (Chapter 9).

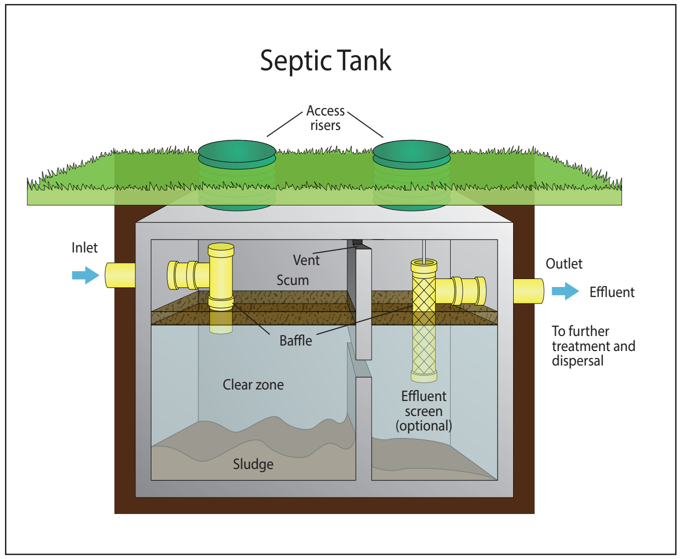

Figure 5-3. Septic tank with an effluent screen installed in the outlet (profile view).

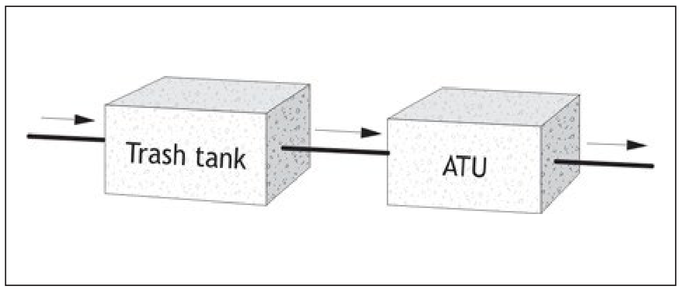

Figure 5-4. Trash tank location within in a treatment train.

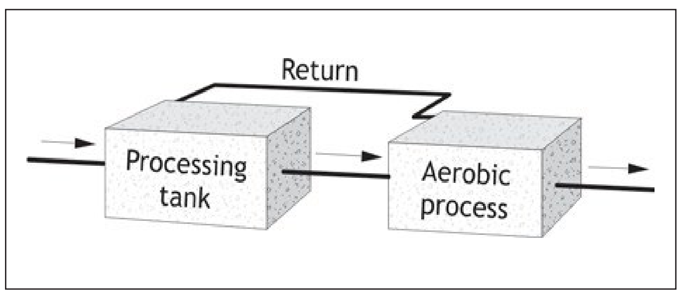

Figure 5-5. **Processing tank location within a treatment train.**

Using Form 5-2: Septic, Trash and Processing Tanks (STPT) Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Septic, Trash and Processing Tanks. The form for documenting inspection points follows the text.

1. Type of tank

Note the type of tank being evaluated: a septic tank, trash tank, or processing tank. Also note whether a pump vault is present within the tank.

2. Conditions at the tank

Check for odors near the tank. There should be no strong odors if the house vent stack is operating properly and there are no breakouts. If odors are detected, determine the source by checking for alternative venting structures, missing caps on inspection ports, damaged lids/risers, or surfacing effluent. Also check the roof vent location, prevailing winds, and atmospheric pressure. Note whether the odor is mild or strong.

3. Tank description

Record the material used for tank construction. Tanks may be made of concrete, plastic or fiberglass. With the availability of newer materials, metal tanks are uncommon. Metal tanks typically have significant problems with watertightness because of corrosion. Record the capacity of the tank. This should be included in the permit. If not, it can be calculated. Calculate the volume in cubic feet based on tank dimensions and use a conversion factor to convert cubic feet to gallons. These calculations are presented in Appendix A.

Note whether the tank is compartmented, the number of compartments in the tank, and, if available, the capacity in gallons of each compartment.

4. Tank access

Note where the access is located on the tank (inlet/outlet/center). If the tank access is farther than 6 to 7 feet from any tank wall, it may limit maintenance in those areas, especially during pumping services.

Tank access must be adequate for inspecting contents and servicing the tank. If there is a riser on the tank it should be in good condition and properly sealed to prevent infiltration. Check the riser/tank seam for root intrusion stains that would indicate infiltration of groundwater or surface water. Ideally, the riser should come to grade so that no digging is required to reach it. Some jurisdictions may not require access to grade. If it is buried, note how much cover is on the tank, and note swing tie measurements from fixed landmarks on the property to the center of any cover(s).

The lid on the tank or riser should be securely fastened with safety screws (screws or bolts that require a non-standard tool) or other means (e.g., a concrete lid weighing more than 60 pounds). The lids must be readily removable by the service provider but child-proof. The lids must be operable as designed, and there should be no obstacle placed near or on top that makes them inoperable. The lids must not be so heavy as to make them inoperable. ***Secondary restraint safety features (secondary lids) are critical, and all tanks should be retrofitted if they are not present.*** If the tank was uncovered by the owner, note that on the checklist.

5. Alarms

Note whether alarms are present and if they are audible or visible. Test to make sure they are fully operational. Check whether monitoring is included (telemetry or electronic monitoring) and test the systems manually (by logging in) to confirm operation.

6. Current tank operating conditions

Under most conditions, the liquid level in a septic tank should be at the invert of the outlet of the tank. The maximum liquid level for a tank is measured from the bottom of the tank to the invert of the outlet pipe. Note whether levels have exceeded the maximum or if the level has dropped without the tank being pumped out (an indication of a leak). Measure the current level in the tank with respect to the outlet. If the level is below the outlet, the tank may not be watertight. If it is higher than the outlet, the effluent screen may need cleaning. If the screen is not the problem, there may be problems in a downstream component that are preventing flow through the system (such as pipe blockage or ponding in the soil treatment area (STA).

Note that some proprietary systems specify that the connection between a trash tank and the aeration chamber remains submerged to prevent air flow back into the source. In these instances, the maximum liquid level for the trash tank is above the outlet pipe.

Evaluate the liquid level markings on the sides of the tank to see if the level has changed over time. Debris hanging over the baffles or other horizontal surfaces would also indicate that the level has been above normal.

If alarms are present, measure the alarm activation level from the invert of the outlet pipe and test the system to ensure it correctly activates.

Check the inlet to evaluate flow into the tank. Normally, the flow will start and stop due to use in the home. Continuous flow into the tank, especially without foaming (commonly associated with washing machine or dishwasher discharge), may indicate a plumbing leak. Notify the owner if this is the case and direct them to check for and correct any plumbing leaks.

Use the table in this section to document details about the effluent. A properly functioning septic or primary treatment tank will have three distinct layers: scum, clarified effluent (a clear zone), and sludge. Processing or recirculation tanks will not typically have this layered condition because of the way effluent flows through them. Check for the presence of these three layers by using a profile probe. Heavy flocculation in the clear zone indicates the need for pumping. Absence of any one of the layers should lead to further evaluation. Common causes of this would be the use of septic tank additives, water treatment device discharge or excessive use of antibiotics or toxic cleaning chemicals. Any of these will affect bacterial activity and some will affect how solids separate in the tank. Measure the depth of sludge/scum accumulation with respect to the bottom of the outlet baffle.

Make a note of the date of the last pumping of the tank. Local regulations may dictate pumping frequency or maximum sludge/scum accumulation before pumping is required.

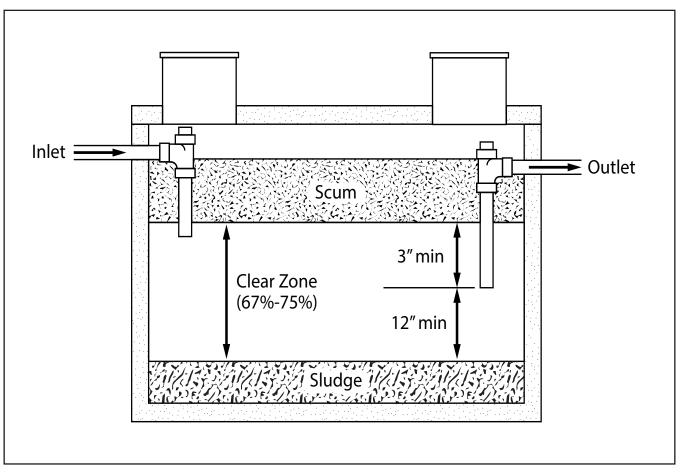

Figure 5-6. Guidelines for pumping a septic tank based upon solids accumulation

Managing solids is fundamental to optimal performance. The clear zone represents the treatment volume in the tank which should be about 67 to 75 percent of the operating tank volume or liquid depth. This means the sludge storage volume is roughly 25 to 33 percent of the liquid depth. Thus, the combined depth of the scum and sludge should not exceed 25 to 33 percent of the total liquid depth. The scum layer should be at least 3 inches above the bottom of the outlet baffle, and the sludge should be at least 12 inches below the bottom of baffle (Figure 5-6). These benchmarks help prevent solids from escaping the primary treatment zone into subsequent components.

Some designs or proprietary products specify a minimum treatment volume within the tank. This specification determines when sludge storage is at capacity.

The depth of sludge/scum accumulation can be measured as a thickness by itself or with respect to the distance between the bottom of the scum layer and the bottom of the outlet baffle.

Note the presence of non-biodegradable items in the tank. This includes sanitary wipes, cigarette butts, toys, hygiene products or similar items.

7. Tank pumping

Note whether conditions dictate pumping the tank.

8. Baffles and screens

An outlet baffle or Tee should be present in the outlet of the tank. This baffle draws effluent from the clear zone which protects the distribution box and soil treatment area from fats, oils grease (FOG) and other suspended solids. In some cases, there may be a baffle on the inlet and a compartment baffle as well. Baffles may be concrete (manufactured as part of the concrete tank) or constructed of PVC (sanitary tee). Occasionally, baffles are made of other materials (often a retrofitted device). The baffle(s) should be in place, functioning to keep the scum layer from intruding into inlet or outlet pipes, and (if concrete) not corroded.

An effluent screen may be in the tank outlet piping. It should be secured in place. Note whether the water level has been above the screen. The presence of an effluent screen can result in a higher operating level in the tank as the screen functions by collecting solids. The plugging effluent screen serves as a flow restrictor, causing the water level in the tank to fluctuate. This water level rise increases as a greater percentage of the screen becomes plugged. There should be no signs of bypass around the screen. Note whether bypass has occurred. When the screen is removed for cleaning, extra effluent can surge into the next component of the treatment system. To avoid this surge, consider pumping out the tank just prior to removing the screen. A clogged screen could be an indicator that the tank may need pumping anyway.

To service (clean) the screen, remove it from the case, inspect it to ensure it is undamaged and operating as designed. Note the extent of screen blockage. Using proper personal protective equipment, spray the screen off over the inlet opening of the tank and re-insert it into the housing at the outlet. Alternately replace it with a new unit and place the old one in a bag for proper disposal or off-site cleaning.

9. Tank structural condition

If the tank is pumped, evaluate structural conditions. ***Do not enter the tank under any circumstances to evaluate integrity.*** Check the integrity of the tank top, sides, and bottom as well as possible from above using either a hand mirror to cast light into the tank or (even better) using a remote camera. The inside of the tank should show no signs of structural failure such as cracks, holes, exposed rebar or rust stains from the rebar in a concrete tank. Spalling (physical degradation of a concrete structure that exposes aggregate and/or structural reinforcement materials) is an indication of possible structural failure and should be noted. For plastic or fiberglass tanks, check for cracks, punctures or deformation that compromises structural integrity.

Because the tank lid is above the liquid level, it is particularly prone to corrosion if constructed of concrete. Inspect the inside of the tank (particularly at the riser/tank seam) to make sure there is no root intrusion that would suggest leakage or infiltration.

10. Contractor

If the tank was pumped, note the name of the contractor, the volume of tank contents removed, and the date the service was performed. Note whether the tank is refilled after pumping. This is sometimes necessary to prevent flotation.

11. Lab samples

If sampling is needed for troubleshooting or to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record the chain of custody (COC) information and deliver the sample to an authorized laboratory. Retain a signed COC from the testing laboratory to complete the system file. Report the information to the proper entities.

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Form 5-2 Operational Checklist: Septic, Trash and Processing Tanks (STPT)

Service provided on: Date:_______________ Time:__________Reference #:_______
Service provided by: Company: _______________ Employee:___________________
Date of last service: _________________________ By: ☐ You ☐ Other:___________
Date of last inspection: ______________________

1. Type:
   ☐ Septic tank ☐ Trash tank
   ☐ Processing tank ☐ Pump vault present
2. Conditions at the tank
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong ☐ Chemical ☐ Sour
   b. Source of odor, if present: ______________________________
3. Tank description
   a. Material: ☐ Concrete ☐ Fiberglass ☐ Plastic
   b. Capacity: ________gal
   c. Compartmented. ☐ Yes ☐ No
   d. Capacities for compartmented system: 1) _____ gal 2) _____ gal
4. Tank access
   a. Access location: ☐ Inlet ☐ Outlet ☐Center
   b. Located at grade. ☐ Yes ☐ No
   c. If 'No', how deep is lid buried. ___________
      Swing tie measurements: ____________________________
   d. Risers on tank. ☐ Yes ☐ No
   e. Evidence of infiltration in risers. ☐ Yes ☐ No
   f. Lids securely fastened. ☐ Yes ☐ No
   g. Secondary restraint safety feature secure ☐ NA ☐ Yes ☐ No
   h. Lid in operable condition. ☐ Yes ☐ No
5. Alarm(s)
   a. Alarm(s) present. ☐ Yes ☐ No
   b. Audible alarm operational. ☐ NA ☐ Yes ☐ No
   c. Visible alarm operational. ☐ NA ☐ Yes ☐ No
   d. Telemetry operational. ☐ NA ☐ Yes ☐ No
6. Current tank operating conditions
   a. Liquid level relative to outlet: ___________in
      ☐ At ☐ Above ☐ Below
   b. Maximum liquid level of tank (invert of inlet pipe):__________in
   c. Height at which alarm is activated as measured from invert of inlet: ___________in
   d. Evidence liquid level has been higher. ☐ Yes ☐ No
   e. Liquid level dropped without pumping. ☐ Yes ☐ No

Notes

2. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

5. ☐ Acceptable ☐ Unacceptable

6. ☐ Acceptable ☐ Unacceptable

Reference #:____________________

f. Evidence of continuous inflow. ☐ Yes ☐ No
g. Date of last pumping: ______________________________________
h. Presence of flocculant in clear zone. ☐ Yes ☐ No
i. Evaluation of layers in tank:

Comp. No.	Scum		Clear Zone		Sludge (inches)		Odor	Other
	Depth (in)	Appearance	Depth (in)	Appearance	Depth (in)	Appearance		
1								
2								

*Color choices:
☐ Clear ☐ Flocced ☐ Milky ☐ Muddy ☐ Grainy
☐ Black ☐ Brown ☐ Mustard ☐ Gray ☐ White

7. Tank pumping recommended. ☐ Yes ☐ No
8. Baffles and screens structurally sound.
   a. Inlet baffle in place. ☐ Yes ☐ No
   b. Outlet baffle in place. ☐ Yes ☐ No
   c. Compartment baffle in place. ☐ NA ☐ Yes ☐ No
   d. Effluent screen. ☐ Yes ☐ No
      Manufacturer:______________Model:______
   e. Screen accessible from ground surface. ☐ Yes ☐ No
   f. If screened, percent plugged: __________%
   g. Screen cleaned. ☐ Yes ☐ No
9. Tank structural condition (evaluate if tank pumped): ☐ NA
   a. Watertight (no visible leaks). ☐ Yes ☐ No
   b. Rebar exposed. ☐ Yes ☐ No
   c. Corrosion present. ☐ Yes ☐ No
   d. Spalling present. ☐ Yes ☐ No
   e. Cracks present. ☐ Yes ☐ No
   f. Root intrusion. ☐ Yes ☐ No
   g. Deflection noted (plastic tanks). ☐ NA ☐ Yes ☐ No
10. Contractor responsible for pumping: ____________________________
   a. Gal removed: ________________ Date: __________________
   b. Tank refilled after pumping ☐ Yes ☐ No
11. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:____
   ____
   ____

7. ☐ Acceptable
☐ Unacceptable

8. ☐ Acceptable
☐ Unacceptable

6 | Dosing Systems and Controls

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Identify various dosing tanks and describe their function.
2. Describe demand and time dosed pump operation.
3. Identify unacceptable conditions in a dosing system.
4. Measure and set sensors used in a dosing tank.
5. Set a timer system.
6. Accurately complete appropriate Operational Checklists.

Overview

Dosing systems are used in many ways in onsite wastewater treatment systems. For example, they may be used to deliver effluent to a soil treatment area at a higher elevation than the wastewater source. In Figure 6-1, effluent is pressure-dosed to the STA using a pressure manifold and parallel gravity distribution. In Figure 6-2, there are two dosing systems, one to dose an advanced treatment component and another to dose a low-pressure distribution STA. Dosing tanks sometimes serve multiple purposes within a treatment train, such as a flow equalization tank, processing tank, recirculation tank, or a sump.

The dosing system consists of a tank, pump or siphon, discharge assembly, controls, and associated electrical components (Figure 6-3). The design of the system is dictated by the nature of the downstream components.

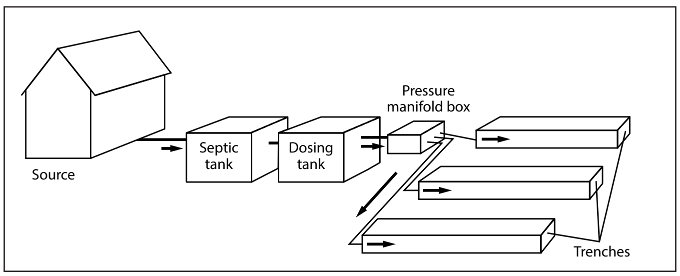

Figure 6-1. Treatment train using a dosing tank to convey effluent to an upslope pressure-dosed gravity STA.

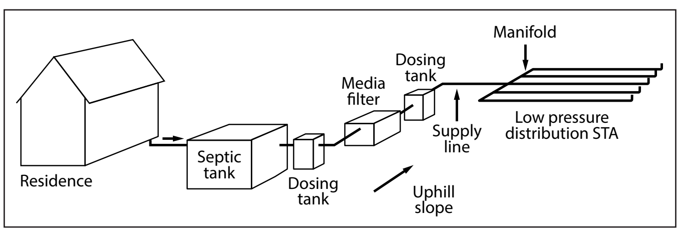

Figure 6-2. Treatment train with two dosing systems, each with a pump and system controls: one for the media filter and one for the low-pressure distribution STA.

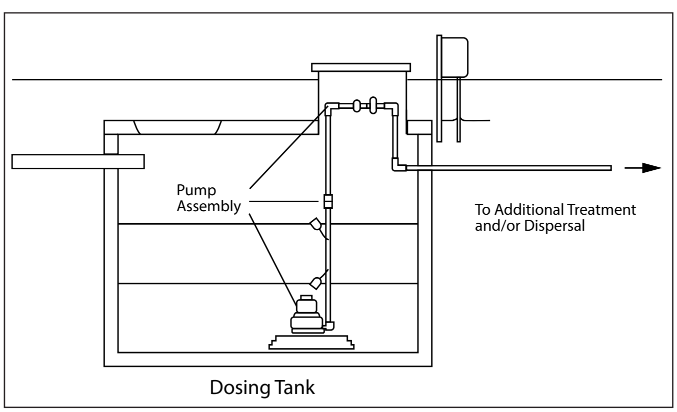

Figure 6-3. Diagram illustrating components of a pump system (profile view)

Dosing Tanks

The dosing tank is typically a concrete, fiberglass, or polyethylene container that collects and stores effluent. Dosing tanks are often separate vessels but may be incorporated in a primary or secondary treatment component. A dosing tank is sized to hold the total effluent dose volume, minimum storage volume for proper operation, and surge volume during high water events. The dose volume is determined based on the daily flow from the facility, the type of distribution system, and how often the advanced treatment unit or final treatment and dispersal area is designed to be dosed.

A dosing tank includes a pump that distributes the wastewater to the next component either on a demand basis determined by the float switch setting or using a timer to control pump operation. These dosing configurations are discussed in the next section.

Surge or flow equalization tanks are typically designed to hold twice the normal daily flow of the home. The flow from a surge or flow equalization tank is delivered to the next component using time dosing (i.e., a pump controlled by a timer) to the next component in fixed amounts with fixed off or rest periods. Time dosing systems are discussed in a succeeding section.

The operation of a low-head pump tends to stir the contents of the tank and solids can thus be resuspended and discharged. High head pumps with flow inducers that draw liquid from the bottom of the housing will draw in settled solids as well. The pump intake may be raised slightly above the bottom with the addition of a block or other device (Figure 6-4). Installation in a pump basin causes the effluent to be drawn from a higher elevation over the lip of the basin (Figure 6-5). Another option is

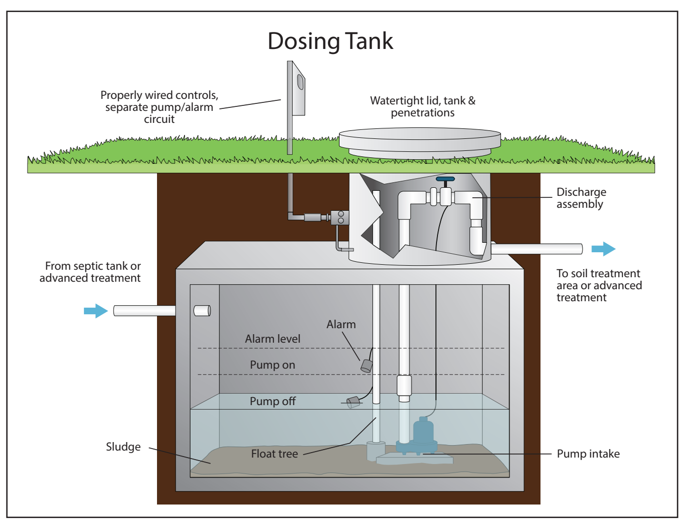

Figure 6-4. Dosing tank with the pump sitting on a block to elevate the intake above any accumulated solids

to install the pump within a vault as shown in Figure 6-6. The vault has openings around the midpoint through which effluent is drawn from the clear zone. The vault may also include an effluent screen to provide further solids removal.

Pumps

Pumps are an important component of many onsite wastewater treatment systems. Pump selection is influenced by solids-handling capability and flow and pressure relationships. The two main types of pumps for sewage purposes are solids-handling pumps and effluent pumps. Clean water sump pumps should not be used in onsite wastewater or sewage applications.

Solids-handling pumps can accept wastewater containing both liquids and solids (up to a specified diameter) are positioned before septic tanks and move raw, unsettled wastewater. Grinder pumps are a type of solids-handling pump that incorporate a grinder or shredder in the impeller design. This grinding/shredding aspect of their operation results in increased suspended solids. If grinder pumps discharge directly into a septic tank, they can disrupt the settling process in the tank and allow solids bypass to downstream components. The implications for system performance are significant since removal of solids in the primary treatment zone is fundamental to effective wastewater treatment.

In contrast, effluent pumps are positioned after septic tanks and used to move effluent that is relatively free of solids. Most effluent pumps use centrifugal force to push the liquid through the pump. Single and multi-stage pumps provide a broad range of pressure and flow options for use with various systems. Note that turbine pumps are more sensitive to the amount and size of solids in the effluent and are more likely to clog if solids remain suspended in the septic tank effluent.

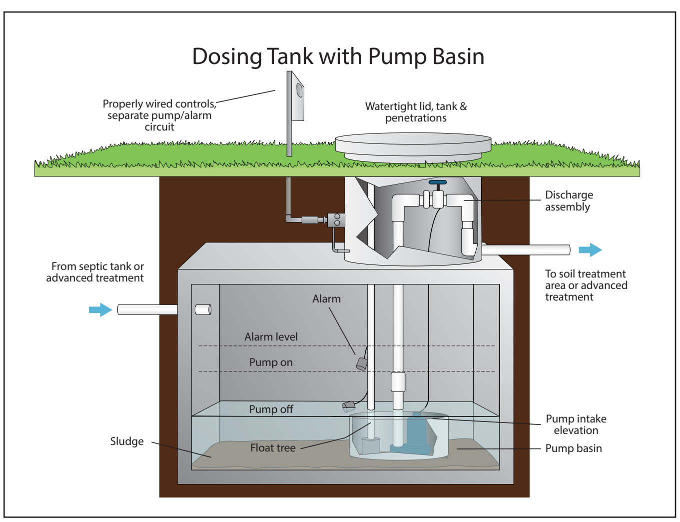

Figure 6-5. Dosing tank with the pump installed inside a pump basin to effectively raise the intake well above the bottom of the tank where solids may accumulate.

Both high-head (multi-stage) and low-head (single stage) pumps are centrifugal pumps (Figure 6-7). They operate similarly in that they draw liquid into the impeller portion of the pump. The spinning movement of the impeller imparts energy to the liquid through centrifugal force. The difference between these two styles of pumps is the method of operation. A low-head (single stage) pump typically consists of a motor above a single impeller. The motor rotates the impeller at a lower speed. The rotating single impeller draws in liquid and transfers energy to the liquid, discharging it from the pump under pressure.

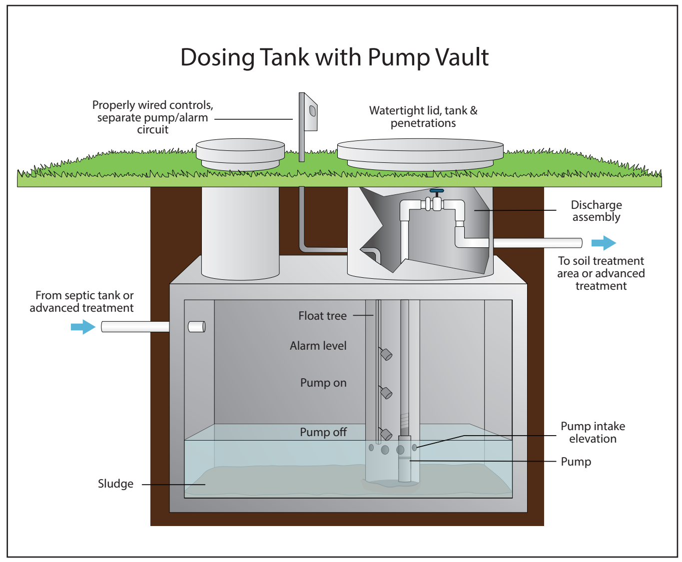

Figure 6-6. Dosing tank showing a pump installed within a pump vault, effectively raising the intake well above the bottom of the tank where solids may accumulate.

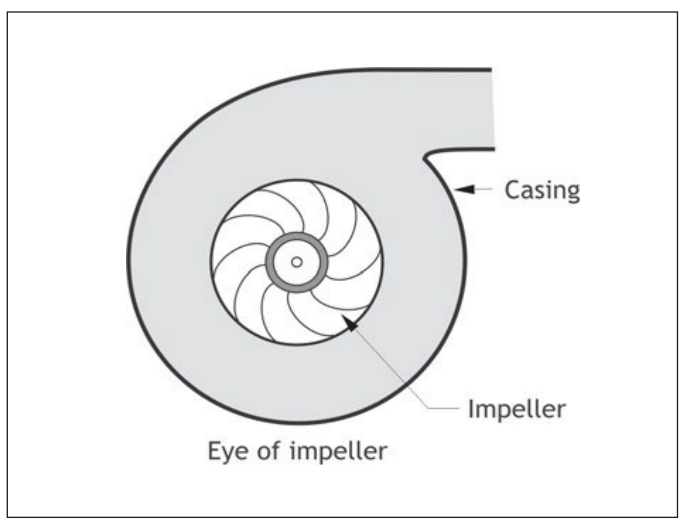

Figure 6-7. Centrifugal low head (single stage) pump (view from bottom).

A high-head pump (like a traditional deep-well motor pump) consists of a motor below a rotating shaft. The motor rotates a series of impellers (usually called stages) mounted on the shaft (Figure 6-8). The first impeller (or stage) draws in liquid, energizes it, and conveys it to the next stage. This passage of liquid from one stage or impeller to the next increases the energy transferred to the liquid. As a result, it is under higher pressure when it leaves the pump relative to pressure generated from a single stage pump.

This distinction is apparent in the pump or performance curves for comparable examples of the two pump types. Low-head pumps (single stage) deliver a relatively higher flow rate at a lower pressure. High-head/turbine pumps (multi-stage) deliver a relatively lower flow rate at a greater pressure. Thus, the slope of the curve for a given high-head pump is steeper than for a comparable low-head pump (Figure 6-9). In performance, this means that a minor reduction in flow rate (caused, for example, by plugging of orifices) will result in a significant increase in pressure with a high-head pump. This pressure increase will push water out of other orifices without giving any indication of plugging problems to the service provider. A low-head pump will show signs of a problem to the service provider by increased pump run time. A low-head pump will more readily pass larger solids than a high-head pump. Table 6-1 shows performance tradeoffs of high-head and low-head pumps. Pump manufacturers are now making low-head pumps with steeper curves to enhance performance.

Pumps are sized according to the specifications for each system including flow and pressure requirements to successfully deliver the correct dose of wastewater to the next component. Verify the original system requirements when replacing pumps in these systems to ensure proper performance.

Pump Discharge Assembly

The discharge assembly is made up of all the piping and components from the pump discharge point to the point at which the supply line leaves the tank (Figure 6-10). The assembly should be accessible and reachable from the surface. Typically, this means the discharge assembly is placed within 14” of final grade. The pump discharge assembly should have a union or other quick-disconnect coupler to facilitate removal of the pump without having to cut the discharge pipe. A length of nylon rope, stainless steel cable, or other non-corrodible material should be attached to the pump to facilitate removal during maintenance activities. An isolation valve should be located on the field side of the quick

Table 6-1. Performance tradeoffs of high-head and low-head pumps.

High-head pumps	Low-head pumps
• Capable of maintaining a constant gallons per minute (GPM) with 80 percent of the orifices plugged because of the high-head and reserve energy of the pump; prevents the alarm from sounding and at the same time overloads portions of the system.	• Sensitive to changes in pressure (plugged orifices); activates the alarm and alerts the owner that a problem is developing.
• Has a lower solids-handling capability, and may require a pre-screening or filtering of the effluent.	• Can accommodate some solids in liquid. Some low-head pumps can handle up to 3-inch spheres in wastewater.
• Pumps relatively less gallons per minute.	• Pumps relatively more gallons per minute.
• Smaller orifices required in distribution networks and are typically placed in a 12 o’clock position to achieve equal loading; orifices of small size and in this position will plug as the lines are continually flooded.	• A higher horse-power/low-head pump may be needed in some applications.
• Requires scheduling to cool pump.	• Need not be sleeved to promote heat exchange to the surrounding liquid.

disconnect to prevent backflow from the supply line during maintenance.

The discharge assembly should include a check valve in the vertical portion of the piping network to prevent drainback of effluent from the supply line and back through the pump after a dosing event. However, if it is possible the liquid in the supply line may freeze, a weep hole allows effluent to drain back into the pump basin without running back through the pump. If a check valve is used, a vent hole (air release) must be provided between the pump and the check valve to prevent airlock of the pump.

If the discharge point is at a lower elevation than the pump-off elevation, an anti-siphon device will prevent continued effluent delivery after pump deactivation. Three common approaches to prevent siphoning from a dosing tank include: (1) A weep hole (as shown in Figure 6-10) is a simple anti-siphon device; (2) A check valve installed in a reverse orientation at the highest point in the discharge pipe closes to allow effluent delivery during a pump event and then opens when the pump deactivates to allow air to enter and break the siphon action, and (3) A spit tube installed at the highest elevation in the discharge pipe directs some of the flow back into the tank during the dosing cycle. When the pump turns off, the air flow through the tube breaks the siphon.

If the system design is such that the supply line from the tank moves first uphill and then downhill to the next component, air may become trapped in the line during rest periods. In this situation, an air release valve should be placed at the highest elevation of the piping. The valve should be housed in a vault that comes to grade to allow for inspection and maintenance.

Controls

Pump systems should include a control panel. The control panel can be quite simple or more complex based on the functions it must perform. Electrical components in the panel respond to water level sensors or floats in the tank to trigger one or more functions:

- Activating or deactivating a pump.
- Sounding and displaying an alarm to indicate problems.
- Initiating timers, meter and counters.

A pump system can be dosed either when a set volume is collected (demand dosed system) or by using pump capacity (gpm) and time (time dosed system). Demand dosing is a common mode for delivering effluent to the final treatment and dispersal component. Timers are more commonly found on treatment devices or systems

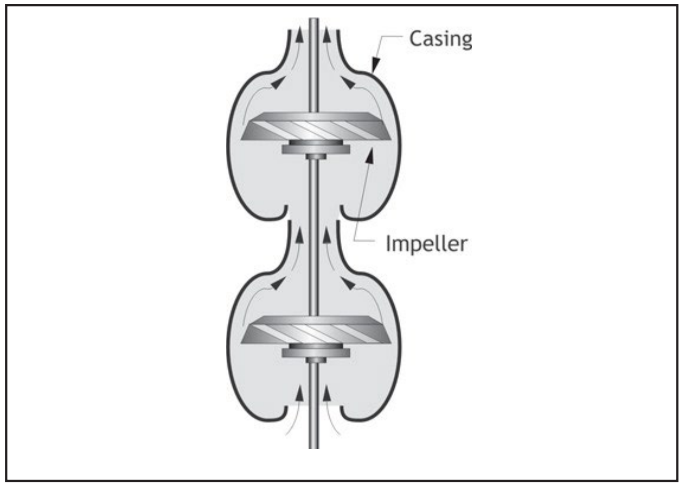

Figure 6-8. Submersible turbine (high head or multi-stage) pump (profile view).

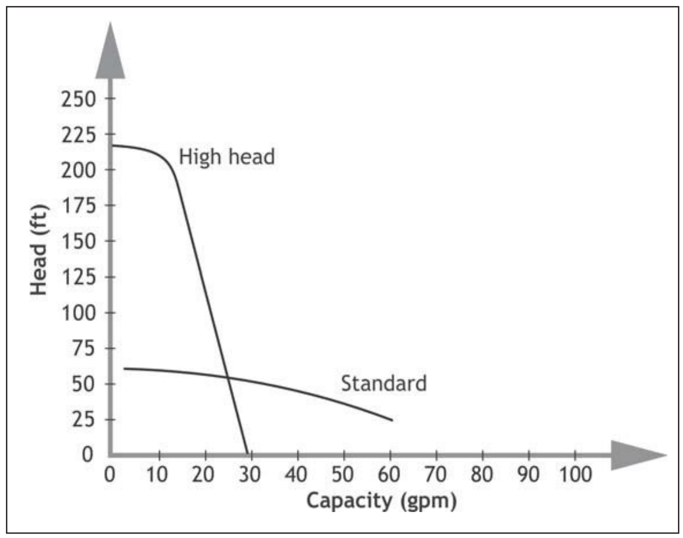

Figure 6-9. Example of a high-head vs. low-head pump curve (for comparison only).

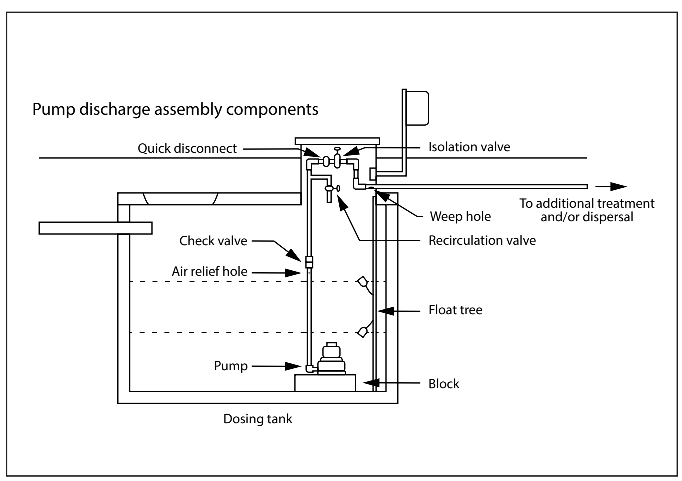

Figure 6-10. Components of a well-equipped pump discharge assembly (profile view).

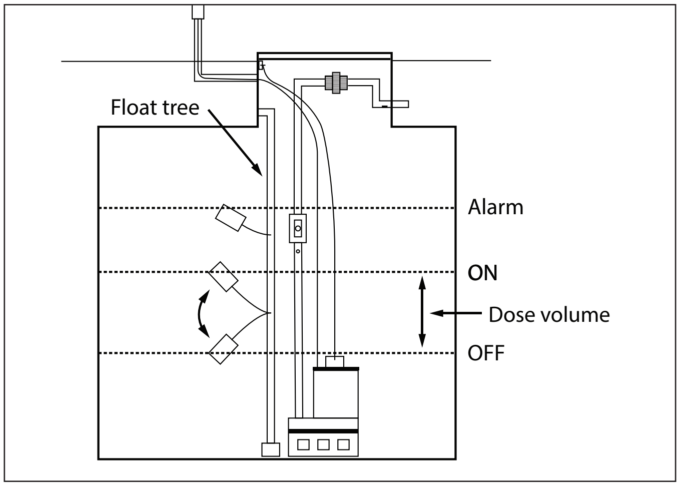

Figure 6-11. Dosing tank with a two-float demand dosing sensor configuration (one single differential float and one alarm float)

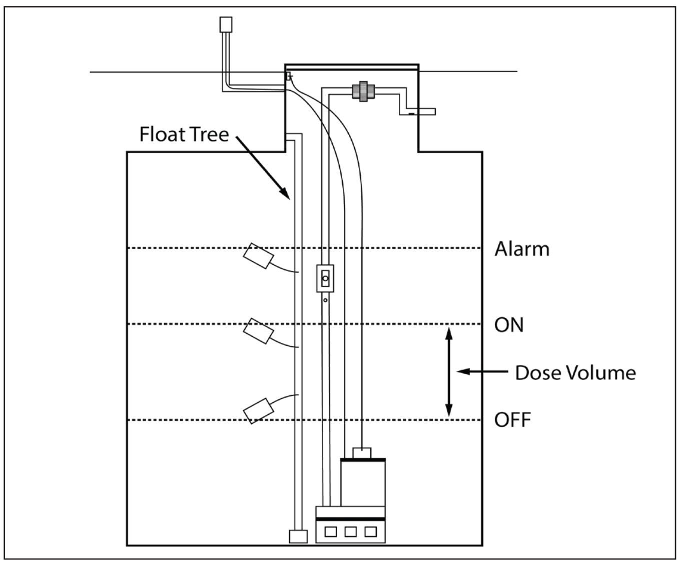

Figure 6-12. Dosing tank with a three-float demand dosing sensor configuration (one "on" float, one "off" float and one alarm float)

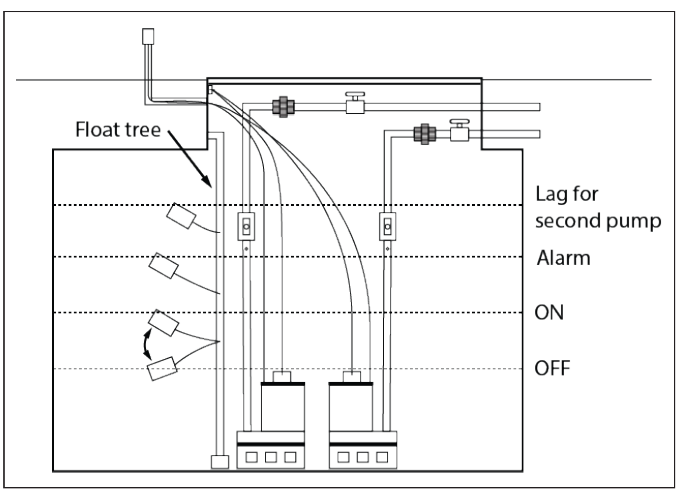

Figure 6-13. Float controls configured to alternately dose a duplex pump system and activate the resting ("lag") pump during high flow periods

requiring flow equalization. These dosing regimens are discussed further below.

The sensors used with dosing tanks are adjustable and each has a specific function. The most used sensors are float controls tethered to a float tree and suspended at specific elevations within the tank. Other types of sensors include pressure transducers, ultrasonic sensors and ohm probes.

Sensors are wired into the control panel to activate pumps and meters and counters track the frequency or length of pump operation.

In all cases, electrical components must be properly protected from the elements and from the corrosive environment of the dosing tank. Ideally, this is achieved through use of devices meeting the standards set by the National Electrical Manufacturers Association (NEMA) as a Type 4X (watertight, airtight, and corrosion-proof).

Another important item to note is whether sensors for pump operation are separately wired from those that trigger alarms. A separate circuit allows the alarm to function in the event of pump malfunction. If both are wired on the same circuit, and there is a problem with the circuit, an alarm will not be able to alert the owner or operator to possible problems with the pump's operation. Alarm function should include both audible and visible notification.

Configurations for demand and time dosing are discussed next.

Demand dosing sensor configurations

In a demand dosed configuration, a designated volume of effluent is delivered based upon the float elevations in the dosing tank. The sensor activates the pump when a prescribed level of effluent is collected in the dosing tank. The dose to the next component is subject to the variations in water use at the source: if the dosing cycle initiates while water is flowing into the system, the pump will remain in operation until the water level drops below the signal activation elevation. While this is a simple dosing regimen, subsequent components receive varying volume of effluent with each dose since residential sources tend to have predictable patterns of peak use at certain times of day.

The simplest form of demand dosing is a float-operated switch into which the pump is plugged. When the float is engaged (in the "up" position), the circuit to the pump is energized and the pump runs until the float disengages (falls to the down position) and de-energizes the circuit. This is called a "piggyback control" and is still used in some areas, but this configuration provides no information on system performance to the service provider and can present electrical safety concerns. If the system has only piggyback controls and system complexity warrants it, an upgrade to a control panel should be recommended to collect system data.

Figure 6-11 shows a sensor configuration consisting of a single differential ("wide angle") float and an alarm float. This is often referred to as a "two-float" configuration. The pump activates when effluent rises to the on-float elevation, pumps effluent down to the off-float elevation, and then deactivates.

Note that designs for dosing systems using pumps will specify that pump deactivation occurs at an elevation that retains sufficient liquid to fully cover the pump housing.

Figure 6-12 illustrates the use of separate "on", "off" and alarm floats and is commonly referred to as a "three-float" configuration. Separate floats for pump operation are often required to accurately deliver either a very small or very large dose volume. A tether length of 3.5" (a typical recommended maximum) on a single differential float will deliver 8" of tank volume. In a typical dosing tank of about 1,000-gallon capacity there are 20 gallons of effluent per inch of depth. Pumping 8 inches delivers a volume of approximately 160 gallons.

In duplex (two-pump) systems, the sensor operates first one, then the other pump in an alternating sequence (Figure 6-13). A lag switch or sensor is either included above (or combined with) the alarm sensor. If one pump fails or if flows are excessive, the effluent level rises to the lag elevation and activates the resting pump. A cycle counter should be included in the control panel to track these events.

Time dosing sensor configurations

Time dosing uses an adjustable timer control to prescribe pump run time, pump rest interval, and specific dosing regimens. By using a timer rather than elevation-dependent float controls, time dosing eliminates variations or peaks in wastewater flow by dosing the dispersal component more evenly throughout the day or night.

When activated, the timer determines how often the pump activates and how long the pump runs. The run time and the pump delivery rate are set to deliver a specified dose volume. Subsequent components receive a consistent volume of effluent with each dose and doses occur at specified intervals. This results in predictable loading to subsequent components which is important for systems that include advanced treatment. Commonly used time dosing sensor configurations are described below.

Timer-enable configuration

In this sensor configuration, effluent rises to the elevation of the "timer enable" sensor (after a designated "off" cycle) and activates the pump for a specific amount of time. The specified dose volume is delivered based upon the actual pump delivery rate (PDR). The timer then turns the pump off for a specified rest period (the "off" cycle). Should the effluent level fall to the level of the "redundant off" sensor, the pump will not operate (Figure 6-14).

Peak-enable configuration (AKA "Override Timer" configuration)

When activated, a peak-enable float engages a secondary timer with a shorter OFF setting, reducing the rest period between normal doses during periods of high flow (Figure 6-15). This effectively increases the number of dosing events each day to draw down the effluent in the tank.

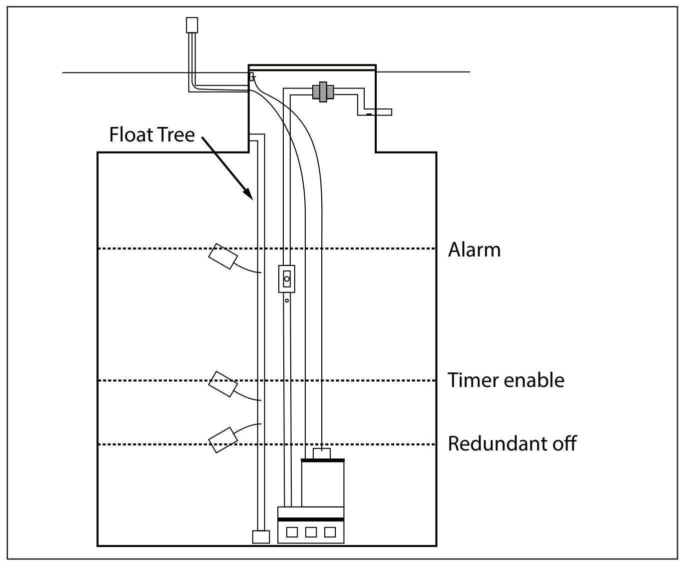

Figure 6-14. Time dosing using a timer enable sensor configuration with redundant off and alarm

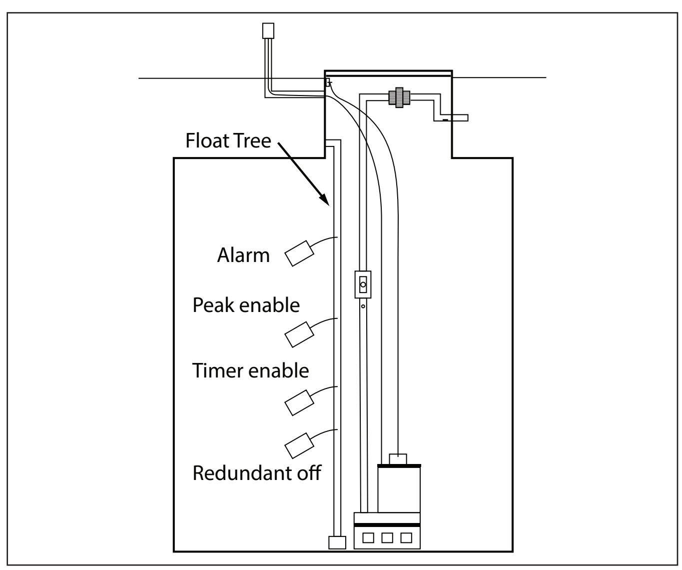

Figure 6-15. Time dosing using a peak enable sensor configuration

Note that systems that include peak enable floats are set such that forward flow does not exceed the capacity of the next component or the design flow of the system. Again, an event counter on this float is recommended for recording performance.

Timer override configuration

In a timer override configuration (Figure 6-16), a sensor (typically a single differential float switch) directly activates the pump when the effluent level reaches a preset, excessively high level in the dosing tank. Pump operation effectively continues in demand mode until the effluent drops below the override sensor off elevation. The primary timer remains engaged but does not control the pump until the override sensor drops out.

Using pump operational data to evaluate performance

Having devices that track pump operation (cycles or elapsed time) allow collection of necessary information for assessing component and system status and use. If the entire treatment and distribution system is gravity flow, then a water meter at the source of the wastewater may be the only available option to determine forward flow (the volume of water that moves through the system over a given period of time). When panels include cycle counters, elapsed time meters, and event counters, we can use that information along with pump dose volume, and pump capacity for both the treatment and final treatment and dispersal components to calculate flow through different system components. Because O&M service includes tracking trends, careful documentation at each visit provides the most accurate assessment of performance.

The pump dose volume is related to either the float settings (dose volume) or the timer settings of that site. In a time-dosed system, the pump flow (gpm) multiplied by the pump run time (min) gives the total volume that the pump delivers to the supply line. Care should be exercised in this calculation, because the volume delivered to the supply line may not be the same volume delivered to the treatment unit (or final treatment and dispersal). The return volume (drainback) coming back to the pump vault (or chamber) when the transport pipe drains needs to be subtracted from the volume delivered to the supply line. Subtracting the drainback (or pipe fill-up volume) from the total dose volume provides the actual volume of effluent delivered to the treatment unit (or the final treatment and dispersal components).

Siphons

A siphon is a passive dosing device that discharges a set dose when liquid levels in the siphon tank displace the air in the trap of the device. The device will only function if the treatment or dispersal component receiving the dosed-flow distribution is at a lower elevation than the siphon discharge by at least several feet. Siphons do

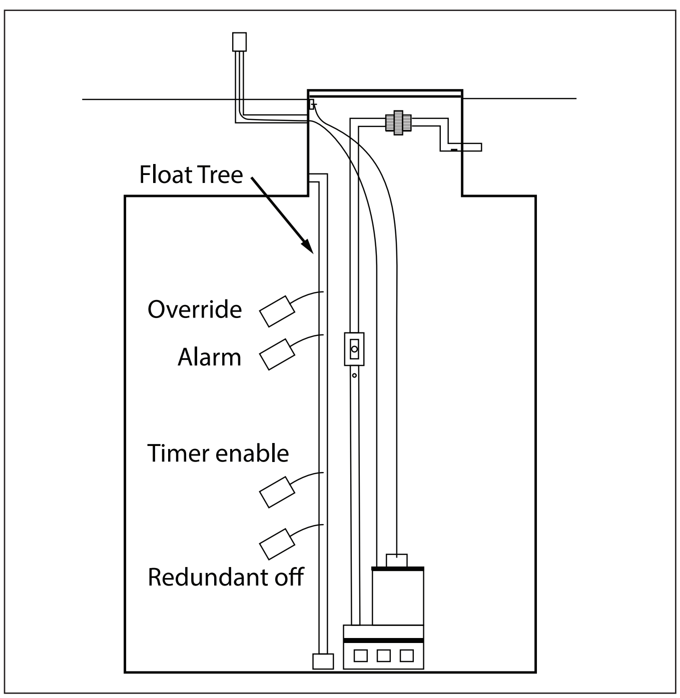

Figure 6-16. Time-dosing using a *timer override* float configuration

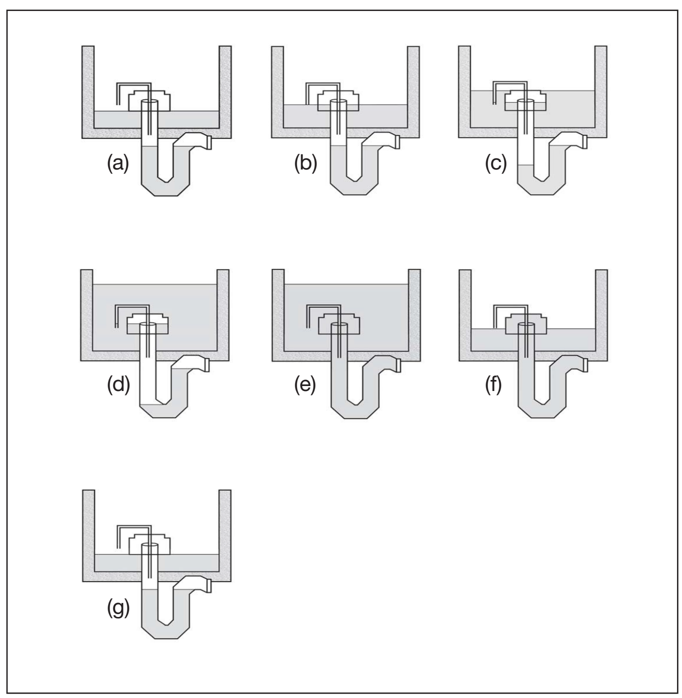

Figure 6-17 a through g. Stepwise operation of a dosing siphon not use floats to operate. Instead, the size of the siphon bell and the height of the siphon trap determine the dose volume that is delivered during each cycle. Siphons do not require a discharge assembly like that included with pump systems. Instead, the discharge pipe delivers the dose to the STA at a lower elevation.

Siphons have discharge rates ranging from 25 gpm up to 3,000 gpm. Siphons used in residential applications generally operate at the lower end of this range. Digital and mechanical cycle counters are available (and strongly recommended) for use with siphons to monitor flow. A high-water alarm may or may not be present on siphon systems, but they are recommended.

When liquid enters the dosing tank, the liquid levels rise in both the tank and siphon bell at the same rate (Figure 6-17(a). The siphon is vented to the atmosphere through vent piping. This rising action continues until the level of the liquid reaches the open end of the outside vent pipe (Figure 6-17(b)).

Once the liquid reaches the outside vent pipe, it creates an air seal. As the level of liquid continues to rise in the tank, the level of liquid in the bell continues to rise but at a much slower rate (Figure 6-17(c)). At the same time, the head of water in the tank exerts pressure on the air trapped in the top of the bell and the long leg of the trap. The air in the long leg of the trap is forced toward the invert of the trap (Figure 6-17(d)).

As the liquid in the tank approaches the high-water line, the liquid in the bell increases to a level just short of the top of the trap, and the air in the long leg of the trap descends to the invert of the trap.

As the liquid in the tank reaches the high-water line, a volume of air is forced around the invert of the trap and out through the discharge leg of the siphon. The escaping air relieves the back pressure within the siphon, and the liquid inside the bell rushes up and fills the siphon trap, thereby starting the siphon action (Figure 6-17(e)).

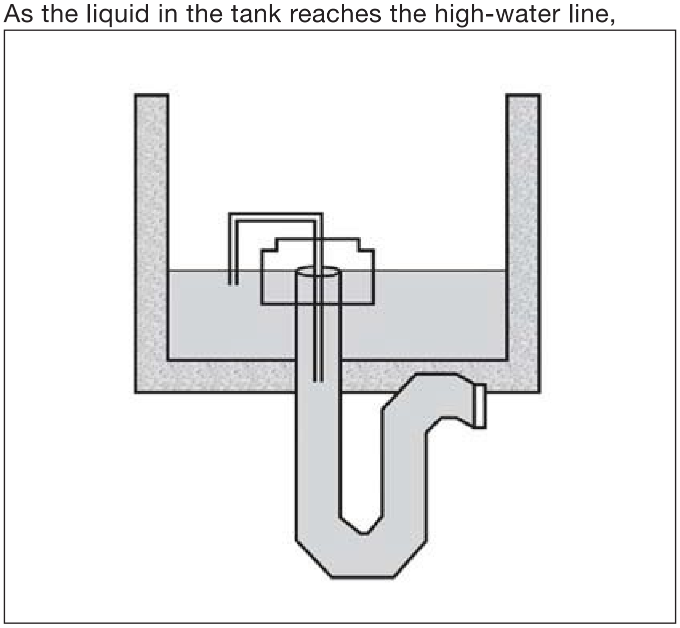

Figure 6-18. Siphon with a loss of prime.

The liquid is drawn out of the tank (Figure 6-17(f) until the liquid in the tank reaches the bottom of the bell. Then the siphon draws air, and the siphon action is stopped (Figure 6-17(g)).

Siphons require regular inspections to ensure proper operation. One of the most common problems with siphons occurs when a siphon is described as having "lost its prime." This means that there is insufficient air volume under the siphon bell (Figure 6-18). This creates a situation where the liquid level cannot achieve the necessary head or pressure to drive the effluent into the distribution system. This causes liquid to dribble or trickle through the siphon, which prevents the wastewater from being distributed properly. The cause may be an air leak at the point where the vent pipe screws into the top of the bell.

Alternately, during periods of rapid flow into the dosing chamber, air entrained in the liquid may collect under the siphon bell, causing the siphon to "burp" well before the high-water line is reached. The air pressure or prime is lost in the burp. The flow into the dosing chamber should be redirected and/or baffled to prevent this.

Poorly designed siphons (frequently home-made versions) often do not get a large enough air bubble across the invert of the siphon to start the siphon. If the dosing chamber fills rapidly the siphon works properly, but when inflow to the dosing chamber is slow, the poorly designed siphon burps but does not start.

Vacation homes can also present problems when using siphon system. If the occupants vacate the house for a period of several weeks and happen to leave while the water level in the dosing chamber is somewhat close to the high-water level (and therefore the air pressure under the bell is high), the air under the bell can be diffused or absorbed into the water, thereby reducing the air volume that is trapped under the bell.

There are two ways to restart a siphon that has lost its prime:

- Drain the dosing tank until the water level is below the open end of the outside vent pipe.
- Blow air under the siphon bell.

Using Form 6-1: Dosing Tank Operation and Maintenance

The text below describes inspection criteria for evaluating performance of dosing tanks. The form for documenting inspection points follows the text.

1. Type

Determine and note the primary use of the dosing tank. Note that this form is also used for processing tanks that include a pump. Record the pump elevation above the bottom of the tank.

2. Conditions at the dosing tank

Check for odors near the tank. There should be no strong odors if the house vent stack is operating properly and there is no effluent surfacing. If odors are detected, determine the source by checking for alternative venting structures, missing caps on inspection ports, damaged lids/risers, or surfacing effluent. Also check the roof vent location, prevailing winds, and atmospheric pressure. Note whether the odor is mild or strong.

3. Tank description

Record the material used to construct the tank. Tanks are typically made of concrete, but plastic and fiberglass are becoming more common with improved construction practices. With the availability of newer materials, metal tanks are uncommon. Metal tanks typically have significant problems with watertightness because of corrosion.

Record the capacity of the tank. This should be included in the permit. If not, it can be calculated. Calculate the volume in cubic feet based on tank dimensions (length times width times depth), convert to volume in gallons using a conversion factor. Divide the resulting total gallons by tank depth in inches to calculate gallons per inch in the tank. These calculations are presented in Appendix A.

4. Tank access

Note where the access is located on the tank (inlet or center). If the tank access is farther than 6 to 7 feet from any tank wall, it may limit access for maintenance in those areas, especially during pumping services.

Tank access must be adequate for inspection and servicing the tank. If there is a riser on the tank, it should be in good condition and properly sealed to prevent infiltration. Check the seams where risers join tanks for stains or root intrusion that may suggest infiltration of groundwater or surface water. Ideally, the top of the riser should come to grade so that no digging is required to reach it. Some jurisdictions may not require access to grade. If it is buried, note how much cover is on the tank after excavation, and note swing tie measurements from nearby fixed landmarks to the cover. Include time for excavation in your ongoing costs or convince the owner to modify the access.

The lid on the tank or riser should be securely fastened with safety screws (screws or bolts that require a non-standard tool) or other means (e.g., a concrete lid weighing more than 60 pounds). The lids must be readily removable by the service provider but child-proof. The lids must be operable as designed, and there should be no obstacle placed near or on top that makes them inoperable. The lids must not be so heavy as to make them inoperable. ***Secondary restraint safety features (secondary lids) are critical, and all holding tanks should be retrofitted if they are not present.*** If the tank was uncovered by the owner, note that on the checklist.

5. Current tank operating conditions

Measure the levels at which the pump activates and deactivates from a fixed reference point such as the top lip of the riser. This could be measured on a single float or two floats. The pump "off" elevation should be such that low-head pump remains submerged after a dose. The pump "off" elevation of a tank with a multi-stage stainless steel pump should be four inches above the intake.

The maximum liquid level for a tank is measured from the bottom of the tank to the invert of the inlet pipe. Note whether levels have exceeded the maximum or if the level has dropped without the tank being pumped out (an indication of a leak). Measure the current level in the tank with respect to the inlet.

Measure the alarm activation level from the invert of the inlet pipe. Check the inlet to evaluate flow into the tank. Normally, the flow will start and stop due to use in the home. Continuous flow may indicate a plumbing leak.

Make note of the date of the last tank pumping.

6. Pump/Siphon

The pump or siphon should be located under the access riser for ease of access. Pull chains/ropes are not used with siphons, but if the system uses a pump, a non-corrodible pull-chain or rope should be attached to allow easy removal when needed. The rope or chain must not interfere with pump or float operation.

7. Discharge assembly

Siphon systems do not include a discharge assembly, but pump systems do. If applicable, check the discharge assembly for the presence or absence of the following devices:

- An anti-siphon or air release device located below the check valve.
- In colder climates, a drain back device (weep hole) oriented in a direction that ensures the discharging liquid does not interfere with normal float function.
- A quick-disconnect union or coupling allows access for easy pump removal.
- An isolation valve on the field side of the assembly to prevent backflow from the field or other downstream component upon disconnection.
- Inline filters before the supply line to protect the pressure distribution system from solids and plugging.

8. Electrical

Wiring for the pump and floats in the dosing tank can be connected either internally or externally to the dosing tank. Because of the combination of moisture and gases, the tank is extremely corrosive to electrical components. All electrical connections should be in a watertight, accessible enclosure. Some codes may allow connections within the tank access riser, but these should be installed in NEMA 4 or 4X (watertight, airtight, and corrosion-proof) enclosures. In either case, gas flow prevention should be included through proper use of duct seal, gas seal-offs, grommets, or cord grips in all electrical connections entering and exiting the tank. Watertight wire nuts are another device to minimize corrosion problems.

9. Tank structural condition

If the tank is pumped, evaluate structural conditions. ***Do not enter the tank under any circumstances to evaluate integrity.*** Check the integrity of the tank top, sides, and bottom only from above using either a hand mirror to cast light into the tank or (even better) using a sewer camera. The inside of the tank should show no signs of structural failure such as exposed rebar or rust stains from the rebar in a concrete tank. Spalling (physical degradation of a concrete structure that exposes aggregate and/or structural reinforcement materials) is an indication of possible structural failure and should be noted. A plastic or fiberglass tank that has cracks, punctures or is deformed has lost a significant amount of its structural integrity.

10. Solids

Sludge will accumulate in the bottom of the dosing tank. Sludge accumulation must be managed at a level below the pump intake to make sure the solids are not sent into the next component. An excessive amount of dosing tank solids may indicate insufficient primary treatment, possibly due to inadequate septic tank capacity, high daily flow, large peak flows, or suggest system abuse or lack of service. Record the amount (in inches) of sludge and solids accumulation. The odor and color of the solids should also be noted.

11. Tank pumping

Note whether the dosing tank needs pumping based upon sludge measurements. A good guideline is to pump when less than 70 percent of the tank volume below the pump intake is operable. The pump intake location will vary.

If the rate of solids accumulation in the dosing tanks increases, it is likely that the entire treatment system requires pumping.

Pumping frequency may be dictated by state or local regulation. When required, solids must be removed and properly disposed of by certified professionals.

12. Contractor

If the tank was pumped, note the name of the contractor, the amount removed, and the date removed.

13. Pump screens

A pump vault or basket may be present in the dosing tank to passively remove solids from the effluent migrating toward the pump inlet. These devices are essentially effluent screens and require periodic cleaning. In-line filters (located after the pump in the discharge assembly) should be checked and cleaned as well.

14. Lab samples

If sampling is needed for troubleshooting or to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record the chain of custody (COC) information and deliver the sample to an authorized laboratory. Retain a signed COC from the testing laboratory to complete the system file. Report the information to the proper entities.

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Form 6-1 Operational Checklist: Dosing Tank (DT)

Service provided on: Date:________________ Time:___________Reference #:______
Service provided by: Company: ________________ Employee:___________________
Date of last service: ___________________________ By: ☐ You ☐ Other:_________
Date of last inspection: _______________________

1. Type:
   ☐ Dosing tank ☐ Siphon tank ☐ Surge/Flow equalization tank
   ☐ Processing tank ☐ Recirculation tank ☐ Internal pump basin sump
   a. Pump intake elevation above bottom of tank:______________
2. Conditions at the dosing tank
   a. Evaluate presence of odor within 10 feet of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ______________________________
3. Tank description
   a. Material: ☐ Concrete ☐ Fiberglass ☐ Plastic
   b. Capacity: _______________gal
   c. Surface area: ______________sq ft
   d. Operational depth: ________________in
   e. Gallons per inch (GPI): _____________gal/in
4. Tank access
   a. Access location: ☐ Inlet ☐ Outlet ☐ Center
   b. Located at grade. ☐ Yes ☐ No
   c. If 'No', how deep is lid buried. ______________
      Swing tie measurements: _______________________________
   d. Risers on tank. ☐ Yes ☐ No
   e. Evidence of infiltration in risers. ☐ Yes ☐ No
   f. Lids securely fastened. ☐ Yes ☐ No
   g. Secondary restraint safety feature secure ☐ NA ☐ Yes ☐ No
   h. Lid in operable condition. ☐ Yes ☐ No
5. Current tank operating conditions
   a. Liquid level between on and off elevations: ☐ Yes ☐ No
      _________in
   b. Maximum liquid level of tank (invert of inlet pipe):________in
   c. Alarm activation elevation relative to inlet _________in
   d. Evidence liquid level has been higher. ☐ Yes ☐ No
   e. Evidence liquid level dropped without pumping. ☐ Yes ☐ No
   f. Evidence of continuous inflow. ☐ Yes ☐ No
   g. Date last pumped: _____________________________________

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

5. ☐ Acceptable
   ☐ Unacceptable

Reference #:________________

6. Pump/Siphon
    a. Pump/Siphon under access. ☐ Yes ☐ No
    b. Pull chain or rope present. ☐ NA ☐ Yes ☐ No
7. Discharge assembly: ☐ NA
    a. Anti siphon device ☐ Yes ☐ No
    b. Backflow preventer (check valve) ☐ Yes ☐ No
    c. Air release located below check valve ☐ Yes ☐ No
    d. Drain back device ☐ Yes ☐ No
    e. Quick disconnect ☐ Yes ☐ No
    f. Isolation valve ☐ Yes ☐ No
    g. Inline filters ☐ Yes ☐ No
8. Electrical components watertight. ☐ NA ☐ Yes ☐ No
9. Tank structural condition (evaluate if tank pumped): ☐ NA
    a. Watertight (no visible leaks). ☐ Yes ☐ No
    b. Rebar exposed. ☐ Yes ☐ No
    c. Corrosion present. ☐ Yes ☐ No
    d. Spalling present. ☐ Yes ☐ No
    e. Cracks present. ☐ Yes ☐ No
    f. Root intrusion. ☐ Yes ☐ No
10. Solids accumulation:

Scum (in)	Sludge (in)	Odor	Color	Other

6. ☐ Acceptable ☐ Unacceptable

7. ☐ Acceptable ☐ Unacceptable

8. ☐ Acceptable ☐ Unacceptable

9. ☐ Acceptable ☐ Unacceptable

10. ☐ Acceptable ☐ Unacceptable

11. Tank pumping recommended. ☐ Yes ☐ No
12. Contractor responsible for pumping:______________________________
    a. Gallons pumped: ____________________ Date: _______________
13. Pump screen(s)
    a. Type of screen: ☐ Vault with basket ☐ Vault with filter ☐ In-line screen
    b. Screen cleaned. ☐ Yes ☐ No
14. Lab samples collected for monitoring. ☐ Yes ☐ No
    Types of analyses:____
    ____
    ____

Using Form 6-2 Pump: Demand Dosed System Operation and Maintenance

Inspection points included on Form 6-2 Pump, Demand dosed (PDD) are described in detail below and the form follows the descriptive text.

1. Controls

Note which type of control is used. If a piggyback control is used, determine if it is functional. If a control panel is used, it should be watertight with all connections sealed to prevent moisture or sewer gases from entering. Check the function of the alarm test switch. The presence of a control (HAND-OFF-AUTO) switch allows the service provider to check pump function without activating a float or program. Note the position of the control switch, keeping in mind that under normal operating conditions, it should be in the AUTO position. If the panel has a cycle counter or an hour or minute meter (elapsed time meter), record the present and last readings. If there are no meters, they are strongly recommended as an upgrade to facilitate O&M activities.

If the system includes telemetry, verify the electronic connection between the control panel and the receiving entity. One way to do this is to trigger an alarm and log into the website or make a phone call to verify that the system logged the alarm event.

Telemetry allows remote communication of system status. Data can be shared with the owner, service provider or manufacturer. Some systems also allow remote system operation. If this option is available, the service provider should verify the connection between the panel and the receiving entity is active. One way is to activate a pump, log into the website or make a phone call to verify that the system logged the pump event

2. Pump/Siphon

Siphon systems often include battery-operated cycle counters as the only metering component. This is critical to determine that the siphon is operating properly. If one is present, record the cycle reading, compare it to the previous reading. Use these figures to calculate the total number of cycles since the last visit and average cycles per day.

If the system uses a siphon, note whether it is operating properly by running water into the tank until it is activated. Be careful to direct the hose spray against the tank wall to avoid introducing air bubbles that may cause the siphon to 'burp.' (NOTE: Measure the ON and OFF elevations and the time it takes to deliver the dose during this operational test. Then move to the calculations in numbers 5 through 8 in this section to complete the O&M service for this component.)

If the system uses a pump, note whether the pump operated properly with the HAND-OFF-AUTO switch in the panel or with the piggyback control. Indicate whether the pump is high-head (multi-stage) or low-head (single stage) and measure the operating amps and voltage. Manually check that the pump turns on and off.

3. Sensors

Note what types of water level sensors are used in the tank: floats, ultrasonic, or pressure transducers or possibly an ohm probe. These should be operated manually (by using a tool to lift the sensor to the appropriate elevation) to ensure proper function of the pump and alarms.

4. Sensor settings

Use the table in this section to record information on sensor settings, function and operational status. Typically, floats are numbered starting at the tank floor and counting upwards. Setting or elevation measurements can either be made from the tank floor (impractical in an actively operated system, but common in system design plans) or from a fixed point at the top of the tank (e.g. top of riser, top of tank; more practical for actively operated systems). Be sure to note what reference point ("Datum"; e.g. top of riser) the measurements are made from.

5. Dose volume

Starting with the float or sensor setting nearest the bottom of the tank, measure from the bottom of the tank lid (or other noted reference point) in inches to determine the elevations of the following:

- Pump OFF elevation
- Pump ON elevation
- Alarm ON elevation
- Lag pump ON elevation (typically in larger systems)

Indicate what function each float has in the system and whether it is operational. Also note whether the float is secured in its position in the dosing tank.

The dose volume (DV) can be calculated by multiplying gallons/inch (GPI) (Form 6-1 item 3.e) by the number of inches of separation between the connection of the pump "on" and pump "off" floats to the float tree as noted in Number 4. (NOTE: Using inches of separation here is valid only if float tether lengths are equal.)

Inches pumped = Pump off (inches) – Pump on (inches)

DV (Gal) = GPI x Inches pumped (dose)

6. Pump delivery rate (PDR)

Calculate the pump delivery rate (PDR) in gallons per minute (GPM) by running the pump for a specified period and measuring the elevation of the effluent at the pump "off" and "on" points. (NOTE: The specified time should allow for full pressurization of the system. A pressure gauge can be used to verify that this has been accomplished. Generally, a runtime of four or five minutes is sufficient.) Using the measurements, PDR in GPM is calculated thus:

PDR (GPM) = DV (gal) ÷ Verified pump run time (min)

7. Total gallons

The total gallons pumped since the last inspection can be calculated using cycle counter readings or elapsed time meter readings.

Using elapsed time meter readings, subtract the last timer reading (LTR) from the present timer reading (PTR) to determine the total run time *in minutes.* Multiply the result by the pump delivery rate (PDR) in gallons per minute as calculated in Number 6:

Total gallons = (PTR – LTR) x GPM

Using cycle readings, subtract the last cycle reading (LCR) from the present cycle reading (PCR) to calculate the total number of cycles. Multiply the result by the dose volume (DV) calculated in Number 5:

Total gal = (PCR – LCR) x DV (gal)

Make a note of how the pump was activated, either by adding water or by lifting the float.

8. Average daily flow (GPD)

The average gallons per day (GPD) can be calculated using the figures from Number 7. Take the total gallons from either equation above and divide by the number of days of operation since the last inspection:

Gal/day (GPD) = Total gallons / Number of days

9. Compare actual pump performance to design

Compare pump performance to design. When using a demand dosed system, the dose volume is used for flow measurement. The total volume that moved through the system can be calculated by multiplying the number of events counted by the cycle counter by the volume in the dose. The number of events is calculated by subtracting the current cycle counter reading from the previous pump cycle counter reading. This is the number of times the pump has been on. Note that this calculation may underestimate total flow through the system – as described above, if water flows into the system while the pump is engaged (preventing the liquid level from dropping in the tank during pump operation), the pump will run continuously until the liquid level drops below the "off" signal elevation. In this instance, the cycle count will show a single event, but the dose volume could be much larger than usual. If an ETM is used with a demand dosed system, the elapsed time can be multiplied by the pump delivery rate to calculate forward flow. Flow calculated by the ETM method should be compared to the value calculated by the cycle counts, and you should note major discrepancies. Whatever the method of determining total flow through the system, average daily flow should be compared to the design flow.

Divide the average daily flow since your last service visit by the daily design flow from the system's plan.

% design capacity = [Average daily flow (gal/day) / daily design flow (gal/day)] x 100

As discussed in Chapter 1, loading a system at greater than 70 percent of design capacity (average daily flow) for prolonged periods means that peak flows may regularly exceed capacity.

See Appendix A for a full presentation of mathematical calculations used here.

Form 6-2 Operational Checklist: Pump: Demand Dosed System (PDD) (Including Siphons)

Service provided on: Date:______________Time:______ Reference #:________________
Service provided by: Company: ____________________ Employee:________________
Date of last service: ______________________________ By: ☐ You ☐ Other:_________
Date of last inspection: ____________________________

System type: ☐ Pump ☐ Siphon

1. Controls
   a. Type: ☐ Piggyback ☐ Control panel
   b. Controls operating properly. ☐ Yes ☐ No
   c. Enclosure watertight. ☐ Yes ☐ No
   d. Alarm test switch working properly. ☐ Yes ☐ No
   e. Control switch (HOA) set at:
      "Hand/Manual"_____________
      "Auto" ____________
      "Off" ____________
   f. Meter readings:

		Reading (current)	Reading (last)	Value	N.A.
i)	ETM			min	
ii)	Cycles/events			Cycles (NC)	

   Calculate cycles/day: _____ [NC] / [Days] = _______ [CPD]
   g. Telemetry operational. ☐ NA ☐ Yes ☐ No
      Type:____

2. Pump/Siphon
   a. Siphon operating properly. ☐ NA ☐ Yes ☐ No
   b. Pump operating properly. ☐ Yes ☐ No
   c. Type of pump: ☐ Multi-stage ☐ Single stage
   d. Amperage: ___________amps
   e. Voltage:_____________volts
   f. Pump turns on/turns off ☐ Yes ☐ No

3. Water level sensors
   a. Type of water level sensor: ☐ Floats ☐ Pressure transducers
      ☐ Ultrasonic ☐ Ohm probe ☐ Other:
   b. Pump floats/sensors functioning properly. ☐ Yes ☐ No
   c. Alarm float/sensor operating both audible and visible. ☐ Yes ☐ No

Notes

1. ☐ Acceptable
   ☐ Unacceptable

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

Reference #:___________________

4. Sensor settings:

Sensor Number*	Function	Operational	Setting**		Secured
			Inches	Datum	
1		☐ Yes ☐ No			☐ Yes ☐ No
2		☐ Yes ☐ No			☐ Yes ☐ No
3		☐ Yes ☐ No			☐ Yes ☐ No
4		☐ Yes ☐ No			☐ Yes ☐ No
5		☐ Yes ☐ No			☐ Yes ☐ No

**Designate starting from bottom of tank.*

***Measurements are taken from a fixed point ("Datum") near the surface or bottom of float tree in inches.*

5. Dose volume (DV)
   a. Pump Off – Pump On = ________inches pumped (dose)
   b. GPI: _______ (Form 6-1, Item 3.e)
      _______dose (inches) x _______________GPI =____________ DV (gallons)
6. Pump delivery rate (PDR)
   a. Dose volume (from Item 5): __________ gal
   b. Verified pump run time "On": __________ min
   _____________ gallons pumped ÷ ___________ min = __________________ GPM
7. Total gallons
   a. Method to activate pump: ☐ Water added ☐ Lifted float
   b. Total gallons (from elapsed time meter)
      [_____(PTR) - _____(LTR)] x _____(GPM) = _______Total Gallons
   OR Total gallons (from event/cycle counter)
      [_____(PCR) - _____(LCR)] x _____(DV) = _______Total Gallons
8. Average daily flow (GPD)

   _____Total gallons ÷ _____No. of days = ________Gallons/day (GPD)

   % design capacity = [Average daily flow (GPD) / daily design flow (GPD] x 100

9. Compare actual pump performance to design
   Using cycle counter:
   [_____(PCR) - _____(LCR)] ÷ _____No. of days = _______Cycles/day (CPD)
   Using elapsed time meter:
   [_____(PTR) - _____(LTR)] ÷ _____No. of cycles = ________Runtime/cycle

ABBREVIATIONS

CPD: Cycles per day
DV: dose volume
ETM: Elapsed time meter
GPI: gallons per inch
GPM: gallons per minute
GPD: gallons per day

HOA: Hand-Off-Auto Switch
LCR: last cycle reading
LTR: last time reading
PCR: present cycle reading
PDR: pump delivery rate
PTR: present time reading

Using Form 6-3 Pump: Time Dosed Operation and Maintenance

Inspection points included on Form 6-3 Pump: Time dosed (PTD) are described in detail below and the form follows the descriptive text.

1. Controls

A control panel used for time dosed systems should be NEMA 4 or 4x rating with all connections sealed to prevent moisture or sewer gases from entering the control panel through the conduit. Check the function of the alarm by operating the test switch. It is important to record the timer setting and the mode setting (hours, minutes, or seconds). Note the position of the control (HAND-OFF-AUTO) switch, keeping in mind that under normal operation it should be in the AUTO position. If the timer settings are changed during the inspection, record the new settings. If the panel has a cycle counter and/or an hour or minute meter (elapsed time meter), record the present and last readings. If the system uses a telemetry system, check to make sure it is operational by logging in to the system, and note the type of system used.

2. Pump

Note whether the pump operated properly using the HAND-OFF-AUTO switch in the panel. Indicate whether the pump is turbine (multi-head) or low-head (single stage), and measure the amps and voltage. Manually check that the pump turns on and off.

3. Water level sensors

Note what types of water level sensors are used in the tank: floats or different types of transducers or ohm probes. These should be operated manually (e.g. by using a tool to lift or depress them) to ensure proper functioning of the timer, pump, and alarms.

4. Sensor settings

Starting with the float nearest the bottom of the tank, measure from the bottom of the tank lid in inches to determine the elevations of the controls. There are several different float configurations a service provider might see for timer control systems; thus, it is important to identify the function of each float carefully.

Indicate what function each float performs in the system and whether it is operational. Also note whether the float is secured in its position in the dosing tank.

5. Pump delivery rate (PDR)

Measure and record the number of minutes or seconds the pump runs during an actual timer cycle to verify that the timer setting is accurate. The function of a repeat cycle timer can be checked by adjusting the settings to lower increments (e.g., a pump run time of 30 seconds, pump off time of 30 seconds). With multiplex pump systems, the pump sequencer function can also be tested this way. (NOTE: Remember to always return the timer to the original or specified settings.)

The pump delivery rate (PDR) should be close to the design delivery rate; it should deliver a certain number of gallons per minute (GPM) at the system's specified total dynamic head (TDH) from the system design. To calculate GPM, conduct a drawdown test by running the pump for a specified period (or for one cycle), and measuring the elevation of the effluent before and after the test. (NOTE: The specified time should allow for full pressurization of the system. A pressure gauge can be used to verify that this has been accomplished. Generally, a runtime of four or five minutes is sufficient.) Note how long (in minutes) the pump ran during this test. Once you know how many inches the liquid level dropped when you ran the pump, you can calculate the volume pumped using the tank's dimensions and calculated gallons per inch (GPI; see Appendix A).

Using the measurements, GPM is calculated thus:

Inches pumped = Pump OFF elevation (in) – Pump ON elevation (in)

Gallons pumped = Inches pumped x Gallons/inch in tank

Gallons per minute (GPM) = Gallons pumped ÷ Minutes run time

6. Dose volume

Using the GPM calculated in Number 5, calculate the Dose Volume (DV) by multiplying the actual pump "on" time by GPM. Pump "on" time was recorded under Number 5 on the form.

Dose volume (DV) (gallons) = Minutes/cycle x Gallons per minute (GPM)

7. Total gallons

The total gallons pumped since the last inspection can be calculated using cycle counter readings or elapsed time meter readings. Using cycle counter readings, calculate the total number of cycles and multiply by the DV calculated in Number 6 on the form:

Total gallons = present cycle reading (PCR) – last cycle reading (LCR) x DV (gallons)

Using elapsed time meter readings, calculate the total run time ***in minutes*** and multiply by the GPM calculated in Number 5:

Total gallons = (PTR – LTR) x GPM

8. Average daily flow (GPD)

The average gallons pumped per day (GPD) can be calculated using the figures calculated in number 8. Simply take the total gallons from either equation above and divide by the number of days since the last inspection.

Total gal ÷ _____No. of days = _____GPD

9. Compare actual pump performance to design

Subtract the last cycle reading from the present cycle reading. Divide that by the number of days to calculate the cycles per day. If using ETM reading, subtract the last reading from the present reading and divide by the number of cycles. The result is the Runtime per cycle. Compare these values to design to track pump performance.

Divide the average daily flow since your last service visit by the daily design flow from the system's plan.

% design capacity = [Average daily flow (gal/day) / daily design flow (gal/day)] x 100

As discussed in Chapter 1, loading a system at greater than 70 percent of design capacity (average daily flow) for prolonged periods means that peak flows may regularly exceed the system's treatment capacity.

See Appendix A for a full presentation of mathematical calculations used here.

Form 6-3 Operational Checklist: Pump: Time Dosed System (PTD)

Service provided on: Date:_______ Time:_____________ Reference #:_____________
Service provided by: Company: ___________________ Employee:__________________
Date of last service: ______________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ___________________________

1. Controls Timer manufacturer: __________________
   a. Enclosure watertight. ☐ Yes ☐ No
   b. Alarm test switch working properly. ☐ Yes ☐ No
   c. Timer set at: "On" ____ Mode setting____
      "Off" ____ Mode setting____
   d. Control switch (HOA) set at: "Hand/Manual" ___________
      "Off" _________________
      "Auto" ________________
   e. If timer was changed, new settings: "On" ____ Mode setting____
      "Off" ____ Mode setting____
   f. Meter readings:

		Reading (this)	Reading (last)	Difference	N.A.
i)	ETM			min	
ii)	Cycle counter			Cycles (NC)	

   Calculate cycles/day: _____ [NC] / [Days] = _______ [CPD]
   g. Telemetry operational. ☐ NA ☐ Yes ☐ No
      Type: ______________________

2. Pump
   a. Pump operating properly. ☐ Yes ☐ No
   b. Type of pump: ☐ Multi-stage ☐ Single stage
   c. Amperage: ___________amps
   d. Voltage: ___________volts
   e. Pump turns on/turns off. ☐ Yes ☐ No

3. Water level sensors
   a. Type of water level sensor: ☐ Floats ☐ Pressure transducers
      ☐ Ultrasonic ☐ Ohm probe ☐ Other: ___________
   b. Pump sensors functioning properly. ☐ Yes ☐ No
   c. Alarm sensor operating audible and visible alarms. ☐ Yes ☐ No

4. Sensor settings:

Sensor Number*	Function	Operational	Set At:		Secured
			Inches**	Datum	
1		☐ Yes ☐ No			☐ Yes ☐ No
2		☐ Yes ☐ No			☐ Yes ☐ No
3		☐ Yes ☐ No			☐ Yes ☐ No
4		☐ Yes ☐ No			☐ Yes ☐ No
5		☐ Yes ☐ No			☐ Yes ☐ No

**Designate starting from bottom of tank.*
***Measurements are taken from a fixed point ("Datum") near the surface or bottom of float tree in inches.*

Notes

1. ☐ Acceptable
   ☐ Unacceptable

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

Reference #:________________

5. Pump delivery rate (PDR) (measured)
   a. Pump Off_____________ – Pump On ________________ = ________inches
   b. GPI: _______ (*From* Form 6-1, Item 3 e)
   c. Verified pump run time: _____________min
   [__________inches x __________GPI] ÷ Pump run time (min) =_______GPM)
6. Dose volume (DV) (from timer setting)
   a. Pump delivery rate: ________________ GPM (from Item 5)
   b. Verified pump run time: ________min
   _________ GPM x _________ minutes/cycle =____________(DV[Gallons/cycle])
7. Total gallons (from elapsed time meter)
   [_______(PTR) - _____(LTR)] x _____(GPM) = _______Total Gallons
   OR Total gallons (from event/cycle counter)
   [_______(PCR) - ____ (LCR)] x _____(DV) =_______Total Gallons
8. Average daily flow (GPD)

   _____Total gallons ÷ _____No. of days = _____Gallons/Day (GPD)

   % design capacity = [Average daily flow (GPD) / daily design flow (GPD)] x 100

9. Compare actual pump performance to design
   Using cycle counter:
   [_____(PCR) - _____(LCR)] ÷_____No. of days = ________Cycles/day (CPD)
   Using elapsed time meter:
   [_____(PTR) - _____(LTR)] ÷ _____No. of cycles = ________Runtime/cycle

ABBREVIATIONS
CPD: cycles per day
DV: dose volume
ETM: elapsed time meter
GPD: gallons per day
GPI: gallons per inch
GPM: gallons per minute
HOA: Hand-Off-Auto Switch
LCR: last cycle reading
LTR: last time reading
PCR: present cycle reading
PDR: pump delivery rate
PTR: present time reading

7

Advanced Treatment

Overview

Broadly speaking, soil-based treatment systems have tremendous capacity to renovate wastewater. Under certain conditions, application of septic tank effluent to the soil treatment area (STA) is completely appropriate. However, not all sites are created equal. Shallow depth to groundwater or bedrock, poor structure, and excessive permeability are just a few examples of conditions that limit the capacity of soils to provide adequate final treatment and dispersal on a site. In these instances, effluent must be treated to a higher standard before being dispersed into the environment, since inadequate treatment may affect public or environmental health, not to mention property values. There are a range of options available to provide advanced treatment, including: media filters, aerobic treatment units (ATU), constructed wetlands and lagoons. Effluent from these advanced treatment components may be subject to additional treatment via disinfection in the most stringent of circumstances (such as spray distribution).

One of the most common applications for advanced treatment technologies is biologically mediated nitrogen removal. In these systems, specific components (like media filters or ATUs) are designed to facilitate the processes of nitrification and denitrification within the treatment train, before effluent is discharged into the environment. This approach, which relies on the conversion of water-soluble forms of nitrogen into nitrogen gas that returns to the atmosphere, offers distinct advantages with respect to overcoming soil limitations, and minimizes nitrogen pollution from wastewater. In nitrogen removal systems, nitrification is typically achieved by passing effluent through aerated media or introducing air in an ATU. Effluent can then be denitrified by returning part of the treated effluent back to a low oxygen/carbon rich environment. However, there are also some nitrogen-removing technologies that rely on media to bind and store specific nitrogen compounds (typically ammonium) in a tank, rather than relying on the above-mentioned microbial transformations of nitrogen forms (i.e. nitrification and denitrification). These technologies are less common, and require that media be replaced, once it is saturated with the compounds it is designed to capture.

Some technologies are designed to simply reduce the amount of organic matter, typically measured as five-day biochemical oxygen demand (BOD_5) (see Chapter 1). Other technologies are designed to immobilize phosphorus or reduce pathogens.

The nature and scope of O&M activities change when a system includes these types of components because the advanced treatment processes require different and specific operating conditions, or the process will not occur or proceed optimally. This Chapter describes the mode of treatment for each category and provides an operational checklist for use in stepwise evaluation of component performance.

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Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe different types of media filters.
2. Differentiate between single pass and recirculating treatment trains.
3. Describe how operating pressure variation may indicate a need for service.
4. Implement typical O&M measures for media filters.
5. Calculate recirculation ratios and assess their influence on media filter performance.
6. Accurately complete Operational Checklist 7-1.

Description and Mode of Treatment

Media filters discussed in this section consist of a lined excavation or watertight structure containing media of predetermined specification and configuration. The purpose of the media is to provide a substrate for growth of organisms that use effluent constituents as a food source. Many media filters are aerobic (surrounded by air containing oxygen), but some are anaerobic (submerged and therefore deprived of oxygen). Bottomless media filters (non-lined and/or non-watertight) are included with final treatment and dispersal components and discussed in Chapter 8.

Media filters use biological processes to transform both dissolved and solid constituents into gases, cell mass, and non-degradable material. The treatment process involves a variety of aerobic and facultative microorganisms living together that can decompose a broad range of materials. Organisms live in an aerobic environment where free oxygen is available for their respiration. Aerobic treatment processes can be used to remove substantial amounts of BOD_5 and TSS that are not removed by simple sedimentation. This process also involves the nitrification of ammonium (NH_4^+) in the waste and the reduction of pathogenic organisms. Nitrification is the conversion of ammonium to nitrate (NO_3^-) by microorganisms in aerobic conditions.

Media filters treat wastewater through four main processes: filtration, sorption (chemical and physical), assimilation, and decomposition of organic material. Filtration removes solid materials by physically straining or screening out particles in the wastewater moving through the bed. Chemical and physical sorption removes materials from the effluent through adsorption to the media surfaces and to the biological growth that adheres to the media surface. Assimilation is the process by which the microbial communities living on the media surfaces transform the material that has been filtered or adsorbed into another chemical state. Decomposition is the process by which organic waste degrades into simpler compounds.

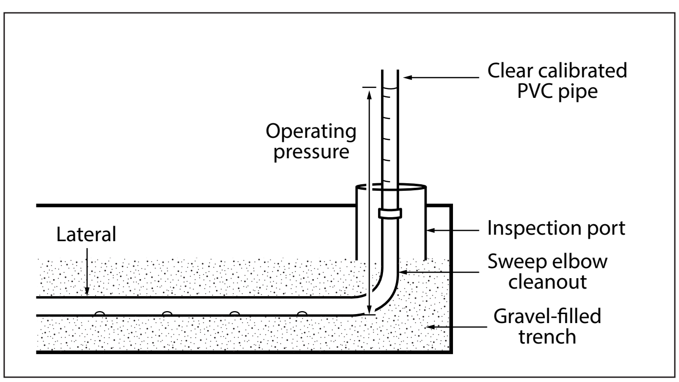

Figure 7-1. Illustration of location for measuring operating pressure (profile view).

Critical Inspection Points: Operating Pressure and Air Release

Many media filters and soil treatment area (STA) options incorporate pressure distribution to deliver effluent. Effluent is moved via pump, travels through the discharge assembly and into the transport or supply line. The supply line typically connects to a manifold (which splits the flow), and from there effluent is forced out of orifices (openings) along the length of each of the system's laterals. In properly operating pressurized systems, all orifices release a similar volume of wastewater at roughly the same rate, resulting in even distribution of the wastewater to the media below the laterals. The performance of these systems is thus acutely dependent on achieving uniform application to maximize the treatment capacity of the component. The degree to which uniform distribution occurs is directly related to how effluent moves within the piping network, which relates directly to the topic of operating pressure and use of air release valves. A deeper discussion follows here.

Operating pressure

Assessing uniform application of wastewater is usually done by measuring operating pressure at the individual laterals dispersing effluent through orifices. Operating pressure is the pressure measurement at a predefined location (typically at the distal or farthest end of the pressure laterals in media filters or low-pressure distribution STAs. Uniform operating pressure at each lateral means that uniform application of wastewater is likely occurring. The operating pressure is typically measured by opening the end of the lateral (which is closed during normal operation) and attaching a clear calibrated PVC pipe to the end of the lateral in a vertical orientation. When the pump activates, measure and record the height the effluent reaches in the clear pipe (Figure 7-1).

Operating pressure is also loosely referred to as "squirt height" or the height that effluent will squirt from an orifice into free air. Generally, the height that wastewater rises in a PVC pipe is somewhat higher than the "squirt height."

Some manufacturers and/or regulatory programs set minimum and/or maximum operating pressure for different types of advanced treatment and final treatment and dispersal units. Service providers should contact the manufacturer or the regulatory jurisdiction for specific requirements. Record the operating pressure at system start up or during the first visit. This value should correspond to the operating pressure specified in the design. This will be the baseline value to which future measurements will be compared.

Any pressurized system handling wastewater (with its dissolved organic matter and nutrients) will accumulate biosolids (microbial biofilm that grows on the inside of pipes and can clog orifices over time). System operating pressure is typically specified to provide enough velocity to scour accumulated biofilms and push them to the distal (farthest) ends of the network. Over time, these biosolids accumulate in fittings (especially elbows and tees) at the ends of laterals, and can clog or plug orifices. Increased operating pressure indicates that orifices are plugging. Some manufacturers establish that the laterals should be cleaned and flushed if the operating pressure increases by more than 20 to 40 percent of the initial value. (NOTE: The laterals should be cleaned if non-uniform distribution of effluent is observed, regardless of operating pressure increases.)

For residential systems, the general practice is that the laterals are flushed, snaked, and flushed without measuring operating pressure. The time required to flush, snake, and flush is equivalent to the time required for measuring the operating pressure, thus saving the service provider valuable time and ensuring treatment goals for the system. Flushing is achieved by opening the cap at the distal end of the lateral and running the pump manually until the effluent coming out is free of accumulated organic matter or debris. Initial flushing of the laterals moves biosolids out of the end of the lateral. Once the accumulated solids (often a "plug") are removed, snaking can occur.

The process of snaking the laterals involves pushing a cleaning device (either a bottlebrush attached to the end of an electrician's or plumber's snake or a small diameter pressure washer nozzle and hose) through each lateral from the distal end. Initial flushing of the laterals moves biosolids to the end of the lateral. Once the laterals are snaked, they should be flushed again to remove any solids that may have been dislodged. Laterals may also be vacuumed out with a pump truck if the orifices are well protected.

The operating pressure should be checked after snaking and flushing the laterals. After cleaning the lateral, the operating pressure should be roughly equivalent to the initial baseline value recorded during system start-up. A decrease in the operating pressure noted over time might be an indication of pump fatigue, clogging or malfunction, or a leak in the distribution system.

Air release valves

Air release valves allow the air in lines to purge, expediting pressurization of the distribution network. After the pump cycles off, the air release valves open automatically to allow air to enter the piping which accelerates the draining process. Air release valves may be needed on some systems and, when needed, are placed at the highest point in the system. They must be protected from damage and freezing. Valve boxes are generally placed around the valve to protect it and to create a void space for air exchange.

Types of Media and Filter Flow Regimens

Media filters can be broadly categorized based upon flow through the component: either a single-pass (effluent passes through the filter only once; Figure 7-2) or recirculating (effluent is dosed to the filter multiple times before dispersal) modes. Most media filters (especially the aerobic ones) are time dosed with a pump, to ensure the filter is not overwhelmed with effluent (leading to saturated conditions and poor treatment performance). Media can also consist of a wide variety of materials.

- Single-pass Media Filters
    - Granular (sand, glass, other)
    - Foam or plastic
    - Peat
    - Coir
- Recirculating Media Filters
    - Granular (sand, gravel, bottom ash, other)
    - Coir
    - Foam or plastic
    - Styrene
    - Textile

Most single-pass or recirculating media filters are "free

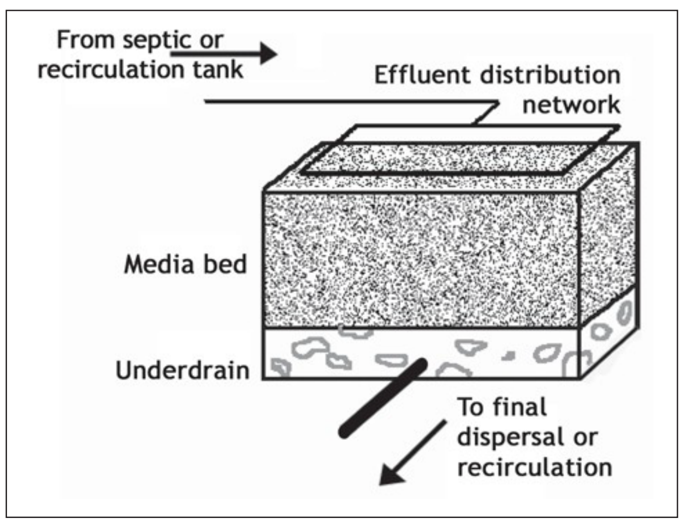

Figure 7-2. General schematic of a single pass media filter.

access," meaning that their surface is either in direct contact with the atmosphere (through a gravel or pea stone layer at finish grade) or is accessible via a hinged lid or risers that come to finish grade.

The generic treatment train for a system includes a media filter preceded by a septic tank, recirculation tank, or processing tank. Regardless of filter type, the media provides a substrate for bacteria and other microorganisms to grow. As the effluent trickles through the filter bed, it is treated by the organisms growing on the media. In top-dosed aerobic media filters, effluent collects at the base of the filter where it is then dispersed to either a soil treatment area (STA) for final treatment and dispersal or sent back to a recirculation/processing tank or a recirculation compartment for additional processing. An aerobic filter bed is never saturated with effluent and the presence of air promotes the establishment of aerobic microorganisms. However, anaerobic upflow filters are designed so that saturated conditions in the media are continuously maintained.

Several different types of media have been used in media filters. Media types can be generally categorized as solid granular or absorbent. In the solid granular media category, there are three materials that have been used: sand or gravel, bottom ash, and crushed glass. Synthetic media are commonly available and widely used.

Media less than 2 millimeters in diameter is sand, and anything larger is referred to as gravel. Sand and gravel have been used in media filters for decades. Sand, through which wastewater flows relatively slowly, is typically used for single-pass filters. Gravel is typically used for recirculating filters, which are designed to receive larger volumes of effluent over time. Nationally and historically more sand filters have been used to treat water and wastewater than probably any other advanced treatment technology. This is a testament to their efficacy, provided appropriate maintenance occurs.

In some regions, other solid granular media such as crushed glass and bottom ash have been used. Also called "slag," bottom ash is a byproduct of coal-fired power plants. Bottom ash is still used in some Appalachian Mountain states where coal-fired power plants are common. The use of glass media has been isolated to the northwestern United States and western Canada and is used on a relatively limited basis today. The service provider is encouraged to check with local and state regulatory programs, as localized use of other solid type media may also occur.

In some instances, absorbent media have been substituted for the non-absorbent granular types mentioned above to help encourage more efficient movement of wastewater and gases in the filter bed. This can allow a reduction in the system footprint if the design is robust. The absorbent media used in a single-pass mode currently includes peat, coir and open-cell foam. Textile, coir (coconut fiber) and open-cell foam media are also used in recirculating filters.

Single-pass media filters

Overview

In aerobic single-pass systems, effluent applied to the filter surface percolates through the media bed and collects at the filter base. As the name implies, wastewater flows though the filter bed only once and then flows to the next treatment and/or dispersal step. Treated effluent is usually pressure-dosed to the STA for final treatment and/or other dispersal. A limited number of media filters may employ gravity flow to feed both the media bed and the STA. Several different types of single-pass filters have been used; the oldest type being the sand filter, which has long served as the industry standard.

Treatment

Single-pass aerobic media filters are designed to treat wastewater by physical filtration of solids; chemical adsorption, assimilation or transformation; and decomposition of organic wastes. They are usually quite effective in removing BOD_5 and TSS but are not effective for nitrogen removal. They are, however, considered good nitrification zones (providing conditions conducive to conversion of organic and ammonium forms of nitrogen to the nitrate-nitrogen form), and some filters can remove appreciable numbers of pathogenic organisms. Single-pass sand filters, for example, can achieve three to four orders of magnitude reduction in fecal coliform bacteria. Effective treatment depends upon the hydraulic and organic loading rates to the filter. The service provider is encouraged to check local and state regulations for approved loading rates.

Typical treatment train options are discussed below. Please note that in the field, actual treatment trains may differ from those shown in Figures 7-3 and 7-4. In a particular system, actual pump locations could possibly be a combination of both internal and external configurations. Although pump locations may differ among regulatory jurisdictions, it is important that the service provider recognizes where major treatment components are located and identifies their function or purpose.

In Figure 7-3, effluent leaves the house and enters a septic tank containing a screened pump vault in the outlet end of the tank. Effluent is usually pressure-dosed (using a programmable timer) over the single-pass media filter surface where it then percolates down through the media bed and is collected in either an internal or external dosing tank to a low-pressure distribution STA.

In Figure 7-4, effluent leaves the house, enters a septic tank, and flows by gravity to a separate dosing tank from where it is dosed to the single-pass media filter. Typically, this pump is controlled by a programmable timer. Filtered effluent is collected in the dosing tank located after the media filter, where it is applied to a low-pressure distribution STA.

Although not that common, some media filters may have a treatment train that is completely gravity fed. In Figure 7-5, effluent flows by gravity from the house into a septic tank and by gravity onto the surface of the media filter. Effluent percolates down through the media, is collected in the filter bottom drain, and flows by gravity into the STA.

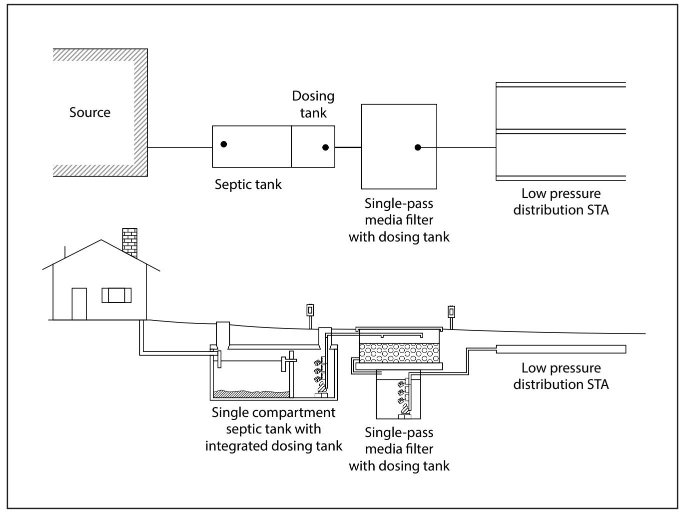

Figure 7-3. Configuration for a single-pass media filter treatment train with an internal pump vault/basin.

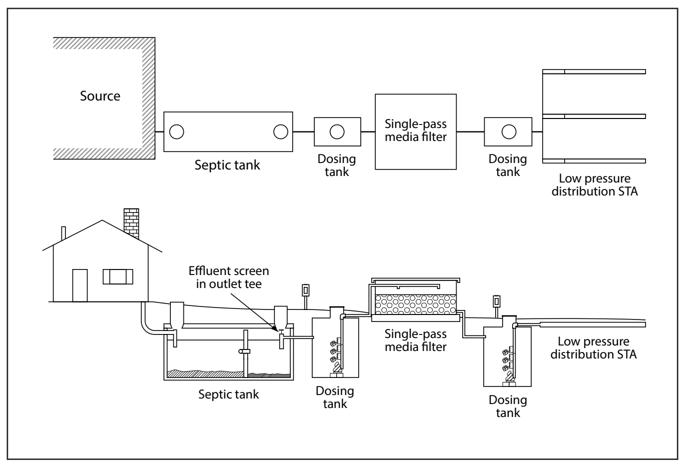

Figure 7-4. Configuration for a single-pass media filter treatment train with external dosing tanks feeding a low-pressure distribution STA.

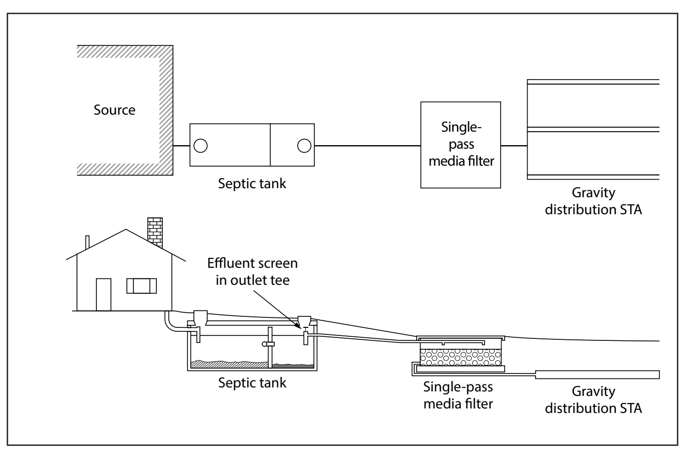

Figure 7-5. Configuration for a single-pass media filter treatment train using gravity flow (top: plan view; bottom: profile view).

Recirculating media filters

Overview

A recirculating media filter treats wastewater by recirculating effluent that has passed through the filter bed back to the septic tank or to a separate recirculation tank. This mixing commonly occurs in a recirculation tank, but in some technologies, it happens in the headworks (inlet end) of the septic tank which also functions as a processing tank. Effluent is recirculated to the filter bed multiple times prior to being dispersed. A programmable timer controls the amount of wastewater recirculated to the filter bed surface (a time dosed regime). Typically, the recirculation is set so that three to five times more effluent is delivered to the filter surface than what is usually generated in the structure/home (forward flow). Filtrate from the media filter is split so that a portion returns to the recirculation tank and a portion goes out for final treatment and dispersal. This splitting process may be controlled in the following ways:

- Dam/divider at the filter bed base either directly below the filter or adjacent to it;
- Floating ball valve device, known as a recirculating splitter valve or floating ball valve, located in the recirculation tank, septic tank, or processing tank;
- Tipping bucket device;
- Splitter box;
- Distribution plate; or
- Pressurized pipe and valve assembly.

Treatment

Recirculating media filters are effective in reducing BOD_5 and TSS in wastewater. Nitrogen removal in recirculating media filters is enhanced by circulating the filtrate back to the carbon-rich, anaerobic processing, septic, or recirculation tanks. Processing tanks are a combination septic and recirculation tank containing a pump vault in

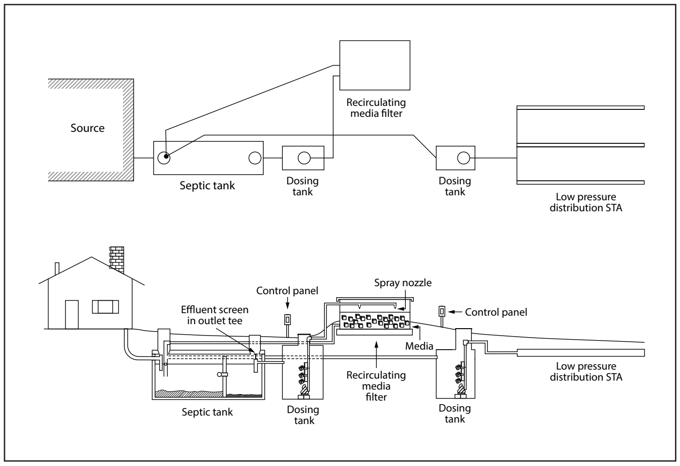

Figure 7-6. Configuration 1 for recirculating media filters using a separate dosing tank.

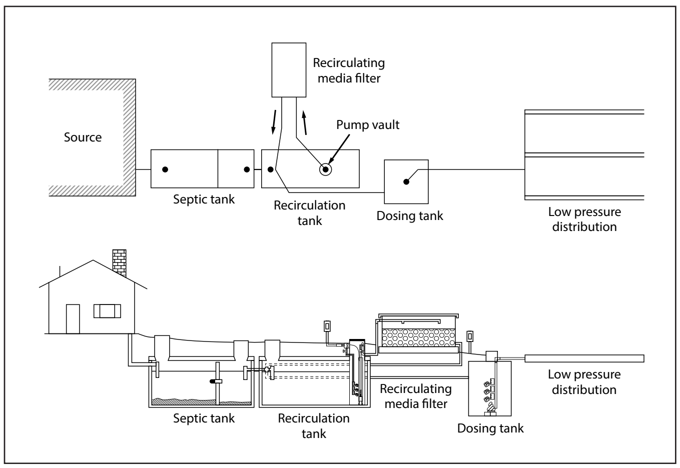

Figure 7-7. Configuration 2 for recirculating media filters using a separate recirculation tank.

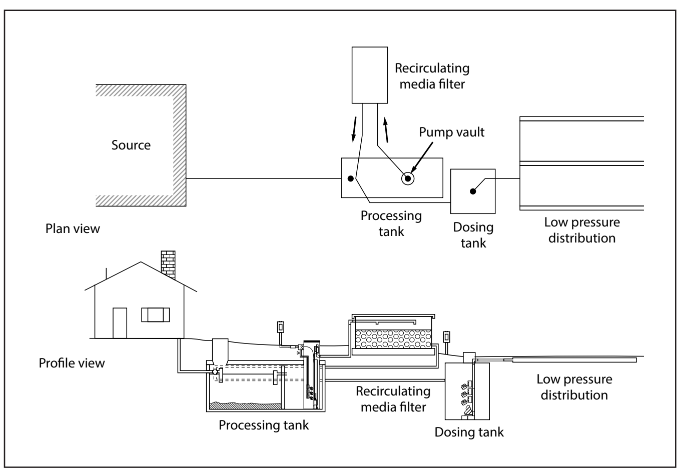

Figure 7-8. Configuration 3 for recirculating media filters using a processing tank.

the outlet end. Solids settling, denitrification, recirculation and mixing, and effluent dosing are all expected to occur in a processing tank. Please see Chapter 5 for further discussion on processing tanks.

Recirculating sand/gravel filters have been used for nitrogen reduction for decades. Recirculating sand or gravel filters differ only in the size of the media used. Textile, foam and plastic media have recently been used for nitrogen reduction. Service providers should check with local or state regulatory programs regarding the status of media filter use for nitrogen removal. Recirculating media filters do achieve some bacterial reduction. However, the reduction is limited (due to high hydraulic loading rates and short retention times), and they are generally not considered pathogen reduction technologies.

In Figure 7-6, effluent leaving the house enters the septic tank and flows by gravity into a dosing tank where it is pressure-dosed to the recirculating filter surface. Typically, effluent is delivered using a time dosed configuration. Effluent is then collected at the media filter base and recirculated back to the septic tank for further treatment. If tank effluent levels are high, effluent is diverted to the dosing tank for final dispersal in the pressure-distribution STA.

In Figure 7-7, effluent leaves the house and enters the septic tank where it then flows by gravity to a separate recirculation tank. The effluent is time dosed to the recirculating media filter surface, passes through the bed, and flows back to the recirculation tank for further treatment. If the wastewater level is high in the recirculation tank, a floating ball valve diverts flow to the STA dosing tank for final dispersal. This is a very typical treatment train for a recirculating sand/gravel filter system.

In Figure 7-8, effluent leaves the house and enters the processing tank containing a screened pump vault in the outlet end of the tank. This tank also serves as a combination septic tank and recirculation tank. Effluent is time dosed to the recirculating media filter surface, percolates through the bed, and collects at the filter base. Filtrate is typically split between recirculating back to the processing tank for further treatment or directed to the STA for dispersal.

There are several methods to achieve recirculation. One common approach is based on gravity flow through a floating splitter ball valve. In this case, filtrate flows back to the tank (by gravity) if the liquid level in the tank is low. If the tank liquid level is high, the floating ball valve prevents effluent from entering the tank, and instead, diverts flow to the STA. Another option is to pressure-dose media filter effluent from a sump in the filter base through gate valves that control flow back to the tank or to the STA. Other technologies may use multiple pumps, a dam or partial barrier at the filter base or an external D-box that diverts gravity flow to both the processing tank and STA.

All these flow splitting methods, except the barrier at the filter base (not usually accessible), would require some level of maintenance. Service providers must determine what splitting method is being used to recirculate effluent.

Circulation and recirculation ratio

The circulation ratio of a system is the amount of effluent that cycles through the treatment unit relative to the amount of effluent delivered to the final treatment and dispersal component. Forward flow is the effluent that reaches the final treatment and dispersal component during a specific period. The volume of effluent generated at the source (the home's forward flow) is the same volume available for final treatment and dispersal (additions to the system from rainfall on the filter are usually not factored in).

The circulation ratio is expressed as a ratio or quotient:

Circulation ratio = total volume dosed to treatment unit / forward flow to the STA

This is expressed as the ratio of circulated flow during a specific period. The typical circulation ratio ranges from 5:1 to 6:1

The recirculation ratio is slightly different: It subtracts the volume of water leaving the system from the volume sent to the treatment unit. Because the recirculation ratio "discounts" the numerator (first value) in the quotient (ratio) is less than the circulation ratio and describes the amount of effluent recycled to the previous component relative to the amount of effluent delivered to the final treatment and dispersal component.

Recirc. ratio = (flow to treatment unit - forward flow to STA) / forward flow to STA

Because recirculation is defined as circulation minus forward flow, the recirculation ratio equals the circulation ratio minus 1. The typical recirculation ratio ranges from 4:1 to 5:1.

The circulation/recirculation ratio directly influences the level of dissolved oxygen (DO) in the recirculating tank (or the processing tank, depending on type of system). Because the media filter uses an aerobic process for treatment, dissolved oxygen is incorporated into the effluent. This is important for nitrification and organic matter decomposition. However, the effluent that passes through the media filter carries some dissolved oxygen as it enters the recirculating tank. A higher recirculating ratio (for example, 6:1 versus 4:1) means that more oxygenated effluent is delivered to the recirculating tank.

DO levels need to be checked in the recirculation tank to assess if the recirculation ratio needs adjustment. Too much recirculation leads to excess oxygen in the recirculation tank, which compromises denitrification efficiency (low DO is needed to promote denitrification). The maximum DO limit for a recirculation tank designed to facilitate denitrification is 0.5 mg/L (optimal levels are 0.1–0.3 mg/L) measured at the inlet side of the recirculation/processing tank. Higher DO than 0.5 mg/L means that the recirculation ratio needs to be reduced, since high DO will inhibit denitrification. If media filter effluent has low DO, is not clear or has some septic odor after passing through the treatment this indicates insufficient aerobic treatment in the media filter. In this case, if the DO at the inlet of the recirculating tank is less than 0.5 mg/L, then the recirculation ratio may be increased (sending more flow to the media filter) to achieve better treatment.

Specific Maintenance Tasks

Single-pass sand filter

Single-pass sand filters are normally used to polish effluent from septic tanks or aerobic treatment processing steps prior to final dispersal (Figure 7-9). The term "sand filter" refers to a biological and physical wastewater treatment component consisting of an underdrain installed in a bed of sand or gravel to which pretreated effluent is periodically applied. Filtrate collected by the underdrain is then distributed to a STA for final treatment and dispersal. These systems are typically buried, meaning the surface of the sand filter is typically not visible – rather it should have appropriate topsoil and vegetation (e.g. maintained grass) above it.

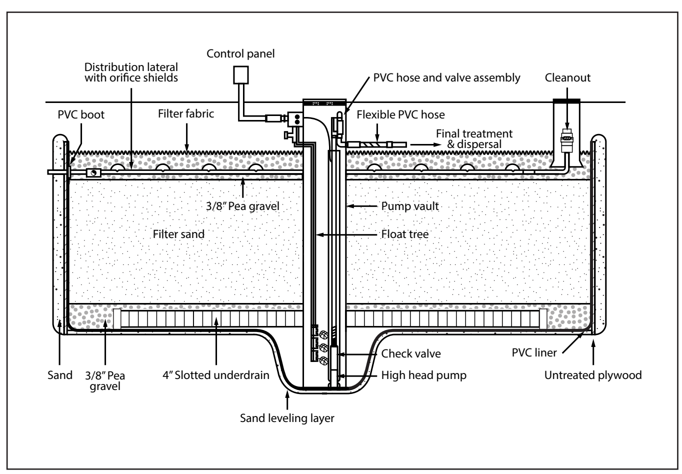

Figure 7-9. Cross section of an example of a buried single-pass sand filter with an internal pump basin sump (profile view).

Specific maintenance tasks for single-pass sand filters

- Check the surface of filter for settling, erosion, or depressions.
- Check the landscape position of the filter. Assess whether runoff/surface water is collecting over the filter. If it is buried, the surface must be mounded to divert stormwater and prevent hydraulic overload.
- Determine whether the type of cover over the system is at grade or below grade. If below grade, note the condition of vegetation over the filter.
- Check clarity, transparency, and odor of effluent after passing through the sand filter. Effluent should be clear, transparent and odorless. Check for an oily film in the effluent that might indicate excessive FOGs.
- Measure operating pressure at the lateral end before and after cleaning.
- Check the effluent level in internal pump basin. The liquid level should be below the elevation of the base of the sand media to avoid wicking effluent up into the sand media.
- Check that the high-level alarm is set to engage below the elevation of the base of the sand media.
- Check for sand media within the sump. Sand in the sump could indicate improper installation of pea gravel within the filter underdrain.
- Clean each of the distribution laterals by flushing (opening the distal end of the lateral and running the pump), snaking with a bottle brush (or pressure washing), and flushing (running the pump) again.
- Check the function of each float in the sump.
- Check pump operation in automatic and manual modes.
- Check electrical junction boxes for damage or moisture.
- Verify proper operation of all alarms.

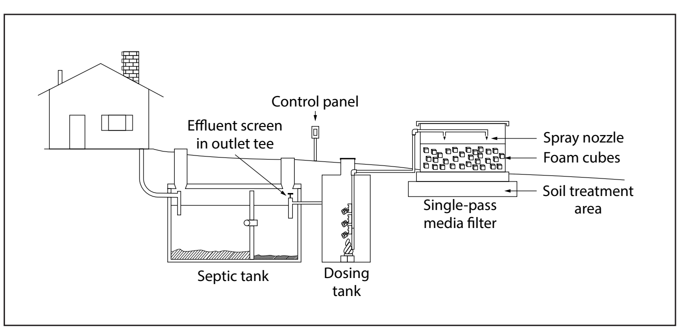

Figure 7-10. System configuration for single-pass foam filters.

(Note: It is important to seek information and training on each specific technology as manufacturer's O&M guidelines will vary. It is recommended that service providers also seek manufacturer training for each product they operate.)

Single-pass foam filter

Foam filters use 2- to 3-inch cubes of open-cell polyurethane foam material that is randomly arranged in prefabricated modular units (Figure 7-10). The absorbent media utilizes internal surface areas within the foam cubes to help maximize microbial treatment and detention times. The foam media is usually dosed by helical spray nozzles. The media and distribution system are housed in a structure with a lid that allows access for operation and maintenance.

Specific maintenance tasks for single-pass foam filters

- Check for soil settling, erosion, depressions, or possibility of surface water collection around filter unit's enclosure.
- Check for damage to the filter cover/lid.
- Check for settling of media within the filter.
- Inspect filter for odors and surface ponding. Ponding on the media is typically a sign of a problem.
- Inspect the overall condition of the media, including for biomat buildup on media surface

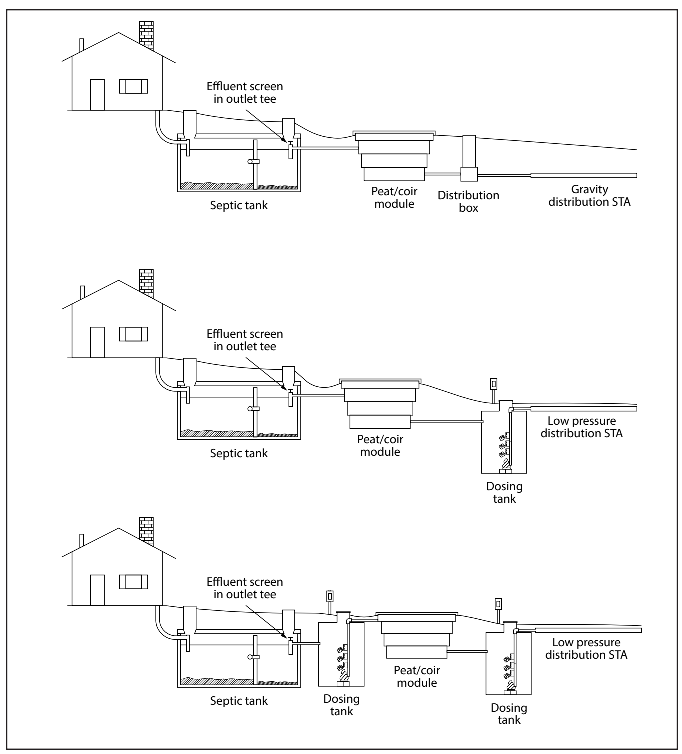

Figure 7-11. System treatment train configurations for peat or coir media filters.

- Check clarity, odor, and transparency of treated effluent. Effluent should be clear, transparent and odorless.

  Check with manufacturers concerning acceptable effluent ponding levels at base of foam filter.

- Remove and clean spray nozzles annually (or as needed), and check for equal spray distribution.
- Flush laterals while nozzles are removed.
- Verify proper operation of all alarms.

(Note: It is important to seek information and training on each specific technology as manufacturer's O&M guidelines will vary. It is recommended that service providers also seek manufacturer training for each product they operate.)

Single-pass peat or coir

Absorbent peat or coir media filters consist of a distribution system, media, and an underdrain system (Figure 7-11). Peat and coir filters typically come in prefabricated modular units made of fiberglass or high-density polyethylene. Some filters are gravity-fed, using a tipping distribution-box mechanism. Others are pressure-dosed using either demand- or time dosing. Types of peat material are sphagnum peat (from North America) and coarse fibric peat (from Ireland). Coir is another term for coconut husk fibers.

Organic fibers settle, decompose, and/or deteriorate over time and may need to be replenished or replaced entirely at some point during service. Replenishment or replacement frequency is dependent upon wastewater flow and characteristics and the type of fiber used.

Additional peat or coir material may need to be added to the module yearly to ensure that distribution laterals remain covered; otherwise, odor problems may occur (especially during cold months of the year).

After effluent passes through a peat filter, it can be pressure-dosed or gravity-fed to the final dispersal component. Some areas allow placement of the module directly on a bed of gravel or crushed stone with drain holes drilled in the bottom of the units. The stone/gravel bed serves as the dispersal component. (See Chapter 8 for peat filters used as a soil treatment area). The service provider is encouraged to check local or state regulations.

Specific maintenance tasks for single-pass peat and coir filters

- Check for surface water and infiltration into components.
- Check for soil settling, damage, erosion, depressions, or possibility of surface water collection around the modules.
- Check for damage to the filter cover/lid. (If the air holes in the lid are allowing reptiles and rodents into the filter, plastic vents may be installed.)
- Check for excessive odors or any ponding at the surface of the filter.
- Check the clarity of the filter effluent. The effluent color may vary from a dark tea to a light amber color from the tannins leaching from the media. The color is darker at the time of start-up and lightens with time.
- Check the odor of the filter effluent. Effluent may smell musty, but it should not smell septic.
- Check for fine particles suspended in effluent. This may indicate that peat is decomposing and needs to be replaced.
- Check for wastewater bypassing the media. Pest damage (from ants, mice, and snakes) and frozen media can divert wastewater flow.
- If peat settling or channeling occurs, media may need to be raked to prevent odors or treatment bypass.
- Rake the media as needed to fluff it up. (Some companies advise against this. Check the manufacturer's guide.)
- Check for settling and decomposition of media and replace it as necessary.
- Check to see if additional material is needed to cover distribution laterals (this will reduce risks of odor).
- Make sure no heavy objects are placed over the filter; they could damage the distribution network.
- Verify proper operation of all alarms.

(Note: It is important to seek information and training on each specific technology as manufacturer's O&M guidelines will vary. It is recommended that service providers also seek manufacturer training for each product they operate.)

Recirculating sand/gravel filters

These at-grade, free access filters are composed of coarse sand and/or fine gravel and are covered with pea stone to grade (Figure 7-12). The larger media size is necessary

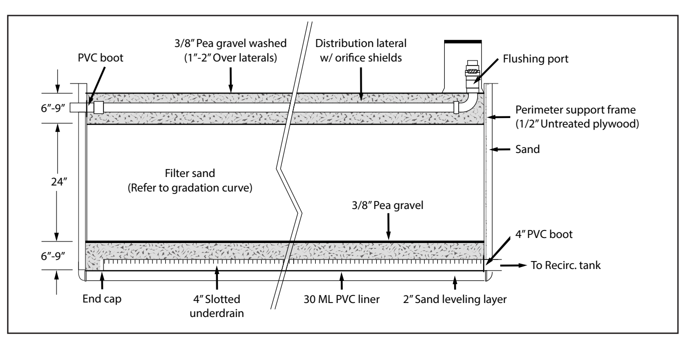

Figure 7-12. Schematic of a recirculating sand/gravel filter.

because of the higher hydraulic loading these filters are designed to handle. The recirculation ratio ranges between 5:1 and 3:1 of the total flow generated at the source (forward flow).

Effluent passing through the recirculating filter is collected in an underdrain pipe. The effluent is then directed to a recirculating device that directs the effluent either to the recirculation tank if the tank liquid level is low or to final treatment and dispersal if the tank liquid level is high.

Specific maintenance task for recirculating sand/gravel filters

- Check the surface of filter for settling, damage, erosion.
- Check for surface water collection or infiltration into the filter or components.
- Inspect the top of the filter and remove any vegetation growing in the pea gravel. Place pressure on the laterals (e.g., gentle foot pressure) so that laterals are not pulled out of the pea gravel during this process.
- Check filter surface and clean/rake if necessary.
- Check for ponding in inspection port (if present).
- Check clarity, transparency, and odor of effluent before the final treatment and dispersal technology. Effluent should be clear, transparent and odorless. Check for an oily film in the effluent that might indicate excessive FOGs.
- Clean each of the distribution laterals by flushing (opening the distal end of the lateral and running the pump), snaking with a bottle brush (or pressure washing), and flushing (running the pump) again.

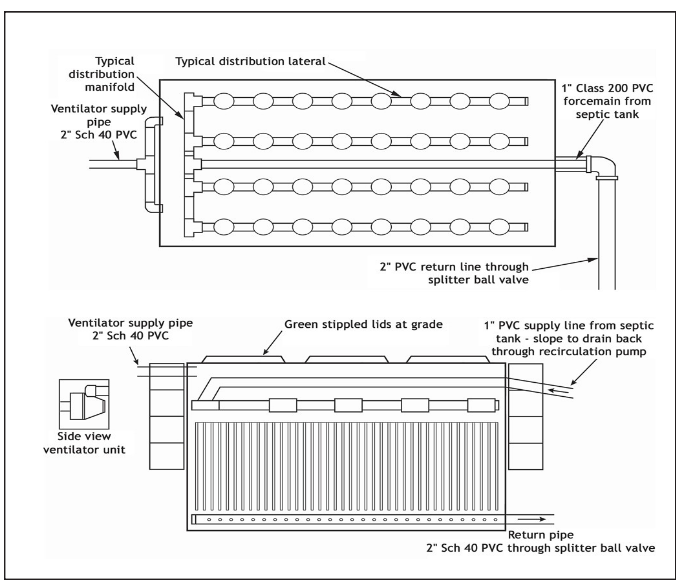

Figure 7-13. Recirculating textile filter schematic

Visually inspect the recirculating device, and clean if necessary.

(Note: It is important to seek information and training on each specific technology as manufacturer's O&M guidelines will vary. It is recommended that service providers also seek manufacturer training for each product they operate.)

Recirculating textile filter

Composed of absorbent geosynthetic fabrics or geotextiles, textile filters provide surface area within the media itself and void volume between the pieces of media (Figure 7-13). Textile filters have two common configurations: (1) randomly sized textile coupons arranged in three separate horizontal lifts and (2) vertically hanging sheets of fabric. The textile material is contained in a prefabricated fiberglass container.

Specific maintenance tasks for recirculating textile filters

- Check for soil settling, damage, erosion, depressions, or possibility of surface water collection around the textile container.
- Inspect filter cover/lid for structural damage.
- Inspect for ponding. The textile filter should never be saturated or have any standing effluent in media.
- Check treated textile filter effluent for clarity, transparency, and odor. Effluent should be clear, transparent and odorless. Check for an oily film in the effluent that might indicate excessive FOGs.
- Check for uniform spray from all orifices (view stains on underside of filter lid or on filter fabric surface for distribution pattern).
- Textile filters should receive a dose of wastewater at least once every 30 minutes to prevent the media from drying out.
- The typical duration of the dose is 20-30 seconds and should not be more than 60 seconds. If orifices are clogged or distribution patterns are not uniform, flush, snake, and re-flush laterals. Laterals can be cleaned by either pressure jetting the lines or snaking with a bottle brush, attached to a plumber's snake or a long flexible fiberglass handle (if laterals are short enough).
- If excessive amounts of solids are on the media surface, check recirculation ratio. The most likely reason for too many solids is too much recirculation (check dissolved oxygen level in processing tank to verify).
- *Cleaning the textile filter:* The media can be cleaned by hosing or lightly pressure washing the media and removing the recirculating device. This allows the

solids to drain back into the processing tank. If the media filter contains hanging sheets of textile fabric, the service provider should be careful not to tear the sheets while pressure washing. (NOTE: It is not recommended to clean the textile media too often, as a light buildup of organic material is normal and beneficial.)

- *Inspect venting/air intake devices:* Identify whether the type of air intake device is passive or active. If passive, vegetation should be removed from around the vent as lack of oxygen flow can impede nitrogen removal. If an active air intake is used, make sure the blower unit is pressurizing the textile filter. In both situations, clean the intake screen as needed.
- Tightly secure the filter lid after service to ensure that a tight seal is made between the lid and gasket to prevent odors from escaping the textile filter.

(Note: It is important to seek information and training on each specific technology as manufacturer's O&M guidelines will vary. It is recommended that service providers also seek manufacturer training for each product they operate.)

Recirculating foam filter

Foam filters use 2- to 3-inch cubes of open-cell polyurethane foam material that is randomly arranged in prefabricated modular units, typically in wire baskets within a container (Figure 7-14). The effluent is distributed evenly over the media by helical-type spray nozzles.

Specific maintenance tasks for recirculating foam filters

- Check for soil settling erosion, depressions, or possibility of surface water collection around filter unit.
- Check for damage to the filter cover/lid.
- Check for settling of media within the filter.
- Inspect filter for odors and surface ponding.
- Inspect the overall condition of the media, including biomat buildup.
- Check clarity, odor, and transparency of treated effluent. Effluent should be clear, transparent and odorless.
- Check with manufacturer concerning acceptable effluent ponding levels at base of foam filter. Some technologies use this sump to dose the STA or recirculate effluent back to the inlet of the septic tank.
- Remove and clean spray nozzles annually (or as needed), reinstall and check for equal spray distribution.
- Flush laterals while nozzles are removed.
- Verify proper operation of all alarms.

(Note: It is important to seek information and training on each specific technology as manufacturer's O&M guidelines will vary. It is recommended that service providers also seek manufacturer training for each product they operate.)

Trickling filter

Trickling filters provide aerobic treatment of wastewater. Wastewater is generally pumped from a recirculation tank or compartment, dispersed over a media bed, and allowed to drain back into the tank (Figure 7-15). The wastewater is aerated as it flows through the media bed, which may consist of a variety of non-absorbent media such as gravel/stone, polystyrene beads and rigid plastics configured into a number of shapes (e.g., honeycomb blocks, rings, or

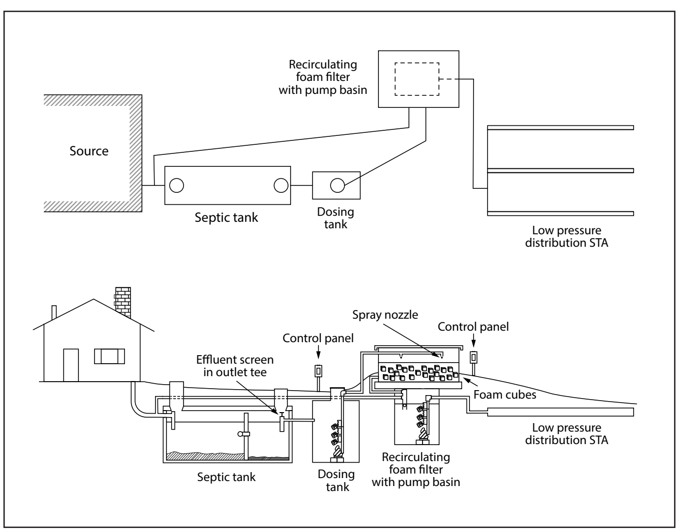

Figure 7-14. System configuration for treatment train using a recirculating foam filter

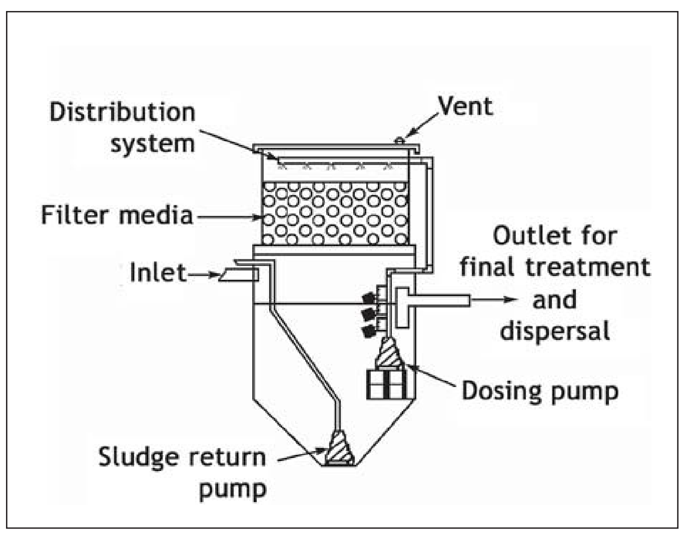

Figure 7-15. Trickling filter schematic (profile view).

cylinders). Some units aerate the effluent as it is sprayed onto the media (e.g. via a venturi device). A trickling filter uses filtration, adsorption, and assimilation for removal of contaminants from wastewater. Wastewater should flow in a thin film over the media to allow time for treatment.

The media serves as a substrate where a biological film grows and is fed by the nutrients contained in the wastewater. As the biofilm is established and continues to grow, it will eventually exceed its own ability to cling to the media surface. The biological film material breaks off and washes down through the media bed, and either returns to the recirculation tank or settles out in a clarifier compartment. The clarifier typically contains a sludge return pump dedicated to moving accumulated settled biological materials back to the head works of the septic tank for decomposition.

Final effluent moves by gravity out of the trickling filter sump through a standard sanitary tee assembly.

Specific maintenance tasks for trickling filters

In the clarification compartment:

- Visually check (using a sludge measuring device) that the solids blanket (composed of accumulating solids that wash off media) is below the inlet of the pump that recirculates effluent to the top of the media. If not, then adjust float accordingly.

In the sludge return compartment or zone:

- Verify that the solids blanket level is slightly above the level of the sludge return pump inlet.
- Adjust the solids return pump rate as needed if a thick solids blanket is present. Record these changes. (See Chapter 6 for more pump O&M).

(Note: It is important to seek information and training on each specific technology as manufacturer's O&M guidelines will vary.

Anaerobic upflow media filters

An anaerobic upflow media filter is characterized by a long detention time and production of anaerobic effluent (Figure 7-16). It uses physical removal mechanisms that include flocculation, sedimentation, and absorption. Anaerobic digestion may also occur in the bed. These filters are housed in prefabricated tanks or modules, generally filled with sand, gravel, or wood chip media, but other non-degradable media types can also be used.

Following a septic tank, anaerobic upflow media filters can remove additional TSS, BOD_5, and nitrate nitrogen. They are generally not used for pathogen removal. For increased nitrogen removal, aerobic treatment processes can be used preceding an anaerobic upflow media filter.

Specific maintenance tasks for anaerobic upflow media filters

- Check for soil settling, damage, erosion, depressions, or possibility of surface water collection around or running into the upflow media filter.
- Inspect filter cover/lid for structural damage.
- Check treated filter effluent for clarity, transparency, and odor. Effluent should be clear, transparent and odorless. Check for oily film in the effluent that might indicate excessive FOGs.
- Periodically flush the accumulated solids in the media. Draining the media and allowing it to air-dry will also unclog the pores in the system.
- Pump sludge accumulation as necessary.
- Inspect the inlet and outlet of the system for plugging. Clean and flush as necessary.
- Check the bypass device for proper function.
- Check for proper functioning of the system alarms.
- Evaluate the odor control system.
- Visit the site three or four times a year for inspection.
- Tightly secure lid after service to ensure that a seal is made between the lid and gasket to prevent odors from escaping the anaerobic upflow media filter.

(Note: It is important to seek information and training on each specific technology as manufacturer's O&M guidelines will vary. It is recommended that service providers also seek manufacturer training for each product they operate.)

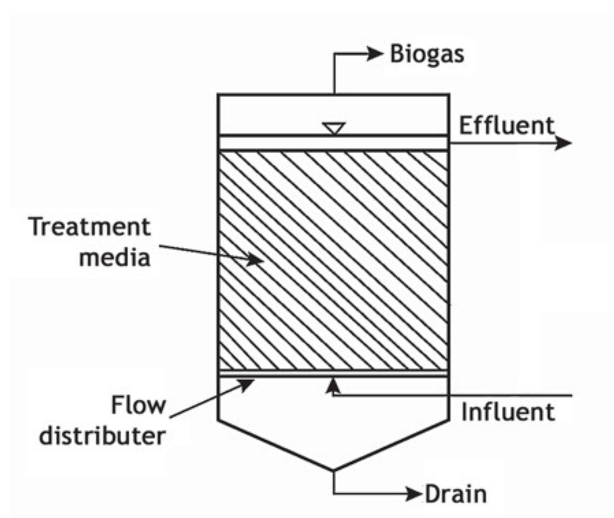

Figure 7-16. Schematic of the anaerobic upflow filter (profile view)

Using Form 7-1: Media Filters Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Media Filters. The form for documenting inspection points follows the text.

1. Type of media filter

Note what kind of system is in place and note the type of media in the filter. If the component is proprietary, record the manufacturer and model number. Determine the type of distribution method on the system: pressure or gravity distribution.

2. Conditions at the media filter

There should be no strong odors near the filter if the venting system is operating properly and there are no breakouts. Note that some media filters have noticeable odors during the startup period. If odors are detected, determine the source by checking for missing caps on inspection ports or damaged lids and risers. Also check the roof vent location, prevailing winds, and atmospheric pressure as these factors can contribute to odor issues. Note whether odors are strong, mild, septic (rotten eggs), chemical, or sour in nature.

3. Cover

Note whether the filter is free access, buried, or has a lid. The lids on media filters should open and close freely and be secured when closed. Free access filters generally have access through the cover material (usually pea gravel). The distribution component should be accessible. There should be no surface water infiltration into the components. No vegetation should be allowed to grow in free access filters. The best type of vegetation on a buried filter is maintained grass or lawn.

4. Venting/Air supply

Air supply/entry can be through the cover material or a specific vent or screen. Determine whether the air intake device is passive or active. If passive, vegetation should be removed from around the vent as lack of oxygen flow inhibits aerobic treatment and can impede decomposition of organic matter and denitrification. If an active air intake is used, make sure the fan or blower is delivering air to the filter. In both situations, clean any intake screens as needed.

If the system has an active air supply, evaluate the system used. The air supply system may be operated in a continuous or timed mode. The time on and time off should be recorded for future reference. The air supply system must have an electrical supply and be operable. The pressure should be measured and recorded using a pressure or vacuum gauge. The air flow can also be measured using an air flow gauge and then recorded.

5. Media surface

The media surface in the filter accepts wastewater and is the starting point for the wastewater treatment process. Vents and inspection ports to the media filter surface or underdrain system allow determination of the level of ponding. Ponding can indicate clogging of the media filter surface. Clogging in the media filter may occur due to either physical and biological factors. Physical clogging is caused by the accumulation of solid material within or on the media surface. Biological clogging is due to excessive microbial growth within the filter. An accumulation of biological slime and a decrease in the rate of decomposition of entrapped wastewater contaminants within the filter accelerates filter clogging. The media filter can be allowed to rest to dry out and break down the biological materials growing in the filter. Some free access media filters can be raked to break the inhibiting crust that has developed on top of the media filter due to the accumulation of fine materials. This will allow effluent to infiltrate into the media. Other media filters can be cleaned.

Where applicable, the surface layer of media can be removed from the filter when it is clogged with fine particles. Media can be replaced if the bed cannot be regenerated. Likewise, if repeated removals of the media surface layers have occurred, then partial replacement will be needed.

If the filter bed has an exposed surface, note damage from animal activity.

6. Effluent quality

Collect a sample from the outlet of the media filter and evaluate for effluent quality. Clarity, turbidity, dissolved oxygen, pH, presence of oily surface film, color, odor, and temperature can provide guidance on the status of the system. Note whether bypass or overflow has occurred.

7. Pressure distribution

Measure the operating pressure before and after cleaning. The operating pressure in the lateral line determines the flow rate of liquid leaving the orifices. Check the operating head at the end of the lateral. Clean laterals by flushing, snaking or pressure-washing. If required, reset the operating pressure to the original value by adjusting the pressure-regulating valve located in the discharge assembly or at the beginning of the lateral in the distribution piping network.

8. Gravity distribution

Gravity distribution systems (typically a tipping D-box) may also be used. Note the gravity distribution device used. If applicable, check for uniform distribution of effluent and proper operation of the distribution device.

9. Filter drainage systems

Check the filter drainage sump for ponding or solids buildup. Clean the sump and pump as needed. Some systems may have gravity drainage to the final treatment and dispersal component. Note whether these systems are operable. Underdrain vents should be present and operable.

10. Control panel

Control panels should be watertight with all connections sealed to prevent moisture or sewer gases from entering. Check the function of the alarm test switch. The presence of a control (HAND-OFF-AUTO) switch allows the service provider to check pump function without activating a float or program. Note the position of the control switch, keeping in mind that under normal operating conditions it should be in the AUTO position. If the panel has a cycle counter, and/or an hour or minute meter (elapsed time meter or ETM), record the present and last readings. If there are no meters, they are strongly recommended as an upgrade to facilitate O&M activities.

Telemetry allows for remote communication of system status. Data can be shared with the owner, service provider, responsible management entity (RME) or manufacturer. Some systems also allow remote system operation. If this option is available, the service provider should verify the connection between the panel and the receiving entity is active. One way is to activate a pump and then log into the website or make a phone call to verify that the system logged the pump event.

11. Alarms

Alarms are used to monitor the effluent level in the unit. Note whether this is present and, if so, operable. Some units may include an event counter to record the number of alarm events. The present reading can be compared to previous readings to determine the number of alarm events. Some units may also have battery backups for alarms. If present, the operation of the alarm using the battery backup should be evaluated.

Telemetry is also an option for remote notification of alarms. If the system includes telemetry, verify the electronic connection between the control panel and the receiving entity. One way to do this is to trigger an alarm and log into the website or make a phone call to verify that the system logged the alarm event.

12. Additional tasks for recirculating filters

Recirculating filters may have a separate recirculation tank that collects effluent from the media filter and returns it to the filter. Some systems may return the partially treated effluent to a septic tank specifically configured for recirculation. If this is the case, inspect the tank with the same procedures as for pretreatment tanks using Form 5-2. The dissolved oxygen (DO) concentration gives an indication of whether the recirculation rate and resulting oxygen transfer are appropriate.

Check the recirculation device and clean if needed. This may be a flow splitting valve, a flow splitting configuration in the bottom of the filter or by way of a recirculation pump. The recirculation rate can be estimated and changed if a different aeration rate is needed. The actual recirculation ratio can be calculated at the site by dividing the actual recirculation pump volume by the actual discharge pump volume. (NOTE: If recirculation is achieved by way of a dam/divider at the filter base, this O&M step is not applicable.)

13. Additional tasks for trickling filters

13.1 Clarification chamber

The clarification chamber collects solids that have fallen off (sloughed) the media surface. The settled solids blanket needs to be below the intake of the recirculation pump. If the pump has a screened inlet or an effluent screen in a pump vault, these screens need to be cleaned.

13.2 Sludge return

A sludge return pump is used to transfer settled solids back to the pretreatment component. The quantity of effluent returned to the pretreatment tank can be adjusted by changing the sludge return pump time on the system programmable timer. In some systems, the sludge return pump may be manually controlled and operated.

14. Manufacturer's required maintenance

Manufacturers of specific units may recommend additional maintenance for their products. Perform and document completion of these activities in the comments section.

15. Lab samples

If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, transport, and store samples using standard wastewater sampling procedures. Record the chain of custody (COC) information and deliver the sample to an authorized laboratory. Retain a signed COC from the testing laboratory to complete the system file. Report the sampling analysis results to the proper entities.

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Form 7-1 Operational Checklist: Media Filter (MF)

Service provided on: Date:_______ Time:_____________ Reference #:_____________
Service provided by: Company: ________________ Employee: ___________________
Date of last service: ___________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ________________________

1. Type of media filter:
Single pass: ☐ Sand ☐ Foam ☐ Peat/Coir ☐ Polystyrene Other: _____________
Recirculating: ☐ Sand ☐ Foam ☐ Peat/Coir ☐ Textile ☐ Polystyrene Other: _____
Trickling filter: ☐ Gravel ☐ Plastic ☐ Textile Other: ______
Upflow filter: ☐ Gravel ☐ Plastic ☐ Wood chips Other: ________________
 a. Manufacturer: _____________________ Model #: _________________________
 b. Distribution method: ☐ Pressure distribution ☐ Gravity distribution
2. Conditions at media filter
 a. Evaluate presence of odor within 10 ft of perimeter of system:
 ☐ None ☐ Mild ☐ Strong ☐ Chemical ☐ Sour
 b. Source of odor, if present: __________________________________
3. Cover
 a. Type of cover: ☐ Buried ☐ Free access ☐ Lid
 b. Filter cover intact and secure. ☐ Yes ☐ No
 c. Distribution component accessible. ☐ Yes ☐ No
 d. Surface water/infiltration into components. ☐ Yes ☐ No
4. Venting/Air supply: ☐ Passive ☐ Active ☐ Not present
 a. Supply: ☐ Aspirator ☐ Compressor ☐ Blower ☐ Free air (go to 4.g)
 b. Operation: ☐ Continuous ☐ Timed (On ___min., Off ___ min)
 c. Air supply unit operating properly. ☐ Yes ☐ No
 d. Pressure at air supply unit: _______________psi
 e. Air flow at air supply unit: _______________cfm
 f. Air filter/screen: ☐ Cleaned ☐ Replaced
 g. Venting appears operable. ☐ Yes ☐ No
5. Media surface
 a. Biomat on surface. ☐ Yes ☐ No
 b. Uniform gravity distribution. ☐ NA ☐ Yes ☐ No
 c. Uniform spray pattern. ☐ NA ☐ Yes ☐ No
 d. Ponding in/on media. ☐ Yes ☐ No
 e. Plugging/clogging of distribution components. ☐ Yes ☐ No
 f. Media appears to be settling. ☐ Yes ☐ No
 g. Appropriate maintenance performed. ☐ Yes ☐ No
 h. Pest activity at surface. ☐ Yes ☐ No
 i. Media in need of replacement ☐ NA ☐ Yes ☐ No

Notes

2. ☐ Acceptable
 ☐ Unacceptable

3. ☐ Acceptable
 ☐ Unacceptable

4. ☐ Acceptable
 ☐ Unacceptable

5. ☐ Acceptable
 ☐ Unacceptable

Reference #:______________

6. Effluent quality
   a. Turbidity: ______________NTU
   b. Oily film on the surface of effluent. ☐ Yes ☐ No
   c. DO at outlet: ______________mg/L
   d. pH at outlet: ________________
   e. Temperature at outlet: ________________
   f. Bypass or overflow noticed. ☐ Yes ☐ No
   g. Effluent odor after passing through media filter:
      ☐ None ☐ Mild ☐ Strong
   h. Effluent color after passing through media filter:
      ☐ Clear ☐ Brown ☐ Black
7. Pressure distribution: ☐ NA
   a. Operating pressure before cleaning
      i) Equal height. ☐ Yes ☐ No
      ii) Height (inches): ________________in
   b. Lateral condition
      i) Laterals in need of cleaning. ☐ Yes ☐ No
      ii) Laterals cleaned. ☐ Yes ☐ No
      iii) Method for cleaning laterals:______________________
   c. Operating pressure after cleaning
      i) Equal height. ☐ Yes ☐ No
      ii) Height (inches): ________________in
8. Gravity distribution: ☐ NA
   a. Device: ____________
   b. Uniform distribution. ☐ Yes ☐ No
   c. Operating properly. ☐ Yes ☐ No
9. Filter drainage systems
   a. Ponding in media filter sump. ☐ Yes ☐ No
   b. Gravity drainage operational. ☐ NA ☐ Yes ☐ No
   c. Solids buildup in sump area. ☐ NA ☐ Yes ☐ No
   d. Underdrain vents present. ☐ NA ☐ Yes ☐ No
   e. Underdrain vents appear operable. ☐ NA ☐ Yes ☐ No
10. Control Panel:
   a. Controls operating properly. ☐ Yes ☐ No
   b. Enclosure water- and gas-tight. ☐ Yes ☐ No
   c. Alarm test switch operating properly. ☐ Yes ☐ No
   d. At time of inspection, control switch was set to:
      ☐ NA "Hand/Manual"_________ "Auto"__________
   e. If auto, setting: Time On: _______ (min) Time Off: _____ (min)
11. Alarm(s): ☐ NA
   a. Types: ☐ Air pressure ☐ High water ☐ Remote
   b. Alarms operating. ☐ Yes ☐ No

Notes

6. ☐ Acceptable ☐ Unacceptable

7. ☐ Acceptable ☐ Unacceptable

8. ☐ Acceptable ☐ Unacceptable

9. ☐ Acceptable ☐ Unacceptable

10. ☐ Acceptable ☐ Unacceptable

11. ☐ Acceptable ☐ Unacceptable

Reference #:______________

c. Alarm readings:

		Reading (present)	Reading (last)	Difference	N.A.
i.	ETM			Hours	
ii.	Alarm counter			Events	

Elapsed time in alarm status: _____(PTR) - _____(LTR) = ______Time (hours)
Number of alarm events: _______(PACR) - _____(LACR) = ______Events (number)

d. Battery backup charged. ☐ NA ☐ Yes ☐ No
e. Telemetry operational. ☐ NA ☐ Yes ☐ No

12. Additional tasks for recirculating filters
    a. DO in recirculation tank: ____________mg/L
    b. Inspected recirculating device. ☐ NA ☐ Yes ☐ No
    c. Cleaned recirculating device. ☐ NA ☐ Yes ☐ No
    d. Design recirculation ratio: ______:______
    e. Actual recirculation ratio: ______:______
    f. Recirculation changed to: ______:______

    *If dam configuration, recirculation device cannot be inspected or cleaned
13. Additional tasks for trickling filters

    13.1 Clarification chamber
    a. Solids blanket below recirculation pump inlet. ☐ Yes ☐ No
       *If no, was system pumped. ☐ Yes ☐ No
    b. If screened inlet, was screen cleaned. ☐ Yes ☐ No

    13.2 Sludge return
    a. Solids blanket slightly above return pump. ☐ Yes ☐ No
    b. Changed solids return rate. ☐ Yes ☐ No
       i) Pump: ☐ Off ☐ On
       ii) Changed from ____ min to ____min
14. Manufacturer's required maintenance performed. ☐ Yes ☐ No

    (If 'Yes' attach Manufacturer Inspection form to this report, if supplied.)
15. Lab samples collected for monitoring. ☐ Yes ☐ No

    Types of analysis:____
    ____
    ____

Notes

12. ☐ Acceptable ☐ Unacceptable

13. ☐ Acceptable ☐ Unacceptable

13.1 ☐ Acceptable ☐ Unacceptable

13.2 ☐ Acceptable ☐ Unacceptable

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Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the components of an aerobic treatment unit (ATU).
2. Differentiate among suspended growth, submerged fixed film and integrated fixed film activated sludge (IFAS) configurations.
3. Identify the different methods used to introduce air into an aeration chamber.
4. Identify the specific periodic activities for media management.
5. Describe the effect of hydraulic loading on the clarifier and organic loading on the aeration chamber.
6. Accurately complete the Operational Checklist 7-2. Aerobic treatment unit (ATU).

Description and Mode of Treatment

An aerobic treatment unit (ATU) typically includes a trash tank (primary treatment chamber), aeration chamber, air supply system, clarifier, and sludge return mechanism. The unit uses biological processes to transform both dissolved and solid constituents into gases, cell mass, and non-degradable material. An important feature of the biological processes that occur in ATUs is the synthesis and separation of microbial cells from the treated effluent. The treatment process involves a variety of aerobic and facultative microorganisms living together that can decompose a broad range of materials. Organisms live in an aerobic environment where free oxygen is available for their respiration. Aerobic treatment processes can be used to remove substantial amounts of BOD_5 and TSS that are not removed by simple sedimentation. This process also involves the nitrification of ammonium (NH_4^+) in the waste and the reduction of pathogenic organisms. Nitrification is the conversion of ammonium to nitrate (NO_3^-) by microorganisms in aerobic conditions.

Aerobic treatment units incorporate processes that collectively function to provide a high-quality effluent. These are: gross solids (trash) removal, aeration, clarification, and sludge return. These processes are generally contained within separate chambers of a single tank as shown in Figure 7-17. In some technologies, a series of tanks can be configured to pass effluent through an aerobic treatment train.

Wastewater generated in the home may enter a trash tank that primarily serves to remove materials that cannot be decomposed with a biological culture (e.g., wipes, plastics, and other objects that do not belong in the wastewater treatment train). Trash tanks provide some level of anaerobic treatment depending upon tank size and configuration. Some treatment trains do not incorporate a separate trash tank. In this case, the materials are all collected in the aeration chamber.

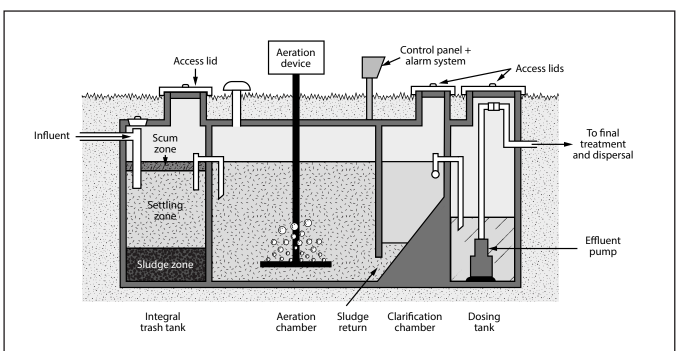

Figure 7-17. Aerobic treatment unit (ATU) schematic (profile view)

Wastewater then enters a mixed culture (mixed liquor) aeration chamber where aerobic organisms live on oxygen provided by an air supply system. The aeration chamber may contain suspended-growth (floating freely in the effluent) and/or attached-growth (attached to media or structures in the effluent) microorganisms.

The vast majority of ATUs employ extended aeration to facilitate aerobic treatment processes. The microbes grow in a submerged condition in the presence of excess oxygen and a limited food supply. The aeration unit holds the wastewater for a relatively long detention time to allow conversion of the waste constituents by the microbes. Because of the limited food supply and excess oxygen, the microbial cells begin to consume their own cell tissue to obtain energy for cell maintenance. This is known as *endogenous respiration* and under these conditions, biomass accumulation is minimized. The rate of biomass accumulation depends on the amount of organic loading to the system.

In both suspended-growth and attached-growth regimens, oxygen is introduced to the aeration chamber using aerators, compressors, or blowers. Aerators develop a vacuum that draws air into the effluent. The air must move freely through the aspirator. Compressors used in aerobic treatment units typically deliver a relatively lower volume of air at a greater pressure. Both rotary and linear compressors are used for onsite wastewater treatment systems. Blowers deliver a greater volume of air at a lower pressure. Because each of these air supply components uses a different mechanism to convey air into the effluent, they are typically not interchangeable. Compressors and blowers typically convey air from the air supply to the aeration chamber through a pipe. Orifices or diffusers with assorted sizes of openings distribute air into the wastewater. The air conveyed into the system must also exit; thus, a venting mechanism is required for proper air flow through the aeration chamber.

Wastewater exiting the aeration chamber enters the clarifier. Calm conditions in the clarifier allow biomass suspended in the wastewater to settle. Turbulence or excessive effluent velocities will carry solids through the clarifier. Clarifiers can be oriented vertically or horizontally. In vertical clarifiers, the flow enters through the bottom of the chamber (Figure 7-18). To prevent solids from moving out of the clarifier, the rate of upward flow of wastewater must be lower than the settling rate of the solids. This diagram has a central point for collection and discharge of the clarified effluent. The clarifier cone pictured in Figure 7-18 would be placed into a tank with an aeration chamber on the outside. Other clarifier configurations have a vertical clarifier in a separate compartment with a single sloping wall. Effluent is collected from a discharge point near the top of the clarifier.

Another approach for vertical clarification is to have the clarifier surround the aeration chamber in a round tank. The discharge weir is a 360-degree circumferential weir.

In horizontal clarifiers, wastewater flows from the inlet to the outlet at a uniform elevation (Figure 7-19). The horizontal velocity through the chamber must allow time for the solids to settle below the elevation of the outlet before the effluent passes through the tank.

Solids settling within the clarifier should be returned to a previous component. Most vertical settling chambers have a passive sludge return process (Figure 7-18). Solids pass through the bottom of the clarifier and return to the aeration chamber. Horizontal clarifiers typically have a separate tank where solids accumulate and require an active sludge return process. Figure 7-19 shows this configuration using a centrifugal pump.

Another approach to clarification of effluent is active filtration. Some aerobic treatment unit products incorporate filtration media to filter biomass from the effluent before it is discharged. These approaches filter the effluent through a porous material or facilitate settling in a plate settling process.

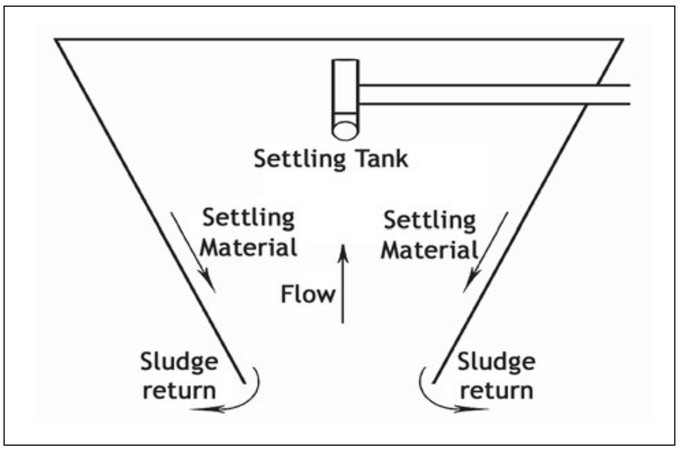

Figure 7-18. Vertical clarifier with a passive sludge return process (profile view)

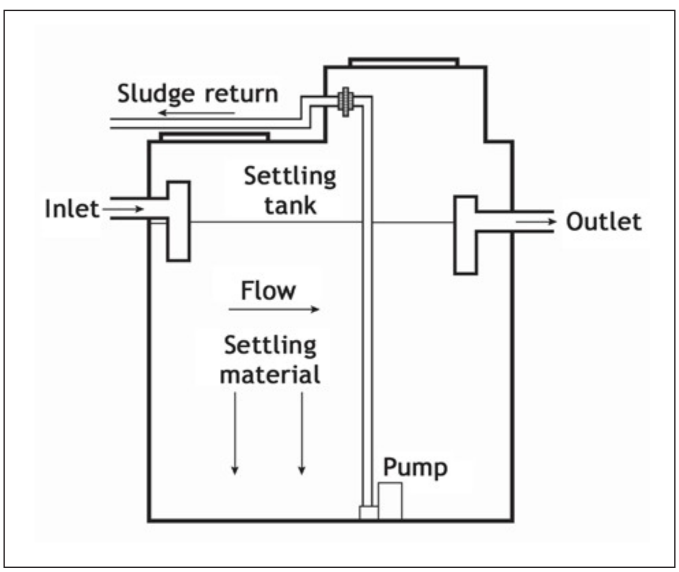

Figure 7-19. Horizontal clarifier with an active sludge return process using a centrifugal pump (profile view)

Air lift pumps are being incorporated into ATUs for a variety of purposes. An air lift pump introduces a stream of air into the bottom of a vertical pipe. This action can be used to move clarified or solids-laden liquid as needed. As the air bubbles rise in the pipe, the liquid level rises above the static liquid level in the tank. The liquid discharges through an overflow while the air is vented through the top.

These devices can be used for a variety of purposes including:

- Skimming solids from the surface of liquid in the clarifier;
- Returning sludge from the bottom of a clarifier or aeration chamber;
- Recirculating effluent for denitrification; or
- Discharging effluent to the next component.

Generic Aerobic Treatment Unit Configurations

Suspended growth

In a suspended-growth system, the microbes float freely in the wastewater in the aeration chamber. Mixing in the chamber brings microbes and wastewater contaminants close together. Aeration is achieved by a pump that introduces air into a diffuser (perforated pipe or ceramic device) near the bottom of the tank. The rising bubbles aerate and circulate the effluent. Alternately, a mechanical aerator with a hollow shaft and impeller creates an area of low pressure which draws air through the shaft and into the effluent. A clarifier allows separation of suspended biomass and an active (e.g. a pump) or passive sludge return directs the settled biomass to an earlier portion of the treatment train (Figure 7-20).

Sequencing batch reactor (SBR)

A sequencing batch reactor is a specific type of aerobic treatment unit that uses a single treatment tank to perform

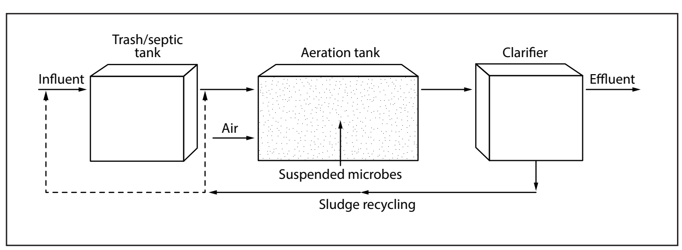

Figure 7-20. Generic treatment train using a suspended-growth treatment process (EPA, 2002)

both aeration and clarification (Figure 7-21). The cycle begins as wastewater enters the tank. The full tank is aerated for biological treatment. After aeration, the mixing system is stopped, and the solids are allowed to settle. Clarified effluent is decanted from the clear zone in the tank. The cycle is completed when the system moves into an idle period for development of anoxic conditions to facilitate nitrogen removal.

Membrane Bioreactor (MBR)

Membrane bioreactors also use combined aeration and clarification in a suspended growth reactor. A ceramic or tubular membrane system extracts clarified effluent, leaving the solids behind in solution. This is achieved by using either:

- A centrifugal pump that creates an area of low pressure that draws the liquid across the membrane or,
- A vacuum pump that extracts the liquid.

Biomass accumulates in solution and is periodically pumped from the reactor. The concentration of suspended solids can be 3 to 4 times the concentration in a normal suspended growth system. The aeration system is located below the membrane and the bubbling action shears or scours the biomass off the membrane (preserving its filtration capacity) and back into solution.

Submerged attached growth/fixed film media

In these systems, the aeration chamber contains static media (generally plastic) that provides a substrate for biomass growth. Wastewater circulates through the

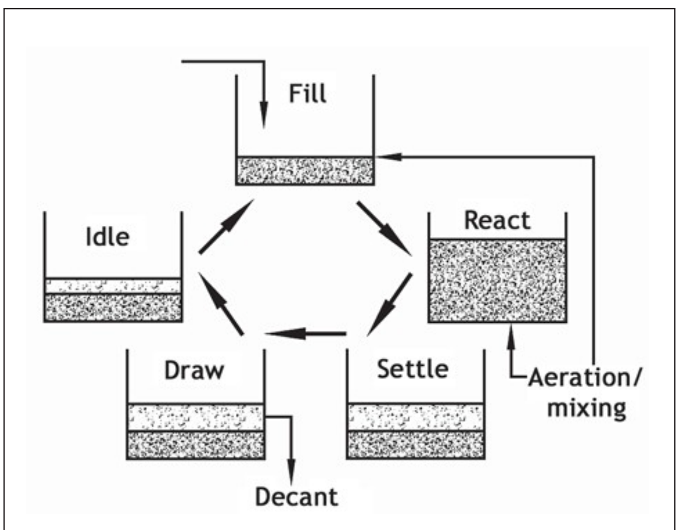

Figure 7-21. Sequence of processes occurring in a sequencing batch reactor. (EPA, 2002)

media, bringing wastewater constituents to microbial biomass (Figure 7-22). The rate of biomass accumulation on the media in attached-growth systems depends on the organic loading. Aeration promotes sloughing of excessive biomass from the media surfaces which must be periodically removed by cleaning and pumping.

Media is submerged in the aeration chamber allowing microbial growth under saturated conditions. The media is typically plastic and shaped to allow liquid and sloughing biomass to pass through. Microbes grow on the surface of the media and process wastewater constituents. Aeration is achieved by a pump that introduces air into a diffuser (perforated pipe or ceramic device) near the bottom of the tank. The rising bubbles aerate and circulate the effluent. Alternately, a mechanical aerator with a hollow shaft and impeller creates an area of low pressure which draws air through the shaft and into the effluent.

A clarifier allows separation of suspended biomass and an active (e.g., a pump) or passive sludge return which directs the settled biomass to an earlier portion of the treatment train. Specific variations of submerged attached growth systems are discussed below

Rotating biological contactor (RBC)

A rotating biological contactor is an aerobic treatment unit that uses an attached-growth media that passes through open air space (Figure 7-23). Media disks attached

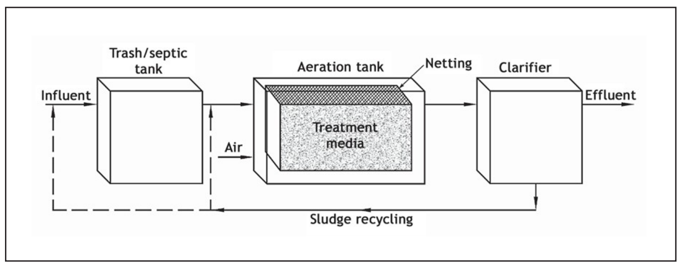

Figure 7-22. Generic treatment train with a submerged-attached growth treatment process (Source: EPA, 2002)

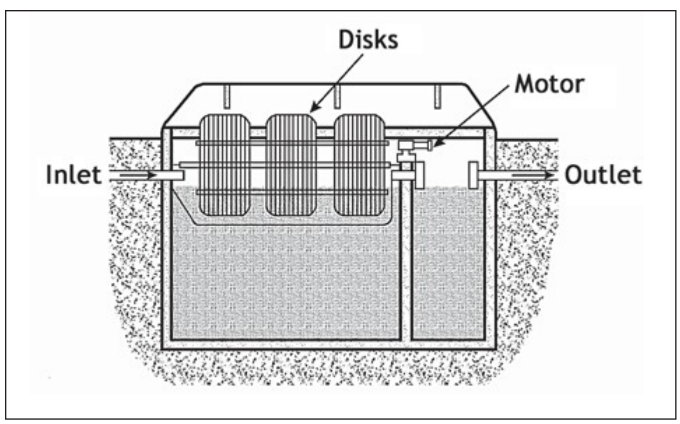

Figure 7-23. Diagram of a generic rotating biological contactor (profile view).

to a central motor-driven rotating shaft pass alternately through wastewater and free air as they rotate. Biomass accumulates on the disks and periodically sloughs and settles on the bottom of the tank. Sludge is managed through regular pumping.

Integrated Fixed Activated Sludge (IFAS)

Some submerged-growth aerobic treatment processes incorporate both suspended- and attached-growth processes. These configurations promote the establishment of microbial populations in both suspended and attached-growth configurations. Static media promotes the growth and accumulation of biomass. Excessive biomass accumulation results in plugging and bridging which restricts flow. Periodic air- or water washing is used to slough excess biomass from the media. As with other ATUs, clarification and sludge return processes follow the aeration process.

Moving Bed Biofilm Reactor (MBBR)

This is a version of an IFAS system that incorporates aggressive aeration for continuous media movement and sloughing. This configuration addresses a limitation of the static bed biofilm process. As the biomass sloughs from the media and begins to bridge, the aggressive aeration maintains sufficient movement of the media to slough excess biomass out of the media bed. Again, clarification and sludge return processes follow the aeration process.

Using Form 7-2: Aerobic Treatment Units Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Aerobic Treatment Units. The form for documenting inspection points follows the text.

1. Type of ATU

Specify the type of aerobic treatment unit and note the manufacturer and model number.

2. Conditions at the ATU

Aerobic microbial treatment processes may have a mild, musty, aerobic smell. However, the odor should not be a strong anaerobic odor. If odors are detected, determine the source by checking for damaged lids and risers. Also check the roof vent location, prevailing winds, and atmospheric pressure, as these factors can contribute to odor issues. Note whether odors are strong, mild, septic (rotten eggs), chemical, or sour in nature.

Further evaluation will be required to determine the actual cause of the odor. Some detergents used at the source may cause some odors. Foaming (caused by filamentous bacteria) can be a valuable component of the wastewater treatment process; however, excessive foaming (foam moving downstream or overflowing from the unit) may also be caused by excessive soap or constituents in the wastewater.

3. ATU access

Make note of where the access is located on the ATU. If access is farther than 6 to 7 feet from any tank wall, it may limit maintenance in those areas, especially during pumping services.

ATU access must be adequate for inspecting contents and servicing the tank. If there is a riser on the tank, it should be in good condition and properly sealed to prevent infiltration. Check the riser/tank seam for stains or root intrusion that would indicate infiltration of groundwater or surface water. Ideally, the riser should come to grade so that no digging is required to reach it. Some jurisdictions may not require access to grade, so some digging may be required. If it is buried, note how much cover is on the tank, and note swing tie measurements from fixed landmarks on the property to the center of any cover(s).

The lid on the tank or riser should be securely fastened with safety screws (screws or bolts that require a non-standard tool) or other means. The lids must be readily removable by the service provider but child-proof. If a concrete lid is used, the weight of the lid will limit unauthorized access. The lids must not be so heavy as to make them inoperable. The lids must be operable as designed, and there should be no obstacle placed near or on top that makes them inoperable. ***Secondary restraint safety features are critical, and all tanks should be retrofitted if they are not present.*** If the tank was uncovered by the owner, note that on the checklist.

4. Venting/Air supply

Evaluate the type of air supply system used to provide air to the unit. The air supply system may be operated in a continuous or timed mode. The time on and time off should be recorded for future reference. The air supply system must have an electrical supply and be operable. The pressure should be measured and recorded using a pressure or vacuum gauge. The air flow can also be measured using an air flow gauge and then recorded. Make sure both the air intake and vent relieving air pressure are free of obstruction. Air supply lines should not leak, nor should they have accumulated water in their piping – this can prevent proper aeration of the system. Clean blocked vents, intakes and access ports as needed.

5. Aeration chamber

Evaluate the aeration chamber to verify proper aeration and mixing of the wastewater. Presence of an obvious rollover (like boiling water) of the contents in the tank verifies that mixing is occurring, and the wastewater constituents are in contact with the microbes.

Test the dissolved oxygen (DO) level in the aeration chamber. DO concentration is critical to support the aerobic environment for the microbes. The dissolved oxygen concentration should be maintained at 2.0 mg/L or above. If DO is too low, increase the length of aeration (if possible), and/or check that the aerator device and piping are working properly – a plugged or leaking air supply line can starve the system of necessary oxygen.

Optimum pH is neutral but can range from 6.5 to 7.5. Lower pH may simply indicate that nitrification is occurring. Temperature in the unit can vary. However, moderate temperatures are best. Excessively low or high temperatures are not conducive to optimal microbial growth.

Perform a settleability test to evaluate the density of mixed liquor in suspended-growth aeration chambers. The settled solids should measure between 20 to 60 percent of the total volume after a period of 30 minutes.

Note the color of the biomass. A good aerobic biomass will have a brown color. A black color indicates an anaerobic condition or dead microbes.

Sludge pumping can be recommended for systems with a settleability rate greater than 60 percent. Some suspended-growth units may need pumping before this density of biomass is reached. Note whether the unit should have sludge pumped. Removing solids from the aeration chamber, pretreatment tank, and dosing tank should be performed at the time of pumping any of the other compartments, such as the septic and trash tank.

6. Biofilm media evaluation

Aerobic treatment units using attached-growth media require a few additional evaluations. The media may become plugged with biomass. The media should be evaluated for proper mixing or effluent flow through the media. Media may float as the biomass accumulates, and some attached growth systems employ restraining methods to keep the media submerged. If the media is floating, it may need cleaning or restraining to keep it submerged. Some media setups require periodic "burping" to release trapped gas bubbles – this is typically done by poking/gently agitating the media with a long stick or tube. Media agitation can also be accomplished using air or water. Note whether this is done, and which method was used. In some systems, the media may need to be replaced.

7. Clarification chamber

The clarification chamber separates solids from the effluent. If a scum layer is present on the clarifier, record the thickness of the layer. This floating material may be removed by pumping, skimming, or mixing to facilitate settling. There should be a clear zone below the outlet to prevent solids bypassing during flow events. An effluent screen or tertiary filter may be placed in the outlet of the clarifier. These may need to be cleaned to remove biomass. The turbidity, dissolved oxygen, pH, and temperature in the clarifier should be recorded to evaluate treatment performance. Note the relative odor and the color of the effluent passing through the unit.

Socks or membranes will collect solids as the effluent is extracted. These must be periodically cleaned by forcing air into the sock or membrane, cleaning in place using a cleaning solution (bleach or weak acid), or removed and soaked in a cleaning solution per the manufacturer's recommendations.

8. Sludge return

The sludge return may operate in a passive or active mode. If active, this may be achieved with either a centrifugal or air lift pump. The passive mode can be evaluated visually by using a profile probe to measure the depth of a clarified zone below the outlet and the settled sludge blanket. Operate the pump manually to evaluate performance of active sludge return configurations.

9. Integral pumps

Integral pumps may be used to recirculate effluent, discharge effluent downstream, or to remove scum from the clarifier. Note whether an air lift or centrifugal pump is used and for what purpose.

Confirm that liquid or scum is flowing as designed in response to pump operation. If adjustment is required, note the new timer settings. If air lift pump flow rate setting is adjusted, note this as well.

10. Control panels

Control panels should be watertight (NEMA 4 or 4X rating) with all connections sealed to prevent moisture or sewer gases from entering. Check the function of the alarm test switch. The presence of a control (HAND-OFF-AUTO) switch allows the service provider to check pump function without activating a float or program. Note the position of the control switch, keeping in mind that under normal operating conditions it should be in the AUTO position. If the panel has a cycle counter, and/or an hour meter (elapsed time meter or ETM), record the present and last readings. If there are no meters, they are strongly recommended as an upgrade to facilitate O&M activities.

Telemetry allows remote communication of system status. Data can be shared with the owner, service provider, responsible management entity (RME) or manufacturer. Some systems also allow remote system operation. If this option is available, the service provider should verify the connection between the panel and the receiving entity is active. One way is to activate a pump, log into the website or make a phone call to verify that the system logged the pump event.

11. Alarms

Alarms are used to monitor the effluent level in the unit and air delivery (e.g. an air pressure sensor in the air supply line) to the aeration chamber. Note whether these are operable.

Some units may include an event counter to record the number of alarm events. The present reading can be compared to previous readings to determine the number of alarm events. Some units may also have battery backups for alarms. If present, the operation of the alarm using the battery backup should be evaluated.

Telemetry is also an option for remote notification of alarms. If the system includes telemetry, verify the electronic connection between the control panel and the receiving entity. One way to do this is to trigger an alarm and log into the website or make a phone call to verify that the system logged the alarm event.

12. Manufacturers required maintenance

Manufacturers of specific units may recommend additional maintenance for their product. These activities should be performed, and the completion of these activities should be documented in the comments section.

13. Lab samples

If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to an authorized laboratory. Retain the COC signed from laboratory to complete the system file. Report the information to the proper entities.

Form 7-2 Operational Checklist: Aerobic Treatment Unit (ATU)

Service provided on: Date:_______ Time:___________ Reference #:________________
Service provided by: Company: __________________ Employee: _________________
Date of last service: ____________________________ By: ☐ You ☐ Other:__________
Date of last inspection: __________________________

1. Type of ATU:
   - ☐ Suspended growth
   - ☐ Membrane bioreactor
   - ☐ Sequencing batch reactor
   - ☐ Submerged attached growth/Fixed film media
   - ☐ Rotating biological contactor
   - ☐ Integrated fixed activated sludge
   - ☐ Moving bed biofilm reactor
   - ☐ Other:________________
   - a. Manufacturer:_______________ Model #: ___________
2. Conditions at the ATU
   - a. Evaluate presence of odor within 10 ft of perimeter of system:
     ☐ None ☐ Mild ☐ Strong ☐ Chemical ☐ Sour
   - b. Source of odor, if present: ____________________________
   - c. Was foam/residue observed outside the unit. ☐ Yes ☐ No
3. ATU access
   - a. Located at grade. ☐ Yes ☐ No
   - b. If 'No', how deep is tank buried. _________________
     Swing tie measurements: _______________________________
   - c. Risers on tank. ☐ Yes ☐ No
   - d. Evidence of infiltration in the risers. ☐ Yes ☐ No
   - e. Lids/secondary restraint secured. ☐ Yes ☐ No
   - f. Lids in operable condition. ☐ Yes ☐ No
4. Venting/Air supply
   - a. Air supply method:
     ☐ Aspirator ☐ Aerator ☐ Compressor ☐ Blower ☐ Free air (go to 4.g)
   - b. Operation: ☐ Continuous ☐ Timed
     If timed, ETM readings and runtime: ______________________
   - c. Air supply unit operating properly. ☐ Yes ☐ No
   - d. Pressure at air supply unit: ______________psi
   - e. Air flow at air supply unit: ______________cfm
   - f. Air filter/screen: ☐ Cleaned ☐ Replaced
   - g. Venting appears operable. ☐ Yes ☐ No
5. Aeration chamber
   - a. Mixing in aeration chamber. ☐ Yes ☐ No
   - b. DO in aeration chamber: ____________mg/L
   - c. pH in aeration chamber: _________________

Notes

2. ☐ Acceptable ☐ Unacceptable

3. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

5. ☐ Acceptable ☐ Unacceptable

Reference #:______________

d. Temperature in aeration chamber:____________________
e. Settleability test:
Settled _____%, Floating _____% in ___________ min
f. Biomass color in the aeration chamber:
☐ Clear ☐ Brown ☐ Black
g. Sludge pumping recommended. ☐ Yes ☐ No

6. Additional tasks for biofilm media evaluation
a. Media plugging. ☐ Yes ☐ No
b. Media floating. ☐ Yes ☐ No
c. Media washed. ☐ Yes ☐ No
If washed, indicate method used: ☐ Air ☐ Water
d. Media replaced. ☐ Yes ☐ No

7. Clarification chamber
a. Scum layer. ☐ Yes ☐ No
If yes, thickness: ________________in
b. Clear zone depth below outlet: ________________in
c. Filtration ☐ NA ☐ Yes ☐ No
☐ Screen ☐ Tertiary filter ☐ Socks ☐ Membrane
☐ Cleaned in place ☐ Removed and cleaned ☐ Replaced
d. DO in clarifier: ______________mg/L
e. pH in clarifier: __________________
f. Temperature in clarifier: __________________
g. Effluent odor after passing through unit:
☐ None ☐ Mild ☐ Strong
h. Effluent color after passing through unit:
☐ Clear ☐ Brown ☐ Black
i. Effluent turbidity: ______________NTU

8. Sludge return operating: ☐ Passive ☐ Active
a. If active, pump was checked manually. ☐ NA ☐ Yes ☐ No
b. If active, pump operating properly. ☐ NA ☐ Yes ☐ No

9. Integral pumps ☐ NA ☐ Yes ☐ No
a. Type of integral pump and purpose
☐ Air lift:
☐ Recirculation ☐ Discharge ☐ Scum removal
☐ Centrifugal:
☐ Recirculation ☐ Discharge
b. Pump operating properly ☐ Yes ☐ No
c. Timer settings changed. ☐ Yes ☐ No
d. Air flow rate changed (air lift pump) ☐ Yes ☐ No

Notes

6. ☐ Acceptable
☐ Unacceptable

7. ☐ Acceptable
☐ Unacceptable

8. ☐ Acceptable
☐ Unacceptable

9. ☐ Acceptable
☐ Unacceptable

Reference #:_______________

Notes

10. Control Panel:
    a. Controls operating properly. ☐ Yes ☐ No
    b. Enclosure water- and gas-tight. ☐ Yes ☐ No
    c. Alarm test switch operating properly. ☐ Yes ☐ No
    d. At time of inspection, control switch was set to:
        N.A.__________ "Hand/Manual" _________ "Auto" __________
    e. If auto, setting: Time On: ________ (min) Time Off: _________ (min)
    f. Telemetry operational
11. Alarm(s): ☐ NA
    a. Types: ☐ Air pressure ☐ High water ☐ Remote
    b. Alarms operating. ☐ Yes ☐ No
    c. Alarm readings:
        Calculate the number of alarm events:
        _________(PACR) - ______(LACR) = _______Events (number)
    d. Battery backup charged. ☐ NA ☐ Yes ☐ No
    e. Telemetry operational. ☐ NA ☐ Yes ☐ No
12. Manufacturer's required maintenance performed. ☐ Yes ☐ No
    (If 'Yes' attach Manufacturer's Inspection form to this report, if supplied.)
13. Lab samples collected for monitoring. ☐ Yes ☐ No
    Types of analysis:____
    ____
    ____

10. ☐ Acceptable
    ☐ Unacceptable

11. ☐ Acceptable
    ☐ Unacceptable

ABBREVIATIONS
ETM: elapsed time meter
LACR: last alarm counter reading
LTR: last time reading
NC: number of cycles
PACR: present alarm counter reading
PTR: present time reading

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Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the treatment processes in constructed wetlands systems (CWS).
2. List the components of a constructed wetland treatment system.
3. Accurately complete Operational Checklist 7-3 Constructed Wetlands (CW).

Overview

The purpose of using a constructed wetland system (CWS) is to recreate the treatment processes that occur in natural wetlands. The CWS is a basin or cell containing media, and plants that support microbial growth that processes wastewater constituents. These systems can be either free-water surface or subsurface flow wetlands. In free-water surface wetlands the media is submerged, and microorganisms attach to the aquatic plants. In subsurface flow wetlands, the cell is filled with graded gravel media or other porous material that is resistant to the corrosive and dissolving properties of wastewater (Figure 7-24).

Description and Mode of Treatment

The wetland cell is constructed as an earthen basin lined with compacted native clay, bentonite clay, concrete, PVC, Hypalon, or ethylene propylene diene terpolymer (EPDM) rubber. Each cell has an influent distribution device and an effluent collection device. Effluent flows through the bed, contacting the media and attached organisms. An even cross-sectional flow through the wetland ensures optimal treatment.

Plant materials used in CWS must be able to survive in a saturated medium. Both soft tissue and hard tissue plants can be used in the wetland. Some experts believe that hard tissue plants are better because they may provide a pathway for oxygen to enter the wetland during the winter months. Certainly, vegetation maintenance is important to prevent clogging due to debris.

CWS receive septic tank effluent. The septic tank should be appropriately sized to maximize the reduction of settling solids and should be serviced at regular intervals to maintain efficient solids removal. Effluent entering the CWS cell is treated by the microbes living on the media and plant roots. The wastewater constituents entering the wetland are removed from the effluent by filtration, nitrification, denitrification, and adsorption.

The plants provide oxygen to the bed and remove a small percentage of the nutrients. The longer the hydraulic retention time in the wetland, the better the quality of the effluent that exits the wetland. As the wastewater flows through the media, it exits the wetland through a water-level control sump. A water-level control device allows the water level to be raised or lowered as needed to prevent overflow and maintain enough effluent for plant growth. Wetlands may be gravity dosed or pressure dosed.

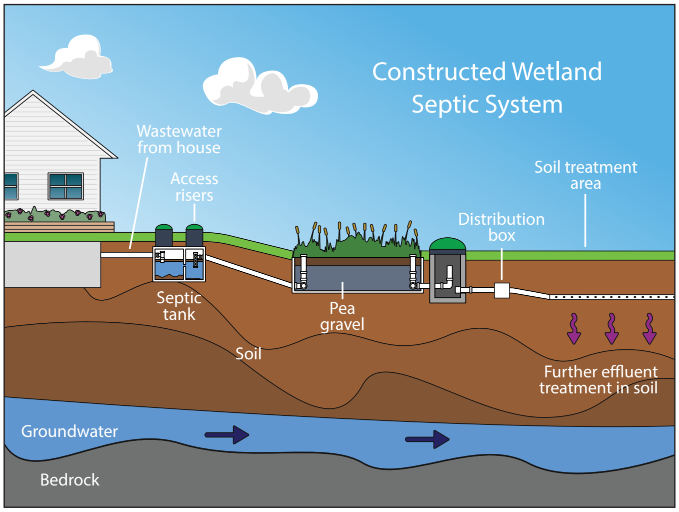

Figure 7-24. General schematic of a subsurface flow constructed wetland (profile view)

Using Form 7-3: Constructed Wetland Systems Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Constructed Wetland Systems. The form for documenting inspection points follows the text.

1. Description of CWS

Evaluate the wetland system one cell at a time and use a new sheet for every cell. Many wetland systems include a series of cells for increased wastewater treatment. Note the type of media and the size of gravel, if used. Identify the flow regimen as a surface, subsurface flow, or combination system. Note whether the wetland system is gravity or pressure dosed.

2. Conditions at the CWS

Evaluate the presence of odor when walking up to the system. Odor is an indication of service or repair being needed. If odors are detected, determine the source by checking for missing caps on inspection ports or damaged lids or risers. Also check the roof vent location, prevailing winds, and atmospheric pressure, as these factors can contribute to odor issues. Note whether odors are strong, mild, septic (rotten eggs), chemical, or sour in nature.

Maintain cover over the sides of synthetic liners (e.g., polyethylene, PVC Hypalon, EPDM, neoprene, or butyl rubber) that extend above the substrate and water level. This will help prevent UV degradation of the liner.

Repair any earthen berm erosion as soon as it is noted. Repair leaks around the berms/retaining walls as soon as noted by plugging or sealing. Mow earthen berms or around retaining dikes to maintain an attractive site. Reroute surface drainage around or away from the wetlands.

As with any onsite system, access should be limited. Prevent access through a combination of signage and adequate fencing.

Note any animal activity at or near the wetland surface. Prevent pets from digging in the wetlands, destroying vegetation, and moving substrate and mulch.

3. Liquid level management

The front of the wetland is more susceptible to plugging due to solids carried over from the septic tank. If the header is plugged, this could be an indication of a problem in the septic tank. There may be an increase in the water level at the header, which may cause odors. The media at the front end of the wetland may need to be cleaned or replaced to prevent plugging.

Check the adjustable standpipe or hose in the water-level control structure to ensure that effluent is not leaking from joints. Repair as necessary.

Maintain the liquid level in the bed during extended periods of no flow (e.g., long vacations). Without flow, wastewater in the cell may evaporate and be used by the plants in hot weather. During severe freezing conditions, effluent may freeze, damaging the roots and tubers. Plan to add water to the system as needed.

4. Vegetation

Vegetation should remain healthy during the growing season. Check the vegetation for signs of disease or other stress (e.g., yellowing or browning, withering, or spots). Natural seasonal changes will occur with temperature and day length changes.

If vegetation does not appear healthy and water levels are correctly maintained, add a balanced liquid fertilizer periodically (three times a growing season) to the wastewater by flushing down a toilet. “Normal” domestic sewage may not contain all the trace nutrients and elements required by vegetation growing in a gravel substrate.

Replace dead plants as necessary and fill voids with new plants. Divide and replant decorative flowering species (e.g., iris) to enhance the appearance of the system. Remove weeds, trees, and shrubs from the wetlands. These species will shade and crowd the desirable wetland plants. Prevent excessive shading of wetland vegetation by controlling growth of trees or high shrubs near the wetland cells. Most wetland plants need at least six hours of sunshine each day. Dispose of plants properly to avoid contact with effluent.

It may be necessary to remove healthy plants with the proper functioning of the system. If the plants are too dense, their roots will take up all the pore space. This will eliminate paths for effluent to flow and lead to hydraulic flow problems.

If desired for visual aesthetics, remove mature wetland vegetation after the plants have browned in the fall. However, cut only about two-thirds of plant height. The removed material may be used to mulch the bed surface, but this may also cause clogging of the substrate.

Do not apply herbicides or pesticides that can damage vegetation either on or near the system.

5. Effluent quality

Evaluate the effluent quality to determine system performance and document the status of the system. Clarity, dissolved oxygen, pH, and temperature should be noted, as well as the relative odor and color of the effluent leaving the cell.

6. Additional tasks for subsurface flow wetlands

A subsurface-flow wetland where effluent ponds may cause odors. Any low and high spots on the substrate surface that create small standing pools should be leveled by raking and/or filling with additional substrate. If the effluent level is too high, lower the water level with the water-level control structure so that the effluent level is about 3 inches below the substrate surface. Adjust wastewater level using the pipe/tubing in the water-level control structure. For a swivel standpipe, gradually rotate it down to lower the level and up to raise the level. For a system with adjustable tubing length, lower or raise the top of the tubing. Note that wastewater levels will temporarily increase with flow surges.

To conveniently check the water level relative to the gravel surface, remove a small area of media or place an inspection port (4-inch diameter) in the gravel and observe the water level inside the pipe.

Surface ponding in the wetland cell that cannot be controlled by water level adjustment is typically caused by either excessive flows above the design basis, clogging of the substrate by excessive solids from the septic tank, or roots that have blocked the underdrain. Check the cleanout in front of the wetland. Solids accumulated in the pipe indicate plugging of the wetland by excessive solids from the septic tank. Plugged substrate may need to be replaced, beginning with the front where most of the plugging typically occurred.

If there are no solids in the cleanout, ponding is typically caused by excessive wastewater flow that exceeds the hydraulic capacity of the substrate. If possible, decrease flow through water conservation. A flow equalization tank can be used to control hydraulic surges. If ponding is not eliminated, additional septic tank and wetlands capacity may be needed for the increased flow.

7. Additional tasks for recirculating wetlands

Recirculating wetlands usually have a recirculation tank for collecting effluent from the constructed wetland and returning it back to the wetland. Some systems may return the partially treated effluent to the septic tank. If this is the case, inspect the septic tank with the same procedures as for a recirculation tank. The dissolved oxygen (DO) concentration gives an indication of the recirculation rate and oxygen transfer. The recirculation device should be checked and cleaned if it contains residuals. The recirculation rate can be estimated and changed if a different aeration rate is needed. The actual recirculation ratio can be calculated at the site by dividing the actual recirculation pump volume by the actual discharge pump volume. (NOTE: If recirculation is achieved by way of a dam/divider at the filter base, this O&M step is not applicable.)

The recirculation tank should be pumped when less than 70 percent of the tank is operable or when there is a substantial increase in sludge accumulation. The allowable sludge accumulation pattern will vary based on the pump location and type. Sludge level should remain below the pump inlet.

8. Inspection ports

Inspection ports are the best method to evaluate the depth of the water. If they are not present, they should be recommended as an improvement.

9. Lab samples

If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to an authorized laboratory. Retain a signed COC from laboratory to complete system file. Report information to the proper entities.

Form 7-3 Operational Checklist: Constructed Wetland (CW)

Service provided on: Date:_______ Time:_____________Reference #:_____________
Service provided by: Company: ____________________ Employee: ______________
Date of last service: __________________________ By: ☐ You ☐ Other:_________
Date of last inspection: ________________________

1. Constructed wetland description: Cell # : ________/ _________
   a. Media: ☐ None ☐ Gravel, average diameter: _________in
      ☐ Other:_____________________________________
   b. Flow regimen: ☐ Surface ☐ Subsurface ☐ Combination
   c. Distribution: ☐ Pressure ☐ Gravity
2. Conditions at the constructed wetland
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong ☐ Chemical ☐ Sour
   b. Source of odor, if present: _______________________________
   c. Type of border material: _____________
   d. Border material in good repair. ☐ Yes ☐ No
   e. Evidence of water/soil entering wetland. ☐ Yes ☐ No
   f. Fence present and operable. ☐ NA ☐ Yes ☐ No
   g. Animal activity at wetland surface. ☐ Yes ☐ No
3. Liquid level management
   a. Header distribution plugged. ☐ Yes ☐ No
   b. Bypass or overflow noted. ☐ Yes ☐ No
   c. Water level control option available. ☐ Yes ☐ No
   d. Water level adjustment needed. ☐ Yes ☐ No
4. Vegetation
   a. Species appropriate for climate. ☐ Yes ☐ No
   b. Vegetation alive. ☐ Yes ☐ No
   c. Replanting needed. ☐ Yes ☐ No
   d. Vegetation removal required. ☐ Yes ☐ No
5. Effluent quality
   a. Turbidity: _______________NTU
   b. DO in outlet: _______________mg/L
   c. pH in outlet: ___________________
   d. Temperature in outlet: ___________________
   e. Effluent odor after passing through wetland:
      ☐ None ☐ Mild ☐ Strong
   f. Effluent color after passing through wetland:
      ☐ Clear ☐ Brown ☐ Black
6. Additional tasks for subsurface flow wetlands
   a. Media surface level. ☐ Yes ☐ No
   b. Water level below media surface: __________in

Notes

2. ☐ Acceptable ☐ Unacceptable

3. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

5. ☐ Acceptable ☐ Unacceptable

6. ☐ Acceptable ☐ Unacceptable

Reference #: ___________________

7. Additional tasks for recirculating wetlands
   a. DO in recirculation tank: _______________mg/L
   b. Inspected recirculating device. ☐ NA ☐ Yes ☐ No
   c. Cleaned recirculating device. ☐ NA ☐ Yes ☐ No
   d. Design recirculation ratio: _______:______
   e. Actual recirculation ratio: _______:______
   f. Recirculation changed to: _______:______
8. Inspection ports
   a. Inspection ports present. ☐ Yes ☐ No
   b. Inspection ports intact. ☐ Yes ☐ No
9. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:____

   ____

   ____

7. ☐ Acceptable
   ☐ Unacceptable

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Define a lagoon treatment system.
2. Describe the main treatment processes occurring in lagoon systems.
3. Accurately complete Operational Checklist 7-4 Lagoon maintenance (LM).

Description and Mode of Treatment

A lagoon is a large basin filled with wastewater undergoing some combination of physical, chemical, and biological treatment processes that render it more acceptable for discharge to the environment. Lagoon treatment systems are ideally preceded by a septic tank placed between the residence and the lagoon. The lagoon will generally have a discharge outfall for effluent exiting the lagoon, although some local regulations may not permit discharge from lagoons. ***(NOTE: This is a high-risk system, and safety issues about public access must be addressed.)***

Lagoons are used for BOD removal, nitrification, phosphorus reduction, and waste stabilization. The following are the four types of lagoons classified based on the presence and source of oxygen:

- Aerobic
- Facultative
- Partial-mixed aerated
- Anaerobic

Aerobic lagoon systems use photosynthesis to provide oxygen for aerobic conditions throughout the water column. *Facultative lagoon systems* have a surface zone that is aerobic and a subsurface zone that may be anoxic or anaerobic. *Partial-mixed aerated lagoon systems* are rendered aerobic using devices such as floating mechanical aerators or submerged diffused aeration. In an *anaerobic lagoon system*, the entire depth is anaerobic. Maintenance for the aerobic and facultative lagoon systems are discussed here since partial-mixed aerated and anaerobic lagoons are primarily used in industrial or agricultural settings.

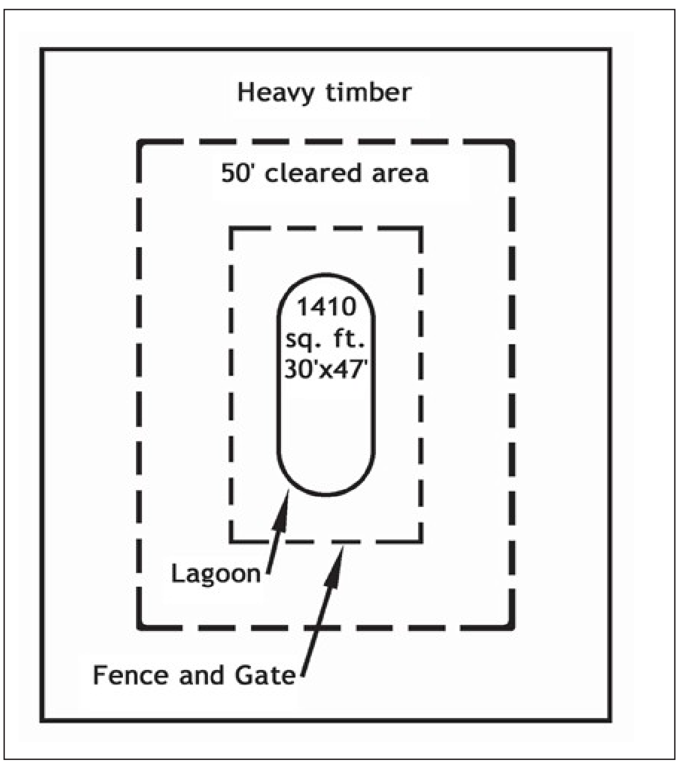

Figure 7-25. Lagoon barriers (plan view)

A lagoon is also called a pond or stabilization pond. Lagoons must be sized with consideration of precipitation and evaporation rates. The total required area is design dependent and must conform to local and state regulations. Most states require berms to prevent overflow, a buffer zone, and a fence to keep children and animals out (Figure 7-25). Lagoons should receive influent that has at least received septic tank treatment (Figure 7-26).

Lagoons perform best when multiple lagoons are placed in a series because this minimizes short-circuiting of the system. They are usually lined with clay or artificial materials to prevent seepage into the soil and groundwater. Unlined lagoons are used when native soil conditions are expected to prevent contamination of groundwater.

It is not unusual for a lagoon to be designed 20 to 150 times greater than the average daily flow from the residence, depending on the final discharge load. Size can usually be reduced if aerated effluent flows into the lagoon. Aerobic lagoons are shallow (with a depth of 1 to 3 feet) to allow light to penetrate the full depth of the lagoon, resulting in photosynthetic activity of algae and other single-cell organisms that produce oxygen. The oxygen produced allows bacteria to degrade organics aerobically. No plants should be present in the lagoon. Typical retention time is short, usually around 5 days. Aerobic lagoons are limited to use in warm, sunny climates.

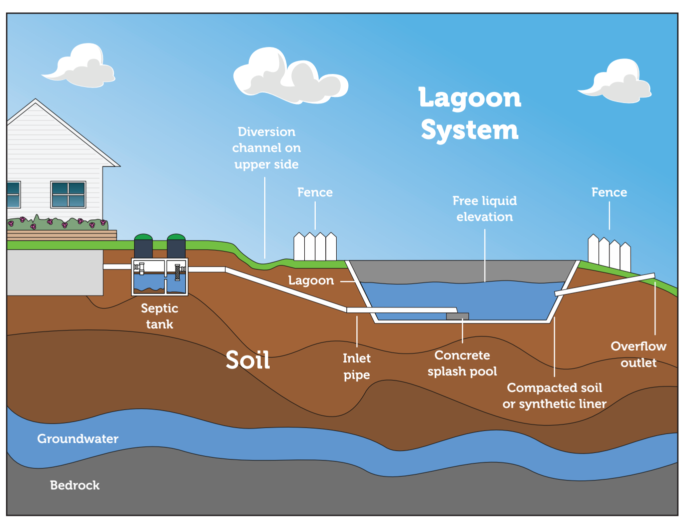

Figure 7-26. Generic treatment train for a lagoon (profile view)

Facultative lagoons are the most common and versatile lagoons for residential onsite wastewater treatment systems. They are 5 to 8 feet deep and designed based on BOD_5 loading rates. Treatment is accomplished by bacterial action in an upper aerobic layer and a lower anaerobic layer. Settleable solids are deposited on the lagoon bottom. Oxygen is provided by natural surface aeration and photosynthesis. The concept is to design for a long enough retention time and low enough organic loading rate to achieve aerobic conditions in the surface area.

Lagoons require berms that are 2 feet above the liquid working level and a buffer area of at least three hundred feet. Trees are removed from the perimeter to maximize the exposure of the lagoon's surface to sunlight and wind.

Using Form 7-4: Lagoon Treatment Systems Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Lagoon Treatment Systems. The form for documenting inspection points follows the text.

1. Type of lagoon system

Evaluate the lagoon system one cell at a time and use a new sheet for every cell. Identify the type of lagoon being used at the site, either aerobic or facultative.

2. Conditions at the lagoon

Evaluate the presence of odor at the system. Strong odor is an indication of anaerobic conditions or improper inlet placement. Note whether odors are strong, mild, septic (rotten eggs), chemical, or sour in nature.

Record the color of the effluent. Color may or may not be a symptom of a problem. Turnovers and blooms are a normal occurrence in lagoons, and they often produce odors. A green color indicates the presence of algae, which may be using all the available oxygen. A purple color indicates the presence of anaerobic bacteria.

The surface should be free of large floating materials. (If preceded by a septic tank, regular O&M on the septic tank should prevent large floating materials from reaching the lagoon.) Periodic pumping of the lagoon may be necessary for solids removal.

3. Border

If the lagoon has an exposed surface, vector activity, such as animals, should be prevented. The top of the berm should be flat and be a minimum of 4 feet wide. The outsides should be gently sloped to shed surface water. Indicate whether the border is in good repair. Any erosion should be filled and reseeded as soon as it is noted. Repair leaks around the berm walls by plugging or sealing as soon as noted. Reroute any surface drainage away from the lagoon. Berms should be free of animal burrows that create structural challenges and channels for water movement.

Berms should have healthy grass cover to reduce erosion. Woody vegetation should not be present on the berms since tree roots develop flow channels that can compromise the structural integrity of the berm. Mow earthen berms to maintain an attractive site.

Fencing should be in place and secured. It should be a minimum of 4 feet tall and equipped with a lockable gate. It should be constructed of chain link, woven or welded wire, hog panel, or cattle panel. Proper signage is necessary to prevent trespassing.

4. Vegetation in lagoon

The lagoon surface should be free of vegetation. If vegetation is present in the lagoon, it should be manually removed using the proper precautionary measures. There may be some vegetation, such as cattails and duck weed, along the edges of the lagoon that will not interfere with treatment, if they are not blocking any inlets or outlets or growing excessively.

5. Liquid level management

Maintain the working water level at least two feet below the top of the berm, dependent upon state regulations. This is the freeboard which represents the emergency volume of the lagoon intended to accommodate extreme weather events.

Measure the depth of the lagoon. If the working water level is too high, check the outflow pipes (if used) for clogging. Liquid levels will temporarily increase with flow surges. Note whether a water level control option is available.

6. Effluent quality

Evaluate effluent quality to determine system performance and document status of the system. Clarity, dissolved oxygen, pH, and temperature should be noted, as well as the relative odor and color of the effluent leaving the cell.

7. Lab samples

If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to an authorized laboratory. Retain a signed COC from the laboratory to complete the system file. Report the information to the proper entities.

Form 7-4 Operational Checklist: Lagoon Maintenance (LM)

Service provided on: Date:_______ Time:_____________ Reference #:____________
Service provided by: Company: ________________ Employee: ___________________
Date of last service: ___________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ________________________

1. Lagoon: Cell #: _____ /_____
   a. Type: ☐ Aerobic ☐ Facultative
2. Conditions at the lagoon
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong ☐ Chemical ☐ Sour
   b. Color of lagoon water:
      ☐ Clear ☐ Green ☐ Purple ☐ Other:_______________
   c. Sludge pumping necessary. ☐ Yes ☐ No
   d. Animal activity at surface. ☐ Yes ☐ No
3. Border around lagoon
   a. Type of border material: ________________
   b. Border material in good repair. ☐ Yes ☐ No
   c. Evidence of water/soil entering lagoon. ☐ Yes ☐ No
   d. Berm free of burrowing animals. ☐ Yes ☐ No
   e. Berm protected from erosion. ☐ Yes ☐ No
   f. Trees present on the berm. ☐ Yes ☐ No
   g. Fencing is present and operable. ☐ Yes ☐ No
4. Vegetation in lagoon
   a. Floating vegetation present. ☐ Yes ☐ No
   b. If yes, vegetation removed. ☐ Yes ☐ No
   c. Vegetation present at edges. ☐ Yes ☐ No
5. Liquid level management
   a. Liquid level below freeboard: ________________ft
   b. Liquid level relative to: ☐ Outlet ☐ Berm
      ☐ Above ☐ Below ____________in
   c. Water level control option available ☐ Yes ☐ No
6. Effluent quality
   a. Clarity: ☐ Clear ☐ Suspended solids present
   b. Oily film on the effluent surface. ☐ Yes ☐ No
   c. DO at outlet or across from inlet: ______________mg/L
   d. pH at outlet or across from inlet: ________________
   e. Temperature in outlet: ________________
   f. Bypass or overflow noted. ☐ Yes ☐ No
   g. Effluent odor after passing through lagoon (if discharging):
      ☐ None ☐ Mild ☐ Strong
   h. Effluent color after passing through lagoon (if discharging):
      ☐ Clear ☐ Brown ☐ Black

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

5. ☐ Acceptable
   ☐ Unacceptable

6. ☐ Acceptable
   ☐ Unacceptable

Reference #:_______________

7. Lab samples collected for monitoring. ☐ Yes ☐ No

   Types of analysis:____

   ____

   ____

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the operation of a chlorine disinfection system.
2. Identify and use safe handling practices.
3. Accurately complete Operational Checklist 7-5 Disinfection Unit-Chlorine (DUC).

Overview

Onsite wastewater treatment systems that apply effluent upon the ground surface are required to include a disinfection component as part of the treatment process. Additionally, some subsurface drip systems applying wastewater into shallow soils require disinfection prior to dispersal. Disinfection is the destruction or inactivation of disease-causing organisms. The disinfection component reduces the concentration of the pathogenic constituents to an acceptable level. This is usually based on a health standard or a maximum allowed number of organisms for infection.

Wastewater can be disinfected with many methods. Chlorine, ultraviolet light, and ozone are typically used for this purpose. For onsite wastewater treatment systems, the most common method of disinfection used is chlorination.

Description and Mode of Treatment

Chlorination is the process of adding chlorine to wastewater to reduce the population of pathogenic organisms. Chlorine passes through the cell walls, oxidizing and destroying cell enzymes. It is important to have adequate holding time to allow the chlorine to react with microorganisms. The length of contact time necessary for proper treatment decreases as the chlorine concentration increases. Thirty to sixty minutes of contact time is required for typical wastewater strengths and chlorine concentrations. Chlorine reacts with ammonia to form chloramines. Chloramines are not as effective as hypochlorous acid (HOCL) and the hypochlorite ion (OCL^-)

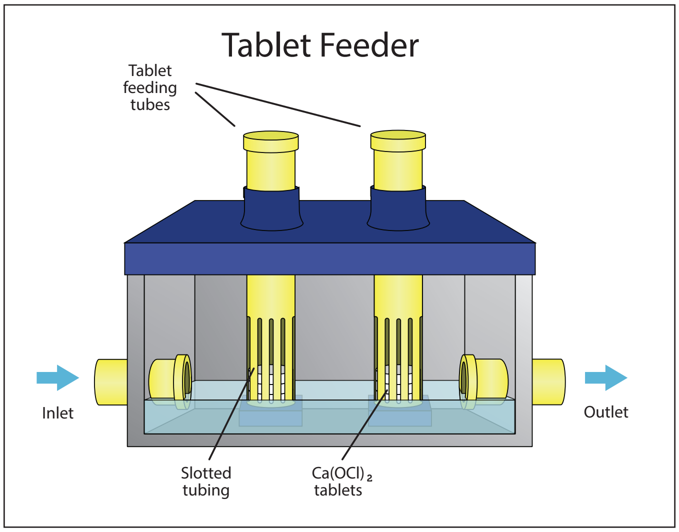

Figure 7-27. Chlorine stack feeder.

for disinfection. Chlorine residual is measured in the dosing tank to ensure that disinfection is effective. Chlorine residual should be adequate to achieve disinfection. The target value is often specified in local or state regulation.

The O&M service provider should be aware of safety and health issues when providing service to a technology that utilizes chlorine. Service providers should familiarize themselves with the proper handling and storage procedures for the different forms of chlorine available.

Chlorinator Configurations

Tablet chlorinators

Tablet chlorinators generally have four components:

- Chlorine tablets
- Tube(s) that holds the tablets
- Device that brings chlorine tablets into contact with the wastewater
- Contact chamber where the chlorinated wastewater is stored to allow sufficient contact time before it is distributed

Chlorination is only effective if effluent is highly treated. Treatment must be sufficient to remove significant amounts of organic matter and solids that reduce the effectiveness of any disinfection process.

A tablet chlorinator usually consists of a basin where the tubes containing a stack of chlorine tablets are placed (Figure 7-27). The top of the tubes should extend above ground surface and be protected by a cap. The bottom tablet in the tube is in contact with the wastewater flowing through the basin. As that tablet dissolves and/or erodes, the tablet above falls by gravity to replace it.

A tablet can dissolve quickly or slowly, depending on the volume and flow of effluent, the properties of the tablet, and the length of contact time. A balance must be struck regarding the contact time in the chlorinator basin. If the contact time is too long, the wastewater becomes over-chlorinated, and the tablets are consumed rapidly; if the contact time is too short, the wastewater is not sufficiently disinfected.

Use only chlorine tablets that are approved for use in wastewater. They are made of calcium hypochlorite ($Ca(OCl)_2$). These tablets dissolve in wastewater and release the hypochlorite that becomes hypochlorous acid, the primary disinfectant.

Do not use swimming pool chlorine tablets. They are often made from trichloroisocyanuric acid, which is not approved for use in wastewater treatment systems. Read the list of active ingredients on the tablet label to make sure you are using calcium hypochlorite.

Growing awareness and understanding of the effects of chlorine on the environment are prompting many companies to optimize the performance, reliability, and safety of their chlorination products. If you measure chlorine residual using the DPD colorimetric method, keep in mind that it is sensitive to heat and sunlight and has a limited shelf life.

Liquid chlorinators

Liquid chlorinators are also used for disinfecting residential wastewater. These devices typically use liquid chlorine bleach that is dosed into wastewater prior to distribution. These systems typically use an aspirator to draw chlorine from a reservoir (Figure 7-28). The chlorine is discharged into the dosing tank to react with the wastewater. The aspirator requires that the pump be operating to develop the vacuum to draw a chlorine dose into the dosing tank.

Dechlorination

Chlorine residual is measured in the dosing tank to ensure that disinfection is effective. Chlorine residual should be less than 0.2 mg/L to ensure that disinfection byproducts are not formed in the receiving environment.

Dechlorination is used to remove excess chlorine before effluent is dispersed. The dechlorination approach currently available is the use of tablets made typically of sodium bisulfate. These tablets are stored in a stack tube and placed in the contact basin. Effluent passes through the contact basin and is treated in the same manner as described for tablet chlorination.

Chlorine residual tests can evaluate proper performance of the dechlorination system. When utilizing a dechlorination system, there should be no chlorine residual measurable in the effluent.

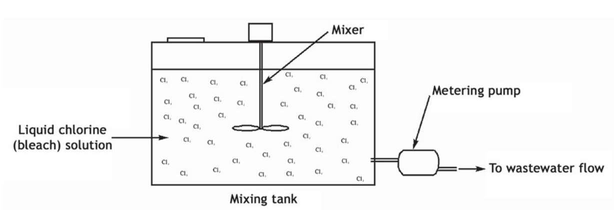

Figure 7-28. General schematic of a liquid chlorination system (profile view).

Using Form 7-5: Disinfection Unit – Chlorine

The text below describes inspection criteria for evaluating performance of Chlorine Disinfection units. The form for documenting inspection points follows the text.

1. Description of chlorination system

If both a chlorinator and dechlorinator are present, use a separate form for each component. Note the manufacturer and the model number for the units. Identify the type of chlorine disinfection method being used at the site: tablet or liquid. Note and record the condition of the unit.

2. Tablet chlorination

Tablet chlorination utilizes the contact basin for contact of the effluent with the tablets. The basin must be level, watertight, and free of residuals. Soil settling/ movement can shift the basin resulting in an off-level basin, a situation that must be corrected upon discovery.

Tablets are placed in the stack tube of the contact basin. Generally, a small number of tablets (three to five) are added at a time. There must be an adequate number of tablets in reserve so they can be readily replenished as needed. Tablets may wick effluent up the stack tube, causing the tablets to expand and lodge in the stack tube instead of feeding down into the effluent. Lodged tablets must be physically removed from the tube. Check the contact chamber for solids that can affect performance. Broken connections may result in short-circuiting of the flow path.

Measure chlorine residual. Chlorine can be read as total or free residual (typically total chlorine). Record the method of testing used.

3. Liquid chlorination

Liquid chlorination systems store chlorine in a reservoir for dosing in the tank. Confirm the presence of liquid chlorine at the proper concentration in the reservoir and note the type of chlorinator and the injection method used. There should be proper mixing of the liquid chlorine from the reservoir with the effluent. Ideally there is a mechanism to stir the dosing tank and incorporate the chlorine. Measure and note the total or free chlorine residual level (typically total chlorine) and the testing method used.

4. Tablet dechlorination

Tablet dechlorination is commonly used to remove chlorine from the effluent before dispersal. These tablet dechlorination devices have similar O&M requirements as tablet chlorinators (see Number 2).

5. Control panel

If a control panel is used, it should be watertight with all connections sealed to prevent moisture or chlorine gases from entering. Check the function of the alarm test switch. The presence of a control (HAND-OFF-AUTO) switch allows the service provider to check pump function without activating a float or program. Note the position of the control switch, keeping in mind that under normal operating conditions it should be in the AUTO position. If the panel has a cycle counter and/or an hour meter (elapsed time meter), record the present and last readings. If there are no meters, they are strongly recommended as an upgrade to facilitate O&M activities.

6. Manufacturer's recommended maintenance performed

Manufacturers of specific units may recommend additional maintenance for their products. These activities should be performed, and the completion of these activities should be documented in the comments section.

7. Lab samples

If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to an authorized laboratory. Retain a signed COC from laboratory to complete system file. Report the information to the proper entities.

Form 7-5 Operational Checklist: Disinfection Unit - Chlorine (DUC)

Service provided on: Date:_______ Time:_____________ Reference #:____________
Service provided by: Company: ________________ Employee: __________________
Date of last service: ___________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ________________________

1. Operation of chlorination system
   a. Manufacturer: Chlorinator: ________ Dechlorinator: ______
   b. Model #: ____
   c. Method: ☐ Tablet ☐ Liquid
   d. Unit appears to be in good condition. ☐ Yes ☐ No
2. Tablet chlorination: ☐ NA
   a. Chlorinator appears to be operable. ☐ Yes ☐ No
   b. Chlorine tablets in place. ☐ Yes ☐ No
      Type:______________________________________
   c. Tablets in contact with effluent. ☐ Yes ☐ No
   d. If tablets added, how many: ___________________
   e. Contact chamber appears operable. ☐ Yes ☐ No
   f. Contact chamber and stack feeder cleaned. ☐ Yes ☐ No
   g. Chlorine residual: ☐ Free ☐ Total _____________mg/L
      Testing method:__________________________________
3. Liquid chlorinator: ☐ NA
   a. Chlorine present in reservoir. ☐ Yes ☐ No
   b. Injection method operating correctly. ☐ Yes ☐ No
      Type:____
   c. Dosing mechanism operable. ☐ Yes ☐ No
   d. Proper mixing occurring. ☐ Yes ☐ No
   e. Chlorine residual: ☐ Free ☐ Total ______________mg/L
      Testing method:__________________________________
4. Tablet dechlorination: ☐ Required ☐ Not required
   a. Dechlorination appears operable. ☐ Yes ☐ No
   b. Dechlorination tablets in place: ☐ Yes ☐ No
      Type:____
   c. Tablets in contact with effluent. ☐ Yes ☐ No
   d. If tablets added, how many:_________________
   e. Contact chamber appears operable. ☐ Yes ☐ No
   f. Contact chamber/stack feeder cleaned. ☐ Yes ☐ No
   g. Chlorine residual: ☐ Free ☐ Total___________________ppm
      Testing method:__________________________________
5. Control panel: ☐ NA
   a. Controls operating properly. ☐ Yes ☐ No

Notes

1. ☐ Acceptable ☐ Unacceptable
2. ☐ Acceptable ☐ Unacceptable
3. ☐ Acceptable ☐ Unacceptable
4. ☐ Acceptable ☐ Unacceptable
5. ☐ Acceptable ☐ Unacceptable

b. Is enclosure watertight. ☐ Yes ☐ No
c. Alarm test switch operating properly. ☐ Yes ☐ No
d. At time of inspection, control switch was set to: ☐ NA
“Hand/Manual”____________“Auto”_____________
e. If auto, setting: Time On: _____ (min) Time Off: ______ (min)

6. Manufacturer’s required maintenance performed. ☐ Yes ☐ No
(If ‘Yes’, attach Manufacturer Inspection form to this report, if supplied.)
7. Lab samples collected for monitoring. ☐ Yes ☐ No
Types of analysis:____
____
____

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the operation of an Ultraviolet light disinfection system.
2. Identify and implement appropriate safety protocols.
3. Accurately complete Operational Checklist 7-6 Disinfection Unit: Ultraviolet Light (DUUL)

Overview

Disinfection by ultraviolet (UV) light is a process in which electromagnetic energy from a source (lamp) is emitted into a chamber or zone through which effluent passes. The UV light destroys the microorganisms present in the effluent by altering or damaging their genetic material and retarding their ability to reproduce. ***Never look directly at UV light units when they are operating. Doing so will cause blindness.***

Description and Mode of Treatment

UV light, created by an electrical current passing through mercury vapor inside a lamp, penetrates the cell wall of microorganisms and damages their genetic material which affects their ability to reproduce. The lamp emitting UV radiation is usually encased in a quartz or Teflon sleeve that comes into direct contact with the wastewater (Figure 7-29).

Wastewater never contacts the UV lamp itself. The effectiveness of a UV disinfection system depends on the following factors: presence of suspended solids, wastewater flow rate, turbidity, time of exposure, distance the UV light needs to travel within the reactor chamber, intensity of the UV light, and the configuration of the system.

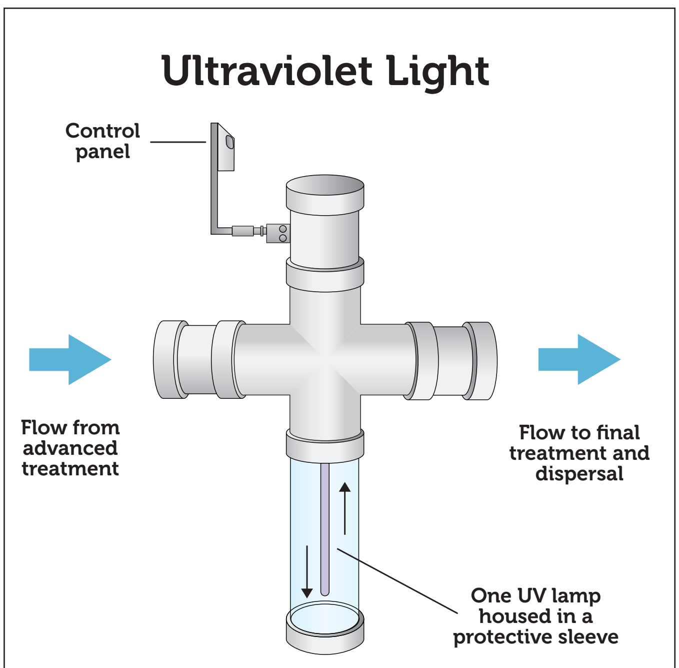

Figure 7-29. Ultraviolet light disinfection unit

Wastewater characteristics

For UV disinfection to be effective, UV radiation must come in direct contact with the microorganisms present in the wastewater. High turbidity and TSS levels limit UV light penetration in the reactor chamber and reduce the amount of UV light absorbed by the organisms. TSS in the wastewater may shield the microorganisms present from the UV light. The type of advanced treatment technology used immediately before the UV unit can have a profound influence on UV light penetration in the reactor chamber and thus on number of organisms killed. (See Table 7-1 below for wastewater characteristics that may affect UV disinfection unit performance.)

Wastewater flow rates

High flow rates through the reactor chamber can also limit UV light contact with organisms, primarily by reducing the organism's time of exposure to UV light.

Intensity of UV light

Such factors as lamp placement and configuration in the reactor, lamp sleeve fouling (from solids buildup), distance between lamp and electrical power source (voltage drop), and age of the lamp all affect the intensity of UV radiation in the reactor chamber.

Unlike increasing the chlorination dosage when there are more interferences present, increasing UV intensity has no effect on high TSS. UV dosage is measured by power or intensity, the surface area, and the contact time. If the UV radiation cannot penetrate the liquid to reach the microorganisms, it is useless.

If the protective sleeve is not cleaned regularly, UV penetration will be poor. Regular cleaning by mechanical, chemical, or ultrasonic methods is needed to ensure system performance. The frequency of cleaning depends on the type of technology that precedes the UV disinfection step and the wastewater characteristics. Generally, time dosed media filters that produce less than 20 mg/L of BOD_5 and TSS each should be visited twice per year to clean tubes. Treatment units without time dosing and technologies producing effluent with higher TSS and BOD_5 levels may require two to four times more frequent cleaning, depending on other factors noted above. The service provider is encouraged to adjust maintenance frequency to meet the demands placed upon each system. For instance, a UV lamp used on a system serving a seasonally used home visited only on weekends would require less quartz tube cleaning than a lamp serving a home that is occupied year-round and is producing wastewater flow at or near design levels.

To clean a small residential UV unit, begin by deenergizing the system. Then, remove remove the lamp and quartz tube assembly from the housing, manually wipe the quartz tube with a clean cloth, and then reassemble the unit. Other manufactured UV products for larger residential or commercial flows may employ a mechanical wiper mechanism and external rod that may not require disassembly. Be sure to get training and follow manufacturer's maintenance instructions prior to servicing any UV units.

Chemical cleaning is usually done with a citric acid solution, but vinegar solutions and sodium hydrosulfite are also used. Chemical and ultrasonic cleaning is usually done only on larger systems. Quartz sleeves or tubes normally last 5 to 8 years but are usually replaced every 5 years.

Most manufacturers of small residential-sized UV units recommend lamp replacement every 12 to 24 months (8,760 to 17,520 hours) for continuously operating lamps. Some units may operate lamps in cycles rather than continuously. Repeated on and off lamp cycles usually reduce their lifespan. The service provider should check with the manufacturer to verify lamp replacement frequency.

The distance of electrical power lines run from power source to lamp may influence voltage at the lamp itself. The manufacturer should be consulted if low voltage is detected at the lamp. Lamp ballast (the device that modulates the current sent to the lamp) lifespans range from 10 to 15 years but are usually replaced every 10 years. Service providers should check with the manufacturer to verify lamp ballast compatibility. Adequate ventilation should be provided for the ballast to prevent overheating, which shortens its life and can even result in fire.

The UV lamp can be in an insulated outdoor structure or in heated space of the structure served, both of which must protect the unit from dust, excessive heat, freezing, and vandals.

UV units may be configured with either gravity flow or pressurized flow.

Table 7-1. Wastewater characteristics affecting UV disinfection performance
(Source: USEPA. 1999.)

Wastewater Characteristic	Effects on UV Disinfection
Ammonia	Minor, if any.
BOD	Minor, if any. Although, if a large portion of the BOD is humic compounds, then UV transmittance may be diminished.
Hardness	Affects the solubility of metals that can absorb UV light. Can lead to the precipitation of carbonates on the quartz tubes.
Humic materials, Iron	High absorbency of UV light. Can coat quartz tubes, inhibiting the transmittance of UV radiation to the organisms.
Nitrate	Minor, if any.
Nitrite	Minor, if any.
pH	Affects solubility of metals and carbonates.

Using Form 7-6: Disinfection Unit – Ultraviolet Light Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Ultraviolet light disinfection units. The form for documenting inspection points follows the text.

NOTE: *Unplug the unit before servicing. Wear proper eye protection when servicing UV disinfection unit. Operators should not look directly at the UV light with the power on.*

1. Power supply

Note whether the unit is dosed by gravity or pressure. Also note the manufacturer and the model number for the unit. Electricity is required for proper operation of the device. Make sure the lamp is turned on during normal operation (before it is turned off for maintenance). Look for corrosion at the point where the lamp plugs into the electrical lead. If corrosion is present, clean the surfaces and check the voltage at the end of the lead. The lamp ballast should be replaced about every 10 years with a compatible part. However, always follow the manufacturer's recommendation. Note whether the ballast was replaced during the visit. If it was not replaced, note the last replacement date.

2. UV controls

If the unit is equipped with a UV light intensity sensor, record the intensity reading. An alarm can monitor light intensity and signal the need for maintenance or repair. If a light intensity alarm is present, check its function manually by turning the light off to ensure it is operating as designed.

3. Contact chamber, lamp and sleeve conditions

Check for any damage to the UV unit and contact chamber that might cause effluent leakage. Note whether the contact chamber is cleaned.

Note whether the sleeve is quartz, Teflon, or some other material. Using gloved hands, remove the sleeve assembly and lamp from the housing after ensuring that the lamp is off. Using a clean cloth, separate the UV lamp from the protective tube. Wipe the outside of the protective sleeve to clean at the recommended frequency of one to four times per year (or more), depending upon site specifics. Note whether the sleeve is replaced during the visit. If it is not replaced, note the last time this was done. Sleeves should be replaced every 5 years or sooner if cracks appear or if discoloration cannot be removed. Note whether the lamp is replaced during this visit. If it is not replaced, note the last date this was done. Replace lamps as recommended by the manufacturer or as required by permit.

4. Influent characteristics

The system requires clear effluent for effective light transmission for disinfection. Check the turbidity with a meter. Evaluate the flow rate as noted in evaluating the pump system (Chapter 6), as excessive flows result in limited treatment. Indicate any other wastewater characteristics that may compromise treatment.

5. Control panel

If a control panel is used, it should be watertight, with all connections sealed to prevent moisture or sewer gases from entering. Check the function of the alarm test switch.

6. Housing

Note where the housing unit is located (buried directly in the ground or in a pump chamber). The UV housing unit or chamber must be inspected for cracks or leaks. Check for excessive dust in the housing unit.

7. Manufacturer's required maintenance performed

Manufacturers of specific units may recommend additional maintenance for their products. These activities should be performed, and the completion of these activities should be documented in the comments section.

8. Lab samples

If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to an authorized laboratory. Retain a signed COC from the laboratory to complete the system file. Report the information to the proper entities.

Form 7-6 Operational Checklist: Disinfection Unit – Ultraviolet Light (DUUL)

Service provided on: Date:_______ Time:_____________ Reference #:_____________
Service provided by: Company: ________________ Employee: ___________________
Date of last service: ___________________________ By: ☐ You ☐ Other:_________
Date of last inspection: ________________________

1. Power supply
   a. Dosing method: ☐ Pressure dosed ☐ Gravity fed
   b. Manufacturer: _______________ Model #: _________________
   c. Power supplied to the unit. ☐ Yes ☐ No
   d. UV lamp 'ON'. ☐ Yes ☐ No
   e. Electrical system free of corrosion/damage. ☐ Yes ☐ No
   f. Ballast replaced during this visit. ☐ Yes ☐ No
   g. Last replacement date: ____ / ____ / _____
2. UV controls
   a. Unit equipped with a lamp intensity sensor. ☐ Yes ☐ No
   b. If so, what was intensity reading: ___________________
   c. Alarm present. ☐ Yes ☐ No
   d. Alarm operating properly. ☐ NA ☐ Yes ☐ No
3. Contact chamber, lamp, and sleeve conditions
   a. Evidence of damage or leakage. ☐ Yes ☐ No
   b. Contact chamber cleaned/flushed of solids. ☐ Yes ☐ No
   c. Type of protective sleeve: ☐ Quartz ☐ Teflon ☐ Other: ______
   d. Protective sleeve free of buildup. ☐ Yes ☐ No
   e. Protective sleeve cleaned. ☐ Yes ☐ No
   f. Protective sleeve replaced during this visit. ☐ Yes ☐ No
   g. Date last replaced: ____ / ____ / _____
   h. UV lamp replaced during this visit. ☐ Yes ☐ No
   i. Date last replaced: ____ / ____ / _____
4. Influent characteristics
   a. Clarity: ☐ Clear ☐ Cloudy
   b. Flow rate: ______________gpm
   c. Indicate wastewater characteristics that may compromise treatment:
      ____
      ____
5. Control panel: ☐ NA
   a. Controls operating properly. ☐ Yes ☐ No
   b. Is enclosure watertight. ☐ Yes ☐ No
   c. Alarm test switch operating properly. ☐ Yes ☐ No
6. Housing unit: Location: _________________
   a. Appears in good condition. ☐ Yes ☐ No

Notes

1. ☐ Acceptable ☐ Unacceptable

2. ☐ Acceptable ☐ Unacceptable

3. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

5. ☐ Acceptable ☐ Unacceptable

6. ☐ Acceptable ☐ Unacceptable

Reference #:________________

b. Leaks/Cracks present. ☐ Yes ☐ No

c. Excessive dust present. ☐ Yes ☐ No

7. Manufacturer's required maintenance performed. ☐ Yes ☐ No

   (If 'Yes' attach Manufacturers Inspection form to this report, if supplied.)

8. Lab samples collected for monitoring. ☐ Yes ☐ No

   Types of analysis:______________________________________

   ____

   ____

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the operation of an ozone disinfection system.
2. Identify and implement appropriate safety protocols.
3. Accurately complete Operational Checklists and 7-7. Disinfection Unit - Ozone (DUO).

Overview

Ozone (O_3) is a powerful disinfectant that, like chlorine, destroys microorganisms through oxidation. It disinfects by reacting with the organic matter of the cell and is particularly effective against *Giardia* and *Cryptosporidium*. It has the very desirable quality that it is unstable and thus leaves no residual. Additionally, ozone does not form disinfection byproducts. The extra oxygen atom binds in a split second to all the organic matter it contacts. After this oxidation process, all that remains is the pure and stable oxygen molecule.

Ozonation equipment for the onsite wastewater treatment industry is not as readily available as other forms of disinfection. This material was developed with the best available information on this technology. As ozone disinfection becomes more readily available, more information on O&M of ozonation equipment will become available. A service provider should review manufacturer maintenance requirements of all technologies to assist with proper O&M.

Description and Mode of Treatment

An ozonation system consists of the ozone generator, an air dryer or oxygen source, a means of adding the ozone into the wastewater, a mixing/contact chamber, and a ventilation device. Ozone is produced by discharging electricity in very dry (desiccated) air. A high voltage (6,000 to 20,000V) is applied to two electrodes to create a continuous arc (corona), and the high voltage converts O_2 to O_3. The feed gas for the ozone generator may be air or pure oxygen. Air feed systems must remove dust and moisture from the incoming air for effective generation. If pure oxygen is used, 1 to 10 percent is converted to ozone; if air is used, only 1 to 4 percent is converted to ozone. About 80 to 95 percent of the energy is converted to heat, which must be dissipated, usually through cooling water.

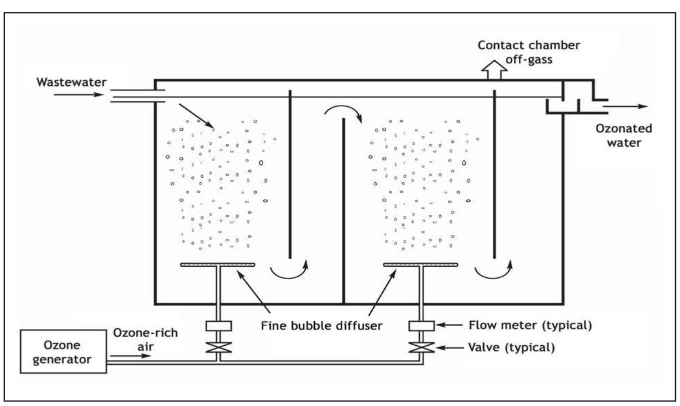

Figure 7-30. General schematic of an ozone system (profile view).

For ozone to be effective, it must be added to the effluent and dispersed as finely as possible. This is accomplished either by using a fine bubble diffuser (Figure 7-30) or a venturi configuration. The mixing/contact chamber must be configured so that there is adequate contact time for disinfection. Note the baffled configuration in Figure 7-30 that slows down the flow through the chamber.

Ozone interferences include TSS, BOD_5, COD, humic materials, nitrite, nitrate, and pH. TSS increases ozone demand (as organic matter in TSS is oxidized by the ozone) and shields embedded bacteria. Organic compounds measured as BOD_5 or COD can exert ozone demand for the same reason. Ozone oxidizes iron, manganese, and hydrogen sulfide, which results in precipitates downstream of the ozone injection point. The degree of interference depends on the functional groups and chemical structure. If a water reuse system is in use, provisions must be made to remove precipitates from the wastewater stream. Settling and filtration are acceptable methods for removal of precipitates in this situation.

Humic materials (common in peat, coir, or woodchip-based effluent) affect the rate of ozone decomposition and exert ozone demand. Nitrite is oxidized by ozone, and nitrate can reduce effectiveness of ozone. Ammonia has little or no effect, except when the pH is high, and then it may react with the ozone. The pH affects the rate of ozone decomposition.

The amount of interference these constituents exert on the effectiveness of ozone disinfection is minimal. This is especially apparent when compared to the decrease in effectiveness of other forms of disinfection due to interferences.

Ozone is acutely toxic. It is important when using this technology to demonstrate extra caution. Ozone is a toxic gas and can cause illness if inhaled in sufficient quantity. Some ozone generators include an ozone monitor and a safety system that shuts down the generator at a concentration of 0.3 ppm. It is best also to set an alarm at 0.1 ppm to allow sufficient time to react to the situation and avoid problems. Checking the function of such an alarm requires the use of a device that introduces ozone into the air space housing the monitor.

Using Form 7-7: Ozone Disinfection Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Ozone disinfection units. The form for documenting inspection points follows the text.

1. Description of ozone generator

Note the manufacturer and the model number for the unit. Also note whether the generator is supplied with free air or pure oxygen. Clean the filter or screen on the air intake. Make sure the ozone generator is operating as designed. You should be able to hear the motor running and see the air being dispersed in the contact chamber.

2. Dosing system

Note if the unit is pressure or gravity dosed. Confirm that the wastewater delivery system is operational. There should be a constant flow of wastewater to the contact chamber.

3. Contact chamber

Confirm that there is sufficient mixing of ozone and wastewater in the contact chamber. Visually inspect the contact chamber for any leaks or cracks. Check the dissolved oxygen concentration in the contact chamber. The DO level should be between 3-5 mg/L.

4. Ventilation

There should be adequate ventilation of the contact chamber. Check the air vent for blockage.

5. Housing

The ozone generator may be located in a tank, a control panel or separately housed. The housing must protect the unit from excess dust, moisture, extreme temperatures, and vandals. Make sure the unit is intact and free of dust that may clog the air intake.

6. Ozone sensor

Make sure the ozone sensor is functioning. Record the ozone detection reading. If a safety alarm is present, make sure it is operating properly. This is done by introducing an outside air source into the ozone sensor chamber to see if the alarm activates.

7. Control panel

If a control panel is used, it should be watertight, with all connections sealed to prevent moisture or sewer gases from entering. Check the function of the alarm test switch. If the panel has an alarm cycle counter, record the present and last readings. If there are no meters, they are strongly recommended as an upgrade to facilitate O&M activities.

8. Manufacturer's required maintenance performed

Manufacturers of specific units may recommend additional maintenance for their products. Perform and document completion of these activities in the comments section.

9. Lab samples

If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to an authorized laboratory. Retain a signed COC from the laboratory to complete the system file. Report the information to the proper entities.

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Form 7-7 Operational Checklist: Disinfection Unit - Ozone (DUO)

Service provided on: Date:_______ Time:_____________ Reference #:_____________
Service provided by: Company: ________________ Employee: ___________________
Date of last service: ___________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ________________________

1. Ozone generator
   a. Manufacturer: ______________ Model #: ______________________
   b. Air supply: ☐ Free air ☐ Pure oxygen
   c. Ozone generator operating as designed. ☐ Yes ☐ No
   d. Filter/Screen: ☐ Cleaned ☐ Replaced
2. Dosing system operating properly. ☐ Yes ☐ No
   a. Dosing method: ☐Pressure-dosed ☐ Gravity-dosed
3. Contact chamber
   a. Proper mixing. ☐ Yes ☐ No
   b. Cracks/leaks present. ☐ Yes ☐ No
   c. DO concentration: ____________ppm
4. Ventilation appears operable. ☐ Yes ☐ No
5. Housing Location: ____________________________________
   a. Appears in good condition. ☐ Yes ☐ No
   b. Leaks/cracks present. ☐ Yes ☐ No
   c. Excessive dust present. ☐ Yes ☐ No
6. Ozone sensor
   a. Sensor functioning. ☐ Yes ☐ No
   b. If 'yes', what was the reading: _____________________ mg/L
   c. Safety alarm present. ☐ Yes ☐ No
   d. Alarm operating properly. ☐ Yes ☐ No
7. Control panel: ☐ NA
   a. Controls operating properly. ☐ Yes ☐ No
   b. Enclosure water- and gas-tight. ☐ Yes ☐ No
   c. Alarm test switch operating properly. ☐ Yes ☐ No
8. Manufacturer's required maintenance performed. ☐ Yes ☐ No
   (If 'Yes' attach Manufacturers Inspection form to this report, if supplied.)
9. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:____
   ____
   ____

Notes

1. ☐ Acceptable ☐ Unacceptable
2. ☐ Acceptable ☐ Unacceptable
3. ☐ Acceptable ☐ Unacceptable
4. ☐ Acceptable ☐ Unacceptable
5. ☐ Acceptable ☐ Unacceptable
6. ☐ Acceptable ☐ Unacceptable
7. ☐ Acceptable ☐ Unacceptable

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8 Final Treatment and Dispersal Components

Introduction

The overall configuration of any decentralized system is ultimately dependent upon the specific soil and site conditions available for final treatment and dispersal of effluent. The potential functions of final treatment and dispersal components may include (to varying degrees and with notable exceptions) acceptance, storage, distribution, treatment, and dispersal of effluent. The goal is non-degradation of ground- and surface water resources. This means that when treated effluent reaches the receiving environment, there is no degradation of water quality.

Increasing population density means that there is potential that overall mass loading may exceed the assimilative capacity of the receiving environment (see discussion in Chapter 1). Technologies used in this industry continue to evolve as priorities change. The ability to treat and disperse effluent from nearly every wastewater source is apparent. The designer's challenge is to select a final treatment and dispersal component that is appropriate for the site conditions and treatment goals.

Traditional technologies have tremendous capacity to reduce most constituents, but nutrients (especially nitrogen and phosphorus) can often pose a problem in this regard. Groundwater must be protected as a potential drinking water source so drinking water standards must be considered. Surface water may also be a drinking water source, but it certainly bears protection because of potential adverse impacts on flora and fauna. In many places, groundwater and surface waters are interconnected, so pollution of one can lead to pollution of the other.

Treatment Mechanisms in Gravity and Pressure Distribution Systems

Gravity distribution systems develop an anaerobic biomat at the infiltrative surface because of concentrated application of effluent. Biomat development progressively moves application of effluent down the length of the trench and restricts effluent movement into the biozone surrounding the trench. The biozone provides aerobic conditions allowing further treatment of constituents. These are naturally fluctuating systems.

Pressurized distribution systems use mechanical components to distribute effluent to the entire infiltrative surface of the STA, effectively improving uniform application. The biozone in these systems provides aerobic treatment. Deviations in uniformity of application result in concentrated overloading. Biomat development in pressure distribution systems should be minimal. If present, it indicates organic overloading.

The key to proper operation is performing proactive maintenance. The inspection points provided in these materials are intended to facilitate a proactive approach.

Critical Inspection Points

Operating pressure

Designs for components that incorporate use of a pump include specification of operating pressure. This is the optimal pressure required for uniform application of effluent to a media filter, pressure dosed gravity system, a low-pressure distribution system, drip or spray systems. In pressure dosed gravity, low-pressure distribution and integrated treatment and dispersal components, operating pressure is measured by opening the end of the lateral (which is closed during normal operation) and attaching a clear calibrated PVC pipe in a vertical orientation. When the pump activates, the effluent rises in the clear pipe, and the height is recorded.

Drip and spray distribution systems operate at relatively higher pressures. For these systems, field pressure is recorded from a field pressure gauge or measured using an external gauge at a pressure port.

Multiple fields and switching valves

Designers may choose to include multiple zones for an STA. Some technologies simply require establishing multiple zones to overcome physical constraints of available pumps. Switching valves are installed to perform this function. In gravity systems, distribution box outlets can be alternately opened and closed. Manual alternating valves (a single diversion valve or a pipe assembly) allow dosing and resting cycles for zones (one zone is in operation at a time.)

In pressure systems, valves may be a hydraulic or electrical mechanical valve. Hydraulic mechanical valve uses water pressure to sequentially dose zones while an electrical mechanical uses an electrically activated solenoid valve to perform this function.

Summary

Effective performance of wastewater treatment components used in soil treatment areas is dependent upon:

- Effective conveyance of effluent through the soil infiltrative surface;
- Further treatment in the soil; and
- Final dispersal into the receiving environment.

The succeeding sections describe the range of options for final treatment and dispersal.

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe gravity soil treatment areas (STA).
2. Identify siphon- and pressure-dosed gravity systems.
3. Describe how biomat develops in an STA and why it is important.
4. Identify unacceptable conditions in the STA.
5. Measure and set operating pressure in a pressure-dosed gravity configuration.
6. Accurately complete Operational Checklist 8-1 Gravity Distribution (GD).

Overview

The main function of a gravity distribution STA is to accept, store, and distribute wastewater so it can be dispersed into the soil and environment. Technologies used for gravity distribution can be divided into media filled (gravel, sand, polystyrene, etc.) and open storage types (chambers made of concrete, plastic, PVC and other materials). These materials or devices may be installed in either a trench (a long, narrow installation with a single lateral) or bed (a wider installation with multiple laterals). Trenches are constructed using washed rock and perforated pipe. At least 50 percent of the media is below the perforated pipe. Regulations will vary as to the depth of media below and above the pipe, trench width and trench spacing.

The media may be covered with a geotextile fabric to prevent soil migration into the media. Native permeable soil is placed on top of the fabric and extended to final grade. Soil is mounded over the trenches to shed rainwater from the STA. Some jurisdictions require an inspection port to be located at the end of the trench, which allows monitoring of the ponding level in the trench.

Gravity trench distribution systems typically receive septic tank effluent (Figure 8-1). Effluent gravity flows through the septic tank and into the soil treatment area. They are typically sized to temporarily store peak flows and allow effluent to infiltrate into native soil for final treatment.

Gravity dosed trench configurations

Final treatment and dispersal systems using gravity distribution often have multiple trenches for acceptance and distribution of effluent. Trench configurations that use gravity to convey effluent include parallel, serial, and sequential. Distribution boxes and drop boxes are typically included to convey effluent.

Parallel distribution implies that effluent is split uniformly and concurrently among all trenches (Figure 8-2). A parallel trench configuration is designed to load multiple trenches at the same rate provided the outlet pipes are at the same elevation and the distribution box itself is level. Flow control devices (adjustable weirs) can be placed in discharge pipes to control flow to individual trenches or improve uniform distribution among individual trenches. Over time, distribution and drop boxes can settle and shift. Surface access is needed to re-level or replace a box that fails to operate as designed or causes problems in the soil treatment area.

Distribution boxes can also be used on sloping sites (Figure 8-3). The distribution box is located at the highest elevation in the soil treatment area and feeds all laterals. Solid piping conveys the effluent down slope to the trenches at the lower elevation.

Sequential distribution is accomplished on sloping sites using a drop box approach (Figure 8-4). Effluent enters the first drop box and the first trench and fills it before flowing over to the second drop box to the next trench. The first trench continues to accept effluent at its long-term acceptance rate (LTAR) and excess effluent enters the second trench. After the second trench reaches its LTAR, effluent will flow down slope to the third trench. The configuration shown in Figure 8-4 illustrates effluent conveyance from one side of the drop box. A drop box can load trenches placed on both sides of the drop box. Therefore, trenches could extend both directions from the drop box along the contour of the site.

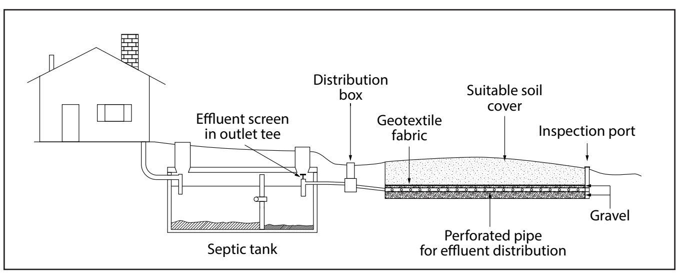

Figure 8-1. Gravity distribution system (profile view)

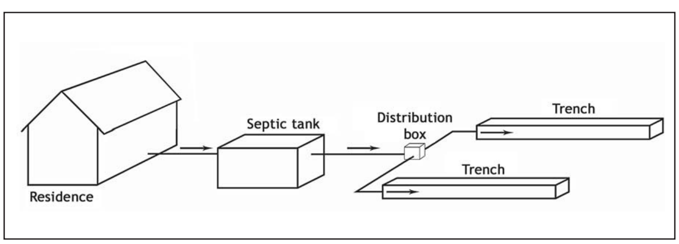

Figure 8-2. Parallel trench using a distribution box on a level site.

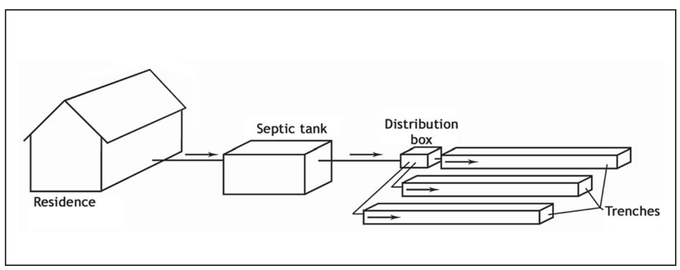

Figure 8-3. Parallel trench using a distribution box on a sloping site.

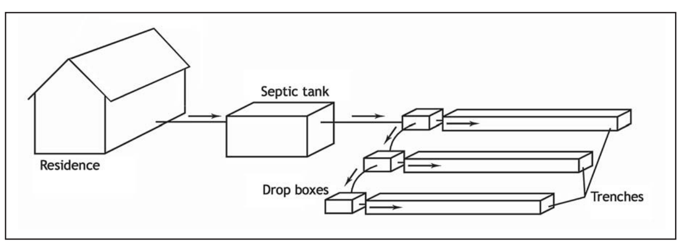

Figure 8-4. Sequential trench using drop boxes on a sloping site.

In a serial configuration, effluent must pond the first trench completely before flowing to the succeeding trench (Figure 8-5). A serial distribution system placed on a sloping site can use either a drop box or stepdown (a configuration of earthen dams and piping) to convey effluent down slope to the second trench.

Pressure-dosed gravity distribution

Gravity distribution trenches are, by necessity, located down slope from the residence. However, the best site for the STA may be upslope from the residence. A dosing tank with a pump can be used to dose effluent to the gravity distribution trenches. A pump is also used if the house plumbing is accidentally stubbed out too low or if the distance between the septic tank and STA too great. In these instances, the dosing system is used to convey effluent under pressure to a distribution box, drop box or a pressure manifold. From that point, effluent flows by gravity within the STA. The dosing system may be configured for either demand or time dosing. Figure 8-6 illustrates pressure dosing to drop boxes in a sequential gravity configuration.

Although pressure-dosing to a distribution box or drop box is not uncommon, using a pressure manifold instead can result in more even distribution. If the manifold is installed in a box with access to grade, the service provider can now access the components for monitoring and maintenance. The pump pressurizes the manifold which then distributes effluent to individual trenches (Figure 8-7). Orifices or ball valves placed in the discharge laterals function as flow controls to regulate flow to each individual trench. Once through the flow control device, effluent flows by gravity to the individual trenches. The trenches can be placed on a flat or sloping site. The pressure manifold must be placed at the highest point in the system. The cleanout of the pressure manifold allows the service provider to measure, record and adjust (if needed) the operating pressure for the system. Figure 8-8 illustrates pressure dosing to a gravity distribution STA using a pressure manifold.

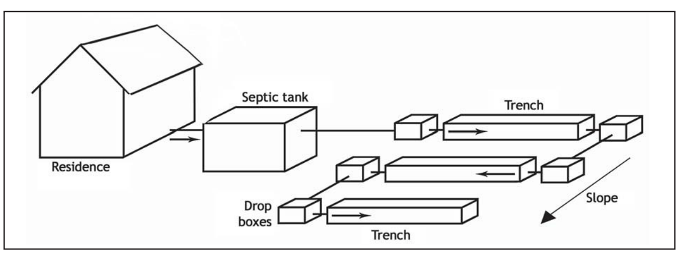

Figure 8-5. Serial trench using drop boxes on a sloping site.

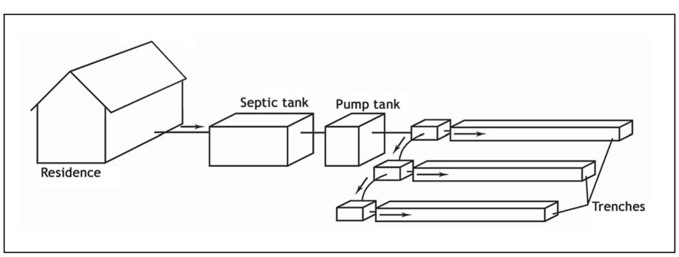

Figure 8-6. Pressure-dosed gravity to sequential trenches on a sloping site

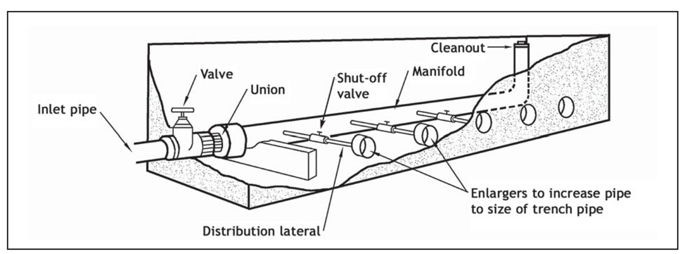

Figure 8-7. Pressure manifold.

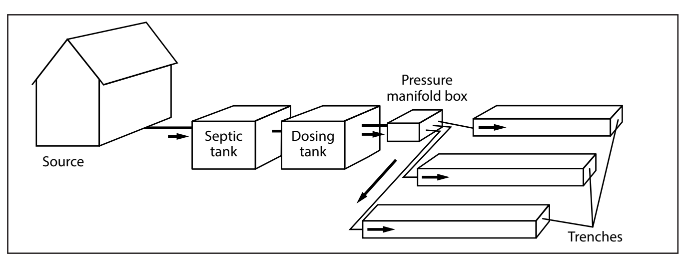

Figure 8-8. Pressure-dosed gravity to gravity parallel trenches using a pressure manifold

Using Form 8-1: Gravity Distribution STA Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Gravity Distribution Soil Treatment Areas (STA). The form for documenting inspection points follows the text.

1. Description

Determine the system type. Record the method for dosing effluent to the STA and then record the method for distribution within the distribution field. Distribution to the field can be accomplished through gravity flow from the treatment device, siphon-dosed gravity, or pressure-dosed gravity. Note whether the STA is configured as a bed or trenches. If trenches are used, note the flow configuration: parallel, sequential, or serial. If no information is available, excavation is the only means of confirming the configuration. This is NOT recommended unless specific circumstances warrant it.

2. Conditions in the STA

Evaluate the presence of odor as you approach the system. There should be no strong odors near the STA if the venting system is operating properly and there are no breakouts. If odors are detected, determine the source by checking for missing caps on inspection ports or damaged lids or risers. Check for any indication of leaks around or above the system. Also check the roof vent location, prevailing winds, and atmospheric pressure, as these factors can contribute to odor issues. Note whether odors are mild or strong. Some jurisdictions require laterals or STAs to have vents in specific applications. These may be a source of odors as well.

Vegetation management on and around the STA is important for proper performance. Appropriate vegetation may be defined by local regulations. Typically, appropriate vegetation includes mowed grasses and/or short non-woody plants. During the growing season, grasses help remove moisture from the STA area. However, some water-loving plants with extensive root systems can cause problems with effluent distribution in the system. Be sure to note the encroachment of any woody plants in the vicinity of the STA. The leaf canopy for woody vegetation is often smaller than the extent of the roots below ground.

3. Distribution device

Examine the distribution devices. A distribution device is needed to distribute effluent to the individual trenches. These include distribution boxes, drop boxes, headers, and manifolds. The distribution devices should be easily accessible via risers or access ports but are often below grade. If conditions indicate that effluent is not being distributed evenly, excavating a d-box or drop box may reveal the source of the problem. Distribution boxes must remain level or have integral leveling devices to assist with water distribution among individual trenches. Presence of sludge in the distribution devices indicates potential solids transport to the trenches. If sludge is detected, it indicates that upstream components require attention. Measure and record the depth of solids below the box outlet.

Check for root intrusion in the distribution device. If the septic tank is due to be pumped, solids should also be removed from the distribution device.

If the system includes a pressure manifold it should be accessible. If so, measure and record the operating pressure at the distal end of the manifold.

Check for equal distribution in the STA. Observe and document grass growth patterns in the yard. Uniform stripes over the laterals indicates uniform distribution.

4. Distribution in STA

If possible, evaluate each trench in the STA and fill out the table. This can be done via sewer cameras if you have access to the distribution device and there are not too many bends preventing the scoping of the system. Observation ports may also be useful to evaluate trench condition or function. If access to subsurface components is not available, the assessment of trenches is limited to observations from the ground surface.

An evaluation of the extent and depth of ponding can provide some indication on how much of the system is being used at the time of inspection and may also be a function of seasonal ground wetness or extreme weather events.

Check for surfacing effluent over each trench and measure the distance effluent traveled across ground surface from trench. Look for any root intrusion or obstruction to the system. Also note any other areas where effluent is surfacing, such as around the distribution device which indicates a problem.

5. Inspection ports

Inspection ports are the best method to evaluate the presence and depth of ponding. If they are not present, they should be recommended as an improvement. No heavy objects or obstructions of any kind (such as improper landscaping) should impede the service provider from accessing the inspection port.

6. Switching valves

Check the function of the switching valves (if present). Record the type of switching valve, and record if any actions were taken for maintenance. Switching valves are used to divert the flow of effluent automatically or manually to another field or a different part of the field. Some switching valves are used to prevent effluent from flowing to specific parts of the field. Record which laterals are in operation before leaving the site. Check that this has not been changed by the owner during the service interval. Note which laterals are in operation.

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Form 8-1 Operational Checklist: Gravity Distribution (Including Pressure-Dosed Gravity) (GD)

Service provided on: Date:_______________Time:______Reference #:____________
Service provided by: Company: _______________ Employee:__________________
Date of last service: _________________________ By: ☐ You ☐ Other:_________
Date of last inspection: ______________________

1. Description of STA
   a. Method of distribution
      ☐ Gravity ☐ Pressure-dosed gravity ☐ Siphon-dosed gravity
   b. Configuration in the field:
      ☐ Bed ☐ Parallel trench ☐ Sequential trench ☐ Serial trench
2. Conditions in the soil treatment area
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: _____________________________
   c. Leaks around/over system. ☐ Yes ☐ No
   d. Vegetation appropriate. ☐ Yes ☐ No
   e. Uneven vegetation. ☐ Yes ☐ No
   f. Vegetation adequately maintained. ☐ Yes ☐ No
   g. Preventing access for maintenance. ☐ Yes ☐ No
3. Distribution device
   a. Type: ☐ Distribution box ☐ Drop box ☐ Header
      ☐ Pressure manifold ☐ Other: __________________
   b. If pressure manifold, operating pressure: ________________
   c. Accessible ☐ Yes ☐ No
   d. Intact, providing equal distribution ☐ Yes ☐ No
   e. Free of solids ☐ Yes ☐ No
   f. If 'No,' depth of solids below outlet (D-box): ____________in
   g. Root intrusion ☐ Yes ☐ No

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

Reference #:______________

4. Distribution in field: Soil treatment area information:

Lateral #	Ponding		Surfacing Effluent		Distance Effluent Traveled (ft)	Obstructions	Notes	Status
	Yes or No	Depth (in)	Yes	No				
1			☐	☐				☐ Acceptable ☐ Unacceptable
2			☐	☐				☐ Acceptable ☐ Unacceptable
3			☐	☐				☐ Acceptable ☐ Unacceptable
4			☐	☐				☐ Acceptable ☐ Unacceptable
5			☐	☐				☐ Acceptable ☐ Unacceptable
6			☐	☐				☐ Acceptable ☐ Unacceptable
Other areas where effluent is surfacing			☐	☐				☐ Acceptable ☐ Unacceptable

5. Inspection ports
   a. Inspection ports present ☐Yes ☐No
   b. Inspection ports intact ☐Yes ☐No
6. Switching valves
   a. Switching valve present ☐Yes ☐No
   b. Type of valve:______________________________
   c. Operating properly ☐Yes ☐No
   d. Action taken if not:______________________________
   e. Laterals in operation: ______________________________

5. ☐ Acceptable
   ☐ Unacceptable

6. ☐ Acceptable
   ☐ Unacceptable

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe low-pressure distribution (LPD) configurations.
2. Conduct the key O&M measures for each configuration.
3. Measure operating pressure in a low-pressure distribution STA.
4. Accurately complete Operational Checklist 8-2 Low-pressure distribution STA (LPD).

Overview

The main objective when using low-pressure distribution is to evenly distribute wastewater over the entire length of the trenches. To accomplish uniform distribution, laterals composed of small diameter pipes with small diameter orifices are used. LPD is typically installed in a trench and the pipe is supported by stone or other material. It is critical for the operator to have access to original LPD designs and as-built drawings, as valve and manifold arrangements can vary widely.

Configurations and Variations

Low-pressure distribution STAs have been used to dose straight septic tank effluent for decades. The design for these systems must account for higher wastewater strength (Figure 8-9) unless advanced treatment is part of the system design. The typical LPD STA consists of a pressure manifold and trenches (although a bed-type configuration may be used). The laterals, usually 1-1/4- to 2-inch diameter PVC pipes, are surrounded by washed stone, gravel, plastic chambers, slotted irrigation pipes, or synthetic media placed in the trench. Normally, a single pressure regulating valve is used to adjust overall field operating pressure. In certain instances, pressure-regulating valves are placed in a valve box at the beginning of each lateral to adjust operating pressure (Figure 8-10). Lateral orifices (1/8 to 1/4 inch in diameter) are typically oriented in a six o'clock position and spaced every 5 feet along the lateral depending on soil type. If the lateral is sleeved in a perforated pipe or a domed shield of some kind, orifices are oriented at the 12 o'clock position. The effluent flows downward on the inner surface of the sleeve or dome. Cleanouts are placed in access ports at the lateral ends to facilitate maintenance and measure and adjust operating pressure. Trenches are backfilled with native material from the excavation.

Trenches must be able to store the effluent until it is accepted by the soil. Media of various types and open chambers are used to construct the trenches (Figure 8-11). Because effluent exits the orifices at a relatively fast rate, temporary ponding occurs in the bottom of the trenches. Ponding can be monitored with inspection ports.

Because straight septic tank effluent is being dosed, the development of a biomat at the trench infiltrative surface is to be expected (See Chapter 8A). However, a fully developed biomat is not required for distribution of the effluent as is needed in gravity distribution trenches. The pipe network with orifices distributes the effluent. The dose volume and resting period controls the quantity of ponding and distribution of the effluent. LPD systems can be either time dosed (promoting flow equalization) or demand dosed.

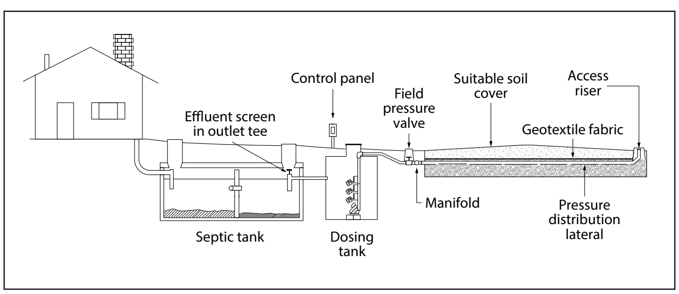

Figure 8-9. Treatment train using low-pressure distribution STA (profile view)

Shallow narrow trench

Shallow narrow trenches are an adaptation of LPD used to disperse wastewater on difficult sites. Typically, this is used

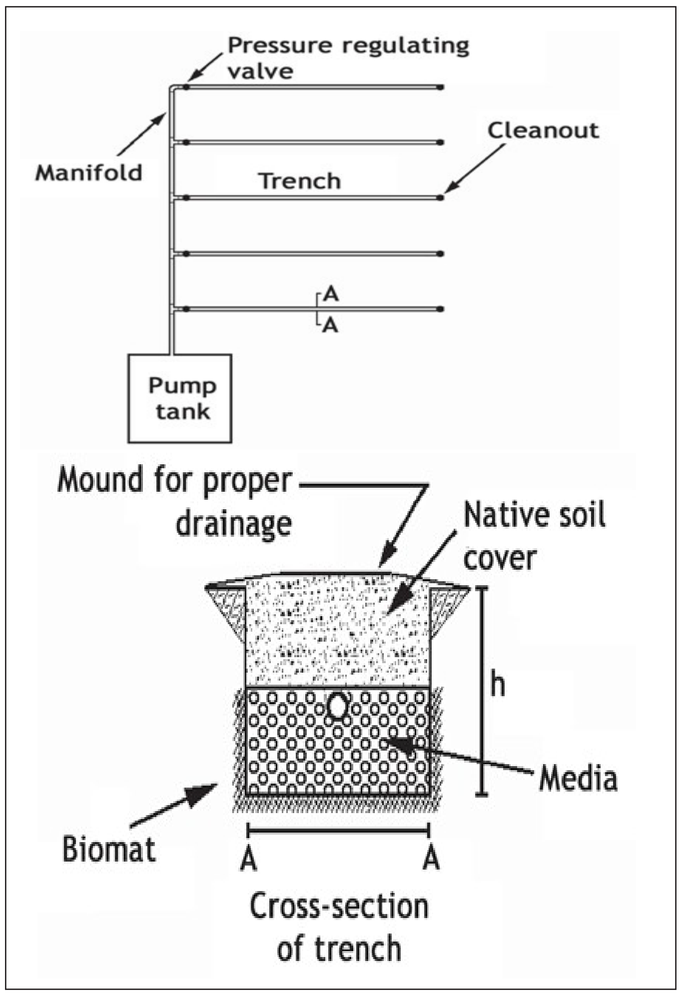

Figure 8-10. Plan view of low-pressure distribution (top) and trench detail (bottom)

for wastewater that has received additional treatment (e.g., via media filter or ATU) and meets a minimum treatment level of 30 mg/L of both BOD_5 and TSS. Shallow narrow trenches are placed in the upper soil layers (6 to 12 inches from the ground surface) for maximum wastewater treatment by natural soil processes. Shallow placement maximizes vertical separation to the groundwater.

Effluent is pressure-dosed into a small diameter PVC lateral, which is typically 3/4 to 2 inches in diameter. The lateral piping usually has 1/8- to 3/16-inch orifices drilled every 18 to 24 inches. The laterals are typically placed on native soil, or on sand media in narrow, shallow trenches. The pressurized effluent squirts up against a cover made of a 12-inch PVC pipe cut lengthwise or a proprietary domed chamber, or the lateral is encased in a packaged combination of non-absorptive and wicking materials (Figure 8-11).

The media protects the trench and helps distribute the effluent evenly over the trench bottom just below the ground surface where biological activity is greatest. Effluent infiltrates the native soil surface and percolates down through underlying soil where additional nutrient and pathogen removal occurs.

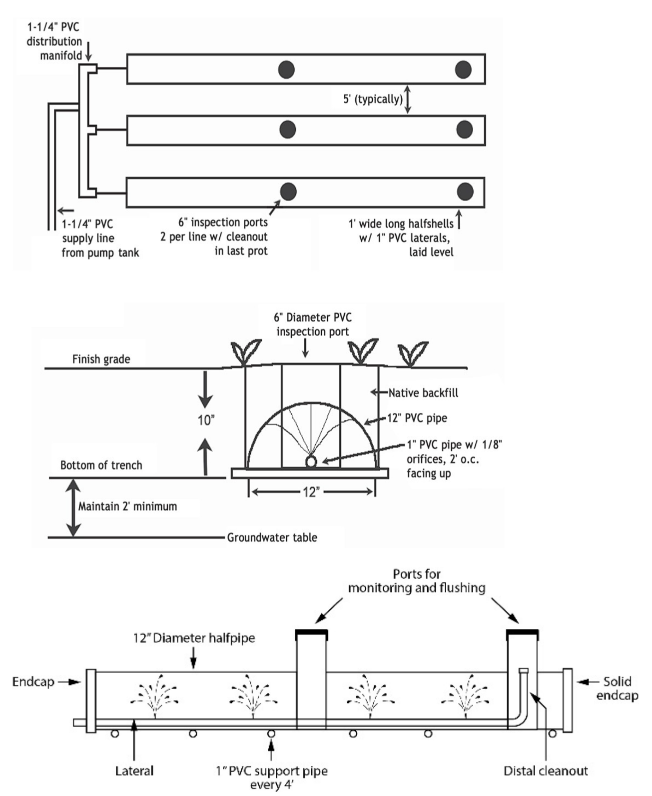

Figure 8-11. Shallow narrow trench detail: plan, cross section, and profile view

Using Form 8-2: Low-pressure Distribution STA Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Low-pressure Distribution Soil Treatment Areas (STA). The form for documenting inspection points follows the text.

1. Effluent quality

Determine whether the effluent entering the system is anaerobic (only septic tank treatment) or aerobic (advanced treatment).

2. Conditions at the LPD

Evaluate the presence of odor as you approach the system. There should be no strong odors near the soil treatment area (STA) if the venting system is operating properly and there are no breakouts. If odors are detected, determine the source by checking for missing caps on inspection ports or damaged lids or risers. Check for any indication of leaks around or above the system. Also check the roof vent location, prevailing winds, and atmospheric pressure, as these factors can contribute to odor issues. Note whether odors are mild or strong.

Vegetation management on and around the STA is important for proper performance. Appropriate vegetation may be defined by local regulations. Typically, appropriate vegetation includes mowed grasses and/or short non-woody plants. During the growing season, grasses help remove moisture from the STA. In shallow narrow trench STAs, very lush grass growth is common above the laterals, and especially noticeable in the shoulder seasons when other grasses have gone dormant on the site. However, some water-loving plants with extensive root systems can cause problems with orifice clogging and water distribution in the system. Check for root intrusion into orifices in the lateral line (while snaking and flushing laterals).

3. Supply line

Check that the supply line drains freely after a dose unless the system has been specifically designed to keep the supply line full between doses. This is common if supply line is exceptionally long, but adequate insulation is critical to keep the pipe from freezing. If the supply line is kept full, both a check valve and an air vent hole are needed below check valve to prevent airlock of the pump.

Check for signs of ponding or saturation along the supply line (puddles, saturated ground, or vegetation patterns). Note if air relief valves are present and operating. Air relief valves should let the air in the line vent until the line is free of air. These valves allow the line to pressurize faster and avoid damage to pipe systems.

4. Switching valves

If present, record the type of switching valve, and record if any actions were taken for maintenance. Switching valves are used to divert the flow of effluent automatically or manually to another field or a different part of the field. Some switching valves are used to stop effluent from gaining access to part of the field (zone). Record which laterals/zone are in operation before leaving the site. Check that this has not been changed by the owner during the service interval.

5. Soil treatment area information

Use the table in number 5 to record information on STA parameters.

Measure the system operating pressure before and after cleaning. The operating pressure in the lateral line determines the flow rate of liquid leaving the orifices. Check the operating pressure at the distal end of the lateral to estimate how evenly the water is being distributed. If required, reset the operating pressure to the original value by adjusting the pressure-regulating valve. This is typically a single gate valve that controls overall pressure. Some designs include valves on each lateral.

View the STA base via inspection ports if present. LPD STAs may have biomat present and some level of ponding and odor. The base of a shallow narrow trench should not have a biomat nor should it have septic odors.

Evaluate each lateral in the STA. An evaluation of the extent and depth of ponding can provide some indication about how much of the system is being utilized at the time of inspection and may also be a function of seasonal ground wetness. Check for surfacing effluent from the laterals and measure the distance the effluent traveled. Look at the lateral ends for damage, root intrusion or obstruction to the system. Note any evidence of vehicular traffic or other heavy loads over the STA.

6. Orifices

Laterals should be regularly flushed to mitigate plugging resulting from solids accumulation. Record the method used to clean them. The distal end of the distribution lateral must be accessible to allow for orifice cleaning.

To flush laterals, open the cap on the distal end of the lateral and run the pump manually until the effluent is free of accumulated organic matter or debris. Initial flushing of the laterals moves biosolids out of the end of the lateral. Once the accumulated solids (often a "plug") are removed, snaking can occur.

The process of snaking the laterals involves pushing a cleaning device (either a bottlebrush attached to the end of an electrician's or plumber's snake or a small diameter pressure washer nozzle and hose) through each lateral from the distal end. Initial flushing of the laterals moves biosolids to the end of the lateral. Once the laterals are snaked, they should be flushed again to remove any solids that may have been dislodged. Laterals may also be vacuumed out with a pump truck if the orifices are well protected.

The operating pressure should be checked after snaking and flushing the laterals. After cleaning the lateral, the operating pressure should be roughly equivalent to the initial baseline value recorded during system start-up. A decrease in the operating pressure noted over time might be an indication of pump fatigue, clogging or malfunction, or a leak in the distribution system.

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Form 8-2 Operational Checklist: Low-pressure Distribution STA (LPD)

Service provided on: Date:________________Time:_______Reference #:_____________
Service provided by: Company: _________________ Employee:____________________
Date of last service: ____________________________ By: ☐ You ☐ Other:___________
Date of last inspection:_________________________

1. Effluent quality: ☐ Aerobic ☐ Septic tank effluent (anaerobic)
2. Conditions at the LPD
   a. Topography: ☐ Level ☐ Sloping: __________ % slope
   b. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   c. Source of odor, if present: _________________________________
   d. Leaks around/above system. ☐ Yes ☐ No
   e. Vegetation appropriate. ☐ Yes ☐ No
   f. Excessive vegetation. ☐ Yes ☐ No
   g. Vegetation adequately maintained. ☐ Yes ☐ No
   h. Preventing access for maintenance. ☐ Yes ☐ No
3. Supply line
   a. Line drains freely. ☐ Yes ☐ No
   b. Ponding/saturation along the supply line. ☐ NA ☐ Yes ☐ No
   c. Air relief(s) valve operating. ☐ NA ☐ Yes ☐ No
4. Switching valves
   a. Switching valve present. ☐ Yes ☐ No
   b. Type of valve:____
   c. Operating properly. ☐ Yes ☐ No
   d. Action taken if not:_____________________________________
   e. Laterals/zones in operation: ______________________________
5. Soil treatment area information:

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

Zone #	Lat. #	Operating pressure		Ponding Yes/No (in)	Surfacing Effluent		Lateral Ends			Root Intrusion (Yes/No)	Other Obstruction (Specify)
		Meas. (in)	Adj. to (in)		Yes/No	Distance Traveled (ft)	Intact	Protected	Accessible		

Reference #: ________________________

6. Orifices
   a. Position: ☐ 6 o'clock ☐ 12 o'clock
   b. Orifices cleaned. ☐ Yes ☐ No
   c. Method: ☐ Hydrojetted ☐ Bottle brushed
   ☐ Flushed ☐ Other:__________________________

6. ☐ Acceptable
   ☐ Unacceptable

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Identify the main process for liquid removal from Evapotranspiration (ET) beds.
2. Describe ET bed configurations.
3. Explain basic vegetative cover management for ET beds.
4. Accurately complete Operational Checklist 8-3 ET beds (ETB).

Overview

An evapotranspiration (ET) bed disperses wastewater by using evapotranspiration which is defined as the loss of water from the soil by a combination of evaporation and transpiration from plants growing there.

ET beds are used where the soil cannot treat wastewater before it percolates to groundwater, such as in rocky soils, or where the soil prevents wastewater from percolating from the soil treatment area, such as in heavy clay soils. ET beds are dependent upon climate and are not suitable for regions that receive more rainfall than evapotranspiration.

Components

There are two types of ET beds: lined and unlined. In lined systems, the ET bed is lined with 20-millimeter plastic, natural clay, synthetic, or concrete liner (Figure 8-12(a)). A liner is required if the surrounding soil is very permeable, such as in sandy, gravelly, or karst limestone soils.

Unlined systems are used in highly impermeable soils such as heavy clays (Figure 8-12(b)). In unlined systems, wastewater is disposed of by a combination of evaporation, transpiration, and absorption, which is often called an evapotranspiration/absorption (ETA) system.

Function

ET bed systems receive effluent that has at least been treated by a septic tank. The effluent is distributed throughout the ET bed system. Final treatment and dispersal occurs when the liquid evaporates and as plants use the water and nutrients in the effluent and release moisture through transpiration through their leaves.

As the water evaporates, salts, minerals, and solids from the effluent accumulate in the bed. During very wet periods when evapotranspiration is low, ET beds store effluent until drier periods when evaporation and transpiration occur.

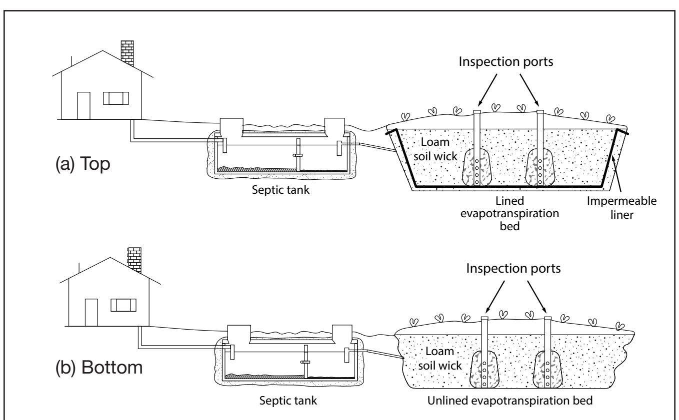

Figure 8-12. Generic treatment train configurations for lined (top) and unlined (bottom) ET bed systems.

Layout

A liner and sand cushion are placed in the ground, and the storage system is set on the bed bottom. Generally, the storage system consists of a bed of rocks or gravel of a uniform size ranging from 3/4 to 2 inches in diameter, filling the bed to a depth of 12 inches or less depending on the bed's overall depth. Distribution pipes are placed not more than 4 feet apart and no less than 2 feet from the bed walls. The top of the distribution pipe must be flush with the top of the rock media.

Other types of media or storage systems, such as leaching chambers, may be used for the storage trenches.

A water-permeable soil barrier (such as a geotextile filter fabric) is placed over the rock. A loam soil is added to fill the bed to within 2 inches of the top. Selecting the proper soil is extremely important in building an ET system. The soil draws the water toward the surface faster than coarse sand.

Wicks (a column of soil that extends through the rock media to the bottom of the bed) draw water continuously from the rocks into the surrounding soil and toward the surface area where it evaporates or is taken up by plants. The total wick area should be 10-15 percent of the bed surface and uniformly spaced throughout the bed. After the loamy soil is in place, the final 2 inches are filled with sandy loam and mounded in the center with a slope of 2-4 percent toward the outside of the bed (to shed rainwater and stormwater). The last step is to plant vegetation specially selected to transpire the most water, such as Bermuda or St. Augustine grass. Placing sod over the bed may be the best approach to establishing a vegetative cover. Using seed may let the mounded soil wash away during heavy rainfall before the grass is established. Larger plants with shallow root systems, such as evergreen bushes, may also be used to help take up water.

If you use grass with a dormant phase, be sure to provide adequate vegetation on the beds during these periods. A common solution is overseeding with winter grasses to provide year-round transpiration.

Using Form 8-3: Evapotranspiration Beds Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Evapotranspiration Beds. The form for documenting inspection points follows the text.

1. Conditions at the ET bed

There should be no strong odors near the bed if the venting system is operating properly and there are no breakouts. If odors are detected, determine the source by checking for missing caps on inspection ports or damaged lids or risers. Check for any indication of leaks around or above the system. Also check the roof vent location, prevailing winds, and atmospheric pressure, as these factors can contribute to odor issues. Note whether odors are mild or strong.

Check the vegetation growing on the system as the system matures. The service provider may need to use salt-tolerant grass, such as Bermuda grass, because salt accumulates in the system. Water leaves salts in the soil when it evaporates. Harvesting salt-tolerant grasses may reduce the salts in the system if the plants can accumulate the salt in their leaves. The potential for high salt concentrations depends on how much salt is in the water supply. Mow the grass cover regularly. Grass cover is important for transpiration of wastewater. Overseed with cool season grasses to provide transpiration in the winter. If grass cover is not maintained, the system may malfunction.

2. Distribution to the ET bed

A distribution device is needed to distribute effluent to the individual trenches. These include distribution boxes, headers, and manifolds. If the system is using a pressure manifold, record the operating pressure. The distribution devices should be easily accessible. Check for equal distribution in the STA.

Look at grass growth patterns in the yard. It should have uniform growth over the beds. The boxes must remain level or include integral leveling devices to assist with water distribution to the individual trenches. Presence of sludge in boxes indicates potential solids transport to the STAs. If sludge is detected, then the solids level is needed to determine pumping needs. Check for root intrusion in the distribution device.

3. Switching valves

Switching valves can be used to direct flow among multiple beds. Check if they are present and operating. When using more than one ET bed, a switching valve connecting the two beds allows alternation of the wastewater flow between the beds. When one bed becomes saturated, turn the valve to divert effluent into the other under-loaded bed. An inspection port added to each bed will help you determine water levels during use. Covering the port prevents insects, small animals, and unauthorized people from accessing the bottom of the bed. Record which beds are in operation before leaving the site.

4. ET Bed condition

Evaluate the presence and depth of ponding in the ET bed. If ponding is excessive, use the switching valve to change to a different bed and note the change in the table. Note whether effluent is surfacing. Check that rainfall and runoff are diverted around the system. The system is designed to handle normal rainfall entering from the top of the system, but excessive rainfall will overload it. Maintain the sloped cover on the system to help rain run off the bed.

5. Inspection ports

Inspection ports are the best method to evaluate the presence and depth of ponding. If they are not present, they should be recommended as an improvement. No heavy objects or obstructions of any kind (such as improper landscaping) should impede the service provider from accessing the STA.

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Form 8-3 Operational Checklist: Evapotranspiration Beds (ETB)

Service provided on: Date:_______________Time:______Reference #:____________

Service provided by: Company: _______________ Employee:________________

Date of last service: __________________________ By: ☐ You ☐ Other:_________

Date of last inspection: _______________________

1. Conditions at the ET bed
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ______________________________
   c. Leaks around/over system. ☐ Yes ☐ No
   d. Vegetation appropriate. ☐ Yes ☐ No
   e. Excessive vegetation. ☐ Yes ☐ No
   f. Vegetation adequately maintained. ☐ Yes ☐ No
   g. Preventing access for maintenance. ☐ Yes ☐ No

1. ☐ Acceptable ☐ Unacceptable

2. Distribution to ET bed
   a. Method for dosing:
      ☐ Gravity ☐ Pressure-dosed gravity
   b. Type: ☐ Distribution box ☐ Header
      ☐ Pressure manifold ☐ Other: _________________
   c. If pressure manifold, operating pressure: _________________
   d. Accessible. ☐ Yes ☐ No
   e. Intact, providing equal distribution. ☐ Yes ☐ No
   f. Free of solids. ☐ Yes ☐ No
   g. If 'No' depth of solids below outlet. __________in
   h. Root intrusion. ☐ Yes ☐ No

2. ☐ Acceptable ☐ Unacceptable

3. Switching valve
   a. Switching valve present. ☐ Yes ☐ No
   b. Type of valve:____
   c. Operating properly. ☐ Yes ☐ No
   d. Action taken if not:____________________________________
   e. Bed in operation: ______________________________________

4. ET bed status

Bed #	Status		Ponding		Surfacing Effluent (Yes/No)	Surface water diverted (Yes/No)
	Current	End of Service Visit	Yes/No	Depth (in)		
1	☐ Active ☐ Resting	☐ Active ☐ Resting				
2	☐ Active ☐ Resting	☐ Active ☐ Resting				

5. Inspection ports
   a. Inspection ports present. ☐ Yes ☐ No
   b. Inspection ports intact. ☐ Yes ☐ No

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Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the components of Integrated Treatment and Dispersal systems with free access or buried configurations.
2. Describe key operation and maintenance elements.
3. Accurately complete the Free Access Bottomless Media Filter (FABMF) and Buried Treatment and Dispersal (BTD) Operational Checklists.

Overview

Some components designed to provide advanced treatment can be installed directly into the STA. The intent of the approach is to combine both treatment and dispersal processes in a single location. These may be either free access or buried and this distinction relates directly to the inspection points used for operation and maintenance activities. Free access options include bottomless sand, peat or coir filters. Buried configurations include elevated systems, soil substitution, amended layer systems, mounds, sand-lined trenches and combined treatment and dispersal.

Free Access Bottomless Media Filters

Several types of media filters are used as soil treatment area (STA) options when they are configured in a bottomless fashion to allow treated effluent to infiltrate directly into the soil beneath the unit. Their design looks quite like the single-pass media filter (see Chapter 7A) without the bottom liner or watertight sealed container. Media filters with an open bottom are specifically intended to disperse wastewater into the soil immediately under and adjacent to their footprint. Bottomless sand filters (BSFs), and bottomless peat or coir (coconut) filters are used in this manner.

Bottomless sand filters (BSF)s

BSFs are similar in several ways to the single-pass sand filter. However, BSF media may be finer textured and less uniform. Typically, BSF sand media have an effective size of 0.33 mm and a uniformity coefficient of 2.5 to 4. In addition, they lack a bottom filter liner and underdrain. Some states allow straight septic tank effluent to be applied to BSFs; whereas others constrain BSF use with wastewater that has met a standard of 30 mg/L for both BOD_5 and TSS. The service provider is encouraged to check with local or state regulatory programs to determine what effluent discharge standards may apply to the BSF.

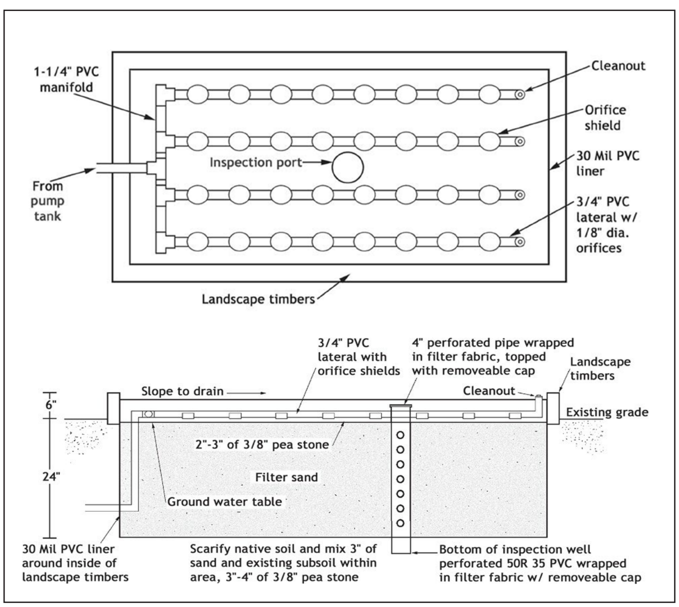

Figure 8-13. Bottomless sand filter

Wastewater is applied under low pressure to the top of a sand bed 2 to 3 feet in depth through a distribution manifold and lateral system (Figure 8-13 [top]). The manifold and laterals are surrounded by pea gravel that extends to the filter surface (free access) (Figure 8-13 [bottom]). Wastewater trickles down in unsaturated thin-film flow through the sand media in a time dosed mode. The effluent then percolates directly into the soil under the filter. Unrestricted air exchange facilitates greater hydraulic loading rates.

BSFs can be designed at-grade, where just 6 to 10 inches of the filter projects above existing grade, or above grade, with the top 24 to 30 inches of the filter above the ground surface.

Bottomless peat or coir filters

Peat or coir (coconut) filters can also be used as an STA option in a bottomless configuration. Prefabricated modules are typically placed on a prepared surface of washed gravel. Effluent is dosed to the top of the filter, trickles down through the media bed, and exits from the module through holes located in the filter base. Some filters can be installed without the bottom and installed directly on the soil surface.

Unlike sand media, organic media like peat and coir tend to settle, decompose, and/or deteriorate over time and may need to be replenished or replaced entirely at some point during use. Replacement frequency is dependent upon the manufacturer's recommendations.

Using Form 8-4a: Free Access Bottomless Media Filter Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Free Access Bottomless Media Filters. The form for documenting inspection points follows the text.

1. Nature of media

Note the nature of the media, whether organic or inorganic.

2. Conditions at the STA

Evaluate the presence of odor as you approach the system. There should be no strong odors near the filter if the venting system is operating properly and no surfacing effluent. If odors are detected, determine the source by checking for missing caps on inspection ports or damaged lids or risers. Check for leaks around or above the system. Also check the roof vent location, prevailing winds, and atmospheric pressure, as these factors can contribute to odor issues. Note whether odors are mild or strong.

Leaks around or on the system are unacceptable and indicate that the dispersal area is not operating properly.

Vegetation management on and around the soil treatment area (STA) is important for proper performance. A free access filter should have no vegetation growing in the pea stone. Appropriate vegetation around the filter may be defined by local regulations. Typically, appropriate vegetation includes mowed grasses and/or short non-woody plants. However, some water-loving plants with extensive root systems can cause problems with orifice clogging and water distribution in the system. Check for root intrusion into orifices in the lateral line (while snaking and flushing laterals).

Stormwater should be effectively diverted away from the structure.

3. Media surface

The media surface in the filter accepts wastewater and is the starting point for the wastewater treatment process. Check for uniform distribution on the surface. Vents and inspection ports to the media filter surface or underdrain system allow determination of the level of ponding. Ponding can indicate clogging of the media filter surface. Clogging in the media filter may occur due to physical and biological factors. Physical clogging is caused by accumulated solids within or on the media surface. Alternatively, fine materials may have washed through the peastone and accumulated in a thin, water-restricting layer at the top of the treatment media. Biological clogging is due to excessive microbial growth within the filter. An accumulation of biological slime and a decrease in the rate of decomposition of entrapped wastewater contaminants within the filter accelerates clogging. Resting the media filter may allow it to dry out and break down the biological materials growing in the filter. Some free access media filters (e.g. those made of organic materials) can be raked to break the inhibiting crust that has developed on top of the media filter due to the accumulation of fine materials. Where applicable, the surface layer of media can be removed from the filter when it is clogged with fine particles. Media can be replaced if the bed cannot be regenerated. Likewise, if repeated removal of the media surface layers has occurred, then partial replacement will be needed.

Media compression is expected in organic materials. As the media compresses, pore space is reduced. This, along with the bioaccumulation of solids restricts liquid flow through the filter. When excessive ponding is present and flow is restricted, the media should be regenerated or replaced based upon manufacturer guidance.

If the filter bed has an exposed surface, note any damage from animal activity, or whether heavy objects or other structures have been placed atop it that might impede airflow.

4. Pressure distribution

Distribution systems should evenly distribute wastewater across the top of the filter. These laterals may need cleaning/flushing. Operating pressure in the laterals may be evaluated using squirt height or liquid height in a clear PVC tube. Measure operating pressure before and after lateral cleaning to gauge effectiveness. Some bottomless peat filters use tipping buckets and/or holes to achieve even distribution.

5. Manufacturer's required maintenance performed

Manufacturers of specific units may recommend additional maintenance for their products. Perform and document completion of these activities in the comments section.

6. Lab samples

If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to the authorized laboratory. Retain signed COC from laboratory to complete system file. Use an authorized laboratory for sample analysis. Report information to the proper entities.

Form 8-4a Operational Checklist: Free Access Bottomless Media Filter (FABMF)

Service provided on: Date:_______________ Time:_____Reference #: ______________
Service provided by: Company: ________________ Employee:___________________
Date of last service: ___________________________ By: ☐ You ☐ Other:__________
Date of last inspection:________________________

1. Nature of media: ☐ Organic ☐ Inorganic
2. Conditions at the STA site
   a. Evidence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: _____________________________
   c. Structure intact. ☐ Yes ☐ No
   d. Vegetation appropriate. ☐ Yes ☐ No
   e. Stormwater management effective. ☐ Yes ☐ No
3. Media surface
   a. Uniform distribution. ☐ NA ☐ Yes ☐ No
   b. Uniform spray pattern ☐ NA ☐ Yes ☐ No
   c. Ponding in media. ☐ Yes ☐ No
   d. Media in need of cleaning. ☐ Yes ☐ No
   e. Additional media needed. ☐ Yes ☐ No
   f. Date of last media replacement:__________________________
   g. Media in need of replacement. ☐ Yes ☐ No
   h. Appropriate maintenance performed. ☐ Yes ☐ No
   i. Animal or human activity at surface. ☐ Yes ☐ No
4. Pressure distribution: ☐ NA
   a. Operating pressure before cleaning
      i) Equal height. ☐ Yes ☐ No
      ii) Height (inches): ______________in
   b. Lateral condition
      i) Needs cleaning. ☐ Yes ☐ No
      ii) Cleaned. ☐ Yes ☐ No
      iii) Method for cleaning:_____________________________
   c. Operating pressure after cleaning
      i) Equal height. ☐ Yes ☐ No
      ii) Height (inches): ______________in
5. Manufacturer required maintenance performed. ☐ NA ☐ Yes ☐ No
   (If 'Yes' attach Manufacturers Inspection form to this report, if supplied.)
6. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:____
   ____
   ____

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

Buried Treatment and Dispersal Systems

These systems are characterized by the fact that they are buried and O&M activities thus present challenges unless inspection ports are present. Descriptions of configurations that fall within this category are included here.

Elevated systems

An elevated system is installed so that the entire infiltrative surface is located above the original ground elevation using suitable imported soil material for fill (Figure 8-14). A variety of dosing and distribution methods (gravity, LPD or drip) may be used. Elevated systems have a final cover of suitable soil which stabilizes the completed installation and supports vegetative growth. The primary focus of O&M activities is the distribution device or method.

Soil substitution

In soil substitution systems, an excavated trench or bed is created to a depth beyond natural restrictive soil layers that inhibit water movement or effluent treatment. The distribution media is installed within an envelope of replacement soil specified by local regulatory requirements. Dosing and distribution may be via pressure or gravity. The primary focus of O&M activities is the distribution device or method.

Amended layer systems

Amended layer systems are designed to target specific wastewater constituents of concern. Native material is excavated to remove existing soil and replaced with one or more layers of material that provide treatment treatment (Figure 8-15). For example, sand overlying Zeolite allows cation exchange for removal of ammonium, metals or other constituents. Sand overlying organic material provides a carbon source for denitrification. The layered materials have specific treatment capacity and require excavation and replacement at some frequency. The primary focus of O&M activities is the distribution device or method and sampling to verify performance. See Figure 8-15 for a rendering of this approach.

Mounds

A mound system is built above the native soil to achieve the required separation distance between the infiltrative surface and the limiting soil condition of the site. A variety of materials can be used for distribution media including gravel, washed stone, plastic chambers or other proprietary media. They are constructed as an elevated system using one to two feet of specified sand (some variation of ASTM C-33 sand criteria). The use of specified sand differentiates a mound from an elevated system, which uses a layer of soil under the distribution components. A top-soil cap, composed of 6 inches of soil, supports vegetation that prevents erosion and gives off moisture through transpiration (Figure 8-16). Mounds incorporate a low-pressure distribution system covered by geotextile fabric. The primary focus of O&M activities is the distribution device or method.

Sand-lined trench

A sand-lined trench system includes trenches excavated through native soil to a depth where acceptable soil conditions are reached (Figure 8-17). The excavation is then backfilled with a specified sand material (some variation of ASTM C-33 sand criteria) followed by a 12-inch washed rock trench and 6 inches of suitable topsoil. They use a variety of distribution methods and have a final cover of suitable soil which stabilizes the completed installation and supports vegetative growth. The primary focus of O&M activities is the distribution device or method.

Combined treatment and dispersal

This category includes proprietary products with American National Standards Institute (ANSI) accreditation. Proprietary distribution media is installed in a sand layer meeting manufacturer specification for quality (some variation of ASTM C-33 sand criteria) and depth. The primary focus of O&M activities is the distribution device or method and sampling to verify performance (Figure 8-18).

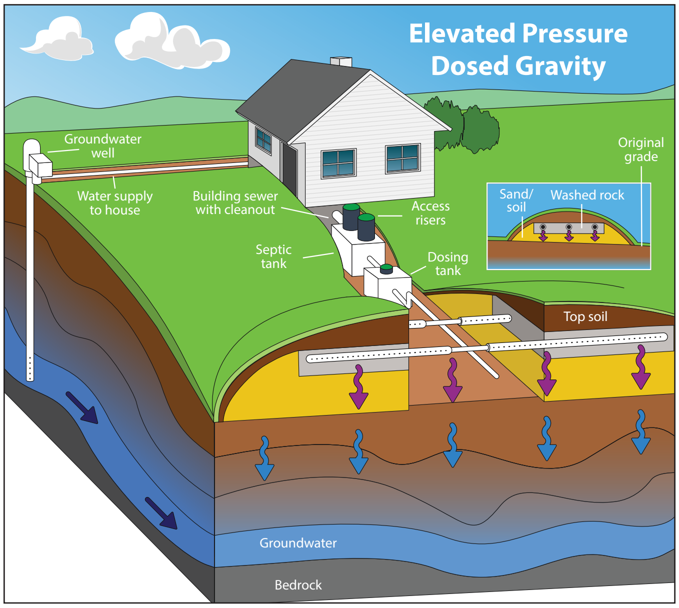

Figure 8-14. Elevated pressure dosed gravity buried treatment and dispersal

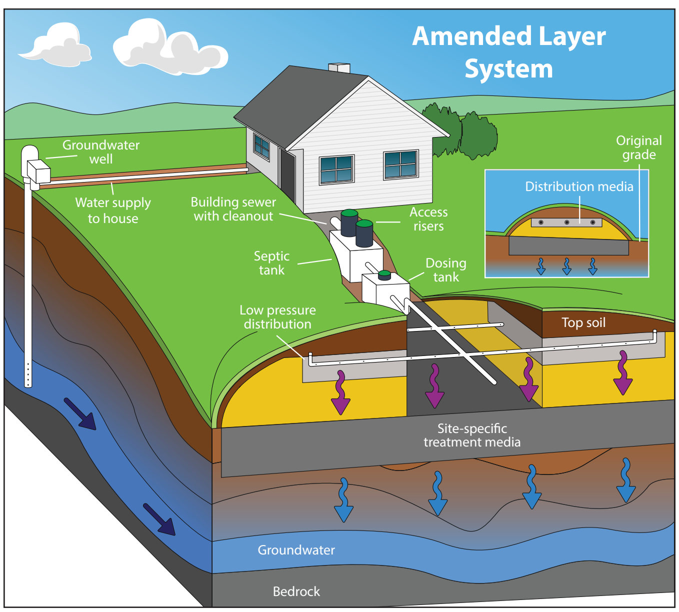

Figure 8-15. Amended layer system buried treatment and dispersal

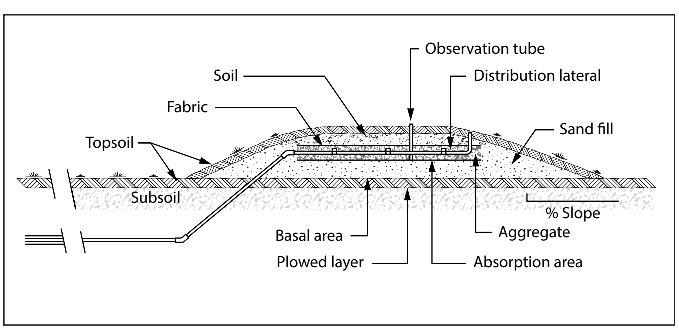

Figure 8-16. A mound system is placed above the natural surface of the ground (profile view).

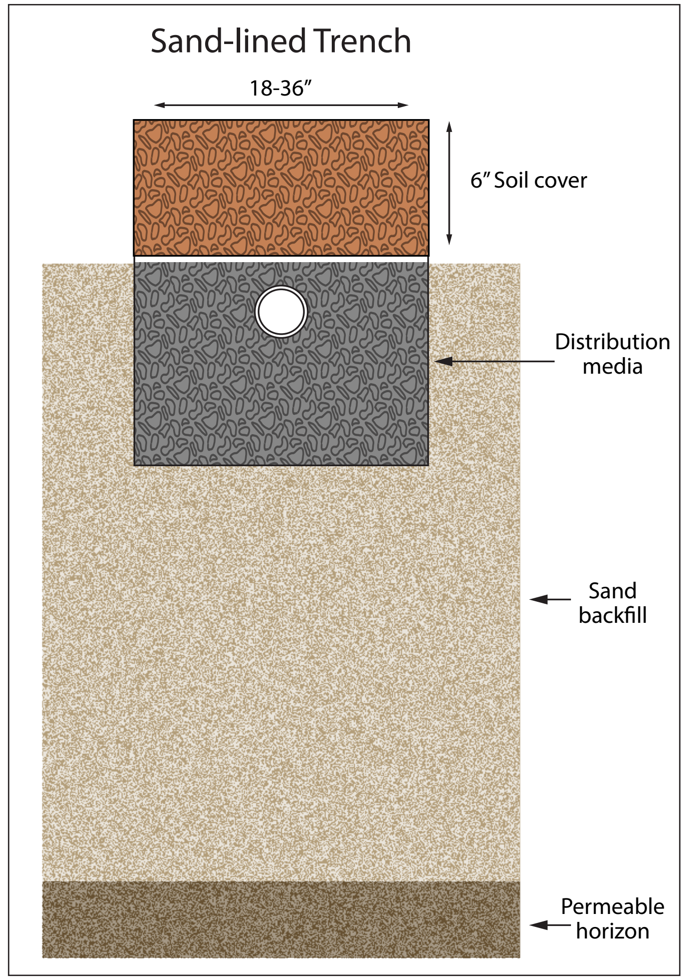

Figure 8-17. Sand-lined trench (cross-section)

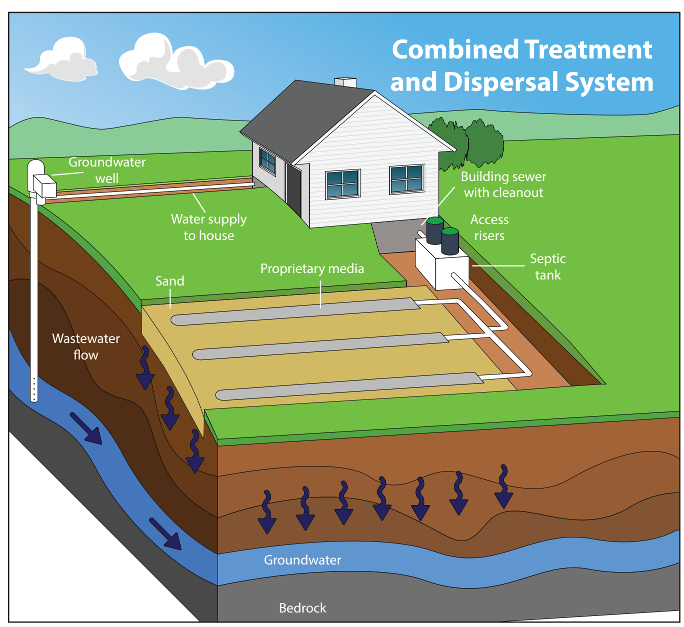

Figure 8-18. Generic treatment train for a combined treatment and dispersal system

Using Form 8-4b: Buried Treatment and Dispersal Systems Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Buried Treatment and Dispersal Systems. The form for documenting inspection points follows the text.

1. Description

Note the type of system in use.

2. Conditions at the STA

Evaluate the presence of odor as you approach the system. There should be no strong odors near the STA if the venting system is operating properly and there is no effluent surfacing. If odors are detected, determine the source by checking for missing caps on inspection ports or damaged lids or risers. Check for leaks around or above the system. Also check the roof vent location, prevailing winds, and atmospheric pressure, as these factors can contribute to odor issues. Note whether odors are mild or strong.

Surfacing effluent around or on the system is unacceptable and indicate that the effluent is not flowing as it should.

Vegetation management on and around the soil treatment area (STA) is important for proper performance. Appropriate vegetation may be defined by local regulations. Typically, appropriate vegetation includes mowed grasses and/or short non-woody plants. During the growing season, grasses help remove moisture from the STA area. However, some water-loving plants with extensive root systems can cause problems with orifice clogging and water distribution in the system. Check for root intrusion into orifices in the lateral line (while snaking and flushing laterals).

3. Media surface

The infiltrative surface of the distribution media in the STA accepts effluent and is the starting point for the treatment processes. Vents and inspection ports to the STA infiltrative surface allow determination of the level of ponding. Note that some systems are designed to encourage some degree of ponding at this interface. Excessive ponding in an elevated system could result in surfacing effluent over or adjacent to the components.

4. Distribution

Distribution systems should evenly distribute wastewater across the top of the STA. Distribution may be achieved via either gravity, pressure-dosed gravity or low-pressure distribution (LPD). Indicate which method is used in the component and the type of device (distribution box, header, or pressure manifold). If the system uses pressure dosed gravity using a manifold, measure and record the operating pressure at the manifold. If a LPD system is used, measure and record operating pressure in the laterals using squirt height or liquid height in a clear PVC tube. The measurement may signal the need to clean laterals.

To flush laterals, open the lateral's distal end and run the pump manually until the effluent is free of accumulated organic matter or debris. Initial flushing of the laterals moves biosolids out of the end of the lateral. Once the accumulated solids (often a "plug") are removed, snaking can occur.

The process of snaking the laterals involves pushing a cleaning device (either a bottlebrush attached to the end of an electrician's or plumber's snake or a small diameter pressure washer nozzle and hose) through each lateral from the distal end. Initial flushing of the laterals moves biosolids to the end of the lateral. Once the laterals are snaked, they should be flushed again to remove any solids that may have been dislodged. Laterals may also be vacuumed out with a pump truck if the orifices are well protected.

If they are cleaned, note the method used. Measuring the operating pressure after cleaning provides insight as to the effectiveness of the method used.

5. Treatment media/natural soil interface

Check for ponding on the surface or seepage at the toe (mound and elevated systems).

6. Inspection ports

Note whether inspection ports are present and intact.

7. Special tasks for amended layer systems

For amended layer systems, note the date that media was installed or last replaced. Media replacement must occur when the design life is exceeded because it is consumed as it processes effluent. If results of effluent sampling indicate a decline in treatment performance, media should be replaced. Service providers should verify permitting requirements (if any) for replacing media.

8. Manufacturer's required maintenance

Manufacturers of specific units may recommend additional maintenance for their products. Perform and document completion of these activities in the comments section.

9. Lab samples

Performance monitoring is conducted by collecting treated effluent from lysimeters located below the designated treatment depth. Lysimeters should be installed before system installation is completed. A suction tube extends from the lysimeter to near the soil surface (protected in a valve box) to facilitate extraction of liquid samples from the buried lysimeter.

If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to the authorized laboratory. Retain signed COC from laboratory to complete system file. Use an authorized laboratory for sample analysis. Report information to the proper entities

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Form 8-4b Operational Checklist: Buried Treatment and Dispersal Systems (BTD)

Service provided on: Date:________________Time:_____Reference #:____________
Service provided by: Company: _______________ Employee:__________________
Date of last service: _________________________ By: ☐ You ☐ Other:_________
Date of last inspection: _____________________

1. Type of system:
   ☐ Mound ☐ Elevated ☐ Soil substitution ☐ Sand lined trench or bed
   ☐ Amended layer system ☐ Combined treatment and dispersal
2. Conditions at the STA site
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ______________________________
   c. Leaks around/above system. ☐ Yes ☐ No
   d. Vegetation appropriate. ☐ Yes ☐ No
   e. Excessive vegetation. ☐ Yes ☐ No
   f. Vegetation maintained. ☐ Yes ☐ No
   g. Preventing access. ☐ Yes ☐ No
3. Media surface
   a. Ponding in media. ☐ Yes ☐ No
   b. Plugged distribution components ☐ Yes ☐ No
4. Distribution
   a. Dosing method
      ☐ Gravity ☐ Pressure dosed gravity
      ☐ Low-pressure distribution (LPD)
   b. Type: ☐ Distribution box ☐ Header ☐ Pressure manifold
      ☐ Other: ____________________
   b. If pressure manifold, operating pressure: ☐ NA
   c. LPD Operating pressure before cleaning ☐ NA
      i) Equal height. ☐ Yes ☐ No
      ii) Height: ____________in
   e. LPD Lateral condition ☐ NA
      i) Needs cleaning. ☐ Yes ☐ No
      ii) Cleaned. ☐ Yes ☐ No
      iii) Method for cleaning:____________________________
   f. LPD Operating pressure after cleaning ☐ NA
      i) Equal height. ☐ Yes ☐ No
      ii) Height: _________inches
5. Treatment media/natural soil interface
   a. Ponding on surface. ☐ Yes ☐ No
   b. Seepage at toe. ☐ Yes ☐ No

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

5. ☐ Acceptable
   ☐ Unacceptable

Reference #:_______________

6. Inspection ports
   a. Present. ☐ Yes ☐ No
   b. Intact. ☐ Yes ☐ No
7. Amended layer systems: ☐ NA
   a. Date of last media replacement:___________________________
   b. Media in need of replacement. ☐ Yes ☐ No
8. Manufacturer required maintenance performed. ☐ NA ☐ Yes ☐ No
   (If 'Yes', attach Manufacturer's Inspection form to this report, if supplied.)
9. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis_______________________________________
   ____
   ____

Notes

7. ☐ Acceptable
   ☐ Unacceptable

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the operating principles of a drip field.
2. Describe the purpose and O&M requirements for the following components in a drip distribution system:
   a. Vacuum breaker
   b. Pressure compensating emitter
   c. Pressure regulator
   d. Field flushing
3. Accurately complete Operational Checklist 8-5 Drip Field (DF).

Description and Mode of Treatment

A drip distribution system delivers small doses of treated effluent to the soil through a system of tubing with flow regulating emitters. The soil accepts the effluent, providing final treatment through removal of contaminants prior to dispersal to the receiving environment.

A complete treatment train consists of six main components (Figure 8-19):

- Treatment device(s)
- Dosing tank
- Pump and controls
- Flow metering device
- Filtration device
- Drip distribution field

The minimum treatment required is a septic tank to settle the solids. Most systems require advanced treatment (Figure 8-20). A dosing tank stores effluent until it is delivered to the field using a high-head pump. Specific activities for these components are discussed in their respective chapters. See Chapter 5 for septic tanks, Chapter 6 for dosing tanks and pump systems and Chapter 7 for advanced treatment components.

Control panels for these systems are typically configured for time dosing to the fields to allow effluent application throughout the day. The panels can also control automatic filter backwashing and field flushing that are unique to these systems. Some systems use demand dosing to the drip fields with a manual filter and field flushing, but this is not recommended.

The effluent is filtered prior to application using a sand filter, disc filter, or screen filter. Filtration removes larger particles that can plug the specialized flow regulating emitters, commonly referred to as drip emitters. Depending on the system design, the filter may have an automatic backwash that activates in response to pressure differential before and after the filter or at a predetermined frequency. The system can also include automatic, manual, and continuous field flushing.

Flow metering allows monitoring of total hydraulic loading to the drip fields. This can be accomplished using a flow meter, or the drip field dosing pump ETM, or cycle/event counter. Flow meters provide a direct measure of flow. Calculating flow based upon ETM and cycle counter readings requires that the service provider determine the dose volume or pump delivery rate. Flow meters can also be used to measure flow rate to the drip fields by recording the volume dosed during a given period. See Appendix A for guidance on mathematical calculations.

The drip distribution system tubing is manufacturer specific but is generally 16 or 17 mm in diameter with emitters in the tubing wall. The pressure inside the tubing is generally operated at 15 to 60 pounds per square inch (psi), with the water exiting the emitter at 0 psi.

A drip field consists of manifolds and runs of drip tubing. Drip tubing is typically placed along the contour to form a run of tubing (which eventually connects to the supply and return manifolds). A run is one drip line along the length of the zone (excluding turns) while the term “lateral” describes the length of tubing (which may include several runs) that extends from the supply manifold to the return manifold. Runs and laterals can be configured in several different ways: A “ladder” configuration results when the supply and return are on opposite ends of the field with single runs (synonomous with ‘laterals’ in this instance) as shown in Figure 8-21(a) extending between the manifolds. In other configurations, laterals may include multiple runs that connect to supply and return manifolds. The manifolds may be located on the same or opposite ends of the lateral (see

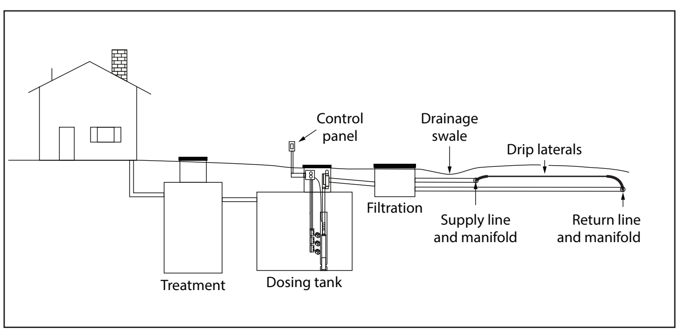

Figure 8-19. Subsurface drip distribution system (profile view)

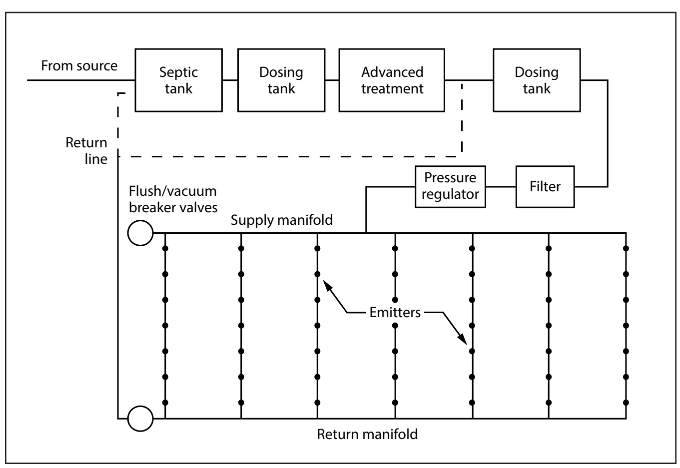

Figure 8-20. Effluent applied to drip distribution systems must at least receive septic tank treatment and advanced treatment is often required.

Figure 8-21(b) and 8-21(c)). Some systems are designed to have multiple zones, each with its own supply and return manifolds. Each manifold includes its own air relief/vacuum breaker (Figure 8-21 and 8-22).

The supply and return manifolds run perpendicular to any slope to facilitate placement of the drip runs along the contour. Effluent in the tubing and manifolds will flow to the lateral at the lowest elevation in a field or individual zones during depressurization. This is known as "draindown". To prevent overloading of laterals at the lowest elevation, designs incorporate features to minimize this outcome. Bottom loading of the supply manifold with check valves after connection to each drip lateral and top exiting return manifold can control draindown. Top loading short supply and return manifolds with small-diameter feeders to the individual drip laterals in the zone can also control draindown.

A given site may require multiple drip zones for efficient effluent distribution. Figure 8-23 is an example of a subsurface drip system layout with two zones on a level site. A switching device is used to direct flow to the fields and may be activated through hydraulic pressure or electrical current. Hydraulic switching valves (also known as sequencing valves) switch to the next zone at the initiation of a dose. An electric switching valve is used to sequentially dose each zone. Check valves at the end of the return manifold allow isolation of the individual zones.

A single return line collects effluent from the individual zones. Effluent (and any accumulated solids) is flushed and returned to the treatment tank or the dosing tank.

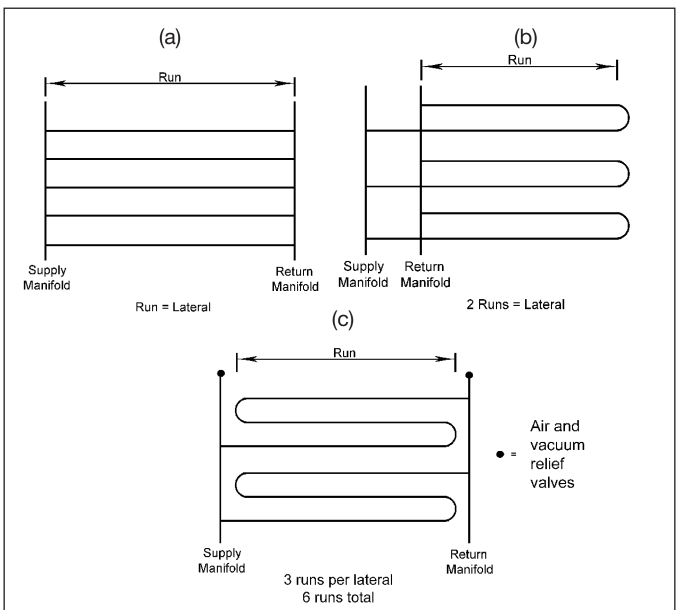

Figure 8-21. Examples of drip distribution field configuration

Air/vacuum relief valves are used to purge air during pressurization of the distribution network. When the pump deactivates, the valves open automatically to allow air entry. Air/vacuum relief valves must be placed in all zones at the highest point and be protected from damage and freezing. Valve boxes not only protect them but also provide void space for air exchange.

Service providers should consult the manufacturer of specific drip systems for recommendations and guidance.

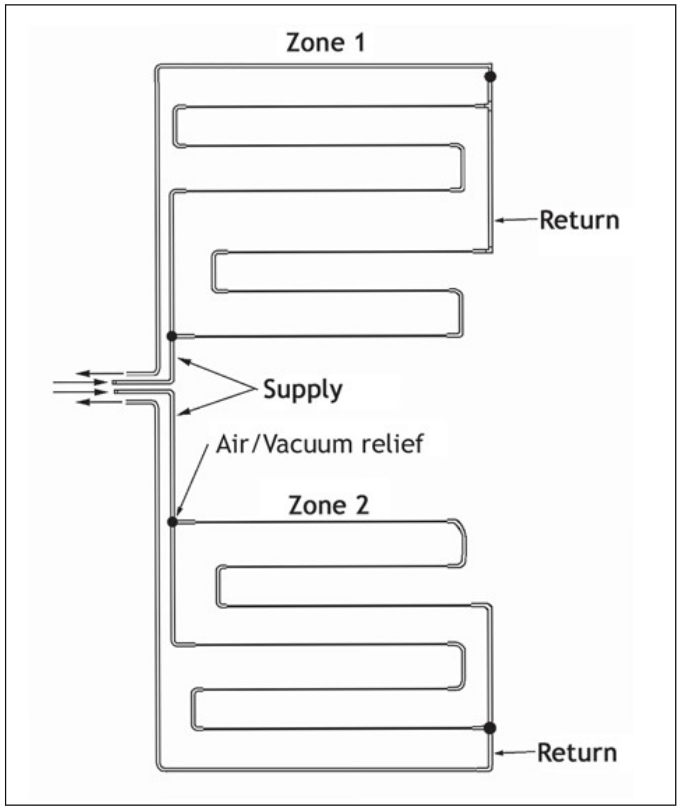

Figure 8-22. Subsurface drip field layout with two zones, each with looped lines, multiple laterals connected to its own supply and return manifold (plan view)

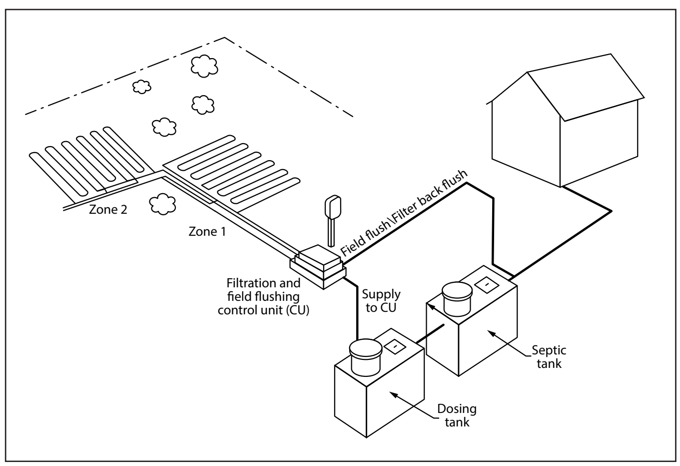

Figure 8-23. Two-zone drip distribution system on a level site

Using Form 8-5: Drip Field STA Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Drip Field Soil Treatment Areas. The form for documenting inspection points follows the text.

1. Conditions at the drip distribution field

Evaluate the presence of odor as you approach the system. There should be no strong odors if the venting system is operating properly and there are no breakouts. If odors are detected, determine the source by checking for missing caps on inspection ports or damaged lids or risers. Check for any indication of surfacing effluent around or above the system. If drip tubing is damaged, the high pressure in the system will result in localized heavy loading of effluent in the soil. Also check the roof vent location, prevailing winds, and atmospheric pressure, as these factors can contribute to odor issues. Note whether odors are mild or strong.

Vegetation management on and around the soil treatment area (STA) is important for proper performance. Appropriate vegetation may be defined by local regulations. Typically, appropriate vegetation includes mowed grass and woody plants. Drip fields can be used in areas with trees and other woody vegetation. During the growing season, grasses established on and around the system absorb moisture from the STA.

Evaluate vegetation in the field for uniformity of growth. The growth pattern of the vegetation can give indications of water and nutrient distribution. Changes in the vegetation patterns can indicate problems so tracking trends is important.

2. Drip filters

Filtration can be accomplished with a variety of filters: sand, screen, and disc. Note which type of filter is used. For disc filters and screens, make sure they are present in the filter holder and have not been removed. Check the operating pressure before and after the filter(s) to determine the level of plugging.

Remove and clean filters during each maintenance visit or as indicated by the manufacturer's specifications. This can be accomplished by washing the filter with water or water containing a disinfectant. Some service providers carry replacement filters that are exchanged with the current filters. The dirty filters are then placed in water containing disinfectants or a plastic bag for transport to their shop and are later cleaned when the filter has been disinfected. Automatic cleaning operations backwash the filters to remove debris. Cycle the system manually to verify operation of the automatic backwashing filter. Systems that require manual cleaning filter systems usually have a bypass valve on the bottom of the filter to return solids-laden liquid back to the pretreatment component. After cleaning the filter, confirm that the bypass valve is in the correct position for normal operation.

If the filter is protected in a housing, note whether it is insulated. If a heater is present, verify that it is operational.

3. Effluent flow metering

It is important to assess the average daily volume delivered to the drip field in gallons per day (to compare to design) as well as the pump delivery rate (PDR) in gallons per minute (to assess orifice plugging).

To assess loading (GPD), record the totalized flow on the meter and compare the figure to a previous reading on a known date. Divide the total flow by the interval in days to calculate average daily loading. Alternatively, use pump operational data (cycle counters and elapsed time meters) to determine average daily flow. This information should be recorded on Form 6-3 where the operational status of the time dosing system was assessed.

To calculate the pump delivery rate (GPM), run the pump for a specified period. If a flow meter is present, record initial and final readings. Divide the difference between the figures by the run time to calculate the PDR. Without a meter, simply conduct a drawdown test by running the pump for a specified period (or for one cycle) and measuring the elevation of the effluent before and after the test. (NOTE: The specified time should allow for full pressurization of the system. A pressure gauge can be used to verify that this has been accomplished. Generally, a runtime of four or five minutes is sufficient.) Note how long (in minutes) the pump ran during this test. Once you know how many inches the liquid level dropped when you ran the pump, you can calculate the volume pumped using the tank's dimensions and calculated gallons per inch (GPI; see Appendix A).

Using the measurements, GPM is calculated thus:

$$\text{Inches pumped} = \text{Pump OFF elevation (in)} - \text{Pump ON elevation (in)}$$

$$\text{Gallons pumped} = \text{Inches pumped} \times \text{Gallons/inch in tank}$$

$$\text{Gallons per minute (GPM)} = \text{Gallons pumped} \div \text{Minutes run time}$$

Compare the pump delivery rate to previous values to determine the extent of emitter plugging. Consult manufacturer specifications for guidance.

4. Switching valves

Switching valves are used to automatically divert the flow of effluent to another field (zone) or a different part of the field. Record the type of switching valve used and verify operation by observing whether zones are dosed sequentially when you initiate a series of manual doses. Note whether any maintenance is performed on the switching or sequencing valve.

5. Field flushing

Field flushing can be accomplished manually, automatically, or continuously. Evaluate the operation of the flushing system by triggering a field flushing event and confirming return flow.

Check the operating pressure in the drip fields to provide an estimate of hydraulic conditions. Check the pressure on the return line at the filtration area. Conduct a field flushing event. Record readings from either an elapsed time meter (ETM) or a cycle counter (CC). Record the present and last flushing time reading (PFTR/ LFTR) or the present and last flushing cycle reading (PFCR/LFCR).

Compare elapsed time meter and cycle/event counter readings at the time of the visit with previous readings to determine number of flushes and total field flush time.

6. Zone operation

Note which zones are in service. The flow should be evaluated for the total flow and flow rate entering each zone. Evaluate the air/vacuum relief valve to ensure operation. Verify that air/vacuum relief valves do not leak effluent once the system pressurizes. If they do, they must be replaced or serviced. Check for excess water or wet areas in the field indicating that effluent is surfacing. Drip tubing can be cut by poking metal objects into the soil. A cut in the tubing will allow excess water to be emitted.

Determine whether check valves are operating properly by comparing flow rate in each zone to design or previous values for that zone. The zone with the correct flow rate for its configuration will tend to be the zone with the failed check valve. The rest will show higher flow and lower pressure.

7. Manufacturer's required maintenance performed

Manufacturers of specific units may recommend additional maintenance for their products. Perform and document completion of these activities in the comments section.

8. Lab samples

If sampling is needed to satisfy regulatory, manufacturer or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to an authorized laboratory. Retain the signed COC from the laboratory to complete the system file. Report the information to the proper entities.

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Form 8-5 Operational Checklist: Drip Field STA (DF)

Service provided on: Date:________________ Time:_____ Reference #:____________
Service provided by: Company: ________________ Employee:____________________
Date of last service: ___________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ________________________

1. Conditions at the drip distribution field
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ____________________________
   c. Leaks around/above system ☐ Yes ☐ No
   d. Vegetation appropriate for climate ☐ Yes ☐ No
   e. Excessive vegetation ☐ Yes ☐ No
   f. Vegetation maintained ☐ Yes ☐ No
   g. Preventing access ☐ Yes ☐ No
2. Drip filter
   a. Type of filter:
      ☐ Sand ☐ Screen ☐ Disc ☐ Other: ______________
   b. Filter in place. ☐ Yes ☐ No
   c. Pre-filter pressure: ______________ psi
   d. Post-filter pressure: ______________ psi
   e. Filter: ☐ Cleaned ☐ Replaced
   f. Automatic cleaning operational. ☐ NA ☐ Yes ☐ No
   g. By-pass flow operating. ☐ NA ☐ Yes ☐ No
   h. Housing insulated. ☐ NA ☐ Yes ☐ No
   i. Heater pad operational. ☐ NA ☐ Yes ☐ No
3. Effluent flow metering
   a. Flow meter:
      Present (PFR): ________gal Date:_________
      Last (LFR): ________gal Date: _________
      Differential ([PFR – LFR] / days):____________________
      ________GPD Days:_________
4. Switching valves
   a. Switching valve present. ☐ Yes ☐ No
   b. Type of valve:______________________________
   c. Operating properly. ☐ Yes ☐ No
   d. Action taken if not:__________________________
   e. Zones in operation: __________________________

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

Reference #:______________

5. Field flushing: ☐ None ☐ Manual ☐ Automatic ☐ Continuous
   a. Operational. ☐ Yes ☐ No
   b. Field flushing operation:

Zone	Manually Flushed Zones	Operating Pressure (psi)		Zone Flushing				Field Dosing			
		Dosing	Flushing	ETM		CC		ETM		CC	
				PFTR	LFTR	PFCR	LFCR	PFTR	LFTR	PFCR	LFCR

6. Zone operation:

Zone #	In service Yes/No	Flow Rate (GPM)	Total Flow (gal) *(since last visit)*	Air/Vacuum relief operating	Surfacing Effluent

Notes

6. ☐ Acceptable
   ☐ Unacceptable

7. Manufacturer's required maintenance performed. ☐ Yes ☐ No
   (If 'Yes' attach Manufacturer Inspection form to this report, if supplied.)
8. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:____
   ____

ABBREVIATIONS
CC- cycle counter
ETM- elapsed time meter
GPM- gallons per minute
LFCR- last flushing cycle reading
LFR- last flow meter reading
LFTR- last flushing time reading
PFCR- present flushing cycle reading
PFR- present flow meter reading
PFTR- present flushing time reading
psi- pounds per square inch
TT- total time

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the operating principles of a spray distribution system.
2. Describe the purpose and O&M requirements for the following components in a spray distribution system:

   a. Sprinkler heads
   b. Zone valves
   c. Vegetation

3. Accurately complete Operational Checklist 8-6 Spray Field (SF).

Description and Mode of Treatment

Spray distribution systems are much like a lawn sprinkler system except they are used to apply treated effluent over the ground surface. Surface application of effluent is a high-risk system. Effluent applied to a spray field must be highly treated because of the risk of human contact. The minimum treatment required is a septic tank to settle the solids, advanced treatment and a disinfection component to reduce pathogens. A dosing tank stores effluent until it is delivered to the field using a high-head pump (Figure 8-24).

A spray distribution system has five primary components (Figure 8-25):

- **Supply line,** which carries effluent from the pump discharge assembly to the manifold. In systems with multiple zones, a switching valve is placed at the end of the main supply line and diverts flow to multiple submains.
- **Manifold**, which carries effluent from the main supply line or submain to laterals.
- **Laterals**, which are connected to the manifold and convey a component of the flow to sprinkler heads.
- **Risers**, which connect the lateral to the sprinkler heads.
- **Sprinkler heads**, which connect to the riser and distribute effluent over the ground surface.

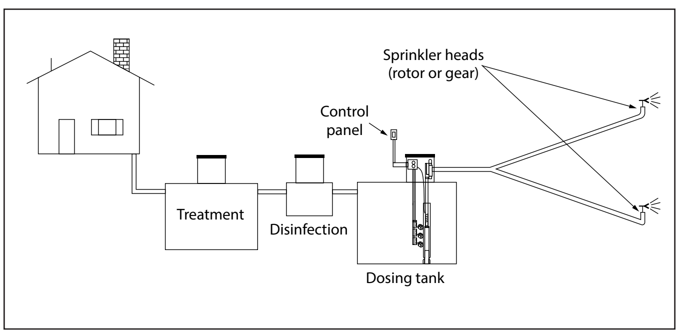

Figure 8-24. Spray distribution system (profile view)

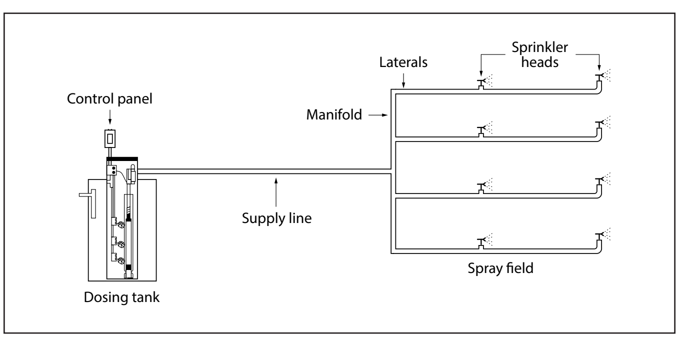

Figure 8-25. Components of a spray distribution system

The components of the spray field should be properly sized to uniformly distribute treated effluent on the ground surface. The main supply line, submains, manifold, laterals, and risers are constructed of PVC pipe. The PVC pipe should be purple in color to denote conveyance of reclaimed water. Non-residential systems can have these components constructed of steel or aluminum piping. Several types of sprinkler heads are used to apply water and include rotor heads, impact heads, and spray heads. Designers will specify a specific type of head for use in the system. These sprinkler heads can be a solid set device or constructed with a retractable sprinkler head and thus operate in a pop-up mode.

The sprinkler heads are connected to the lateral using a riser. The riser can be a solid rigid pipe extending from the lateral to the sprinkler head located above grade. The riser can alternately be constructed using flexible piping to allow greater ability to set the sprinkler head location and ease of repair (Figure 8-26). There are three options for flexible connections:

- A swing joint consisting of flexible PVC piping and connection;
- A flexible nipple with multiple threaded sections cut to a length that places the sprinkler head at the soil surface; or
- A flexible connection using flexible pipe as a riser.

Flexible piping allows adjustment of the elevation of the sprinkler head relative to the ground surface and can reduce the time and effort associated with repairs. A sprinkler head and riser can be broken due to landscape maintenance. Lawn mowers, people, and animals can move sprinkler heads and break nonflexible components. The repair of broken risers can be difficult if the lateral fitting is broken. These flexible risers will generally break before the lateral and fittings are damaged.

Because of the potential for human contact with wastewater, a spray distribution system must treat the wastewater to a very high quality before spraying it onto the landscape. This system must treat the effluent to “secondary-quality effluent,” which typically means 85-

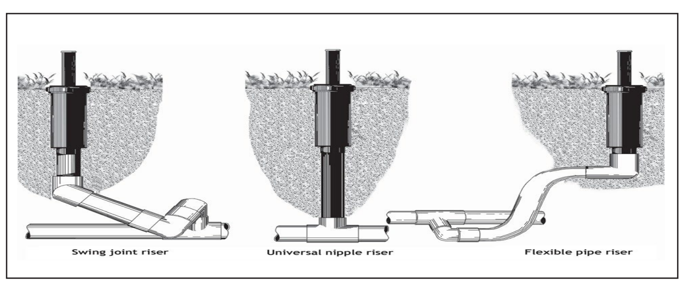

Figure 8-26. Riser options for connecting sprinkler heads to laterals (profile view)

98 percent solids and organic matter removal as well as disinfection to reduce pathogens. Effluent must be treated so that BOD_5 is less than 30 parts per million (ppm) and TSS concentration is less than 30 ppm (depending on local and state regulations). To ensure pathogen reduction, measure chlorine residual level in the dosing tank (for chlorination systems) or perform a microbial test for the presence of indicator organisms at acceptable levels (UV and ozone systems).

Although the effluent is relatively clean when it meets these standards, it can still contain nutrients such as nitrogen and phosphorus. Some advanced treatment systems may also remove these nutrients. Spray distribution systems rely on the soil for final treatment. The soil must be able to support vegetation that uses the nutrients in the wastewater. Plants use nitrogen and phosphorus in the effluent, preventing those nutrients from leaching to groundwater or flowing into surface water supplies.

Regulations may require that the system be designed to handle the greatest amount of wastewater expected, even during the wettest season of the year, without it flowing onto neighboring properties. Therefore, in the driest times of the year, there may not be enough water to meet all the water requirements of the vegetation. Landscapes that require a lot of water will need supplemental irrigation.

Using Form 8-6: Spray Field STA Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Spray Field Soil Treatment Areas. The form for documenting inspection points follows the text.

1. Conditions at the spray distribution field

Evaluate the presence of odor as you approach the system. If odors are detected, determine the source by checking for missing caps on inspection ports or damaged lids or risers. Check for any indication of leaks around or above the system. Also check the roof vent location, prevailing winds, and atmospheric pressure, as these factors can contribute to odor issues. Note whether odors are strong, mild, or septic (rotten eggs) in nature.

Vegetation management on and around the soil treatment area (STA) is important for proper performance. Appropriate vegetation may be defined by local regulations. Typically, appropriate vegetation includes mowed grasses and/or short non-woody plants. Tall plants near the sprinkler heads can obstruct the spray pattern and cause problems with effluent distribution. Vegetation should not restrict access for maintenance. During the growing season, grasses help remove moisture from the STA. Supplemental irrigation may be required during periods of low precipitation if vegetation is compromised.

2. Distribution approach

Distribution can be accomplished with single or multiple zones. Record the number of zones in the system.

3. Switching valves

Switching valves are used to automatically divert the flow of effluent to another field or a different part of the field. Record the type of switching valve used and verify operation. Note whether any maintenance is performed.

4. Site conditions

Check the conditions at the spray distribution site. Purple color coding of components is a universal designation of parts and devices marketed for use in reclaimed water systems. The sprinkler heads, valve boxes, and piping should display purple coloring. Some jurisdictions may require signage or fencing to raise awareness regarding reclaimed water distribution or limiting access. If the jurisdiction requires these items, verify their presence.

5. System operating pressure

Record the operating pressure of the distribution system. This information can be measured at the discharge assembly of the pump or at the sprinkler heads. However, due to the risk of contact with the effluent, this is more safely measured at the discharge assembly. Note the location of the operating pressure reading.

Sprinkler heads generally have a droplet size and operating pressure relationship. Greater operating pressures generally result in smaller droplet sizes. These smaller droplets can easily drift outside the dispersal field on wind currents. An operating pressure of less than 40 psi will generally prevent the water droplets from becoming too small and subsequently reduce the risk of spray drift.

6. Control panel

Verify that all components control panel components are operating properly. If a timer, photocell, or rainfall shutoff are present, manually test the components to assess proper operation. Some panels include a rainfall shutoff function as well.

In areas subject to freezing conditions, heat trace and insulation should be included to protect the distribution components. A thermostat control energizes the heat trace below a specified temperature. Verify the thermostat setting. Turn the setting above the current ambient temperature to verify proper operation of the heat trace. Reset the thermostat after testing.

7. Sprinkler head operation

Some sprinkler heads have low-pressure shutoff valves to prevent lateral line drainage from exiting the lowest head. In-line filters in the sprinkler heads prevent solids from clogging the nozzle. These filters may need to be cleaned to remove debris. The sprinkler heads may require adjustment to achieve the proper distribution pattern, or the head may be worn-out and require replacement. Pop-up heads need to have a clear area around the sprinkler head to prevent debris from catching in the head as it retracts.

Verify that all sprinkler heads are operating. Verify if the heads are in single zone or multiple zones. Verify the number of heads and whether they are operating in a low angle mode. The distribution pattern should be verified with respect to the design. Sprinkler heads are operated in either a full circle or partial circle pattern. This pattern is generally noted by the degrees of a circle with 360°, 180°, and 90° being a full circle, half circle, and quarter circle, respectively.

Note the type of sprinkler head in use. Options include a rotor, impact, or spray head. Low pressure drains are usually only needed in colder climatic regions to prevent static water in the risers. Lines can be drained back to the dosing tank, or individual risers may have a localized drain. The riser must remain intact to convey effluent to the sprinkler head. Some systems will have protective devices placed around the riser to limit access to the riser and sprinkler head. Note the status of the riser.

8. Zone operation

Evaluate the operational conditions in each zone of the dispersal field. Note any erosion on the dispersal field since it can indicate concentrated water flow across the field. Look for areas where effluent is ponding on the ground surface or signs of runoff. Vegetation must be present to use moisture and nutrients. The presence of excessive vegetation around the sprinkler heads can cause uneven distribution. Wet areas around sprinkler heads could be caused by tall vegetation or slow drainage after the system turns off. Trees or shrubs within ten feet of the sprinkler heads can disrupt the spray pattern resulting in uneven distribution. Gardens are generally not allowed in the spray distribution field.

9. Manufacturer's required maintenance performed

Manufacturers of specific units may recommend additional maintenance for their products. Perform and document completion of these activities in the comments section.

10. Lab samples

If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to an authorized laboratory. Retain the signed COC from the laboratory to complete the system file. Report the information to the proper entities.

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Form 8-6 Operational Checklist: Spray Field STA (SF)

Service provided on: Date:________________Time:_____________ Reference #:________
Service provided by: Company: _________________ Employee:______________________
Date of last service: ____________________________ By: ☐ You ☐ Other:____________
Date of last inspection: _________________________

1. Conditions at the spray distribution field
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: _________________________________
   c. Leaks around/above system ☐ Yes ☐ No
   d. Vegetation appropriate ☐ Yes ☐ No
   e. Excessive vegetation ☐ Yes ☐ No
   f. Vegetation maintained ☐ Yes ☐ No
   g. Preventing access ☐ Yes ☐ No
2. Distribution approach
   a. Zones: ☐ Single ☐ Multiple: #___________________________
3. Switching valves
   a. Switching valve present. ☐ Yes ☐ No
   b. Type of valve:____
   c. Operating properly. ☐ Yes ☐ No
   d. Action taken if not:______________________________
   e. Zones in operation: ______________________________
4. Site conditions
   a. Color coded ☐ Yes ☐ No
   b. Signage present ☐ NA ☐ Yes ☐ No
   c. Fencing present and secure ☐ NA ☐ Yes ☐ No
5. System operating pressure: ____________ psi
   a. Location of pressure reading: ____________________________
6. Control panel
   a. Timer operating properly. ☐ NA ☐ Yes ☐ No
      i) Timer settings: ON __________________min
      OFF _________________ min
   b. Photocell functioning. ☐ NA ☐ Yes ☐ No
   c. Rainfall shutoff functioning. ☐ NA ☐ Yes ☐ No
   d. Freeze protection operational ☐ NA ☐ Yes ☐ No
7. Sprinkler head operation
   a. Low-pressure shutoff valve. ☐ NA ☐ Yes ☐ No
   b. In-line filter cleaned. ☐ NA ☐ Yes ☐ No
   c. Heads in proper adjustment. ☐ Yes ☐ No
   d. Pop-up heads retract. ☐ NA ☐ Yes ☐ No

Notes

1. ☐ Acceptable ☐ Unacceptable

3. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

6. ☐ Acceptable ☐ Unacceptable

7. ☐ Acceptable ☐ Unacceptable

Reference #:______________________

e. Sprinkler head operation summary:

Zone	Low Angle Nozzle	Pattern		Operation (Impact, Rotor, Spray)	Low-Pressure Drain	Riser Intact
		Current Pattern	Designed Pattern			

8. Zone operation:

Zone	Erosion	Wastewater Runoff	Ponding	Vegetation	
				Does not disrupt spray pattern	Type

9. Manufacturer's required maintenance performed. ☐ Yes ☐ No
   (If 'Yes' attach Manufacturer Inspection form to this report, if supplied.)
10. Lab samples collected for monitoring. ☐ Yes ☐ No
    Types of analysis:______________________________________
    ____
    ____

ABBREVIATIONS
psi - pounds per square inch

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the operating principles of outfalls.
2. Accurately complete Operational Checklist 8-7 Outfalls (OS).

Overview

Outfalls are used after highly treated effluent has been generated by advanced treatment systems. These systems utilize a discharge pipe delivering the wastewater directly to a waterway, road ditch, or the ground surface on the property. ***These are considered high-risk systems because of the possibility for human contact.***

Using Form 8-7: Outfalls Operation and Maintenance

The text below describes inspection criteria for evaluating performance of Outfalls. The form for documenting inspection points follows the text.

1. Type of outfall

Note the source of water exiting the outfall. Some treatment components have a built-in overflow to protect the structure, such as a lagoon. Other treatment systems have an outfall for final treatment and dispersal.

The flow exiting the outfall can gravity flow from the component or be collected in a dosing tank and be pumped to the outfall. Note the type of flow delivery.

2. Discharge effluent condition

There should be no strong odors near the outfall. If there is an odor present, note whether the odor is strong, mild, or septic in nature, and determine the source of that odor.

Effluent exiting the outfall should be noted. Some outfalls only discharge during wetter weather conditions. Indicate the rate of discharge, whether it is dripping, trickling, or flowing. A visual inspection of the discharging effluent should be conducted to evaluate the presence of residual solids in the effluent. The discharged effluent may be a location for animals and/or vectors (e.g., mosquitoes, flies) to gather or grow. A visual inspection of the condition of the discharged effluent should be conducted. The presence of animal activity or the identification of vectors living and growing in the discharged effluent should be noted.

3. Outfall structure

The outfall structure outlet should be free of obstructions. There should be no vegetation blocking the outlet, which could cause plugging and backing up of the system. There should be no erosion around the outlet pipe. If erosion is present, an erosion control plan should be considered. The pipe should not be crushed or broken. Record if any maintenance on the outfall structure was needed and when it was completed.

4. Lab samples

If sampling is needed to satisfy regulatory, manufacturer, or designer O&M requirements, collect, preserve, transport, and store samples using standard wastewater procedures. Record chain of custody (COC) information for delivery with the sample to the authorized laboratory. Retain signed COC from laboratory to complete system file. Use an authorized laboratory for sample analysis. Report information to the proper entities.

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Form 8-7 Operational Checklist: Outfall (OS)

Service provided on: Date:________ Time:__________ Reference #:______________
Service provided by: Company: ________________ Employee:__________________
Date of last service: ________________________ By: ☐ You ☐ Other:_________
Date of last inspection: ______________________

1. Type of outfall
   a. Treatment component:
      ☐ Lagoon ☐ Media filter ☐ Aerobic treatment unit
   b. Flow delivery: ☐ Gravity flow ☐ Pumped flow
2. Discharge effluent condition
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ______________________________
   c. Evidence of discharge. ☐ Yes ☐ No
   d. If evidence of discharge, describe status: ☐ Current ☐ Previous
   e. If current discharge, describe rate of discharge:
      ☐ Dripping ☐ Trickling ☐ Flowing
   f. Residuals in discharging effluent. ☐ Yes ☐ No
   g. Animal or vector activity in discharged effluent. ☐ Yes ☐ No
3. Outfall structure
   a. Outlet unobstructed. ☐ Yes ☐ No
   b. Vegetation maintenance necessary. ☐ Yes ☐ No
   c. Erosion around outlet pipe. ☐ Yes ☐ No
   d. Outlet protected from animal activity. ☐ Yes ☐ No
   e. Discharge pipe in good condition. ☐ Yes ☐ No
   f. Maintenance completed. ☐ Yes ☐ No
4. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:_______________________________________
   ____
   ____

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

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9 | Troubleshooting

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe how to use basic troubleshooting skills to identify the root cause of deviations from normal operational conditions.
2. Identify the potential root causes of solids carry over in treatment systems.
3. Describe methods to troubleshoot for hydraulic and organic loading to treatment components.
4. Identify proper procedures to characterize effluent quality in wastewater treatment systems.
5. Accurately complete Residential Survey using Form 9-3 (RS).
6. Identify pump operational data indicating a change in hydraulic loading or need for component maintenance.

Introduction

This chapter describes basic approaches to troubleshooting onsite wastewater treatment system components. Troubleshooting requires extensive knowledge, skills, and abilities to effectively evaluate system components and determine the root causes of malfunction. This introduction to troubleshooting is intended to support this training program by delineating how information collected through routine operation and maintenance service visits is critical to supporting system troubleshooting to improve performance or correct unacceptable conditions.

The basic troubleshooting information in these training materials is shared to develop the following skills:

- Use basic troubleshooting practices during regular operational evaluations.
- Recognize conditions that warrant additional investigation.
- Identify specific causes of problems and potential solutions.
- Collect information to communicate system status while seeking outside assistance.

9a Root Causes of System Malfunction

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Identify the potential root causes of solids carry over in treatment systems.
2. Describe methods to troubleshoot for hydraulic, organic, and nutrient loading to treatment components.
3. Explain causes of microbial inhibition within a treatment train.
4. Describe methods to manage water movement within and near the soil treatment area (STA) for optimal treatment and dispersal.

Overview

Identifying the root cause of system malfunction is the first step to effective problem resolution. Dispersal of effluent with minimal solids is a fundamental and essential objective in every system. Each system is designed to process a specific hydraulic, organic and nutrient load. Excessive amounts of any of these loads can result in solids moving downstream. When this occurs, the most basic assessment is evaluating the presence of solids in downstream components: dosing tank, distribution box, media filter surface, distribution piping, STA components. Solids carry-over results when one or more of the following conditions develop in the system: excessive hydraulic, organic or nutrient loading or microbial inhibition. Evaluating these conditions in treatment components may reveal the root cause of malfunction and lead to resolution. It may be necessary to specifically investigate the STA if conditions point to problems with liquid movement through various boundaries in the final treatment and dispersal component.

The succeeding discussion of troubleshooting methods is very basic. It provides more detail on hydraulic, organic and nutrient loading issues and describes associated investigative techniques. Although there is an introductory discussion of potential remedies, it should not be considered an exhaustive list.

Potential Root Causes for System Malfunction

Hydraulic loading

The rate of effluent flow through the treatment system must provide sufficient detention time for treatment processes to occur. Sedimentation and clarification are critical to reducing the suspended particulates in effluent and excessive hydraulic loading will disrupt the processes. The timing and duration of excessive hydraulic flow events may occur daily (gallons per day or GPD), hourly (gallons per hour or GPH) or as a peak instantaneous flow (gallons per minute or GPM).

The service provider can assess the effluent volume passing through the system with respect to the design hydraulic capacity of treatment components. A water meter reading or pump operational data provides clues regarding the hydraulic loading. Periodic data recording provides an estimate of average hydraulic loading (daily and perhaps hourly) while continuous recording of data can facilitate identification of peak instantaneous flows. In the absence of system operational data, the service provider must consider interviewing the user to determine if peak flow events have occurred since the last service visit.

The service provider should assess the water tightness of the tanks and risers to determine whether infiltration implicates weather events (e.g., heavy rainfall or snowmelt) as the cause of excessive flow recorded through system monitoring. If flow from the source is the problem, educate the owner regarding leaking fixtures, investigate the use of low-flow fixtures and alteration of water use habits (e.g., spreading laundry loads).

Organic loading

An organic overload can result from current organic content in the waste stream or an accumulation of solids in the treatment train. The organic loading is a result of the addition of digestible carbon material [BOD, TSS and fats, oils, and grease (FOG)] to the treatment system.

Although actual organic loading can be measured via laboratory analysis, preliminary onsite measurement of dissolved oxygen (DO) concentration of the effluent and sludge accumulation in the treatment train provides valuable information.

Measure the amount of dissolved oxygen (DO) in effluent from an advanced treatment component. The effluent DO concentration indicates whether there is sufficient oxygen available for aerobic treatment processes. Optimal DO can vary according to the treatment system configuration. For a submerged aeration system DO should be greater than 2.0 mg/L. If DO levels are low, verify function of aeration components or consider adjusting the circulation ratio (see Chapter 9D).

Assess the sludge storage capacity in the treatment unit by measuring the amount of accumulated sludge in bottom and floating scum in the liquid using a profile probe (clear tube). Generally, a septic tank with accumulated scum and sludge exceeding 33% of capacity is considered full and should be pumped. Additionally, if excess solids accumulate near the outlet baffle, they may pass out of the tank with high flows.

Measure biomass of a sample from the aeration chamber of a suspended growth treatment process using a 30-minute settleability test. Alternatively, perform a microscopic evaluation of food to microorganism ratio (F:M) on a sample from the aeration chamber.

If DO, settleability and sludge capacity are within acceptable ranges, the next step is to sample and analyze effluent entering and exiting the treatment component for BOD_5 to determine overall organic removal through the treatment system. Calculate organic mass loading before and after a treatment process using the BOD_5 concentration and hydraulic loading in gallons per day (gpd). The organic removal rate is the difference between the influent and effluent values. If the organic mass removal rate matches the design specification or manufacturer recommended value, the treatment unit is operating as expected from the perspective of organic load reduction.

Nutrient loading

Excessive levels of nutrients (typically nitrogen and phosphorus) may compromise the treatment capacity of the system. Examples include waste streams composed of mostly urine (event venues, houses of worship, bars and taverns). Also, facilities that use excessive amounts of cleaners (quaternary ammonium compounds or straight ammonia) such as clinical facilities, or short-term accommodations like hotels, motels, and residential rental properties where occupancy turnover results in frequent and robust cleaning activities that generate wastewater that is high in N and P.

If nitrogen reduction is inadequate, evaluate the treatment environment for deviations from optimal parameters. Perform onsite analyses of temperature, pH and oxygen levels. Temperatures below about 50 degrees could inhibit nitrification and denitrification processes. The pH should be close to 7.0, which is considered neutral. Acidic conditions (pH below 6.5) may inhibit the nitrification process. Carbonate addition may be needed to facilitate nitrification. Optimal DO concentration for nitrification is greater than 2.0 mg/L and for denitrification, less than 0.3 mg/L.

Calculate nutrient mass loading of nitrogen species (nitrate, ammonium, or total nitrogen) before and after a treatment process using the laboratory results of effluent sampling and hydraulic loading in gallons per day (gpd). Species used to calculate the nutrient mass loading depends upon the target of the troubleshooting investigation: whether process optimization or system performance. If the nutrient mass removal rate matches the design specification or manufacturer recommended value, the treatment unit is operating as expected from the perspective of nutrient loading.

Phosphorus removal typically occurs in soil with adequate adsorption sites. Excessive phosphorus loading or soils with limited adsorption capacity can result in phosphorus breakthrough. Media used in phosphorus reduction technologies must be periodically replaced to maintain performance.

Microbial inhibition

A robust microbial population provides significant treatment capacity to reduce contaminants of concern in wastewater. Microbial activity can be inhibited by fluctuations in the following:

- Temperature
- pH
- Oxygen state
- Chemical concentrations
- Presence of medications or strong disinfectants
- Low or excessive nutrient composition

Perform onsite analyses for the first three parameters and laboratory analyses for the last three.

Temperatures between 68- and 95-degrees F are optimal for reducing organic loading. Lower temperatures suppress microbial population and organic biomass will accumulate. Higher temperatures allow FOGs to remain suspended in the effluent, potentially overwhelming the microbial population and moving downstream. Optimal DO concentration for microbial reduction of organic loading and for nitrification is greater than 2.0 mg/L and for denitrification, less than 0.3 mg/L.

Potential fixes include:

- Adjust temperature of incoming wastewater
- Insulate tanks and piping
- Add ventilation
- Add carbonate to adjust pH
- Evaluate and adjust circulation ratio
- Reduce chemical additions or change products
- Reduce or add nutrients (phosphorus may be limited in some streams)

Soil Treatment Area (STA) Water Movement Boundaries

The soil treatment area is a component with unique water dispersal features that must be evaluated to identify potential root causes of malfunction. As with all treatment train components, hydraulic and organic contaminant mass loading are of concern. Further, since the STA is the point at which dispersal back to the receiving environment occurs, effluent acceptance is paramount.

Soil treatment areas have multiple boundaries through which effluent must pass to achieve final dispersal into the environment. These boundaries are defined as:

- The infiltrative surface, which will vary depending upon the distribution method (trench bottom and sidewalls, drip tubing, ground surface);

- The soil treatment volume;
- Soil profile limiting conditions; and
- The window of acceptance around the dispersal area.

Each boundary has unique conditions which affect the ability of effluent to pass through and be dispersed to the receiving environment.

Infiltrative surface boundary

The most common infiltrative surface is the bottom and sidewalls of a trench. The effluent applied to the trench must exit the trench through the surrounding soil. Constituents that reach the infiltrative surface of the STA include biochemical oxygen demand (BOD), total suspended solids (TSS), volatile suspended solids (VSS), fixed suspended solids (FSS), volatile dissolved solids (VDS), and fats, oils and grease (FOG). The result is restricted liquid movement at the infiltrative surface because of either *biological* or *physical* plugging of the soil pores.

Each of these descriptors have a specific impact on the biological and physical plugging of soil pores.

- Biochemical oxygen demand (BOD) is the amount of oxygen required by bacteria to digest all contaminants that can be aerobically treated in the soil. It is an indicator of how much food is available to bacteria.
- Volatile suspended and dissolved solids (VSS and VDS) include the mass of organic contaminants requiring treatment in the soil. The mass of oxygen required to biochemically convert the volatile solids is represented by the BOD value. Volatile solids contribute to *biological plugging* at the infiltrative surface boundary.
- Fixed suspended solids (FSS) is the mass of non-degradable contaminants. These contaminants *physically* plug the soil pores as effluent flows through the infiltrative surface and solids are retained at the boundary.
- Fats, oils and grease (FOG) application to the infiltrative surface results in plugging that is characterized as *both biological and physical* because the time frame for soil recovery from this degree of biological plugging is relatively long.

Although the nature of infiltrative surface plugging can be both biological and physical, biological plugging is a recoverable condition, while physical plugging requires replacement or relocation of the infiltrative surface (replacement of the STA).

Biological plugging at the infiltrative surface of a gravity distribution STA is known as the *biomat* (Figure 9-1). It is defined as a layer of biological growth and organic residue that develops at the infiltrative surface. The plugging results from the accumulation of volatile suspended and dissolved organic material and the microbes which feed on it. Biomat development and the resulting restriction of water movement occurs naturally but is limited by the mass of oxygen available to the aerobic soil organisms that consume it. These aerobic soil organisms function in the biologically active zone ("biozone") beyond the infiltrative surface boundary in the area that constitutes the soil treatment volume.

The degree of biomat development can be predicted based upon BOD values (essentially, food supply) and the soil organic loading rate. Biological plugging increases with addition of BOD compounds that provide a food source to microorganisms. Excessive BOD loading from the source will eventually lead to problems due to excessive biomat development and restricted water movement. Reducing BOD load from the source or adding advanced treatment to decrease contaminant load can effectively control biomat development. Resting individual trenches or zones (such as in STAs with dual alternating fields) periodically ceases application of BOD for a specified time, causing the biomat to recede.

The theory behind using pressure distribution in a STA is to spread effluent (and thus, BOD) across the entire footprint of the infiltrative surface, in contrast to the concentrated loading that occurs with gravity distribution.

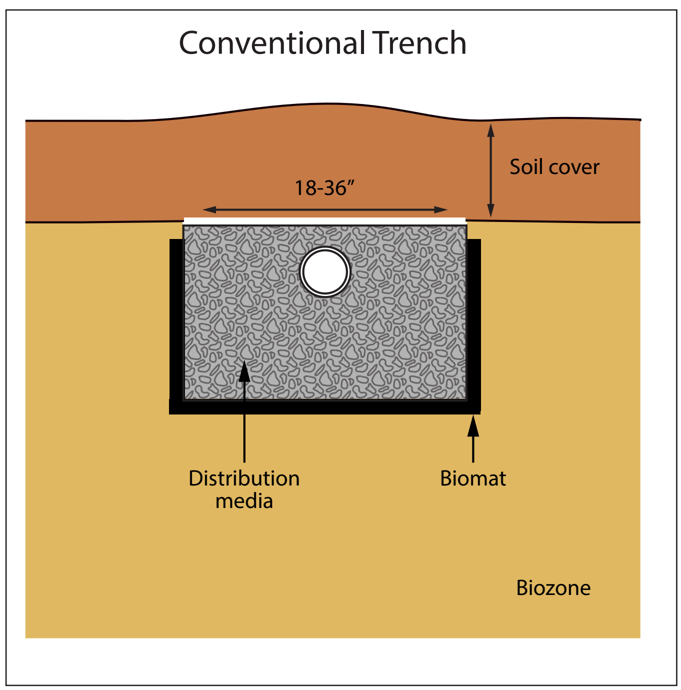

Figure 9-1. Gravity trench with biomat development around trench and biozone development in the soil treatment volume.

The uniform liquid distribution facilitates application of the organic loading at a rate that matches the oxygen transfer capacity of the site. An active biozone is required beyond the infiltrative surface to support the aerobic soil organisms consuming the organic material. However, BOD loading at rates greater than the soil's ability to transfer oxygen can result in biomass accumulation resembling the characteristics of a biomat. Therefore, uniform water distribution is critical to limit the risk of excessive BOD loading. For example, as orifices plug in a distribution lateral, the effluent discharges from remaining free-flowing orifices at a higher rate and concentrates hydraulic and organic loading in some areas more than others. This condition manifests as ponding and (perhaps) surfacing in isolated areas in a pressure distribution STA.

Organic loading rate quantifies the inherent capacity of the soil to transmit oxygen to the infiltrative surface to support microbiological digestion of volatile organic compounds. It is expressed as a *mass per area per unit time* (e.g., pounds per square foot per day). *Hydraulic loading rate* is the quantity of liquid applied to a given treatment component, usually expressed as *volume per unit of infiltrative surface area per unit time* (e.g., gallons per square foot per day).

The combination of the organic and hydraulic loading rate to the infiltrative surface is called the soil *long-term acceptance rate* (LTAR) because the term describes an equilibrium condition that develops over time, usually expressed as *volume per unit of infiltrative surface area per unit time* (e.g., gallons per square foot per day). Published LTARs commonly used to design systems use a theoretical value for the organic contaminant mass load in effluent. In reality, the LTAR at a specific site is determined by the actual mass of organic contaminants as compared to the theoretical value.

The hydraulic loading rate along a trench, bed or drip line is defined as the *linear loading rate*. It is defined as the volume of effluent applied along the length of the lateral per unit of time, usually expressed as volume per unit length per unit time (e.g., gallons per foot per day).

Soil treatment volume boundary

Water movement in the soil treatment volume surrounding the infiltrative surface occurs under both unsaturated and saturated flow conditions. Unsaturated flow occurs through soil capillary action as soil draws water from areas of greater soil moisture to areas of lesser soil moisture. Unsaturated soil moisture movement is along the surface of soil particles in all directions. Saturated soil water movement is through the soil pore space and along macropore structural features. This is vertical movement driven by gravity. Water movement in the soil treatment volume facilitates uptake by the plants and subsequent transpiration to the atmosphere. Additionally, under unsaturated conditions soil moisture is wicked toward the soil surface where it evaporates into the atmosphere. The combination of evaporation and transpiration from the soil is known as evapotranspiration. Evapotranspiration rates are influenced by vegetative cover, active plant growth, climatic conditions, and presence of soil moisture. Therefore, the effective evapotranspiration rate varies both seasonally and geographically based upon climate.

The hydraulic loading rate to the soil treatment volume is defined as the *areal loading rate* because it is the quantity of effluent applied to the footprint of the STA usually expressed as *volume* per unit of STA footprint (area) per unit time (e.g., gallons per square foot per day). Trench configurations provide an overall lower areal loading rate because of the separation distance between the trenches. In bed, low pressure distribution and drip configurations, the infiltrative surface loading rate approaches the areal loading rate.

Soil treatment volume on a site should be identified through comprehensive site assessment. The areal loading rate for a given site indicates the capacity for effluent to enter and pass through the soil treatment volume. The site assessment must also include an assessment of climatic conditions such as the presence or absence of beneficial water removal from a site based upon localized evapotranspiration rates.

An unsaturated condition in the soil treatment volume is essential. While water tables can vary because of catastrophic or unusual weather events, careful site selection based upon soil profile investigation is fundamental. Retroactive installation of drainage or diversion measures may address site-specific problems.

Soil limiting condition boundary

Water movement downward through the soil profile continues along the pores and through the pore space until conditions that restrict water movement are encountered. The "limiting conditions" are site-specific natural soil features such as depth to poorly structured soil, bedrock, or even to a seasonal shallow water table. The volume of soil from the infiltrative surface to a limiting condition is the soil treatment volume discussed above. It is typically specified as "minimum required depth to a limiting condition" in regulatory language and is intended to provide sufficient soil volume for effective treatment on a given site. Ultimately, a limiting condition results in soil saturation in the soil profile. As liquid collects at the elevation of the limiting condition, a hydraulic gradient will develop. On level sites, the accumulating liquid creates a mounded gradient that drives horizontal movement through the soil treatment volume in all directions toward the perimeter of the STA. On sloping sites, liquid will flow across the surface of the limiting condition toward the downslope edge of the STA. The height of groundwater mounding is defined by the mounded gradient required to move the liquid to the perimeter of the STA (Figure 9-2).

Window of acceptance boundary

Water movement from the soil treatment volume into the receiving environment occurs through the window of acceptance. On level sites, the window for liquid movement is the perimeter of the STA. On sloping sites, the window through which liquid moves is located at the downslope edge of the STA. In all cases, the window for water movement must have appropriate soil hydraulic conductivity, soil depth and associated gradient for water movement from the STA. The hydraulic loading rate through the window at the perimeter of a STA is defined as *landscape linear loading rate*. Because most sites have a downslope condition, the loading rate for the exit window is typically described as a *contour loading rate* which is essentially equal to the landscape linear loading rate (Figure 9-3).

Troubleshooting water movement boundaries

Effluent dispersal through the infiltrative surface and through the soil treatment volume is impacted by hydraulic, organic, and inorganic loading issues. Dispersal into the receiving environment is controlled by soil limiting conditions and the nature of the window of acceptance. When problems manifest as a ponded condition, the root cause may be either excessive hydraulic or organic loading in the STA. The root cause of the malfunction can be determined through evaluating the boundary where restriction occurs. Therefore, troubleshooting a STA requires identifying the location of all boundaries for water movement at a site and then systematically evaluating the root cause for restriction at each boundary.

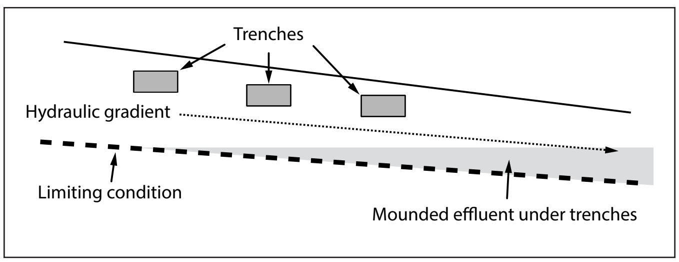

Figure 9-2. Soil limiting condition with mounded effluent moving downslope

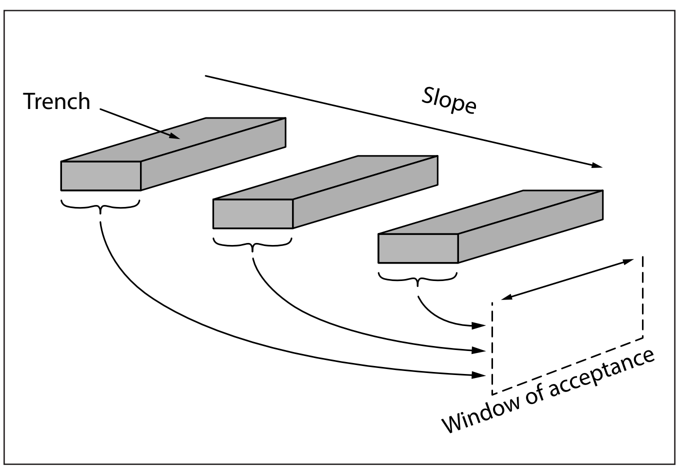

Figure 9-3. STA with effluent accumulating and moving downslope toward the window of acceptance and dispersal to the receiving environment

Excess Hydraulic Loading

Hydraulic overloading may occur because of owner abuse, plumbing leaks or infiltration of extraneous water. Any problems related to these items should have been addressed through use of Operational Checklists. To review:

- If the problem is the source, educate the users.
- If components are not watertight, seal seams or replace leaky devices.
- Crown the final grade over components to shed surface water.
- Collect and divert stormwater using gutters, swales and berms that drain away from the system.
- Intercept and divert laterally flowing groundwater to a suitable outlet.
- Reduce hydraulic loading rate to match the window of acceptance contour loading rate.

Excess Organic Loading

The infiltrative surface of the STA is where biomass accumulation occurs. If biomass assessment is required, excavation is necessary unless inspection ports provide access for investigation. Potential causes and possible resolutions are discussed here.

- Excess organic loading to the infiltrative surface typically results from BOD additions from the source. Reduce BOD by educating the user regarding kitchen habits or other inappropriate waste additions (e.g., pet excrement).
- FOG bypass through treatment components may occur because of addition of chemicals through excessive use of cleaners and emulsifiers. If products are used as directed, problems may be eliminated.
- FOG may remain in suspension if the temperature of effluent is high. High temperatures can be mitigated through additional tank capacity to promote cooling to separate out the FOGs.

- Non-uniform effluent distribution in the STA may be corrected by performing maintenance on the distribution system component or replacing parts as needed.
- Verify proper operation of treatment components (septic tank, effluent screen, and any advanced treatment) to ensure effluent is adequately treated.

Excess Inorganic Loading

Fixed solids that bypass treatment components (essentially, ash) can plug the soil at the infiltrative surface. The solution in this case is often replacement of the STA. Excessive introduction of sodium destroys soil structure through chemical dispersion of clay particles within the soil treatment volume. Adding lime or gypsum can resolve this issue by restoring the balance of sodium, calcium, and magnesium ions in the soil. Performing appropriate maintenance (pump septic tank and dosing tank solids, clean or add an effluent screen, add a pump basin or vault to the dosing tank) can significantly reduce inorganics and just makes good sense.

If soil pores become plugged because of excessive suspended fixed solids, it can result in an STA that cannot be revived and must be replaced.

Restricted Air Exchange in STAs

As with all system components, STAs require air exchange to maintain aerobic soil conditions conducive to effective contaminant removal and optimal liquid conveyance. System configuration can fundamentally affect air exchange rates in the STA. Using pressure distribution facilitates good air exchange because the trench “breathes”. As liquid is pressure dosed to the trench, air is displaced from the trench. As liquid exits, air returns. At a fundamental level, inherent soil and site features directly determine capacity for effective air exchange. This highlights the critical importance of soil characteristics and site features.

Soil texture and structure impact the soil’s air exchange rate. Coarser texture improves air exchange. Well-developed soil structural features provide macropores for liquid and air movement. Plant root growth helps to develop soil structure and paths for air exchange. Air diffusion through plants conveys some oxygen to the roots and surrounding soil. A permeable soil surface with healthy vegetative cover promotes air exchange with the atmosphere. Air exchange and thus oxygen state is fundamentally dependent on inherent soil drainage capacity which can be adversely affected by human activity on and adjacent to the STA.

Soil compaction adversely affects soil characteristics that allow air exchange. Compaction will result from establishment of driveways, parking areas or playgrounds over STAs. Allowing livestock to graze during wet conditions will compact soil as well. Installation during adverse soil moisture conditions destroys soil structure through compaction and smearing. If construction site access is located along the downslope side of the site, the window of acceptance for final treatment and dispersal is effectively closed.

Extreme restriction of air exchange results from locating a structure, paved parking lot or patio on the STA. Decks and walkways will restrict air exchange across the ground surface and prevent establishment of a vegetative cover.

Protecting the soil and site is the foundation of optimal system management.

Summary

Onsite wastewater treatment systems will function for decades if properly designed, installed, used and maintained. Using the Operational Checklists should reveal the cause of most problems. With more complicated issues, the first step toward resolution is identifying the root cause of malfunction. Since solids removal is often at the heart of problems perform a basic assessment for the presence of solids in downstream components: dosing tank, distribution box, media filter surface, distribution piping, STA components. Determine where the problem originates and evaluate the potential root cause: excessive hydraulic, organic, or nutrient loading or microbial inhibition.

If necessary, investigate and troubleshoot the STA. This requires full understanding of the water movement boundaries within this component. To identify the cause of malfunction, begin by identifying the boundary where water movement is restricted:

- infiltrative surface,
- soil treatment volume,
- soil profile limiting condition(s), or
- window of acceptance for dispersal to the receiving environment.

Once the boundary is identified, consider the potential options for resolution and implement them as appropriate.

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Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the purpose(s) of effluent sampling.
2. Implement proper sample collection, transport, and handling procedures.
3. Accurately process Chain of Custody documentation.

Overview

Wastewater sampling is a critical skill for assessing the status of treatment components. A treatment system operating at an optimum condition provides a healthy environment for microbial treatment. Typically, optimum growing conditions are described relative to temperature, pH and dissolved oxygen. Additionally, each stage of the treatment train should produce effluent meeting the quality required for effective treatment in the next stage. For example, a disinfection process must receive effluent with minimal suspend solids and organic matter to minimize treatment interferences. Therefore, the upstream process must produce an effluent with limited BOD_5 and TSS.

Conduct wastewater sampling to either evaluate system performance relative to site specific criteria or to troubleshoot components and optimize treatment processes. When assessing overall system performance and/or compliance with final treatment goals, collect samples at the outlet of the advanced treatment component prior to final treatment and dispersal.

When diagnosing and/or troubleshooting a system that is not performing as intended, begin by sampling the effluent from whatever component must be investigated. Troubleshooting samples may be collected at multiple locations depending upon observations that prompt investigation of a particular process or processes. For example, when indicators (odors, cloudy conditions, exceeding regulatory limits) are noted in an ATU, it makes sense to evaluate not only the aeration process, but also the quality of influent to the aeration process (effluent from previous component). Both the aeration method and contaminant loading impact the effectiveness of the treatment processes.

When troubleshooting nitrogen reduction components, measuring DO at various locations through the processes is critical. This information must be evaluated prior to adjusting any system controls that affect optimal nitrification and denitrification processes.

The following discussion presents key concepts for sampling onsite wastewater treatment systems in a manner that produces accurate, reliable and defensible results. Sampling locations are usually at the inlet or outlet point of a treatment component. These samples are respectively defined as *influent* and *effluent* samples. *Influent samples* are those collected from within the treatment train to determine the characteristics of the effluent undergoing a specific treatment process. For example, to assess the processes occurring in an aeration chamber, collect a sample at the outlet of the trash tank that precedes it. Even though this sample is commonly called an effluent sample following primary treatment in the trash tank, the treatment system performance effluent sample notation is generally reserved for the final step in the treatment train.

Component treatment capacity is based upon component volume and guidance provided by manufacturers. Scientific principles define the biochemical transformation capacity of wastewater constituents (e.g. organic matter, nutrients) relative to component tank capacity or media filter volume. These values are typically calculated on a mass loading basis instead of a concentration basis. The actual treatment performance is assessed relative to the specific influent quality for the target contaminants. Troubleshooting requires conversion of the laboratory concentration data to a mass loading rate to the component. To calculate the mass loading, multiply the concentration (mass/volume, e.g. mg/L) by the flow over a specific period (volume/time, e.g. gallons/day). Convert units to match. See Appendix A for more detail on how to perform these calculations.

Performance monitoring requirements consider the risk to public health and environment because of system malfunction. Residential and commercial systems are assigned different levels of risk. Therefore, the type of facility being served dictates the specific evaluation requirements. Depending on local code, residential systems may have a reporting requirement regarding component operational status and disinfection performance. Also depending on local code, commercial systems may have a reporting requirement such as component operational status, disinfection performance, and effluent quality (BOD_5 and TSS) sample analysis.

Onsite Analytical Methods

There are many inexpensive and straightforward methods for collecting system data during an investigation. These are described below with information on devices for field use and what the results may indicate.

- Dissolved oxygen (DO)
  - DO meter (sometimes part of a multi-probe) or test kit
  - Evaluate the DO concentrations in different components and compare them to manufacturer's recommendations
- pH
  - pH meter (sometimes part of a multi-probe) or colorimetric test strips or paper
  - Fluctuations affect microbes
  - Specific microbiological processes require a

specific pH range; some processes lower or raise pH, so evaluating pH in/after specific treatment components can be helpful

- Temperature
  - Thermometer (sometimes part of a multi-probe)
  - Fluctuations affect microbial activity: very low temperatures inhibit some processes, while higher temperatures accelerate many processes (until the temperature gets too high for the microbes to tolerate)
  - During cold weather, components drawing ambient air (e.g., aerators) will lower the temperature of the liquid
- Sludge and scum accumulation
  - Profile probe (clear tube), scum hook
  - Evaluate available sludge storage volume (septic tanks and ATUs)
  - Excessive accumulation of solids (scum and sludge) decreases the available treatment volume (reducing hydraulic residence time) and risks solids carry-over to subsequent components
- Suspended biomass
  - 30-minute settleability test
  - Checking for excessive biomass and viable microbial population
  - The amount of biomass (mixed liquor suspended solids or MLSS) is measured using a 30-minute settleability test. For this you'll need a beaker or other opaque container (Settlometer) with 10 equal graduations on the side of it. A mixed liquor sample is pulled from the aeration chamber and allowed to settle for 30 minutes in the beaker. Settlometers are available from a variety of commercial sources.
  - At the end of the 30 minutes, the solids and liquids have separated.
  - The solids should be somewhere between 20 to 60% of the volume or 1,500 to 3,000 mg/L MLSS. If the volume is less than 20% the microbial population is likely inadequate to provide treatment.
  - If the volume is greater than 60%, or higher than 3,000 MLSS, solids may need to be pumped from the system.
  - This general guidance is offered as a starting point. Always check manufacturer guidance for specific information. For example, membrane bioreactors (MBR) may function well at MLSS greater than 3,000 mg/L.
- Clarity (Turbidity)
  - Turbidimeter (light transmittance through effluent)
  - Sight – visual evaluation of clarity
  - Effluent destined for a disinfection process must be clear
  - Collect effluent samples from septic tank, ATU, media filter (each has specific expectations for clarity)
- Odor
  - Your nose: none, mild, strong, chemical or sour
  - Mild – aerobic
  - Strong – anaerobic, typically contains sulfur (think rotten eggs) compounds
  - Chemical – chemical addition or ammonia
  - Sour: low pH (acidic) conditions due to fatty acids (THINK GREASE INTERCEPTOR)
- Chlorine residual
  - Chlorine test kit
  - Indication of effective disinfection process
- Nitrogen species
  - Colorimetric reaction and analysis via portable field photometer; some multiprobes have a nitrate probe
  - Collect samples or measure concentration in primary treatment zone, aerobic zone (media filter or aerated zone of ATU), and final effluent discharge point. Look for concentrations of ammonium and nitrate in each part of the treatment train and compare them to manufacturer's recommendations and component's intended function.
  - In recirculated systems, be aware that recirculated water is continuously conditioning (or diluting) raw incoming wastewater, so you may not be able to measure a true starting nitrogen concentration for the system.

Sometimes these simple and relatively inexpensive tests can reveal the cause of a malfunction. If additional information is needed, samples may require laboratory analysis.

Laboratory Analytical Methods

Selecting a qualified laboratory helps to ensure accurate results. Regulatory jurisdictions (or legal prudence) may necessitate the use of a certified or sanctioned laboratory.

Check applicable requirements for this information.

Laboratories typically perform the analyses listed below. Verify that the lab used is certified and accredited to perform the specific test(s). Some constituents may be required to be analyzed on a specific frequency as established by the regulatory authority. Consult the available facilities to verify they are equipped to perform the required analyses at the required frequency for the system in question.

- Biochemical oxygen demand, 5-day (BOD_5)
- Carbonaceous biochemical oxygen demand, 5-day ($CBOD_5$)
- Total suspended solids (TSS)
- Fats, oils, and grease (FOG)
- Chemical oxygen demand (COD)
- Total nitrogen (TN), ammonium-nitrogen, nitrate-nitrogen
- Total phosphorus (TP)
- Fecal coliform (FC)
- Alkalinity

Analyses should be conducted in accordance with Standard Methods for Water and Wastewater Analysis. Make sure the expected range of constituent concentrations in the sample falls within the range of lab equipment capacity. Analysis that returns results such as "non-detectable", "greater than X", or "too numerous to count" are not helpful. Verify laboratory operating hours, sampling container protocols, and Chain of Custody (COC) procedures and documentation.

Sampling Equipment

Sample collection can be achieved with a long-handled dipper or other container. A sampling probe can also be used to collect a sample for analysis. In some instances, a vacuum pump may be used to collect the sample. Sometimes the sample must be collected in an Imhoff cone to remove settable solids.

Observe proper protocols to prevent cross contamination of samples. If multiple diagnostic samples are being collected from the same treatment train without cleaning the device between sample collections, start collecting samples from the effluent end (cleanest effluent) of the treatment train and move upstream. Using proper methods to collect, handle and preserve samples will result in the most accurate results.

Wear proper personal protective equipment (nitrile gloves) to minimize the chance of contamination and use appropriate methods for cleaning, disinfecting and storing tools, equipment and clothing.

Sampling Modes

There are three main types of samples that can be collected: composite, integrated, and grab samples. A *grab sample* is one sample taken from one point in time. This type of sample gives a picture of water quality only for the moment it was collected. An *integrated sample* is a combination of grab samples collected at the same time but at different locations. A *composite sample* is a collection of multiple samples taken from the same location over a specific period and blended. A composite sample can also be derived by taking multiple grab samples during different flow periods. Samples may be of equal volume or proportional to the flow at time of sampling. The composite sample represents the average water quality conditions over the time the samples were collected. Composite samples may require that special refrigeration equipment be available on site the day before sampling to preserve a 24-hour composite. Certain sampling locations within a treatment train, such as a septic tank or dosing tank, are considered to provide a composite sample.

Timing of Sample Collection

The timing of sample collection influences how representative the sample is. Depending on the timing, the effluent collected may be freshly flowing effluent or processed effluent. Freshly flowing effluent is typically preferred because it is actively moving through the system. Processed effluent often sits in the outlet baffle of a treatment component or within the subsequent system component. This effluent may be subjected to additional treatment processes within the subsequent component prior to the sample being collected.

A sample collected during a surge flow period may have greater quantities of solids, FOG, or flocculent than one collected during a period of normal flow. Effluent temperature may be elevated due to activity at the source (hot dishwashing or laundry discharge) or because ambient air temperature or other factors cause effluent temperatures to rise.

Appropriate arrangements should be made with the laboratory for time and day regarding analysis of specific parameters. All sample parameters have specific maximum holding times. Some laboratories accept samples at specific hours of the day and days of the week to comply with the maximum holding times.

A sample collected from a surge or dosing tank should be collected during the off cycle of the pump. The sample is not representative if it was collected right after the pump cycled. A pump typically mixes the effluent in the tank, potentially suspending solids that settled in the bottom of the tank.

Sampling Location

The appropriate location for collecting the sample is dependent on the tests to be performed and purpose of the tests. Samples are collected from various locations in the treatment train depending on what component is being diagnosed. Outlet baffles are often used to collect samples, although the best sampling locations are external sampling ports. If water collects in the sampling location rather than flowing straight through the location, the wastewater collected from that point is more like a composite sample than a grab sample (see Figure 9-4). However, it depends on the size of the port. A small port will not provide for much of a composite because of its size. Also, ports may collect solids over time making the sample no longer representative due to excessive solids in the port. It may be best to clean out the port and let it fill with effluent before sampling.

It is important to note that when a sample is collected from a baffle or test port, loose biological material should be dislodged from the sidewalls before the sample

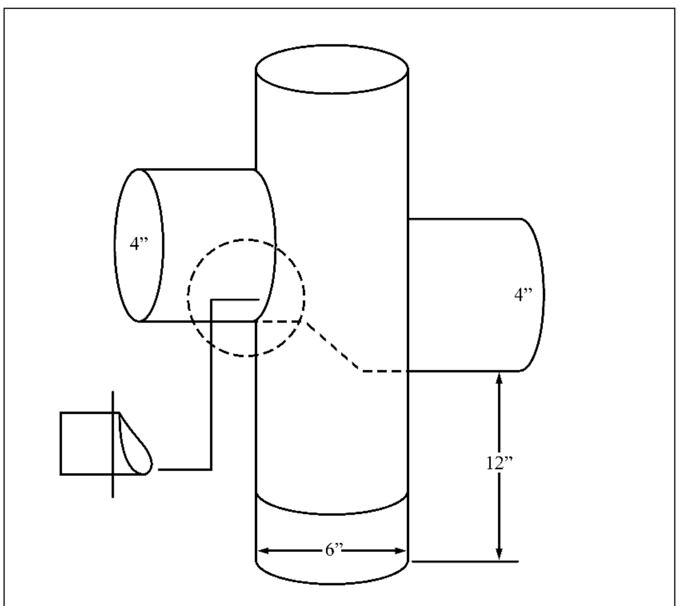

Figure 9-4. Inline sampling port.

is collected. Let the biological material settle before collecting the sample. If these materials are knocked off the walls during sampling and enter the sample, the results are impacted due to excess biomass and are not representative of effluent quality.

Sample Collection Protocols

Consult the laboratory for specific requirements. The type of container used to store the collected sample can affect the results. Plastic containers are allowed for most tests; however, grease analysis requires a glass container. Most laboratories will furnish a clean and prepared container for transporting the sample.

Proper sample storage usually means transporting the sample to the laboratory in an ice chest at 4°C to limit microbial activity. Make sure the bottle is filled with the wastewater sample, sample lids are tightly sealed, and that the bottles are upright during transport. Some tests require a preservative to be placed in the sample to stop chemical reactions. Sample bottles obtained from the laboratory usually contain the appropriate quantity of preservative, based on the analyses to be performed on the sample. Be careful not to wash out the preservative from the container.

There is a maximum sample holding time for certain analyses. Consider not only the time for sample collection but also travel time to ensure samples arrive in a timely fashion. Make sure that the sampling and travel schedule allow timely delivery to the lab. See Table 9-1 for collection, preservation, and holding time information.

Chain of Custody (COC) is a legal term that refers to the process for documenting and maintaining a chronological history of a sample from collection through the reporting of analysis results. Label each container with a unique sample idientifier. Use Form 9-1 Chain of Custody to document the sample identifier, collection date and time.

Sample Documentation

Documents should include the name or initials of the individual collecting the sample, each person or entity subsequently having custody of it, each date and time the sample was collected or transferred, employer or agency, sample number, and a brief description of the sample. It is important to note that most labs will not validate the test results without proper COC documentation.

Table 9-1. Required containers, preservation techniques and holding times (Hach, 1997)[1]

Parameter Name	Container[2]	Preservation[3,4]Maximum	Holding Time[5]
Bacterial Tests			
Coliform, fecal and total	P, G	Cool, 4°C, 0.0008% $Na_2S_2O_3$[5]	6 hours
Fecal Streptococci	P, G	Cool, 4°C, 0.0008% $Na_2S_2O_3$[5]	6 hours
Inorganic Tests			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Biochemical oxygen demand (BOD)	P, G	Cool, 4°C	48 hours
Boron	P, PFTE or quartz	HNO_3 to pH<2	6 months
Bromid	P, G	None required	28 days
Biochemical oxygen demand, carbonaceou	P, G	Cool, 4°C	48 hours
Chemical oxygen demand	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chloride	P, G	None required	28 days
Chlorine, total residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, total and amenable to chlorination	P, G	Cool, 4°C, NaOH to pH<12, 0.6 g ascorbic acid[6]	14 days[7]
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 to pH<2, H_2SO_4 to pH<2	6 months
Hydrogen ion (pH)	P, G	None required	Analyze immediately
Kjeldahl and organic nitrogen	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrate	P, G	Cool, 4°C	48 hours
Nitrate-nitrite	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 hours
Nitrite	P, G	Cool, 4°C	48 hours
Oil and Grease	G	Cool, 4°C, HCl or H_2SO_4 to pH<2	28 days
Organic carbon	P, G	Cool, 4°C, HCl or H_2SO_4 or H_3PO_4 to pH<2	28 days
Orthophospate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, dissolved probe	G bottle and top	None required	Analyze immediately
Dissolved oxygen, Winkler method	G bottle and top	Fix on site and store in dark	8 hours
Phenols	G only	Cool, 4°C, H_2SO_4 to pH<2	28 days
Phosphorus, elemental	G	Cool, 4°C	48 hours
Phosphorus, total	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Residue, total	P, G	Cool, 4°C	7 days
Residue, filterable	P, G	Cool, 4°C	7 days
Residue, nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, settleable	P, G	Cool, 4°C	48 hours
Residue, volatile	P, G	Cool, 4°C	7 days
Silica	P, PFTE or quartz	Cool, 4°C	28 days
Specific conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days
Sulfide	P, G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH>9	7 days
Sulfite	P, G	none required	Analyze immediately
Surfactants	P, G	Cool, 4°C	48 hours
Temperature	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours

Notes:

1. This table was taken from Table II published in the Federal Register, July 1, 1995, 40 CFR, Part 136.3, pages 643-645. Organic tests are not included.

2. Polyethylene (P) or glass (G), or PTFE Teflon

3. Sample preservation should be performed immediately upon sample collection. For composite chemical samples, each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4 °C until compositing and sample splitting is completed.

4. When any sample is to be shipped by common carrier or sent through US Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance.

5. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. The term analyze immediately usually means within 15 minutes or less after sample collection.

6. Should only be used in the presence of residual chlorine.

7. Maximum holding time is 24 hours when sulfide is present. Optionally all samples may be tested with lead acetate paper before pH adjustments to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

Form 9-1 Example Chain of Custody Record

CHAIN OF CUSTODY RECORD

Lab ID No.: ____________________

This information will be used for reporting/billing

Name: ____________________

Attention: ____________________

Address: ____________________

____

Phone: ____________________

		Collection Data				No. of	**INSTRUCTIONS: use one line per sample & indicate tests to be performed by checking appropriate boxes**												
Lab Use	Sample ID /Collection Point	Date	Time	Comp.	Grab	bottles	BOD_5	TSS	O&G	pH	FC	TC	TKN	NH3-N	NO_2	NO_3			Notes

Samplers Signature: ____________________

Print Name: ____________________

Relinquished To Lab By: ____________________

Special Instructions - Client:

Shipped Via:
☐ UPS
☐ Hand
☐ Other ____________________

Temperature Acceptable:
☐ Yes ☐ No

Using Form 9-2: Sampling Documentation

This form provides a location to document sampling events as well as the results of laboratory and onsite analyses.

Form 9-2 Sampling Documentation

Reference #:____________________

Form completed by: Company: ______________________ Employee:______________

Client Contact Information Client Name:

Address:____________________________ Time:_______ Date: ___________

Phone #: ________________________

Designer:____________________________ Cell #:_________________________

Design flow:__________________________ Installer:_______________________

Facility in a rural setting__________GPD Date of last pump out:____________

☐ Yes ☐ No

Sampling

Client Name:

Chain of custody complete_______________ Time:_______ Date: ___________

☐ Yes ☐ No

Laboratory Results

BOD_5:

TSS: _____________________________ mg/L SS:____________________ mg/L

O & G: _____________________________ mg/L FC:_______________ MPN/100 mL

pH: _____________________________ mg/L TKN:____________________mg/L

Temp: __________________________ std. units NH_3:___________________mg/L

_____________________________ ^{o}C NO_2^-:___________________ mg/L

DO: ______________________________ mg/L NO_3^-:___________________ mg/L

DO: ______________________________ mg/L (of water supply)

(NOTE: If a chemical analysis of the tap water has been performed, please provide test date.)

Microscopic examination: ____

____

____

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Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe the user impact on hydraulic, organic and nutrient loading to an onsite wastewater treatment system.
2. List the potential effects of excessive use of household cleaning and personal care products on microbial activity.
3. Accurately complete Form 9-3 Residential Survey (RS).

Using Form 9-3: Residential Survey (RS) for Troubleshooting

The users directly affect the nature and volume of wastewater entering the onsite wastewater treatment system and thus, their habits directly affect treatment performance. Using the Residential Survey, the service provider can gather more detailed information on hydraulic, organic and nutrient loading. This survey is not required for baseline information; instead, it is used in troubleshooting. The Survey facilitates documentation of the user's wastewater production habits and management. Responses often reveal potential causes of system malfunction and logically direct subsequent efforts toward problem resolution.

The text below describes inspection criteria for conducting a Residential Survey. The form for documenting responses follows the text. Note that some inquiries may be of a personal nature. Questions about the use of prescription medications is a perfect example. Tact and diplomacy are the best tools for these situations.

Client contact information

When analyzing a system, the more information that is available for analysis, the better. Baseline data collected before trouble occurs can be beneficial for use with the survey form. Use of operational checklists presented in these training materials guide the user in a thorough evaluation of each component in a treatment train during service visits and facilitate the collection of baseline data.

Every checklist begins with collection of the same client information including:

- Person who has completed the survey – may indicate the reliability of the responses. It may be useful to know who completed the survey should follow-up questions arise.
- A reference number for personal records to keep track of an individual onsite wastewater treatment system. A file of each treatment system you are servicing should be kept in your records.
- Date and time of the visit – allow determination of quantitative results, such as the average daily flow. The time of day also gives some additional understanding to the responses to questions in the survey. For instance, a sample that was collected during a peak flow may not be indicative of the constituents during average flow.
- Name or company of the designer and installer – contact information should be available in your records in case any questions related to the design or installation arise.
- System design flow – allows for evaluation of the hydraulic loading of the system.
- Date of the last pumping – allows you to evaluate the need for the system to be pumped again or determine if frequent pumping is an indication of a more serious problem. Lack of pumping may indicate solids are not collecting in the tank as they should be.

A. Operational data

The first section poses questions that help gather information relevant to the operational habits of the system user.

A.1 Is this your first home with an onsite wastewater treatment system?

This question gives the service provider or inspector an idea of the level of knowledge the client has concerning onsite wastewater treatment systems. First time users of onsite wastewater treatment systems can make poor choices. Individuals who have lived in an urban area on a sewer grid their entire life may not have adjusted their water use habits for onsite wastewater treatment. They may not be aware of how hydraulic or organic overloading of the system can result from their actions. Understanding the relative experience of the user helps identify potential system problems. The homeowner must be made aware of the connection between what goes down the drain or toilet and what goes through the system.

A.2 Have you ever received any onsite wastewater treatment system user information?

Several educational materials are available for owners to help understand their responsibility towards the system. The homeowners may have received information about onsite wastewater treatment system care and water use when they moved into the home or installed the system. If not, then your company may be able to provide the homeowner with some literature that explains basic onsite wastewater treatment system care and maintenance needs. National programs like the U.S. EPA SepticSmart, and University Cooperative Extension programs are good sources of information and/or factsheets crafted for homeowners. Not using this material is another source of potential mistakes.

A.3 Did you receive the plans or as-built drawing for the system?

The system plans or as-built drawings provide a record of how the wastewater treatment system was installed and should assist in locating the components. Some jurisdictions have these available online or at the county offices or local town hall. Your company may want to make a copy of the as-built drawings for your own records.

A.4 Type of use: how is this property (and therefore the system) used, relative to its design? Does someone live here full-time, year-round, or only for part(s) of the year? Who lives here when the home is occupied? How many bedrooms, bathrooms and laundry facilities are connected to the system?

The amount of time spent at the facility impacts how the system operates. The longer the system is in use, the shorter the resting period that is available. First, find out if the system is used year-round or seasonally. If it is only used seasonally, determine the months the onsite wastewater treatment system will be in use. This is important for maintenance or service visits; if the system has not been in use for several months, some of the indicator tests used to check the system will give unreliable results. Some seasonal systems may also be short-term rental properties which can be subject to significant water flows.

The number and ages of the people living in the home directly affect water use. Teenagers and athletes typically use more water than the average adult, and older people tend to use significantly less water than the average person. Females tend to use more products such as lotions and oils (such as conditioners and sunscreens) that can lead to an increase in the FOG levels in onsite wastewater treatment system components.

Number of bedrooms, bathrooms, and laundry rooms can indicate the capability for peak flows. Residences with a single bathroom means the shower or bathing water use will be distributed. However, multiple bathrooms associated with bedrooms allow multiple showers/baths at the same time. Multiple laundry rooms allow people to do multiple loads of laundry at the same time. Water-efficient washing machines can reduce hydraulic load.

A.5 Water supply: Where does the water used in your home come from?

Determine the water source for the residence: a private well, a centralized system, or another supply (e.g., a cistern). If the home is connected to central water, the service provider can gain access to water use records. In some areas, this information can no longer be released to third party individuals. The service provider may have to ask the homeowner to request that information. Other water sources may impact water quality and quantity going into the onsite wastewater treatment system. Water from a private well may have a high mineral content, low alkalinity, or low pH that will affect the treatment capabilities of the system.

A.6 Do you have an in-home business? If "yes", what type?

Since the onsite wastewater treatment system was designed based on average household use, any other water use in the home could affect the system. For example, a home photography developing lab may be flushing processing chemicals down the drain. These harsh chemicals can upset the delicate balance of microorganisms in the onsite wastewater treatment system. Other small businesses may indicate the use of chemicals that could directly impact the system. These include: antique refinishing, beauty shops, professional painters, lawn care, photo labs, dog grooming, and taxidermy shops. Barbershops and beauty shops typically discharge large amounts of hair. Daycare can increase the overall flow and can increase the use of antibacterial soaps. A home bakery business can add a lot of organic matter, FOG and flow to the system. Also, additional water use for any at-home business can create a hydraulic overload to the system. A system is designed to handle a certain amount of water; excess water flushes the wastewater through the system too quickly without adequate time for treatment. Reduction in hydraulic detention time results in poor treatment potential.

A.7 Do you use septic system additives? If "yes", what products?

Treatment system additives are often used to overcome a perceived or confirmed problem. The use of non-specific septic tank additives to overcome a perceived issue is not proven to be beneficial to system performance. Their use is not recommended.

General purpose additives claim to reduce the frequency of septic tank pumping events. Some manufacturers claim that their products work by breaking up the solid particles that settle to the bottom of the tank or the scum that floats at the top of the tank, effectively resuspending the particles. Their conclusion is that there is less scum and sludge, and the tank will not have to be pumped as often. The separation of layers is fundamental to the treatment processes that occur in a septic tank, but additives intentionally disrupt this function. Resuspended particles can clog downstream components.

If a system is used heavily, defined as actual flow to the system exceeding 70% of design flow, solids will accumulate more rapidly, and pumping frequency should increase. Use of additives will not solve this problem.

Some additives are introduced to overcome specifically identified issues in the treatment process, and in some case, these additives are recommended by the system manufacturers. Potential issues are insufficient organic carbon, alkalinity, nitrogen, or phosphorus in the wastewater stream. Potential additives to overcome these issues include sugar, corn meal, methanol, soda ash, or limestone. These proprietary products target a specific deficiency or condition by, for example:

- Adding a carbon food source for microbial growth
- Adjusting alkalinity to facilitate treatment processes like nitrification
- Providing specific supplemental nutrients necessary for proper treatment (wastewater from wineries, coffee shops and similar facilities lacks nutrients for certain processes)

Proprietary products are available that have been proven to enhance treatment process performance. Careful use of these after troubleshooting to identify specific problems can be very effective.

A.8 Square footage of the house

Houses with larger square footage relative to the number of bedrooms tend to exhibit higher levels of water use. This may be due to the ability to have larger gatherings, presence of higher capacity water use devices (multi-head showers for example), or less careful water use habits.

B. Water use habits

The next section of questions in the survey relates to the water use habits at the source. Responses to these questions can help characterize constituents that may be present in the waste stream. Effluent characteristics directly reflect dietary habits and medical conditions. Note that posing questions related to health issues is tricky. Proceed carefully.

B.1 Is any resident using long-term prescription drugs or antibiotics? If "yes", what type?

Prescription antibiotics and drugs are extremely hard on the biology of the system. Chemotherapy drugs, antibiotics, or other prescription drugs can kill the microbes living in the onsite wastewater treatment system. These drugs are designed to kill harmful organisms or cancer cells in the body, but they will not discriminate against organisms in the onsite wastewater treatment system.

Although asking the homeowner to discontinue use of these prescription drugs is out of the question, it is useful information to know. If the system is not functioning as designed, additional treatment components may need to be added to the system in order for it to function properly. An increase in maintenance is recommended.

B.2 Do any residents use bath/skin oil/moisturizer/daily sunblock?

Heavy use of bath and body oils can raise the FOG concentration—mainly the grease content in the system. The homeowner should be made aware of the negative effects on the system due to use of these products. Removal or reduction of these can improve system performance. If usage of these products is high, then more operation and maintenance service visits may be needed in order to ensure proper function of the system.

B.3 Is a garbage disposal (in-sink grinder) used?

Use of a garbage disposal has a dramatic impact on pumping frequency and organic loading to the system. Garbage disposals can deposit significant amounts of undigested solids into a septic tank, increasing scum and sludge accumulation by as much as 20%. Households that use garbage disposals typically need to have their septic tank pumped 1 to 2 years sooner. If used, a garbage disposal adds to the organic and hydraulic loading of the system. The garbage disposal adds to the loadings in three ways:

- The organic matter has not been digested so it will take longer to break down.
- More water is used to rinse the sink out.
- Smaller particles are generated/produced that will take longer to settle.

Some homes with garbage disposals have a larger sized septic tank to counteract the effects of the disposal. Be sure to check the design or do an infield inspection to check for a tank upsizing.

B.4 Is a dishwasher used?

Innovation in dishwasher technology has drastically reduced the amount of water used per cycle. The number of cycles run per day is still important and dependent upon the user. Residential water use is now significantly higher for hand washing versus use of mechanical dishwashers. Actual flow is dependent upon user habits.

B.5 Laundry:

Laundry is a significant part of the source in terms of water use. The detergents used have a direct effect on the chemistry of the wastewater and the number of loads done affects the flow of wastewater through the system.

Powdered detergent and soaps containing bentonite can potentially cause plugging of the infiltrative surface of the soil treatment area. Using alternatives (liquid or sheets) can improve long-term performance.

Excessive use of a bleach additive will affect the biology of the septic tank and the rest of the system. A small amount of bleach (e.g. less than half a cup) in a load of laundry once or twice a week is unlikely to have a measurable negative effect.

The amount of laundry done each day is also important. Even with modern high efficiency washing machines, spreading loads out over time helps the system perform at its best. If all loads are done in one day, more water could be added to the system than it is designed to manage. This creates a surge flow that can flush inadequately treated wastewater through the system. Solids carryover may become a serious issue.

Water temperature used in laundry loads affects performance as well. Using excessive amounts of hot water will keep FOGs in suspension, possibly resulting in problems in subsequent components.

B.6 Is a whirlpool tub being used?

Jetted, deep whirlpool or Jacuzzi tubs (inside the dwelling) typically use large volumes of water. Information on how much water these devices use and the pattern of their use helps the service provider assess the impact on the system. Just like the washing machine, they can cause hydraulic surges in the wastewater stream. Outdoor hot tubs should not be plumbed to the wastewater treatment system.

B.7 Is a drain cleaner used?

The use of toxic drain cleaners can impact the ability of the system to properly treat wastewater. These chemicals directly affect the activity of the bacteria, resulting in a tank full of dead organisms and leading to poor treatment. In addition, frequent use of a drain cleaner for plumbing issues may be an indication of more complex issues with the onsite wastewater treatment system. Excessive use of drain cleaners may further aggravate these issues.

B.8 Hand-washing soap brand:

Antibacterial soap also affects the biology of the tank. Liquid soap tends to be easily overused and may create problems in the system. Even biodegradable products containing naturally antimicrobial oils (e.g., peppermint oil) can be problematic when used in large amounts.

B.9 Number of rolls of toilet paper used per week:

Excessive toilet paper going into the wastewater treatment system results in faster sludge build-up. Treated toilet paper, such as those containing lotion, can prevent toilet paper from settling and form a thick layer of scum at the top of the tank. Additionally, disposing of other types of products such as wet wipes and feminine hygiene products into the system can cause problems and should be discouraged, even if products are labeled as flushable. Non-flushable items (anything that isn't readily biodegradable) should be disposed of in the trash.

B.10 Toilet cleaning product brand, Continuous cleaner used in toilet:

Toilet chemicals can also directly affect the system. Antibacterial products cause problems for the biological components of the system if used excessively. Continuous cleaners (e.g. those designed to discharge each time the toilet is flushed) should not be used. The impact of these chemicals on the system can cause long-term problems.

B.11 Please list commonly used brands of cleaning supplies and any antibacterial products:

Listing the cleaning products used in the residence raises owner awareness concerning the types of products used. Listing antibacterial products used in the residence is helpful. These products can have a cumulative effect on the treatment system.

Looking at labels can greatly assist in the choice of cleaning products:

- DANGER: Means the chemical will kill the bacteria, and its use should be minimized or eliminated
- WARNING: Means limited use should have a minimal impact on the system.
- CAUTION: Typically means the product will have little effect unless used excessively.

C. Onsite wastewater treatment system

The final series of questions address characterization of the onsite wastewater treatment system.

C.1 Actual water use

Monitoring hydraulic flow is important for problem identification. It allows for proactive versus reactive behavior by the service provider or the homeowner. It is important to collect as complete a data set as possible to provide accurate average daily, peak, and low flow values.

Note the source of the data.

C.2 What is the water pressure?

Note the water pressure. It can influence the flow per fixture. The higher the water pressure, the higher the flow from water fixtures. Generally, the volume of water per flush for a toilet is not impacted by water pressure. If a home is equipped with water-saving devices, then the assumed average daily flow per person is often only 60 gallons per day instead of 75 gallons per day. Water-saving devices reduce wastewater flow but concurrently increase wastewater strength.

Note whether there are any automatic flush fixtures. Automatic flush fixtures must be set correctly to only flush following use. Improper settings can result in unnecessarily frequent flushing.

C.3 Water treatment device:

Use of water treatment devices with automatic back flushing adds extra water into the system. Also, some water conditioning units back wash chemicals into the effluent stream that may reduce the effectiveness of biological and physical processes in the septic tank. Reverse osmosis units may waste a large percentage of the water they treat. If this water is wasted into the onsite wastewater treatment system, it may hydraulically overload the system.

C.4 Air conditioner unit(s):

Condensate from air conditioning units is clear water and may be directed to other beneficial uses. It should not be plumbed into the wastewater system.

C.5 Commercial ice machine:

Use of commercial ice machines can add large amounts of clear water. Dilution of wastewater is not always a helpful solution for proper treatment. Condensate discharge may be directed to other beneficial uses.

C.6 Are footing drains from basement sump pumps connected to the system?

Footing drains and sump pumps collect clear water from below the foundation to lower the surrounding water table. These clear water sources can overload the system and cause a hydraulic malfunction if connected to the wastewater treatment system.

C.7 Monthly water readings for one year period:

If available, these readings can assist in determining if the system was designed properly. Evaluating them for at least one year provides an indication of trends and use.

C.8 Location of sampling point:

Sampling may be recommended or required. Where the sample is taken from in the treatment train gives value to the results. Please attach Form 9-2 to this survey if sampling has occurred.

Form 9-3 Residential Survey (RS)

Reference #:____________________

Form completed by: Company: ______________________ Employee:______________

Client Contact Information

Client Name: _________________________ Time:_______ Date: ___________

Address: ____

Phone #: ____________________________ Cell #:_________________________

Designer: ___________________________ Installer:_______________________

Design flow: ____________________GPD Date of last pump out:___________

Facility in a rural setting ☐ Yes ☐ No

A. Operational data

A.1 Is this your first home with an onsite wastewater treatment system? ☐ Yes ☐ No
A.2 Have you ever received any treatment system user information? ☐ Yes ☐ No
A.3 Did you receive the as-built drawing for the treatment system? ☐ Yes ☐ No
A.4 Type of use:
 a. Permanent: ☐ Seasonal: ☐ If seasonal, # of months used: ______
 b. Number of people living in the house:
 Adult: Teenagers: Children:
 M ___ F ___ M ___ F ___ M ___ F___
 c. Number of bedrooms: _________________
 d. Number of bathrooms: ________________
 e. Number of laundry rooms: ______________
A.5 Water supply
A.6 Do you have an in-home business? ☐ Yes ☐ No
 a. If "yes", what type? ______________________________________
A.7 Do you use septic system additives? ☐ Yes ☐ No
 a. If "yes", what products? ___________________________________
A.8 Square footage of house: _____________________ ft^2

B. Water use habits

B.1 Is any resident using long-term prescription drugs or antibiotics? ☐ Yes ☐ No
 a. If "yes", what products? ___________________________________
B.2 Do any residents use bath/skin oil/moisturizers? ☐ Yes ☐ No
B.3 Garbage disposal use ☐ Yes ☐ No
B.4 Dishwasher use ☐ Yes ☐ No

Reference #:_______________

B.5 Laundry machine use: ☐ Yes ☐ No
- a. High efficiency machine ☐ Yes ☐ No
- b. Max loads per day: _______________ Total loads per week: ____________
- c. Are loads done consecutively? ☐ Yes ☐ No
- d. Brand of laundry detergent: ______________Powder: ☐ Liquid: ☐
- e. Is Bleach used?
  Powder: ☐ Liquid: ☐ Cups/load: ________ Loads/week: _______
- f. Water temperature preference: Hot ☐ Warm ☐ Cold ☐

B.6 Whirlpool tub/Jacuzzi ☐ Yes ☐ No
- a. Use: ______________ times/day ______________ days/week

B.7 Drain cleaner used ☐ Yes ☐ No
- a. Type: ____________________ Frequency of use: ______________________

B.8 Hand washing soap brand: _____________________
- a. Antibacterial: ☐ Yes ☐ No
- b. Liquid: ☐ Yes ☐ No

B.9 Number of toilet paper rolls used per week __________________________ rolls
Feminine hygiene products, or baby wipes flushed: ☐ Yes ☐ No

B.10 Toilet cleaning product brand: ________________________
- a. Cleanings per month: _________________________
- b. Continuous cleaner used in toilet tank: _______________________

B.11 List commonly used brands of cleaning supplies and antibacterial products:
Shower: ________________________ Kitchen: _______________________
Floor: __________________________ Other: ________________________

C. Onsite wastewater treatment system

C.1 Actual water use (GPD)
- a. Average: ___________ Peak: ____________ Low: ______________
- b. Reading this data from:
  Cycle counter: ___________________ Elapsed time meter: _____________
  Water meter: ___________________ Other: ________________________

C.2 What is the water pressure? ______________ psi
- a. Are bathroom fixtures or other devices low flow rated? ☐ Yes ☐ No
- b. If "yes", please list: ____
  ____
  ____
- c. Are there automatic flush fixtures? ☐ Yes ☐ No

C.3 Water treatment device: ☐ Yes ☐ No
- a. Is a water softener used? ☐ Yes ☐ No
  If yes, back flushes to: ____
- b. Is reverse osmosis used? ☐ Yes ☐ No
  If yes, reject flow discharges to: ___________________________________

C.4 Air conditioning unit(s): ☐ Yes ☐ No
- a. If yes, condensate drains to: _____________________________________

Reference #:_______________

C.5 Commercial ice machine: ☐ Yes ☐ No

a. If yes, condensate drains to: ______________________________

C.6 Footing drains or sump pumps connected into the system: ☐ Yes ☐ No

C.7 Monthly water readings for one year period:

Jan ____ Feb ___ Mar ____ April ____ May ____ June ____

July ____ Aug ___ Sept ____ Oct ____ Nov ____ Dec ____

C.8 Location of sampling point: ______________________________

(Please attach Form 9-2)

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9d | Oxygen State of Treatment Components

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Explain the importance of air exchange for proper system performance.
2. Evaluate dissolved oxygen (DO) concentrations in treatment components and describe how they affect performance.
3. Describe methods to calculate the circulation ratio in treatment systems.
4. Describe methods to change the circulation ratio in treatment systems.

Overview

Air exchange is critical to OWTS operation. Air exchange is necessary for liquid to flow through certain parts of the treatment train. Further, air exchange supplies the oxygen required for advanced treatment components to properly function. Our atmosphere serves as an oxygen reservoir and oxygen delivery to the OWTS occurs through air exchange. Air is composed of approximately 21 percent oxygen on a volume basis and 23 percent on a mass basis. Thus, the air present in treatment components can support a finite amount of aerobic activity. Aerobic treatment processes consume oxygen and release carbon dioxide and adequate air exchange (i.e., both in and out) must occur to support continued performance within treatment components.

Assessing Air Exchange in the OWTS

Many OWTS exchange air through a plumbing vent on the building roof. In the most used component, a septic tank, liquid enters the tank, raises the liquid level and displaces the air in the head space of the tank. As effluent leaves the tank, the liquid level drops and air is drawn through the plumbing vent to fill the head space of the tank. Therefore, the septic tank "breathes" as the liquid level increases and decreases. A tank with structural issues that restrict air exchange will not "breathe" and is described as being "air locked". This condition restricts all flow both into and out of the tank.

Advanced treatment components must exchange air to maintain aerobic conditions. Configurations with passive air exchange have a vent on the treatment unit and a connection to the house plumbing vent. The treatment unit vent allows air entry while building plumbing vent allows air exit. The presence of a building plumbing vent creates a "chimney" effect which supports air exchange through the advanced treatment component and back through the structure plumbing. This "chimney effect" is critical to aerobic treatment in passive aeration systems. A key element of troubleshooting these is to determine whether air flows freely from the vent inlet on the treatment unit to the plumbing vent. If conditions warrant such an investigation (for example, odors or poor performance), a smoke test can be performed on the treatment unit to verify air exchange.

All buildings should have plumbing vents through the roof. However, some buildings use air admittance valves that allow air to enter the plumbing to support liquid flow in the piping. Air admittance valves are one-way vents supporting air entry into plumbing. However, air cannot flow from external plumbing into the structure. The "chimney" affect is not available to support treatment unit air exchange. In these cases, a plumbing vent located outside the building can provide an air exchange mechanism in the treatment units.

Advanced treatment components using compressed aeration must vent the pressurized air to the atmosphere. All pressurized aeration units must have a method to release air such as connection to a building plumbing vent, designated exterior vents or non-sealed riser lids. Designated vents are typically piping extending from the tank to above the ground surface, air release valves in riser lids, and vent covers in riser lids. All riser lids must be secured to restrict unauthorized access. However, non-sealed lids have the seal between the lid and riser lip removed to allow air exchange. If the air exchange mechanism is specified as non-sealed risers, any retrofitted sealed riser lids will restrict air exit from the treatment unit. Troubleshooting activities for a pressurized aeration system include verification that the air exchange mechanism is functional.

A dosing tank or flow equalization tank delivering liquid to treatment units stops air exchange through building plumbing vents. The pump discharge assembly does not support air return from downstream treatment units to the dosing tank. In this case, all treatment components downstream of a dosing tank must vent to the atmosphere. A physical vent pipe extending above finished grade promotes air exchange with the atmosphere. Note that treatment units that rely on passive air exchange through the building plumbing vent may experience air exchange issues when receiving liquid from a dosing tank.

Free access or buried media filters must exchange air with the atmosphere to maintain aerobic conditions. Media filters with exposed sand or rock surfaces must maintain air exchange through the rock or sand. Impervious materials placed over the rock surface will restrict air exchange. Buried media filters have soil cover over the treatment media. The soil restricts air exchange. Blockage of vent ports on containerized media filters also limits air exchange. The vents can be pipes or ports in the side of containers extending above finished grade. These air exchange ports must remain open to promote air exchange.

Distribution components in the STA must also breathe. In a system composed of a septic tank, distribution box and gravity distribution STA, air is vented all the way back through the house plumbing. If effluent ponds within off-grade piping, venting ceases. In pressure distribution systems (LPD, drip), the force of delivering effluent drives air out and air is pulled in during resting cycles. The system must have the capacity to vent for this to occur.

Adjusting effluent dose volume or delivery rate to match the air exchange capacity may mitigate this. Supplemental venting to the ground surface is another option.

Soil treatment areas require air exchange to maintain aerobic soil conditions conducive to effective contaminant removal and optimal liquid conveyance. Air exchange rate between the soil and atmosphere is slow. The soil texture and structure impact the soil's air exchange rate. Soil structural features provide macropores to facilitate greater water and air movement rates. Plant roots provide flow paths for air exchange. Plants require aerobic conditions along the roots for growth. Air diffusion through the plant can convey some oxygen to the roots and surrounding soil.

Soil treatment area conditions promoting air exchange include:

- relatively shallow placement of effluent distribution media and piping;
- use of pressure distribution configurations
- open soil surface for air exchange
- coarser soil texture
- soil structural features promoting vertical macropores
- moderate soil moisture content
- healthy vegetation with robust root growth

Soil treatment area conditions restricting air exchange include:

- deeper placement of effluent distribution system
- impervious cover over soil treatment area
- finer soil texture
- massive or platy soil structures
- saturated soil
- mounded groundwater
- poor vegetation and root growth in soil profile
- soil compaction
- smearing of infiltrative surface during installation

Oxygen State in Advanced Treatment Components

Treatment systems are developed as a treatment train providing tanks with a habitat for specific microorganisms that metabolically convert and reduce specific wastewater contaminants. Optimal growing conditions are necessary to maximize the microbial treatment achieved in the treatment tanks and oxygen state is critical to the establishment of a healthy microbial population. Dissolved oxygen (DO) can be measured in the field and the system settings can be appropriately adjusted.

In general, aerobic treatment components should produce effluent with at least 2 mg/L of DO to ensure aerobic processes function as intended. Anaerobic components should have DO concentrations of less than 0.3 mg/L or anaerobic processes may not occur. The microbes in these zones may facultatively use oxygen rather than less energetically favorable anaerobic metabolic processes.

The configuration of the advanced treatment component determines appropriate methods for adjusting the oxygen condition. Media filters are inherently designed to create aerobic conditions. They typically incorporate a recirculation tank for recycling liquid through the filter. Submerged aeration systems are designed to diffuse oxygen into the effluent. Aerated effluent recirculates and mixes with anaerobic effluent to achieve a specific oxygen state. The volume of recirculation affects the oxygen state for each process and the recirculation ratio is thus the focus for adjustment when needed. Evaluate the aeration or recirculation system to determine how to adjust the oxygen condition.

Understanding Circulation and Recirculation Ratios

The circulation ratio of a system is the amount of effluent that cycles through the treatment unit relative to the amount of effluent delivered to the final treatment and dispersal component. The recirculation ratio is less than the circulation ratio and describes the amount of effluent recycled to the previous component relative to the amount of effluent delivered to the final treatment and dispersal component.

Forward flow is the effluent that reaches the final treatment and dispersal component during a specific period. The volume of effluent generated at the source (the home's forward flow) is the same volume available for final treatment and dispersal (additions to the system from rainfall on the filter are usually not factored in).

Circulation ratio = total volume dosed to treatment unit / forward flow to the STA

This is expressed as the ratio of circulated flow to the forward flow during a specific period. The typical circulation ratio ranges from 5:1 to 6:1. Because recirculation is defined as circulation minus forward flow, the recirculation ratio equals the circulation ratio minus 1. The typical recirculation ratio ranges from 4:1 to 5:1.

Oxygen State in Recirculating Media Filters

In a media filter system, the circulation/recirculation ratio directly influences the level of dissolved oxygen (DO) in the recirculating tank (or the processing tank, depending on type of system). Because a media filter uses an aerobic process for treatment, the effluent that passes through the unit delivers oxygenated effluent back to the recirculating tank. A higher recirculating ratio (for example, 6:1 versus 4:1) means that more oxygenated effluent is delivered to the recirculating tank.

Check DO levels in the recirculation tank to assess if the recirculation ratio needs adjustment. Too much recirculation leads to excess oxygen in the recirculation tank, which compromises denitrification efficiency (low DO is needed to promote denitrification). The maximum DO limit is 0.5 mg/L (ppm) (optimal levels are 0.1–0.3 mg/L) measured at the inlet side of the recirculation/processing tank. Higher DO than 0.5 mg/L means that the recirculation ratio needs to be reduced. If effluent is not clear or has some septic odor after passing through treatment and if the DO at the inlet of the recirculating tank is less than 0.5 mg/L, then the recirculation ratio may be increased to achieve more treatment.

Adjusting Circulation/ Recirculation Ratios in Time Dosed Pumping Systems

The circulation/recirculation ratio of a system can be changed by simply changing the amount of effluent pumped to the treatment unit over time. The average forward flow of a treatment unit is not likely to change if the use of the residence remains the same, but the timers that control the amount of effluent to the treatment unit can be adjusted to suit the system's needs.

In a typical recirculating system, a programmable timer activates the pump at preset intervals (see Chapter 6). The most common way to adjust the pumping intervals is to change the pump 'off' time, increasing or decreasing the number of pump events to the treatment unit. The shorter the pump 'off' time, the more the treatment unit will circulate and vice versa.

The pump 'on' time is generally set by the manufacturer or designer and is a function of how the unit accepts and treats a certain amount of effluent, so generally it is not advisable to change the pump 'on' time.

The circulation volume to the treatment unit can be calculated from the readings at the control panel. The pump cycle counters, pump 'on' time, and the pump delivery rate for both the pump delivering effluent to the treatment unit and the pump delivering effluent to final dispersal are needed to calculate the circulation ratio. Please review the calculation example in Appendix A for more detail.

Changing the recirculation ratio to more than 5:1 when dosing a media filter may exceed the media hydraulic capacity which could saturate the media and therefore not provide adequate aerobic treatment. Consult the manufacturer or designer of the filter for a recirculation ratio greater than 5:1.

Adjusting Circulation Ratios in Air Lift Pumping Systems

As previously stated, the circulation ratio of a system can be changed by changing the volume of effluent returned over time to the preceding component. Air lift pumping systems introduce air into the base of a pipe where air bubbles form and rise upward in the pipe (Figure 9-5). The rising air bubbles carry effluent above the static water level causing it to overflow to the piping outlet. The air is vented through an opening in the top of the pipe. In some ATUs, air lift pumps provide both aeration of the effluent in the aeration zone, as well as recirculation of a portion of the effluent to an anaerobic compartment closer to the headworks of the treatment train (see chapter 7B).

The air flow rate directly affects the liquid flow rate. As air flow rate is increased the liquid flow rate also increases. Air lift pump operation can also be controlled by adjusting

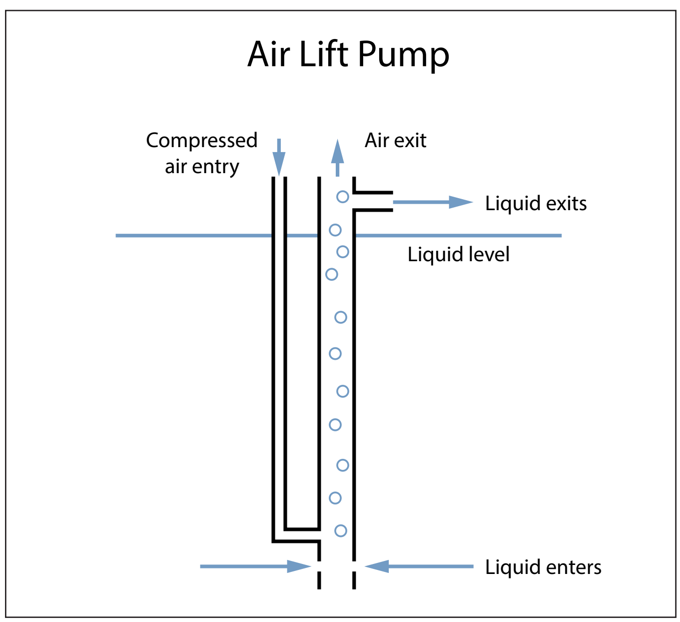

Figure 9-5. Air lift pump operation

the time of air delivery to the pump. A timer activates air delivery to the air lift pump for a specified 'on' period. The 'off' period can be adjusted to control the number of dosing events returning liquid to the previous component and thus the circulation ratio.

So, the service provider can adjust either air flow rate or time of air delivery to the air lift pump to achieve the desired oxygen concentration. Because the liquid return rate is not typically known for an air lift pumping system, adjusting the timer setting of air delivery is considered the most effective method for adjusting the circulation rate.

Assessing Submerged Aeration Systems

Many submerged aeration treatment units use a continuous aeration time mode to deliver oxygen to the treatment units. Therefore, the aeration rate is not adjustable. However, some units use a timer to activate the aeration pump for a specific number of discrete intervals over a 24-hour period.

The timed operations offer the ability to change the air delivery interval to the aeration chamber to change the aeration time and thus adjust the oxygen delivery to the treatment unit.

For example, submerged aeration systems in ATUs function as nitrogen reducing technologies by recirculating nitrified effluent from the clarifier or downstream dosing tank to an anaerobic tank serving as an anoxic tank. The recirculation pump may function as a sludge return mechanism in addition to returning nitrified effluent. Adjust the pump operation cycles to obtain the optimal dissolved oxygen concentration in the anoxic treatment tank (less than 0.5 mg/L). Again, shortening the pump 'off' time allows a greater return volume by increasing the number of cycles per day. The maximum volume returned during a dose is limited by the hydraulic capacity of the clarifier. Therefore, increase the number of dosing cycles rather than the run time per cycle.

Summary

If DO is too low (< 2mg/L) in effluent exiting an aerobic treatment step, investigate the aeration component. Verify whether oxygenated air is introduced to the system as intended (check intake vents for media filters, and air supply lines for aerators or air lift pumps). If venting is operational, increase the number of doses to the media filter, increase the air delivery in an air lift system, or increase the aeration time in intermittently aerated systems.

If DO in the anoxic areas receiving aerated effluent is too high (> 0.3 mg/L), reduce the number of times the media filter is dosed (longer off times between cycles), reduce the airlift flow rate, or reduce the number of effluent return cycles from the aerated zone.

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Troubleshooting Dosing Systems and Controls

Learning Objectives

Upon completion of this chapter, participants should be able to:

1. Describe interaction of pump performance and system curves and identify the duty point.
2. List the causes for an increase in pump run time per cycle in a demand dosing system.
3. List the causes of a decrease in pump run time per cycle in a demand dosing system.
4. List the causes of an increase in pump cycles per day in a time dosing system.
5. List the causes of a decrease in pump cycles per day in a time dosing system.

Troubleshooting Pumps and Controls

Pumps serve a critical purpose in our wastewater treatment systems. Pumps function to move liquid under pressure to increase the liquid elevation, transport liquid to another location and assist in uniform distribution. A variety of pumps are available to serve these important functions. However, the pumps available to meet the requirements for onsite wastewater treatment system needs are limited. This discussion will focus on the pumps available for meeting our needs and fabricating a system to effectively utilize these pumps.

Pump characteristics

A pump is a mechanical device constructed to add energy to a liquid. Most pumps used in onsite wastewater treatment systems are categorized as centrifugal pumps. A centrifugal pump has a rotating impeller inside a volute that transfers the rotating energy of the impeller to the liquid. The rotating impeller develops a region of low pressure at the center, atmospheric pressure pushes liquid into the center of the impeller and, as the liquid moves outward along the impeller vanes, energy is imparted to the liquid. The liquid exits the pump housing at a flow rate and pressure corresponding to the pump performance curve and the system pressure resisting liquid flow at the pump discharge. The horsepower to turn the rotating impeller is directly related to the energy imparted to the liquid. The mass of liquid moved, and the energy imparted to the liquid define the required horsepower to turn the impeller(s).

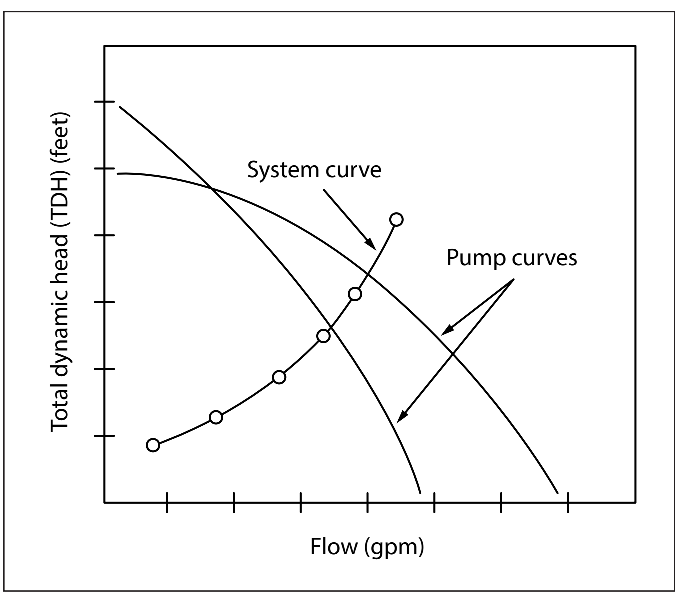

Figure 9-6. Pump and system performance curves illustrating the relationship between total dynamic head (TDH) and flow.

Pumps are designed to have a specific capacity to pass solids through the pump. Pump impellers have solids handling capability which is directly related to the impeller design and the volute. An open face impeller can transfer larger solids when compared to an enclosed impeller. The restriction of particle size for an open face impeller is related to the opening between the impeller and the volute. The particle size restriction for a closed impeller is the opening between the sides of the impeller. A pump is categorized as a "sewage pump" or an "effluent pump" based upon the specified ability to pass solids. The pump manufacturer specifies the solids handling capacity of each pump model. A grinder pump is a special category of pump with the capacity to cut solids passing through the pump inlet into smaller sized particles capable of passing through the pump.

Pump and system curves

Pump performance curves illustrate the relationship between head and flow. These graphs include both a system curve and one or more pump curves (Figure 9-6). The system curve is based upon both *static head* and *dynamic head* in feet as described in a design. Static head is fixed and includes both the difference in elevation between pump "off" and the highest point in the system as well as the operating pressure specified in the design. The dynamic (variable) head in a system is the friction loss (in feet) in piping resulting from interaction of the liquid and the inside of the piping and fittings. Friction losses vary with the flow rate and velocity in the piping and fittings.

The pump curve is based upon dynamic head and illustrates the relative amount of energy delivered to move a specific mass of liquid by a specific pump impeller. When both curves are plotted, it is a graphical representation of the interaction between a specific system and a specific pump. The Y axis on these graphs may labeled as "total dynamic head" or "total head". In this context, there is no distinction.

The flow and head have an inverse relationship. As the flow increases, the total dynamic head decreases. A pump in each system will operate at some point along the performance curve. Ideally, the pump selected is one which operates somewhere near the middle of the pump curve. This results in optimal pump performance and longevity.

An onsite wastewater treatment system has a system curve describing the flow and total head relationship required to operate at an optimal point. This is the system *duty point* and describes the desired pump total dynamic head and flow rate to achieve optimum operating conditions. The pump duty point is the intersection of the system curve and the pump performance curve.

For example, low-pressure distribution may require two feet of head at the orifice for a specific design flow rate. The dynamic head is the friction loss in the piping before and after the pump. The dynamic head increases as the velocity in the piping network increases. The total dynamic head generated by the pump must meet both the static and dynamic head requirements of the system. Therefore, the pump total dynamic head includes static elevation, static operating pressure and dynamic friction loss in the piping network.

Adjusting the system curve

A pump operates on the pump performance curve. A pump with a flow:pressure capacity greater than the system duty point will deliver a greater volume of effluent, thus increasing the friction in the piping network which allows operation on the performance curve. Ideally, the pump was selected for operation in a specified, efficient section of the pump curve, which should also correspond to greater pump longevity. In many instances, the desired system duty point is close to and below the pump performance curve and preferred pump operational range. Therefore, the increased flow rate and operating pressure does not impact system operation and pump performance.

The system duty point does not always align well with the best operation range of the pump. In this instance, the system curve can be adjusted to better match the best operation range of the pump. This can be achieved by adding flow, increasing friction loss, or both. Extra flow is achieved by adding a recirculation line equipped with a gate valve to the pump discharge assembly. The extra flow recirculates back into the dosing tank. Increase the friction loss by adding a gate valve in the discharge piping at the outlet of the dosing tank. The gate valve is adjusted slowly downward, thus increasing the piping friction loss to an optimal value. In some situations, both recirculation and increased friction loss is required to move the system curve to an ideal location in pump performance curve.

Troubleshooting pump operation

Pumping systems convey a volume of effluent to a downstream component at a particular flow rate and pressure. The dose volume (gallons) when combined with the expected flow rate defines a specific pump run time for dose delivery. Therefore, based upon the dose volume, expected flow rate and expected pump run time, a given customer will have a characteristic number of pump cycles and pump run time to dose their effluent to the onsite wastewater treatment system. The characteristic number of doses and pump run time serves as base data to identify data trends or anomalies indicating changes from normal operational characteristics.

Pump operational changes indicate changes in onsite wastewater treatment system operation. These OWTS changes are due to variability in water volume pumped, pump operation, and piping system operation. A customer's water use pattern can be established with time. Their water use habits will define the volume of water used during a weekly or seasonal period. The pump operation can change as the pump components wear or maintenance is required. Piping system operation will change in response to clogging of distribution piping, orifices, emitters and nozzles. Many of these changes indicate the need for maintenance to be performed.

Pumping control systems are described as demand or time dosing operation. Demand dosing systems provide unrestricted power to the pump motor. Therefore, the pump continues to run for the time required to remove the liquid from the dosing tank. Time dosing systems restrict power to a pump for a designated dosing 'on' period. Therefore, the pump in a time dosing system is restricted from running for a longer period to remove the liquid from the dosing tank.

Pump operation is controlled differently in demand and time dosing systems. Therefore, operation changes in water volume, pump operation and piping system are observed in different data trends.

The scenarios below describe an approach for proactive maintenance. Evaluate the operational data in the system, identify changes and try to determine the reason for the change. Changes may indicate the need for maintenance activities. Alternatively, it may be sufficient to simply understand what has changed.

Increasing cycles per day in demand-dosed systems

An increasing number of pump cycles per day is generally associated with a greater volume of effluent passing through the system. The extra liquid may originate from the source. However, extraneous sources may be the problem:

- Liquid can drain back to the dosing tank from a flooded soil treatment area.
- Ground or surface water can infiltrate into the tanks during rainfall events or during wet times of the year.
- Leaking risers, piping, tanks, and tank lids and seams add water to the OWTS.

Alternatively, system operational parameters may have been changed. The owner (or another service provider) may have shortened the float tether length, thus reducing dose volume and increasing the number of cycles required to disperse effluent from the dosing tank. Check the floats to make sure they are properly configured.

Decreasing cycles per day in demand dosed systems

A decreasing number of pump cycles per day is generally associated with a lesser volume of effluent passing through the system.

- The amount of water use at the source can decrease due to the owner leaving for vacation or changes in the number of residents.
- The weather pattern can change to a dryer time of year resulting in less water infiltration into the OWTS.
- The service provider may have performed maintenance to repair leaking piping, risers or tank seams.
- Roots may have entered the OWTS to remove water from the system and decrease the volume available for dispersal.

Decreasing pump cycles may be due to altered operational settings:

- The float switch may malfunction while in the energized mode resulting in continuous pump operation.
- The tanks can develop leaks allowing water exfiltration, thus reducing the dosing cycles.
- The circulation rate for an advanced treatment system may have been reduced resulting in a lesser number of dosing events.
- The service provider increased the float switch tether length, changed the dose volume and reduced the required number of dosing events.

Increasing run time per cycle in demand dosed systems

An increasing run time per cycle indicates a decrease in pump delivery rate. The pump is running for a longer period to distribute the same volume of effluent through the distribution system.

- The piping distribution network is experiencing plugging of orifices, emitters, or nozzles.
- The filter is plugging and reducing the flow rate through the filter.
- A water meter with an internal screen restricts water movement.
- The piping has accumulated debris or scaling that increases friction loss and reduces flow rate.
- The piping is crushed, which decreases the flow rate.
- An in-line flow regulating valve was adjusted closed, increasing the system friction loss and decreasing flow rate.
- An in-line recirculation valve was opened to allow more effluent return to the dosing tank.
- The pump head is wearing, causing a reduced total head capacity and reduced pump delivery rate.
- The pump impeller has debris lodged in the closed face impeller disrupting the centrifugal flow pattern and decreasing pressurization and flow rate.
- The pump inlet screen is plugged which reduces the flow rate entering the pump head.

Decreasing run time per cycle in demand dosed systems

A decreasing run time per cycle typically indicates an increase in pump delivery rate.

- Maintenance activities for the distribution system can increase water flow rate and, in turn, decrease run time per cycle.
- The distribution piping or fittings may be broken, allowing a greater effluent flow rate.
- The in-line gate valve is open allowing a greater flow rate to the distribution system.
- The in-line recirculation valve is closed resulting in a greater discharge rate.
- The pump is replaced with a new pump returning the system to the original flow rate or the pump delivery rate is greater with the new pump.
- Pump maintenance is performed to remove debris from the inlet screen or inside the impellers.

Increasing pump cycles per day in time dosed systems

An increasing number of pump cycles per day can indicate a greater water volume entering the OWTS. The extra water can originate from the water source or from an extraneous source.

- Effluent can drain back to the dosing tank from a flooded soil treatment area.
- Ground or surface water can infiltrate into the tanks during rainfall events or during wet times of the year.
- Leaking risers, piping, tanks, and tank lids and seams add water to the OWTS.

An increasing number of pump cycles per day can also indicate the need for maintenance on the OWTS.

- The pump head is worn and causing a reduced total head capacity and reduced pump delivery rate.
- The pump impeller has debris lodged in the closed face impeller disrupting the centrifugal flow pattern and decreasing pressurization and flow rate.

- The pump inlet screen is plugged which reduces the flow rate entering the pump head.
- The pump was replaced with a pump with a reduced flow rate and pressure capacity.
- The piping distribution network is experiencing plugging of orifices, emitters, or nozzles.
- The filter is plugging and reducing the flow rate through the filter.
- A water meter with an internal screen restricts water movement.
- The piping has accumulated debris or scaling that increases friction loss and reduces flow rate.
- The piping is crushed, which decreases the flow rate.
- An in-line flow regulating valve was adjusted closed, increasing the system friction loss and decreasing flow rate.
- An in-line recirculation valve was opened to allow more effluent return to the dosing tank.

Operational parameters may have been altered by the owner or others.

- The operator changed the pump 'on' time, thus reducing the dose volume per dosing event.

Decreasing pump cycles per day in time dosed systems

A decreasing number of pump cycles per day can indicate a lesser water volume entering the OWTS.

- The source water can be decreased due to the owner leaving for vacation or changes in the number of residents.
- The weather pattern can change to a dryer time of year resulting in less water infiltration into the OWTS.
- The service provider can perform maintenance which repairs the leaking piping, risers or tank seams.
- Roots may have entered the OWTS to remove water from the system and decrease the volume available for dispersal.
- The tanks can develop leaks allowing water exfiltration, thus reducing the dosing cycles.
- The distribution piping can have broken piping and fittings allowing a greater effluent flow rate.
- The pump is replaced with a new pump returning the system to the original flow rate or the pump delivery rate is greater with the new pump.
- Pump maintenance is performed to remove debris from the inlet screen or inside the impellers.

Operational parameters may have changed.

- The service provider increased the pump 'on' time, changed the dose volume and reduced the required number of dosing events.
- The circulation ratio for an advanced treatment system is reduced resulting in a lesser number of dosing events.
- The in-line gate valve is open allowing a greater flow rate to the distribution system.
- The in-line recirculation valve is closed resulting in a greater discharge rate.

Short-cycling in time dosed systems

A time dosing system has a timer enable float switch that activates when sufficient effluent volume is in the dosing tank for distribution of a dosing event. The timer starts in the 'off' mode when timer enable float activates. During the off mode, effluent continues to collect in the dosing tank. During a subsequent dosing event, the timer enable float may deactivate and deenergize the pump prior to delivering a full dose volume. This will occur when tank levels have been dropped to the off level of the timer enable float. Therefore, all mechanical time dosing systems should have a short cycle time on the last dosing event which deactivates the timer enable float. Programmable time dosing systems can continue to provide power to a pump after timer enable float deactivation. Such systems will typically include a redundant off float that ensures that sufficient effluent is present for proper operation.

A condition where the average run time per cycle is much less than the normal dosing time would indicate relative low water use, and the timer enable float switch is activating and deactivating the timer multiple times per day.

High water alarms as a maintenance indicator

Time dosing systems are subject to high water alarm conditions. Time dosing systems limit pump run time to a maximum number of minutes per day. An increase in water usage or decrease in pump delivery rate results in a high-water alarm condition. Many people believe the high-water alarm should never be activated. In timed dosing systems, alarm conditions are the key to communicating the need for maintenance to the owner and service provider. A timer override float switch is added to the dosing tank to change system operation to a demand dosing system. The timer override float switch allows unlimited pump run time and removes the communication mechanism to the owner or service provider of the need for system maintenance. An event counter should record the activation of timer override events to communicate the occurrence of these conditions and indicate troubleshooting should be conducted to determine the root cause of the high-water condition.

Troubleshooting electrical controls

Control system troubleshooting requires advanced skills as a maintenance provider. Some jurisdictions require an electrical license to perform troubleshooting on electrical systems. A service provider should only work on electrical systems within the scope of their knowledge, skills and abilities. Acquiring and maintaining the associated credentials has inherent value. At a minimum, the service provider should be proficient in using a multimeter for measuring voltage, current, and continuity in electrical components. Additionally, the service provider MUST have sufficient electrical knowledge to perform and comply with lock-out, tag-out procedures associated with deenergizing electrical circuits while performing service tasks.

This troubleshooting section only discusses basic identification of electrical components and good practices for sealing electrical wiring to prevent liquid and gas penetration.

Electrical systems supply the correct power to the treatment components. Electrical power is described using terms such as phase, voltage, and amperage as well as alternating (AC) or direct (DC) current. The service provider should determine the power supplied to the control panel before opening it. Electricity readily flows from source to ground. Physical contact with a live circuit can result in the most direct path to ground through the person. Therefore, direct physical contact with a live circuit can result in an electrical shock or even death.

Electricity in residential systems is typically single-phase power with a voltage rating of 115 or 230 volts. The voltage is measured using a multimeter in an alternating current voltage mode by placing the lead on the hot wire and the ground in the panel. It is important to verify that the incoming power is appropriate to run the system components. In commercial installations, the hot wire may originate from a three phase 208 service. The maximum voltage can be 208 volts which is insufficient voltage for electrical motors requiring 230 voltage service.

Float sensors used in OWTS can perform multiple actions. The float functions as a switch that interrupts the electrical flow through the wiring based upon changing liquid levels. The float switch moves into the "open" and "closed" positions as the float rises and falls with fluctuating liquid level in a tank. The normal position of a float switch is the relaxed position or hanging down. A "normally open" float switch will have an open circuit (no current flow) in the down position and a closed circuit (current can flow) in the up position. Normally open floats are typically used in onsite wastewater treatment systems. To illustrate, as effluent level rises in a dosing tank, the float sensor moves from the "open circuit" position into the "closed circuit" position allowing electrical current to flow to a device. Normally closed float switches may be used in proprietary units or specialized control circuits. A "normally closed" float switch will have a closed circuit (current can flow) in the down position and an open circuit (no current flow) in the up position.

Float sensors have specific operational capacity and are designated as being either control floats or pump floats. A control float has limited current rating and is used to operate timers, counters and similar devices. Control floats may have either a narrow or wide angle of operation

A float switch designated for pump operation is rated for the current required for the specific horsepower and amperage rating of the pump. Pump floats have a wide angle of operation, and the minimum tether length is 3.5 inches. With this setup, the minimum liquid level change (drawdown) is 7". Increasing tether length results in a greater drawdown during a pump cycle. Consult manufacture guidance regarding the maximum tether length for a given switch. If the desired drawdown is less than 7" or exceeds the specified maximum drawdown for a switch, a two-float configuration is required.

Float switch activation level is directly related to the float switch angle of operation and tether length. A control float classified as a narrow-angle float installed with a 3.5-inch tether length will activate at an elevation 1.5-inches above the attachment point. A pump switch classified as a wide-angle float installed with a 3.5-inch tether length will activate at an elevation 3.5 inches above the attachment point. The switch will deactivate the pump after a 7-inch drop in the liquid level. A wide angle of operation for pump switches limits the risk of rapid on/off cycles ("chattering").

Consult manufacturer literature for the specific product to determine the pumping range or activation level with a specific tether length.

Float switches are mechanical devices and will therefore malfunction as the number of activation cycles reaches their prescribed life expectancy. Float switches can malfunction in a variety of ways and in both the open and closed positions. The pump will not activate, or it will operate continuously. Some float switches will bleed voltage as the contactors malfunction and a low voltage will continue to pass through the pump or control circuit. Additionally, a sensor float switch located at an elevation too close to the pump 'on' level can fluctuate between the on and off position (known as "chattering") of the contactors.

Electric motors draw the power required to deliver the horsepower needed to energize the liquid mass moved at the specified total dynamic head (TDH). The power delivered is a product of the voltage and amperage which is described as watts.

Voltage (V) x amperage (A) = watts (W)

The power in watts translates to horsepower using the relationship of one horsepower being equal to 746 watts. If the mass of water conveyed or TDH increases, the amperage reading will increase assuming the voltage remains constant. Alternately, if the mass of water conveyed or the TDH decreases, the amperage decreases assuming the voltage remains constant. A break in a pipe allows more liquid to be conveyed but typically at a lower TDH and amperage reading will drop. If a valve is closed or clogged, the pump is not moving liquid and amperage readings will decrease. As system operating pressure increases due to plugging in the filtration or distribution network, greater pressure is required to move the same volume of liquid, resulting in an amperage increase.

All electrical wires must be installed in a manner to prevent water and gas entry inside the plastic coating. Corrosive gases and water can move along the electrical wire inside the coating. As the wire corrodes resistance to electrical flow along the wire surface will occur. Since voltage is the driving force moving the current along and through wire strands, resistance resulting from corrosion causes a voltage drop across the corroded wires. The reduced voltage results in more amperage draw to deliver the required power. Eventually, this condition will decrease the motor service life. Variations in electrical amperage readings indicate greater power usage resulting from voltage losses due to corrosion of coated wiring.

Electrical cords must be sealed to prohibit water movement in the cords. Electrical cords have paper insulation surrounding the wiring. A cord with an end open to the liquid and gas vapors can wick water through the cord to the float switch, causing the float switch bulb to fill with liquid. Verify that the cord ends are sealed to limit the risk of liquid moving down a cord with an exposed end. A heat shrink tubing with liquid sealant can serve as a seal for cord ends.

Telematics-assisted Troubleshooting and Maintenance

Telematics is the combination of telecommunication and information technology. Telematics provides a means to communicate onsite wastewater treatment system data to a centralized data collection and management facility. For decades, control systems have recorded, analyzed and communicated data regarding the status of technologies to the manufacturer, service provider and regulatory authority. The expansion of telecommunication and data storage and processing capacity is facilitating real time data analysis to identify trends and distinguish normal operational patterns from anomalies. The real time analysis identifies trends indicating component operation is outside normal operational criteria and indicates that system maintenance is required to return the component to within the normal operational range.

Traditionally, the service provider manually recorded, tracked, and analyzed system operational data during service visits to identify conditions outside of normal operating ranges and communicated the information to the customer. Information technology is performing this analysis on a real time basis and communicating the need for maintenance to the identified entities (owner, service provider, responsible management entity and regulatory authority). Information technology is a tool available to service providers to support performance of proactive maintenance rather than reactive maintenance as components malfunction.

Summary

Troubleshooting requires an advanced level of knowledge, skills and abilities. Data tracking and analysis can reduce the time spent troubleshooting systems. The operational data provides information for use in tracking trends to identify deviations from normal operational conditions. Data may be recorded on Operational Checklists, a control panel with data storage capability or it may be communicated and stored at a remote location using telemetry. Telematics supports a service provider's ability to conduct data tracking over time and perform analysis on the data. Further, it serves as a method to communicate the need for maintenance to the owner, service provider, and responsible management entity.

As the service provider's experience and proficiency increase, the associated ability to evaluate the data and identify the root cause of a malfunction will also increase. A knowledgeable service provider can use the operational data to communicate the system status to the owner.

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Learning Objectives

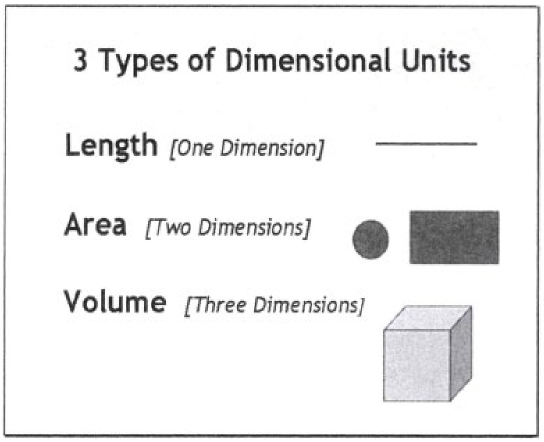
Upon completion of this chapter, participants should be able to:

1. Given tank dimensions, calculate the liquid volume or operating volume.
2. Given the length and diameter of a pipe, calculate the liquid volume.
3. Describe the difference between the terms flow rate and flow velocity.
4. Describe and calculate flow in gallons per day (GPD) or other appropriate units of measure.
5. Define and calculate:
    - Pump delivery rate (PDR)
    - Detention time
    - Hydraulic loading rate

Preface

Appendix A discusses and illustrates the necessary formulae and math principles used to solve basic problems associated with operation of onsite wastewater treatment systems. This section begins with simple but fundamental mathematical concepts that serve as the basis for equations used in troubleshooting.

Fundamental Concepts



Length: [One-dimensional]

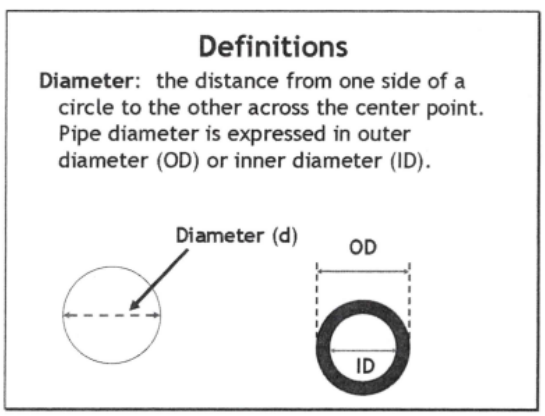
- Inches
- Feet
- Yards
- Miles
- Meters

Area: [Two-dimensional]
The measurement of a surface in square units. Expressed in:

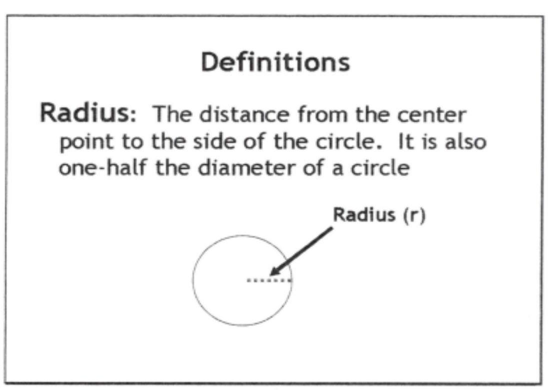
- $Inches^2$ or square inches
- $Feet^2$ or square feet
- $Yards^2$ or square yards
- Acres

Volume: [Three-dimensional]
The capacity of a container such as a pipe or a tank. Expressed in:

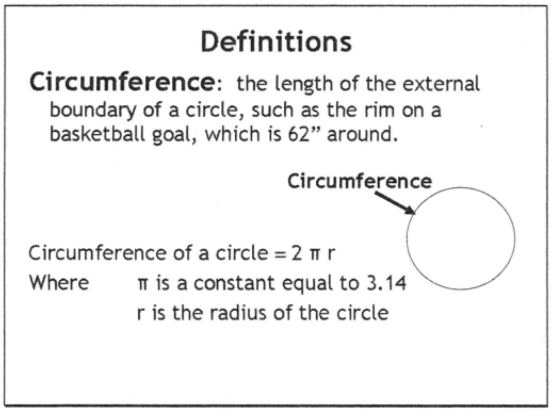
- $Inches^3$ or cubic inches
- $Feet^3$ or cubic feet
- $Yards^3$ or cubic yards
- Gallons, liters



Note the difference between ID (inside diameter) and OD (outside diameter) of a pipe. The abbreviation for diameter is "d".



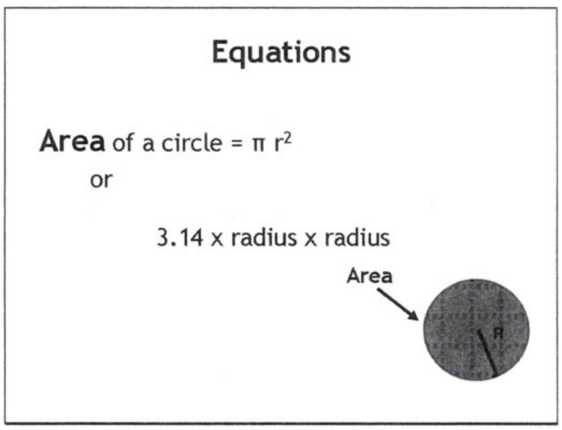
The radius (one-half the diameter) of a circle is an important term. It will be used later to calculate the area of a circle. The symbol for radius is "r".



This term is seldom used in wastewater systems, but to differentiate from area and for a quick review.

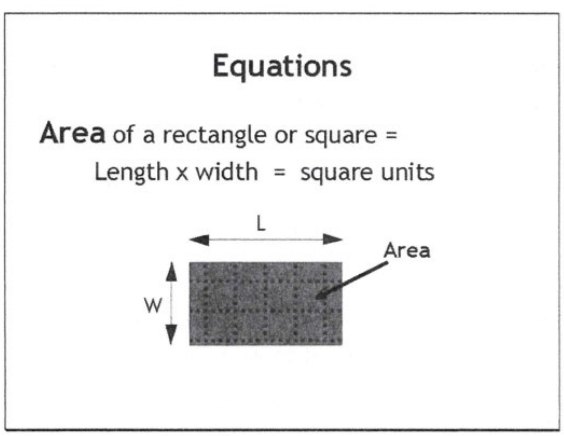
For example, a pipe with a diameter of 3-inch OD, would have a circumference of:

$$2 \times 3.14 \times 1.5'' = 9.42''$$

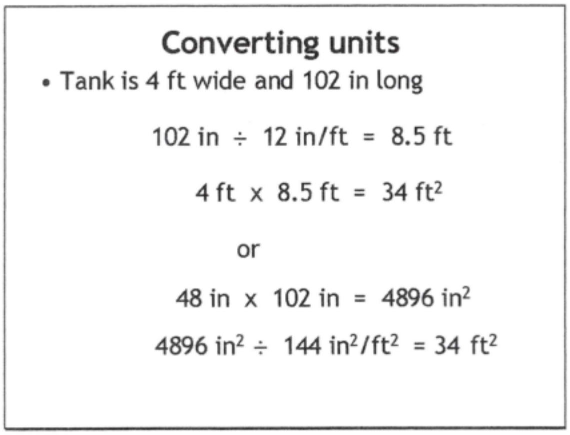


The area of a circle with a diameter of 3 inches would then be:

$$3.14 \times (1.5 \text{ in} \times 1.5 \text{ in}) = 7.07 \text{ in}^2$$



The area of squares and rectangles is the application of the simple formula L x W. One could count all the little units in this example or just multiply the two dimensions to arrive at the same answer.



Always remember to keep track of the units when applying formulas. You cannot multiply Width in inches by Length in feet and get any meaningful numbers.

For example, if a tank is 4 feet wide and 102 inches long, you must first convert length to feet or width to inches before multiplying. As in:

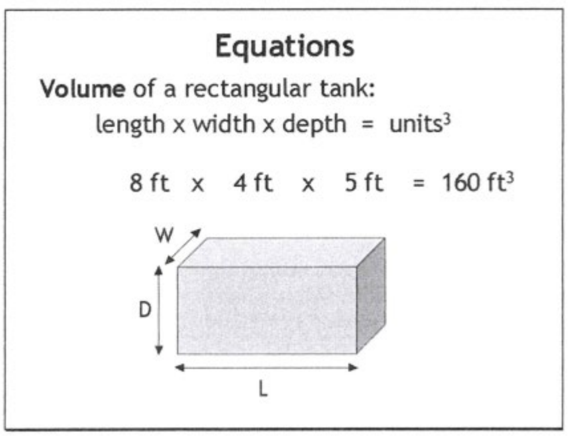
$$4' \times 8.5' = 34\ ft^2$$

or

$$48'' \times 102'' = 4896\ in^2$$

Both answers are correct, but they are expressed in different units.

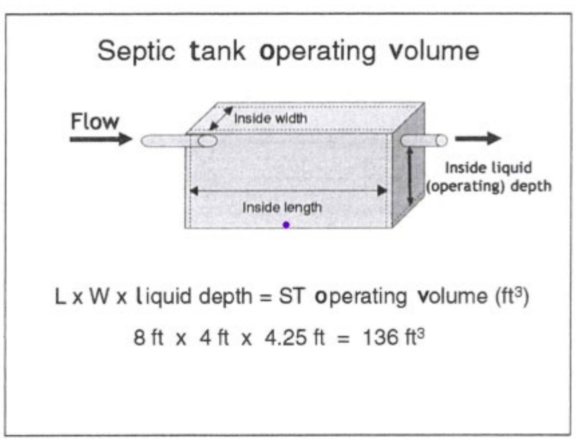
To convert square inches to square feet, divide by 144 or $(12)^2$. To convert square feet to square inches multiply by 144.



A tank is 4 feet wide, 5 feet deep, and 8 feet long. What is the volume in cubic feet?

Again, the units have to all be the same.

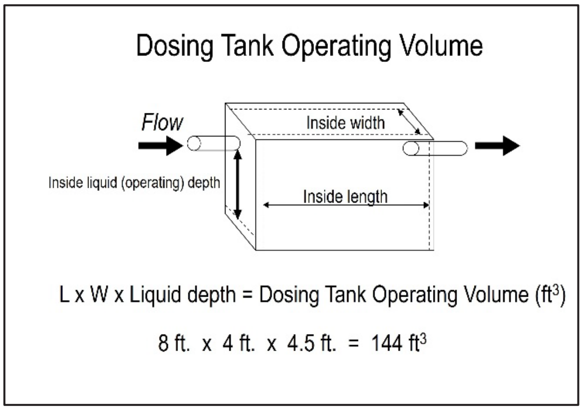
$$8\ ft \times 4\ ft \times 5\ ft = 160\ ft^3$$



A more useful calculation is the operating volume of a tank. For a septic tank, the operating volume is the volume calculated using the depth from the invert of the OUTLET to the bottom of the tank.

L x W x liquid depth = ST operating volume (ft^3)

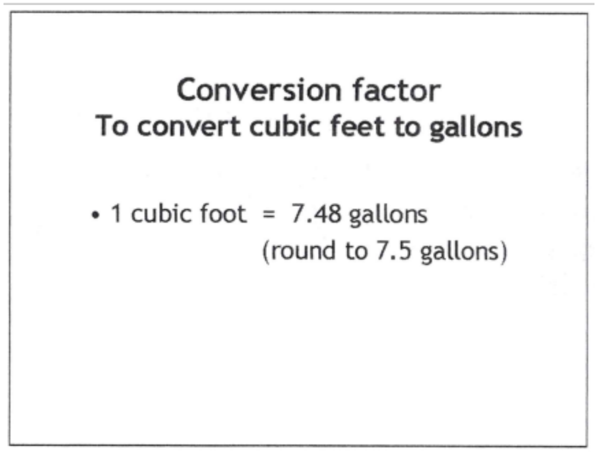
Note that liquid depth is measured inside the tank. DO NOT ENTER THE TANK.



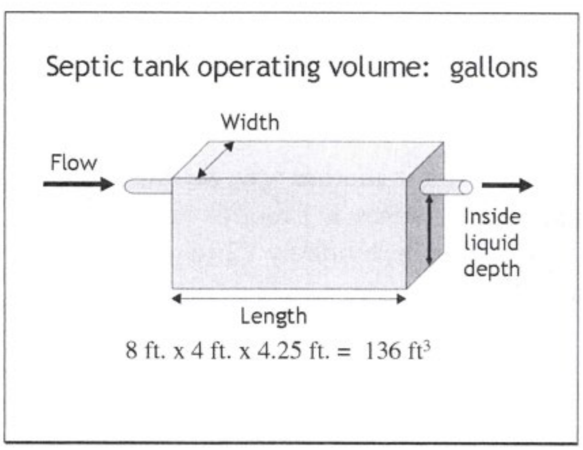
For a dosing tank, the operating volume is the volume calculated using the depth from the invert of the INLET to the bottom of the tank.

L x W x liquid depth = operating volume (ft^3)

Note that liquid depth is measured INSIDE the tank. DO NOT ENTER THE TANK.

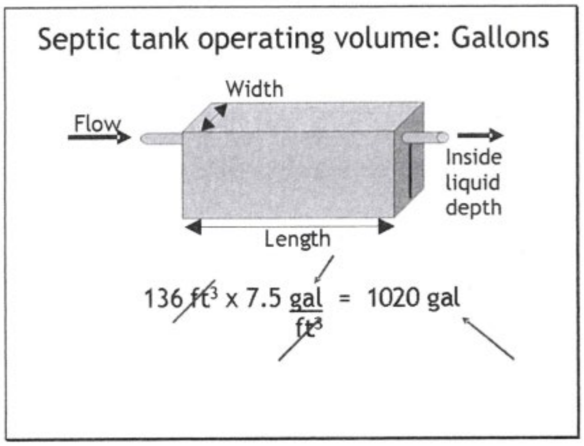


To express tank operating volume in gallons, we use a Conversion Factor. One cubic foot (1 ft^3) holds 7.48 gallons of water or effluent. This is a number that is used repeatedly in operation and maintenance and is worth remembering. For residential systems, it is reasonable to round 7.48 to 7.5 gallons per cubic foot. However, rounding 7.48 to 7.5 may affect the accuracy of calculations related to larger capacity systems.



To calculate a tank's operating volume in gallons, first calculate the volume in cubic feet.

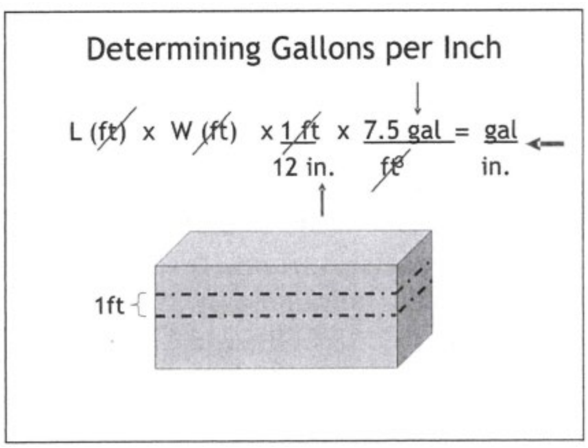
Volume = length x width x liquid depth



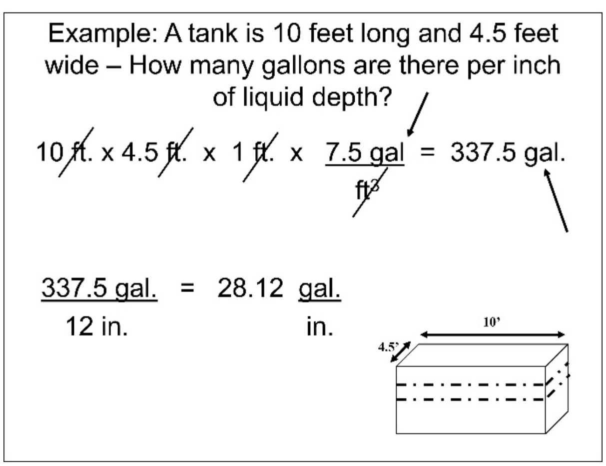
Then convert the operating volume of the tank in cubic feet into gallons using the conversion factor:

136 ft^3 x 7.5 gal/ft^3 = 1020 gallons

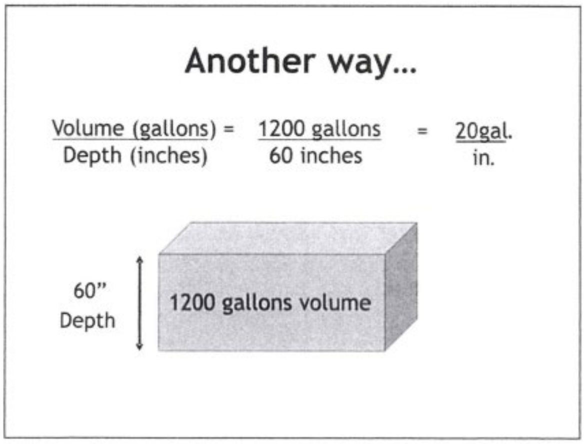
Notice how the units cancel out to give the appropriate answer expressed as capacity in gallons.



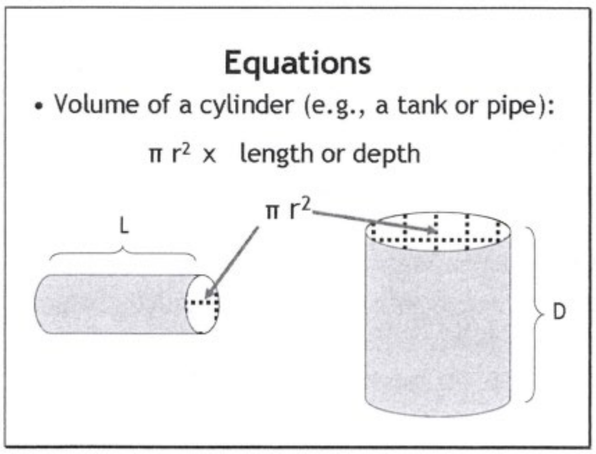
Using tank length and width, calculate the liquid capacity in gallons per inch of tank depth. The units cancel out to leave gallons per inch of tank depth.



Using another method, calculate the volume of 1 foot of tank depth in gallons and then divide by 12 to get gallons per inch.



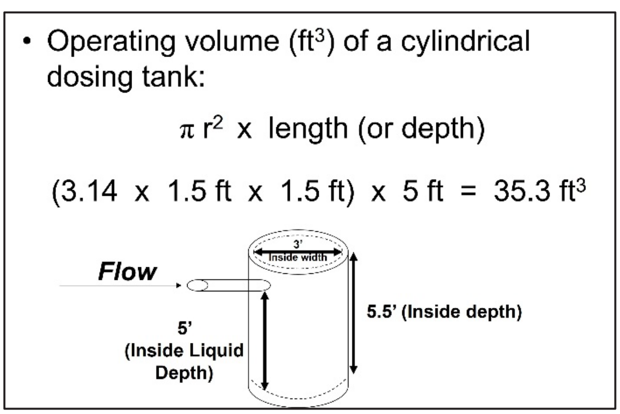
To look at it still another way, if you know the total tank volume in gallons and the total tank depth in inches, divide total tank volume by total tank depth to get gallons per inch.



To calculate volume of a cylindrical tank or in a pipe (which is just a long cylinder), this is the formula that applies:

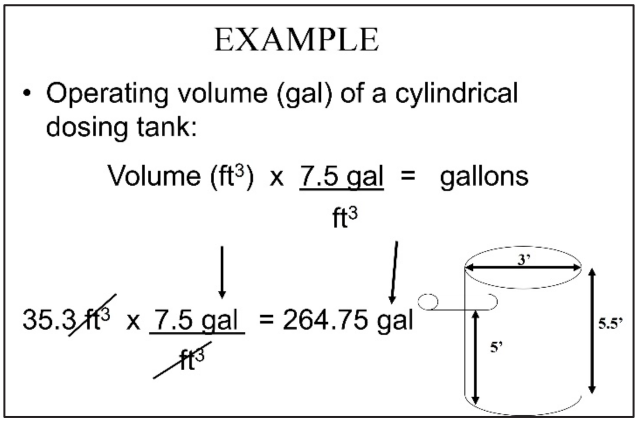
(πr^2) x length

Calculate the area of the circle and multiply the area times the length or height of the cylinder.

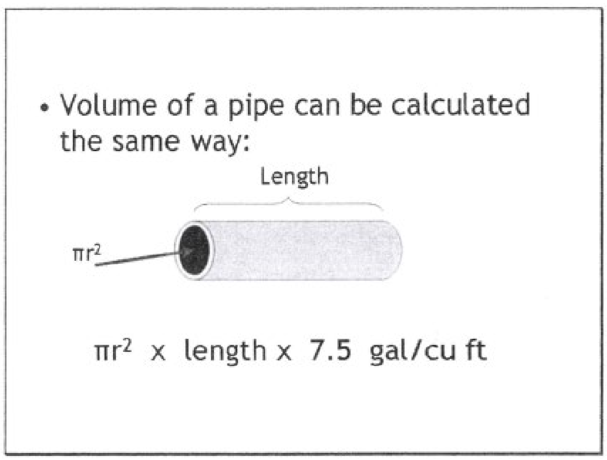


Here is an example of a cylindrical dosing tank that is 3 feet in diameter and 5.5 feet tall. The invert of the inlet to the tank is 5 ft above the bottom. The radius equals one-half of the diameter.

In this example, the radius would be 1.5 feet. Multiply the radius times itself (squaring it). Multiply by pi and the operating depth. The answer is in cubic feet which can be converted to gallons in one more step.



To convert the operating volume in cubic feet calculated above to gallons, multiply cubic feet times the conversion factor of 7.5 gal/ft. Note that the units cancel out to leave the answer in gallons.



This calculation can be important if the volume of effluent in the supply line drains to the field after the pump turns off. For extremely long supply lines, the volume can be significant.

Note: Nominal pipe does not measure exactly as named. For instance, 2-inch Sch. 40 pipe has an internal diameter of 2.067 inches while 2-inch Sch. 80 measures 1.939 inches inside.

Pipeline Volume
(Gallons per 100 feet)

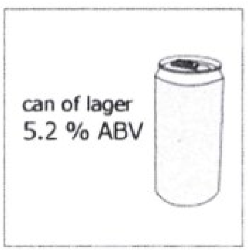
	PVC Rigid Pipe		PVC Flexible Pressure Pipe		
Nominal Size (inches)	Schedule 40	Schedule 80	SDR 26 (160 psi)	SDR 21 (200 psi)	Corrugated tubing
¾	2.8	2.2			
1	4.5	3.7	5.8	5.5	
1 ¼	7.8	6.7	9.6	9.2	
1 ½	10.6	9.2	12.6	12.1	
2	17.4	15.3	19.6	18.8	
3	38.4	34.3	42.6	40.9	
4	66.1	59.7	70.4	67.7	65.3
6	150	135	153	147	147

Tables provided later in this Appendix include the calculated values for pipes of various materials.

Units of Measure and Calculations

Percent (%)

- Latin for "parts of a hundred"



Percent is an important calculation.

Calculating percent

First, divide one number into another:

A ÷ B = quotient

The quotient expresses how many time a quantity is contained in another.

A = 20 ; B = 30

20 ÷ 30 = 0.67

So, A is: 0.67 the size of B

Calculating percent

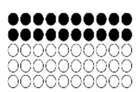
When we multiply the quotient by 100 we obtain how many times a number is contained in 100 of another (percent).

Using the same example:

0.67 x 100 = 67

So, A is: 67% the size of B

Calculating percent



There are 50 dots shown above, 30 are white and 20 of them are black. What percent of the dots are black?

20 ÷ 50 = 0.4	Divide # black by total number
0.4 x 100 = 40%	Convert to percent

The concept of percentage provides an indication of the ratio or proportion of one parameter to another.

Calculating percent solids in a septic tank

- Liquid depth = 60”
- Scum depth = 6”
- Sludge depth = 18”

18”+ 6” = 24	Add amount of scum and sludge
24 ÷ 60” = 0.4	Divide by tank liquid depth
0.4 x 100 = 40 %	Convert to percent

This is particularly useful for determining whether a tank needs to be pumped out but is useful for other things as well.

Converting percent to a fraction

20% = 20/100 = 1/5
33% = 33/100 = 1/3
25% = 25/100 = 1/4
50% = 50/100 = 1/2
75% = 75/100 = 3/4

Tanks should be pumped when the depth of scum and sludge equal 1/4 to 1/3 of the liquid depth of the tank.

Sometimes it is helpful to express percent as a fraction.

Units

Pressure: Force applied to a unit area. Expressed in:

- **pounds per square inch (psi)**
  ex./ Pressure of water in a force main that is 60 psi.
- **Feet of head**
  An alternative expression of water pressure
  psi x 2.31 = Head (ft)
- **pounds per square foot (psf)**
  ex./ A tank lid that is designed to support 150 psf.

Additional terms related to operation and maintenance of wastewater systems.

psi can be converted to pressure head and vice-versa.

Units

- **Concentration**
  - Milligrams per liter (mg/L)
  - Parts per Million (ppm)

  Ex: A system may have a requirement for the effluent not to exceed 10 mg/L (or ppm) of nitrate nitrogen.

Milligrams per liter (mg/L) is the same as parts per million (ppm) for water. Remember that wastewater effluent is 99.9% water.

% Reduction

- A reflection of the treatment efficiency of a system component.

$$\% \text{ reduction} = \frac{\text{influent} - \text{effluent}}{\text{influent}} \times 100$$

Percent reduction is an important concept in wastewater treatment. The concept describes the mass removed in the treatment process relative to the original mass.

The mass removal can be described as concentration (mg/L) or mass per unit time (pounds per day).

% Reduction in Concentration

The influent concentration to a sand filter is 300 ppm BOD. The effluent concentration is 30 ppm BOD. What is the % reduction in concentration?

$$\% \text{ reduction} = \frac{\text{influent} - \text{effluent}}{\text{influent}} \times 100$$

$$\% \text{ reduction} = \frac{300 - 30}{300} \times 100 = 90\%$$

For example, using concentration, calculate percent reduction in concentration by subtracting effluent concentration from influent concentration; then, divide by influent concentration; then multiply by 100.

Units

Flow rate is volume per unit time

- Gallons per minute (gpm)
- Gallons per day (gpd)
- Cubic feet per sec (cfs)

Flow rate is important for calculating pump delivery rate and daily flow to a system. It is a measure of volume per unit of time (in other words, how much liquid moves over time). The concept of flow to a system may be one of the most important measurements that a service provider can make during a visit. Several examples of flow rate are presented later.

Units

Flow Velocity is distance per unit time

- Feet per sec (fps)

Flow velocity refers to distance per unit of time, such as the flow through a pipe. In other words, it measures how fast the water is moving over a given distance in a specific period.

Flow velocity

- Should be at least 2 fps for good scour
- Minimum flow rate is needed to achieve this
- Equation to calculate minimum flow rate:

$$4.896 \times [\text{pipe diameter (in)}]^2 = \text{gpm required}$$

In general, a flow velocity of at least 2 feet per second (fps) is needed to scour excess solids that accumulate on the walls of piping. Calculate the minimum required flow rate to achieve good scour velocity by using a standard conversion factor (4.896) by the pipe diameter squared.

Flow rate in gallons per minute to achieve a velocity of 2 feet per second in PVC pipe

Schedule 40 PVC		Schedule 80 PVC	
Nominal Dia. (inches)	Flow Rate (gpm)	Nominal Dia. (inches)	Flow Rate (gpm)
1	5.4	1	4.5
1 ¼	9.3	1 ¼	8.0
1 ½	14.2	1 ½	12.4
2	20.9	2	18.4
2 ½	29.8	2 ½	26.4
3	46.1	3	41.2
4	79.4	4	71.7
6	180	6	162.5

This table provides the minimum flow needed to achieve 2 fps in Schedule 40 and 80 rigid pipe.

Flow rate in gallons per minute to achieve a velocity of 2 feet per second in PVC pipe

SDR 21		SDR 26	
Nominal Dia. (inches)	Flow Rate (gpm)	Nominal Dia. (inches)	Flow Rate (gpm)
1	7.2	1	7.0
1 ¼	11.1	1 ¼	11.5
1 ½	14.5	1 ½	15.1
2	22.6	2	23.5
2 ½	33.1	2 ½	39.9
3	49.1	3	51.1
4	82.2	4	84.5
6	175.8	6	183.1

This table provides the minimum flow needed to achieve 2 fps in SDR 21 and 26 piping.

Definitions

Pump Delivery Rate (PDR): the rate at which wastewater is pumped to the drainfield or treatment unit in gallons per minute **(gpm)**

$$PDR = \frac{\text{gallons of water pumped (gal)}}{\text{pump run time (min)}}$$

$$\frac{40 \text{ gallons}}{5 \text{ minutes}} = 8 \text{ gal/min}$$

As an operation and maintenance service provider, it is essential to be able to accurately calculate pump delivery rate (PDR).

Equations

Detention Time - This term is used in design and operation of grease traps, septic tanks, lagoons, and contact chambers.

Expressed in hours or days.

$$\frac{\text{Tank Volume (gal)} \times 24 \text{ hrs/day}}{\text{Flow in gpd}} = \text{Hours}$$

$$\frac{\text{Tank Volume}}{\text{Flow in gal/day}} = \text{Days}$$

Detention Time: As flow (GPD) increases, the contact time in the treatment volume decreases. This is known as an inverse relationship.

Detention time can be calculated in hours or days. An example follows.

What is the **Detention time** of a 1000 gallon tank with a flow of 360 gpd:

$$= \frac{\text{Tank Volume x 24 hrs/day}}{\text{Flow in gpd}}$$

$$= \frac{\text{1000 gal. x 24 hrs/day}}{\text{360 gpd}}$$

$$= \frac{\text{24,000 gal / hr / day}}{\text{360 gal/day}} = \text{66.66 hrs}$$

For Example, a 1000-gallon septic tank receives a flow of 360 gallons each day (24 hours). What is the detention time? (Assume no sludge or scum has accumulated.)

Note that the units cancel out.

What is the Detention time (in days) of a 1000 gallon tank with a flow of 360 gpd:

$$= \frac{\text{Tank Volume}}{\text{Flow in gpd}}$$

$$= \frac{\text{1000 gal.}}{\text{360 gal/day}} = \text{2.78 days}$$

The calculation can also be done to provide a solution in days.

Definitions

Hydraulic loading rate: the amount of wastewater applied per day to a given area of trench bottom or sand filter surface expressed as:

gallons per day per square foot

or

gpd / ft^2

It is important to understand the concept of hydraulic loading rate to system components.

This is a measure of flow per unit of area.

Calculate the Hydraulic Loading Rate to a sand filter surface, given:

3 Bedroom home: 360 gpd

Sand Filter is 18' x 10'

$$\text{HLR} = \frac{\text{gal. applied per day (gpd)}}{\text{area (ft}^2\text{)}}$$

$$= \frac{360 \text{ gpd}}{180 \text{ ft}^2} = 2.0 \frac{\text{gpd}}{\text{ft}^2}$$

For example, a sand filter measures 18 ft. by 10 ft. and serves a house with a design flow of 360 gpd. What is the hydraulic loading rate? The calculation is relatively straightforward (divide the daily flow by the area of the sand filter) and the result is expressed in gallons per day per square foot or gpd/ft^2.

$$\text{HLR} = \frac{\text{(gpd)}}{\text{area (ft}^2\text{)}}$$

$$\text{area (ft}^2\text{)} \times \text{HLR} = \frac{\text{(gpd)}}{\cancel{\text{area (ft}^2\text{)}}} \times \cancel{\text{area (ft}^2\text{)}}$$

$$\text{area (ft}^2\text{)} \times \text{HLR} = \text{gpd}$$

Let's look at hydraulic loading rate from a different angle. This is an example of how much wastewater can be applied to a system without exceeding the design flow rate. To use the information in this equation, we have to manipulate it a bit. What are we looking for: "How many gallons per day?"

$$\text{HLR} = \frac{\text{(gpd)}}{\text{area (ft}^2\text{)}}$$

$$\text{area (ft}^2\text{)} \times \text{HLR} = \frac{\text{(gpd)}}{\cancel{\text{area (ft}^2\text{)}}} \times \cancel{\text{area (ft}^2\text{)}}$$

$$\text{area (ft}^2\text{)} \times \text{HLR} = \text{gpd}$$

If we multiply both sides of the equation by the same item, we preserve the overall relationship between the elements here. To wind up with GPD alone on one side of the equation multiply both sides of the equation by AREA and cancel out the units where appropriate.

A low-pressure STA is 30' x 90' or 2700 ft^2. How many gallons per day can be dosed to the STA without exceeding the permit limit of 0.2 gpd/ft^2?

$$\text{area } (ft^2) \times \text{HLR} = \text{gpd}$$

$$2700\ \cancel{ft^2} \times \frac{0.2\ \text{gpd}}{\cancel{ft^2}} = 540\ \text{gpd}$$

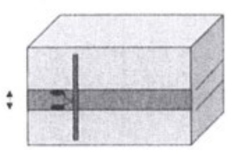
This is an example of how much wastewater can be applied to a system without exceeding the design flow rate. Note that units cancel out.

Determining Pump Drawdown

If you know gallons per inch, the drawdown determines the volume of effluent delivered per dose.

$$\textit{Drawdown (in.)} = \frac{\textit{Gal per Dose}}{\textit{Gal per inch}}$$

Example: A tank with 31.2 gpi has a design requirement of delivering 290 gallons per dose. What should the drawdown be set at?



In demand dosed pump applications, floats are set at specific intervals to engage the pump to deliver a specific volume of liquid. If the number of gallons per inch (gpi) in the dosing tank is known, adjust the float to deliver the correct dose volume of effluent to a soil treatment area.

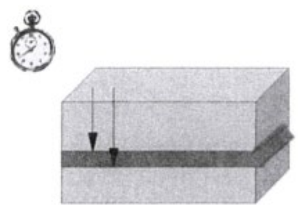
$$\frac{290\ \text{gal/dose}}{31.2\ \text{gal/inch}} = 9.3 \text{ inches dosed}$$

Figuring Pump Delivery Rate (PDR)

If you know the gpi in a tank, the pump delivery rate to the field can be measured.

$$PDR = \frac{\text{inches of liquid drop x gpi}}{\text{minutes pumped}}$$

Ex. The pump is run for 5 minutes and the liquid level drops from 78' to 84". The tank's gpi is 31.2 What is the PDR?



To calculate the pump delivery rate in gallons per minute, run the pump for a specified time and note by how many inches the liquid level drops. Using the gallons per inch in the pump tank, determine the total number of gallons pumped during the time interval by the equation:

For example,

$$PDR = \frac{\text{inches of liquid drop x gpi}}{\text{minutes pumped}}$$

$$PDR = \frac{(84 - 78)\text{" x } 31.25 \text{ gpi}}{5 \text{ min}} = 37.5 \text{ gpm}$$

Figuring Daily Flow (GPD) from Elapsed Time Meter Readings

If you measure the PDR of the system, the gallons per day can be determined from the elapsed time meters.

Ex. The elapsed time meter readings were recorded as follows:

March 1 - 125.1 hours
May 30 - 140.5 hours

The PDR is 37.5 gpm.

What is the average daily flow from the facility?

$$\frac{\text{Run Time (min)}}{\text{\# days}} \text{ x } \frac{\text{gal}}{\text{min}} = \frac{\text{gal (avg)}}{\text{day}}$$

The pump ran 140.5 - 125.1 or 15.4 hours
15.4 hours x 60 min/hour = 924 minutes

$$\frac{924 \text{ min x } 37.5 \text{ gal/min}}{90 \text{ days}} = 385 \text{ gal/day (GPD)}$$

Figuring Daily Flow (GPD) from Event (Cycle) Counters

If you know the gallons delivered per dose, the gallons per day can be determined from the event counters.

$$GPD = \frac{\#\ events \times gallons/event}{\#\ days}$$

Ex. The event counter readings were recorded as follows:

March 1 - 105 events
May 30 - 192 events

The pump delivers 344 gal/event.

What is the average daily flow from the facility?

11 inches/dose x 31.25 gal/inch = 343.75 gal/dose

Figuring Daily Flow (GPD) from Event (Cycle) Counters

If you know the gallons delivered per dose, the gallons per day can be determined from the event counters.

$$GPD = \frac{\#\ events \times gallons/event}{\#\ days}$$

Ex. The event counter readings were recorded as follows:

March 1 - 105 events
May 30 - 192 events

The pump delivers 344 gal/event.

What is the average daily flow from the facility?

The pump cycled 192 - 105 = 87 times

$$\frac{87\ events \times 344\ gal/event}{90\ days} = 332\ GPD$$

Figuring Gallons per Event from the Pump Timer Setting

(timer dose system)

If you know the pump run-time setting and the PDR, the gallons per dose can be determined.

$$\frac{\text{minutes}}{\text{dose}} \times \frac{\text{gallons}}{\text{min.}} = \frac{\text{gallons}}{\text{dose}}$$

Ex. A pump in a timer controlled setting runs for 6.5 minutes per dose. The pump delivers 37.5 gpm. How many gallons are delivered at each dose?

6.5 min/dose x 37.5 gpm = 243.7 gal/dose

To Set up a Dosing Regime for a Timer Dosed Panel

System design flow is 720 GPD

PDR is 37.5 GPM

System is designed to dose 4 times per day*

Step 1: Calculate the dosing volume:

Design daily flow ÷ # Doses desired

* Per design - specific to the system

Design daily flow = 720 gallons

Doses desired = 4

$$\frac{720 \text{ gallons}}{4 \text{ doses}} = 180 \text{ gal/dose}$$

To Set up a Dosing Regime for a Timer Dosed Panel

System design flow is 720 GPD

PDR is 37.5 GPM

System is designed to dose 4 times per day

Step 2: Calculate the pump-run time:

Dosing volume = 180 gal/dose

$$\text{Run-time} = \frac{\text{Dosing Volume}}{\text{Pump Delivery Rate}}$$

$$\frac{180 \text{ gal/dose}}{37.5\text{gpm}} = 4.8 \text{ minutes run time}$$

To Set up a dosing regime for a timer dosed panel

System design flow is 720 GPD

PDR is 37.5 GPM

System is designed to dose 4 times per day.

ON cycle is 4.8 minutes

Step 3: Calculate the Pump-Rest Time:

$$\text{Pump Off time} = \frac{24 \text{ hours}}{\# \text{ Rest cycles}} - \text{Min. ON}$$

$$\frac{24 \text{ Hr/day}}{4 \text{ rest cycles}} - \text{Min. ON}$$

= 6 hrs OFF time - 4.8 min On

= 5 hrs. 55.2 min

A pump delivery rate is measured at 37 gpm. The pump runs an average of 16 minutes per day as indicated by the elapsed time meter. Is this system within the design flow for a 3 bedroom home?

A. GPD(actual) = gpm x runtime (min)

B. GPD (design) = 3 Br X 120 GPD/Br
= 360 GPD

A. 37 gpm x 16 min/day = 592 GPD

B. Therefore:
The system is not adequately sized for the actual flow.
(Example assumes 120 gpd/Br)

A pump delivers effluent to a drainfield at a rate of 36 gpm. The pump runs 8 minutes per day. The system is designed for 360 gpd.

A. Is this facility within the permit limits?

Flow (gpm) x Daily runtime (Min) = gpd

B. If this house has only 3 occupants, should the owner and/or operator be concerned?

(Residential Design flow is 60 gpd/person)

A. 36 gpm x 8 min/day = 288 GPD

Yes, the facility is not exceeding design flow of 360 gpd and is thus within permit limits.

B. 3 people x 60 gpd/person = 180 GPD

Yes, the flow is over 50% higher than what should be generated by 3 people (based upon 60 gal/person/day). Look for plumbing problems, excess water use, leaks into the tanks.

A pump in an LPP system delivers 50 gpm. The ETM in the control panel has the following readings:

- **March 1: 378.0 (h)**
- **April 1: 380.0 (h)**

A. How many gallons did it pump between those dates?

Volume (gal) = gpm x runtime (min)

B. What is the average gallons per day for this time period?

GPD (avg) = Volume (gal) / Interval (days)

A. 50 GPM x 120 Minutes = 6000 Gallons

B. 6000 Gallons / 30 days = 200 GPD

Mass Loading

Constituent concentration in the wastewater

$$\text{Mass (lb.)} = C\ (\text{mg/L}) \times Q\ (\text{gpd}) \times (8.34/1{,}000{,}000)$$

Constituent mass loading per person

$$\text{Mass (lb.)} = P\ (\text{\# of people}) \times O_L\ (\text{lbs. per capita-day})$$

Now we will consider two different methods to calculate the mass loading to an onsite wastewater treatment system:

1. Concentration of constituent in the wastewater, and

2. Mass loading based on number of people.

The equation used is:

Mass (lb.) equals the Concentration in mg/L times the flowrate, Q (gpd) and 0.00000834

This equation uses the conversion factor of 0.00000834. One part per million (ppm) equals 1 mg/L. One gallon of water weighs 8.34 pounds. Thus, 1 mg/L concentration of a constituent equals 8.34 pounds of that constituent in one million gallons of water.

Mass loading can also be estimated by using a per capita organic loading rate. The equation for calculating mass loading based on people and organic load is:

Mass (lb.) = # of people x the per capita loading rate O_L (lbs. per capita-day)

Mass Loading Calculation Example

Residential strength

- Calculate organic mass loading where:
  - BOD_5 = 300 mg/L and
  - Average daily flow = 450 gpd

Mass (lb) = 300 (mg/L) x 450 (gpd) x (8.34/1,000,000)

Mass (lb) = 1.13 lbs. per day

Mass loading: Here is an example of how to calculate mass loading followed by examples for residential and commercial sources.

For a residential strength system, the BOD_5 concentration is 300 mg/L and the daily flow rate is 450 gpd. When multiplied together with the conversion factor, the mass loading is 1.13 lbs. per day.

This calculation can be used to calculate a loading for any constituent that is known on a concentration basis. Some example constituents could be BOD, nitrogen, and phosphorus. Other constituents may be of concern in specific locations.

Mass Loading Calculation Examples

Commercial strength

- Calculate organic mass loading where:
  - BOD_5 = 500 mg/L, and
  - Average daily flow = 600 gpd

Mass (lb.) = C (mg/L) x Q (gpd) x (8.34/1,000,000)

Mass (lb.) = 500 (mg/L) x 600 (gpd) x (8.34/1,000,000)

Mass (lb.) = 2.5 lbs. per day

A commercial facility has a wastewater constituent concentration of 500 mg/L in the wastewater and the facility has an average daily flow of 600 gallons per day. The 500 mg/L concentration is placed in the C location in the equation and the 600 gpd is placed in the Q location.

Mass (lb) =

C (mg/L) x Q (gpd) x 0.00000834

Mass (lb) =

500(mg/L) x 600(gpd) x 0.00000834

These numbers are then multiplied together with the conversion factor to calculate a loading to the facility. For this example, the mass loading is 2.5 lbs. per day.

This calculation can be used to calculate a loading for any constituent that is known on a concentration basis. Some example constituents could be BOD, nitrogen, and phosphorus. Other constituents may be of concern in specific locations.

Constituent Mass Loading

- Calculate constituent mass loading where:
  - Number of people (capita) = 5
  - Organic loading rate = 0.17 lbs. per capita -day (Average)

Mass (lb.) = P (# of people) x O_L (lbs. per capita-day)

Mass (lb.) = 5 (# of people) x 0.17 (lbs. per capita-day)

Mass (lb.) = 0.85 lbs. per day

Class	Persons Per Unit	gal/cap/day	lbs BOD_5/cap/day Average	lbs BOD_5/cap/day with Garbage Grinder
Subdivisions, Higher Cost	3.5	100	0.17	0.25
Subdivisions, Average	3.5	90	0.17	0.23
Subdivisions, Low Cost	3.5	70	0.17	0.20

(Goldstein and Moberg, 1973)

This example demonstrates another approach to calculate mass loading based on a per capita loading. The equation for calculating mass loading based on people and organic load is:

Mass (lb.) = P (# of people) x O_L (lbs. per capita-day). We use the number of people using a facility and their organic loading to the facility to determine the mass loading to the system.

The table at the bottom of the slide shows some examples of loading values. The BOD loading in pounds per person per day is in the right two columns. The first column presents an average organic loading on a per person basis of 0.17 lbs. per person per day. The second column presents a distinction regarding the use of a garbage disposal in the residence. The organic loading increases with an anticipated greater use of a garbage disposal.

In this situation, we assume 5 people in the residence and a per person organic loading of 0.17 lbs./day. The mass loading from the facility is 0.85 lbs. per day.

Calculating circulation ratios

Circulation tank data:

Previous pump counter:	5698
Current pump counter:	7453
Pump delivery rate (PDR)	28.6 gal/min
Timer on:	30 sec
Discharge diameter:	1.25 inch
Discharge length:	8 feet
Transport pipe diameter:	1.00 inch
Transport pipe length:	12 feet

Soil treatment area dosing tank data:

Previous pump counter:	1366
Current pump counter:	1895
PDR:	22.3 gal/min
Timer on:	40 sec
Discharge diameter:	1.25 inch
Discharge length:	8 feet
Transport pipe diameter:	1.00 inch
Transport pipe length:	60 feet

Circulation Volume

Circulation tank calculations:

1. Pump volume delivered to pipe = PDR (gpm) x timer on (min)
   = 28.6 gal/min x 30 sec x (1/60 min/sec)
   = 14.3 gal (per dose)

2. No. of times pump on = current pump counter - previous pump counter
   = 7453 – 5698 = 1755

Pipe fill-up volume calculations:

1. Pipe volume = πr^2 length
   r (radius): half of diameter (in feet)
   π (pi): constant value (3.1415)
   length: length of pipe (in feet)

   = π x [(1.25 inch:2) =12 inch/feet] ^{2} x 8 feet
   = 0.068 cubic feet
   = 0.51 gal (using 7.48 gal per 1 cubic feet)

2. Pipe volume (transport) = π x [(1.00 inch÷2) ÷12 inch/feet] ^{2} x 12 feet
   = 0.065 cubic feet
   = 0.50 gal (using 7.48 gal per 1 cubic feet)

3. Total pipe volume = 0.51 gal + 0.50 gal = 1.01 gal

Calculate circulation volume:

1. Volume delivered to unit (per dose) = Volume delivered to pipe - Total pipe volume
   = 14.3 gal - 1.01 gal = 13.29 gal

2. Total volume delivered to unit from previous pump count (Total volume):

   Total volume = # of times pump on x Volume delivered to unit (per dose)
   = 1755 x 13.29 gal = 23324 gal (circulation)

Forward flow
Soil treatment area calculations:

1. Pump volume delivered to pipe = PDR (gpm) x timer on (min)
   = 22.3 gal/min x 40 sec x (1/60min/sec)
   = 14.86 gal (per dose)

2. No. times pump on = current pump counter - previous pump counter
   = 1895 - 1366 = 529

.

3. Pipe volume (transport) = π x [(1.00 inch÷2) ÷12 inch/feet) ^{2}x 60 feet
   = 0.33 cubic feet
   = 2.45 gal (using 7.48 gal per 1 cubic feet)

Pipe fill-up volume calculations:

1. Pipe volume = π x r^2 length
   r (radius): half of diameter (in feet)
   π (pi): constant value (3.1415)
   length: length of pipe (in feet)
2. Pipe volume (discharge) = π x [(1.25 inch÷2) ÷12 inch/feet] ^{2} x 8 feet
   = 0.068 cubic feet
   = 0.51 gal (using 7.48 gal per 1 cubic feet)
3. Total pipe volume = 0.51 gal + 2.45 gal = 2.96 gal

Calculate forward flow

1. Volume delivered to unit (per dose) = Volume delivered to pipe - Total pipe volume
   = 14.86 gal - 2.96 gal = 11.9 gal
2. Total volume delivered to dispersal from previous pump count (Total volume):
   Total volume = # of times pump on x Volume delivered to unit (per dose)
   = 529 × 11.9 gal = 6295 gal (forward flow)

Calculate circulation ratio

Circulation ratio = Circulation volume ÷ Forward flow
= 23324 ÷ 6295 = 3.71 or 3.71 : 1

The data can also be calculated in a similar manner using the previous and current elapsed time meter readings.

Table A-1. Conversion factors.

Multiply	By	To obtain
Acres	43560	Square feet
Atmospheres	33.9	Feet of water
Centimeter	0.3937	Inches
Cubic feet	7.48052	Gallons
Cubic feet	28.32	Liters
Cubic feet/sec	449	Gallons/min
Cubic meters	35.31	Cubic feet
Cubic meters	264.2	Gallons
Cubic meters	10^3	Liters
Cubic yards	27	Cubic feet
Cubic yards	202	Gallons
Feet	30.48	Centimeters
Feet	0.3048	Meters
Feet of water	62.43	Lbs./sq. ft.
Feet of water	0.434	psi (lbs./sq. in.
Gallons	3785	Cubic centimeters
Gallons	0.1337	Cubic feet
Gallons	3.785	Liters
Gallons water	8.3453	Pounds of water
Gallons/min.	$2.228 x 10^3$	Cubic feet/sec.
Gallons/min.	1440	Gallons/day
Gallons/min.	0.06308	Liters/sec.
Gallons/day	6.944×10^4	Gallons/min.
Gallons/day/sq. ft.	1.604	Inches/day
Grams	$2.205 x 10^3$	Pounds
Grams/liter	1000	Parts/million
Hectares	2.471	Acres
Horsepower	33,000	Foot-lbs/min.
Horsepower	0.7457	Kilowatts
Inches	2.54	Centimeters
Inches/day	0.6234	Gallons/day/sq-ft.
Kilograms	2.205	Lbs.
Kilowatts	1.341	Horsepower
Kilowatt-hour	2.655×10^6	Foot-lbs.
Liters	100	Cubic centimeters
Liters	0.03531	Cubic feet
Liters	0.2642	Gallons
Meters	3.281	Feet
Milligrams/liter (mg/L)	1	Parts/million (ppm)
Million gals/day (MGD))	1.54723	Cubic ft./sec.
Parts/million (ppm)	8.345	Lbs./million gal
Pounds	453.5074	Grams
Pounds of water	0.1198	Gallons
psi (lbs./sq. in.)	2.31	Feet of water
Square feet	2.296×10^5	Acres
Temp. (°C) + 17.78	1.8	Temp. (°F)
Temp, (°F) - 32	5/9	Temp. (°C)

Table A-2. Friction loss (feet per 100 foot).

	Pipe size (inches)					
Flow (GPM)	1 (1.049)	1-1/4 (1.38)	1-1/2 (1.61)	2 (2.067)	3 (3.068)	4 (4.026)
1	0.09					
2	0.32	0.09				
3	0.68	0.18	0.08			
4	1.17	.031	0.14			
5	1.76	0.46	0.22	0.06		
6	2.47	0.65	0.31	0.09		
7	3.28	0.86	0.41	0.12		
8	4.2	1.1	0.52	0.15		
9	5.22	1.35	0.65	0.19		
10	6.35	1.67	0.79	0.23		
11	7.57	1.99	0.94	0.28		
12		2.34	1.1	0.33		
13		2.71	1.28	0.38		
14		3.11	1.47	0.43	0.06	
15		3.54	1.67	0.49	0.07	
16		3.98	1.88	0.56	0.08	
17		4.46	2.1	0.62	0.09	
19		5.47	2.58	0.77	0.11	
20		6.02	2.84	0.84	0.12	
25			4.29	1.27	0.19	
30			6.02	1.78	0.26	0.07
35				2.37	0.35	0.09
45				3.77	0.55	0.15
50				4.58	0.67	0.25
60				6.42	0.94	0.33
70					1.25	0.43
80					1.6	0.53
90					1.99	0.64
100					2.41	0.97
125					3.65	1.36
150					5.11	1.81
175					6.8	2.32
200						2.88
225						3.5
250						4.18
275						4.91
300						5.69
350						6.53
375						7.41

*Assumed to be Sch 40 PVC, C=140

$H = (0.00113 \times L \times Q^{1.85})/d^{4.87}$

Where Hf =head loss (feet)
L-pipe length (feet)
Q-flow (gpm)
d-pipe inside diameter (inches)

Table A-3. Allowance in equivalent length of pipe for friction loss in valves and threaded fittings ASA A40.8- 1955

Diameter of fitting	90 deg standard ell	45 deg standard ell	90 deg standard tee	Coupling or str run of tee	Gate valve	Glove valve	Angle valve	Check valve
Inches	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
3/8	1	0.6	1.5	0.3	0.2	8	4	3
1/2	2	1.2	3	0.6	0.4	15	8	5
3/4	2.5	1.5	4	0.8	0.5	20	12	7
1	3	1.8	5	0.9	0.6	25	15	8
1 1/4	4	2.4	6	1.2	0.8	35	18	11
1 1/2	5	3	7	1.5	1	45	22	14
2	7	4	10	2	1.3	55	28	19
2 1/2	8	5	12	2.5	1.6	65	34	22
3	10	6	15	3	2	80	40	27
3 1/2	12	7	18	3.6	2.4	100	50	32
4	14	8	21	4	2.7	125	55	38
5	17	10	25	5	3.3	140	70	46
6	20	12	30	6	4	165	80	54

Table A-4a Pipeline volume (gallons per 100 feet of pipe).

Pipe	PVC flexible	Pressure pipe	PVC rigid pipe		Corrugated tubing
Size (inches)	SDR 26 (160 psi)	SDR 21 (200 psi)	Sch 40	Sch 80	
3/4			2.80	2.20	
1	5.80	5.80	4.50	3.70	
1 1/4	9.60	9.20	7.80	6.70	
1 1/2	12.60	12.10	10.60	9.20	
2	19.60	18.80	17.40	15.30	
3	42.60	40.90	38.40	34.30	
4	70.40	67.70	66.00	59.70	65.30
6	153.00	147.00	150.00	135.00	147.00
8	259.00	249.00	260.00	237.00	

Table A-4b. Pipeline volume (gallons per foot).

Pipe	PVC flexible	Pressure pipe	PVC rigid pipe		Corrugated tubing
Size (inches)	SDR 26 (160 psi)	SDR 21 (200 psi)	Sch 40	Sch 80	
3/4			0.03	0.02	
1	0.06	0.06	0.05	0.04	
1 1/4	0.10	0.09	0.08	0.07	
1 1/2	0.13	0.12	0.11	0.09	
2	0.20	0.19	0.17	0.15	
3	0.43	0.41	0.38	0.34	
4	0.70	0.68	0.66	0.60	0.65
6	1.53	1.47	1.50	1.35	1.47
8	2.59	2.49	2.60	2.37	

Table A-5a. Flow velocities: Flow rate in gallons per minute to achieve a flow velocity of 2 feet per second in rigid PVC pipe

Schedule 40		Schedule 80	
Nominal dia. (inches)	Flow rate (gpm)	Nominal dia. (inches)	Flow rate (gpm)
1	5.4	1	4.5
1 1/4	9.3	1 1/4	8.0
1 1/2	14.2	1 1/2	12.4
2	20.9	2	18.4
2 1/2	29.8	2 1/2	26.4
3	46.1	3	41.2
4	79.4	4	71.7
6	180	6	162.5

Table A-5b. Flow velocities: Flow rate in gallons per minute to achieve a flow velocity of 2 feet per second in flexible PVC pipe.

SDR 21		SDR 26	
Nominal dia. (inches)	Flow rate (gpm)	Nominal dia. (inches)	Flow rate (gpm)
1	7.2	1	7.0
1 1/4	11.1	1 1/4	11.5
1 1/2	14.5	1 1/2	15.1
2	22.6	2	23.5
2 1/2	33.1	2 1/2	39.9
3	49.1	3	51.1
4	82.2	4	84.5
6	175.8	6	183.1

Table A-6. Orifice flow for various orifice sizes and pressure heads.

Orifice	3/32"	1/8"	5/32"	3/16"	7/32"	1/4"	9/32"	5/16"	11/32"	3/8"
Size	**0.094**	**0.125**	**0.156**	**0.188**	**0.219**	**0.25**	**0.281**	**0.313**	**0.344**	**0.375**
Press head										
2.0	0.15	.024	0.41	0.59	0.80	1.04	1.32	1.63	1.97	2.34
2.1	0.15	0.27	0.42	0.60	0.82	1.07	1.35	1.67	2.02	2.40
2.2	0.15	0.27	0.43	0.61	0.84	1.09	1.38	1.71	2.07	2.46
2.3	0.16	0.28	0.44	0.63	0.86	1.12	1.41	1.75	2.11	2.51
2.4	0.16	0.29	0.45	0.64	0.87	1.14	1.44	1.78	2.16	2.57
2.5	0.16	0.29	0.46	0.66	0.89	1.17	1.47	1.82	2.20	2.62
2.6	0.17	0.30	0.46	0.67	0.91	1.19	1.50	1.86	2.25	2.67
2.7	0.17	0.30	0.47	0.68	0.93	1.21	1.53	1.89	2.29	2.72
2.8	0.17	0.31	0.48	0.69	0.94	1.23	1.56	1.93	2.33	2.77
2.9	0.18	0.31	0.49	0.71	0.96	1.25	1.59	1.96	2.37	2.82
3.0	0.18	0.32	0.50	0.72	0.98	1.28	1.62	1.99	2.41	2.873
3.1	0.18	0.32	0.51	0.73	0.99	1.30	1.64	2.03	2.45	2.92
3.2	0.19	0.33	0.51	0.74	1.01	1.32	1.67	2.06	2.49	2.97
3.3	0.19	0.33	0.52	0.75	1.02	1.34	1.69	2.09	2.53	3.01
3.4	0.19	0.34	0.53	0.76	1.04	1.36	1.72	2.12	2.57	3.06
3.5	0.19	0.34	0.54	0.78	1.06	1.38	1.74	2.15	2.61	3.10
3.6	0.20	0.35	0.55	0.79	1.07	1.40	1.77	2.18	2.64	3.15
3.7	0.20	0.35	0.55	0.80	1.09	1.42	1.79	2.21	2.68	3.19
3.8	0.20	0.36	0.56	0.81	1.10	1.44	1.82	2.24	2.72	3.23
3.9	0.20	0.36	0.57	0.82	1.11	1.46	1.84	2.27	2.75	3.27
4.0	0.21	0.37	0.58	0.83	1.13	1.47	1.87	2.30	2.79	3.32
4.1	0.21	0.37	0.58	0.84	1.14	1.49	1.89	2.33	2.82	3.36
4.2	0.21	0.38	0.59	0.85	1.16	1.51	1.91	2.36	2.86	3.40
4.3	0.21	0.38	0.60	0.86	1.17	1.53	1.93	2.39	2.89	3.44
4.4	0.22	0.39	0.60	0.87	1.18	1.55	1.96	2.42	2.92	3.48
4.5	0.22	0.39	0.61	0.88	1.20	1.56	1.98	2.44	2.96	3.52
4.6	0.22	0.40	0.62	0.89	1.21	1.58	2.00	2.47	2.99	3.56
4.7	0.22	0.40	0.62	0.90	1.22	1.60	2.02	2.50	3.02	3.59
4.8	0.23	0.40	0.63	0.91	1.24	1.61	2.04	2.52	3.05	3.63
4.9	0.23	0.41	0.64	0.92	1.25	1.63	2.06	2.55	3.08	3.67
5.0	0.23	0.41	0.64	0.93	1.26	1.65	2.09	2.57	3.12	3.71

Note: Values based on orifice equation

$Q = 11.79\, d^2\, h^{1/2}$

Where Q = flow per orifice (gpm)
d = diameter of orifice (inches)
h = pressure head (feet)

Table A-7a. Flow through orifices, pressure manifolds schedule 40 taps

	Hole size					
Head (ft)	**1/2 inch**	**3/4 inch**	**1 inch**	**1 1/4 inch**	**1 1/2 inch**	**2 inch**
	(0.622)	**(0.824)**	**(1.049)**	**(1.38)**	**(1.61)**	**(2.067)**
1.5	6.16	10.8	17.5	30.3	41.3	68
2	7.11	12.5	20.2	35	47.7	78.5
2.5	7.95	14	22.6	39.1	53.3	87.8
3	8.71	15.3	24.8	42.9	58.4	96.2
3.5	9.41	16.5	26.8	46.3	63	104
4	10.1	17.7	28.6	49.5	67.4	111

Note: Values based on orifice equation

$Q = 11.79\ d^2\ h^{1/2}$

Where Q = flow per orifice (gpm)

d = diameter of orifice (inches)

h = pressure head (feet)

Table A-7b. Flow through orifices, pressure manifolds schedule 80 taps

	Hole size					
Head (ft)	**1/2 inch**	**3/4 inch**	**1 inch**	**1 1/4 inch**	**1 1/2 inch**	**2 inch**
	(0.546)	**(0.742)**	**(0.957)**	**(1.278)**	**(1.50)**	**(1.939)**
1.5	4.75	8.77	14.6	26	35.8	59.9
2	5.48	10.1	16.8	30	41.4	69.1
2.5	6.13	11.3	18.8	33.6	46.2	77.3
3	6.71	12.4	20.6	36.8	50.7	84.7
3.5	7.25	13.4	22.3	39.7	54.7	91.4
4	7.75	14.3	23.8	42.5	58.5	97.8

Note: Values based on orifice equation

$Q = 13\ d^2\ h^{1/2}$

Where Q = flow per orifice (gpm)

d = diameter of orifice (inches)

h = pressure head (feet)

Table A-8. Flow through orifices, LPP (gallons per minute).

	Drilled hole diameter (inches)				
Head (ft)	**1/8**	**5/32**	**3/16**	**7/32**	**1/4**
2	0.26	0.41	0.59	0.8	1.04
2.5	0.29	0.46	.066	0.89	1.17
3	0.32	0.5	0.72	0.98	1.28
3.5	0.34	0.54	0.78	1.06	1.38
4	0.37	0.58	0.83	1.13	1.48
4.5	0.39	0.61	0.88	1.2	1.56
5	0.41	0.64	0.93	1.26	1.65

Note: Values based on orifice equation

$Q = 11.79\ d^2\ h^{1/2}$

Where Q = flow per orifice (gpm)

d = diameter of orifice (inches)

h = pressure head (feet)

Appendix B: Forms

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Form 3-1 Operational Checklist: System Description (SD)

(This form is used for the initial system evaluation for the facility and the site. It should be kept on file, and a copy should accompany the service provider at each O&M service visit. Any changes to the system facility should be recorded on the form, along with the date the change was noted.)

A. Client Contact Information

Name of owner:______________________________ Reference #:__________

Phone:______________________________ T:___R:___Sec:___No.:____

Cell:______________________________ E-mail:______________________________

Site address/County:______________________________

____

Mailing address/County (if different):______________________________

____

Directions to site:______________________________

B. System Documentation Available (If no documentation, complete Section D.)

Date installed:______________________________

Installer:______________________________ License #:______________

Phone:______________ Cell:________________ Fax:________________

E-mail:______________________________

Designer:______________________________ License #:______________

Phone:______________ Cell:________________ Fax:________________

E-mail:______________________________

Previous service provider:______________________ License #:______________

Phone:______________ Cell:________________ Fax:________________

E-mail:______________________________

Design flow: ____________Gal per day

C. Operational Checklists

Identify operational checklists for components included in system.

Form 4-1 Site Assessment on File. ☐ Yes ☐ No

Treatment Tanks and Dosing Systems and Controls (Chapters 5 and 6):

- ☐ Holding tank: ________________ ☐ Septic/trash/processing (tank): ______
- ☐ Grease interceptor: ____________ ☐ Dosing tank: ____________________
- ☐ Pump: Demand dose system:_____ ☐ Pump: Time dose system: __________

Advanced Treatment Components (Chapter 7):

- ☐ Media filter: ________________ ☐ Aerobic treatment unit:____________
- ☐ Constructed wetland: __________ ☐ Lagoon: ______________________

Reference #:____________________

☐ Disinfection unit–chlorine: ______ ☐ Disinfection unit–ultraviolet light: _____
☐ Disinfection unit–ozone: ________

Final Treatment and Dispersal Components (Chapter 8):

☐ Gravity distribution STA:___________ ☐ Low pressure distribution STA: _____
☐ Drip distribution STA: _____________ ☐ Spray distribution STA: ___________
☐ Evapotranspiration bed: ___________ ☐ Free access media filter: ___________
☐ Buried treatment/dispersal:_________ ☐ Outfall: ________________________

D. No Permit or Other Paperwork

Complete the section on Facility Details with any available information on the source. The section on System Details allows the service provider to capture as many specifications as possible and requires a visit to the system.

Facility Details

1. Number of bedrooms: ____________
2. Square footage of facility: ________sq ft
3. Number of current occupants: ____________
4. Design flow: ________gpd
5. Design strength: _______BOD_5 (mg/L) ______TSS (mg/L) _______FOG (mg/L)
6. Water supply:
   - ☐ Private water supply
   - ☐ Public water supply
7. Water source (if private supply): Lateral distance to water supply
   - ☐ Groundwater well: _________ ft
   - ☐ Spring: _________ ft
   - ☐ Surface water (i.e. creek, lake, etc.): _________ ft
8. Garbage disposal present: ☐ Yes ☐ No
9. Water softener or water treatment chemicals used: ☐ Yes ☐ No
   - ☐ Softener backwash drains to system: ☐ Yes ☐ No
10. Facility has NOT been remodeled since original construction: ☐ Yes ☐ No

System Details

1. Site
   a. Landscape position: ____
   b. Drainage: ☐ None ☐ Surface/gravity ☐ Subsurface/gravity ☐ Subsurface/pump
   c. Monitoring well present. ☐ Yes ☐ No
2. Pretreatment components - Tanks
   a. Holding tank
      1) Capacity:____gal
      2) Material: ☐ Concrete ☐ Fiberglass ☐ Plastic ☐ Other ______________
         i) Manufacturer:________________________
      3) Access to surface. ☐ Yes ☐ No

Reference #:______________

4) Location (GIS): ______/_____

b. Septic tank /Trash tank

1) Capacity (total): __________gal

i) Compartmented. ☐ Yes ☐ No

ii) Capacities for compartmented system: 1)_____gal 2)____gal

2) Material: ☐ Concrete ☐ Fiberglass ☐ Plastic ☐ Other

i) Manufacturer:_________________________________

3) Access to surface. ☐ Yes ☐ No

4) Location (GIS): ______/_____

5) Effluent screen. ☐ Yes ☐ No

i) Manufacturer:_____________________ Model: ________________

c. Flow equalization tank (surge, etc.)

1) Capacity: ________gal/in

2) Material: ☐Concrete ☐ Fiberglass ☐ Plastic ☐ Other

3) Access to surface. ☐ Yes ☐ No

4) Location (GIS): ______/_____

5) Dosing tank: ☐ NA

i) Manufacturer:____

6) Pump: ☐ NA

i) Manufacturer:_____________________ Model:_________ HP:___

7) Pump operating condition

i) Discharge Rate: ________gal/in

ii) Operating Pressure: __________ft

8) Control method

i) Sensors: ☐ Floats ☐ Pressure transducer ☐ Ultrasonic ☐ Other

ii) Description:____

9) Pump dose settings

i) Frequency _____ doses/day

ii) Interval _____sec/dose

iii) Volume _____ gal/dose

10) Control panel

i) Manufacturer:_____________________ Model:________________

11) Electrical

i) Separate circuits (pump, alarm). ☐ Yes ☐ No

ii) Breaker size: ____________

12) Alarm

i) Manufacturer: ____

ii) Sensors: ☐ Floats ☐ Pressure transducer ☐ Ultrasonic ☐ Other

iii) Description:____

Reference #:______________

d. Dosing tank
   1) Capacity: _______ gal/in
   2) Material: ☐ Concrete ☐ Fiberglass ☐ Plastic
   3) Access to surface. ☐ Yes ☐ No
   4) Location (GIS): _______/______
   5) Dosing tank: ☐ NA
      i) Manufacturer:____
   6) Pump: ☐ NA
      i) Manufacturer:______________________ Model:__________ HP:___
   7) Pump operating condition
      i) Discharge Rate: ______ gal/min
      ii) Head: ____________ft
   8) Control method
      i) Sensors: ☐ Floats ☐ Pressure transducer ☐ Ultrasonic ☐ Other
      ii) Description:____
   9) Pump dose settings
      i) Frequency: ______doses/day
      ii) Interval: ______sec/dose
      iii) Volume: ______gal/dose
   10) Panel for sensors
      i) Manufacturer:______________________ Model:__________________
   11) Electrical
      i) Separate circuits (pump, alarm). ☐ Yes ☐ No
      ii) Breaker size: ______________
   12) Alarm
      i) Manufacturer:____
      ii) Sensors: ☐ Floats ☐ Pressure transducer ☐ Ultrasonic ☐ Other
      iii) Description:____

3. Advanced Treatment Components
   a. Aerobic treatment unit (ATU)
      1) Treatment method:
      ☐ Suspended growth ☐ Sequencing batch reactor ☐ Membrane bioreactor
      ☐ Attached growth ☐ Rotating biological contactor ☐ Integrated fixed/activated sludge
      ☐ Moving bed bioreactor ☐ Other: ___________________________
      2) Capacity: __________gpd
      3) Material: ☐ Concrete ☐ Fiberglass ☐ Plastic
         i) Manufacturer:______________________ Model #:________________
         ii) Product serial #:____
      4) Access to surface. ☐ Yes ☐ No
      5) Location (GIS): _______/______

Reference #:______________

6) Effluent screen / Tertiary filter ☐ NA
   i) Manufacturer:______________________________
7) Air supply
   i) Air supply method: ☐ Aspirator ☐ Compressor ☐ Blower ☐ Free Air
   ii) Manufacturer:______________ Model #:__________
8) Sludge return method: ______________________________

b. Single pass filter
1) Media: ☐ Sand ☐ Glass ☐ Foam ☐ Peat/Coir ☐ Other: __________
   i) Media depth: __________in
   ii) Liner material:______________________________
2) Filter size: __________sq ft
   i) Dimensions: _____ft x __ft
   ii) Accessibility: ☐ Buried ☐ Free Access ☐ Covered
   iii) Cover material:______________________________
   iv) Lid insulated. ☐ Yes ☐ No
3) Distribution method: ☐ Pressure ☐ Gravity
   i) Pipe diameter: __________in
   ii) Flow control: ☐ Orifice ☐ Spray nozzle ☐ Other: __________
   Orifice orientation: ______________________
   iii) Flow control diameter: __________in
   iv) Number of flow controls (orifices, nozzles, etc.): __________
   v) Squirt height/Operating Pressure: __________in
   vi) Clean outs/Inspection ports: Number_____ ☐ Yes ☐ No
   vii) Clean out access to surface. ☐ Yes ☐ No
4) Filtrate collection system: ______

c. Recirculating Filter
1) Media: ☐ Sand ☐ Gravel ☐ Polystyrene ☐ Peat/Coir ☐ Foam ☐ Textile
   ☐ Other:______________________________
   i) Media depth: __________in
   ii) Liner material: __________
   iii) Recirculation method: __________
2) Filter size: __________sq ft
   i) Dimensions: _____ft x __ft
   ii) Accessibility: ☐ Buried ☐ Free Access
   iii) Cover material:______________________________
   iv) Lid insulated. ☐ Yes ☐ No
3) Distribution method
   i) Pipe diameter: __________in
   ii) Flow control: ☐ Orifice ☐ Spray nozzle ☐ Other: __________
   Orifice position: ______________________

Reference #:______________

iii) Flow control diameter: ___________in

iv) Number of flow controls (orifices, nozzles, etc.): ____________

v) Squirt height/Operating head: ___________in

vi) Clean outs/Inspection ports: Number_____ ☐ Yes ☐ No

vii) Clean out access to surface. ☐ Yes ☐ No

4) Filtrate collection system: ____________

5) Forced aeration: ☐ NA

i) Description:____

d. Trickling filter

1) Media: ☐ Gravel ☐ Foam ☐ Textile ☐ Plastic ☐ Other:______________

i) Media depth: ___________in

ii) Liner material: ____________

2) Filter size: _________sq ft

i) Dimensions: _____ft x ___ft

3) Distribution method

i) Pipe diameter: ___________in

ii) Flow control: ☐ Orifice ☐ Spray nozzle ☐ Other: ______________

Orifice position: ________________________________

iii) Flow control diameter: ___________in

iv) Number of flow controls (orifices, nozzles, etc.): ____________

v) Squirt height/Operating Pressure: ___________in

vi) Clean outs/Inspection ports: Number_____ ☐ Yes ☐ No

vii) Clean out access to surface. ☐ Yes ☐ No

4) Filtrate collection system: ____________

5) Forced aeration: ☐ NA

i) Description: ____

e. Constructed wetland

1) Bed media: ☐ None ☐ Gravel ☐ Other:_____________________________

i) Number of cells: ____________

ii) Media depth: ___________in

iii) Water depth: ___________in

iv) Liner material: ____________

v) Border material: ____________

2) Size: _________sqft

i) Dimensions: _____ft x ___ft

ii) Length to width ratio: ______ : _____

3) Distribution method

i) Pipe diameter: ___________in

ii) Flow control: ☐ Orifice ☐ Spray nozzle ☐ Other: _____________

Orifice position: ________________________________

iii) Flow control diameter: ___________in

iv) Number of flow controls (orifices, nozzles, etc.): ____________

Reference #:________________

v) Squirt height/Operating Pressure: __________in
vi) Clean outs/Inspection ports: Number_____Yes___No___
vii) Clean out access to surface. Yes___No___

4) Surface loading rate: ____________________________gpd/sq ft
5) Filtrate collection system:____
6) Monitoring location: ____
7) Vegetation: ☐ NA
   i) Description:____
8) Water level control: ☐ NA
   i) Description:____

f. Lagoon system

1) Type: ☐ Aerobic ☐ Facultative ☐ Partial-mixed aerated ☐ Anaerobic
   i) Water depth_________________ft
   ii) Liner material: __________________________________
2) Lagoon size: _________sq ft
   i) Dimensions: _____ft x __ft
   ii) Length to width ratio: _____ : ______
3) Inlet to lagoon
   i) Pipe description:____
   ii) Pipe diameter: __________in
   iii) Clean outs. ☐ Yes ☐ No
4) Surface loading rate: ______________________________________gpd/sq ft
5) Monitoring location: ____
6) Vegetation: ☐ NA
   i) Description:____
7) Water level control: ☐ NA
   i) Description:____

g. Disinfection unit

1) Chlorine – tablet
   i) Manufacturer:______________________ Model:_________________
2) Chorine – liquid
   i) Manufacturer:______________________ Model:_________________
3) Ultraviolet light
   i) Manufacturer:______________________ Model:_________________
4) Ozone
   i) Manufacturer:______________________ Model:_________________
5) Other:____
6) Disinfection monitoring location:______________________________________
7) Dechlorination
   i) Type: ____
   ii) Manufacturer:______________________ Model:_________________
8) Dechlorination monitoring location: __________________________________

Reference #:_______________

4. Final treatment and dispersal
   a. Gravity
      1) Type: ☐ Trench ☐ Bed ☐ ET bed
         i) If lined ET bed, describe liner material:___________________________
      2) Distribution: ☐ Gravity ☐ Pressure-dosed gravity ☐ Siphon-dosed gravity
      3) Configuration: ☐ Parallel ☐ Serial ☐ Sequential
      4) Distribution approach: ☐ Distribution box ☐ Header ☐ Drop box ☐ Stepdown
      5) Distribution media
         i) Material: ☐ Gravelless ☐ Multi-pipe ☐ Chamber
            ☐ Washed rock ☐ Polystyrene ☐ Other:________________________
            ☐ Combined treatment and dispersal:____________________________
   b. Pressure
      1) Low pressure distribution
         i) Level ☐ Yes ☐ No
         ii) Number of zones: _____________
         iii) Switching method: ☐ NA ☐ Hydraulic valves ☐ Separate pumps
              ☐ Other:________________________________
         iii) Distribution method
              a) Pipe diameter: __________in
              b) Orifice diameter: __________in
              c) Orifice orientation: _____________
              d) Number of orifices: _____________
              e) Squirt height/Operating head: __________in
              f) Clean outs/Inspection ports: Number______ ☐ Yes ☐ No
              g) Clean out access to surface. ☐ Yes ☐ No
         iv) Number of trenches/beds: _____________
         v) Dimensions of trenches/beds: _____ft x __ft
      2) Drip distribution STA
         i) Distribution field: ☐ Surface ☐ Subsurface
         ii) Drip tubing manufacturer:_____________ Model:__________________
         iii) Filtration: ☐ Screen ☐ Disk ☐ Sand
              Manufacturer:_______________________ Model:__________________
         iv) Filter cleaning: ☐ Automated ☐ Manual/Continuous flush
         v) Number of zones: _____________
            a) If multiple, switching device: _____________
            b) Zone area(s): _____sq ft ___ sq ft _____sq ft
         vi) Field flushing: ☐ Automated ☐ Continuous ☐ Manual
         vii) Air release/Vacuum breaker: ☐ NA
            a) Manufacturer:________________ Model:__________________
         viii) Inspection ports. ☐ Yes ☐ No
            a) Locations:____

Reference #:_______________

3) Spray distribution STA
   i) Number of zones: _____________
      a) If multiple, switching device:______________________________
   ii) Sprinkler heads per zone: _____________
      a) Manufacturer:________________ Model(s):________________
      b) Pattern(s):____
   iii) In-line filtration: ☐ None ☐ Screen ☐ Disc ☐ Sand
      a) Manufacturer:________________ Model:__________________
   iv) Total area of spray distribution fields: _________sq ft
   v) Gauging device:____

c. Surface discharge (outfall)
   1) Permit number:____
   2) Permit requirements:____
   3) Location:____
   4) Monitoring location:____

Reference #:_______________

E. Sketch of system

Scale 1 in = _______ ft

Form 3-2 Operational Checklist: System Evaluation (SE)

This form is used to determine system design flow, gather the operational checklists needed to conduct an O&M service visit, and provides a template on which to summarize overall system status to the owner or others.

A. Client Contact Information

Name of owner:________________________________ Reference #____________

Site address/County:____

____

Date of last service:______________________________

B. System Documentation (*See Form 3-1 System Description (SD) for complete documentation)*

Design flow: _________Gal per day

C. Operational Checklists *(from Form 3-1 System Description (SD) Section C)*

Form 4-1 Site Assessment on File. ☐ Yes ☐ No

Treatment Tanks and Dosing Systems and Controls (Chapters 5 and 6):

☐ Holding tank: ________________ ☐ Septic/trash/processing (tank): ______

☐ Dosing tank: ________________ ☐ Pump: Demand dosed system: ______

☐ Pump: Time dosed system: ______

Advanced Treatment Components (Chapter 7):

☐ Media filter: ____________________ ☐ Aerobic treatment unit: ________

☐ Constructed wetland: _____________ ☐ Lagoon: ____________________

☐ Disinfection unit–chlorine: ___ ☐ Disinfection unit–ultraviolet light: _________

☐ Disinfection unit–ozone: ________

Final Treatment and Dispersal Components (Chapter 8):

☐ Gravity distribution STA: ________ ☐ Low pressure distribution STA:_________

☐ Drip distribution STA: ___________ ☐ Spray distribution STA: ______________

☐ Evapotranspiration bed: _________ ☐ Free access media filter: ______________

☐ Buried treatment/dispersal: _____ ☐ Outfall: ____________________________

D. System Evaluation

1. O&M service provided on: Date:________________________ Time:______________

2. Observation and assessment of the site (on lot and in neighborhood)

   a. Evaluate presence of odor within 10 ft of perimeter of system:

      ☐ None ☐ Mild ☐ Strong

      i) Source of odor, if present: _____________________________________

   b. Surfacing or breakouts. ☐ Yes ☐ No

   c. Construction, utility work, or changes in drainage patterns. ☐ Yes ☐ No

   d. All components present and not modified. ☐ Yes ☐ No

Reference #:______________

e. Access lid at grade and secure. ☐ Yes ☐ No
f. Secondary restraint safety feature present and secure. ☐ Yes ☐ No
g. Traffic on onsite wastewater system. ☐ Yes ☐ No

3. Estimated system flow: ___________ gallons per day

Indicate method used for estimate:

☐ Source water meter reading:

This time: __________(gal) - Last time: ________(gal) = ______gal

___________________(gal) / __________________days = ___________GPD

☐ Dosing tank control panel meter readings (indicate form used):

☐ PDD ☐ PTD

☐ Discharge line meter ____________GPD

☐ Estimate based on number of occupants: _________People

4. Complete operational checklists for pretreatment tanks, dosing systems and controls (Chapters 5 and 6).
5. Complete operational checklists for advanced treatment components (Chapter 7).
6. Complete operational checklists for final treatment and dispersal components (Chapter 8).
7. Updates required on **Form 3-1 System Description**:

____

____

____

8. Site status at conclusion of O&M service visit:

☐ Verify controls are set in the appropriate mode.
☐ Verify power is on to all components.
☐ Revisit all components to verify lids are secure.
☐ Gather all tools for removal from the site.
☐ Verify no sewage is on the ground surface.
☐ Leave service notification for owner.

9. Comments:

____

____

____

10. Overall system condition:

☐ Acceptable
☐ Unacceptable
☐ Maintenance needed
☐ Maintenance performed
☐ Mitigation required

Reference #:_______________

Company name: ____
____
____

Agreement period from: ______________________________to ________________________

This report indicates the condition of the above onsite wastewater treatment system at the time of the O&M service visit. It does not guarantee that it will continue to function satisfactorily.

Signature of service provider:______________________________________Date:_________________

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Form 4-1 Operational Checklist: Site Assessment (SA)

Complete this form during an initial site assessment and use as a reference for all other O&M service visits.

Service provided on: Date________________Time: ________Reference:_____________

Service provided by: Company: ________________ Employee:___________________

Date of last service: ____________________________ By: ☐ You ☐ Other:__________

Date of last inspection: ________________________

1. Odor within 10 ft of perimeter of the system:
   a. Evaluate presence of odor:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ______________________________
2. Surface water management
   a. Surface water effectively diverted from site ☐ Yes ☐ No
   b. Surface water diverted from system ☐ Yes ☐ No
   c. System components free from settling/erosion ☐ Yes ☐ No
3. Subsurface water management
   a. Type: ☐ Gravity ☐ Pump ☐ NA
   b. Outlet open to drainage. ☐ Yes ☐ No
   c. Rodent guard on outlet. ☐ Yes ☐ No
   d. Pumped drainage operational ☐ NA ☐ Yes ☐ No
   e. Stabilized drainage outlet ☐ NA ☐ Yes ☐ No
4. System encroachment *(If yes, indicate all that apply.)* ☐ Yes ☐ No
   ☐ Driveway ☐ Utility easement ☐ Patio ☐ Deck ☐ Gardening
   ☐ Vehicular traffic ☐ Construction ☐ Pets /Livestock
   ☐ Other: ______________________________
5. Vegetation and soils
   a. Trees in soil treatment area ☐ Yes ☐ No
      Species: _____________________________
      Location: _____________________________
   b. Excessive vegetation ☐ Yes ☐ No
      Location: _____________________________
   c. Uneven vegetation ☐ Yes ☐ No
      Location: _____________________________
   d. Poor vegetation ☐ Yes ☐ No
      Location: _____________________________
   e. Soil fertility and salinity sampling (if required) ☐ Yes ☐ No
6. Groundwater monitoring wells NA_________________
   a. Present ☐ Yes ☐ No
   b. Accessible ☐ Yes ☐ No
   c. Intact ☐ Yes ☐ No
   d. Protected ☐ Yes ☐ No
   e. Labels and tags in place ☐ Yes ☐ No

Notes

1. ☐ Acceptable ☐ Unacceptable

3. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

5. ☐ Acceptable ☐ Unacceptable

6. ☐ Acceptable ☐ Unacceptable

Reference # :_____________

f. Groundwater sampling (if required) ☐ Yes ☐ No

7. Additional comments:

____

____

____

Attach any photographs.

Form 5-1 Operational Checklist: Holding Tank (HT)

Service provided on: Date:_______________Time:_____Reference #:_______________
Service provided by: Company: _________________ Employee:____________________
Date of last service: _____________________________ By: ☐ You ☐ Other:__________
Date of last inspection: _________________________

1. Conditions at the holding tank
   a. Evaluate presence of odor within 10 ft of perimeter of system: ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ______________________________
2. Tank description
   a. Material: ☐ Concrete ☐ Fiberglass ☐ Plastic
   b. Capacity: __________gal
3. Tank access
   a. Access location: ☐ Inlet ☐ Center
   b. Located at grade. ☐ Yes ☐ No
   c. If 'No', how deep is lid buried. ____________
   d. Risers on tank. ☐ Yes ☐ No
   e. Evidence of infiltration in risers. ☐ Yes ☐ No
   f. Lids securely fastened. ☐ Yes ☐ No
   g. Lid in operable condition. ☐ Yes ☐ No
   h. Secondary restraint safety feature secure ☐ NA ☐ Yes ☐ No
4. Alarm(s)
   a. Alarm(s) present. ☐ Yes ☐ No
   b. Audible alarm operational. ☐ NA ☐ Yes ☐ No
   c. Visible alarm operational. ☐ NA ☐ Yes ☐ No
   d. Telemetry operational. ☐ NA ☐ Yes ☐ No
5. Current tank operating conditions
   a. Liquid level relative to inlet invert: __________ in
      ☐ At ☐ Above ☐ Below
   b. Maximum liquid level of tank (invert of inlet pipe):________in
   c. Height at which alarm is activated as measured from invert of inlet: _____in
   d. Evidence liquid level has been higher. ☐ Yes ☐ No
   e. Evidence liquid level dropped without pumping. ☐ Yes ☐ No
   f. Evidence of continuous inflow. ☐ Yes ☐ No
   g. Date of last pump out: ________________________________
6. Tank structural condition (evaluate if tank pumped): ☐ NA
   a. Watertight (no visible leaks). ☐ Yes ☐ No
   b. Rebar exposed. ☐ Yes ☐ No
   c. Corrosion present. ☐ Yes ☐ No
   d. Spalling present. ☐ Yes ☐ No

Notes

1. ☐ Acceptable ☐ Unacceptable

3. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

5. ☐ Acceptable ☐ Unacceptable

6. ☐ Acceptable ☐ Unacceptable

Reference #: ____________________

e. Cracks present. ☐ Yes ☐ No
f. Root intrusion. ☐ Yes ☐ No
g. Deflection in plastic tanks. ☐ NA ☐ Yes ☐ No

7. Holding tank pumping recommended. ☐ Yes ☐ No
8. Contractor responsible for pumping:_________________________________
    a. Gal removed: ____________________Date: _____________________

Form 5-2 Operational Checklist: Septic, Trash and Processing Tanks (STPT)

Service provided on: Date:________________ Time:___________Reference #:________
Service provided by: Company: ________________ Employee:____________________
Date of last service: ___________________________ By: ☐ You ☐ Other:____________
Date of last inspection: ________________________

Notes

1. Type:
   ☐ Septic tank ☐ Trash tank
   ☐ Processing tank ☐ Pump vault present
2. Conditions at the tank
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong ☐ Chemical ☐ Sour
   b. Source of odor, if present: _________________________________

   2. ☐ Acceptable ☐ Unacceptable
3. Tank description
   a. Material: ☐ Concrete ☐ Fiberglass ☐ Plastic
   b. Capacity: _________gal
   c. Compartmented. ☐ Yes ☐ No
   d. Capacities for compartmented system: 1) _____ gal 2) _____ gal
4. Tank access
   a. Access location: ☐ Inlet ☐ Outlet ☐Center
   b. Located at grade. ☐ Yes ☐ No
   c. If 'No', how deep is lid buried. ____________
      Swing tie measurements: ______________________________
   d. Risers on tank. ☐ Yes ☐ No
   e. Evidence of infiltration in risers. ☐ Yes ☐ No
   f. Lids securely fastened. ☐ Yes ☐ No
   g. Secondary restraint safety feature secure ☐ NA ☐ Yes ☐ No
   h. Lid in operable condition. ☐ Yes ☐ No

   4. ☐ Acceptable ☐ Unacceptable
5. Alarm(s)
   a. Alarm(s) present. ☐ Yes ☐ No
   b. Audible alarm operational. ☐ NA ☐ Yes ☐ No
   c. Visible alarm operational. ☐ NA ☐ Yes ☐ No
   d. Telemetry operational. ☐ NA ☐ Yes ☐ No

   5. ☐ Acceptable ☐ Unacceptable
6. Current tank operating conditions
   a. Liquid level relative to outlet: _____________in
      ☐ At ☐ Above ☐ Below
   b. Maximum liquid level of tank (invert of inlet pipe):___________in
   c. Height at which alarm is activated as measured from invert of inlet: _____________in
   d. Evidence liquid level has been higher. ☐ Yes ☐ No
   e. Liquid level dropped without pumping. ☐ Yes ☐ No

   6. ☐ Acceptable ☐ Unacceptable

Reference #:____________________

f. Evidence of continuous inflow. ☐ Yes ☐ No
g. Date of last pumping: ____________________________________
h. Presence of flocculant in clear zone. ☐ Yes ☐ No
i. Evaluation of layers in tank:

Comp. No.	Scum		Clear Zone		Sludge (inches)		Odor	Other
	Depth (in)	Appearance	Depth (in)	Appearance	Depth (in)	Appearance		
1								
2								

*Color choices:
☐ Clear ☐ Flocced ☐ Milky ☐ Muddy ☐ Grainy
☐ Black ☐ Brown ☐ Mustard ☐ Gray ☐ White

7. Tank pumping recommended. ☐ Yes ☐ No
8. Baffles and screens structurally sound.
   a. Inlet baffle in place. ☐ Yes ☐ No
   b. Outlet baffle in place. ☐ Yes ☐ No
   c. Compartment baffle in place. ☐ NA ☐ Yes ☐ No
   d. Effluent screen. ☐ Yes ☐ No
      Manufacturer:______________Model:______
   e. Screen accessible from ground surface. ☐ Yes ☐ No
   f. If screened, percent plugged: __________%
   g. Screen cleaned. ☐ Yes ☐ No
9. Tank structural condition (evaluate if tank pumped): ☐ NA
   a. Watertight (no visible leaks). ☐ Yes ☐ No
   b. Rebar exposed. ☐ Yes ☐ No
   c. Corrosion present. ☐ Yes ☐ No
   d. Spalling present. ☐ Yes ☐ No
   e. Cracks present. ☐ Yes ☐ No
   f. Root intrusion. ☐ Yes ☐ No
   g. Deflection noted (plastic tanks). ☐ NA ☐ Yes ☐ No
10. Contractor responsible for pumping: ______________________________
   a. Gal removed: ________________ Date: __________________
   b. Tank refilled after pumping ☐ Yes ☐ No
11. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:____
   ____
   ____

7. ☐ Acceptable
   ☐ Unacceptable

8. ☐ Acceptable
   ☐ Unacceptable

Form 6-1 Operational Checklist: Dosing Tank (DT)

Service provided on: Date:________________ Time:___________Reference #:______
Service provided by: Company: ________________ Employee:__________________
Date of last service: ___________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ________________________

1. Type:
   ☐ Dosing tank ☐ Siphon tank ☐ Surge/Flow equalization tank
   ☐ Processing tank ☐ Recirculation tank ☐ Internal pump basin sump
   a. Pump intake elevation above bottom of tank:______________
2. Conditions at the dosing tank
   a. Evaluate presence of odor within 10 feet of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ______________________________
3. Tank description
   a. Material: ☐ Concrete ☐ Fiberglass ☐ Plastic
   b. Capacity: ______________gal
   c. Surface area: ______________sq ft
   d. Operational depth: ________________in
   e. Gallons per inch (GPI): _____________gal/in
4. Tank access
   a. Access location: ☐ Inlet ☐ Outlet ☐ Center
   b. Located at grade. ☐ Yes ☐ No
   c. If 'No', how deep is lid buried. ______________
      Swing tie measurements: _______________________________
   d. Risers on tank. ☐ Yes ☐ No
   e. Evidence of infiltration in risers. ☐ Yes ☐ No
   f. Lids securely fastened. ☐ Yes ☐ No
   g. Secondary restraint safety feature secure ☐ NA ☐ Yes ☐ No
   h. Lid in operable condition. ☐ Yes ☐ No
5. Current tank operating conditions
   a. Liquid level between on and off elevations: ☐ Yes ☐ No
      _________in
   b. Maximum liquid level of tank (invert of inlet pipe):________in
   c. Alarm activation elevation relative to inlet _________in
   d. Evidence liquid level has been higher. ☐ Yes ☐ No
   e. Evidence liquid level dropped without pumping. ☐ Yes ☐ No
   f. Evidence of continuous inflow. ☐ Yes ☐ No
   g. Date last pumped: _____________________________________

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

5. ☐ Acceptable
   ☐ Unacceptable

Reference #:________________

6. Pump/Siphon
   a. Pump/Siphon under access. ☐ Yes ☐ No
   b. Pull chain or rope present. ☐ NA ☐ Yes ☐ No
7. Discharge assembly: ☐ NA
   a. Anti siphon device ☐ Yes ☐ No
   b. Backflow preventer (check valve) ☐ Yes ☐ No
   c. Air release located below check valve ☐ Yes ☐ No
   d. Drain back device ☐ Yes ☐ No
   e. Quick disconnect ☐ Yes ☐ No
   f. Isolation valve ☐ Yes ☐ No
   g. Inline filters ☐ Yes ☐ No
8. Electrical components watertight. ☐ NA ☐ Yes ☐ No
9. Tank structural condition (evaluate if tank pumped): ☐ NA
   a. Watertight (no visible leaks). ☐ Yes ☐ No
   b. Rebar exposed. ☐ Yes ☐ No
   c. Corrosion present. ☐ Yes ☐ No
   d. Spalling present. ☐ Yes ☐ No
   e. Cracks present. ☐ Yes ☐ No
   f. Root intrusion. ☐ Yes ☐ No
10. Solids accumulation:

Scum (in)	Sludge (in)	Odor	Color	Other

11. Tank pumping recommended. ☐ Yes ☐ No
12. Contractor responsible for pumping:______________________________
    a. Gallons pumped: ____________________ Date: _______________
13. Pump screen(s)
    a. Type of screen: ☐ Vault with basket ☐ Vault with filter ☐ In-line screen
    b. Screen cleaned. ☐ Yes ☐ No
14. Lab samples collected for monitoring. ☐ Yes ☐ No
    Types of analyses:____
    ____
    ____

6. ☐ Acceptable
   ☐ Unacceptable

7. ☐ Acceptable
   ☐ Unacceptable

8. ☐ Acceptable
   ☐ Unacceptable

9. ☐ Acceptable
   ☐ Unacceptable

10. ☐ Acceptable
    ☐ Unacceptable

Form 6-2 Operational Checklist: Pump: Demand Dosed System (PDD) (Including Siphons)

Service provided on: Date:______________Time:______ Reference #:_________________
Service provided by: Company: ____________________ Employee:___________________
Date of last service: _______________________________ By: ☐ You ☐ Other:_________
Date of last inspection: _____________________________

System type: ☐ Pump ☐ Siphon

1. Controls
   a. Type: ☐ Piggyback ☐ Control panel
   b. Controls operating properly. ☐ Yes ☐ No
   c. Enclosure watertight. ☐ Yes ☐ No
   d. Alarm test switch working properly. ☐ Yes ☐ No
   e. Control switch (HOA) set at:
      "Hand/Manual"_____________
      "Auto" ____________
      "Off" ____________
   f. Meter readings:

		Reading (current)	Reading (last)	Value	N.A.
i)	ETM			min	
ii)	Cycles/events			Cycles (NC)	

   Calculate cycles/day: _____ [NC] / [Days] = _______ [CPD]
   g. Telemetry operational. ☐ NA ☐ Yes ☐ No
      Type:____
2. Pump/Siphon
   a. Siphon operating properly. ☐ NA ☐ Yes ☐ No
   b. Pump operating properly. ☐ Yes ☐ No
   c. Type of pump: ☐ Multi-stage ☐ Single stage
   d. Amperage: ___________amps
   e. Voltage:______________volts
   f. Pump turns on/turns off ☐ Yes ☐ No
3. Water level sensors
   a. Type of water level sensor: ☐ Floats ☐ Pressure transducers
      ☐ Ultrasonic ☐ Ohm probe ☐ Other:
   b. Pump floats/sensors functioning properly. ☐ Yes ☐ No
   c. Alarm float/sensor operating both audible and visible. ☐ Yes ☐ No

Notes

1. ☐ Acceptable
   ☐ Unacceptable

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

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Form 6-3 Operational Checklist: Pump: Time Dosed System (PTD)

Service provided on: Date:_______ Time:____________ Reference #:______________
Service provided by: Company: __________________ Employee:___________________
Date of last service: ____________________________ By: ☐ You ☐ Other:_________
Date of last inspection: ___________________________

1. Controls Timer manufacturer: __________________
   a. Enclosure watertight. ☐ Yes ☐ No
   b. Alarm test switch working properly. ☐ Yes ☐ No
   c. Timer set at: "On" ____ Mode setting____
      "Off" ____ Mode setting____
   d. Control switch (HOA) set at: "Hand/Manual" ___________
      "Off" ___________________
      "Auto" __________________
   e. If timer was changed, new settings: "On" ____ Mode setting____
      "Off" ____ Mode setting____
   f. Meter readings:

		Reading (this)	Reading (last)	Difference	N.A.
i)	ETM			min	
ii)	Cycle counter			Cycles (NC)	

   Calculate cycles/day: _____ [NC] / [Days] = _______ [CPD]
   g. Telemetry operational. ☐ NA ☐ Yes ☐ No
      Type: ______________________

2. Pump
   a. Pump operating properly. ☐ Yes ☐ No
   b. Type of pump: ☐ Multi-stage ☐ Single stage
   c. Amperage: ___________amps
   d. Voltage: ___________volts
   e. Pump turns on/turns off. ☐ Yes ☐ No
3. Water level sensors
   a. Type of water level sensor: ☐ Floats ☐ Pressure transducers
      ☐ Ultrasonic ☐ Ohm probe ☐ Other: ___________
   b. Pump sensors functioning properly. ☐ Yes ☐ No
   c. Alarm sensor operating audible and visible alarms. ☐ Yes ☐ No
4. Sensor settings:

Sensor Number*	Function	Operational	Set At:		Secured
			Inches**	Datum	
1		☐ Yes ☐ No			☐ Yes ☐ No
2		☐ Yes ☐ No			☐ Yes ☐ No
3		☐ Yes ☐ No			☐ Yes ☐ No
4		☐ Yes ☐ No			☐ Yes ☐ No
5		☐ Yes ☐ No			☐ Yes ☐ No

**Designate starting from bottom of tank.*
***Measurements are taken from a fixed point ("Datum") near the surface or bottom of float tree in inches.*

Notes

1. ☐ Acceptable
   ☐ Unacceptable

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

Reference #:_________________

5. Pump delivery rate (PDR) (measured)
   a. Pump Off_____________ – Pump On ________________ = ________inches
   b. GPI: _______ (*From* Form 6-1, Item 3 e)
   c. Verified pump run time: _____________min
      [__________inches x __________GPI] ÷ Pump run time (min) =_______GPM)
6. Dose volume (DV) (from timer setting)
   a. Pump delivery rate: ________________ GPM (from Item 5)
   b. Verified pump run time: ________min
      _________ GPM x _________ minutes/cycle =____________(DV[Gallons/cycle])
7. Total gallons (from elapsed time meter)
      [_______(PTR) - _____(LTR)] x _____(GPM) = _______Total Gallons
   OR Total gallons (from event/cycle counter)
      [_______(PCR) - ____ (LCR)] x _____(DV) =_______Total Gallons
8. Average daily flow (GPD)

   _____Total gallons ÷ _____No. of days = _____Gallons/Day (GPD)

   % design capacity = [Average daily flow (GPD) / daily design flow (GPD)] x 100

9. Compare actual pump performance to design
   Using cycle counter:
   [_____(PCR) - _____(LCR)] ÷_____No. of days = ________Cycles/day (CPD)
   Using elapsed time meter:
   [_____(PTR) - _____(LTR)] ÷ _____No. of cycles = ________Runtime/cycle

ABBREVIATIONS
CPD: cycles per day
DV: dose volume
ETM: elapsed time meter
GPD: gallons per day
GPI: gallons per inch
GPM: gallons per minute
HOA: Hand-Off-Auto Switch
LCR: last cycle reading
LTR: last time reading
PCR: present cycle reading
PDR: pump delivery rate
PTR: present time reading

Form 7-1 Operational Checklist: Media Filter (MF)

Service provided on: Date:_______ Time:_____________ Reference #:_____________
Service provided by: Company: ________________ Employee: ___________________
Date of last service: ___________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ________________________

1. Type of media filter:

Single pass: ☐ Sand ☐ Foam ☐ Peat/Coir ☐ Polystyrene Other: _____________
Recirculating: ☐ Sand ☐ Foam ☐ Peat/Coir ☐ Textile ☐ Polystyrene Other: ____
Trickling filter: ☐ Gravel ☐ Plastic ☐ Textile Other: ______
Upflow filter: ☐ Gravel ☐ Plastic ☐ Wood chips Other: _______________

   a. Manufacturer: ____________________ Model #: ________________________
   b. Distribution method: ☐ Pressure distribution ☐ Gravity distribution

2. Conditions at media filter
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong ☐ Chemical ☐ Sour
   b. Source of odor, if present: _________________________________
3. Cover
   a. Type of cover: ☐ Buried ☐ Free access ☐ Lid
   b. Filter cover intact and secure. ☐ Yes ☐ No
   c. Distribution component accessible. ☐ Yes ☐ No
   d. Surface water/infiltration into components. ☐ Yes ☐ No
4. Venting/Air supply: ☐ Passive ☐ Active ☐ Not present
   a. Supply: ☐ Aspirator ☐ Compressor ☐ Blower ☐ Free air (go to 4.g)
   b. Operation: ☐ Continuous ☐ Timed (On ___min., Off __ min)
   c. Air supply unit operating properly. ☐ Yes ☐ No
   d. Pressure at air supply unit: _______________psi
   e. Air flow at air supply unit: ______________cfm
   f. Air filter/screen: ☐ Cleaned ☐ Replaced
   g. Venting appears operable. ☐ Yes ☐ No
5. Media surface
   a. Biomat on surface. ☐ Yes ☐ No
   b. Uniform gravity distribution. ☐ NA ☐ Yes ☐ No
   c. Uniform spray pattern. ☐ NA ☐ Yes ☐ No
   d. Ponding in/on media. ☐ Yes ☐ No
   e. Plugging/clogging of distribution components. ☐ Yes ☐ No
   f. Media appears to be settling. ☐ Yes ☐ No
   g. Appropriate maintenance performed. ☐ Yes ☐ No
   h. Pest activity at surface. ☐ Yes ☐ No
   i. Media in need of replacement ☐ NA ☐ Yes ☐ No

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

5. ☐ Acceptable
   ☐ Unacceptable

Reference #:______________

6. Effluent quality
    a. Turbidity: ____________NTU
    b. Oily film on the surface of effluent. ☐ Yes ☐ No
    c. DO at outlet: ____________mg/L
    d. pH at outlet: ____________
    e. Temperature at outlet: ____________
    f. Bypass or overflow noticed. ☐ Yes ☐ No
    g. Effluent odor after passing through media filter:
       ☐ None ☐ Mild ☐ Strong
    h. Effluent color after passing through media filter:
       ☐ Clear ☐ Brown ☐ Black
7. Pressure distribution: ☐ NA
    a. Operating pressure before cleaning
        i) Equal height. ☐ Yes ☐ No
        ii) Height (inches): ____________in
    b. Lateral condition
        i) Laterals in need of cleaning. ☐ Yes ☐ No
        ii) Laterals cleaned. ☐ Yes ☐ No
        iii) Method for cleaning laterals:____________
    c. Operating pressure after cleaning
        i) Equal height. ☐ Yes ☐ No
        ii) Height (inches): ____________in
8. Gravity distribution: ☐ NA
    a. Device: ____________
    b. Uniform distribution. ☐ Yes ☐ No
    c. Operating properly. ☐ Yes ☐ No
9. Filter drainage systems
    a. Ponding in media filter sump. ☐ Yes ☐ No
    b. Gravity drainage operational. ☐ NA ☐ Yes ☐ No
    c. Solids buildup in sump area. ☐ NA ☐ Yes ☐ No
    d. Underdrain vents present. ☐ NA ☐ Yes ☐ No
    e. Underdrain vents appear operable. ☐ NA ☐ Yes ☐ No
10. Control Panel:
    a. Controls operating properly. ☐ Yes ☐ No
    b. Enclosure water- and gas-tight. ☐ Yes ☐ No
    c. Alarm test switch operating properly. ☐ Yes ☐ No
    d. At time of inspection, control switch was set to:
       ☐ NA "Hand/Manual"_________ "Auto"_________
    e. If auto, setting: Time On: _______ (min) Time Off: ______ (min)
11. Alarm(s): ☐ NA
    a. Types: ☐ Air pressure ☐ High water ☐ Remote
    b. Alarms operating. ☐ Yes ☐ No

Notes

6. ☐ Acceptable ☐ Unacceptable

7. ☐ Acceptable ☐ Unacceptable

8. ☐ Acceptable ☐ Unacceptable

9. ☐ Acceptable ☐ Unacceptable

10. ☐ Acceptable ☐ Unacceptable

11. ☐ Acceptable ☐ Unacceptable

Reference #:_______________

c. Alarm readings:

		Reading (present)	Reading (last)	Difference	N.A.
i.	ETM			Hours	
ii.	Alarm counter			Events	

Elapsed time in alarm status: _____(PTR) - _____(LTR) = ______Time (hours)
Number of alarm events: _______(PACR) - _____(LACR) = ______Events (number)

d. Battery backup charged. ☐ NA ☐ Yes ☐ No
e. Telemetry operational. ☐ NA ☐ Yes ☐ No

12. Additional tasks for recirculating filters
    a. DO in recirculation tank: ____________mg/L
    b. Inspected recirculating device. ☐ NA ☐ Yes ☐ No
    c. Cleaned recirculating device. ☐ NA ☐ Yes ☐ No
    d. Design recirculation ratio: _______:______
    e. Actual recirculation ratio: _______:______
    f. Recirculation changed to: _______:______
    *If dam configuration, recirculation device cannot be inspected or cleaned
13. Additional tasks for trickling filters
    13.1 Clarification chamber
    a. Solids blanket below recirculation pump inlet. ☐ Yes ☐ No
       *If no, was system pumped. ☐ Yes ☐ No
    b. If screened inlet, was screen cleaned. ☐ Yes ☐ No
    13.2 Sludge return
    a. Solids blanket slightly above return pump. ☐ Yes ☐ No
    b. Changed solids return rate. ☐ Yes ☐ No
       i) Pump: ☐ Off ☐ On
       ii) Changed from ____ min to ____min
14. Manufacturer's required maintenance performed. ☐ Yes ☐ No
    (If 'Yes' attach Manufacturer Inspection form to this report, if supplied.)
15. Lab samples collected for monitoring. ☐ Yes ☐ No
    Types of analysis:____
    ____
    ____

Notes

12. ☐ Acceptable
    ☐ Unacceptable

13. ☐ Acceptable
    ☐ Unacceptable

13.1 ☐ Acceptable
     ☐ Unacceptable

13.2 ☐ Acceptable
     ☐ Unacceptable

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Form 7-2 Operational Checklist: Aerobic Treatment Unit (ATU)

Service provided on: Date:_______ Time:___________ Reference #:________________
Service provided by: Company: __________________ Employee: __________________
Date of last service: ____________________________ By: ☐ You ☐ Other:_________
Date of last inspection: _________________________

1. Type of ATU:
   - ☐ Suspended growth
   - ☐ Membrane bioreactor
   - ☐ Sequencing batch reactor
   - ☐ Submerged attached growth/Fixed film media
   - ☐ Rotating biological contactor
   - ☐ Integrated fixed activated sludge
   - ☐ Moving bed biofilm reactor
   - ☐ Other:________________
   - a. Manufacturer:_______________ Model #: ____________
2. Conditions at the ATU
   - a. Evaluate presence of odor within 10 ft of perimeter of system:
     ☐ None ☐ Mild ☐ Strong ☐ Chemical ☐ Sour
   - b. Source of odor, if present: ______________________________
   - c. Was foam/residue observed outside the unit. ☐ Yes ☐ No
3. ATU access
   - a. Located at grade. ☐ Yes ☐ No
   - b. If 'No', how deep is tank buried. __________________
     Swing tie measurements: ________________________________
   - c. Risers on tank. ☐ Yes ☐ No
   - d. Evidence of infiltration in the risers. ☐ Yes ☐ No
   - e. Lids/secondary restraint secured. ☐ Yes ☐ No
   - f. Lids in operable condition. ☐ Yes ☐ No
4. Venting/Air supply
   - a. Air supply method:
     ☐ Aspirator ☐ Aerator ☐ Compressor ☐ Blower ☐ Free air (go to 4.g)
   - b. Operation: ☐ Continuous ☐ Timed
     If timed, ETM readings and runtime: ________________________
   - c. Air supply unit operating properly. ☐ Yes ☐ No
   - d. Pressure at air supply unit: _______________psi
   - e. Air flow at air supply unit: ______________cfm
   - f. Air filter/screen: ☐ Cleaned ☐ Replaced
   - g. Venting appears operable. ☐ Yes ☐ No
5. Aeration chamber
   - a. Mixing in aeration chamber. ☐ Yes ☐ No
   - b. DO in aeration chamber: _____________mg/L
   - c. pH in aeration chamber: __________________

Notes

2. ☐ Acceptable ☐ Unacceptable

3. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

5. ☐ Acceptable ☐ Unacceptable

Reference #:______________

d. Temperature in aeration chamber:____________________
e. Settleability test:
Settled _____%, Floating _____% in ___________ min
f. Biomass color in the aeration chamber:
☐ Clear ☐ Brown ☐ Black
g. Sludge pumping recommended. ☐ Yes ☐ No

6. Additional tasks for biofilm media evaluation
a. Media plugging. ☐ Yes ☐ No
b. Media floating. ☐ Yes ☐ No
c. Media washed. ☐ Yes ☐ No
If washed, indicate method used: ☐ Air ☐ Water
d. Media replaced. ☐ Yes ☐ No

7. Clarification chamber
a. Scum layer. ☐ Yes ☐ No
If yes, thickness: ________________in
b. Clear zone depth below outlet: ________________in
c. Filtration ☐ NA ☐ Yes ☐ No
☐ Screen ☐ Tertiary filter ☐ Socks ☐ Membrane
☐ Cleaned in place ☐ Removed and cleaned ☐ Replaced
d. DO in clarifier: ______________mg/L
e. pH in clarifier: __________________
f. Temperature in clarifier: __________________
g. Effluent odor after passing through unit:
☐ None ☐ Mild ☐ Strong
h. Effluent color after passing through unit:
☐ Clear ☐ Brown ☐ Black
i. Effluent turbidity: ______________NTU

8. Sludge return operating: ☐ Passive ☐ Active
a. If active, pump was checked manually. ☐ NA ☐ Yes ☐ No
b. If active, pump operating properly. ☐ NA ☐ Yes ☐ No

9. Integral pumps ☐ NA ☐ Yes ☐ No
a. Type of integral pump and purpose
☐ Air lift:
☐ Recirculation ☐ Discharge ☐ Scum removal
☐ Centrifugal:
☐ Recirculation ☐ Discharge
b. Pump operating properly ☐ Yes ☐ No
c. Timer settings changed. ☐ Yes ☐ No
d. Air flow rate changed (air lift pump) ☐ Yes ☐ No

Notes

6. ☐ Acceptable
☐ Unacceptable

7. ☐ Acceptable
☐ Unacceptable

8. ☐ Acceptable
☐ Unacceptable

9. ☐ Acceptable
☐ Unacceptable

Reference #:_______________

Notes

Notes
10. ☐ Acceptable ☐ Unacceptable
11. ☐ Acceptable ☐ Unacceptable

10. Control Panel:
    a. Controls operating properly. ☐ Yes ☐ No
    b. Enclosure water- and gas-tight. ☐ Yes ☐ No
    c. Alarm test switch operating properly. ☐ Yes ☐ No
    d. At time of inspection, control switch was set to:
    N.A.__________ "Hand/Manual" _________ "Auto" __________
    e. If auto, setting: Time On: ________ (min) Time Off: _________ (min)
    f. Telemetry operational

11. Alarm(s): ☐ NA
    a. Types: ☐ Air pressure ☐ High water ☐ Remote
    b. Alarms operating. ☐ Yes ☐ No
    c. Alarm readings:
    Calculate the number of alarm events:
    ________(PACR) - ______(LACR) = ______Events (number)
    d. Battery backup charged. ☐ NA ☐ Yes ☐ No
    e. Telemetry operational. ☐ NA ☐ Yes ☐ No

12. Manufacturer's required maintenance performed. ☐ Yes ☐ No
    (If 'Yes' attach Manufacturer's Inspection form to this report, if supplied.)

13. Lab samples collected for monitoring. ☐ Yes ☐ No
    Types of analysis:____
    ____
    ____

ABBREVIATIONS
ETM: elapsed time meter
LACR: last alarm counter reading
LTR: last time reading
NC: number of cycles
PACR: present alarm counter reading
PTR: present time reading

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Form 7-3 Operational Checklist: Constructed Wetland (CW)

Service provided on: Date:_______ Time:_____________Reference #:_____________
Service provided by: Company: ____________________ Employee: ______________
Date of last service: __________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ________________________

1. Constructed wetland description: Cell # : ________/ _________
   a. Media: ☐ None ☐ Gravel, average diameter: _________in
      ☐ Other:_________________________________
   b. Flow regimen: ☐ Surface ☐ Subsurface ☐ Combination
   c. Distribution: ☐ Pressure ☐ Gravity
2. Conditions at the constructed wetland
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong ☐ Chemical ☐ Sour
   b. Source of odor, if present: ______________________________
   c. Type of border material: _____________
   d. Border material in good repair. ☐ Yes ☐ No
   e. Evidence of water/soil entering wetland. ☐ Yes ☐ No
   f. Fence present and operable. ☐ NA ☐ Yes ☐ No
   g. Animal activity at wetland surface. ☐ Yes ☐ No
3. Liquid level management
   a. Header distribution plugged. ☐ Yes ☐ No
   b. Bypass or overflow noted. ☐ Yes ☐ No
   c. Water level control option available. ☐ Yes ☐ No
   d. Water level adjustment needed. ☐ Yes ☐ No
4. Vegetation
   a. Species appropriate for climate. ☐ Yes ☐ No
   b. Vegetation alive. ☐ Yes ☐ No
   c. Replanting needed. ☐ Yes ☐ No
   d. Vegetation removal required. ☐ Yes ☐ No
5. Effluent quality
   a. Turbidity: _______________NTU
   b. DO in outlet: _______________mg/L
   c. pH in outlet: ___________________
   d. Temperature in outlet: ___________________
   e. Effluent odor after passing through wetland:
      ☐ None ☐ Mild ☐ Strong
   f. Effluent color after passing through wetland:
      ☐ Clear ☐ Brown ☐ Black
6. Additional tasks for subsurface flow wetlands
   a. Media surface level. ☐ Yes ☐ No
   b. Water level below media surface: __________in

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

5. ☐ Acceptable
   ☐ Unacceptable

6. ☐ Acceptable
   ☐ Unacceptable

Reference #: ___________________

7. Additional tasks for recirculating wetlands
   a. DO in recirculation tank: _______________mg/L
   b. Inspected recirculating device. ☐ NA ☐ Yes ☐ No
   c. Cleaned recirculating device. ☐ NA ☐ Yes ☐ No
   d. Design recirculation ratio: _______:______
   e. Actual recirculation ratio: _______:______
   f. Recirculation changed to: _______:______
8. Inspection ports
   a. Inspection ports present. ☐ Yes ☐ No
   b. Inspection ports intact. ☐ Yes ☐ No
9. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:____
   ____
   ____

7. ☐ Acceptable
☐ Unacceptable

Form 7-4 Operational Checklist: Lagoon Maintenance (LM)

Service provided on: Date:_______ Time:_____________ Reference #:_____________
Service provided by: Company: ________________ Employee: ___________________
Date of last service: ___________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ________________________

1. Lagoon: Cell #: ______ /______
   a. Type: ☐ Aerobic ☐ Facultative
2. Conditions at the lagoon
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong ☐ Chemical ☐ Sour
   b. Color of lagoon water:
      ☐ Clear ☐ Green ☐ Purple ☐ Other:________________
   c. Sludge pumping necessary. ☐ Yes ☐ No
   d. Animal activity at surface. ☐ Yes ☐ No
3. Border around lagoon
   a. Type of border material: ___________________
   b. Border material in good repair. ☐ Yes ☐ No
   c. Evidence of water/soil entering lagoon. ☐ Yes ☐ No
   d. Berm free of burrowing animals. ☐ Yes ☐ No
   e. Berm protected from erosion. ☐ Yes ☐ No
   f. Trees present on the berm. ☐ Yes ☐ No
   g. Fencing is present and operable. ☐ Yes ☐ No
4. Vegetation in lagoon
   a. Floating vegetation present. ☐ Yes ☐ No
   b. If yes, vegetation removed. ☐ Yes ☐ No
   c. Vegetation present at edges. ☐ Yes ☐ No
5. Liquid level management
   a. Liquid level below freeboard: ________________ft
   b. Liquid level relative to: ☐ Outlet ☐ Berm
      ☐ Above ☐ Below _____________in
   c. Water level control option available ☐ Yes ☐ No
6. Effluent quality
   a. Clarity: ☐ Clear ☐ Suspended solids present
   b. Oily film on the effluent surface. ☐ Yes ☐ No
   c. DO at outlet or across from inlet: _______________mg/L
   d. pH at outlet or across from inlet: ___________________
   e. Temperature in outlet: ___________________
   f. Bypass or overflow noted. ☐ Yes ☐ No
   g. Effluent odor after passing through lagoon (if discharging):
      ☐ None ☐ Mild ☐ Strong
   h. Effluent color after passing through lagoon (if discharging):
      ☐ Clear ☐ Brown ☐ Black

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

5. ☐ Acceptable
   ☐ Unacceptable

6. ☐ Acceptable
   ☐ Unacceptable

Reference #:_______________

7. Lab samples collected for monitoring. ☐ Yes ☐ No

   Types of analysis:____

   ____

   ____

Form 7-5 Operational Checklist: Disinfection Unit - Chlorine (DUC)

Service provided on: Date:_______ Time:_____________ Reference #:____________
Service provided by: Company: ________________ Employee: ________________
Date of last service: ___________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ________________________

1. Operation of chlorination system
   a. Manufacturer: Chlorinator: ________ Dechlorinator: ______
   b. Model #: ____
   c. Method: ☐ Tablet ☐ Liquid
   d. Unit appears to be in good condition. ☐ Yes ☐ No
2. Tablet chlorination: ☐ NA
   a. Chlorinator appears to be operable. ☐ Yes ☐ No
   b. Chlorine tablets in place. ☐ Yes ☐ No
      Type:____
   c. Tablets in contact with effluent. ☐ Yes ☐ No
   d. If tablets added, how many: ________________
   e. Contact chamber appears operable. ☐ Yes ☐ No
   f. Contact chamber and stack feeder cleaned. ☐ Yes ☐ No
   g. Chlorine residual: ☐ Free ☐ Total ______________mg/L
      Testing method:____________________________________
3. Liquid chlorinator: ☐ NA
   a. Chlorine present in reservoir. ☐ Yes ☐ No
   b. Injection method operating correctly. ☐ Yes ☐ No
      Type:____
   c. Dosing mechanism operable. ☐ Yes ☐ No
   d. Proper mixing occurring. ☐ Yes ☐ No
   e. Chlorine residual: ☐ Free ☐ Total ______________mg/L
      Testing method:____________________________________
4. Tablet dechlorination: ☐ Required ☐ Not required
   a. Dechlorination appears operable. ☐ Yes ☐ No
   b. Dechlorination tablets in place: ☐ Yes ☐ No
      Type:____
   c. Tablets in contact with effluent. ☐ Yes ☐ No
   d. If tablets added, how many:________________
   e. Contact chamber appears operable. ☐ Yes ☐ No
   f. Contact chamber/stack feeder cleaned. ☐ Yes ☐ No
   g. Chlorine residual: ☐ Free ☐ Total__________________ppm
      Testing method:____________________________________
5. Control panel: ☐ NA
   a. Controls operating properly. ☐ Yes ☐ No

Notes

1. ☐ Acceptable ☐ Unacceptable

2. ☐ Acceptable ☐ Unacceptable

3. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

5. ☐ Acceptable ☐ Unacceptable

Reference #:_______________

b. Is enclosure watertight. ☐ Yes ☐ No
c. Alarm test switch operating properly. ☐ Yes ☐ No
d. At time of inspection, control switch was set to: ☐ NA
“Hand/Manual”____________“Auto”_____________
e. If auto, setting: Time On: _____ (min) Time Off: ______ (min)

6. Manufacturer’s required maintenance performed. ☐ Yes ☐ No
(If ‘Yes’, attach Manufacturer Inspection form to this report, if supplied.)
7. Lab samples collected for monitoring. ☐ Yes ☐ No
Types of analysis:____
____
____

Form 7-6 Operational Checklist: Disinfection Unit – Ultraviolet Light (DUUL)

Service provided on: Date:_______ Time:_____________ Reference #:_____________
Service provided by: Company: ________________ Employee: ___________________
Date of last service: ____________________________ By: ☐ You ☐ Other:_________
Date of last inspection: _________________________

1. Power supply
   a. Dosing method: ☐ Pressure dosed ☐ Gravity fed
   b. Manufacturer: _______________ Model #: _________________
   c. Power supplied to the unit. ☐ Yes ☐ No
   d. UV lamp 'ON'. ☐ Yes ☐ No
   e. Electrical system free of corrosion/damage. ☐ Yes ☐ No
   f. Ballast replaced during this visit. ☐ Yes ☐ No
   g. Last replacement date: ____ / ____ / _____
2. UV controls
   a. Unit equipped with a lamp intensity sensor. ☐ Yes ☐ No
   b. If so, what was intensity reading: ___________________
   c. Alarm present. ☐ Yes ☐ No
   d. Alarm operating properly. ☐ NA ☐ Yes ☐ No
3. Contact chamber, lamp, and sleeve conditions
   a. Evidence of damage or leakage. ☐ Yes ☐ No
   b. Contact chamber cleaned/flushed of solids. ☐ Yes ☐ No
   c. Type of protective sleeve: ☐ Quartz ☐ Teflon ☐ Other: _______
   d. Protective sleeve free of buildup. ☐ Yes ☐ No
   e. Protective sleeve cleaned. ☐ Yes ☐ No
   f. Protective sleeve replaced during this visit. ☐ Yes ☐ No
   g. Date last replaced: ____ / ____ / _____
   h. UV lamp replaced during this visit. ☐ Yes ☐ No
   i. Date last replaced: ____ / ____ / _____
4. Influent characteristics
   a. Clarity: ☐ Clear ☐ Cloudy
   b. Flow rate: ______________gpm
   c. Indicate wastewater characteristics that may compromise treatment:
   ____
   ____
5. Control panel: ☐ NA
   a. Controls operating properly. ☐ Yes ☐ No
   b. Is enclosure watertight. ☐ Yes ☐ No
   c. Alarm test switch operating properly. ☐ Yes ☐ No
6. Housing unit: Location: _________________
   a. Appears in good condition. ☐ Yes ☐ No

Notes

1. ☐ Acceptable ☐ Unacceptable
2. ☐ Acceptable ☐ Unacceptable
3. ☐ Acceptable ☐ Unacceptable
4. ☐ Acceptable ☐ Unacceptable
5. ☐ Acceptable ☐ Unacceptable
6. ☐ Acceptable ☐ Unacceptable

Reference #:__________________

b. Leaks/Cracks present. ☐ Yes ☐ No

c. Excessive dust present. ☐ Yes ☐ No

7. Manufacturer's required maintenance performed. ☐ Yes ☐ No

   (If 'Yes' attach Manufacturers Inspection form to this report, if supplied.)

8. Lab samples collected for monitoring. ☐ Yes ☐ No

   Types of analysis:____

   ____

   ____

Form 7-7 Operational Checklist: Disinfection Unit - Ozone (DUO)

Service provided on: Date:_______ Time:_____________ Reference #:_____________
Service provided by: Company: _________________ Employee: ___________________
Date of last service: ___________________________ By: ☐ You ☐ Other:__________
Date of last inspection: ________________________

1. Ozone generator
   a. Manufacturer: ______________ Model #: ______________________
   b. Air supply: ☐ Free air ☐ Pure oxygen
   c. Ozone generator operating as designed. ☐ Yes ☐ No
   d. Filter/Screen: ☐ Cleaned ☐ Replaced
2. Dosing system operating properly. ☐ Yes ☐ No
   a. Dosing method: ☐Pressure-dosed ☐ Gravity-dosed
3. Contact chamber
   a. Proper mixing. ☐ Yes ☐ No
   b. Cracks/leaks present. ☐ Yes ☐ No
   c. DO concentration: ___________ppm
4. Ventilation appears operable. ☐ Yes ☐ No
5. Housing Location: ____________________________________
   a. Appears in good condition. ☐ Yes ☐ No
   b. Leaks/cracks present. ☐ Yes ☐ No
   c. Excessive dust present. ☐ Yes ☐ No
6. Ozone sensor
   a. Sensor functioning. ☐ Yes ☐ No
   b. If 'yes', what was the reading: _____________________ mg/L
   c. Safety alarm present. ☐ Yes ☐ No
   d. Alarm operating properly. ☐ Yes ☐ No
7. Control panel: ☐ NA
   a. Controls operating properly. ☐ Yes ☐ No
   b. Enclosure water- and gas-tight. ☐ Yes ☐ No
   c. Alarm test switch operating properly. ☐ Yes ☐ No
8. Manufacturer's required maintenance performed. ☐ Yes ☐ No
   (If 'Yes' attach Manufacturers Inspection form to this report, if supplied.)
9. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:____
   ____
   ____

Notes

1. ☐ Acceptable
   ☐ Unacceptable
2. ☐ Acceptable
   ☐ Unacceptable
3. ☐ Acceptable
   ☐ Unacceptable
4. ☐ Acceptable
   ☐ Unacceptable
5. ☐ Acceptable
   ☐ Unacceptable
6. ☐ Acceptable
   ☐ Unacceptable
7. ☐ Acceptable
   ☐ Unacceptable

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Form 8-1 Operational Checklist: Gravity Distribution (Including Pressure-Dosed Gravity) (GD)

Service provided on: Date:_______________Time:______Reference #:____________
Service provided by: Company: ________________ Employee:___________________
Date of last service: __________________________ By: ☐ You ☐ Other:_________
Date of last inspection: _______________________

1. Description of STA
   a. Method of distribution
      ☐ Gravity ☐ Pressure-dosed gravity ☐ Siphon-dosed gravity
   b. Configuration in the field:
      ☐ Bed ☐ Parallel trench ☐ Sequential trench ☐ Serial trench
2. Conditions in the soil treatment area
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ______________________________
   c. Leaks around/over system. ☐ Yes ☐ No
   d. Vegetation appropriate. ☐ Yes ☐ No
   e. Uneven vegetation. ☐ Yes ☐ No
   f. Vegetation adequately maintained. ☐ Yes ☐ No
   g. Preventing access for maintenance. ☐ Yes ☐ No
3. Distribution device
   a. Type: ☐ Distribution box ☐ Drop box ☐ Header
      ☐ Pressure manifold ☐ Other: __________________
   b. If pressure manifold, operating pressure: ________________
   c. Accessible ☐ Yes ☐ No
   d. Intact, providing equal distribution ☐ Yes ☐ No
   e. Free of solids ☐ Yes ☐ No
   f. If 'No,' depth of solids below outlet (D-box): ____________in
   g. Root intrusion ☐ Yes ☐ No

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

Reference #:______________

4. Distribution in field: Soil treatment area information:

Lateral #	Ponding		Surfacing Effluent		Distance Effluent Traveled (ft)	Obstructions	Notes	Status
	Yes or No	Depth (in)	Yes	No				
1			☐	☐				☐ Acceptable ☐ Unacceptable
2			☐	☐				☐ Acceptable ☐ Unacceptable
3			☐	☐				☐ Acceptable ☐ Unacceptable
4			☐	☐				☐ Acceptable ☐ Unacceptable
5			☐	☐				☐ Acceptable ☐ Unacceptable
6			☐	☐				☐ Acceptable ☐ Unacceptable
Other areas where effluent is surfacing			☐	☐				☐ Acceptable ☐ Unacceptable

5. Inspection ports
   a. Inspection ports present ☐Yes ☐No
   b. Inspection ports intact ☐Yes ☐No
6. Switching valves
   a. Switching valve present ☐Yes ☐No
   b. Type of valve:______________________________
   c. Operating properly ☐Yes ☐No
   d. Action taken if not:______________________________
   e. Laterals in operation: ______________________________

5. ☐ Acceptable
   ☐ Unacceptable

6. ☐ Acceptable
   ☐ Unacceptable

Form 8-2 Operational Checklist: Low-pressure Distribution STA (LPD)

Service provided on: Date:______________Time:______Reference #:___________
Service provided by: Company: _______________ Employee:________________
Date of last service: ______________________ By: ☐ You ☐ Other:_________
Date of last inspection:____________________

1. Effluent quality: ☐ Aerobic ☐ Septic tank effluent (anaerobic)
2. Conditions at the LPD
   a. Topography: ☐ Level ☐ Sloping: _________ % slope
   b. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   c. Source of odor, if present: ______________________________
   d. Leaks around/above system. ☐ Yes ☐ No
   e. Vegetation appropriate. ☐ Yes ☐ No
   f. Excessive vegetation. ☐ Yes ☐ No
   g. Vegetation adequately maintained. ☐ Yes ☐ No
   h. Preventing access for maintenance. ☐ Yes ☐ No
3. Supply line
   a. Line drains freely. ☐ Yes ☐ No
   b. Ponding/saturation along the supply line. ☐ NA ☐ Yes ☐ No
   c. Air relief(s) valve operating. ☐ NA ☐ Yes ☐ No
4. Switching valves
   a. Switching valve present. ☐ Yes ☐ No
   b. Type of valve:______________________________________
   c. Operating properly. ☐ Yes ☐ No
   d. Action taken if not:__________________________________
   e. Laterals/zones in operation: ___________________________
5. Soil treatment area information:

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

Zone #	Lat. #	Operating pressure		Ponding Yes/No (in)	Surfacing Effluent		Lateral Ends			Root Intrusion (Yes/No)	Other Obstruction (Specify)
		Meas. (in)	Adj. to (in)		Yes/No	Distance Traveled (ft)	Intact	Protected	Accessible		

Reference #: ______________________

6. Orifices
   a. Position: ☐ 6 o'clock ☐ 12 o'clock
   b. Orifices cleaned. ☐ Yes ☐ No
   c. Method: ☐ Hydrojetted ☐ Bottle brushed
   ☐ Flushed ☐ Other:________________________

6. ☐ Acceptable
   ☐ Unacceptable

Form 8-3 Operational Checklist: Evapotranspiration Beds (ETB)

Service provided on: Date:_______________Time:______Reference #:____________

Service provided by: Company: _______________ Employee:_______________

Date of last service: _________________________ By: ☐ You ☐ Other:_________

Date of last inspection: _____________________

1. Conditions at the ET bed
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ____________________________
   c. Leaks around/over system. ☐ Yes ☐ No
   d. Vegetation appropriate. ☐ Yes ☐ No
   e. Excessive vegetation. ☐ Yes ☐ No
   f. Vegetation adequately maintained. ☐ Yes ☐ No
   g. Preventing access for maintenance. ☐ Yes ☐ No

1. ☐ Acceptable ☐ Unacceptable

2. Distribution to ET bed
   a. Method for dosing:
      ☐ Gravity ☐ Pressure-dosed gravity
   b. Type: ☐ Distribution box ☐ Header
      ☐ Pressure manifold ☐ Other: _______________
   c. If pressure manifold, operating pressure: ______________
   d. Accessible. ☐ Yes ☐ No
   e. Intact, providing equal distribution. ☐ Yes ☐ No
   f. Free of solids. ☐ Yes ☐ No
   g. If 'No' depth of solids below outlet. _________in
   h. Root intrusion. ☐ Yes ☐ No

2. ☐ Acceptable ☐ Unacceptable

3. Switching valve
   a. Switching valve present. ☐ Yes ☐ No
   b. Type of valve:_______________________________
   c. Operating properly. ☐ Yes ☐ No
   d. Action taken if not:____________________________
   e. Bed in operation: ______________________________
4. ET bed status

Bed #	Status		Ponding		Surfacing Effluent (Yes/No)	Surface water diverted (Yes/No)
	Current	End of Service Visit	Yes/No	Depth (in)		
1	☐ Active ☐ Resting	☐ Active ☐ Resting				
2	☐ Active ☐ Resting	☐ Active ☐ Resting				

5. Inspection ports
   a. Inspection ports present. ☐ Yes ☐ No
   b. Inspection ports intact. ☐ Yes ☐ No

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Form 8-4a Operational Checklist: Free Access Bottomless Media Filter (FABMF)

Service provided on: Date:_______________ Time:_____Reference #: _____________
Service provided by: Company: ________________ Employee:_________________
Date of last service: ___________________________ By: ☐ You ☐ Other:_________
Date of last inspection:________________________

1. Nature of media: ☐ Organic ☐ Inorganic
2. Conditions at the STA site
   a. Evidence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: _____________________________
   c. Structure intact. ☐ Yes ☐ No
   d. Vegetation appropriate. ☐ Yes ☐ No
   e. Stormwater management effective. ☐ Yes ☐ No
3. Media surface
   a. Uniform distribution. ☐ NA ☐ Yes ☐ No
   b. Uniform spray pattern ☐ NA ☐ Yes ☐ No
   c. Ponding in media. ☐ Yes ☐ No
   d. Media in need of cleaning. ☐ Yes ☐ No
   e. Additional media needed. ☐ Yes ☐ No
   f. Date of last media replacement:__________________________
   g. Media in need of replacement. ☐ Yes ☐ No
   h. Appropriate maintenance performed. ☐ Yes ☐ No
   i. Animal or human activity at surface. ☐ Yes ☐ No
4. Pressure distribution: ☐ NA
   a. Operating pressure before cleaning
      i) Equal height. ☐ Yes ☐ No
      ii) Height (inches): ______________in
   b. Lateral condition
      i) Needs cleaning. ☐ Yes ☐ No
      ii) Cleaned. ☐ Yes ☐ No
      iii) Method for cleaning:_____________________________
   c. Operating pressure after cleaning
      i) Equal height. ☐ Yes ☐ No
      ii) Height (inches): ______________in
5. Manufacturer required maintenance performed. ☐ NA ☐ Yes ☐ No
   (If 'Yes' attach Manufacturers Inspection form to this report, if supplied.)
6. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:____
   ____
   ____

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

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Form 8-4b Operational Checklist: Buried Treatment and Dispersal Systems (BTD)

Service provided on: Date:________________Time:_____Reference #:____________
Service provided by: Company: _______________ Employee:__________________
Date of last service: __________________________ By: ☐ You ☐ Other:_________
Date of last inspection: _______________________

1. Type of system:
   ☐ Mound ☐ Elevated ☐ Soil substitution ☐ Sand lined trench or bed
   ☐ Amended layer system ☐ Combined treatment and dispersal
2. Conditions at the STA site
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ______________________________
   c. Leaks around/above system. ☐ Yes ☐ No
   d. Vegetation appropriate. ☐ Yes ☐ No
   e. Excessive vegetation. ☐ Yes ☐ No
   f. Vegetation maintained. ☐ Yes ☐ No
   g. Preventing access. ☐ Yes ☐ No
3. Media surface
   a. Ponding in media. ☐ Yes ☐ No
   b. Plugged distribution components ☐ Yes ☐ No
4. Distribution
   a. Dosing method
      ☐ Gravity ☐ Pressure dosed gravity
      ☐ Low-pressure distribution (LPD)
   b. Type: ☐ Distribution box ☐ Header ☐ Pressure manifold
      ☐ Other: ____________________
   b. If pressure manifold, operating pressure: ☐ NA
   c. LPD Operating pressure before cleaning ☐ NA
      i) Equal height. ☐ Yes ☐ No
      ii) Height: ____________in
   e. LPD Lateral condition ☐ NA
      i) Needs cleaning. ☐ Yes ☐ No
      ii) Cleaned. ☐ Yes ☐ No
      iii) Method for cleaning:____________________________
   f. LPD Operating pressure after cleaning ☐ NA
      i) Equal height. ☐ Yes ☐ No
      ii) Height: _________inches
5. Treatment media/natural soil interface
   a. Ponding on surface. ☐ Yes ☐ No
   b. Seepage at toe. ☐ Yes ☐ No

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

5. ☐ Acceptable
   ☐ Unacceptable

Reference #:_______________

6. Inspection ports
   a. Present. ☐ Yes ☐ No
   b. Intact. ☐ Yes ☐ No
7. Amended layer systems: ☐ NA
   a. Date of last media replacement:____________________________
   b. Media in need of replacement. ☐ Yes ☐ No
8. Manufacturer required maintenance performed. ☐ NA ☐ Yes ☐ No
   (If 'Yes', attach Manufacturer's Inspection form to this report, if supplied.)
9. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis____
   ____
   ____

Notes

7. ☐ Acceptable
   ☐ Unacceptable

Form 8-5 Operational Checklist: Drip Field STA (DF)

Service provided on: Date:________________Time:_____Reference #:____________
Service provided by: Company: ________________ Employee:__________________
Date of last service: __________________________ By: ☐ You ☐ Other:__________
Date of last inspection: _______________________

1. Conditions at the drip distribution field
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: ____________________________
   c. Leaks around/above system ☐ Yes ☐ No
   d. Vegetation appropriate for climate ☐ Yes ☐ No
   e. Excessive vegetation ☐ Yes ☐ No
   f. Vegetation maintained ☐ Yes ☐ No
   g. Preventing access ☐ Yes ☐ No
2. Drip filter
   a. Type of filter:
      ☐ Sand ☐ Screen ☐ Disc ☐ Other: ______________
   b. Filter in place. ☐ Yes ☐ No
   c. Pre-filter pressure: ______________ psi
   d. Post-filter pressure: ______________ psi
   e. Filter: ☐ Cleaned ☐ Replaced
   f. Automatic cleaning operational. ☐ NA ☐ Yes ☐ No
   g. By-pass flow operating. ☐ NA ☐ Yes ☐ No
   h. Housing insulated. ☐ NA ☐ Yes ☐ No
   i. Heater pad operational. ☐ NA ☐ Yes ☐ No
3. Effluent flow metering
   a. Flow meter:
      Present (PFR): ________gal Date:_________
      Last (LFR): ________gal Date: _________
      Differential ([PFR – LFR] / days):_________________________
      ________GPD Days:_________
4. Switching valves
   a. Switching valve present. ☐ Yes ☐ No
   b. Type of valve:___________________________________
   c. Operating properly. ☐ Yes ☐ No
   d. Action taken if not:_______________________________
   e. Zones in operation: ______________________________

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

4. ☐ Acceptable
   ☐ Unacceptable

Reference #:______________

5. Field flushing: ☐ None ☐ Manual ☐ Automatic ☐ Continuous
   a. Operational. ☐ Yes ☐ No
   b. Field flushing operation:

Zone	Manually Flushed Zones	Operating Pressure (psi)		Zone Flushing				Field Dosing			
		Dosing	Flushing	ETM		CC		ETM		CC	
				PFTR	LFTR	PFCR	LFCR	PFTR	LFTR	PFCR	LFCR

6. Zone operation:

Zone #	In service Yes/No	Flow Rate (GPM)	Total Flow (gal) *(since last visit)*	Air/Vacuum relief operating	Surfacing Effluent

Notes

6. ☐ Acceptable
   ☐ Unacceptable

7. Manufacturer's required maintenance performed. ☐ Yes ☐ No
   (If 'Yes' attach Manufacturer Inspection form to this report, if supplied.)
8. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:____
   ____

ABBREVIATIONS

CC- cycle counter
ETM- elapsed time meter
GPM- gallons per minute
LFCR- last flushing cycle reading
LFR- last flow meter reading
LFTR- last flushing time reading
PFCR- present flushing cycle reading
PFR- present flow meter reading
PFTR- present flushing time reading
psi- pounds per square inch
TT- total time

Form 8-6 Operational Checklist: Spray Field STA (SF)

Service provided on: Date:________________Time:_____________ Reference #:________
Service provided by: Company: _________________ Employee:_____________________
Date of last service: ____________________________ By: ☐ You ☐ Other:___________
Date of last inspection: _________________________

1. Conditions at the spray distribution field
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: _________________________________
   c. Leaks around/above system ☐ Yes ☐ No
   d. Vegetation appropriate ☐ Yes ☐ No
   e. Excessive vegetation ☐ Yes ☐ No
   f. Vegetation maintained ☐ Yes ☐ No
   g. Preventing access ☐ Yes ☐ No
2. Distribution approach
   a. Zones: ☐ Single ☐ Multiple: #___________________________
3. Switching valves
   a. Switching valve present. ☐ Yes ☐ No
   b. Type of valve:____
   c. Operating properly. ☐ Yes ☐ No
   d. Action taken if not:________________________________
   e. Zones in operation: ________________________________
4. Site conditions
   a. Color coded ☐ Yes ☐ No
   b. Signage present ☐ NA ☐ Yes ☐ No
   c. Fencing present and secure ☐ NA ☐ Yes ☐ No
5. System operating pressure: ____________ psi
   a. Location of pressure reading: _____________________________
6. Control panel
   a. Timer operating properly. ☐ NA ☐ Yes ☐ No
      i) Timer settings: ON __________________min
      OFF _________________ min
   b. Photocell functioning. ☐ NA ☐ Yes ☐ No
   c. Rainfall shutoff functioning. ☐ NA ☐ Yes ☐ No
   d. Freeze protection operational ☐ NA ☐ Yes ☐ No
7. Sprinkler head operation
   a. Low-pressure shutoff valve. ☐ NA ☐ Yes ☐ No
   b. In-line filter cleaned. ☐ NA ☐ Yes ☐ No
   c. Heads in proper adjustment. ☐ Yes ☐ No
   d. Pop-up heads retract. ☐ NA ☐ Yes ☐ No

Notes

1. ☐ Acceptable ☐ Unacceptable

3. ☐ Acceptable ☐ Unacceptable

4. ☐ Acceptable ☐ Unacceptable

6. ☐ Acceptable ☐ Unacceptable

7. ☐ Acceptable ☐ Unacceptable

Reference #:______________________________

e. Sprinkler head operation summary:

Zone	Low Angle Nozzle	Pattern		Operation (Impact, Rotor, Spray)	Low-Pressure Drain	Riser Intact
		Current Pattern	Designed Pattern			

8. Zone operation:

Zone	Erosion	Wastewater Runoff	Ponding	Vegetation	
				Does not disrupt spray pattern	Type

9. Manufacturer's required maintenance performed. ☐ Yes ☐ No
   (If 'Yes' attach Manufacturer Inspection form to this report, if supplied.)
10. Lab samples collected for monitoring. ☐ Yes ☐ No
    Types of analysis:____
    ____
    ____

ABBREVIATIONS
psi - pounds per square inch

Form 8-7 Operational Checklist: Outfall (OS)

Service provided on: Date:________Time:___________Reference #:_______________
Service provided by: Company: ________________ Employee:___________________
Date of last service: ___________________________ By: ☐ You ☐ Other:_________
Date of last inspection: ________________________

1. Type of outfall
   a. Treatment component:
      ☐ Lagoon ☐ Media filter ☐ Aerobic treatment unit
   b. Flow delivery: ☐ Gravity flow ☐ Pumped flow
2. Discharge effluent condition
   a. Evaluate presence of odor within 10 ft of perimeter of system:
      ☐ None ☐ Mild ☐ Strong
   b. Source of odor, if present: _________________________________
   c. Evidence of discharge. ☐ Yes ☐ No
   d. If evidence of discharge, describe status: ☐ Current ☐ Previous
   e. If current discharge, describe rate of discharge:
      ☐ Dripping ☐ Trickling ☐ Flowing
   f. Residuals in discharging effluent. ☐ Yes ☐ No
   g. Animal or vector activity in discharged effluent. ☐ Yes ☐ No
3. Outfall structure
   a. Outlet unobstructed. ☐ Yes ☐ No
   b. Vegetation maintenance necessary. ☐ Yes ☐ No
   c. Erosion around outlet pipe. ☐ Yes ☐ No
   d. Outlet protected from animal activity. ☐ Yes ☐ No
   e. Discharge pipe in good condition. ☐ Yes ☐ No
   f. Maintenance completed. ☐ Yes ☐ No
4. Lab samples collected for monitoring. ☐ Yes ☐ No
   Types of analysis:____
   ____
   ____

Notes

2. ☐ Acceptable
   ☐ Unacceptable

3. ☐ Acceptable
   ☐ Unacceptable

Form 9-1 Example Chain of Custody Record

CHAIN OF CUSTODY RECORD

Lab ID No.: ____________________

This information will be used for reporting/billing

Name: ____________________

Attention: ____________________

Address: ____________________

____

Phone: ____________________

		Collection Data				No. of	**INSTRUCTIONS: use one line per sample & indicate tests to be performed by checking appropriate boxes**												
Lab Use	Sample ID /Collection Point	Date	Time	Comp.	Grab	bottles	BOD_5	TSS	O&G	pH	FC	TC	TKN	NH3-N	NO_2	NO_3			Notes

Samplers Signature: ____________________

Print Name: ____________________

Relinquished To Lab By: ____________________

Special Instructions - Client:

Shipped Via:
☐ UPS
☐ Hand
☐ Other ____________________

Temperature Acceptable:
☐ Yes ☐ No

Form 9-2 is also a good documentation resource for recording site information and test results.

Form 9-2 Sampling Documentation

Reference #:____________________

Form completed by: Company: ______________________ Employee:______________

Client Contact Information Client Name:

Address:____________________________ Time:________ Date: ____________

Phone #: ________________________

Designer:____________________________ Cell #:__________________________

Design flow:_________________________ Installer:________________________

Facility in a rural setting__________GPD Date of last pump out:____________

☐ Yes ☐ No

Sampling

Client Name:

Chain of custody complete_____________ Time:________ Date: ____________

☐ Yes ☐ No

Laboratory Results

BOD_5:

TSS: ______________________________ mg/L SS:______________________ mg/L

O & G:______________________________ mg/L FC:________________ MPN/100 mL

pH: ______________________________ mg/L TKN:_____________________mg/L

Temp:____________________________ std. units NH_3:____________________mg/L

______________________________ °C NO_2^-:___________________ mg/L

DO: ________________________________ mg/L NO_3^-:___________________ mg/L

DO: ________________________________ mg/L (of water supply)

(NOTE: If a chemical analysis of the tap water has been performed, please provide test date.)

Microscopic examination: ____

____

____

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Form 9-3 Residential Survey (RS)

Reference #:____________________

Form completed by: Company: ______________________ Employee:______________

Client Contact Information

Client Name: _________________________ Time:________ Date: ___________

Address: ____

Phone #: ____________________________ Cell #:_________________________

Designer: ____________________________ Installer:______________________

Design flow: ____________________GPD Date of last pump out:___________

Facility in a rural setting ☐ Yes ☐ No

A. Operational data

A.1 Is this your first home with an onsite wastewater treatment system? ☐ Yes ☐ No
A.2 Have you ever received any treatment system user information? ☐ Yes ☐ No
A.3 Did you receive the as-built drawing for the treatment system? ☐ Yes ☐ No
A.4 Type of use:
a. Permanent: ☐ Seasonal: ☐ If seasonal, # of months used: _______
b. Number of people living in the house:
Adult: Teenagers: Children:
M ___ F ___ M ___ F ___ M ___ F___
c. Number of bedrooms: __________________
d. Number of bathrooms: _________________
e. Number of laundry rooms: ______________
A.5 Water supply
A.6 Do you have an in-home business? ☐ Yes ☐ No
a. If “yes”, what type? ____
A.7 Do you use septic system additives? ☐ Yes ☐ No
a. If “yes”, what products? _______________________________________
A.8 Square footage of house: ______________________ ft^2

B. Water use habits

B.1 Is any resident using long-term prescription drugs or antibiotics? ☐ Yes ☐ No
a. If “yes”, what products? _______________________________________
B.2 Do any residents use bath/skin oil/moisturizers? ☐ Yes ☐ No
B.3 Garbage disposal use ☐ Yes ☐ No
B.4 Dishwasher use ☐ Yes ☐ No

Reference #:_______________

B.5 Laundry machine use: ☐ Yes ☐ No
- a. High efficiency machine ☐ Yes ☐ No
- b. Max loads per day: _______________ Total loads per week: _______________
- c. Are loads done consecutively? ☐ Yes ☐ No
- d. Brand of laundry detergent: ______________ Powder: ☐ Liquid: ☐
- e. Is Bleach used?
  Powder: ☐ Liquid: ☐ Cups/load: ________ Loads/week: _______
- f. Water temperature preference: Hot ☐ Warm ☐ Cold ☐

B.6 Whirlpool tub/Jacuzzi ☐ Yes ☐ No
- a. Use: ______________ times/day ______________ days/week

B.7 Drain cleaner used ☐ Yes ☐ No
- a. Type: ____________________ Frequency of use: ______________________

B.8 Hand washing soap brand: _____________________
- a. Antibacterial: ☐ Yes ☐ No
- b. Liquid: ☐ Yes ☐ No

B.9 Number of toilet paper rolls used per week __________________________ rolls
Feminine hygiene products, or baby wipes flushed: ☐ Yes ☐ No

B.10 Toilet cleaning product brand: ________________________
- a. Cleanings per month: _________________________
- b. Continuous cleaner used in toilet tank: _______________________

B.11 List commonly used brands of cleaning supplies and antibacterial products:
Shower: ________________________ Kitchen: ______________________
Floor: __________________________ Other: ________________________

C. Onsite wastewater treatment system

C.1 Actual water use (GPD)
- a. Average: ___________ Peak: ____________ Low: ______________
- b. Reading this data from:
  Cycle counter: ___________________ Elapsed time meter: _____________
  Water meter: ___________________ Other: ________________________

C.2 What is the water pressure? ______________ psi
- a. Are bathroom fixtures or other devices low flow rated? ☐ Yes ☐ No
- b. If "yes", please list: ____
  ____
  ____
- c. Are there automatic flush fixtures? ☐ Yes ☐ No

C.3 Water treatment device: ☐ Yes ☐ No
- a. Is a water softener used? ☐ Yes ☐ No
  If yes, back flushes to: ____
- b. Is reverse osmosis used? ☐ Yes ☐ No
  If yes, reject flow discharges to: _____________________________________

C.4 Air conditioning unit(s): ☐ Yes ☐ No
- a. If yes, condensate drains to: ____

Reference #:_______________

C.5 Commercial ice machine: ☐ Yes ☐ No

a. If yes, condensate drains to: ____

C.6 Footing drains or sump pumps connected into the system: ☐ Yes ☐ No

C.7 Monthly water readings for one year period:

Jan ___ Feb ___ Mar ___ April ___ May ___ June ___

July ___ Aug ___ Sept ___ Oct ___ Nov ___ Dec ___

C.8 Location of sampling point: ____

(Please attach Form 9-2)

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Appendix C: Tools

- Permit/as-built plans/specs
- Clip board/O&M forms/pencil
- Calculator
- Binoculars for viewing remote components
- Hand mirror for viewing tank interiors
- Stethoscope for verifying mixing in enclosed tanks and for assessing pump bearing degradation
- Digital camera
- Sewer camera
- Timing device (watch or stop watch)
- Radios/communication devices
- Flash light
- Global Positioning System (GPS)
- Key map

- **Safety and personal protection**
  - Sunscreen/hat
  - Bug repellant
  - Drinking water
  - Rubber gloves
  - Leather gloves
  - Safety glasses, goggles, face shields
  - Bucket/chlorine
  - Wash water
  - Coveralls
  - Confined space equipment (for use by properly trained personnel)
  - Waterless hand cleaner
  - Disinfecting wipes
  - First-aid kit
  - Fire extinguisher

- **Measuring devices:**
  - Scum hook
  - Water column measuring device for measuring sludge depth, depth of clear zone, water clarity and biomass settleability
  - Standpipe with level indicator for measuring operating pressure
  - Measuring tape
  - Turbidity meter
  - Dissolved oxygen meter or test kit
  - pH meter or test kit
  - Thermometer
  - Pressure/vacuum gauge for air flow
  - Schrader valve
  - Chlorine test kit
  - Water meter

- **Hand tools**
  - Pipe wrenches
  - Wrenches
  - Pliers
  - Wire stripper
  - Screwdrivers
  - Hacksaw or cordless saw (for cutting large pipe)
  - PVC cutter (for cutting small pipe)
  - Valve keys
  - Cordless drill and bit set
  - Hammer
  - Shovel
  - Rake
  - Auger
  - Lid lifter or pry bar
  - Probe with insulated handles
  - Float switch lifter
  - Specialized tools for safety screws
  - Plumber's snake
  - Bottle brush for flushing laterals
  - Pressure washer for flushing laterals
  - Electrician's snake

- **Electrical tools and supplies (Check local electrical code)**
  - Electrical tape
  - Spare fuses or breakers
  - Spare light bulbs
  - Watertight wire nuts
  - Nylon wire ties
  - Multi-meter
  - Wire soap for lubricating wire during replacement
  - Duct seal
  - Liquid tape for sealing connections
  - Anti-oxidizing compound for application to electrical connections
  - GFCI drop cord
  - Electrical wire
- **Miscellaneous**
  - PVC cleaner and glue
  - PVC adapters and common fittings
  - Petroleum jelly to lubricate O-rings and grommets
  - Liquid or powder tracing dye
  - Hose with backflow prevention device and nozzle
  - Hose reel
  - Hydraulic cement
  - Duct tape
  - Tarp for placing soil on, collecting debris
  - Plastic trash can for storing/collecting contaminated debris
  - Spare trash bags
  - Five-gallon bucket
  - Small utility sump pump
  - Leaf blower

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An Operation and Maintenance Service Provider Program
Third Edition
National Onsite Wastewater Recycling Association
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