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# TITLE 5 RECIRCULATING SAND FILTERS DESIGN GUIDANCE

Effective Date: June 24, 2002 (updated April 2006) Policy # : BRP/BWP/WPeP/G02-3

Program Applicability: BRP/DWM/Watershed Permitting/ Title 5 Program

Supersedes: Recirculating Sand Filters (RSF) Design Guide
Regulation Reference: 310 CMR 15.202

Approved By: ____ [signed] ____________________
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## I. PURPOSE

This document has been prepared by the Department of Environmental Protection to serve as a guide to the design of "Recirculating Sand Filters" (RSF). This is not intended to be a comprehensive design manual nor is it intended to restrict professional judgment in the design but rather reflects accepted design criteria for a typical RSF. This guidance also does not apply to proprietary sand filter systems with certifications or approvals from the Department. Deviations from the design guidelines presented in this document can be allowed by DEP if scientifically and technically valid. The design criteria described herein generally apply to larger systems (i.e. greater than 2000 gallons per day). Accordingly, changes in the design parameters may be necessary and desirable when designing for smaller systems.

## II. INTRODUCTION

In recent years, a variety of environmental, economic and technological factors have conjoined to make enhanced treatment of sanitary sewage a viable alternative to the conventional on-site septic tank and soil absorption system. These alternative systems can treat sanitary sewage to produce effluent meeting or bettering secondary standards of 30 milligrams per liter (mg/L) biochemical oxygen demand ($BOD_5$) and 30 mg/L total suspended solids (TSS). In addition, some of these systems will nitrify and denitrify, to produce an effluent with a total nitrogen concentration of 25 mg/L or less. While many enhanced treatment systems rely on proprietary technology, the RSF can provide a non-proprietary enhanced treatment alternative. Title 5, 310 CMR 15.000, requires the use of RSF, or equivalent alternative technology, for facilities with design flows from 2,000 to less than 10,000 gallons per day (GPD) when located in nitrogen sensitive areas.

RSF are Certified for General Use for enhanced nitrogen removal and approved for Remedial Use under Title 5's approval process for alternative systems (310 CMR 15.280 *et seq.).* Title 5 recognizes the denitrifying capability of the RSF. For facilities with a design flow up to 10,000 GPD, 310 CMR 15.2 17 allows an increase in wastewater loading to 550 GPD per acre with the use of an RSF or equivalent alternative technology.

## III. PROCESS SUMMARY

A typical RSF system consists of a septic tank, may include an equalization tank prior to the recirculation tank and a sand filter followed by a soil absorption system (SAS). The septic tank provides primary treatment for the influent. The septic tank effluent may first flow to an equalization tank and then to the recirculation tank. Both tanks would also receive recirculated wastewater that has already been treated through the sand filter.

In time controlled small doses, the mixture of septic tank effluent and sand filter filtrate is applied to a sand filter bed. The wastewater is evenly distributed over the media bed by a pressure distribution system. The sand filter unit should be split so that 80 percent of the effluent is returned to the recirculation tank and 20 percent to the equalization tank (if an equalization tank is included), with separate collection chambers and underdrains. As the wastewater trickles downward through the media, biological treatment on the surface of the media particles reduces $BOD_5$, TSS, and bacteria and nitrifies the filtrate. The filtrate is than collected at the bottom of the sand filter, and is returned by gravity to the recirculation tank and equalization tank. If an equalization tank is not required, the 20 percent flow is returned to the septic tank. This highly oxygenated filtrate mixes with anoxic effluent from the septic tank in the equalization or septic tanks and recirculation tank.

A portion of the recirculation tank mixture is discharged to the SAS, the remainder is recirculated to the sand filter where the cycle is repeated. The contents of the recirculation tank should be discharged to the SAS by a timer controlled pump equipped with a low level shutoff located at the two-thirds full depth of the recirculation tank.

In accordance with 310 CMR 15.202(4)(f), all RSF systems serving a facility with a design flow of 2,000 GPD or greater must discharge effluent to the SAS using pressure distribution.

Sand filter design is based on several important factors:

- The recirculation ratio (RR);
- $BOD_5$ concentration of the sewage; and
- The time frame over which flow is generated in the facility.

Changing any of these factors may alter the size of the recirculation tank or the surface area of the sand filter.

The RR is defined as the ratio of the total flow through the sand filter to the forward (average design) wastewater flow. Typical RR values for an RSF system range between 3 and 5:1. The RR not only determines the amount of wastewater to be pumped to the RSF, but reduces or eliminates odors by mixing a large volume of treated, highly oxygenated filtrate in the recirculation tank with septic tank effluent before the mixture is applied to the sand filter.

The time frame in which flow is generated, e.g.- schools, 6 hours; or restaurants, 8 to 12 hours, are examples of **compressed flows.** A compressed flow is a flow rate that will discharge the average daily design flow volume to the septic tank in less than 24 hours. A compressed flow produces a higher flow rate than the design flows listed in 310 CMR 15.203. This discharge of the design flow to the septic tank in a much shorter time interval than 24 hours (12 hours or less) must be taken into account by utilizing a properly designed equalization tank.

The size of the equalization tank should be determined through a hydraulic analysis of the system that distributes the compressed flow over a 20 to 24-hour time period and eliminates surcharging of the sand filter. Flow equalization should be provided when the total daily flow (TDF) occurs over a period of twelve hours or less and should be sized based on a hydraulic analysis of hourly flows. The minimum size equalization tank should be 0.5 times TDF. The equalization tank mixture is pumped to the recirculation tank at a rate that equalizes total flow over a 24-hour period. A timer with a high-level override control should operate the pumps in the equalization tank.

## IV. DESIGN PROCEDURE

The design of the RSF system requires, at a minimum, the following steps:

1. Determine the average daily flow by taking into account flows that are generated in less than 24 hours, compressed flows, and wastewater strength based on influent analysis. The organic loading should not exceed 0.005 lbs $BOD_5$ per square foot or 5 lbs per 1,000 square feet of filter area. Sampling of existing nonresidential wastewater systems prior to design is recommended. For new facilities, wastewater characteristics such as $BOD_5$, TSS, Nitrogen, etc. should be estimated on the basis of the best available comparative information. Organic loading, rather than hydraulic loading, may be the determining factor on nonresidential systems.

2. Determine the appropriate recirculation ratio, RR. Generally, this ratio ranges between 3:1 and 5:1. However, certain designs may require different recirculation ratios.

3. Design for compressed flows generated over less than a 24 hour period, generally 12 hours or less, by utilizing a flow equalization tank.

4. Size the sand filter based on the appropriate loading rate, either hydraulic, 3 to 5 GPD/SF or organic limit, 0.005 lbs $BOD_5$/SF. When the organic loading rate is the criteria that control the sizing of the filter a hydraulic loading rate of less than 3 GPD/SF may be required.

5. Size the recirculating pumps based on the recirculation ratio, average daily flow, desired pump cycle time, and the sand filter pressure distribution system design.

6. Size the SAS according to the loading rates and other pertinent design criteria in accordance with 310 CMR 15.000.

7. For systems designed to nitrify and reduce nitrogen, the alkalinity of the influent shall be determined. If the alkalinity is low the design should include a method for adding and monitoring alkalinity to the system. Approximately 8 milligrams of alkalinity are consumed for every milligram of ammonia oxidized.

## V. INFLUENT CRITERIA

### A. Pre-treatment:

Wastewater must receive initial treatment in a septic tank. Effluent from the septic tank shall discharge to an appropriately sized equalization tank, if required, prior to the recirculation tank that discharges to the recirculating sand filter. All units shall be designed and constructed in accordance with 310 CMR 15.221 and 15.223 through 15.229. An effluent tee filter on the septic tank outlet pipe is required for all RSF applications.

### B. Wastewater Strength - $BOD_5$:

The recirculating sand filter can treat wastewater with higher concentrations of pollutants (such as $BOD_5$ and TSS) than normal residential sanitary wastewater. Using $BOD_5$ as a wastewater strength indicator, the recirculating sand filter influent $BOD_5$ may be greater than 230 mg/L, but should be less than 720 mg/L. The filter media for stronger waste, i.e.- $BOD_5$ greater than 350 mg/L, should be coarser than media used for residential wastewater. When the $BOD_5$ concentration equals or exceeds 350 mg/L, an organic loading value of 0.005 lb $BOD_5$/SF must be used to size the filter.

**C. Wastewater Organic Load:**

1. Residential: For residential applications the influent $BOD_5$ should be based on 230 mg/L. For repair, upgrade, or expansion, composite sampling is recommended where the $BOD_5$ is suspected to exceed 230 mg/L. For new developments, where higher strength wastewater is anticipated (such as nursing homes or institutional living situations), the $BOD_5$ should be estimated on the basis of the best available comparative information.

2. Nonresidential: The repair, upgrade or expansion of existing systems provides the opportunity for sampling and testing existing wastewater streams. In all cases, composite sampling is recommended. For new developments, the $BOD_5$ should be estimated on the basis of the best available comparative information from similar facilities.

**D. Daily Wastewater Flow - Design Criteria:**

1. Residential: Design flows shall be based upon design criteria in 310 CMR 15.203.

2. Nonresidential: Design flows shall be based on 310 CMR 15.203 (3)(4) and (5). When Title 5 does not provide design flows for a facility, those flows shall be developed using 310 CMR 15.203 (6). Note: if the facility discharges to the RSF system over less than 24 hours the design should be handled as a compressed flow situation. The design flow for the other components of the system such as the septic tank and the SAS must be developed in accordance with 310 CMR 15.203.

## VI. RECIRCULATION TANK

**A. Recirculation Tank Ratio:**

The recirculation ratio is defined as the ratio of the total flow through the filter to the forward or average design flow. Recirculation ratios should fall within the range of 3:1 to 5:1. Generally a 5:1 RR is preferable. The designer should, however, determine the appropriate RR based on experience. If the design engineer proposes a RR outside this range, appropriate documentation should be provided to justify the RR selected and DEP approval is required.

**B. Recirculation Tank Design Criteria:**

The materials and construction requirements for the recirculation tanks and equalization tanks shall be in accordance with the provisions of 310 CMR 15.221. Appurtenances to the recirculation tank, including pumps, inlet and discharge piping, discharge valves, or other necessary equipment for its proper function shall be designed in accordance with the provisions of 310 CMR 15.221 to 15.229.

The tank volume shall be based on the following (expressed in gallons):

1. For all residential systems use the design flow, 310 CMR 15.203, times 150 percent. For nonresidential systems use the design flow, 310 CMR 15.203, times 200 percent adjusted for the hours flow is generated.

The return piping from the sand filter should enter at the inlet end of the recirculation and equalization tanks remote from the pump location, to allow mixing of septic effluent with treated recirculated filtrate.

**C. Recirculating Pump:**

The size of the recirculating pump controls the recirculation ratio and dosing frequency. Daily dose frequencies should be based on media grain size, wastewater strength and operating temperatures. Coarse media (> 1.0 mm) require more frequent doses to ensure that sufficient wastewater residence time is provided in the filter. Sizing of the filter on organic loading rather than hydraulic must be checked to determine which is larger. When $BOD_5$ concentrations, as determined in Section IV, 1., are greater than 350 mg/L, the filter should be sized on organic loading of 0.005 lb BOD/SF. Multiple pumps discharging to segmented sand filters provide more flexibility in operation and maintenance of the RSFs.

High strength wastes require more contact time with the filter media and must be dosed more frequently at smaller volumes. The dosing frequency should allow for complete draining of the filter between doses for adequate aeration of the filter.

Based on typical design criteria, the recirculating pump should be controlled by a timer, in continuous cycles (3 to 5 minutes on; 25 to 27 minutes off; for a total cycle time of 30 minutes). This dosing schedule provides 48 dosing periods over 24 hours, allowing a recirculation ratio from 3:1 to 5:1. If different ratios are used, other than 3:1 or 5:1, the pump cycles and dosing periods should be adjusted accordingly.

Adjustable timers are required so that dosing schedules can be modified as site conditions warrant. Both timer and float switch controls are required; timers shall be used as the primary method of operation. Float switches, for use in the event of timer malfunction, shall be wired in parallel with the timer to control the pump during periods of high or low wastewater flows. Proper sizing of the recirculation tank should minimize float switch operation.

The recirculating pump should be sized based on the average daily flow, recirculation ratio, number of cycles, duration of each cycle and anticipated back-flow (if any) per cycle.

The following example illustrates typical calculations for sizing the recirculating pump:

Assume
1. Flow 2,000 GPD
2. Number of doses 48 per day
3. Dose duration 5 minutes
4. Recirculation ratio 5:1
5. Back-flow per dose 10 gallons

Note: The back-flow per dose of 10 gallons is shown for illustrative purposes only. The actual back-flow must be calculated based on pipe diameter and length and other relevant factors.

Total volume pumped = Average daily flow, GPD + Recirculated flow, GPD + Back-flow, GPD =
2,000 + (5 x 2,000) + (48 x 10)
= 12,480 GPD

Total pump run time = Number of doses x Dose duration in minutes =
48 x 5
= 240 min

Pump flow rate = Total volume pumped in GPD/ Total pump run time in minutes per day =
12,480 /240
= 52 GPM

This flow rate is based on the recirculation requirements and must be checked against the flow rate required for pressure distribution to the sand filter. The higher flow requirement will govern pump selection. Every pump shall be equipped with event counters and recording elapsed time meters.

Systems with a design flow of 2,000 GPD or greater require at least two pumps in the recirculating tank. The pumps shall alternate, and all recirculating tanks, regardless of design flow, shall be equipped with high water level alarms that are to be wired to a circuit separate from the pumps in accordance with 310 CMR 15.23 1(9).

In accordance with 310 CMR 15.202(4)(f), pumps designed for pressure distribution of effluent to the SAS are required for all RSF systems serving a facility with design flows of 2,000 GPD or greater. RSFs designed pursuant to the Department's Approval for Remedial Use for RSFs also require pressure distribution. A minimum of two pumps shall be provided and be equipped with timer controls with high water level override switches and automatic alternating capabilities. The pressure distribution system shall be designed in accordance with the Department's "Title 5 Pressure Distribution Design Guidance" document.

The following schematic flow diagram, Figure 1, illustrates the relationship of the unit operations comprising the system.

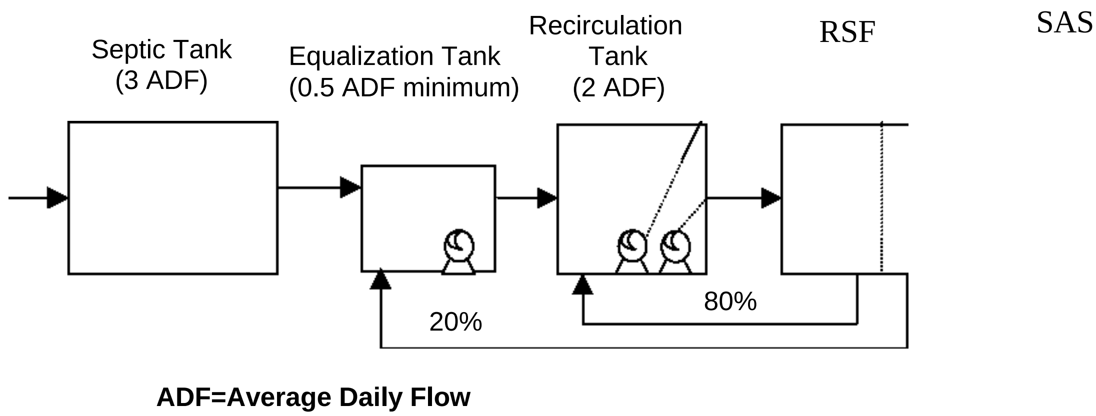


**Figure 1. RSF Schematic Flow Diagram**

## VII. SAND MEDIA FILTER DESIGN CRITERIA

### A. Filter Bed Containment:

The filter bed shall be constructed in accordance with 310 CMR 15.221; the bed should be either a concrete or other suitable vessel in accordance with the provisions for constructing septic tanks described in 310 CMR 15.226 and 310 CMR 15.228, or an earthen structure with an exterior plywood perimeter support lined with an impervious (PVC-30 mil min.) membrane. The top of the containment structure shall be designed to extend above final grade to prevent the infiltration of surface runoff into the filter. If the filter is constructed above natural grade, fill should be placed around the unit up to the top of the containment wall. In either case, the containment structure shall be adequately protected from the weather.

Enclosed sand filters shall be designed to allow adequate venting in accordance with the provisions of 310 CMR 15.241, and for access for inspection and maintenance. When the filter is not designed enclosed, the designer shall provide adequate cover material for insulation and protection from freezing. Insulation should not inhibit airflow between the sand filter and the atmosphere.

### B. Filter Bed Piping:

Distribution piping shall be installed on top of the filter media. The filter manifold should be designed with a minimum 5-foot pressure residual at the most remote orifice, and should have no more than a 10 percent differential in flow between any two orifices. A flushing valve enclosed in a valve box installed at grade shall be provided at the distal end of each distribution pipe. Provisions shall be incorporated to allow for cleaning the distribution lines with a bottle washer and plumber's snake.

The sand media shall have a minimum effective depth of 24 inches. Collection piping shall be installed at the bottom of the containment structure and placed within a 6-inch layer of 3/4 inch to 1-1/2 inch stone. A 3-inch layer of pea gravel (1/8 inch to 1/2 inch stone) shall be added between this stone layer and the filter sand media.

**C. Media Specifications:**

Filter media shall meet the particle size criteria below, based upon a particle sieve analysis conducted at a certified soils testing laboratory. This analysis must be performed according to standard testing methods. Each load of media shall be sieve tested at the installation site to assure compliance with filter media specifications.

a. Effective Size: 1 mm to 2 mm.

b. Uniformity coefficient: less than or equal to 3.0.

c. Filter media must be double washed and less than 1 percent (by weight) shall pass a #200 sieve.

Media not meeting these design specifications shall be removed immediately from the site and replaced with media that conform to the specifications.

**D. Filter Bed Sizing:**

**Loading Rate (LR):** shall be calculated on the basis of the $BOD_5$ of the septic tank effluent. The loading rate shall be calculated as follows:

$$LR 1150 BOD_5$$

Where: LR = Loading rate, GPD/SF
$BOD_5$= Septic effluent, mg/L
1150= Conversion factor

For residential applications with a $BOD_5$ of 230 mg/L or less, the loading rate typically ranges between 3 to 5 GPD/SF. A loading rate of less than 5 GPD/SF shall be used if the $BOD_5$ is greater than 230 mg/L. For nonresidential applications where the $BOD_5$ of the wastewater approaches 350 mg/L, the hydraulic loading shall be reduced to 3 GPD/SF. Where the $BOD_5$ is greater than 350 mg/L, the design of the filter shall be based on the organic loading rate.

**Surface Area of Filter Bed (SA):** shall be determined by either dividing the wastewater design flow in GPD, by the loading rate, LR in GPD/SF:

For hydraulic loading as the determining factor:

$$Q\ / LR\ SA$$

Where: Q= Design flow, GPD
LR= Loading rate, GPD/SF
SA= Surface area of filter, SF

or shall be determined based on $BOD_5$:

For organic loading as the determining factor:

$$BOD_5\ /0.005\ SA$$

Where: $BOD_5$ = ($BOD_5$ in mg/L)x(Flow in MGD)x(8.34 lbs/MG)= lbs of $BOD_5$
0.005= Loading rate per SF of filter
SA= Surface area of filter, SF

**Depth (thickness) of media gravel:** shall range between 33 and 36 inches with at least 6 inches of stone, 24 inches of sand and 3 inches of pea stone.

Figures 2 and 3 illustrate typical sections through the filter.

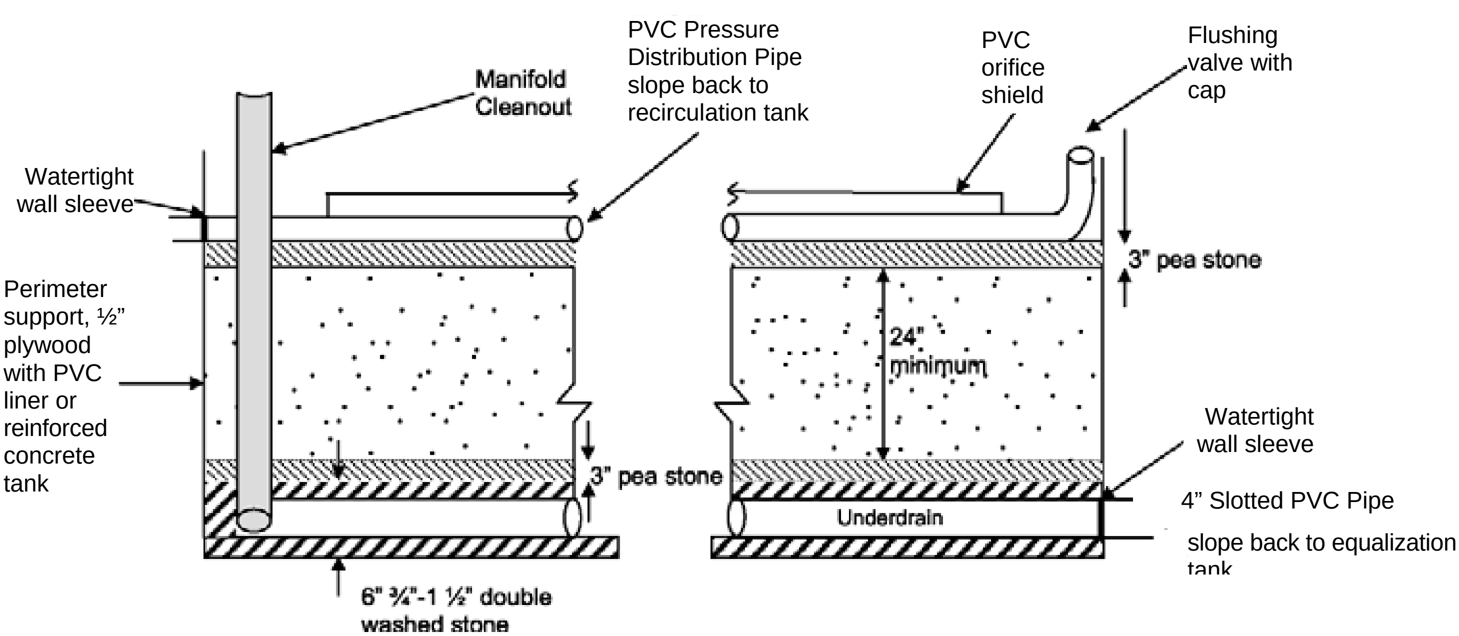


**Figure 2. RSF Longitudinal Section View**

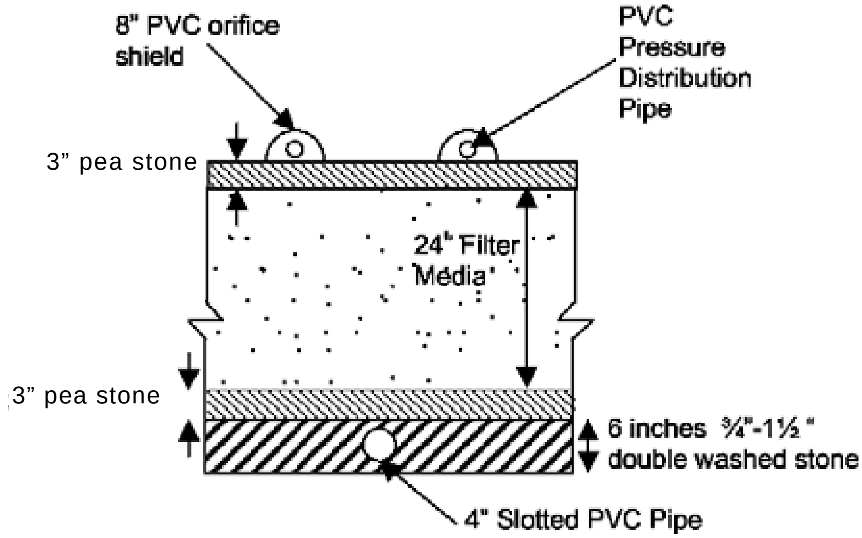


**Figure 3. RSF Transverse Section**

### E. Filter Bypass:

The sand filter **shall not** be designed with a bypass that allows for direct discharge to the SAS.

### F. Influent Wastewater Distribution

Influent to the sand filter shall be evenly distributed by a pressure distribution system designed in accordance with the Department's "Title 5 Pressure Distribution Design Guidance". The Guidance applies to pumps, sumps, controls, and any other pressure distribution-related components. The sand filter should be divided into a minimum of two parallel treatment units that allow a unit to be removed from service for maintenance and repair purposes. Multiple pumping systems may be required for divided systems.

### G. Filtrate Collection and Discharge

Filtrate shall be collected and discharged from the bottom of the sand filter by either a gravity flow underdrain system or a pumped system. A single pipe in the middle of the filter shall not be used as an underdrain. The design shall allow the underdrain area to remain aerobic. Piping should be sized large enough to allow for the rapid return of the filtrate to the recirculation and equalization tanks to prevent ponding in the filter. Underdrain pipes shall be minimum 4-inch diameter PVC Schedule 40 slotted pipe with 1/4-inch slots, 2 inches long and spaced 4 inches apart. A minimum of two underdrain pipes shall be provided for each filter section. The pipes shall be placed upon the impervious liner at the bottom of the sand filter with the slots facing upward. The distal end of the under drain shall be brought to grade and covered with a removable cap housed in a protective chamber. The underdrain pipe shall be installed at a 0.5 percent grade and be connected to a manifold outside the filter. Underdrain pipes shall be spaced a maximum of 8 feet on center.

An observation pipe consisting of a 4 inch slotted pipe, capped at the bottom and wrapped in filter cloth shall be installed in the center of each side of the split sand filter and brought to finished grade and covered with a removable cap.

### H. Pipe Sizing between Sand Filter and Recirculation (and Equalization) Tank:

The Hazen-Williams (H-W) equation or other acceptable hydraulic formula can be used in sizing the pipe from the sand filter to the recirculation tank. The H-W equation relates flow, pipe diameter, slope, and pipe smoothness. Typically, it is expressed as follows:

$$S = \left[2.31\, Q / \left(C d^{2.63}\right)\right]^{1.852}$$

Where: S = Slope of energy gradient, feet/foot Q = Design flow, cubic feet per second

C = Dimensionless smoothness coefficient (typically C = 150 for PVC pipe)

d = Inside diameter of pipe, feet

Rearranging this equation and multiplying by 12 provides an equation to calculate the appropriate pipe diameter, in inches, for the gravity flow under drain pipe and filter-to-recirculation tank transport pipe.

$$d_{inches} = 12\left[2.31\, Q / \left(C S^{0.54}\right)\right]^{0.38}$$

### I. Sand Filter Effluent Disposal Criteria

Recirculating sand filter effluent (filtrate) from systems serving a facility with design flows from 2,000 to 10,000 GPD must be discharged to a SAS by a pressure distribution system designed in accordance with 310 CMR 15.254 and the Department’s “Title 5 Pressure Distribution Design Guidance”. RSF systems designed for Remedial Use pursuant to DEP’s Remedial Use Approval of RSFs shall be designed with pressure distribution to the SAS.

## VIII. MANAGEMENT, OPERATION & MAINTENANCE

Operation and maintenance and monitoring and reporting requirements depend on whether the system is approved under Certification for General Use, Remedial Use or nitrogen reduction for use in an area subject to the 440 GPDA nitrogen loading limitation in Title 5, 310 CMR 15.214. Approval from the DEP regional office is required for RSF that are to be constructed in a Nitrogen Sensitive Area.

No RSF system shall be used until an operation and maintenance (O&M) agreement and contingency plan are submitted to the local approving authority and DEP, if DEP approval of the system is required that:

1. Provides for contracting of a person or firm trained in operating the RSF and competent in providing services consistent with the RSF's specification and the O&M requirements specified by the designer and those specified by the Department.
2. Provides the name of the operator, which must be a Massachusetts certified operator as required by 257 CMR 2.00 that will operate and monitor the System.

### A. Operation and Maintenance User's Manual:

An O&M manual for the RSF system must be provided by the system designer at the time of application for a disposal system construction permit. These materials must contain at a minimum the following:

1. Diagrams of all system components and their proposed location.

2. Explanation of general system function, operational expectations, and owner responsibility.

3. Specifications and diagrams of all electrical and mechanical components installed.

4. Names and telephone numbers for the system designer, approving authority, component manufacturer, supplier/installer, and the management entity and regulatory authority to be contacted in the event of a failure.

5. Information on the periodic maintenance requirements of the system: septic tank, equalization tank, recirculation tank, sand filter unit, pumps, switches, alarms and SAS.

6. Information on "trouble-shooting" common operational problems that might occur. This information should be as detailed and complete as needed.

7. Information on the proper disposal of discarded filter media. Before the filter media is removed for disposal to allow installation of new media, the O&M contractor shall notify the local approving authority and obtain approval for the proper disposal of the discarded media. Transport and disposal shall be in accordance with applicable laws and regulations.

**B. Maintenance:**

For the on-site treatment and disposal system to operate properly, the various components need periodic inspection and maintenance by the system operator. In addition to the following maintenance requirements and schedule, the approving authority may specify additional requirements.

1. Septic tank: Inspect and pump at the direction of a certified operator under a maintenance agreement and in accordance with 310 CMR 15.351. Effluent tee filters shall be inspected at each service call and cleaned as necessary, at least annually, and each time the septic tank is pumped.

2. Recirculation tanks: Inspect at each service call. Pump the accumulated sludge from the bottom of the chambers whenever the septic tank is pumped, or every three years, whichever is sooner.

3. Equalization tank: Inspect at each service call. Pump the accumulated sludge from the bottom of the equalization tank whenever the septic tank is pumped or every three years, whichever is sooner.

4. Pump switches, floats, timers, alarm system: inspect and test at each maintenance inspection, repair as needed and clean all equipment at least annually.

5. Pump and pump screen: Inspect at each maintenance inspection and clean at least yearly.

6. Recirculating Sand Filter: Inspect and remove debris from the bed surface at each service call. Test the distribution system at least annually to ensure equal distribution of wastewater over the bed surface.

## IX. PERFORMANCE MONITORING

Performance monitoring shall be conducted in accordance with the Certification for General Use, the Remedial Use Approval or 310 CMR 15.202, as applicable.
Common problems associated with the proper operation of RSFs can be caused by any of the following conditions or factors:

1. Improper use of unit;
2. Age of system;
3. Nuisance factors, such as odors;
4. Malfunction of electrical equipment such as timers, counters, control boxes, or other electrical components;
5. Material fatigue due to system age, corrosion problems due to use of improper materials, and structural problems due to improper design;
6. Neglect or improper use, such as loading beyond the design rate, poor maintenance, or excessive weed growth;
7. Installation problems, such as improper location of under drains, pumps, etc.;
8. Septic tank maintenance, including improper or inadequate pumping, groundwater infiltration due to structural problems or improper sizing;
9. Pump chamber maintenance, including improper or inadequate maintenance, groundwater infiltration due to structural problems, or improper sizing;
10. Overflow or backflow problems due to valve failure or improper valving;
11. Pump malfunctions problems including improper dosing volume, poor or over-pressurization, impeller clogging, motor burnout, or pump cycling;
12. Pump control switch malfunctions, including improper switch settings, electrical failure, mechanical failure; and
13. Poor removal of indicators, such as $BOD_5$, TSS, Total Nitrogen or fecal or total coliform

Performance monitoring involving additional sampling and testing may be required by the local approving authority or the Department on a case-by-case basis, depending on the nature of the problem.

The Department has developed forms to assist the operators in their normal inspection of RSFs. Click on this link to obtain a copy of the RSF System Operation and Maintenance Inspection Checklist Form. This form should be used and submitted to the local approving authority and the Department for each inspection conducted on an RSF.

**REFERENCES**

The following references and sources were used in developing this guidance document. Designers and approving authorities should obtain copies of several of these documents.


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