Recommended Standards and Guidance for Performance, Application, Design, and Operation & Maintenance

Recirculating Gravel Filter Systems

February 2021

Washington State Department of Health

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Performance, Application, Design, and Operation & Maintenance

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Washington State Department of
Health

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Preface

The standard recommended in this document are developed for statewide application. Regional differences, however, may result in application of this technology in a manner different than what is presented here. In some areas, greater allowances than those described here may be granted. In other areas, allowances provided for in this document may be further restricted. In either case, the local health officer has full authority in the application of this technology, consistent with WAC 246-272A and local jurisdictional rules. If any provision of these recommended standards is inconsistent with local jurisdictional rules, regulations, ordinances, policies, procedures, or practices, the local standards take precedence.

Local jurisdictional application of these recommended standards may be:

1) **Adopted as part of local rules, regulations or ordinances -** When the recommended standards, either as they are written or modified to more accurately reflect local conditions, are adopted as part of the local rules, their application is governed by local rule authority.

2) **Referred to as technical guidance in the application of the technology -** The recommended standards, either as they are written or modified to more accurately reflect local conditions, may be used locally as technical guidance.

Application of these recommended standards may combine these two approaches. How these recommended standards are applied at the local jurisdictional level remains at the discretion of the local health officer and the local board of health, provided the application does not deviate from WAC 246-272A.

The recommended standards are provided in typical rule language to assist those local jurisdictions where adoption in local rules is the preferred option. Other information and guidance is presented in text boxes in italics to easily distinguish it from the recommended standards.

Glossary of Terms: A glossary of common terms for all RS&Gs can be found on the DOH Web site at http://www.doh.wa.gov/Portals/1/Documents/Pubs/337-028.pdf.

The recommended standards contained in this document have been primarily written to support the design of on-site sewage systems (OSS) with design flows less than 3500 gpd, but may also be applied to large on-site sewage systems (LOSS).

With the adoption of the revised LOSS rule, chapter 246-272B WAC, in 2011, some provisions of the RS&Gs may not be appropriate or allowed for LOSS. Many applicable requirements from the RS&Gs have already been included in the LOSS rule. Design engineers and others interested in LOSS are directed to consult the rule and LOSS program staff before or instead of the RS&Gs.

Typical RS&G Organization:

Standards Section	Explanation
Performance	How this technology is expected to perform (treatment level and function)
Application	How this technology is to be applied. This section includes conditions that must be met prior to proceeding with design. Topics in this section describe the “approved” status of the technology, component listing requirements, permitting, installation, testing and inspection requirements, etc.
Design	How this technology is to be designed and constructed (includes minimum standards that must be met to obtain a permit).
Operation and Maintenance	How this technology is to be operated and maintained (includes responsibilities of various parties, recommended maintenance tasks and frequency, assurance measures, etc)
Appendices	Design examples, figures and tables, specific applications, and design and installation issues.

Introduction

Recirculating gravel filters provide biodegradation or decomposition of wastewater constituents by bringing the wastewater into close contact with a well-developed aerobic biological community attached to the surfaces of the filter media. The media is similar to pea gravel as specified in Appendix A. The media is contained in a watertight vessel either below the surface of the ground or wholly or partially elevated in a containment vessel. Proper function requires that influent to the filter be distributed over the media in frequent, cycled uniform doses. In order to achieve accurate dosing, these systems require timed dosing with associated pump chambers, electrical components, and pressure distribution networks. Frequent, cycled dosing provides a constantly wetted media. As the wastewater percolates through the media suspended solids and carbonaceous biochemical oxygen demand (CBOD) are removed. The effluent is collected in the bottom of the filter and returned to the recirculating/mixing tank or septic tank where it mixes with fresh septic tank effluent or a portion of the effluent is discharged to the soil dispersal component. Flow splitting mechanisms are used to control recirculation, flow splitting and discharge to the soil dispersal component. The treated wastewater is discharged to an approved soil dispersal component, usually a pressure distribution drainfield.

The recommended standards contained in this document address the following types of recirculate gravel filters:

- Section 1 – Recirculating gravel filter
- Section 2 – Nitrifying recirculating gravel filter with vegetated denitrifying woodchip bed

Differences in individual design characteristics, construction materials and methods combine to make each of these types of systems the same in name only (e.g. "recirculating gravel filter"). Each of these recirculating systems has attributes which may make them good choices for specific applications. Each system type also has characteristics which make them poor choices when not taking into account specific site conditions. Careful evaluation of site-specific conditions and wastewater characteristics as well as an informed decision about which type of recirculating gravel filter to select, is important in accurately matching project and treatment options.

Recirculating gravel filters may be selected for treating wastewater with higher concentrations of pollutants such as BOD_5 and TSS than typical residential sewage. As septic tank effluent is mixed with filtered effluent and diluted in the recirculating/mixing tank, higher hydraulic loading rates are possible with recirculating gravel filters. The filter will be smaller in size than an intermittent sand filter and may be preferred for this reason. The recirculating gravel filter is also not as susceptible to hydraulic and biological overloading as an intermittent sand filter. This technology is used where size is a constraint and where wastewater strength is moderately greater than what is typically generated in a single-family residence. Recirculating gravel filter effluent may be discharged to a soil profile containing as little as 24 inches of vertical separation.

Recirculating gravel filters and recirculating gravel filters with vegetated denitrifying woodchip bed may also be selected for removing up to 50% nitrogen in residential strength wastewater. This may be a beneficial alternative in areas where nitrogen has been identified as a contaminant of concern. For effective removal, influent from the septic tank must first be nitrified by periodically dosing it from a recirculating/mixing tank to the surface of the filter where effluent percolating through the filter draws in oxygen that promotes aerobic treatment. In addition to having an ample oxygen supply, nitrification performance is a function of the relative wastewater alkalinity and TN concentrations of the influent.

Field experience indicates that mixing tanks often have DO too high and BOD too low for denitrification. If you are going to add carbon, you also need to add enough to consume the DO that's in the tank.

1. Recirculating Gravel Filter (RGF)

1.1. Performance Standards

1.1.1. **Performance Criteria**

1.1.2. When sited, designed, operated and maintained, consistent with these recommended standards and guidance a recirculating gravel filter or a recirculating gravel filter with a vegetative denitrifying woodchip bed, is expected to reduce residential strength effluent nitrogen by 50% and achieve Treatment Level C.

1.1.3. Effluent from a recirculating gravel filter can be discharged to soil dispersal components with vertical separations of at least 24 inches in soil types 2 through 6 and at least 60 inches in soil type 1.

1.2. Application Standards

These standards apply to on-site sewage systems with design flows less than 3,500 GPD. For systems with design flows from 3,500 to 100,000 GPD, standards in the LOSS rule (WAC 246-272B-00650) apply.

1.2.1. **Listing**

1.2.1.1. Recirculating gravel filters are public domain treatment technologies and are included in the Department of Health's List of Registered On-site Treatment and Distribution Products as a Category 1 treatment component (designed to treat typical residential sewage). A 50% nitrogen reduction credit may be applied to residential strength effluent. The recirculating gravel filter may also be used as a Category 2 treatment component (designed to treat sewage with organic strength higher than typical residential sewage from both residential and non-residential sources.

1.2.2. **Permitting**

1.2.2.1. Installation, and if required, operational, permits must be obtained from the appropriate local health officer prior to installation and use.

1.3. Design Standards

1.3.1. Design Approval: Before construction can begin, the design must be approved by a local health or other appropriate jurisdiction. All site inspections before, during, and after the construction must be accomplished by local health, other appropriate jurisdiction, or by a designer or engineer appointed by the appropriate jurisdiction.

Figure 1 - Typical Layout of a Recirculating Gravel Filter

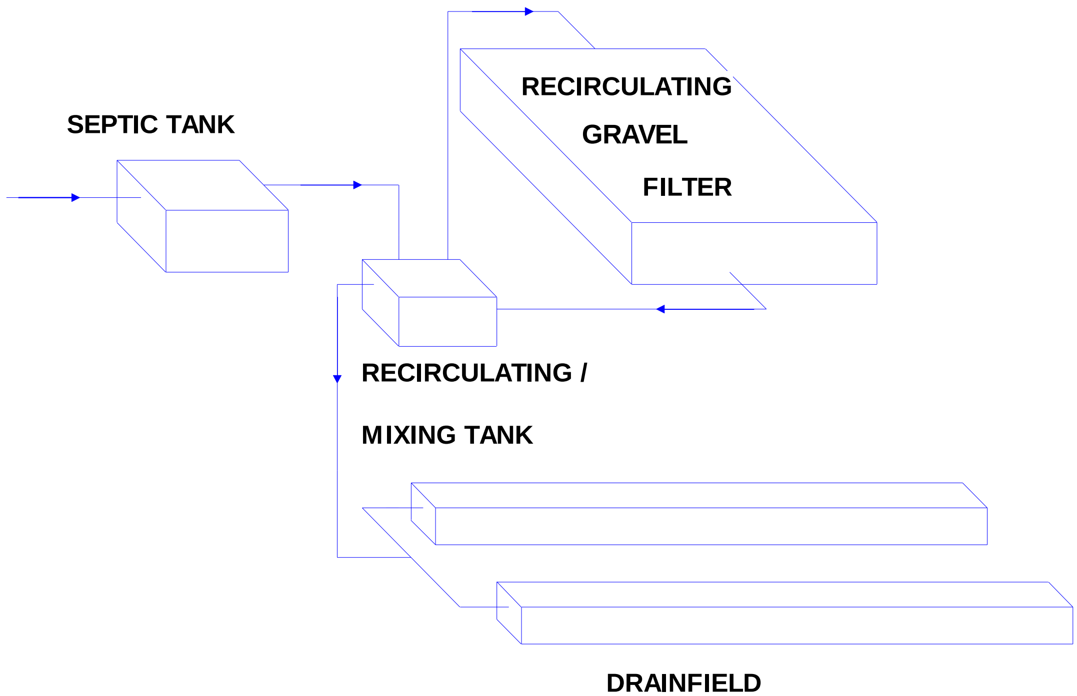
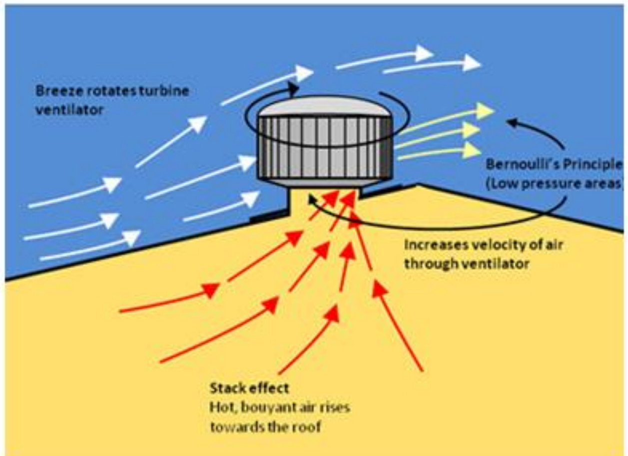


Figure 2 – Cross-Section of a Typical Recirculating Gravel Filter

Field experience indicates that adding spinning barn vents – turbine ventilators- may aid in oxygen flow.



Slots must be in the 12 o'clock position

> *Vertical piping from the underdrain to the surface may help with rehabilitation of failed filters.*

1.4. Influent Characteristics

1.4.1. Residential Wastewater: Recirculating gravel filters are suitable for treating residential strength wastewater. The filter will be smaller in size than an intermittent sand filter and may be preferred for this reason. Recirculating gravel filters are not as susceptible to hydraulic and biological overloading as intermittent sand filters.

1.4.2. Non-Residential Wastewater: Recirculating gravel filters are suitable for high strength residential and light commercial wastewater where the BOD_5 does not exceed 720 mg/L.

> *Some on-site sewage system professionals have reported recirculating gravel filters may be susceptible to premature failure. Reduced treatment levels, or clogging if influent fats, oils, and greases are elevated in wastewater loads or BOD_5 approaches 720 mg/l. The Technical Review Committee acknowledges these reports but concludes available r3search data is currently inconclusive. Until modifications to the standards and guidance are made based on future research and findings, it's suggested that influent BOD_5 not exceed 400 mg/l and fats, oils, and greases not exceed 30 mg/l.*

1.5. Design Flow (Daily Wastewater Flow Estimates)

1.5.1. Residential: For all residential applications, a minimum wastewater design flow of at least 120 gallons/bedroom/day must be used.

1.5.2. Non-Residential: For non-residential applications, a minimum wastewater design flow equal to 150% of the estimated design flow based on an average must be used.

1.6. Treatment

1.6.1. Primary Treatment

1.6.1.1. For residential sewage, settleable and floatable solid separation must be achieved using a properly sized, registered, two-compartment septic tank with effluent baffle screening, or equivalent wastewater sedimentation/initial treatment unit.

1.6.1.2. For wastewater from non-domestic sources, primary treatment other than a septic tank may be required if the influent to the gravel filter is not within the allowable limits for recirculating gravel filters.

Aerobic treatment or some other treatment process may be needed to modify the influent to the recirculating gravel filter to within the range of residential septic tank effluent quality.

1.6.2. Location Requirements: The minimum setback requirements for recirculating gravel filters are the same as required for sewage tanks (WAC 262-272A-0210).

1.7. Filter Bed

1.7.1. Media Specifications: Filter media must meet the fine gravel media specification for particle size graduation detailed in Appendix A, Section II. Media used in constructing a recirculating gravel filter must be accompanied with a written certification from the supplier that the media fully conforms to the media specifications listed in Appendix A as determined by ASTM C-136 and ASTM C-117.

1.7.2. Filter Bed Sizing

1.7.2.1. Hydraulic Loading Rate: The loading rate must be calculated on the basis of the incoming BOD_5. Repair, alteration, and expansion projects provide the opportunity to sample and test the actual wastewater. New sites must rely on wastewater strength estimates from similar facilities. The loading rate must be calculated as follows:

$$\text{Loading Rate (expressed as GPD / FT}^2\text{)} = \frac{1150}{\text{BOD}_5 \text{ of septic tank effluent}}$$

Note: The dimensionless value of 1150 in the above equation is derived from the following calculation and assumptions:

$$\frac{0.0096 \text{ lb BOD/ft}^2\text{/day}}{2.2046 \times 10^{-6} \text{ lbs./mg} \times 3.785 \text{ L/gal}} = 1150$$

- 1 mg/L = 2.2046×10^{-6} pounds/ mg
- 1 gal = 3.785 L/gal
- mass loading = 0.0096 pounds BOD_5/ft^2/day

For residential applications, the maximum allowable loading rate is 5.0 gpd/ft^2. The loading rate should be less than 5.0 gpd/ft^2 if it is suspected that the BOD_5 of the particular residential wastewater is greater than 230 mg/l. For any high strength sewage application, the septic tank effluent waste strength must not exceed 720 mg/L BOD_5.

1.7.2.2. Surface area of filter bed: The surface area must be determined by dividing the design flow estimate by the loading rate.

1.7.2.3. Depth of media: The media depth must be a minimum of 24 inches.

1.7.3. Surface of the Recirculating Gravel Filter: The surface of recirculating gravel filters differs from intermittent sand filters, sand-lined trenches and stratified sand filters since the surface (top) must remain open to air to encourage oxygenation of the filter. Cover soil may not be placed on top of the upper layer of drainrock in recirculating gravel filters.

1.7.4. Monitoring Ports: Recirculating gravel filters must have a minimum of two monitoring ports. One must be placed at the bottom of the drainrock/top of the media interface (infiltrative surface of the gravel filter) or to the interior of the chamber if gravelless chambers are used. The other port must be placed at the bottom of underdrain system. See Appendix E for examples of monitoring ports and anchoring methods.

1.7.5. Filter Bed Containment: The filter bed may be contained either in a synthetic membrane liner or an engineered concrete cast-in-place containment vessel. Design and construction must conform to the containment vessel standards set forth in Appendix B for synthetic membrane liners or WAC 246-272C for cast-in-place concrete containment vessels.

1.8. Effluent Distribution

1.8.1. Pressure Distribution: A method providing pressure distribution with timed dosing throughout the recirculating gravel filter is required and must comply with pressure distribution standards and guidance. The distribution system and pump chamber must be designed according to the Recommended Standards and Guidance for Pressure Distribution or Recommended Standards and Guidance for Subsurface Drip Systems. This requirement applies to all pressure distribution related components.

1.8.2. Effluent Application to the Filter Bed: The effluent must be applied to the layer of drainrock on top of the filter media by pressure distribution. In place of a layer of drainrock, effluent may be applied to the filter media by pressure distribution using a proprietary distribution product, such as a gravelless distribution or subsurface dripline product. When gravelless chambers are used, at least two inches of drainrock or pea gravel must be placed over the chambers for surface cover.

1.8.3. When a proprietary distribution product, such as a gravelless distribution or subsurface dripline product, is used in place of drainrock in a recirculating gravel filter, only those distribution products on the current List of Registered On-site Treatment and Distribution Products may be permitted by the local health officer.

Field experience indicates that the 12 o'clock spray on the inside arch of gravelless chambers provides a more even distribution of the effluent than using orifice shields

Recirculating gravel filter media may be utilized in lieu of drainrock in the top of the filter bed.

1.9. Recirculating/Mixing Tank

1.9.1. The recirculating/mixing tank must be on the Department of Health's List of Registered Sewage Tanks.

1.9.2. The volume of the recirculating/mixing tank is determined by the following:

1.9.2.1. For residential systems: 150% of the daily wastewater design flow estimate.

1.9.2.2. For non-residential systems: 100% of the daily wastewater design flow estimate.

1.10. Recirculating Pump

1.10.1. Console: The recirculating pump must be controlled by a timer with a dosing schedule that provides for frequent, cycled and uniform doses, allowing the influent/filtrate mixture to pass through the filter about five times for a 5:1 ratio before being discharged.

Recirculation provides control of treatment processes by changes that can be made to the recirculation ratios and dosing frequencies.

A 5:1 ratio means that 5 volumes are recirculated for every 1 volume of raw wastewater.

Typical pumping cycles are for one continuous cycle every 30 minutes (48 cycles per day) with the off cycle set for approximately 25 minutes. The on cycle should be set so that the orifice discharge per dose cycle does not exceed 1 gallon per orifice.

Both timer and float switch controls are required (see Figure 3). To protect the pump and the distribution pipe network orifices, the outlet of the septic tank must include screening of the effluent unless screening of the pump is provided (see standards and guidance for pressure distribution systems for effluent screening).

In the event of low levels in the recirculating/mixing tank, to protect the pump by assuring adequate pump submergence, a redundant off/low level alarm control float is recommended (see Figure 3). The redundant off/low level alarm must be installed in accordance with the pump manufacturer's recommendations to assure adequate pump submergence.

In conditions where wastewater daily flows are highly variable, a pump control system equipped with "peak" and/or "low" dose enable floats and circuits are recommended. These controls respond to peak and low flow conditions by increasing or decreasing the dosing frequency when high or low levels in the recirculating/mixing tank are reached and then reverting back to the standard dosing cycle when these floats have returned to their "off" position.

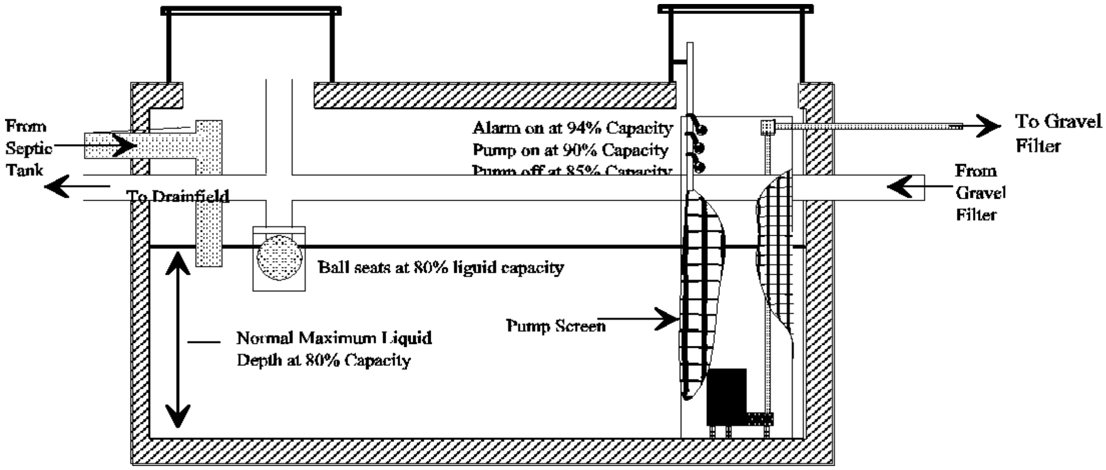
Flow rate for recirculating pump: Recirculation ratios are not recommended to be greater than 8 (8:1). (DNR, MO). Low recirculation ratios range are not recommended to be lower than 3:1 to 4:1 (J. Anderson).

Iowa DNR suggest that a high ratio of 7:1 or 8:1 may deplete the alkalinity and pH so it may be too low which may allow filamentous growth causing clogging of the orifices.

The recirculation ratio (RR) is the daily volume applied to the filter divided by the forward flow volume. The RR usually ranges from 3 to 5, with 4 being typical (Tchobanoglous 1991; Loudon 1996). Systems should be designed for an RR of 4, but the pumps should be sized so that an RR of 5 is attainable.

Increasing the ratio will increase the dissolved oxygen which will control some filamentous bacteria such as Thiothrix and Beggiatoa.

Figure 3 – Recirculating/Mixing Tank with a Splitter Valve



1.10.2. The minimum recirculating pump flows, in gallons per minute, can be calculated by the following formulas:

Daily Design Flow (GPD) x the recirculation ratio ÷ 1 = Through – filter flow (GPD)

$$\frac{\text{Through} - \text{filter flow (GPD)}}{\text{pump cycles per day}} = \text{Gallons per cycle}$$

$$\frac{\text{Gallons per cycle}}{\text{minutes per on cycle}} = \text{Gallons per minute}$$

*Note that the pressure distribution network design in the recirculating gravel filter may result in a higher discharge rate.

1.11. Treated Effluent (Filtrate) Collection and Discharge

1.11.1. Filtrate may be collected and discharged from the bottom of the gravel filter by either a gravity-flow underdrain or a pump discharge underdrain. A gravity-flow underdrain is the preferred method for collecting and discharging the filtrate back to the recirculating tank. When gravel filters are membrane-lined, gravity-flow underdrains must exit through a boot. The boot and exit pipe must be installed and tested according to the standards in Appendix B.

1.11.2. Filter to recirculating/mixing tank pipe sizing: The pipe from the filter to the recirculating/mixing tank can be sized using the Manning’s equation, which relates flow, pipe diameter, slope, and pipe smoothness. Typically it is expressed in the following manner:

$$Q = (1.49/n)\ A\ R_h^{2/3}\ S^{1/2}$$

Where:
Q = Flow in pipe, cubic feet per second
n = Manning roughness coefficient (dimensionless - assume 0.013 for PVC pipes)
S = Slope of the pipe, feet per foot
A = Cross-sectional area of flow, square feet = $\pi D^2/8$ for half-pipe
R_h = Hydraulic radius, feet = A/wetted perimeter of pipe, feet
For gravity flow, assume the pipe is half full, so $R_h = [(\pi/8)\ D^2]/[\pi/2d] = D/4$

*For PVC pipes flowing half full Manning's equation can be reduced to:

$$Q = 17.9\ D^{8/3}\ S^{1/2} \text{ or}$$

$$D = \left(\frac{Q}{17.9\ S^{\frac{1}{2}}}\right)^{3/8}$$

Where Q is in cubic feet per second, D is the diameter of the pipe in feet, S is feet/foot and engineers must perform all necessary conversions.

1.11.3. Recirculation Flow Splitting Mechanisms: Effluent treated in the recirculating gravel filter collects at the bottom of the filter through an underdrain and a portion is returned to the recirculating/mixing tank. In a 5:1 recirculation ratio, the collected flow must be split to redirect 85% of the treated effluent back to the recirculating/mixing or septic tank. Balance of the treated effluent is routed to the soil dispersal component.

1.11.4. Options and comments concerning flow splitting are noted in Appendix D.

To encourage mixing of fresh influent with partially treated recirculating return filtrate, the return line from the filter should enter the recirculating/mixing tank at the same end of the tank as the influent from the septic tank and at the opposite end from the recirculating pump.

2. Nitrifying Recirculating Gravel Filter with Vegetated Denitrifying Woodchip Bed

2.1. Performance Standards

2.1.1. When properly sited, designed, installed, operated, and maintained, a nitrifying recirculating gravel filter followed by a vegetated denitrifying woodchip bed consistent with these recommended standards and guidance is expected to achieve treatment performance equal to Treatment Levels N and C.

2.1.2. Effluent from a nitrifying recirculating gravel filter followed by a vegetated denitrifying woodchip bed can be discharged to soil dispersal components with vertical separations of at least 24 inches in soil types 2 through 6 and at least 60 inches in soil type 1.

2.2. Application Standards

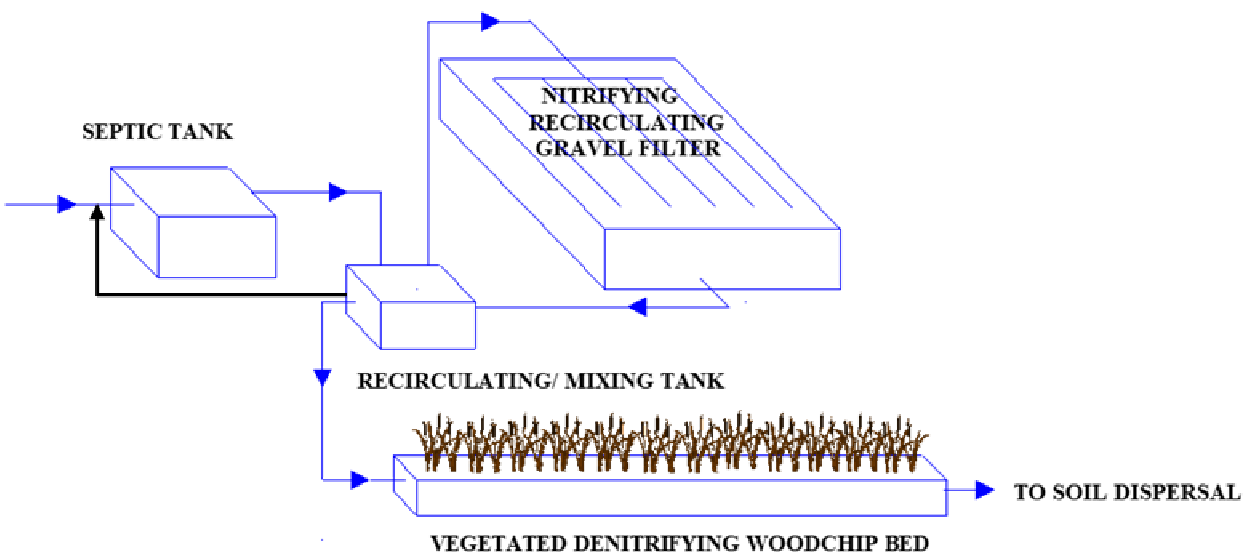
2.2.1. Listing: Nitrifying recirculating gravel filters followed by vegetated denitrifying woodchip beds are "public domain" treatment technologies and are included in the Department of Health's List of Registered On-site Treatment and Distribution Products as a Category 1 treatment sequence (designed to treat typical residential sewage) meeting Treatment Levels C and N.

2.2.2. Permitting: Installation and, if required, operational permits must be obtained from the appropriate local health officer prior to installation and use. The local health officer may permit a nitrifying recirculating gravel filter with vegetated denitrifying woodchip bed for removal of nitrogen in areas where nitrogen has been identified as a contaminant of concern.

2.3. Design Standards

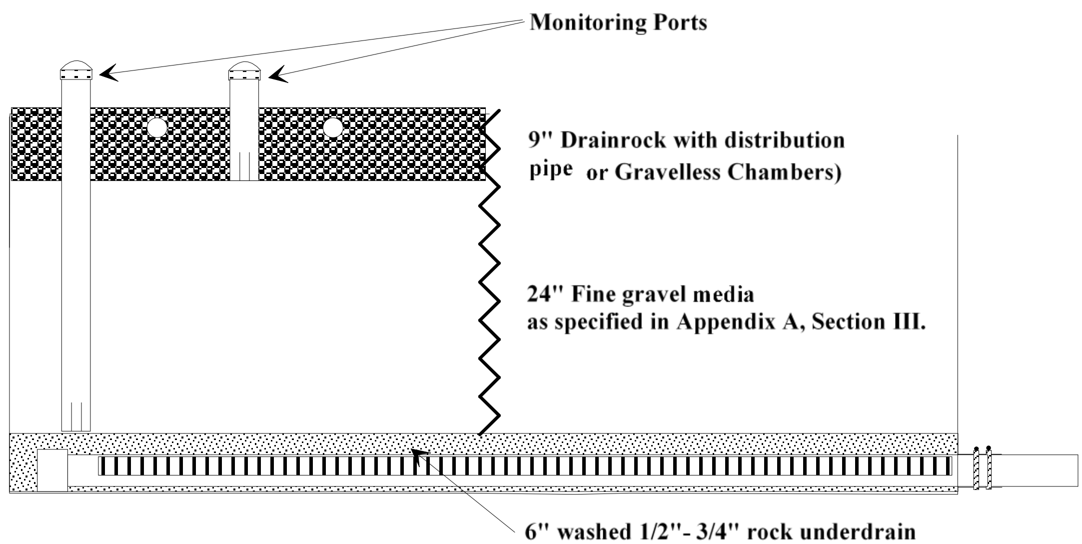
2.3.1. Design Approval: Before construction can begin, the design must be approved by the local health officer. All site inspections before, during, and after the construction must be accomplished by local health, other appropriate jurisdiction, or by a designer or engineer appointed by the appropriate jurisdiction.

Figure 4. Layout of a Nitrifying Recirculating Gravel Filter and a Vegetated Denitrifying Woodchip Bed



The recirculated effluent may be returned to either the recirculating mixing tank, the septic tank, or the sequence of the recirculation tank to the septic tank.

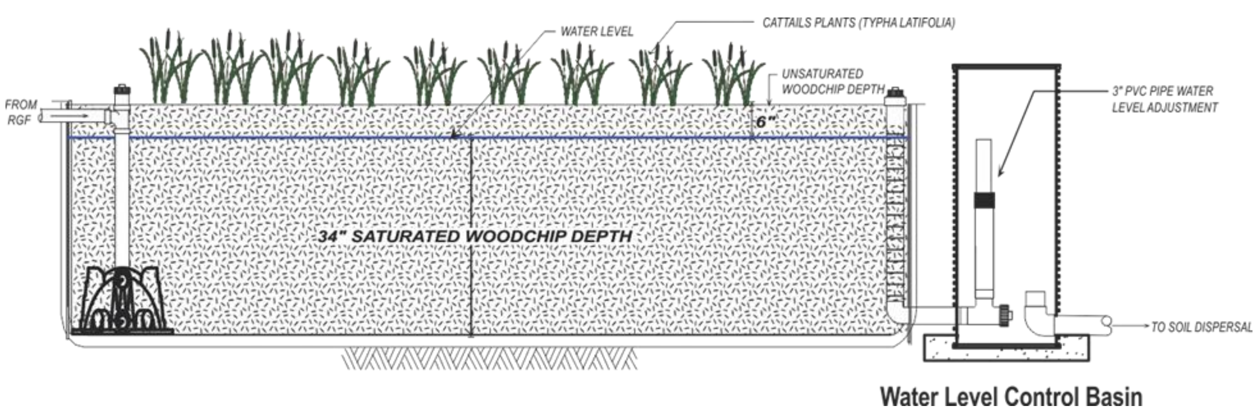
Figure 5. Cross-section of a Typical Nitrifying Recirculating Gravel Filter



Slots must be in the 12 o'clock position

Field experience indicates that adding vertical piping from the underdrain to the surface may help with rehabilitation of failed filters. Spinning barn vents (turbine ventilator) may aid in oxygen flow.

Figure 6. Cross-section of a Typical Vegetated Denitrifying Woodchip Bed



2.4. Influent Characteristics

2.4.1. Residential Wastewater: Nitrifying recirculating gravel filters are suitable for treating residential strength wastewater. In addition to being designed for nitrogen removal, the filters are typically smaller than intermittent sand filters, and may be preferred for this reason. Recirculating gravel filters are not as susceptible to hydraulic and biological overloading as intermittent sand filters.

2.4.2. Non-Residential Wastewater: Nitrifying recirculating gravel filters are suitable for high strength residential and light commercial wastewater where the BOD_5 does not exceed 400 mg/L and O&G does not exceed 30 mg/L

2.5. Design Flow (Daily Wastewater Flow Estimates)

2.5.1. Residential: For all residential applications, a minimum wastewater design flow of at least 120 gallons/bedroom/day must be used.

2.5.2. Non-Residential: For non-residential applications, a minimum wastewater design flow equal to 150% of the estimated daily flow should be used.

2.6. Primary Treatment

2.6.1. For residential sewage, settleable and floatable solid separation must be achieved using a properly sized, registered, two-compartment septic tank with effluent baffle screening, or equivalent wastewater sedimentation/initial treatment unit.

2.6.2. For wastewater from non-domestic sources, influent to the nitrifying gravel filter must be equivalent to residential strength septic tank effluent. The organic loading rate to the filter must not be more than 0.005 lb BOD/ft^2/day.

2.7. Location Requirements: The minimum setback requirements for nitrifying recirculating gravel filters and vegetated denitrifying woodchip beds are the same as required for sewage tanks (WAC 262-272A-0210).

2.8. Filter Bed

2.8.1. Media Specifications: Filter media must meet the fine gravel media specification for particle size graduation detailed in Appendix A, Section III. Media used in constructing a nitrifying recirculating gravel filter must be accompanied with a written certification from the supplier that the media fully conforms to the media specifications listed in Appendix A as determined by ASTM C-136 and ASTM C-117.

2.8.2. Filter Bed Sizing

2.8.2.1. Hydraulic Loading Rate: The loading rate to the nitrifying recirculating gravel filter for residential applications must not exceed 5.0 gallons/day/square feet, using appropriate daily wastewater flow design estimate.

2.8.2.2. Surface area of filter bed: The surface area must be determined by dividing the design flow estimate by the loading rate.

2.8.2.3. Depth of media: The media depth must be a minimum of 24 inches.

2.8.3. Surface of the Nitrifying Recirculating Gravel Filter: The surface (top) of the recirculating gravel filters differ from the intermittent sand filter, sand-lined trenches, and stratified sand filters since the surface must remain open to air to encourage oxygenation of the filter. Cover soil must not be placed on top of the upper layer of drainrock in the recirculating gravel filters.

2.8.4. Monitoring Ports: Nitrifying recirculating gravel filters must have a minimum of two monitoring ports. One must be placed at the bottom of the drainrock/top of the media interface (infiltrative surface of the gravel filter) or to the interior of the chamber if gravelless chambers are used. The other port must be at the bottom of the underdrain system. See Appendix E for examples of monitoring ports and anchoring methods.

2.8.5. Filter bed containment: The filter bed may be contained either in a synthetic membrane liner or an engineered, designed concrete, cast-in-place containment vessel. Design and construction must conform to the containment vessel standards set forth in Appendix B for synthetic membrane liners or WAC 246-272C for cast-in-place concrete containment vessels.

2.9. Effluent Distribution

2.9.1. Pressure distribution: A method providing pressure distribution with timed dosing throughout the nitrifying recirculating gravel filter is required and must comply with pressure distribution standards and guidance. The distribution system and pump chamber must be designed according to the Recommended Standards and Guidance for Pressure Distribution or Recommended Standards and Guidance for Subsurface Drip Systems. This requirement applies to all pressure distribution related components.

2.9.2. Effluent application to the filter bed: The effluent must be applied to the layer of drainrock on top of the filter media by pressure distribution. In place of a layer of drainrock, effluent may be applied to the filter media by pressure distribution using a proprietary distribution product, such as a gravelless distribution or subsurface dripline product. When gravelless chambers are used, at least two inches of drainrock or pea gravel must be placed over the chambers for surface cover.

2.9.3. When a proprietary distribution product, such as a gravelless distribution or subsurface dripline product, is used in place of drainrock in a recirculating gravel filter, only those distribution products on the current List of Registered On-site Treatment and Distribution Products may be permitted by the local health jurisdiction.

Nitrifying recirculating gravel filter media may be utilized in lieu of drainrock in the top of the filter bed.

2.10. Recirculating/Mixing Tank

2.10.1. The recirculating/mixing tank must be on the Department of Health's List of Registered Sewage Tanks

2.10.2. The volume of the recirculating/mixing tank is determined by the following:

2.10.2.1. For residential systems: 150% of the daily wastewater design flow estimate.

2.10.2.2. For non-residential systems: 100% of the daily wastewater design flow estimate.

2.11. Recirculating Pump

2.11.1. Controls: The recirculating pump must be controlled by a timer with a dosing schedule that provides for frequent, cycled and uniform doses, allowing the influent/filtrate mixture to pass through the filter about six times before being discharged to the vegetated wood chip bed.

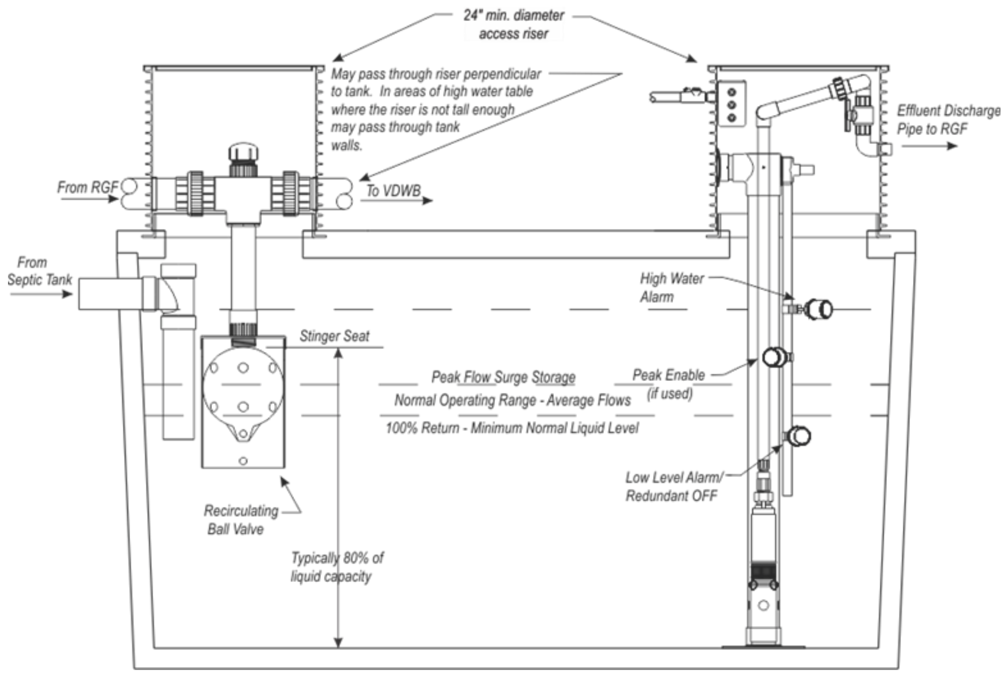
Recirculation provides control of treatment processes by changes that can be made to the recirculation ratios and dosing frequencies. Typical pumping cycles are for one continuous cycle every 20 to 30 minutes (48 to 72 cycles per day) with the "pump on" time set for 1 to 3 minutes. The "pump on" cycle should be set so that the orifice discharge per dose cycle does not exceed 1 gallon per orifice.

Both timer and float switch controls are required (see Figure 7). To protect the pump and the distribution pipe network orifices, the outlet of the septic tank must include screening of the effluent unless screening of the pump is provided (see standards and guidance for pressure distribution systems for effluent screening).

In the event of low levels in the recirculating/mixing tank, to protect the pump by assuring adequate pump submergence, a redundant off/low level alarm control float is recommended as shown in Figure 7. The redundant off/low level alarm must be installed in accordance with the pump manufacturer's recommendations to assure adequate pump submergence.

In conditions where wastewater daily flows are highly variable, a pump control system equipped with "peak" and/or "low" dose enable floats and circuits is recommended. These controls respond to peak and low flow conditions by increasing or decreasing the dosing frequency when high or low levels in the recirculating/mixing tank are reached and then reverting back to the standard dosing cycle when these floats have returned to their "off" position.

Figure 7. Example of a Recirculating/Mixing Tank with a Recirculating Ball Valve



2.11.2. Flow rate for recirculating pump: The minimum recirculating pump flows, in gallons per minute, can be calculated by the following formulas:

$$\text{Daily Design Flow (GPD) x 6} = \text{Through} - \text{filter flow (GPD)}$$

$$\frac{\text{Through} - \text{filter flow (GPD)}}{\text{pump cycles per day}} = \text{Gallons per cycle}$$

$$\frac{\text{Through} - \text{filter flow (GPD)}}{\text{pump cycles per day}} = \text{Gallons per cycle}$$

*Note that the pressure distribution network design in the nitrifying recirculating gravel filter may result in a higher discharge rate.

Filtrate is collected and discharged from the bottom of the gravel filter by either a gravity-flow underdrain or a pump discharge underdrain. A gravity-flow underdrain is the preferred method for collecting and discharging the filtrate back to the recirculating tank. When gravel filters are membrane-lined, gravity-flow underdrains must exit through a boot. The boot and exit pipe must be installed and tested according to the standards in Appendix B.

2.12. Treated Wastewater (Filtrate) Collection and Discharge

2.12.1. Recirculation Flow Splitting Mechanisms: Effluent treated in the recirculating gravel filter collects at the bottom of the filter through an underdrain and a portion is returned to the recirculating/mixing tank.

2.12.2. The collected flow must be split to redirect 75-85% of the treated effluent back to the recirculating/mixing tank or septic tank. The balance of the treated effluent is routed to the vegetated denitrifying woodchip bed. Options and comments concerning flow splitting are noted in Appendix D.

A return method to the septic tank that minimizes stirring of solids is to increase the diameter of the return line for at least 10 feet prior to the sewage tank.

To encourage mixing of fresh influent with partially treated recirculating return filtrate, the return line from the filter should enter the recirculating/mixing tank near the influent from the septic tank

Alkalinity Addition

The nitrification reaction (the conversion of ammonia to nitrate) consumes 7.1mg/L of alkalinity for each mg/L of ammonia nitrogen oxidized. Calcium carbonate may need to be added to the water supply to achieve optimal nitrification. (OSWW final report)

Approximate Septic Tank Influent Alkalinity Needed to Produce Nitrified Effluent NH_3-N Concentration of 1.0 mg/L as a Function of the Influent TN Concentration

Influent TN, mg/L-N	*Influent Alkalinity if denitrification is in separate tank/system as $CaCO_3$, mg/L*	*Influent alkalinity if denitrification is present as $CaCO_3$, mg/L*
80	*557*	
70	*487*	*313*
60	*416*	*265*
50	*345*	*218*
40	*275*	*170*
30	*204*	*123*

Recirculating gravel filter recirculating/mixing tanks and septic tanks generally have conditions that promote denitrification, including anoxic conditions (low dissolved oxygen) and biodegradable carbon. However, denitrification tends to be carbon limited because much of the CBOD is removed by aerobic microbial respiration, which is conducive to nitrification in the filter, and is no longer available for denitrification in the recirculating/mixing tank. Consequently, nitrified RGF effluents typically must have an external carbon source added to supply enough energy to enhance denitrification. One source of carbon is the septic tank liquid. The vegetated denitrifying woodchip bed uses woodchips as a readily available solid carbon source for denitrification following a nitrifying recirculating gravel filter to overcome this problem. However, this new nitrogen reduction option is not without limitations or additional field evaluation needs.

2.13. Vegetated Denitrifying Woodchip Bed (VDWB)

2.13.1. Media Specifications

2.13.1.1. Woodchip media must be of alder wood, free of bark, leaves, twigs, dirt, rocks, and foreign material and not from treated wood.

2.13.1.2. The particle size must be 0.5 to 3 inches in length, not less than 0.375 inches in width, and not less than 0.0625 inches thick.

2.13.1.3. At least 85% by volume, must conform to the size specified.

2.13.2. Woodchip Bed Sizing

2.13.2.1. Hydraulic Loading Rate: The loading rate must not exceed 8 gallons/day/square foot, based on the top area of the bed.

2.13.2.2. Surface area of filter bed: The surface area must be determined by dividing the daily design flow estimate by the loading rate.

2.13.2.3. Aspect (Length to Width) Ratio of Bed: The VDWB must have an aspect ratio ranging from 5:1 to 4:1 to ensure proper water flow through the bed.

2.13.2.4. Depth (thickness) of Woodchip Media

2.13.2.4.1. A minimum depth of 40 inches of woodchip media must be placed in all VDWBs. The water level should be maintained at least 6 inches below the surface of the woodchips at all times to prevent odors and for disease vector control. The water level must be set at least 34 inches above the VDWB bottom (see Figure 8).

2.13.2.4.2. The surface of the woodchip media should be level.

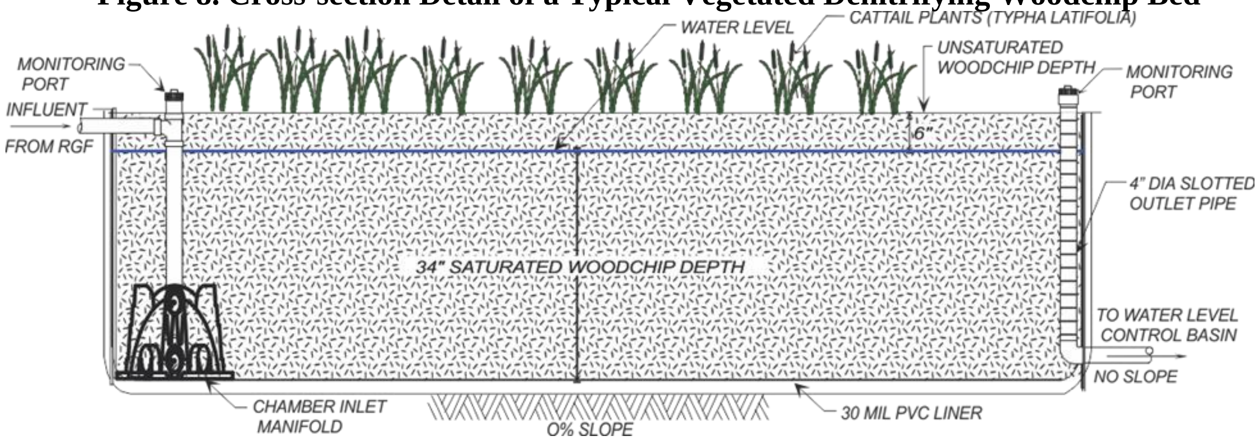
Research has shown cooler temperatures reduce microbial action, reducing denitrification processes in the VDWB. Steps can be taken to help reduce the VDWB sensitivity to temperatures and the risk of freezing in areas with seasonal cold weather. These steps may include installing one to two inch rigid foam panels around the perimeter of the VDWB and RGF containment vessels, using lids with 2-inch foam insulation on sewage tanks, and/or placing a 6-inch layer of straw mulch layer on top of the woodchip media.

Design standards for VDWB sizing provide a hydraulic retention time (amount of time effluent needs to stay in the VDWB) of approximately two days. The retention time inside the VDWB is important, particularly at low operating temperatures, because there must be sufficient time for the desired denitrification processes to occur. Longer retention times provide excellent nitrate removal. However, studies show that sulfate reduction can occur if the water stays in the VDWB too long, when nitrate has been almost completely removed, and often at high temperatures. Sulfate reduction can be a concern because it represents a loss of carbon for denitrifiers and it produces hydrogen sulfide that can be a noxious gas.

VDWBs can be designed and maintained to minimize sulfate reduction by retaining low concentrations of nitrate in the effluent (e.g.; 1.0 – 2.0 mg/L nitrate). If hydrogen sulfide odor (i.e.; a rotten egg smell) is noted inside the flow control basin on an on-going basis, the water *level in the VDWB should be lowered to obtain a high enough flow rate to not fully reduce nitrate in the treated effluent.*

On sites known to have extreme low flow conditions, the VDWB also can be designed with flow splitting between two or more equally sized beds to lessen the impact on the cattail plants if VDWB water level lowering is needed. See Section 2.4.5.2 Water Level Adjustment Pipe for water level adjustment details.

Figure 8. Cross-section Detail of a Typical Vegetated Denitrifying Woodchip Bed



2.13.3. Woodchip Bed Containment

2.13.3.1. The bed slope bottom must be flat to the horizontal plane.

2.13.3.2. The filter bed may be contained either in a synthetic membrane liner, or an engineered-designed, concrete, cast-in place containment vessel. Design and construction must conform to the containment vessel standards set forth in Appendix B.

Due to the hydrostatic pressure produced by the water depth in a VDWB, a PVC boot at the bottom of outlet of end of a VDWB can be more prone to leaking than a boot in a RGF underdrain system. When installing boots to penetrate a liner, the manufacturer's installation instructions must be followed exactly. Orienting the boot so the stainless-steel clamps are inside the liner of a VDWB instead of the outside may help prevent boot leakage.

2.13.4. Woodchip Bed Inlet End and Outlet End Manifolds

2.13.4.1. Inlet End Manifold: A high capacity gravelless chamber placed along the entire bottom width of the inlet end serves as an inlet manifold in the VDWB. Septic tank effluent enters through the side of the VDWB and flows downward into the top midpoint of the chamber. The invert of the inlet pipe entering the VDWB is a minimum of 3 inches above the top of the 3-inch PVC water-level-adjustment pipe in the water-level control basin. The chamber distributes influent evenly across the width of the VDWB. The interior of chamber allows for the settling of solids at the inlet end of the VDWB and later pumping of the solids during maintenance.

2.13.4.2. Monitoring Port: A 4-inch diameter monitoring port is part of the influent inlet pipe connected to the top of the chamber. The port is brought to grade and covered with a removable cap providing access to the interior of the chamber from the top of the VDWB as shown in Figure 8.

2.13.4.3. Influent Distribution: The VDWB may be gravity-fed or pressure-dosed to the chamber inlet manifold. Pressure dosing allows the VDWB to be placed at an elevation higher in the landscape than the RGF but necessitates the use of an additional pump.

Influent may be discharged to the gravelless chamber placed at the bottom of the VDWB inlet by either a gravity fed or pressure-dosed distribution system. When pressure dosing, the individual dose volume to a VDWB must be kept to a maximum 10 gallons per dose.

"Field cut" the chamber to fit the bed's width and place it flush against the sidewall of the bed. Cover the ends with a thick geotextile fabric to prevent woodchips from entering the inside of the chamber and to protect the liner from any rough-cut edges on the chamber.

Chamber end caps may be used, but it may be difficult to "field fit" the cut end without the use of fabric, and approximately one foot is lost on each end of the chamber due to the end caps.

2.13.4.4. Outlet End Manifold: After effluent travels horizontally across the woodchips of the VDWB, a submerged vertically placed 4-inch diameter slotted PVC pipe collects the treated effluent at the center outlet end of the VDWB. Slots should be cut ¼ inch wide and 2.5 inches deep at every 4 inches on center. To avoid the slots being pushed against the liner, they must be faced towards the inlet end of the bed. The distal end of the slotted pipe must be brought to grade and covered with a removable cap. The 4-inch diameter solid PVC outlet pipe exiting the VDWB is located 4 inches from the bottom of the bed (see Figure 8).

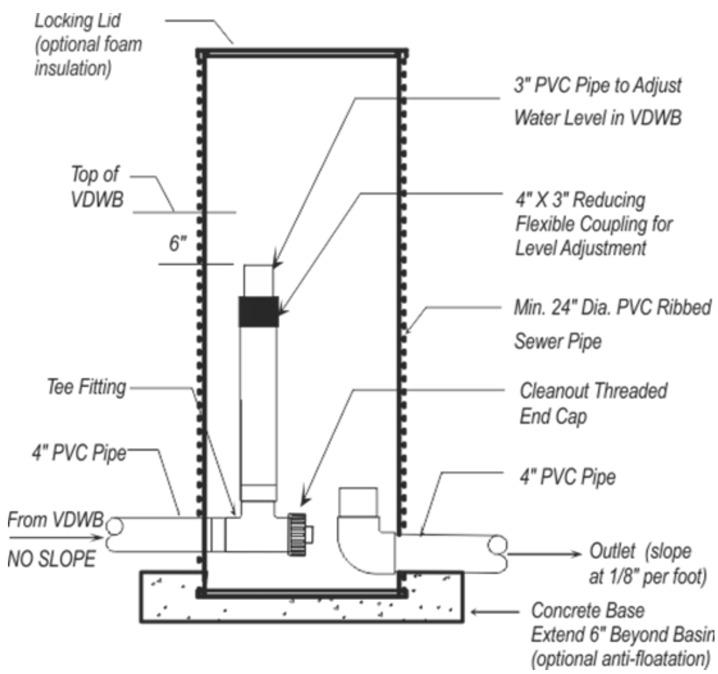
2.13.5. Woodchip Bed Water-Level Control Basin

2.13.5.1. From the VDWB, denitrified effluent goes to a watertight, water-level control basin that allows the water level in the bed to be set at least 34 inches above the VDWB bottom and 6 inches below the surface of the woodchips. This is important because the water level must remain below the surface of the bed in order to prevent odors yet be high enough to prevent plant roots in the bed from drying or freezing.

2.13.5.2. Water-Level Adjustment Pipe: A water-level adjustment standpipe located inside the basin is used to adjust the operational depth in the VDWB. The pipe assembly consists of a 4-inch PVC Tee with end screw cap; a 4-inch x 3-inch PVC-to-PVC flexible sewer coupler reducer and 3-inch PVC pipe at the top to adjust and maintain the water level. Effluent overflows the top of the 3-inch standpipe and into the water-level control basin when additional wastewater enters the VDWB (see Figure 9).

2.13.5.3. Treated Effluent Discharge: Effluent is discharged from the bottom of the water-level control basin by a gravity-flow outlet pipe. After treatment in the VDWB, effluent travels to a soil dispersal component for further treatment and dispersal (see Figure 9).

Figure 9. Example of a Water-Level Control Basin



2.13.6. Woodchip Bed Vegetation

2.13.6.1. Roles of Plants: Plants will absorb some of the nutrients from the effluent, and they also play a role in carbon cycling and insulating against seasonal low temperature effects. Plants root structure helps water flow and prevents woodchip media settling.

2.13.6.2. Planting: After filling the VDWB with water at a depth of 6 inches below the surface of the woodchip media, cattails (Typha latifolia) must be planted into the woodchips in rows with a density of approximately one plant per square foot. The rows should be perpendicular to the direction of effluent subsurface flow. Be sure the roots are free of soil and debris before placing them in the woodchip media. While keeping the cattail shoots above the surface of the woodchips, ensure the roots are inserted into the bed at a depth greater than 6 inches.

It is recommended to fill the VDWB with water before installing the plants to keep the roots saturated to prevent them from dying.

When planting the cattails, always plant to obtain a uniform plant cover over the entire top of the VDWB. To accomplish this, place the rows and cattails 12 inches apart and staggered 6 inches. Ensure the plants are a depth (greater than 6 inches) where roots are in the water.

The cattails should be planted in the spring for best opportunity for survival. If after six weeks the plants do not seem to be taking hold and growing, replant in between the original plants in a similar pattern.

Living and dead plant material should never be removed from the VDWB as this material is necessary for nitrogen removal.

3. Operation and Maintenance Standards

3.1. Management

3.1.1. The local health officer may require a maintenance agreement with supporting legal documents before approving a proposed recirculating gravel filter system. Maintenance agreements are recommended when, in the opinion of the local health jurisdiction, optimum operation of a recirculating gravel filter system is assured by such an agreement.

3.1.2. Owner Responsibilities: The owner of the residence or facility served by a recirculating gravel filter system is responsible for assuring proper operation and providing timely maintenance for all components of the on-site wastewater treatment and soil dispersal system. This includes inspecting the entire system at a frequency appropriate for the site conditions and the type of on-site sewage system as specified by the local health jurisdiction. Contact the local health department/district to find the required qualifications of a person to perform any specialized monitoring and maintenance activities.

3.2. Operation and Maintenance (O&M) Manual

3.2.1. An O&M manual for the recirculating gravel filter system must be provided by the system designer. The manual must contain the following, at a minimum:

3.2.1.1. The system owner’s responsibilities, including established system operation, inspection, record keeping, reporting, and permit requirements.

3.2.1.2. Key contact information, including names and telephone numbers of the local health jurisdiction, system designer, component manufacturer, supplier/installer, and/or the management entity to be contacted in the event of an emergency or system failure.

3.2.1.3. Design description, including a narrative that describes how the system works, its intended performance, and operating limits of the design. The narrative should include a brief description of each major process or component and discuss its function in the system and its expected performance. For proprietary products, include manufacturer’s standard product literature, including performance specifications and maintenance recommendations needed for operation, monitoring, and maintenance.

3.2.1.4. Diagrams of all major system components, including system design drawings, system record drawings, and schematics for all electrical and mechanical components installed.

3.2.1.5. Information on the periodic monitoring and maintenance requirements of the system. List and describe monitoring and maintenance activities for septic tank, dosing and recirculating/mixing tanks, gravel filter, drainfield, control panel, pumps, motors, valves, switches, alarms, etc. including recommended component settings for routine operation and monitoring.

3.2.2. A list of description of key operating activities and steps that should be used or avoided to protect the sewage system’s treatment processes and components. Examples include the use of low-flow fixtures, spreading ut laundry and other high water use activities over several days, infrequent and limited use of bleach and other household chemicals, not using garbage grinders, not disposing any medications down the drain, and maintaining suitable soil cover, landscaping, and vegetation for the sand-lined trench system and the reserve area.

3.2.3. A trouble-shooting guide, with information on identifying and fixing problem that might occur. This information should be as detailed and complete as needed to assist the system owner to make accurate decisions about when and how to attempt corrections of problems and when to call for professional assistance.

3.3. Monitoring and Maintenance: For the on-site sewage system to operate properly, its various components need periodic monitoring and maintenance.

3.3.1. Responsibility: Monitoring and maintenance are the responsibility of the system owner but may be best performed by experienced and qualified service providers. An O&M Manual must be developed and/or provided by the system designer with copies provided to the local health officer, system owner, and maintenance contractor. The maintenance manual must include the recommended maintenance descriptions and schedules listed in section 5.3.2. The local health officer may specify additional requirements.

3.3.2. Minimum Monitoring and Maintenance Description and Service Items:

3.3.2.1. Type of use

3.3.2.2. Age of system

3.3.2.3. Specifications of all electrical and mechanical components installed (occasionally components other than those specified on the plans are used)

3.3.2.4. Nuisance factors, such as odors or user complaints

3.3.2.5. Septic tank

3.3.2.5.1. Inspect yearly for structural integrity, proper baffling, screen, ground water intrusion, and proper sizing

3.3.2.5.2. Inspect and clean effluent baffle screen

3.3.2.5.3. Pump tank as needed

3.3.2.6. Dosing and Recirculating/Mixing Tanks

3.3.2.6.1. Clean the effluent screen (spraying with a hose is a common cleaning method)

3.3.2.6.2. Inspect and clean the pump switches and floats yearly

3.3.2.6.3. Pump the accumulated sludge from the bottom of the chambers, every time the septic tank is pumped, or more often if necessary

3.3.2.7. Pumpwell

3.3.2.7.1. Inspect for infiltration, structural problems, and improper sizing

3.3.2.7.2. Check for pump or siphon malfunctions, including problems related to dosing volume, pressurization, breakdown, clogging, burnout, or cycling

3.3.2.7.3. Pump the accumulated sludge from the bottom of the pumpwell, every time the septic tank is pumped, or whenever necessary

3.3.2.8. Check monitoring ports for ponding

3.3.2.8.1. Conditions in the observation ports must be observed and recorded by the service provider during all operation and maintenance activities for the recirculating gravel filter and other system components.

3.3.2.8.2. For reduced-sized drainfields, these observations must be reported to the local health jurisdiction responsible for permitting the system.

3.3.2.9. Inspect and test yearly for malfunction of electrical equipment such as timers, counters, control boxes, pump switches, floats, alarm system or other electrical components, and repair as needed. System checks should include improper setting or failure, of electrical, mechanical, or manual switches.

3.3.2.10. Mechanical malfunctions (other than those affecting sewage pumps) including problems with valves, or other mechanical or plumbing components.

3.3.2.11. Malfunction of electrical equipment (other than pump switches) such as timers, counters, control boxes, or other electrical components.

3.3.2.12. Material fatigue, failure, corrosion problems, or use of improper materials, as related to construction or structural design.

3.3.2.13. Neglect or improper use, such as loading beyond the design rate, poor maintenance, or excessive weed growth.

3.3.2.14. Installation problems, such as improper location or failure to follow design.

3.3.2.15. Overflow or backup problems where sewage is involved.

3.3.2.16. Recirculating Gravel Filter/exposed-surface filter bed: weed and remove debris from the bed surface, quarterly.

3.3.2.17. Specific chemical/biological indicators, such as BOD, TSS, fecal or total coliforms, etc. Sampling and testing may be required by the local health officer on a case-by-case basis, depending on the nature of the problem, availability of laboratories, or other factors.

3.3.2.18. Information on the safe disposal of discarded filter media (see Appendix E).

3.4. Observed Conditions/Action

3.4.1. When a system evaluation, or any other observation, reveals either of the following listed conditions, the owner of the system must take appropriate action to correct the situation according to the direction and approval of the local health officer:

3.4.1.1. Recirculating gravel filter system failure, as defined in WAC 246-272A-0010, or

3.4.1.2. A history of long-term, continuous, and increasing ponding of effluent within the system, which if left unresolved, will probably result in untimely system or component failure.

3.4.2. Appropriate actions include:

3.4.2.1. Evaluation of building usage for a change in wastewater quantity or quality, or other conditions that could be causing the observed ponding within the system or failure.

3.4.2.2. Repair or modification of the recirculating gravel filter system,

3.4.2.3. Expansion of the recirculating gravel filter system, or

3.4.2.4. Modifications or changes within the structure relative to wastewater strength or hydraulic flows

3.5. Troubleshooting

3.5.1. Look for any obvious signs of ponding. For laterals bedded under the media, look for any wetness on the surface, which indicates localized fouling of the media. Where monitoring tubes have been installed, they should be observed for ponded water. Tubes penetrating to the surface of the treatment media should not show ponded water, except perhaps for a brief period after a dose. Where ponding remains for minutes after a dose, the dose volume is either too large or fouling of the media starting to occur. If either of these conditions are occurring, it is an early indication of media clogging, and the operator should consider taking the filter cell offline and allowing it to rest.

3.5.2. The operator should also observe the biological activity in the filter. Look for any tan to light gray gelatinous deposits around the orifices, orifice caps, and media immediately around these zones. If present, this is an aerobic floc that is starting to build and is an indication that the applied effluent <u>dosing is occurring too often</u>. The operator should either reduce pump run time or increase the pump off time to allow for the proper recirculation ratio. It is experienced that a time delay of 25 to 30 minutes between dosing on a single zone is optimal.

3.5.3. Also look for black deposits. If present, this is an indication of anaerobic overload conditions. It may mean that the organic loading rate is too high or that the recirculation ratio is too low. Sometimes black deposits may build during cold weather and dissipate when it warms up, even if the organic loading and the recirculation ratio are both within the proper range. As long as the black deposits go away seasonally, it is not a major problem.

Local permits must be obtained before construction begins, according to local health jurisdiction requirements. Any observed problem, repair or modification activity must be reported as part of the monitoring activity for the site. For an on-site sewage system with a reduced size drainfield, the repair or modification required may include the installation of additional drainfield to enlarge the system to 100% of the initial design size. Repair or modification is not limited to an action of drainfield enlargement.

Appendix A -- Filter Media Specifications

I **Particle Size Analysis**: The standard method to be used for performing particle size analysis must comply with one of the following:

A. The sieve method specified in ASTM D136 and ASTM C-117

B. The method specified in Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples, Soil Survey Investigation Report #1, US Department of Agriculture, 1984.

II Recirculating Gravel Filter Media Specification for High Strength Sewage—All four conditions must be met to satisfy media criteria:

A. Particle Size Distribution:

Sieve	Particle Size	Percent Passing
3/8 inch	9.50 mm	100%
No. 4	4.75 mm	0 to 95
No. 8	2.36 mm	0 to 2
No. 30	0.60 mm	0 to 1

B. Effective Particle Size: 3 mm to 5 mm

C. Uniformity coefficient (D60/D10): less than or equal to 2.

D. Filter media must be washed.

III Recirculating Gravel Filter Media Specification for Nitrogen Removal—All four conditions must be met to satisfy media criteria:

A. Particle size distribution:

Sieve	Particle Size	Percent Passing
3/8 inch	9.50 mm	100%
No. 4	4.75 mm	0 to 95
No. 8	2.36 mm	0 to 2
No. 30	0.60 mm	0 to 1

B. Effective Particle Size (D10): 2.0 mm – 4.0 mm

C. Uniformity coefficient (D60/D10): less than or equal to 2

D. Filter media must be washed

Appendix B - Containment Vessel Standards

I Synthetic Membrane Lined Pit - when a gravel filter is constructed in a synthetic-membrane lined excavated pit, the following criteria must be met: (Note: The majority of the following liner specifications are from the State of Oregon On-Site Sewage Disposal Rules.)

A. Polyvinyl chloride (PVC) membrane liners must have the following properties:

PROPERTY	TEST METHOD	
(a) Thickness	ASTM D1593 Para 9.1.3	30 mil minimum
(b) Specific Gravity (Minimum)	ASTM D792 Method A	
(c) Minimum Tensile Properties (each direction)	ASTM D882	
(A) Breaking Factor (pounds/inch width)	Method A or B (1 inch wide)	69
(B) Elongation at Break (percent)	Method A or B	300
(C) Modulus (force) at 100% Elongation (pounds/inch width)	Method A or B	27
(d) Tear Resistance (pounds, minimum)	ASTM D1004 Die C	8
(e) Low Temperature	ASTM D1790	-20°F
(f) Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 15 min.	± 5
(g) Water Extraction	ASTM D1239	-0.35% max.
(h) Volatile Loss	ASTM D1203 Method A	0.7% max.
(I) Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083	
(A) Breaking Factor		-5
(B) Elongation at Break		-20
(C) Modulus at 100% Elongation		±10
(j) Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083	55.2
(k) Hydrostatic Resistance	ASTM D751 Method A	82

B. Installation Standards

1. Patches, repairs and seams of membrane liners must have the same physical properties as the parent membrane material;

2. Site considerations and preparation:

    a. The supporting surface slopes and foundation to accept the liner shall be stable and structurally sound including appropriate compaction. Make sure the potential of sink hole development and differential settlement is avoided;

    b. Soil stabilizers such as cementations or chemical binding agents must not adversely affect the membrane since they may be potentially abrasive agents.

3. To avoid deterioration of the membrane liner caused by exposure to weather or sunlight, the liner must be protected by being fully buried. In cases where portions of the liner may be subject to direct exposure to the weather (for example in a recirculating gravel filter system in which the top edges of the liner may not be buried due to the system design requirements), the exposed portions of the liner must be covered. A construction option to accomplish this is to construct a finish rim over the exposed liner portions.

4. Non-reinforced liners have high elongation and can conform to irregular surfaces and follow settlements—within limits. Unreasonable strain reduces thickness and may reduce life expectancy by lessening the chemical resistance of the thinner (stretched) material. Membrane liners must be installed to minimize strain (or elongation to the fabric) anywhere in the flexible membrane liner system.

5. Construction and installation:

    a. The bottom of the pit must be covered with:

        (1) Sand to “bed” liner, at a minimum 3 inches to protect the liner from puncture, or
        (2) A non-woven needle-punched synthetic geotextile fabric, with a thickness strong enough to protect the liner.

    b. Grade the bottom to provide a sloping liner surface, from the outer edge of the filter toward the point of underdrain collection. Slope must be equal to 8 inches fall overall, or 1 inch of fall per 1 foot of run, whichever is greater.

    c. The sides of the pit must be smooth and free of possible puncture points from foreign objects.

    d. Climatic conditions:

(1) Temperature: The desirable temperature range for membrane installation is 42° F to 78° F. Lower or higher temperatures may have an adverse effect on transportation, storage, field handling and placement, seaming and backfilling and attaching boots and patches may be difficult. Installing liners outside the desirable temperature range must be avoided at all times;

(2) Wind: Wind may have an adverse effect on liner installation such as interfering with liner placement. Mechanical damage may result. Cleanliness of areas for boot connection and patching may not be possible. Alignment of seams and maintaining fabric cleanliness may not be possible. Installing the liner in high-wind conditions must be avoided at all times;

(3) Precipitation: When field seaming is adversely affected by moisture, portable protective structures and/or other methods must be used to maintain a dry sealing surface. Proper surface preparation for bonding boots and patches may not be possible in wet conditions. Seaming, patching and attaching 'boots' is recommended only during dry weather conditions.

e. Boots: Any penetration through the PVC-lined wall must be done with a PVC boot attachment glued to the liner with the vinyl sealer. The boot and exit pipe must be installed according to the following criteria:

(1) The system designer must identify the use of a gravel filter liner with underdrain and boot as a part of the application for on-site sewage system and provide specifications detailing design and installation requirements.

(2) The boot must be installed according to the manufacturer's requirements and watertight.

(3) The boot outlet must be imbedded in sand.

(4) The boot must be sized to accommodate a 4-inch, underdrain outlet pipe.

(5) The boot must be secured to the 4-inch underdrain outlet pipe with two (2) stainless steel bands and screws, and sealant strips as recommended by the manufacturer.

(6) The underdrain must be designed in accordance with Appendix C, Underdrains and must exit the side of the liner.

(7) An inspection port must be installed in the sewer pipe from the filter to the drainfield.

(8) Gravity sewer pipe from the filter to the drainfield must be ASTM 3034 ring tight.

(9) When site conditions are such that the trench from the sand filter to the drainfield may act as a conduit for ground water movement towards the drainfield (for example on sites with shallow groundwater of poorly drained sites), the trench must be back-filled with a minimum 5 lineal feet clay mix (or bentonite mix) dam.

(10) If the boot might be submerged in a seasonal high-water table, performance testing of the gravel filter/boot for leakage must be conducted in the following manner:

(a) Block outlet pipe;

(b) Fill underdrain gravel with water;

(c) Measure and record elevation of water through observation/inspection port;

(d) Let stand 24 hours minimum;

(e) Measure and record elevation of water through observation/inspection port;

(f) No allowable drop in the water level.

f. Liner Placement:

(1) Size: The final cut size of the liner shall be carefully determined and ordered to generously fit the container geometry without field seaming or excess straining of the linear material;

(2) Transportation, handling and storage: Transportation, handling and storage procedures must be planned to prevent material damage. Material must be stored in a secured area and protected from adverse weather;

(3) Site inspection: A site inspection must be carried out by two entities: the local health officer, other appropriate jurisdiction, or by a designer or engineer appointed by the appropriate jurisdiction, *and* the installer prior to liner installation to verify surface conditions, etc.;

(4) Deployment: Panels must be positioned to minimize handling. Seaming should not be necessary. Bridging or stressed conditions must be avoided with proper slack allowances for shrinkage. The liner must be secured to prevent movement and promptly backfilled;

(5) Anchoring trenches: The liner edges should be secured frequently in a backfilled trench;

(6) Field seaming: Field seaming, if absolutely necessary, must only be attempted when weather conditions are favorable. The contact surfaces of the materials should be clean of dirt, dust, moisture, or other foreign materials. The contact surfaces must be aligned with sufficient overlap and bonded in accordance with the suppliers recommended procedures. Wrinkles must be smoothed out and seams should be inspected by non-destructive testing techniques to verify their integrity. As seaming occurs during installation, the field seams must be inspected continuously, and any visible faulty area repaired immediately;

(7) Field repairs: It is important that traffic on the lined area be minimized. Any necessary repairs to the liner must be patched using the same lining material and following the recommended procedure of the supplier;

(8) Final inspection and acceptance: Completed liner installations must be visually checked for punctures, rips, tears, and seam discontinuities before placement of any backfill. At this time the installer must also manually check all factory and field seams with an appropriate tool. In lieu of, or in addition to manual checking of seams by the installer, either of the following tests may be performed;

(a) Wet Test: The lined basin must be flooded with water to the one (1) foot level with water after inlets and outlets have been plugged. There must not be any loss of water in a 24-hour test period.

(b) Air Lance Test: Check all bonded seams using a minimum 50 PSI (gauge) air supply directed through a 3/16 inch (typical) nozzle held not more than 2 inches from the seam edge and directed at the seam edge. Riffles indicate unbonded areas within the seam, or other undesirable seam construction.

C. Lined Framework: A perimeter support frame to hold the liner in place during construction must be used. The supporting framework may be constructed of wood or cast-in-place concrete. Framework must be straight, free from warps or bends. Framework must be of sufficient rigidity so that springing will not occur under the weight of the media and/or backfill placement. Framework must be sufficiently supported to prevent excessive deflection of the framework.

When plywood is used, a 2x4 framing support (or minimum 2-foot centers) is the suggested construction method. Treated wood should be used to prevent deterioration of the wood by termites, decomposition, etc.

D. Media and liner placement

1. It is important that sand is placed between the framework and excavated soil at the same time as the placement of the treatment media. This keeps the framework and

liner vertical during the course of construction and results in a sand cushion around the outside perimeter of the lined framework. All nails or staples used must have their sharp ends pointed away from the liner. The PVC liner is unfolded from the center of the excavation and draped over the top edges of the perimeter support frame. Care should be taken to prevent contact between the liner and the sharp edges of the top of the perimeter support frame.

A garden hose that has been cut longitudinally and placed on the top edge of the support frame would be a suggested method.

2. Care must be taken to ensure that the liner is in full contact with the bottom and sides and that no bridging occurs.

Pleats or wrinkles in the liner should be minimized. Pleats and wrinkles in the liner may allow for a tunneling effect of effluent through the pleat or wrinkle.

E. **Backfill around framework**: If site conditions are such that a partially elevated filter is desired or necessary, backfill around the sides of the filter must be non-clay material containing no pieces more than 3 inches across, no frozen lumps, and no wood or other foreign material. The backfill material around the sides of the filter must be placed in layers no more than 2 feet thick, with each layer then tamped and graded so that final settling will provide for side slopes on the sides of the filter backfill to be approximately 3:1 from the top of the filter, to native ground.

II Concrete Containment Vessel

Concrete containment vessels must be reviewed and approved by the Department of Health as a concrete cast-in place tank according to sewage tank requirements in WAC 246-272C.

Appendix C - Underdrains

For synthetic-membrane lined pits or concrete cast-in-place containment vessels: Gravel filter filtrate is collected in in an underdrain underlying the filter media. While either a gravity-discharge underdrain or pump-discharge underdrain may be used, gravity discharge is preferable.

Underdrains: Underdrains must be designed with sufficient void storage volume to provide for a single drainfield dose with reserve capacity to maintain unsaturated filter media above the underdrain system. Collection pipe must be at least 4-inch diameter, with adequate perforations, or slots so that filtrate can flow from the void storage space into the collection pipe rapidly enough to maintain unsaturated filter media above the underdrain system.

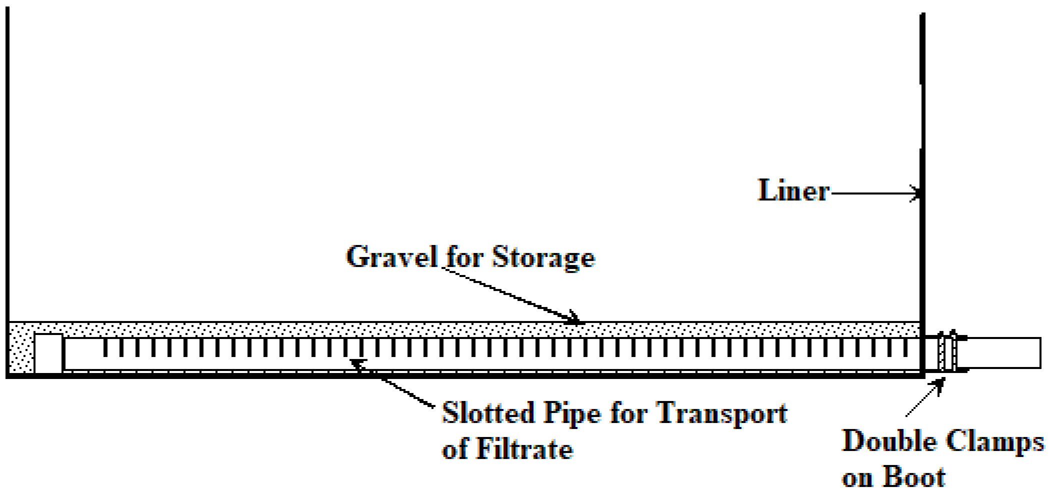
Underdrains may be designed in a variety of ways. One possible way is:

Place a 3-inch layer of pea gravel over a 6-inch layer of 3/4 to 2-1/2 inch gravel containing the underdrain collection pipe. The purpose of the pea gravel is to restrict the migration of sand into the gravel and pipe in the underdrain. The gravel surrounding the slotted or perforated pipe should be sized larger than the slots or perforations to prevent migration of gravel into the pipe. See figure below. For the purpose of calculating void storage space in the medium gravel (3/4 to 2-1/2 inch), a maximum of 3.0 gallons per cubic foot may be used assuming 40% void space per cubic foot.

The underdrain's liquid volume in gallons per inch can be determined by:

1) *Multiply underdrain's width (feet) x length (feet) to get the area in square feet.*
2) *Multiply the area by 7.5 to get the gallons per foot and divide by 12 to determine the gallons per inch in the underdrain*
3) *Multiply by 0.4 (40% average void space of gravel) to get gallons per inch of void space (liquid volume – the liquid goes into the void space.*

Figure 10. Cross-section of a Basic Recirculating Gravel Filter Underdrain

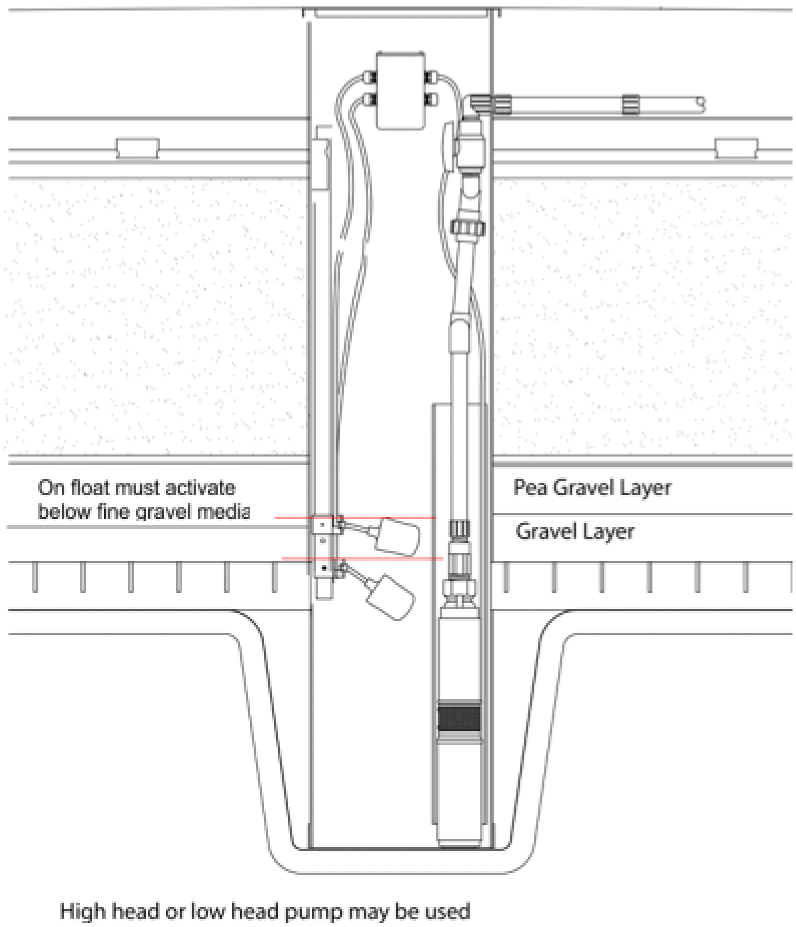


Slots must be in the 12 o'clock position

> *Field experience indicates that vertical piping from the underdrain to the surface may help with rehabilitation of failed filters.*

Internal Pump Basin Assemblies: Pump basins may be designed a variety of ways, but they typically are constructed of large diameter PVC ribbed pipe (see Figure 11). A sufficient number and size of holes must exist in the pump basin, at the level of the underdrain system, so that filtrate can flow into the pump basin, from the underdrain void space, as rapidly as the filtrate is pumped out of the pump basin. The pump basin must be adequately supported on both sides of the synthetic membrane.

Figure 11. Example of an Internal Pump Basin Assembly (w/Float Setting Detail)



Appendix D – Options/Comments – Flow Splitting

Splitting the return flow from the recirculating gravel filter to direct a minimum of 75-85% of the treated effluent back to the recirculating/mixing tank and the remainder to the soil dispersal component can be accomplished in a variety of ways. Following are two customary and/or suggested splitting methods and a potential option that does not incorporate flow splitting:

Option 1. Recirculating Ball Valve (Buoyant-Ball Check Valve) (see Figure 12)

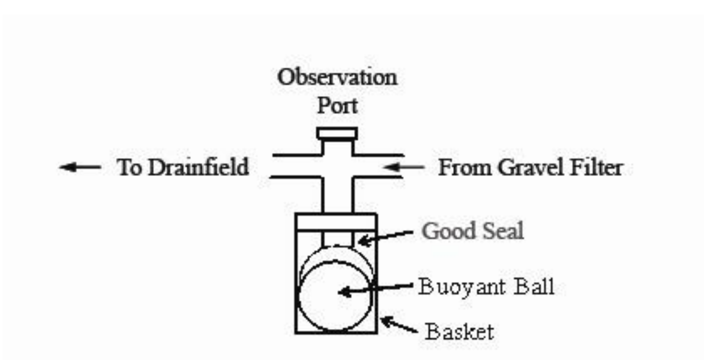
Description: The recirculating ball valve typically consists of:

1) an inlet from the filter,
2) an outlet to the drainfield,
3) an outlet downward (into the mixing chamber),
4) a buoyant ball which seals the downward outlet,
5) a basket which retains the ball below the downward outlet, and
6) an observation port.

Operation: During periods of low flow, all return flow from the recirculating gravel filter is returned to the recirculating/mixing tank through the ball valve. As the level of the liquid in the recirculating/mixing tank rises, the ball exerts enough force to make a firm seal. The upward force that the ball exerts needs to be sufficient to maintain a complete seal even with the return line (from the gravel filter) completely full. When the ball seals the downward outlet, filtrate is discharged to the drainfield. This discharge continues until the level in the tank drops enough to unseat the ball in the valve. For systems with a high velocity of effluent in the return pipe (filter to mixing tank), the ball valve assembly may need to be equipped with a baffle to “slow” the effluent down as it enters the recirculating/mixing tank to help prevent bypassing the downward outlet.

There are commercially available recirculating ball valves. Design and selection of a commercially available valve assembly must be in accordance with the manufacturer’s recommendations.

Figure 12. Example of a Recirculating Ball Valve



Tables 2 & 3 are provided as a guide in designing a recirculating ball valve. Actual inside diameters of the pipe and actual outside diameters of the ball must be used. The weight of the column of liquid in the return pipe must be overcome by the buoyant force of the ball. (Note: the weight of the sphere is neglected.) Density of effluent is assumed to be approximately 62.4 pounds/ft^3.

Table 2 - Weight of a Cylindrical Column of Effluent									
Diameter, Inches	2	3	4	5	6	7	8	10	12
Length, Inches	Weight of a cylindrical column of effluent, in pounds								
4	0.5	1.0	1.8	2.8	4.1	5.6	7.3	11.3	16.3
5	0.6	1.3	2.3	3.5	5.1	6.9	9.1	14.2	20.4
6	0.7	1.5	2.7	4.3	6.1	8.3	10.9	17.0	24.5
7	0.8	1.7	3.2	5.0	7.1	9.7	12.7	19.8	28.6
8	0.9	2.0	3.6	5.7	8.2	11.1	14.5	22.7	32.6
9	1.0	2.3	4.1	6.4	9.2	12.5	16.3	25.5	36.7
10	1.1	2.6	4.5	7.1	10.2	13.9	18.1	28.3	40.8
11	1.3	2.8	5.0	7.8	11.2	15.3	20.0	31.2	44.9
12	1.4	3.1	5.4	8.5	12.2	16.7	21.8	34.0	49.0
13	1.5	3.3	5.9	9.2	13.3	18.1	23.6	36.8	53.1
14	1.6	3.6	6.3	9.9	14.3	19.4	25.4	39.7	57.1
15	1.7	3.8	6.8	10.6	15.3	20.8	27.2	42.5	61.2
16	1.8	4.1	7.3	11.3	16.3	22.2	29.0	45.3	65.3
17	1.9	4.3	7.7	12.0	17.3	23.6	30.8	48.2	69.4
18	2.0	4.6	8.2	12.8	18.4	25.0	32.6	51.0	73.5

Table 3 - Buoyancy of a Sphere (Weight of the sphere has been neglected)			
Diameter Inches	Buoyancy Lbs.	Diameter Inches	Buoyancy Lbs.
2.0	0.15	8.0	9.68
3.0	0.51	8.5	11.61
4.0	1.21	9.0	13.78
4.5	1.72	9.5	16.21
5.0	2.37	10.0	18.91
5.5	3.15	10.5	21.89
6.0	4.08	11.0	25.17
6.5	5.19	11.5	28.76
7.0	6.49	12.0	32.67
7.5	7.98		

Option 2. Gravity Flow from the Recirculating/Mixing Tank <u>Without</u> the Use of Splitting Devices

Description: With this concept, all of the return flow from the filter is directed back to the recirculating mixing tank where it mixes with influent from the septic tank. An outlet sanitary tee is installed in the recirculating mixing tank at approximately 80% of the liquid capacity of the mixing tank. Once the liquid level is reached in the mixing tank, effluent is allowed to exit the mixing tank to final disposal. No splitting devices are used.

The timer settings on the recirculation pump control the recirculation rate to the filter. The splitter device is the component that directs or divides the treated effluent from the filter back to the recirculating/mixing and/or to final disposal. The splitter device assures that during periods of peak flow, mixed effluent from the recirculating/mixing tank will only exit the tank by passing through the recirculating gravel filter one more time prior to disposal. It is possible to design a recirculating gravel filter system without the use of a splitter device. However, designing without a splitter device may lower the expected levels of treatment under peak flow conditions.

Considerable discussion regarding this concept was conducted by the Technical Review Committee. Due to limited experience with this concept at this time, the impact of not using a splitter device is unknown. If this concept is used, the following are recommended and strongly encouraged:

- Extending the influent sanitary tee deeper into the tank to maximize mixing with recirculated effluent.
- An effluent sampling program to verify that the performance standards are being met.
- "Pump fail" alarm in the control panel.

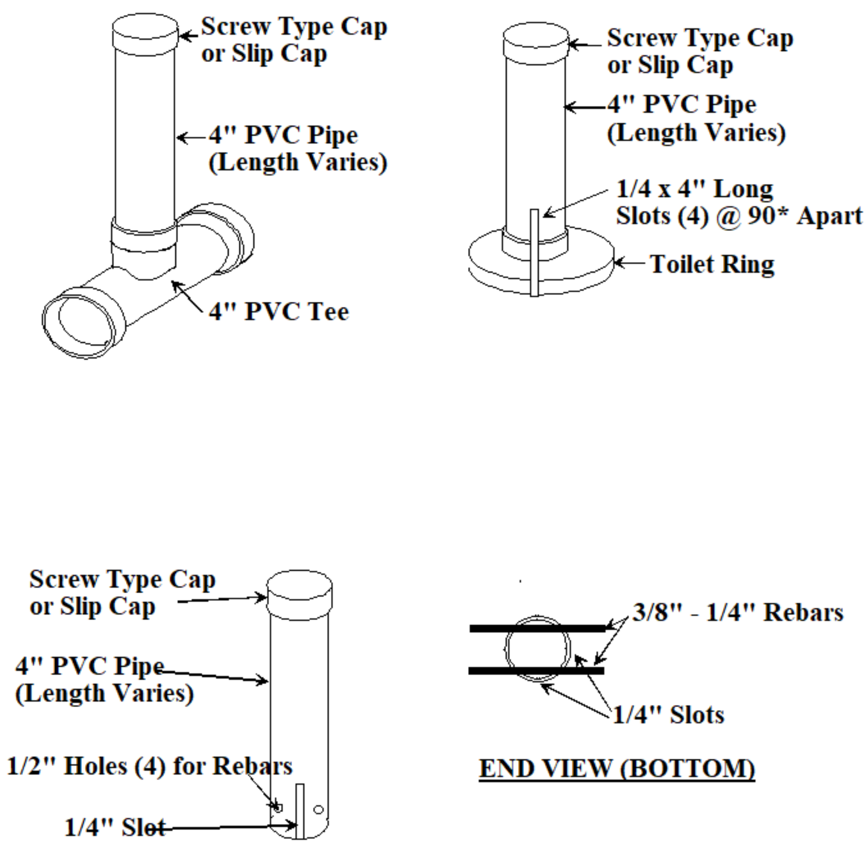
Appendix E – Monitoring Ports

The installation of monitoring ports in recirculating gravel filters is for the purpose of observing system status and aiding in problem analysis. A minimum of two monitoring ports must be installed in the gravel filter. One monitoring port must be installed to the bottom of the drain rock/top of the media interface or the top of the media if gravelless chambers are used in place of the layer of drain rock. A second monitoring port must be installed to the bottom of the underdrain. Some gravel filters may require additional monitoring ports to achieve observations representative of other treatment zones. Well-designed and installed monitoring ports:

- extend to at least the media's surface of the final landscape grade surface,
- are firmly anchored to prohibited unauthorized removal,
- are accessible for routine observation,
- are secured or otherwise protected for accidental or unauthorized access, and

- provide visual access to the filter-bedbottom in the gravel portion of a gravel-filled recirculating gravel filter and, in gravelless chambers to the interior of the chamber.

Figure 13. Example of Monitoring Ports
(Note: ports should only be perforated at the bottom)



Appendix F – Disposal of Contaminated Filter Media

Whenever filter media is removed from a used filter, removing and disposing of contaminated filter media must to be done in a manner approved by the local health officer. Handle this material carefully by using adequate protective sanitation measures. Thoroughly wash hands and any other exposed skin with hot water and soap, following contact with contaminated gravel filter media.

The contaminated filter media can be buried with at least 6 inches of cover on a site approved by the local health officer. If the material must be placed at grade, it must be covered with at least a 6-inch soil cap. Sloping sites should be avoided.

For either of these methods, the drainfield setbacks and vertical separations requirements in WAC 246-272A must be met and the material must not be used in agronomic applications for 12 months.

If the material must be disposed of at the local sanitary landfill, contact them for their requirements.

This material may be applied to the soil, according to the following guidance, only when approved by the local health officer.

APPLICATION	RESTRICTIONS/TIMETABLE
1. Root crops, low-growing vegetables, fruits, berries used for human consumption.	Contaminated material must be stabilized and applied 12 months prior to planting.
2. Forage and pasture crops for consumption by dairy cattle.	Forage and pasture crops not usable until one month after application of stabilized material.
3. Forage and pasture crops for consumption by non-dairy livestock.	Forage and pasture crops not available until two weeks after application of stabilized material.
4. Orchards or other agricultural areas where the material will not directly contact food products, or where stabilized material has undergone further treatment, such as pathogen reduction or sterilization.	Less severe restrictions may be applicable.

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