Wastewater Subsurface Drip Distribution

Peer-Reviewed Guidelines for Design, Operation, and Maintenance

Technical Report

Wastewater Subsurface Drip Distribution

Peer Reviewed Guidelines for Design, Operation, and Maintenance

1007406

Final Report, March 2004 (Revised May 2004)

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This report describes research sponsored by EPRI and the Tennessee Valley Authority.

The report is a corporate document that should be cited in the literature in the following manner:

Wastewater Subsurface Drip Distribution: Peer Reviewed Guidelines for Design, Operation, and Maintenance, EPRI, Palo Alto, CA, and Tennessee Valley Authority, Chattanooga, TN: 2004. 1007406.

PRODUCT DESCRIPTION

Subsurface drip distribution is the most efficient method currently available for application and subsurface dispersal of wastewater to soil. Because it is so effective, drip distribution represents a viable option for wastewater disposal and reuse for all soil types. The technology is commonly used at sites where point source discharges and National Pollutant Discharge Elimination System (NPDES) permits are not appropriate due to environmental sensitivity of receiving streams. It is also commonly used at sites where conventional drainfields are not appropriate due to site constraints such as shallow soils above a restrictive layer (for example, rock, groundwater, and hardpan), steep slopes, or clay soils with low permeability.

Until recently, the only guidelines for design, operation, and maintenance of these systems have been basic information provided by manufacturers and suppliers of drip tubing and related system materials. In addition, the National On-Site Wastewater Recycling Association (NOWRA) recently developed a more comprehensive set of guidelines in the form of a regional workshop manual and a technical practice standard. However, none of these documents have undergone a peer review process to establish the state-of-the-art for the technology.

Results & Findings

In establishing the state-of-the-art for subsurface drip distribution, this study addressed the following aspects of the technology: (a) siting, design, performance, operation, maintenance, monitoring, and costs; (b) hydraulic and mass loading rates based on both soil and wastewater characteristics; (c) adapting the design process to a spreadsheet method that standardizes basic steps and helps prevent errors; and, (d) providing design criteria with acceptable ranges to increase flexibility for applying the technology to special conditions (for example, rolling and steep terrain, obstacles, shallow soils, and clay soils).

Specifically, the report provides peer reviewed guidelines for the design, operation, and maintenance of drip distribution systems for subsurface dispersal of wastewater to soil. Information is provided on basic components and materials typically included in a wastewater drip system. Concepts that are critical to successfully applying the technology are presented. Detailed design procedures and calculations are provided based on two examples. Calculations are provided for pressure compensating and non-pressure compensating emitters. Microsoft Excel™ spreadsheets were developed and included to aid the design process. Design procedures include water and nutrient balances. Operation and maintenance guidance is provided for routine operations and troubleshooting. Representative system costs are provided. Issues are identified that are constraining the technology. These represent aspects that need additional study or research. Detailed information is provided on eight case study projects.

Challenges & Objective(s)
These guidelines are primarily intended for engineers and other types of professionals who either design or regulate wastewater drip technology. The document compiles detailed information that was previously scattered and difficult to obtain. Key concepts are presented including those where technical reviewers are generally in consensus and those that remain controversial. Where consensus is not available, opposing perspectives are provided. These represent issues that need additional funding to resolve. Information is generally adequate to successfully apply the technology but not to optimize it for most site conditions. Consequently, systems will typically be larger and more expensive than may be needed. Cost is typically the limiting factor. A commitment to proper operation and maintenance also must be made for the life of the system.

Applications, Values & Use
The market for wastewater drip technology is in a growth phase. This trend is expected to continue for many years due to the increasing need to develop sites where discharge permits or conventional septic systems are not appropriate. As barriers to decentralized wastewater concepts are removed, drip technology will become an increasingly important tool for site development in an environmentally friendly manner as well as remediating existing failed or noncompliant onsite and other types of wastewater systems. For maximum growth of the market potential, additional research is needed on key technical issues identified in the guidelines.

EPRI Perspective
These guidelines represent an unbiased perspective on wastewater drip distribution technology. They also represent the input and cooperation of many technical experts, manufacturers, and vendors that otherwise would not have occurred. The guidelines are a key tool for promoting drip technology as the most efficient method for wastewater distribution to soil. However, as with all tools, there is a need for periodic review and updating to ensure that the information remains current and useful, particularly since the market is highly competitive and in a growth phase.

Approach
The approach to the project included nine basic activities: (1) develop the project's detailed outline, scope, and approach and select the peer review team, (2) identify and visit representative projects, (3) summarize existing design, performance, operation, maintenance, monitoring, and cost information (including review of information by a representative of each project), (4) identify key design issues and summarize corresponding background information, (5) identify any short-term special studies that may be critical to resolving these issues and implement as necessary (using university soil science departments or other credible researchers), (6) develop design approaches and rationales for each issue (use spreadsheet methods where practicable), (7) develop representative computer-aided design (CAD) drawings for each system component, (8) develop detailed guidelines covering design, construction, operation and maintenance (O&M), costs, and performance monitoring, and (9) review technology transfer. During implementation, more or less emphasis was placed on each activity based on information as it was obtained.

Keywords
Drip distribution
Drip irrigation
Decentralized wastewater
Infiltrative surface
Onsite systems
Wastewater reuse

ABSTRACT

Guidelines are summarized for use of drip distribution technology for wastewater. The guidelines were developed over a period of 3 years through the assistance of the drip line manufacturers (Geoflow and Netafim), a peer review team of national experts, and engineers and other professionals that design, use, or regulate drip systems. The guidelines represent a standard for the design, performance, operation, and maintenance of drip technology as it is currently applied for subsurface dispersal of wastewater.

ACKNOWLEDGMENTS

This document reflects information and assistance from many individuals and companies. It would not have been possible otherwise. Those making significant contributions are listed below.

Geoflow, Inc.:

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Rodney Ruskin

Netafim USA, Inc.:

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METRIC CONVERSION FACTORS

Factors for the conversion of U.S. Customary Units to the International System (SI) of units

Multiply the U.S. Customary Unit		**By**	**To Obtain the Corresponding SI Unit**	
Unit	Abbreviation		Unit	Abbreviation
acre	ac	4047	square meter	m^2
acre	ac	0.4047	hectare	ha
cubic foot	ft^3	0.2832	cubic meter	m^3
cubic foot	ft^3	28.32	liter	l
cubic foot per gallon	ft^3/gal	7.4805	cubic meters per cubic meter	m^3/m^3
cubic foot per minute	ft^3/min	0.0004719	cubic meters per second	m^3/s
day	d	86.4	kilosecond	ks
degree Fahrenheit	°F	0.555(°F–32)	degree Celsius	°C
foot	ft	0.3048	meter	m
feet per day	ft/d	0.3048	meters per day	m/d
feet per minute	ft/min	0.00508	meters per second	m/s
feet per second	ft/s	0.3048	meters per second	m/s
gallon	gal	0.003785	cubic meter	m^3
gallon	gal	3.785	liter	l
gallons per day	gal/d	3.785	liters per day	l/d
gallons per day per foot	gal/d/ft	12.419	liters per day per meter	l/d/m
gallons per day per square foot	gal/d/ft^2	40.746	liters per day per square meter	l/d/m^2
gallons per hour	gal/h	3.785	liters per hour	l/h
gallons per minute	gal/min	0.631	liters per second	l/s
horsepower	hp	0.7457	kilowatt	kW
inch	in	2.54	centimeter	cm
inch	in	0.0254	meter	m
inches per day	in/d	2.54	centimeters per day	cm/d
inches per foot	in/ft	8.3333	centimeters per meter	cm/m
inches per hour	in/h	2.54	centimeters per hour	cm/hr
inches per month	in/mo	2.54	centimeters per month	cm/mo
inches per week	in/wk	2.54	centimeters per week	cm/wk
inches per year	in/yr	2.54	centimeters per year	cm/yr
parts per million	ppm	is approximately	milligrams per liter	mg/l
pound	lb	0.4536	kilogram	kg
pounds per acre	lb/ac	0.1122	grams per square meter	g/m^2
pounds per acre	lb/ac	1.122	kilograms per hectare	kg/ha
pounds per cubic foot	lb/ft^3	16.019	kilograms per cubic meter	kg/m^3
pounds per square inch	psi	6.895	kilonewtons per square meter	kN/m^2
million gallons per day	Mgal/d	0.4381	cubic meter per second	m^3/s
minutes per inch	min/in	0.3937	minutes per centimeter	min/cm
square foot	ft^2	0.0929	square meter	m^2

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CHAPTER 1—PURPOSE AND OBJECTIVE

Subsurface drip irrigation, or more appropriately for wastewater applications, subsurface drip distribution (SDD) is the most efficient method currently available for application and subsurface dispersal of wastewater to soil. Because it is so effective, drip distribution represents a viable option for wastewater disposal for all soil types. The technology is commonly used at sites where point source discharges and National Pollutant Discharge Elimination System (NPDES) permits are not appropriate due to the environmental sensitivity of receiving streams. It is also commonly used at sites where conventional drainfields are not appropriate due to site constraints such as shallow soils above a restrictive layer (e.g., rock, groundwater, hardpan, etc.), steep slopes, or clay soils with low permeability.

Until recently the only guidelines for design, operation, and maintenance of these systems have been the basic information provided by manufacturers and suppliers of drip tubing and related system materials. The most recent versions of this information include guidelines from Geoflow, Netafim, Waste Water Systems, Inc. (WWSI), American Manufacturing Company, Inc. (AMC), and Delta Environmental Products, Inc. (DEP) [1,2,3,4,5]. In addition, the National On-Site Wastewater Recycling Association (NOWRA) recently developed a more comprehensive set of guidelines in the form of a regional workshop manual and a technical practice standard [6,7]. However, none of these documents have undergone a peer review process to establish the state-of-the-art for the technology.

This is the objective of this project. Establishing the state-of-the-art will address the following aspects of the technology:

- Siting, design, performance, operation, maintenance, monitoring, and costs.
- Hydraulic and mass loading rates based on both soil and wastewater characteristics.
- Adapting the design process to a spreadsheet method that standardizes basic steps and helps prevent errors.
- Providing design criteria with acceptable ranges to increase flexibility for applying to special conditions (e.g., rolling and steep terrain, obstacles, shallow soils, clay soils, etc.).

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CHAPTER 2—APPROACH

The approach to the project included nine basic activities:

1. Develop the project's detailed outline, scope, and approach and select the Peer Review Team (PRT).
2. Identify and visit representative projects.
3. Summarize existing design, performance, operation, maintenance, monitoring, and cost information (including review of information by a representative of each project).
4. Identify key design issues and summarize corresponding background information.
5. Identify any **short-term** special studies that may be critical to resolving these issues and implement as necessary (using university soil science departments or other credible researchers).
6. Develop design approach and rationale to each issue (use spreadsheet methods where practicable).
7. Develop representative Computer-Aided Design (CAD) drawings (using AutoCAD software) needed for detailed design of each system component.
8. Develop detailed guidelines covering design, construction, operation and maintenance (O&M), costs, and performance monitoring.
9. Technology transfer.

Activity 1: Develop detailed outline, scope, and approach, and select the Peer Review Team (PRT)

Plans for implementing each activity were developed and revised based on changes in scope or redirection of any activity as new information, including direction from members of the PRT, became available.

The PRT was established to ensure that the project was well planned and implemented and that results will be credible and have national significance. The manufacturers of drip tubing specifically intended for wastewater application, Geoflow, Inc. (Geoflow), and Netafim Irrigation, Inc. (Netafim), were requested to provide a list of suggested experts to include on this team. The team consists of the following five experts:

Robert E. Lee, P.E., Loudoun County Environmental Health Dept., Leesburg, VA, retired Environmental Protection Agency (EPA) Engineer, and former Executive Director, NOWRA, Laurel, Maryland

David Morgan, Regional Sales Manager, DEP, Saltillo, Mississippi

Richard J. Otis, Ph.D., P.E., Vice President of Applied Technologies, Ayres Associates, Madison, Wisconsin

A. Robert Rubin, Ph.D., Professor and Extension Specialist, North Carolina State University, Raleigh, North Carolina

Thomas A. Sinclair, President, WWSI, Ellijay, Georgia

Other professionals that reviewed the report and provided valuable input include James F. Kreissl, Environmental Consultant and retired EPA Engineer; Robert B. Mayer, P.E., President, and Tom Ashton, EHS, CPSS, American Manufacturing Co, Inc.; Brian Britain, WWSI., Jean Caudill, R.S., Ohio Department of Health; Garry Grabow, P.E., North Carolina State University; Steven J. Berkowitz, P.E., North Carolina Department of Environment and Natural Resources; David F. Zoldoske, Center for Irrigation Technology, California State University; and John R. Buchanan, P.E., University of Tennessee. Key representatives for Geoflow and Netafim also reviewed and commented on the document.

Activity 2: Identify and visit representative projects

Sites representative of each brand and type of dripline were identified and visited. Geoflow markets two types of wastewater dripline under the name of Wasteflow®: Classic and Pressure Compensating (PC). Netafim markets one brand and type of dripline for wastewater applications: BioLine®, which is a PC dripline.

Other companies may provide a drip distribution system using dripline manufactured by Geoflow and Netafim to their customers under a different name. For example, WWSI, Elijay, Georgia, developed the Perc-Rite® system, which uses Netafim's BioLine®. AMC, Manassas, Virginia, purchased worldwide rights (except for Georgia) to the Perc-Rite® system. Others include DEP, Denham Springs, Louisiana, (Whitewater Preengineered Drip Disposal Systems, which uses Geoflow and Netafim tubing), Hydro-Action, Inc., Beaumont, Texas, (Aqua Drip, which uses Geoflow tubing), and Zabel Environmental Technology, Crestwood, Kentucky (Geoflow tubing). Since there are many other primary distributors and their status may change with time, contact Geoflow (www.geoflow.com) and Netafim (www.netafim-usa.com) for a current list.

Potential sites were identified by Geoflow, Netafim, the PRT, and other applicable sources. Tennessee Valley Authority (TVA) contacted representatives of these systems to obtain basic, preliminary system information and determine whether the system owners were willing to participate in the study. Factors considered in selecting sites included geographical area, soil and site characteristics, age of system, accessibility, system size, wastewater characteristics, filter characteristics, and performance history. A total of 39 sites were visited. Complete documentation of system details was not available for most of the sites. For those with good documentation, eight were selected as case studies. This information is contained in appendix A.

Activity 3: Summarize existing design, performance, operation, maintenance, monitoring, and cost information

Information obtained on each case study site is summarized in appendix A.

Activity 4: Identify key design issues and summarize corresponding background information

Besides documenting basic system and component details, the information collected and assessed focused on the following factors:

- Hydraulic loading rates based on soil characteristics and pretreatment.
- Effect of pretreatment on dripline performance.
- Water balance for the wastewater applied to the soil (short-term storage, evapotranspiration, deep percolation).
- Fate of specific contaminants that may affect system design (e.g., fecal coliforms and nitrates).
- Subsurface movement of the wastewater that can be expected to percolate deeply into the soil.
- Issues related to system operational automation (control panels, automatic flushing, terminal mode communications, etc.).
- Climatic issues that significantly affect system details such as freezing in northern states and evapotranspiration in western states.

Each of the above factors represents an important design and performance consideration, but guidance previously available is very limited.

Activity 5: Identify any short-term special studies that may be critical to resolving these issues and implement as necessary (using university soil science departments or other credible researchers)

Much of the information needed to address adequately the factors identified in Activity 4 is expected to be unavailable. Specific issues were identified during discussions with engineers, university researchers, and drip system representatives. These are listed in chapter 9. Preliminary discussions were held with professors at several universities, but no studies have been initiated.

Activity 6: Develop design approach and rationale to each issue

Design of drip distribution systems is a structured process using basic hydraulic concepts and calculations for determining the layout of the drip fields, required pump characteristics, and peripheral components such as filters and pressure reducers. The process is iterative to match desired hydraulic characteristics to available pumps, pipes, and driplines. Multiple drip field zones and systems may be needed for large flows and variations in soils, slopes, vegetation, sun exposure, etc. To facilitate design and reduce the chance of errors in the design process, a spreadsheet is usually used. The process requires that basic design criteria and acceptable ranges be established. In addition, the spreadsheet needs to be flexible to accommodate new components and devices that may be used to upgrade or improve system performance and operation.

TVA has developed Microsoft Excel spreadsheets that may be useful for this process. One is based on Geoflow tubing and components, and another is provided for Netafim tubing and components. Details are provided on the attached computer disc.

Other useful tools such as water and nutrient balances can also be adapted to spreadsheet calculations. One version of this type of tool is also included on the attached computer disc.

Activity 7: Develop representative Computer-Aided Design (CAD) drawings (through the use of AutoCAD software) needed for detailed design of each system component

To assist engineers in the design of SDD systems and reduce design costs, CAD drawings are needed for typical components. These drawings are available from the component manufacturer or supplier via their Web sites. Scale model drawings is the preferred format using AutoCAD (which is the most common CAD software used by the engineering profession). No additional drawings were needed for this project. Contact the manufacturers and their authorized representatives as needed for these drawings.

Activity 8: Develop detailed guidelines covering performance, design, construction, operation and maintenance (O&M), costs, and monitoring

Guidelines have been developed based on the information obtained from all sources. The scope of the guidelines include performance expectations based on information obtained on representative systems across the country and system design, construction, O&M, costs, and monitoring.

These guidelines have been reviewed and revised based on comments from the PRT, additional experts, Geoflow, and Netafim. Where major controversial issues occurred, alternate perspectives have been provided so that users of the guidelines will have the benefit of all relevant information.

Activity 9: Technology transfer

The guidelines are available for general distribution. They are copyrighted by EPRI, but one of the project objectives is to provide a document that will be readily available to any person interested in the technology free of charge or available for a nominal reproduction and postage cost.

The guidelines are available to download without cost on TVA's Public Power Institute Web site (www.publicpowerinstitute.org/energyuse.html). A limited number of printed copies and computer discs will also be made and distributed upon request to TVA. In addition, design workshops will be conducted after the guidelines are completed to provide hands-on guidance and experience in the design and use of the technology. The guidelines will also be publicized through conference presentations.

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CHAPTER 3—THE SDD CONCEPT FOR WASTEWATER DISPOSAL/REUSE

3.1 Controlled and Uniform Dosing Over the SDD Field

Drip systems represent the best available technology for uniformly dispersing (and reusing) wastewater over a large area beneath the soil surface. A small volume of wastewater is dosed at predetermined time intervals throughout the day to the soil through a pressurized piping network that comes close to achieving uniform distribution over the entire footprint of the dispersal area. The design objective is to minimize or preclude soil saturation while still achieving equal distribution. This optimizes attenuation of any remaining pollutants, dispersal (three dimensionally) of the wastewater through the soil, and plant uptake of the wastewater through their root systems.

This is achieved through use of several key system components; however, it is critical that the technology be considered as an integrated system rather than individual components. Failure or problems with any key component typically results in problems or failure of the overall system. For example, failure of a check valve results in partially dosing the zone that is supposed to remain isolated by the problem valve every time other zones are dosed. This zone will be loaded much higher than designed, typically resulting in surfacing wastewater. Many other examples of how the performance of the system depends on the reliability of individual components (including how well they are operated and maintained) will be provided throughout this report. Consequently, a thorough understanding of each component and how it affects the overall system during both functional and failure modes is critical to the long-term success of a drip system.

The basic components and materials that typically are included in a system include:

- Dripline
- Pumps
- Filters
- Flow meter
- Control system
- Supply line and manifold
- Return manifold and line
- Flexible hose
- Air/Vacuum valves
- Flush valve
- Specialty connectors and fittings
- Valve boxes
- Pressure regulators

If a system has multiple zones, the components may also include:

- Zone valves
- Check valves

Technical terms associated with these components and other aspects of drip systems are listed and defined in the glossary and acronyms section (appendix B).

3.1.1 Tubing and Emitter Types and Performance

A drip distribution system starts with the dripline or tubing and the in-line emitters. The tubing is flexible polyethylene (PE) available in several diameters with a nominal 1/2 inch (in) as the typical size for wastewater application. The tubing is typically sold in 500- and 1000-foot (ft) rolls.

Drip emitters are prespaced evenly along the line with 24-in spacing as the most commonly used. Spacing for special applications include 6, 9, 12, and 18 in (varies by manufacturer), but other options are also available by request. The emitters may be either PC or non-PC turbulent flow.

Selection of the most appropriate spacing of emitters along the drip tubing should be a function of tubing hydraulics and site loading rates. These concepts are explained in more detail in following sections.

PC emitters are available for nominal flow rates, ranging from 0.4 to 1 gallon per hour (gal/h) (varies by manufacturer). A relatively constant drip rate can be obtained for line pressures ranging from about 5 to 70 pounds per square inch (psi). The operating range recommended by the manufacturers is typically smaller (see Geoflow's and Netafim's brochures contained in appendices C and D). A PC emitter designed for use with wastewater uses an elastomeric diaphragm or disk placed over a turbulent-flow labyrinth to reduce variable inlet pressures to a constant outlet pressure and uniform flow rate out the outlet orifice. Higher flow rate emitters typically have larger cross-sectional diameters in the flow path. Details vary based on manufacturer.

Steady flow rates with varying line pressures from PC emitters simplify design of drip fields installed on sites with slopes or rolling terrain. They also allow use of longer laterals compared to non-PC emitters (greater pressures can be used to accommodate greater head losses for the length of tubing, since the emitter flow is uniform over a wider range of pressures). Suggested maximum lateral lengths based on maintaining minimum operating pressures for uniform emitter flow are provided by the manufacturers (Geoflow and Netafim) for each of their dripline models (see appendices C and D). The emitters are also designed and tested to meet industry discharge uniformity standards and manufacturing coefficient of variation. For a more comprehensive presentation on these parameters and their significance to system performance, the reader is referred to literature on agricultural drip irrigation such as the *American Society of Agricultural Engineers Standard EP405-1* or the *B.C. Trickle Irrigation Manual* [8,9].

Non-PC emitters do not employ the elastomeric diaphragm to vary the size of the flow passage with changing pressure. Consequently, pressure changes resulting from friction losses, changes in elevation, and saturated soils around the emitter result in different drip emitter discharge rates. This type of dripline is currently provided by only one manufacturer, Geoflow, for wastewater applications. The dripline model is known as the Wasteflow Classic, which is available in two standard models, 12- or 24-in emitter spacing with a nominal drip rate of 1.3 gal/h. Some designers prefer this dripline, since it has no moveable parts. Design must account for variable emitter flow rates based on lateral length and elevation differences between laterals. Pressure regulators are typically used to obtain similar design pressures at the start of each zone or subzone, lateral lengths are typically restricted to 210 ft or less for the standard emitter spacing (2 ft), and elevation differences are typically limited to 6 ft or less to keep pressure differentials and emitter flow variation within recommended guidelines. Number of laterals per zone must also be limited to assure pressure variations from first to last lateral are minimal and to facilitate adequate flushing velocities throughout the system.

There is disagreement concerning which type of dripline is easier to troubleshoot. The argument for PC tubing is based on the constant flow rate obtained from each emitter for a wide pressure range. With a flow meter, dose volumes and flow rates can be compared to design values to determine the extent of emitter clogging or to detect system leaks. Troubleshooting non-PC systems requires pressure data in addition to flow data because drip rates vary with pressure. Pressure differentials (different from those included in the design process) occur due to clogged emitters and saturated soil around the emitter as a result of dosing. Since pressure reducers are always recommended at the inlet to each zone to non-PC systems, clogged emitters should not cause pressure within the drip tubing to increase above the design inlet pressure. The effect of saturated soils can be significant, variable, and difficult to quantify. In tight soils, pressure around the emitter may deviate from atmospheric at the beginning of the dose (nonsaturated) to relatively high pressures at the end of the dose depending on the type of soil, the emitter drip rate, dose duration, and potential changes in the soil structure based on wastewater dosing.[1] Although these instantaneous pressures should quickly dissipate after a dose cycle as the wastewater is dispersed by gravity and matrix forces, if they occur, they could significantly affect the drip rate from non-PC emitters; and the effect may range from none at the beginning of a dose to very significant at the end of a dose. The net effect would be to lower the drip rate, since the pressure differential between the inlet and outlet of the emitters should be less than design. The high drip rates (1.3 gal/h and higher) for non-PC emitters are also more conducive to soil saturation around the emitters in tight soils. To minimize the problem, the emitter drip rate and dose duration need to be carefully matched to the soil characteristics to minimize the bulb of saturation around the emitter.

The counter argument contends that PC emitters are the most likely type to have variable flow as the systems age due to damage by chemicals, bacterial buildup, and wear and tear on the diaphragm. The diaphragm may also be susceptible to being held open by roots, dirt, and debris, increasing the drip rate. Root intrusion initially opens the diaphragm (increasing flow), followed

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[1] Soil structural changes (including biomats) that could result in hydraulic pressures above atmospheric have been suggested by a small number of people interviewed based on hydraulic conditions discovered during excavation of “failed” driplines.

by a gradual closing of the orifice (decreasing flow). This process may be repeated at other emitters as roots seek new sources of water. As a result, comparing actual flows to design flows may not necessarily provide an accurate reflection of the overall status of emitters, since some may be blocked open with drip rates above design, and some may be partially to completely clogged.[2] However, if a significant deviation is found between actual and design dose flow rates, troubleshooting needs to be expanded to determine the reasons for the deviation (see section 7.2). Most of these potential problems can be minimized through design (i.e., root inhibitors can be incorporated through dripline selection or the filter system; some emitter types have special design features to minimize these types of problems; air/vacuum (A/V) relief valves need to be properly located and sized; and the system needs to be adequately designed for flushing) and O&M (i.e., routine flushing cycles; routine servicing of the A/V relief valves; and periodic comparison of actual dose volumes, flow rates, and system pressures compared to design to determine if chemical cleaning is needed).

The designer should work closely with the manufacturer or authorized representative to determine appropriate design details for the components to be used and site characteristics. Preengineered systems are available from several vendors.

3.1.2 Emitter Selection and Placement

Drip tubing is typically installed at depths of 6 to 12 in below the soil surface. In northern areas, 12- to 24-in burial depths are sometimes used to increase frost protection (using fill over the native soil as necessary). The tubing is typically installed using a vibratory plow, a specially designed chisel-type or static plow, or a trencher. The tubing should always be placed along the contours of the site. Level tubing minimizes potential drain-back and siphoning after a dose. Consideration should also be given to placing as many of the tubing laterals as practicable on the same elevation to minimize potential drain-back and siphoning.

Tubing is typically spaced 24 in apart. In sandy or clay soils or for application of anaerobic effluent, the spacing between driplines may be reduced to 12 or 18 in to wet the total footprint area more effectively and to increase the actual or effective infiltrative surface area.[3] Lateral movement of the wastewater perpendicular to the driplines is restricted in these soil types, but wastewater may effectively follow the drip tubing between the emitters because there is typically a small annular void space between the tubing and the soil created by tubing expansion during

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[2] As with many perspectives included within this document, no published documentation of this phenomenon is available from sources contacted. Widely disparate perspectives on important issues are included to provide users with information on each view. More research is needed to resolve these issues. One major source for technical information on drip technology is the Center for Irrigation Technology, California State University, Fresno, California (559-278-2066, http://cati.csufresno.edu/cit/).

[3] If lateral spacing smaller than 24 in is used, the total footprint area should not be changed. Using smaller lateral spacing increases the amount of tubing and number of emitters within the footprint area. See section 3.2.1 for more information on the actual or effective infiltrative surface area. Not all reviewers agree with this approach. At least one strongly believes that reducing either the emitter or tubing spacing to less than 24 in in clay soils will greatly increase the risk of overlapping wetting fronts and soil saturation (see figures 3-1 and 3-2), particularly if the same dosing time or volume dosed per emitter is used.

dosing or by the installation technique if a static plow is used. These specially spaced applications are currently rare, but they may become more common as the technology is refined and advanced, especially for difficult conditions.

Other spacing intervals may be used by some designers. For example, 5-ft spacing between driplines is used on several systems. The rationale for the greater spacing is an assumed greater effluent storage and pollutant dilution capacity within the application area during the nongrowing season where evaporation is minimal and precipitation may be high. Rainfall and wastewater storage is assumed to be available over an effective area of 10 square feet (ft^2) rather than the typical 4 ft^2 for emitters and tubing spaced on 2-ft centers. For this strategy to be effective, the hydraulic application rate for the system's footprint would need to be proportionally reduced (more than 2.5 times) relative to that used for conventional spacing intervals. When this is not done, the effect is to increase the hydraulic loading for the actual wetted area around the drip emitters. For example, assuming a footprint loading of 0.2 gallons per day (gal/d)/ft^2, the linear loading rate[4] would be 1 gal/d/ft of dripline using 5-ft spacing rather than 0.4 gal/d/ft of dripline using 2-ft spacing. More uniform distribution of the same volume of water and a lower risk of wastewater surfacing will be achieved using the typical 2-ft spacing.

The ideal wetting pattern is shown in figure 3-1. Most experts believe that for most soil types there will be a small zone of saturation immediately around each emitter regardless of effluent quality. The wetted volume from one emitter should approach the boundary of the wetted volume for adjacent emitters, both on the same dripline and parallel driplines. The diameter of the wetted area will generally increase with an increase in the soil clay content (i.e., a reduction in pore size) or an increase in emitter drip rate [9]. The wetted volume for clay soils depends mainly on capillary forces while gravitational forces have a greater effect in sandier soils. The relative effect of soil types on the size and shape of the wetted volume is shown in figure 3-2. A larger lateral spread of the wetting front typically occurs with increasing fines and/or higher drip rates.

As indicated in figure 3-2, one factor influencing the size of the wetted area around the emitters is the volume of water discharged from the dripline. This depends on the drip rate of the emitter selected for the system and the dosing time. Flexibility exists for both of these factors. PC emitters are available for nominal flow rates of 0.4, 0.5, 0.6, 0.9, and 1.0 gal/h. The flow rates for non-PC emitters depend on the actual operating pressures but are typically higher than PC emitters. For example, Geoflow's Wasteflow Classic dripline is rated at 1.3 gal/h at 20 psi.

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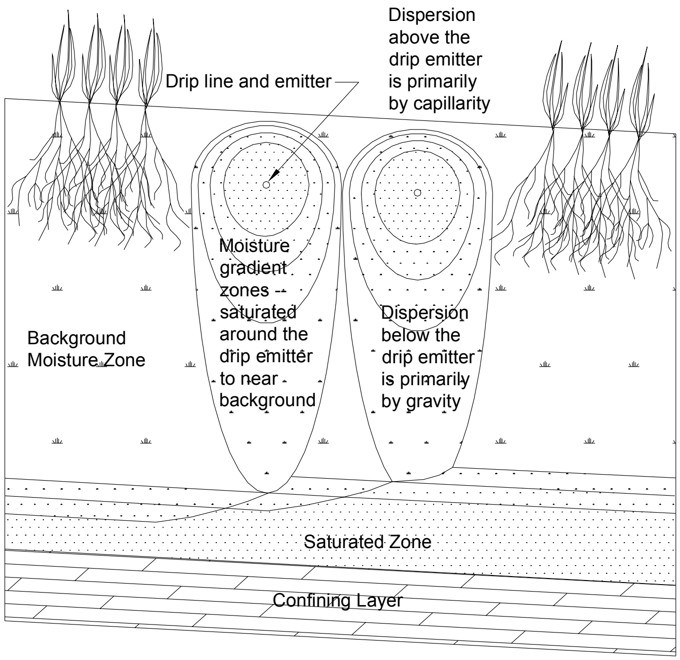
[4] Linear loading rate is used in this document as the hydraulic loading rate per unit measure of length along the dripline. For a given footprint loading rate, the linear loading rate would be obtained by dividing the footprint loading rate by the distance between the driplines or tubing. If there is any significant elevation difference associated with a site, the driplines should be located to the extent practicable along the same elevation or contour and stairstepped up or down the site as needed. The cumulative linear loading for all of the driplines placed along the contours of the site is referred to as the contour loading rate (the linear loading rate multiplied by the number of driplines). The cumulative rate needs to be considered for sites where a shallow restrictive layer may result in horizontal flow.



The relative size and shape of the moisture zones (especially the saturation zone) depends on the soil characteristics and the length of the dosing cycle. These zones are dynamic (changing with time). By the time of the next dose, the saturated zone around the emitters will no longer exist due to moisture losses through drainage, capillary action, and evapotranspiration. If the wastewater is strong enough to form a biomat, the saturated zone will typically stay saturated all of the time. Longer saturation times increase the potential for higher drainback volumes unless the system is designed to minimize this type of problem. For shallow soils, linear loading rates need to be considered to prevent mounding from reaching the drip tubing at the downgradient boundary of the system.

Figure 3-1
Simplified Schematic of Water Gradients and Movement at the end of a Dosing Cycle

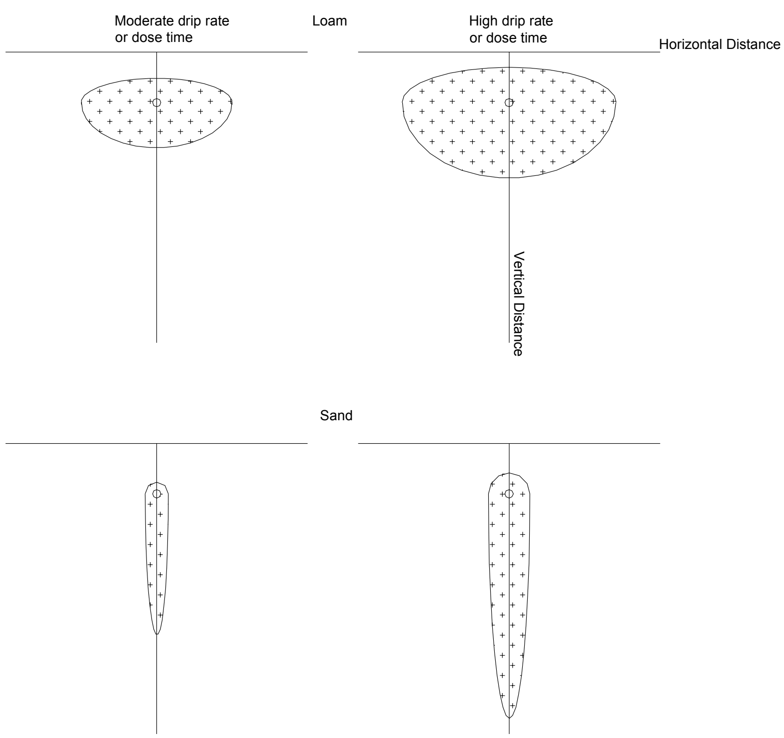


Figure 3-2
Simplified Schematic of Relative Differences in Water Movement for Different Soil Types and Dosing Rates

The success of drip dispersion depends on how successfully the wastewater dose rate and volume is matched to the soil and site characteristics. Poor matches result in either poor hydraulic performance with saturated soils and environmental, public health, and aesthetic problems or a system that is not cost efficient due to significant over-sizing. Both of these problems need to be avoided; however, in reality, this is hard to do because of inadequate technical information. The hydraulic processes are complicated and the number of variables is large. Also, an adequate safety factor always needs to be applied to any design to process excess water that can occur from several sources (including water stored during system repairs). This can be accomplished in several ways. Guidance is provided in the following sections.

3.2 Matching the Dose Rate and Volume to the Soil and Site Characteristics

Drip dispersion is a four-dimensional process involving the three spatial planes and time. Critical factors that affect water movement include types and characteristics of wastewater, soils, boundaries, and vegetation; temperature; precipitation; and drip dosing rate, duration, and cycle interval.

3.2.1 Soil Types and Critical Characteristics

Soil texture and structure must be evaluated to determine appropriate dose rate and volume. Soil texture refers to the relative percentage of sand, silt, and clay-sized particles. Texture affects both the rate of water movement within the soil column and the spatial movement or dispersion. A loam refers to a soil that includes a “balanced” mix of coarse and fine particles with properties that blend those of sand, silt, and clay [10]. As indicated in figure 3-2, water movement is typically slower as the percentage of fine materials (silt and clay) increase. However, horizontal dispersion of water is typically larger as the percentage of fines increases.

Soil structure is defined as the size, shape, and arrangement of aggregates and pores of the soil or to units composed of primary particles [11,12]. The natural soil units are called peds. Water movement and aeration within the soil as well as soil strength and compaction are strongly influenced by structure.

There are four typical types or shape classifications for structural soils:

- Platelike: arranged in relatively thin, flat plates, leaflets, or lenses that are generally horizontal and overlapping.
- Prismlike: vertically oriented prisms or pillars with two subtypes. If the tops of the individual units are angular and relatively flat, the subtype is prismatic. If the tops are rounded, the subtype is columnar.
- Blocklike: polyhedral peds that are usually six-faced with their three dimensions roughly equal.
- Spheroidal or Granular: curved, irregular shape with units that usually are separated from each other.

In general, water movement is rapid in spherical or granular shaped soils, moderate in blocky and prismatic soils, and slow in platy and columnar soils.

Soil structure is also classified by class (the relative size of the peds) and grade (the relative strength and distinctiveness of the peds). There are five classes: very fine (or very thin), fine (or thin), medium, coarse (or thick), and very coarse (or very thick). The grades categories are:

- Weak: poorly formed and indistinct peds that break into a mixture of whole and broken units and much material that exhibits no planes of weakness.
- Moderate: well-formed and evident peds in undisturbed soil that break into a mixture of many whole units, some broken units, and material that is not in units.
- Strong: well-formed and distinct peds that break almost completely into entire peds.

Some soils lack structure and are classified as structureless. These soils may be either single grains or massive. Massive soils are tightly packed in large cohesive blocks such as dried clay, and water movement is slow through them [10].

Because soil particles differ in shape, size, and orientation and because the differences are affected by environmental factors (e.g., climate and biological activity) and disturbance resulting from human activity, structure can be a very complicated factor.

The effect of both texture and structure on infiltration rates considering wastewater quality, site slope, and soil depth or infiltration distance has been summarized by Tyler [13]. The information is reproduced in table 3-1. Suggested infiltration loading rates range from low to zero for massive (one of the structureless grades) and platy soil structures for any soil texture. These rates are for conventional drainfields and not directly applicable for drip distribution because of differences in the surface area hydraulic loading and differences in the reaeration potential of the soil due to the shallow placement and spacing of driplines and the use of timed dosing. The exposed infiltrative surface for conventional drainfields is considered to be the gravel-filled trench width, which is typically either 2 or 3 ft. The corresponding infiltrative surface for driplines is less obvious. By definition, the infiltrative surface is the area where free water meets the soil surface. Lesikar and Converse suggest a value of 1 ft^2 for every 5 linear ft of dripline based on effluent moving along the annular surface of the dripline [6,14].[5] This is equivalent to the area occupied by the pipe circumference (about 2 in or 0.17 ft for the nominal 1/2-in tubing).

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[5] There is a difference in opinion concerning the applicability of this value for the infiltrative surface. One point of view applies it to all drip systems. The other view is that it applies only to septic effluents where biomat formation causes the wastewater to flow along the tubing wall (as the path of least resistance). For this latter view, closer spacing for tubing and emitters is suggested to avoid biomats, resulting in an infiltrative surface that is believed to approach the footprint surface area (1 ft^2 per linear foot of dripline for 12-inch tubing and emitter spacing). Otis and Apfel suggested the value of 1 ft^2 per 5 linear ft of dripline as a minimum for the infiltrative surface area based on observations at five WWSI systems in Georgia in 1994 [14]. The effluent quality (BOD5) for the five sites ranged from higher than typical for septic tank effluent to secondary quality (from 280 mg/l to 20 mg/l) based on a single set of grab samples. Biomats were observed at about half of the excavations. Observed soil colors around the tubing indicated that the extent of reduced conditions (when it occurred) was very limited, typically no larger than a 2- to 4-inch envelope around the tubing. In most excavations, the area around the perimeter of the drip tubing appeared to be the active infiltrative surface.

Table 3-1
Suggested Hydraulic Loading Rates Based on Soil Characteristics for Conventional Septic Systems[1]

Soil Characteristics			Infiltration Loading Rate gal/d/ft²		Hydraulic Linear Loading Rate[2], gal/d/ft — Slope								
	Structure		>30 mg/l	<30 mg/l	0-4% Infiltration distance, inch			5-9% Infiltration distance, inch			>10% Infiltration distance, inch		
Texture	Shape	Grade	BOD	BOD	8-12	12-24	24-48	8-12	12-24	24-48	8-12	12-24	24-48
COS, S, LCOS, LS	--	0SG	0.8	1.6	4.0	5.0	6.0	5.0	6.0	7.0	6.0	7.0	8.0
FS, VFS, LFS, LVFS	--	0SG	0.4	1.0	3.5	4.5	5.5	4.0	5.0	6.0	5.0	6.0	7.0
CSL, SL	--	0M	0.2	0.6	3.0	3.5	4.0	3.6	4.1	4.6	5.0	6.0	7.0
	PL	1	0.2	0.5	3.0	3.5	4.0	3.6	4.1	4.6	4.0	5.0	6.0
		2,3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK /GR	1	0.4	0.7	3.5	4.5	5.5	4.0	5.0	6.0	5.0	6.0	7.0
		2,3	0.6	1.0	3.5	4.5	5.5	4.0	5.0	6.0	5.0	6.0	7.0
FSL, VFSL	--	0M	0.2	0.5	2.0	2.3	2.6	2.4	2.7	3.0	2.7	3.2	3.7
	PL	1,2,3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK /GR	1	0.2	0.6	3.0	3.5	4.0	3.3	3.8	4.3	3.6	4.1	4.6
		2,3	0.4	0.8	3.3	3.8	4.3	3.6	4.1	4.6	3.9	4.4	4.9
L	--	0M	0.2	0.5	2.0	2.3	2.6	2.4	2.7	3.0	2.7	3.2	3.7
	PL	1,2,3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK /GR	1	0.4	0.6	3.0	3.5	4.0	3.3	3.8	4.3	3.6	4.1	4.6
		2,3	0.6	0.8	3.3	3.8	4.3	3.6	4.1	4.6	3.9	4.4	4.9
SIL	--	0M	0.0	0.2	2.0	2.5	3.0	2.2	2.7	3.2	2.4	2.9	3.4
	PL	1,2,3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK /GR	1	0.4	0.6	2.4	2.7	3.0	2.7	3.0	3.3	3.0	3.5	4.0
		2,3	0.6	0.8	2.7	3.0	3.3	3.0	3.5	4.0	3.3	3.8	4.3
SCL, CL, SICL	--	0M	0.0	0.0	-	-	-	-	-	-	-	-	-
	PL	1,2,3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK /GR	1	0.2	0.3	2.0	2.5	3.0	2.2	2.7	3.2	2.4	2.9	3.4
		2,3	0.4	0.6	2.4	2.9	3.4	2.7	3.0	3.3	3.0	3.5	4.0
SC, C, SIC	--	0M	0.0	0.0	-	-	-	-	-	-	-	-	-
	PL	1,2,3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK /GR	1	0.0	0.0	-	-	-	-	-	-	-	-	-
		2,3	0.2	0.3	2.0	2.5	3.0	2.2	2.7	3.2	2.4	2.9	3.4

Notes:
1. © 2000 by E. Jerry Tyler, printed with permission.
2. The hydraulic linear loading rate is applied to the total trench width of the drainfield and is equivalent to the contour loading rate as used in these guidelines.
3. Values assume wastewater volume of >150 gal/d/bedroom. If horizon consistence is stronger than firm or any cemented class or the clay mineralogy is smectitic, the horizon is limiting regardless of other soil characteristics.
4. Texture abbreviations: COS = coarse sand, S = sand, LCOS = loamy coarse sand, LS = loamy sand, FS = fine sand, VFS = very fine sand, LFS = loamy fine sand, LVFS = loamy very fine sand, CSL = coarse sandy loam, SL = sandy loam, FLS = fine sandy loam, VFSL = very fine sandy loam, L = loam, SIL = silt loam, SCL = sandy clay loam, CL = clay loam, SICL = silty clay loam, SC = sandy clay, C = clay, SIC = silty clay
5. Structure abbreviations: PL = platy, PR = prismatic, BK = blocky, GR = granular, 0SG = structureless single grain, 0M = structureless massive, 1 = weak, 2 = moderate, 3 = strong

Based on a typical 2- by 2-ft emitter and tubing spacing, the infiltrative surface area would be only about 0.4 ft^2 rather than the 4 ft^2 footprint surface area. Consequently, converting the typical drip application rates from a footprint basis to an infiltrative surface basis, the loading rates would be about 10 times higher than those used for conventional drainfields. Similarly, if the infiltration loading rates in table 3-1 were applied to the annular surface area around drip tubing, the corresponding application rate per emitter would be much lower than those suggested by the dripline manufacturers. For example, the suggested infiltration loading rate from table 3-1 for loam with good structure (prismatic, blocky, or granular) is 0.6 gal/d/ft^2 for treated wastewater (biochemical oxygen demand [BOD] less than 30 milligrams per liter [mg/l]). Using the infiltrative surface area for drip tubing of 1 ft^2 per 5 linear ft, the corresponding number of emitters serving this 1 ft^2 area would be 2.5 (at a 2-ft emitter spacing). The equivalent emitter application rate would be 0.24 gal/d per emitter (0.6 gal/d/ft^2 ÷ 2.5 emitters/ft^2) for the standard 2-ft emitter spacing. Geoflow's suggested application rate for loam is 0.7 gal/d/ft^2, but the rate is a footprint rate. Since each emitter is typically expected to cover an area of 4 ft^2, the equivalent emitter application rate is 2.8 gal/d per emitter (0.7 gal/d/ft^2 x 4 ft^2/emitter). This is almost 12 times higher than the equivalent emitter rate obtained from converting Tyler's suggested infiltration loading rate for conventional drainfields. Alternately, if the infiltrative loading rates for conventional drainfields are converted to a footprint basis, the rates would be reduced by about one-third, since trenches are typically spaced three times the width of the trench on a center-to-center basis. This would result in a footprint application rate of 0.2 gal/d/ft^2 for the 0.6 gal/d/ft^2 infiltrative loading rate for conventional drainfields compared to the 0.7 gal/d/ft^2 footprint application rate suggested by Geoflow for similar soils (Netafim's suggested footprint application rate for a loam with moderate to strong structure is 0.5 gal/d/ft^2). Consequently, comparison of application rates needs to be done on an equivalent basis, or they may be very misleading. Loadings based on wetted surface area are typically not the same as average footprint loadings.[6] Also, when comparing and using application rates, it is very important to know the applicable design flows that the rates are based upon. Application rates are typically based on conservative design flows that are several times higher than actual average flows. Typical design values are 150 gal/d/bedroom or 450 gal/d for a three-bedroom house and 600 gal/d for a four-bedroom house while actual flows for homes built after 1994 are closer to 108 to 168 gal/d per home based on typical average daily wastewater flows of 40 to 60 gallons/person/day with an average occupancy of 2.7 persons per home [15]. If actual flows are used for design, appropriate peaking factors or flow equalization need to be considered to ensure that periodic maximum or peak daily flows do not exceed the capacity of the drip system; otherwise, adjusted application rates may be needed to obtain an equivalent footprint area. A typical drip system can readily process or attenuate peak hourly flows, but peak daily flows need special consideration (see the design examples in chapter 5).

As reflected in Tyler's table, the soil depth is a key consideration for design of either a conventional drainfield or a drip system. The cumulative hydraulic linear (or contour) loading rate must not exceed the ability of the soil profile to move the water away from the site,

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[6] Footprint hydraulic loading is used in this document to describe the hydraulic loading rate on a surface area basis. "Landscape" and "areal" are other terms that have been used in other sources for the same purpose. These are equivalent terms.

preferably saturating only a portion of the available soil profile beneath the dripline. This concept is more fully addressed in the following section.

3.2.2 Water Balance Considerations

The ideal situation for dispersal of wastewater into soils is to obtain equal distribution over the entire area to be used with as small a dose as possible so that ample oxygen is present at the start of the dose to satisfy the oxygen demand of the applied wastewater. There must be sufficient time between doses to replenish the oxygen before the next dose. The zone of saturation is spatially and temporally limited (as depicted in figures 3-1 and 3-2). This provides the best conditions for attenuation of most pollutants.[7] Damage or alteration of soil structure is minimized, and the soil column remains aerated.[8] Aerobic conditions optimize microbial breakdown of organic pollutants.

Good dosing procedures also contribute to nonsaturated film flow (by a negative or suction pressure gradient) over soil particle surfaces. This enables more intimate contact between pollutants and the soil, facilitating purification. Film flow also ensures the longest retention time within the soil. Depending on performance requirements, soil retention time may control application rates and dosing volumes and frequencies.

Dosing must be done correctly to preclude potential hydraulic problems within the system. As the frequency of dosing increases, the potential also increases for saturating the soil around drip laterals at lower elevations as water drains from laterals at higher elevations following each dose. This is referred to as "drain-back." Design approaches and methods for avoiding this problem are summarized in section 5.6.2.

Saturation of the soil by wastewater typically results in anaerobic conditions, which are not conducive to effective pollutant attenuation (nitrates are a very significant exception). This is primarily related to limited oxygen for microbial activity, but water and, therefore, pollutants also move faster due to differences in hydraulic conductivity between unsaturated and saturated soils. All of the pores are water filled and conducting when saturated, and conductivity is at a maximum. Unsaturated soils contain air filled pores, reducing the conductive portion of the cross section. The largest pores are also the first to drain, which increases tortuosity, since flow is restricted to the smaller, less conductive pores [10]. The cumulative effect is slower water movement in unsaturated soils within each structural class.[9] There will also be less contact of

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[7] There are significant exceptions such as nitrates. Nitrates are typically removed through the denitrification process, which requires anaerobic conditions with an adequate carbon source.

[8] There may still be significant physical, chemical, and biological changes in the soil because the hydraulic flux is one to two orders of magnitude higher than normal.

[9] Unsaturated sand can conduct more water than saturated clays at low moisture tensions. The description of the relative movement of water for saturated and unsaturated soils is intended for soils with similar textural and structural characteristics.

pollutants with soil surfaces under saturated conditions. This adversely affects treatment because of the lack of access to chemi-absorption sites.

Soil saturation also increases the potential for altering or damaging soil structure. For fine textured soils, emitter rates that result in soil saturation "force" the water through the soil (by the positive pressure gradient that is analogous to the pressure gradient across the drip emitter) and may wash or move fines to the outer boundary of the saturated zone, possibly destroying soil structure with time and creating a hardpan that would be hydraulically equivalent to a biomat. Studies are needed to determine if saturated flow actually causes this progressive type of failure and, if so, to identify design solutions to prevent the problem (such as new dripline options with lower emitter rates or use of sand as a secondary distribution method on top of fine textured soils).

Structural soil damage may occur with any drip system where the instantaneous loading rate results in soil saturation around the tubing; however, anaerobic drip systems may have a greater potential for damaging the soil structure. The higher organic loading rates are more likely to create a biomat around the drip tubing.[10] A biomat slows drainage and may increase the hydrostatic pressure around or outside the drip tubing during the wastewater dose, contributing to movement of soil fines to the biomat zone or creating preferential flow channels that can result in water surfacing above the drip tubing.[11] It may also extend the time that the soil around the tubing remains saturated between doses.

Biomat formation may be minimized by increasing the infiltration surface area.[12] This should be the objective for anaerobic drip systems. Drip rates and dosing volumes should typically be selected to allow aerobic treatment in the soil of anaerobic effluent.

Soil fauna (worms, insects, etc.) are believed to have an important role controlling the hydraulics of the biomat over the long term [16]. The fauna are attracted by the moisture (if less than saturated) and the nutrients, but oxygen must also be available. They bore into the biomat and help to keep it open. This activity may be very significant around driplines and may be one of the reasons that drip fields can be loaded at much higher rates than conventional septic systems

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[10] Design procedures are typically modified for application of septic effluent. These are covered in the next section, but they include one or more of the following: increasing the footprint area, increasing the number of emitters, and decreasing the spacing between driplines. These methods more effectively spread the organic load to the soil around each emitter. One peer reviewer believes that it is not necessary to revise design procedures assuming that the footprint application rates are conservatively based on the soil characteristics.

[11] Preferential flow channels are not necessarily associated with biomats. They may occur at any time the soil structure is altered by animals, vegetation, or human activity. They are particularly prevalent immediately following system start-up when the soil structure is altered due to installation of the drip tubing and instantaneous loadings are high before a biomat is created.

[12] Biomat considerations remain controversial with several unresolved aspects. At least one peer reviewer believes that biomat formation cannot be avoided and that a biomat is not necessarily a "bad" thing, since it helps distribute water along the dripline; it is composed of fauna that help remove fecal indicators; and the organics added can help in ped formation. There is consensus that the "degree" of biomat formation can be controlled through design of the drip system.

(on an equivalent basis, see section 3.2.1). Plant roots, which are attracted to the moisture and nutrients, will also improve soil characteristics.

There are also other hydraulic issues related to zones of saturation. A saturated zone around the drip emitters may not allow the driplines to drain naturally to surrounding soils between doses, keeping both the driplines and the supply line filled with water (assuming check or isolation valves function correctly). A system without isolation valves or with failed valves may find excessive volumes of water drained back to the dosing tank between dose cycles, since water may drain from the soil back through the emitters into the drip distribution piping. On the other hand, drip systems designed to minimize the zone of saturation around the emitters do allow good drainage of water from the driplines between doses.

Existing information is adequate to allow rough estimates for what happens to the volume of water that would be dosed from a drip emitter. Assuming that the drip system is installed within the vegetative root zone, a portion of the water will be used by the vegetation. Most of the water taken by the plants will be evapotranspirated to the atmosphere. How much of the water used by the plants depends on how well the dosed volume matches the needs of the plants. This varies based on the maturity and density of the plants and the relative time or location within the growing season, atmospheric conditions such as sunlight, temperature, relative humidity, etc., and the amount of available soil moisture due to natural precipitation.

Examples of estimated monthly potential evapotranspiration for various regions in the United States are provided in tables 3-2 and 3-3. These values range from 0 during winter months with snow coverage to about 24 centimeters per month (cm/mo) for pastures in arid environments during July. Annually, the amount of water that will be evapotranspirated ranges from about 61 centimeters per year (cm/yr) in relatively humid areas such as Brevard, North Carolina, and Hanover, New Hampshire, to 149 cm/yr in the San Joaquin Valley, California. However, if the design is based on evapotranspiration and percolation, a complete water balance must be made to account for months with heavy rainfall when the system must be capable of either storing or dispersing the excess water.

State regulatory agencies that are responsible for permitting drip systems as land application systems (rather than septic or on-site systems) may require drip system design to be based on water and nutrient balance calculations for the site. Monthly estimates are made for evapotranspiration, percolation, and precipitation. Runoff should also be included in the calculations (but typically is not), since a large percentage of precipitation typically does not soak into the ground. The allowable percolation rates are typically only a fraction of the saturated vertical hydraulic conductivity. The allowable drip hydraulic application rate is then calculated for each month. The size of the drip field is based on the amount of area needed to apply safely all of the wastewater during periods when net evapotranspiration is at the minimum (typically winter months). As with other land application systems, the provision of effluent storage capacity during wet weather periods could be used to reduce the total field size requirement or enable some sites that are seasonally too wet still to be utilized. These approaches minimize the potential for undesirable saturated soil conditions. The allowable percolation rates are not adjusted based on effluent quality; however, the footprint hydraulic application rate may need to be adjusted based on the nutrient balance for the site. The wastewater percolate is typically limited to a maximum of 10 mg/l as nitrate nitrogen. An example design is provided in section 5.3.7.

Table 3-2
Examples of Estimated Monthly Potential Evapotranspiration for Humid and Subhumid Climates

	Centimeters					
Month	**Paris, TX**	**Central MO**	**Brevard, NC**	**Jonesboro, GA**	**Hanover, NH**	**Seabrook, NJ**
Jan	1.5	0.7	0.2	1.3	0.0	0.2
Feb	1.5	1.3	0.3	1.3	0.0	0.3
Mar	3.6	3.0	2.1	3.0	0.1	2.0
Apr	6.8	6.6	4.6	5.8	2.9	4.0
May	9.9	10.8	7.6	10.9	8.2	7.4
Jun	14.7	14.5	10.2	14.7	12.9	11.4
Jul	16.0	16.9	11.4	15.7	13.7	13.9
Aug	16.2	15.2	10.4	15.0	11.9	13.6
Sep	9.7	10.3	7.4	10.9	7.4	9.9
Oct	6.4	6.3	4.6	5.8	4.0	4.9
Nov	2.7	2.6	1.6	2.5	0.3	2.1
Dec	1.4	1.1	0.3	1.3	0.0	0.3
Annual	90.4	89.3	60.7	88.2	61.4	70.0

Source: Process Design Manual, Land Treatment of Municipal Wastewater [17]

Table 3-3
Consumptive Water Use and Irrigation Requirements for Selected Crops at San Joaquin Valley, California[1]

	Pastures or Alfalfa[2]	
	Depth of Water (cm)	
Month	Consumptive Use	Irrigation Requirements
Jan	2.3	3.0
Feb	5.1	6.9
Mar	9.7	13.0
Apr	13.2	17.8
May	17.8	23.9
Jun	21.8	29.2
Jul	23.9	32.0
Aug	22.1	29.7
Sep	14.7	19.8
Oct	10.9	14.7
Nov	5.1	6.9
Dec	2.5	3.3
Total	149.1	200.2

1. Other crops having similar growing seasons and ground cover will have similar consumptive use.
2. Estimated maximum consumptive use (evapotranspiration) of water by mature crops with nearly complete ground cover throughout the year.

Source: *Process Design Manual, Land Treatment of Municipal Wastewater* [17]

Any amount of water applied to the soil that exceeds the effective soil water storage or holding capacity will be loss to either surface drainage or deep percolation. A guide for storage or holding capacity based on textural class is provided in table 3-4. The capacities range from 1 in of water per ft of soil for sand to 3 in per ft for organic soils.

Table 3-4
Guide to Available Water Storage Capacities of Soils

	Available Water Storage Capacity	
Textural Class	**(in of Water/ft of Soil)**	**(cm of Water/Meter of Soil)**
Sand	1.0	8.3
Loamy Sand	1.2	10.0
Sandy Loam	1.5	12.5
Fine Sandy Loam	1.7	14.2
Loam	2.1	17.5
Silt Loam	2.5	20.8
Clay Loam	2.4	20.0
Clay	2.4	20.0
Organic Soils (muck)	3.0	25.0

Source: *B. C. Trickle Irrigation Manual* [9]

As reflected by the water balance calculations, a relatively large percentage of the water applied to the soil will eventually percolate to a restrictive layer or a water table beneath the drip system. The restrictive layer may be in the form of rock or a relatively impermeable soil layer such as a hardpan or massive clay. Depending upon site conditions and the system design, groundwater mounding may occur. Mound heights will be greatest in low permeability soils and shallow restrictive layers with flat slopes [18]. Mounding becomes critical if it extends into the allowable, regulatory separation distance between the bottom of the dripline and the restrictive layer (groundwater in this instance–see figure 3-1).

There are differences in opinion concerning the need for a detailed evaluation of the mounding potential, partly because the mounding analysis is complex; detailed data are needed that are typically expensive to obtain and are not readily available; and wastewater flows are often an insignificant component of the site's total hydrology (except for large systems). Also, the assumptions used in the models rarely compare well to the physical characteristics of most sites. Methods normally used for the analysis are described by Finnemore [18,19]. In addition, simplified techniques for preliminary estimates have also been proposed [20,21]. In practice, mounding analysis is rarely done.[13] However, designers that are aware of the potential problems will incorporate design features that reduce mound heights. These include dividing the disposal area into widely separated subareas and enlarging or elongating the field (parallel to the surface contour). Drip system design is particularly adaptable to these concepts.

[13] In North Carolina, mounding analysis is required for level sites, and lateral flow analysis is required for sloping sites for all large (>3000 gal/d) and many smaller drip systems (including residential) on the most limiting sites.

Rather than performing a complex mounding analysis, contour hydraulic loading rates based on experience or calculations based on Darcy's law are more often used to minimize water mounding beneath a disposal field. In effect, these methods elongate the disposal system relative to site contours. Using experience with Wisconsin mounds, hydraulic contour loading rates range from about 1 to 10 gal/d/ft [22]. The lower portion of the range is suggested when flow is primarily horizontal because of a shallow restrictive layer or limiting condition such as seasonal saturation or bedrock. Note that the contour loading rate is considered to be a cumulative value for the soil profile at the downgradient end of the disposal system (i.e., total design flow applied along the maximum length of the disposal system, which in this case is the basal length of the mound; for a drip system it would be length of the longest drip run). Also, contour loadings are strictly a hydraulic consideration and are not dependent on effluent quality.

The actual contour loading for a drip system depends on its configuration or layout as shown in figures 3-3 and 3-4. The potential rise in the water table based on deep percolation of the wastewater to the restrictive layer should always be below the minimum acceptable nonsaturated depth established for the system.

Tyler has adapted this information to provide more detailed guidelines for any type of wastewater distribution system based on soil texture and structure, slope, and depth, as shown in table 3-1. Note that the loadings are not based on effluent quality.

Horizontal flow depths can also be estimated using Darcy's law:

$$Q = kiA$$

Where: Q is the flow rate
k is the horizontal hydraulic conductivity of the soil
i is the hydraulic gradient
A is the vertical cross-sectional area for the flow

For example, for a design flow of 1000 gal/d applied along a strip 200 ft long on a site with soils with a horizontal permeability of about 3 ft/day (roughly equivalent to a loamy soil) and a hydraulic gradient of 2%, the thickness of soil beneath the system available to laterally transmit effluent would need to be at least 11 ft. The hydraulic contour loading rate for this application would be 5 gal/d/ft. On a more sloping site with a hydraulic gradient of 4%, the required thickness of effluent-transmitting soil beneath the system would be half as much (5.6 ft), but the contour loading rate would remain the same.

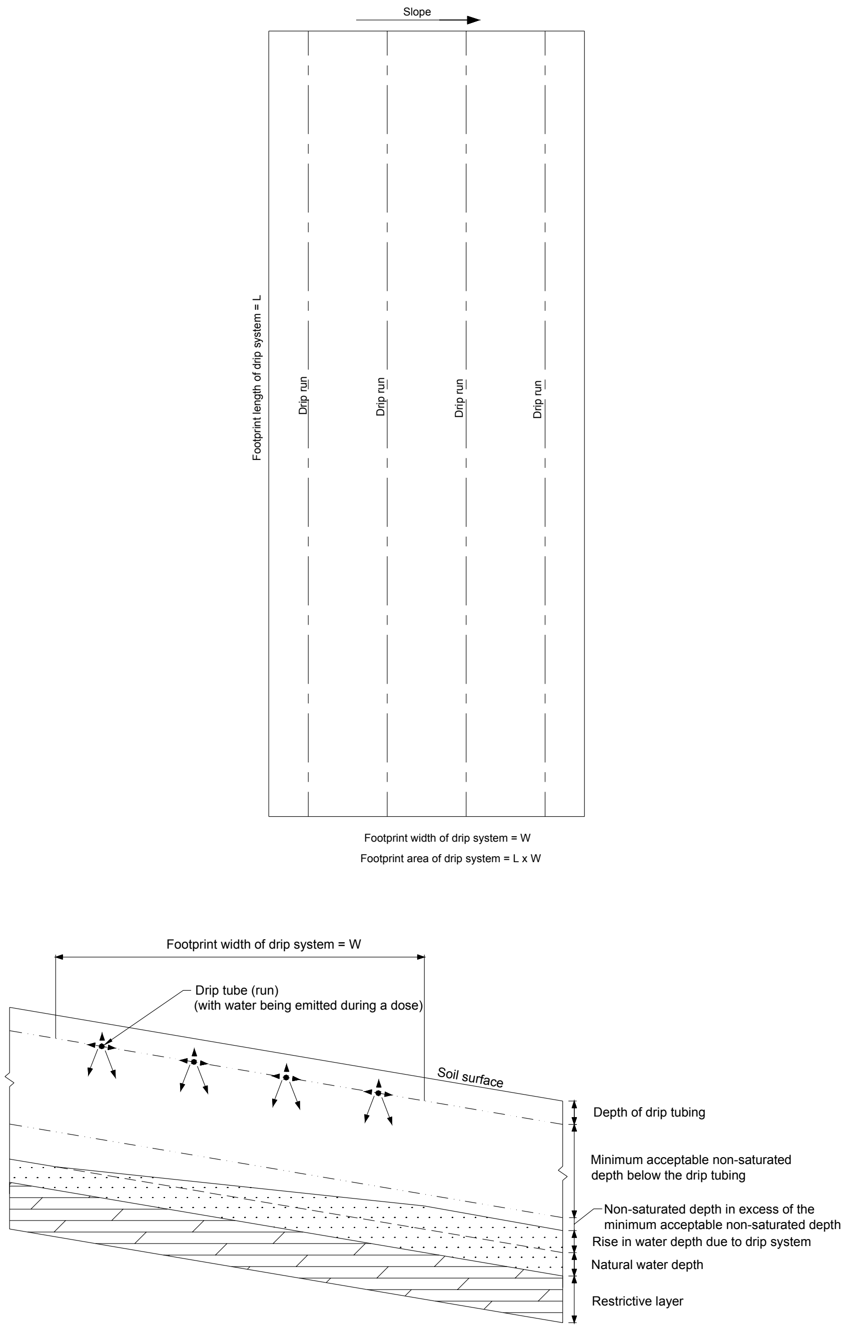

Figure 3-3
Contour Loading Concept

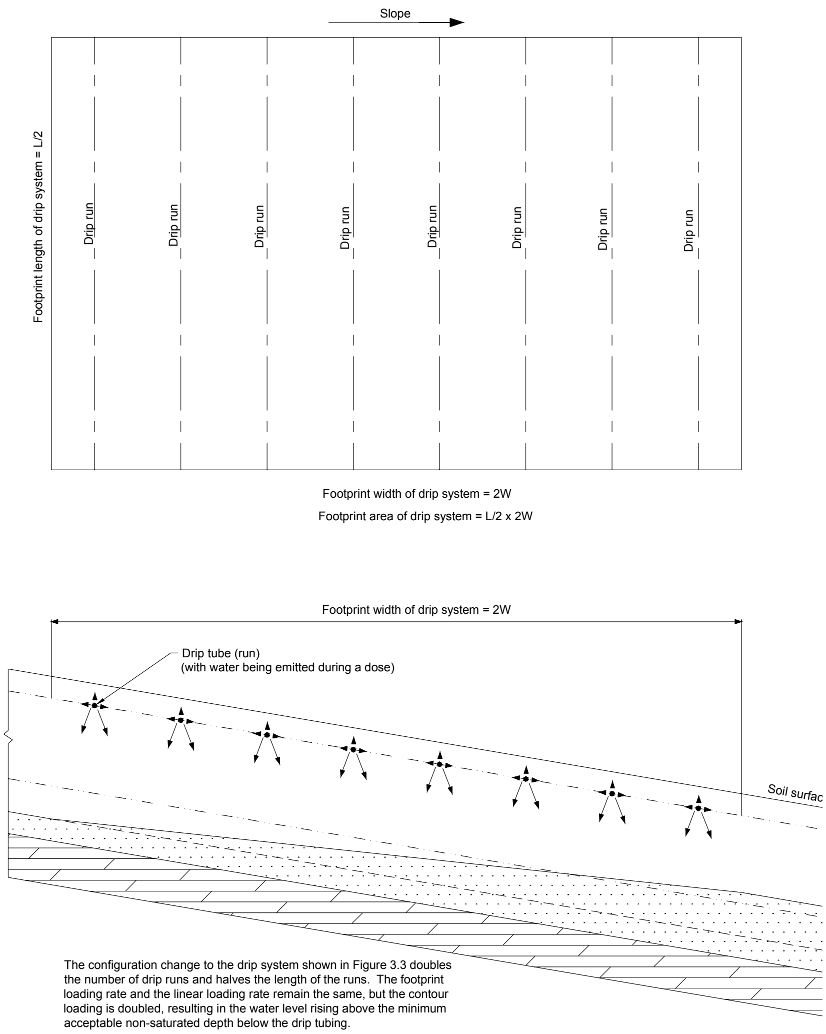

Figure 3-4
Configuration Effects on Contour Loading

These types of estimates are mostly useful for preliminary planning and determining basic design approaches, since they do not account for major site-specific factors including the water balance (rainfall, evapotranspiration, runoff and runon, subsurface saturation and flow due to naturally occurring drainage from above the system, and percolation and preferential flow paths in the restrictive layer are not considered). Another limitation is the accuracy of the values for horizontal permeability and the hydraulic gradient, which would typically only be measured on larger project sites.[14]

It may be very difficult or impossible to meet the contour loading rates suggested by Converse and Tyler for a large system at a site with shallow soils. For this situation, evaluation of the types

[14] As noted previously, North Carolina requires this type of analysis for many of the sites for smaller drip systems, since these are usually the most marginal, and mounding (level sites) or lateral flow (sloping sites) can significantly impact projected system performance.

and extent of redoximorphic features at the rock interface and use of saturated conductivity values for the rock type and degree of weathering can be useful in estimating leakage to the rock layer. In general, bedrock with some fracturing and few redoximorphic features (mottles) can be assumed to have good potential for saturated vertical leakage. In addition to using a longer layout along the contour, footprint loading rates may also need to be significantly reduced for these types of sites (increasing the total area needed). Values suggested by AMC are 1 to 2 in per week (in/wk) (0.09 to 0.18 gal/d/ft^2) for loamy soils, decreasing to 1/2 in/wk (0.045 gal/d/ft^2) for shallow clayey soils and increasing to 3 in/wk (0.27 gal/d/ft^2) for deep sandy soils [23].

3.2.3 Wastewater Quality Considerations

A key issue for wastewater drip distribution technology is the level of treatment that should be provided prior to the drip system. Several technology experts believe that systems using septic tank effluent are the most reliable and cost effective, while others believe that the drip system should only be designed to dispose of secondary or higher quality effluents. There are also some designers that will use either approach depending on site conditions and regulatory requirements.

There are obvious pros and cons to each approach. Systems designed for septic tank or primary effluents (referred to as “anaerobic”) eliminate the capital and O&M costs associated with secondary or advanced treatment (referred to as “aerobic”), but typically require a larger drip system. Considering only the drip component of the overall treatment and disposal system, there are only a few major differences in design and O&M between the anaerobic and aerobic drip approaches. The soil hydraulic application rates are typically lower for primary effluent, resulting in a larger drip system. There may also be many more emission points, since emitter and line spacing may be closer in a larger footprint area. This approach is based on biomat considerations and the need to assure that the oxygen demand of the wastewater can be readily met [6]. Since the oxygen demand is very low for aerobic effluents, it is assumed that the footprint hydraulic loading rate can be higher than for anaerobic effluent. However, an alternate perspective is that the footprint loading rate is strictly a landscape loading issue and should not depend on effluent quality. Under this approach, higher organic loads are addressed by increasing the infiltration surface area rather than the footprint size. This is accomplished by adding more dripline but keeping the footprint loading the same. The spacing of the driplines is reduced from the typical 24-in separation distance to 12 or 18-in (although this may be dependent on soil characteristics). One option keeps the standard 24-in emitter spacing and uses the infiltrative surface area of 1 ft^2 per 5 linear ft of dripline (see section 3.2.1). Another option reduces both the tubing and emitter spacing to 12-in and assumes an infiltrative and treatment surface area of 1 ft^2 per linear ft of dripline (but still retaining the overall footprint size based on the conventional 4 ft^2 per emitter). This reduces the daily or per emitter loading rate by a factor of four compared to the conventional 24- x 24-in pattern. Some systems installed in North Carolina use the 2-ft tube spacing and 18- or 12-in orifice spacing to reduce total run times and total orifice loadings without changing the infiltrative or treatment surface area so the portion of the dose delivered under pipe-full conditions can remain high.

Filtering and flushing for any type of drip system are critical. These functions are typically automated for larger systems. The filter system for anaerobic effluents is larger than for aerobic systems because of higher solids and organic loading rates. The flushing frequency for filters and drip zones is dependent on effluent quality. The relative frequencies are typically much greater for anaerobic designs. Filters are typically flushed at the start of each dosing cycle and zones are typically flushed after about 20 to 50 dosing cycles. Flushing for systems following media filters or fixed film processes is typically much lower. Filters may be flushed once per day or once every six months, and zones are typically flushed once or twice per year. For activated sludge processes, the filter flushing frequency may also be high because the systems are typically not as stable or robust and have a history of “burping” solids. Sand filters may be used following this type of treatment system to provide additional filtering capacity. Frequent flushing intervals increase the hydraulic load on the treatment process, since the flush water is recycled.

Advocates for the aerobic type of system typically consider these systems to be much more “robust” over the long term; however, advocates for the anaerobic approach make the same claim, arguing that anaerobic effluent is much more consistent in quality from day to day than the effluent from some aerobic treatment systems. Since the drip system is designed for handling anaerobic effluent, the system operation may be more reliable on a daily basis than that for an aerobic system where the effectiveness of biological treatment may be more sensitive to O&M, toxics, flow surges, freezing temperatures, etc.

Environmentally, there are some major differences in perspectives for what happens between the two types of systems once the wastewater is dripped from the emitter. The different perspectives apply to soil hydraulics as well as pollutant attenuation.

There is general agreement that high organic concentrations can result in a biomat around the drip tubing. This occurs when the oxygen demand cannot be met within the immediate area around the emitter [6]. However, there is not agreement or consensus on the importance of the biomat with respect to either hydraulics or pollutant attenuation. One perspective contends that the biomat will typically occur with currently recommended loading rates and, like a conventional septic system, is essential for good treatment of anaerobic drip effluents. Another viewpoint (unanimously endorsed by the peer reviewers) is that drip technology provides the opportunity to control the hydraulic and organic loading around the emitters so that the oxygen demand can be met. It also allows better control of soil moisture so that moisture tension can be kept high. This results in a long residence time in the unsaturated zone. Therefore, the clogging mat can be minimized. Drip systems should be designed so that soil moisture tension is high beneath the drip tubing (flow will be predominately aerobic, nonsaturated, film flow[15]) to allow the soil and its fauna to remove pollutants within 2 to 3 ft of the drip tubing. This assures that both hydraulic and pollutant attenuation processes are optimized from an environmental perspective.

Performance of drip systems using anaerobic effluent have been reported by Otis and Apfel; Rubin, et al.; McCarthy, et al.; Jnad; Bohrer and Converse; Berkowitz; Sievers and Miles; and Hayes [14,24,25,26,27,28,29,30].

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[15] Soil may be temporarily saturated within a small bulb around the emitter, but the wastewater within this bulb should disperse so that the area is reaerated and nonsaturated by the time of the next dose.

Advocates for aerobic drip systems emphasize that the primary function of the soil around the drip system is dispersal of the wastewater. This perspective typically assumes that wastewater has already been treated prior to the drip system to meet performance-based standards based on environmental and health protection. These systems are typically permitted as land application systems under a state's applicable point source discharge permitting authority rather than as "septic systems" approved under the various health department authorities. Only a few state health departments have adopted performance standards for on-site or decentralized wastewater systems; however, this may change after NOWRA completes the model performance-based code.

Under a performance-based permit that requires secondary or advanced treatment, it is typically assumed that the hydraulic capacity of the soils may be utilized for moving a greater volume of wastewater through the soil profile, since the oxygen demand of the wastewater is very low [6]. An opposing viewpoint contends that the soil hydraulics for dispersing either type of effluent should be identical because both approaches attempt to balance the volume of wastewater to the soil characteristics so that nonsaturated film flow occurs rather than saturated flow. Additionally, even with film flow, application rates should be low enough that groundwater mounding never exceeds seasonal limits. For highly treated effluents, a nonsaturated zone of at least 12 in is still desired at all times below the drip emitters. How to achieve this with certainty is still difficult based on our current state of knowledge.

If the aerobic treatment system does not include effective pathogen removal or disinfection, soil depths greater than 12 in may be needed to reduce public health risks. The combination of higher loading rates and fecal coliform concentrations in the effluent may result in greater fecal coliform penetration depths [31]. This can be a very important consideration in the design or technology selection process for sites where soil depth above the restrictive layer may be shallow, since secondary or advanced treatment is often used to avoid or minimize the amount of fill material needed for the drip system.

The effectiveness of the soil to provide any additional treatment of the effluent after it drips from the tubing depends on the residence time of the wastewater in the soil and maintaining predominantly aerobic (nonsaturated flow) conditions. Both of these factors depend on rates of application and the soil's moisture tension, or matric suction. Information is not adequate to correlate moisture tension and treatment based on application rates.

Existing information does not allow a definitive resolution of the issues between anaerobic and aerobic drip concepts. Specific studies are needed to determine the following:

- Which approach is generally the most cost-effective in terms of both capital and long-term O&M when compared for equivalent applications?
- Are environmental risks different between the two approaches?
- What are the specific conditions where one approach may be better than another?
- How does treatment correlate to moisture tension (matric suction) for various application rates?

- Do soil fauna (e.g., worms) and roots significantly impact infiltration and treatment below driplines and biomats; if so, can conditions be managed to optimize their effects?
- How do soil conductivities change over time in the vicinity of anaerobic and aerobic drip emitters, and how do these changes relate to the selection of appropriate loading rates?

Guidelines are available from state regulatory agencies and the dripline manufacturers or their representatives for hydraulic application rates based on effluent quality. These are summarized in tables 3-5, 3-6, 3-7, and 3-8. These guidelines are intended primarily for small systems where design flows are assumed to be conservatively established by the appropriate regulatory agency. For residences, the design flow is typically 150 gal/d per bedroom. Spacing for driplines and emitters is assumed to be 2 ft for secondary treated effluent unless otherwise noted but may vary for stronger effluents. The area required is always considered to be the minimum footprint area. Contact the manufacturer or representative for additional assumptions and details.

Use the applications guidelines only as a guide. Actual application rates for design of a system should be established by a qualified, professional soils evaluator based on a detailed site assessment (see chapter 4). An experienced soil evaluator can establish application rates that will be applicable for either anaerobic or aerobic effluents.

Table 3-5
Geoflow Application Guidelines for Secondary Treated Effluent

Soil Class	Soil Type	Estimated Soil Percolation Rate (min/in)	Hydraulic Conductivity (in/h)	Design Hydraulic Loading Rate (gal/d/ft^2)	Total Area Required (ft^2/100 gal/d)
I	Coarse sand	<5	>2	1.4	71.5
I	Fine sand	5-10	1.5-2	1.2	83.3
II	Sandy loam	10-20	1.0-1.5	1.0	100
II	Loam	20-30	0.75-1.0	0.7	143
III	Clay loam	30-45	0.5-0.75	0.6	167
III	Silt clay loam	45-60	0.3-0.5	0.4	250
IV	Clay nonswell	60-90	0.2-0.3	0.2	500
IV	Clay swell	90-120	0.1-0.2	0.1	1000
IV	Poor clay	>120	<0.1	0.075	1334

Source: *Geoflow Wastewater Design, Installation and Installation Guidelines* [1]

Table 3-6
Geoflow Application Guidelines for Primary Treated Effluent

Soil Type	Approximate Percolation Rate (min/in)	Design Hydraulic Loading Rate (gal/d/ft^2)	Area Required (ft^2/100 gal/d)	Minimum Number of drippers/ft^2					
				BOD (mg/l)					
				<30	<60	<90	<120	<150	<180
Coarse sand	<5	1.0	100	1.00	1.00	1.00	1.00	1.25	1.50
Fine sand	5-10	0.8	125	0.50	0.50	0.75	1.00	1.25	1.50
Sandy loam	10-20	0.6	167	0.25	0.50	0.75	1.00	1.25	1.50
Loam	20-30	0.5	200	0.25	0.50	0.75	1.00	1.25	1.50
Clay loam	30-45	0.4	250	0.25	0.50	0.75	1.00	1.25	1.50
Silt clay loam	45-60	0.3	333	0.25	0.50	0.75	1.00	1.25	1.50
Clay nonswell	60-90	0.15	667	0.25	0.50	0.75	1.00	1.25	1.50
Clay swell	90-120	0.1	1000	0.50	1.00	1.00	1.00	1.25	1.50
Poor clay	>120	0.05	2000	1.00	1.00	1.00	1.00	1.25	1.50

Source: *Subsurface Drip Disposal of Primary Treated Effluent* [32]

Table 3-7
Netafim's Recommended Soil Loading Rate

Soil Texture	Soil Structure	Maximum Monthly Average Loading Rate (gal/d/ft^2)	Area Required (ft^2/100 gal/d)[1]
Coarse Sand; Loamy Coarse Sand	n/a	1.50	66.7
Sand	n/a	0.80	125
Loamy Sand; Fine Sand; Loamy Fine Sands; Very Fine Sand; Loamy Very Fine Sand	moderate to strong massive to weak	0.80 0.50	125 200
Sandy Loam	moderate to strong weak to massive	0.50 0.30	200 333
Loam; Silt Loamy	moderate to strong weak, weak platy massive	0.50 0.20	200 500
Sandy Clay Loam; Clay Loam; Silty Clay Loam	moderate to strong weak, weak platy massive	0.30 0.20 0.15	333 500 667
Sandy Clay; Clay; Silty Clay	moderate to strong massive to weak	0.10 0.05	1000 2000

[1] Netafim guidelines use area required per 1000 gal/d rather than 100 gal/d. The unit is downsized in this document to allow easier comparison with Geoflow guidelines.

Table 3-8
Drip Application Guidelines for Perc-Rite® On-Site Anaerobic Management Systems[1]

Soil Group	Soil Textural Classes (USDA Classification)		Maximum Hydraulic Loading Rate (gal/d/ft^2)	Area Required (ft^2/100 gal/d)[2]
I	Sands (with S or PS structure)	Sand – S Loamy Sand – LS	0.4 – 0.3	250 - 333
II	Coarse Loams (with S or PS structure)	Sandy Loam – SL Loam – L	0.3 – 0.15	333 - 667
III	Fine Loams (with S or PS structure)	Sandy Clay Loam – SCL Silt Loam – SIL Clay Loam – CL Silty Clay Loam – SICL	0.15 – 0.10	667 – 1000
IV	Clays (with S or PS structure)	Sandy Clay – SC Silty Clay – SIC Clay – C	0.10 – 0.03	1000 – 3333

Notes:

1. © 1992, Rev. 8 -94, WWSI, used by permission.
2. Column added to Perc-Rite's guidelines to allow comparison to other guidelines.

The Geoflow guidelines increase the disposal area based on effluent quality and the number of drippers or emitters within the disposal area. These guidelines are based on varying the spacing of the driplines and emitters. For example, for a loam soil, the minimum recommended footprint is 200 ft^2/100 gal/d with dripline and emitters spaced on 1-ft centers for wastewater with a BOD <120 mg/l rather than the minimum recommended footprint of 143 ft^2/100 gal/d with dripline and emitters spaced on 2-ft centers for secondary effluent. For stronger effluent, the emitter spacing would most likely be further reduced (for BOD < 180 mg/l, the emitters would need to be spaced at no larger than 8-in intervals if the spacing for drip runs remains 1 ft). Geoflow also recommends that the 1/2-gal/h emitter be used for anaerobic effluent, which precludes use of the non-PC dripline (Classic).

Netafim's current application guidelines address secondary quality wastewaters only [2]. These are listed in table 3-7. WWSI and AMC have published application guidelines for septic tank effluent. This information is contained in the tables 3-8 and 3-9.

Table 3-9
American Manufacturing Company Septic Drip Application Guidelines

Septic Drip Hydraulic Loading Rates							
Texture Group	**Estimated Percolation Rate (mpi)**	**Soils Group**	**USDA Textural Class**	**Hydraulic Load – High gal/d/ft²**	**Hydraulic Load – Low gal/d/ft²**	**Hydraulic Load – High gal/d/lf**	**Hydraulic Load – Low gal/d/lf**
I	0-15	Sands	S,LS	0.40	0.30	0.8	0.6
IIA	16-25	Coarse Loams	SL,L	0.30	0.23	0.60	0.46
IIB	26-45	Med. Loams	SL,L,SCL	0.23	0.20	0.46	0.40
IIIA	46-70	Silt Loams	SiL,CL	0.20	0.15	0.40	0.30
IIIB	71-90	Clay Loams	CL,SiCL	0.15	0.125	0.30	0.25
IVA	91-120	Clays	SC,SiC,C	0.125	0.075	0.25	0.15
IVB	>120	Fine Clays	C	0.075	<0.075	0.15	0
Septic Drip Organic and Grease Loading Rates							
Texture Group	**Estimated Percolation Rate (mpi)**	**Soils Group**	**USDA Textural Class**	**BOD High lbs/d/lf**	**BOD Low lbs/d/lf**	**FOG High lbs/d/lf**	**FOG Low lbs/d/lf**
I	0-15	Sands	S,LS	0.002000	0.001500	0.000160	0.000120
IIA	16-25	Coarse Loams	SL,L	0.001500	0.001150	0.000120	0.000092
IIB	26-45	Med. Loams	SL,L,SCL	0.001150	0.001000	0.000092	0.000080
IIIA	46-70	Silt Loams	SiL,CL	0.001000	0.000750	0.000080	0.000060
IIIB	71-90	Clay Loams	CL,SiCL	0.000750	0.000625	0.000060	0.000050
IVA	91-120	Clays	SC,SiC,C	0.000625	0.000375	0.000050	0.000030
IVB	>120	Fine Clays	C	0.000375	0	0.000030	0

Abbreviations: mpi = minutes per inch; gal/d/ft² = gallons per day per square foot; gal/d/lf²= gallons per day per square linear foot; gal/d/lf = gallons per day per linear foot; mg/l = milligrams per liter; lbs = pounds

1. Copyright© American Manufacturing Company (AMC), Inc., 2000, used by permission [33].
2. AMC acquired worldwide rights (except for Georgia) to Perc-Rite® systems from WWSI in 2000.
3. Contaminant concentrations are based on: BOD5 (5-day Biochemical Oxygen Demand): 300 mg/l, 0.25 lbs/day/100 gal

   FOG (Fats, Oils, and Grease): 25 mg/l, 0.02 lbs/day/100 gal
4. High and low values provide a recommended range of application rates based on design flow and the above concentrations.

Although details differ among manufacturers, vendors, and drip system designers, these differences should not mask the basic advantage of drip technology when correctly applied, i.e., near optimal dispersal of wastewater to the soil regardless of effluent quality. Existing information is generally adequate to ensure that the products can be selected to perform reliably within the environment in which they will be placed. From a purely technological perspective, the decision concerning the amount of pretreatment needed prior to SDD should be based on a thorough evaluation of the site characteristics considering hydraulic, organic, and nutrient loading and assimilation (a pure "performance-based" approach).[16] An example is provided in section 5.3. If the site evaluation indicates that either aerobic or anaerobic effluent can be assimilated, system details should then be based on other key factors such as costs, reliability, etc. In addition, the assessment could be expanded to include a comprehensive risk assessment to determine the level of treatment needed [34].

3.2.4 Conclusions

Better information is still needed to accurately match drip hydraulic application rates and volumes to soil and site conditions. The number of variables is large and the key cause and effect relationships are only generally known. Based on our current state of knowledge, the following guidelines are provided.

Differences in opinions exist as to whether it is better to apply anaerobic or aerobic effluent to soils. Additional studies are needed to resolve emitter and lateral clogging concerns and hydraulic and pollutant attenuation issues. However, existing information is generally adequate to ensure that the products can be selected to perform reliably within the environment in which they will be placed. The decision concerning the amount of pretreatment needed prior to SDD should be based on a thorough evaluation of the site characteristics considering hydraulic, organic, and nutrient loading and assimilation. A comprehensive risk assessment is one tool that could be used to help determine the level of treatment needed. The reliability of the system components or equipment is another factor that needs to be considered.

The hydraulic loading rates established by a qualified soil evaluator based on a detailed site assessment are used to determine the footprint area needed for the drip system. These rates may be applicable for either anaerobic or aerobic effluent (although the designer needs to confirm this with the soils evaluator). Use the hydraulic loading rates suggested by the manufacturers and their representatives only as a guide. Alternately, the water and nutrient balance approach such as that required by the Georgia Department of Natural Resources, Environmental Protection Division (GA EPD), for determining the wetted field area should provide a conservative design approach for either anaerobic or aerobic drip systems [35]. Although this method is relatively complicated and considers several components (average daily flow, wet weather or emergency storage, operational storage, water balance storage, and wastewater loading based on a nutrient balance), the final calculated acreage is typically large enough that soil saturation is limited to the area around the tubing and the potential for preferential flow to the surface is minimized. The differences in footprint size based on these different approaches are demonstrated in the design example provided in section 5.3.7.

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[16] Unfortunately, the ability to perform "good" hydraulic and pollutant attenuation analyses is still relatively poor and simplistic. The methods need to be advanced and enhanced to provide more useful tools.

If the system is designed for anaerobic effluent, linear loading rates will need to be considered to minimize biomats. There is no consensus on the best way to adjust linear loading rates, but in general the concept involves closer spacing of drip tubing within the footprint area (more drip tubing is used within the footprint area to spread the organic load more effectively to the soil around each emitter).

It is also important to note that hydraulic application rates typically assume design flows that are much higher than actual flows (resulting in a conservative footprint area). If actual flows are to be used for design, appropriate peaking factors or flow equalization need to be considered to ensure that periodic maximum or peak daily flows do not exceed the capacity of the drip system; otherwise, adjusted application rates may be needed to obtain an equivalent footprint area.

The designer also needs to consider the contour hydraulic loading rate. The guidelines by Tyler contained in table 3-1 represent the best information currently available for contour loading rates (contour loading rates do not depend on effluent quality or whether the areal loading is based on the infiltrative surface or the footprint).

It may be very difficult or impossible to meet the contour loading rates suggested by Converse and Tyler for a large system at a site with shallow soils. For this situation, evaluation of the types and extent of redoximorphic features at the rock interface and use of saturated conductivity values for the rock type and degree of weathering can be useful in estimating leakage to the rock layer. In general, bedrock with some fracturing and few redoximorphic features (mottles) can be assumed to have good potential for saturated vertical leakage. Mounding and lateral flow analyses using site-specific data may be needed for large systems.

There is consensus that it is typically better to design conservatively, since the least expensive part of the drip system is the tubing.

3.3 Drip Distribution System Components and Their Purposes

A drip system consists of several key groups of components that need to be hydraulically matched for good performance. These groups are:

- The drip field containing the dripline, supply and return manifolds, valves (zone, check, flush, A/V release, isolation), pressure regulators (as needed), and associated components (e.g., flexible hose, special connectors and fittings, and valve boxes or other types of containers). The drip field may consist of several zones that are independently dosed. Many of these components are depicted in figure 3-5.
- The pumping system for pressurizing the driplines, including the pumps, dosing tank, float tree, pump vault (optional), and associated piping, valves, and fittings. Figure 3-6 depicts a representative dosing tank containing submersible pumps.
- The filter system for filtering suspended solids and other debris that could clog the drip emitters. The system may include a flow meter, pressure gauges, isolation valves, and a pressure reducer. Figures 3-7 and 3-8 show representative systems.

- The control system for the pumps and solenoid valves for dosing the drip fields, filtering the wastewater, flushing the drip field and filters, alarms if the system is not functioning properly, and, optionally, displaying system and component status. The types and options vary greatly. Contact Geoflow, Netafim, or their representatives to obtain specific information.

Each of these components is described in more detail below.

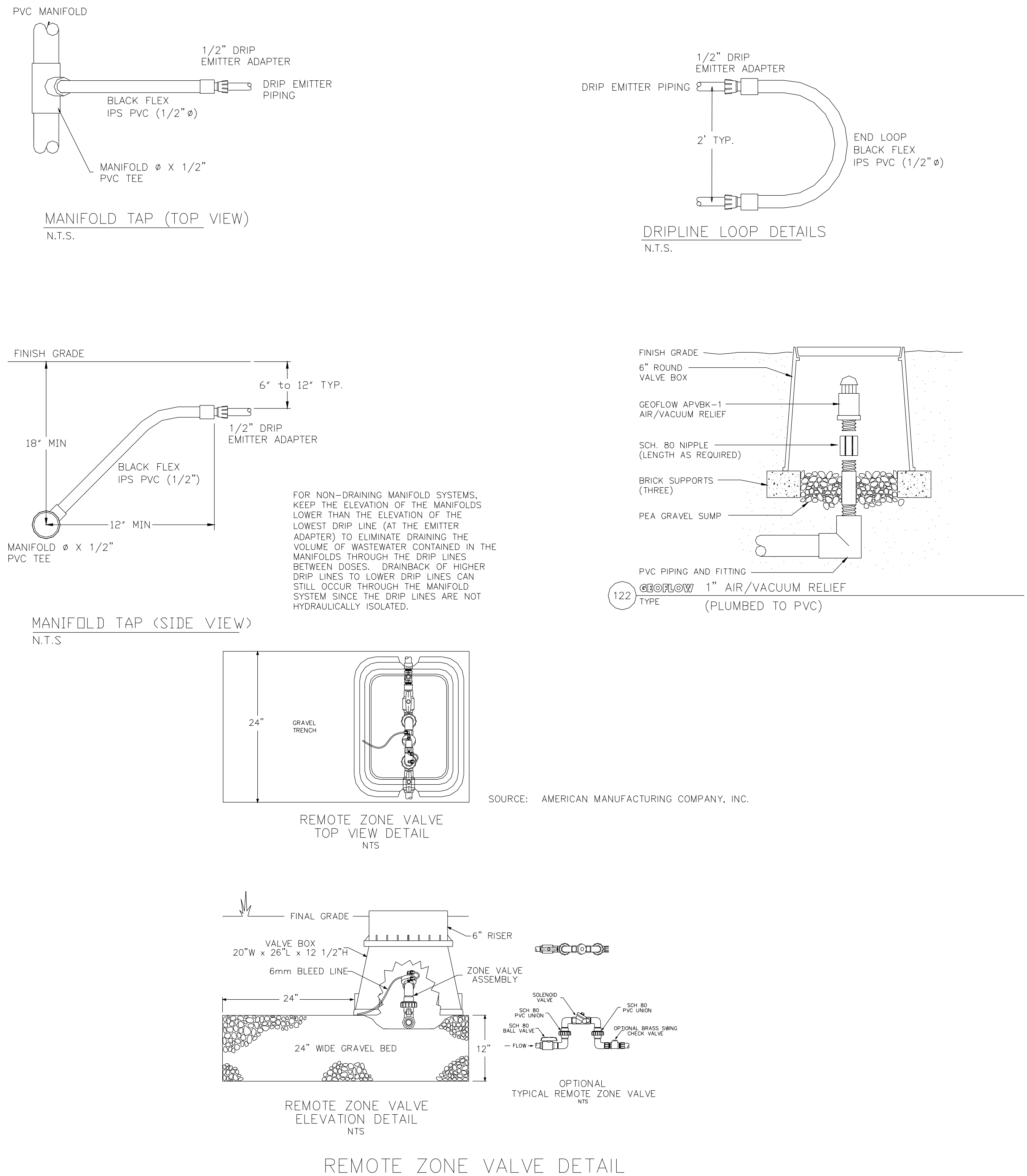

Figure 3-5
Drip Distribution Field Components

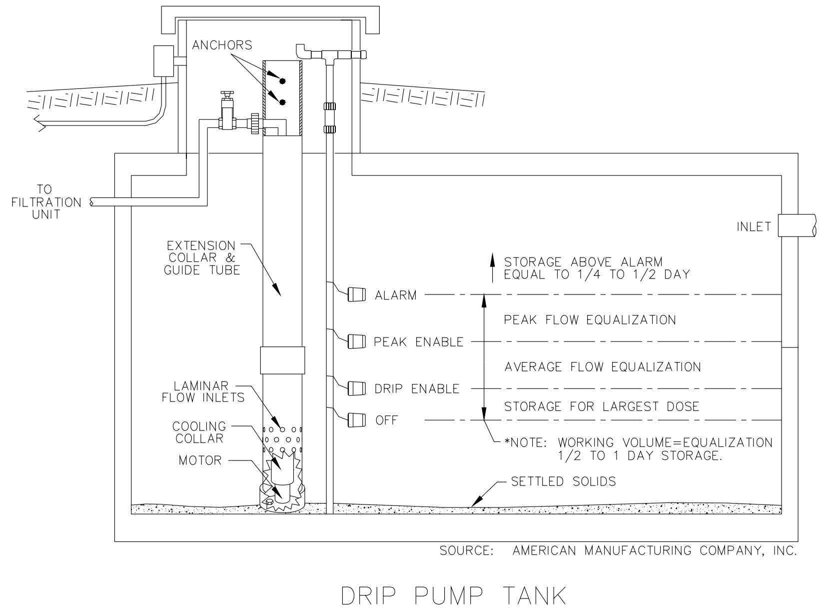

Figure 3-6
Dosing System with Submersible Effluent Pumps

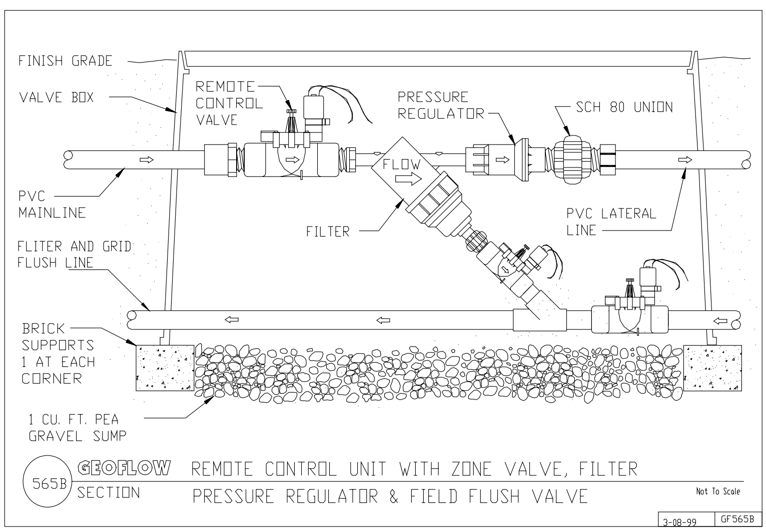

Figure 3-7
Automated Spin (Screen) Filter System

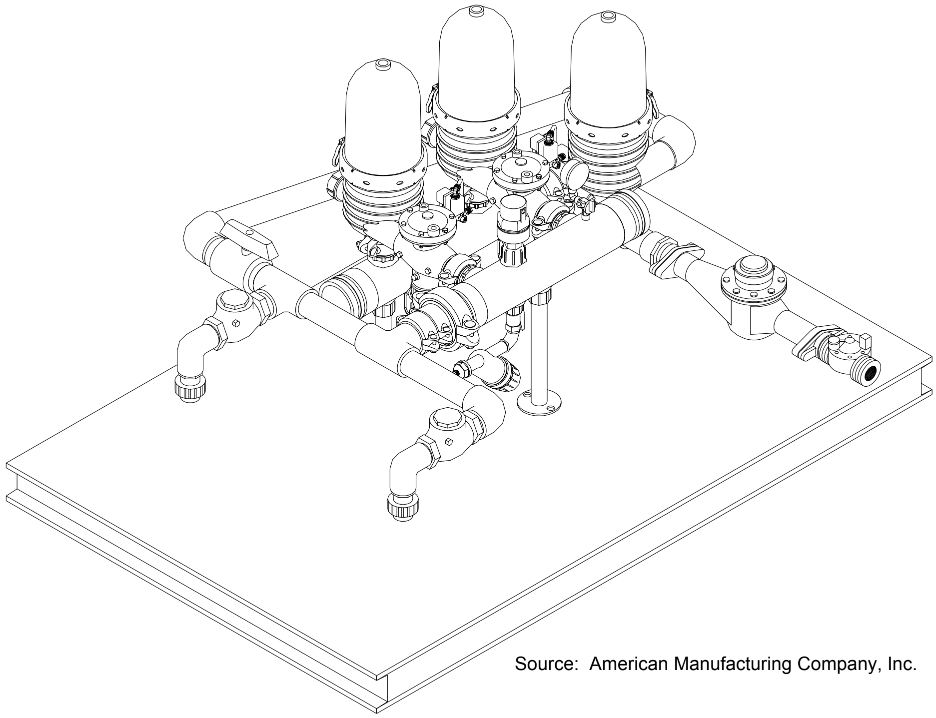

Figure 3-8
Automated Disk Filter System

3.3.1 Dripline

The types of driplines and emitters and the various options that are available were identified in section 3.1.1. These include PC and non-PC models with nominal flow rates for the PC models ranging from 0.4 to 1.0 gal/h. The nominal flow rate for the non-PC dripline is 1.3 gal/h at 20 psi.

Spacing for the emitters is typically 24 in, but optional spacing intervals include 6, 9, 12, and 18 in. Line size is typically 1/2 in but other diameters are also available if needed. More detailed information is contained in Geoflow's and Netafim's guidelines contained in appendices C and D.

Special orders for alternative flow rates, diameters, and spacing are available from each of the manufacturers.

There are several design decisions that must be made with respect to the dripline. These include:

- Determining whether to use PC or non-PC tubing.
- If PC tubing is selected, determining which brand to use based on its features and other factors.
- Matching the drip rate and volume and the emitter and dripline spacing to the soil characteristics to minimize soil saturation.
- Determining the appropriate tubing diameter and maximum line (lateral) length based on acceptable pressure loss, site constraints, and linear (contour) loading rate.

- Determining the total amount of dripline needed based on footprint loading and dripline spacing (based on soil characteristics) for dispersing the daily design flow, any extra water storage requirements determined through water balance and nutrient loading considerations, and any extra line needed based on such factors as aging tubing, removing zones from service to facilitate mowing or maintenance, and infiltrative surface area loading.
- Determining the maximum number of laterals per zone that can be used based on commonly available pumps and site constraints. This aspect includes consideration of pressures and flows needed for periodically flushing the laterals to remove fine solids that may have settled in the tubing and microbial growth on the tubing walls. Also, the number of zones that may be needed will need to be determined based on flushing and dose times and other factors.

Geoflow lists the advantages and disadvantages of PC tubing as follows:

- Advantages of PC tubing:
  - Very long lateral runs are possible.
  - Steep slopes require fewer pressure regulators.
  - Use for rolling terrain where the difference of height from trough to peak is greater than 6 ft.
- Disadvantages of PC tubing:
  - More expensive (Geoflow PC versus Geoflow Classic)
  - Contains a silicon rubber diaphragm that may not last as long as the plastic components.
  - Systems with large elevation changes that are not designed very carefully are prone to the creation of vacuum upon shut down, causing soil ingestion.[17] The dirt may lodge permanently under the diaphragm.

Most of the advantages associated with PC tubing relate to uniform flow rates within the rated pressure ranges. This simplifies design, operation, and maintenance, particularly for sloped sites. The various nominal emitter rates available for PC tubing also allows more flexibility to match the instantaneous loading rates to soil characteristics. Geoflow does not recommend non-PC tubing for heavy clay soils or for effluents with high BOD (anaerobic effluent).

Drip distribution of wastewater should only be done with drip tubing specifically designed and approved for wastewater application. During development of these guidelines, the only two known active manufacturers were Geoflow[18] and Netafim. Drip tubing from other manufacturers has been used for specific projects, but several failures and lawsuits have been reported.

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[17] This is also true for non-PC emitters.

[18] Geoflow tubing is manufactured by TORO Agricultural Irrigation.

Geoflow and Netafim and their authorized dealers and distributors also have different features and approaches to the unique problems associated with application of wastewater. With respect to drip tubing, the major differences include:

- Geoflow markets both PC and non-PC tubing for wastewater application. Netafim markets only the PC tubing for wastewater.
- Geoflow incorporates a bactericide lining on the inside wall of its tubing and recommends routine flushing to control slimes. Netafim incorporates a bactericide in the emitters and recommends routine flushing to control slimes in the tubing.[19]
- Geoflow incorporates an herbicide in its emitters to control root intrusion. Netafim employs a physical barrier in the emitters, supplemented where required or desired by an herbicide incorporated in its line of disk filters (Techfilter System).
- Netafim and Geoflow's emitters are designed to disrupt the accumulation of small dirt particles that may be "inhaled" at the end of the dose cycle. In Netafim's emitter, the silicone rubber diaphragm serves as one wall of the turbulent-flow path. The vibration of the diaphragm at the start of the dose cycle typically disrupts the bridging of soil particles, and the emitter clears itself. In the case of the Geoflow emitter, the silicone rubber diaphragm at rest moves back a distance of 0.035 in from the metering flow path. When pressure is applied at the start of a dose, the diaphragm moves forward, pumping a small cleaning burst of effluent out of the dripper.

When PC tubing is specified, 1/2-in diameter tubing with 24-in emitter spacing and a nominal drip rate of 0.5 or 0.6 gal/h (depending on brand or manufacturer) is used for most applications. The manufacturers state that the driplines with higher drip rates (0.9 or 1.0 gal/h) are more appropriate for sandier soils (except coarse sand) and the lower rates (0.4 to 0.6 gal/h) are most appropriate for heavier soils. The "typical" tubing (1/2-in tubing with drip rates of 0.5 to 0.6 gal/h) can be confidently used in most wastewater applications assuming the rest of the design process is satisfactory.

Matching the dose rate and volume to the soil and site characteristics is addressed in section 3.2. Until better information becomes available, it is suggested that the designer use the guidelines contained in section 3.2.4.

The selection of tubing diameter is a relatively simple process. The nominal 1/2-in tubing diameter is appropriate for most wastewater applications. Larger diameter tubing is also available from the manufacturers and has sometimes been used for large systems when longer lateral runs are desired to match the available site. The choice relates to the acceptable friction loss for the length of the lateral. Larger diameter tubing has a lower friction coefficient that results in longer laterals for a specified design head loss. If larger tubing is used, the site may also need to be able to handle much greater dose volumes to assure most of the dose is delivered with the lines fully pressurized (see section 5.2.6).

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[19] Bactericides and herbicides are consumable materials that have a finite life span. Consequently, they represent a long-term performance and maintenance issue. Geoflow and Netafim warrant their tubing for subsurface installations for a period of 10 years and 7 years, respectively, when stored and installed according to their recommendations.

There is no established criterion or target for the allowable head loss through the dripline tubing.[20] The objective is to maintain pressure from beginning to end of each lateral within the emitter's recommended operating range while at the same time allowing the laterals to be effectively flushed. The design process must carefully consider the total dynamic head (TDH) and instantaneous flow requirements for the system and adjust the design to accommodate commercially available pumps. This process is detailed in the design examples contained in sections 5.2 and 5.3. Using 10 psi as an example design head loss from the inlet to the outlet of nominal 1/2-in PC tubing with 24-in emitter spacing and nominal emitter rates of 0.5 or 0.6 gal/h, laterals lengths up to about 410 ft for the Geoflow PC tubing and about 430 ft for the Netafim PC tubing could be installed. The corresponding minimum pressure at the inlet to the drip field would need to be 15 to 18 psi in order to maintain the minimum 5 to 8 psi pressure at the outlet for uniform emitter flow. These lengths can be doubled (with the same pressure loss) using nominal 3/4-in tubing diameter. More even distribution will be obtained using short lateral lengths or two pumps operating simultaneously at the start of the dose cycle. Both of the alternate methods allow a shorter time period for filling or pressurizing the lateral (emitters will drip wastewater as the lateral pressurizes), resulting in proportionally larger volumes dripped from the emitters under full pressurization during a dose cycle compared to the amount delivered nonuniformly during the fill period and the period of drainage from the laterals and the supply and return manifolds at the end of the dose cycle. Shorter lateral lengths may also facilitate flushing, since less volume is needed; however, there are trade-offs as shown below.

The lateral lengths for non-PC tubing will typically be much shorter for maintaining similar flows from the emitters. For example, if the objective is to maintain emitter flows with no more than a 10% variance from nominal design rates, the maximum length of a lateral without any elevation difference for a typical inlet pressure of 20 psi (emitter flow rate of 1.30 gal/h) will be about 175 ft (corresponding to a pressure loss of 3 psi for an emitter flow of 1.17 gal/h at 17 psi). Also, when the drip tubing is flushed, the pressure drops substantially with a greater differential between the supply and return ends, increasing the flow variance between the emitters at the supply end versus those at the return end. This needs to be accounted for in the design of both PC and non-PC systems, but the effect of the pressure change on emitter flow rates will be greater with non-PC driplines. This is also more difficult to predict for non-PC systems.

Some designers effectively break the dripline lateral into parallel sections using flexible polyvinyl chloride (PVC) pipe, blank dripline, or elbows and dripline pipe at the end of each section to form a U-shaped loop as depicted in figure 3-5.[21] There are several potential advantages to using loops to increase the length of individual dripline laterals. Loops allow the

[20] Some states require that flow deviation cannot exceed 10% ± between any two emitters within the same zone. This standard is usually based on drip rates at design operating pressure. It does not typically consider the volume or amount of water loss during pressurization and depressurization; however, check with the applicable regulatory agency to ensure correct application.

[21] A lateral is defined as the length of drip tubing between the supply and return manifolds. If loops are used, a lateral will contain two or more "runs." A run is defined as the length of drip tubing between a manifold and a loop or between two loops. A run is typically placed on contour. A lateral may contain runs on different contours. Wastewater will drain to low points in the network when the pump is off. Special precautions are needed to prevent drainage to the lowest runs within a zone or subzone.

number of laterals with a drip field or zone to be reduced to fit the available area for the system. Reducing the number of laterals within a drip field or zone reduces the pump rate needed to flush the lines periodically to remove fine solids and microbial growth within the tubing, manifolds, and supply and return piping networks (see the design examples). This significantly increases flexibility for design layout and pump selection.[22] Loops are also used to place the supply and return manifolds in the same trench, reducing construction costs and consolidating the system layout. Disadvantages to increasing the length of each lateral using loops is the increased friction loss that has to be accommodated and the added volume of wastewater needed to fill and flush the laterals.

An individual lateral may also be modified by including flexible PVC pipe or blank dripline tubing (with no emitters) to bypass obstacles (e.g., trees, boulders, ditches, etc.) or other site conditions where emitters are not desired (typically small isolated areas within an otherwise usable area).

3.3.2 Pumps

Pumps provide the hydraulic energy needed for distributing the wastewater to the drip field, periodically flushing the drip system, and filtering the wastewater prior to the drip field. Two types of pumps are commonly used: centrifugal and vertical (turbine) pumps.[23] Centrifugal pumps may be either separately coupled or frame-mounted pumps that have their own shafts or submersible pumps that are close-coupled with a submersible motor [37]. Vertical (turbine) pumps are typically submersible models and are based on potable water well pumps modified for wastewater applications.

Due to the relatively high heads that are needed, most installations will use either frame-mounted centrifugal pumps or vertical submersible turbine pumps (see figure 3-9). The choice is largely based on preference and cost, since both types are very reliable when properly sized and installed and easily replaceable when needed. The frame-mounted centrifugal pumps are typically less expensive for equivalent hydraulic performance, but they require the additional expense for a building or shelter for protection and easy access. They are relatively easy to drain and repair or replace. The pumps are self-priming (after manual priming at installation) so long as the built-in foot valve in the intake pipe functions. The submersible turbine pumps are typically more expensive, but they are contained in the dosing tank (no added expense) and only the control panel and system headworks (filters, control valves, etc.) need to be weatherproof or located within a structure or shelter. To remove or service the pump, the tank riser access lid is removed and a pipe union and electric cord are disconnected. The turbine pumps are mostly used on smaller systems so the size and weight are relatively small and easy to handle (less than 50 pounds). Turbine pumps are not designed for pumping solids; consequently, they are typically used within screened pump vaults or following treatment units that remove most of the suspended solids.

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[22] Geoflow believes that high flushing velocities are not needed for their driplines because a bactericide lining is incorporated on the inner wall of the tubing to prevent microbial buildup [36]. Pump selection is not based on flushing requirements and number of laterals but only on the number of emitters.

[23] Centrifugal pumps are equipped with a volute or casing to collect the liquid discharged by the impeller and to convert some of the kinetic energy into pressure energy. Vertical pumps are equipped with an axial diffuser or discharge bowl rather than a volute. The diffuser performs the same basic functions as the volute [37].

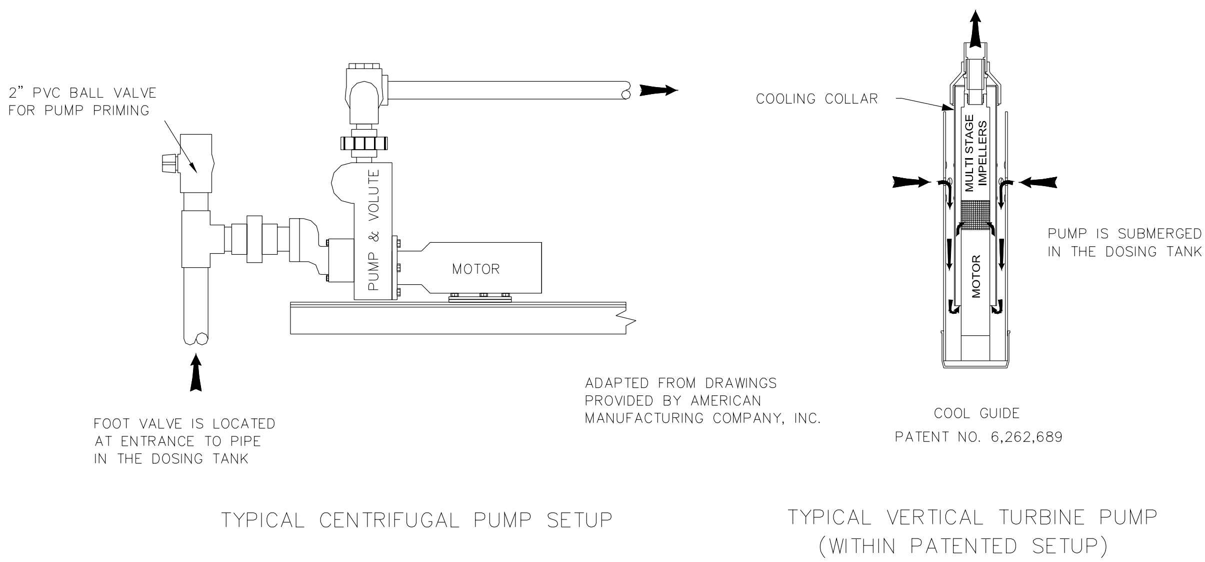

Figure 3-9
Centrifugal and Vertical Turbine Pumps

Pump selection depends on the maximum flow rate and TDH needed for the system. The flow rate and TDH may be the highest for dosing and flushing the largest drip zone, or when disk or sand filters are used, filter flushing may result in the largest system flows and TDH. Since the pumping requirements may be so varied and details depend on the individual components, preengineered packages can be very useful for ensuring that all system needs are met quickly and easily.

Two pumps may be installed to provide duplex (alternating pump usage) capability for long-term system reliability and, if needed, to provide the necessary increase in flow rate for periodic filter and zone flushing. They can also be used together to shorten pressurization time at the start of a dose. Duplex systems are most commonly used on large and commercial systems.

Typical sizes for small systems will range from 1/2 to 1 1/2 horsepower for flows ranging from 15 to 70 gallons per minute (gal/min) for TDHs ranging from 50 to 150 ft. Most of these pumps are typically single-phase, 115 or 230 volt, but some of the larger frame-mounted centrifugal pumps may be 3-phase, 230 volt. For larger systems, larger horsepower (2 to 30), 3-phase, 230- to 460-volt pumps are needed to meet the demand for larger flow rates and high heads. Precautions may be needed to ensure that pressure limits are not exceeded for any component at any location within the system.

3.3.3 Filters and Screens

All drip systems include a filter or screen system to protect the emitters from suspended solids that may pass through the wastewater treatment component and other debris that may find its way into the pumping system. Filtration is one of the most complex parts of designing and constructing a reliable drip system for wastewater applications. There are three types of filters or screens that are typically used for wastewater applications: spin (also known as a screen filter), disk, and sand.

The spin screens and disk filters are relatively small and are sized to match maximum flow rates. Routine flushing or back-flushing are critical to both their short- and long-term performance.

Dripline manufacturers typically specify that solids should be filtered to 100 to 130 microns. This is accomplished using 120 to 150 mesh filters. This filtered size is much smaller than the entrance to the emitters. Turbulent flow within the emitter keeps smaller particles suspended during their passage through the emitter, minimizing the clogging potential within the emitter structure.

A stainless steel screen is used in the spin screens, and stacked, grooved disks are used in the disk filters. There are advantages associated with each type. The spin screens are designed to be self-cleaning via vortex, scouring velocities within the applicable design flow range, and generally have a higher head loss at design flows than disk filters. Screens cannot be effectively backwashed, and when particles become embedded in the screen, the unit needs to be disassembled and manually cleaned. A technical or reliability issue that has been associated with this type of unit for wastewater applications is shearing of solids, which may allow passage through the screen. However, thousands of these filters are reported to be in the field in successful applications where flushing is continuous and not automatic. Disk filters have both surface area and depth. They are able to hold a larger amount of debris than screens and are not prone to solids shearing, but the disks have a tendency to stick together. Larger flow rates and pumps are needed to adequately separate the disks and back-flush properly. Disk filters are used for both anaerobic and aerobic effluents. Additional details are provided in the Netafim's guidelines contained in appendix D.

Both types may need to be periodically disassembled and hand cleaned using chlorine or diluted acid cleaners. Disk filters have an option to use compressed air to aid automatic back-flushing (see www.industrialfiltration.com) and reduce the need for periodic disassembly, but the option is not commonly used or needed for wastewater applications.

Manufacturer representatives offer filter packages as a preengineered, sled-mounted unit that includes solenoid valves, multiple parallel filters (including series filters for some larger applications if necessary), pressure gages (or ports) and/or sensors, a flow meter, isolation valves, and, as needed, a pressure reducer. These systems can be mechanically complex.

Pressure sand filters are often used on commercial systems and typically follow aerobic treatment units. They are typically provided as a preengineered, packaged component of the drip system. Consequently, they are normally presized to match both the effluent quality and other drip system components. Compared to the spin screens or disk filters, sand filters typically require larger percentages (6-25% compared to 1% or less) of water to back-flush and larger pumps.

A different version of screen has recently been used at several sites where manual flushing occurs. This screen, the GAG Sim/Tech Filter, is used as a prefilter immediately following the pump(s). This allows much longer periods between screen flushing and manual servicing.[24] The screen is similar to the smaller spin screens, consisting of a stainless steel screen that is self-cleaning during operation due to a vortex spinning action that scrubs the filter. However, the

[24] The filter is not needed for a properly designed automated or semiautomated drip system.

screen holes are much larger (0.062-in diameter), which significantly reduces head losses through the filter. An optional disposable polyester or nylon sock allows screening of smaller particles ranging from 100 to 600 microns in size. After dosing, solids scrubbed from the screen settle down the vertical effluent pipe, through the pump, and back to the dosing tank.[25] The screens are available in either 2- or 3-in diameters and are 18 in long. Additional details are contained at the manufacturer's Web site (www.gag-simtech.com).

Regardless of the type of filter or screen used, flush water needs to be properly managed, since it contains the solids filtered from the wastewater. Any flush water should typically be routed to either a separate settling tank or the pretreatment system prior to the drip distribution system.[26] This prevents solids from being recycled back through the drip filter system. Additionally, flushing cycles need to be optimized, since too much flushing may overload the pretreatment system. Too little flushing presents a maintenance issue for the drip system.

3.3.4 Controllers

For the drip system to function properly, the wastewater must be periodically dosed to the soil. The component that allows this to happen is the controller or control panel. The panels range from very simple (demand dosing) to very complex (computer boards).

Demand dosing occurs when floats are used to control the amount of wastewater pumped to the drip field. The volume of wastewater pumped during each dose depends on the dimensions of the dose tank, the vertical distance between the pump-on and -off floats, and the amount of inflow during the dosing event. The frequency between doses depends on the time required to fill the dose tank volume between the two floats. During surge flows, this interval may be very short (or pumps may run continuously for a relatively long time if the inflow exceeds the pump rate), and during nonpeak flow periods, the interval may be very long. Consequently, flow is not equalized very well during the day. This type of dosing has been used for many drip systems but is currently rarely used for new systems because the dosing does not optimize the treatment and hydraulic capacity of the soil and can hydraulically overload the soil if doses occur for long time periods or are too close together during peak flow periods. The only time demand dosing may be appropriate for a drip system would be following treatment systems such as a recirculating sand filter (RSF) where a timer is used to equalize flow prior to the drip system.

With the above exception, timed dosing is the only recommended application method for drip systems. When properly matched to tank unit volumes and pumps, timers allow precise control of both the volume and frequency of the applied wastewater. In conjunction with flow meters

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[25] Any return of solids to the dosing tank is undesirable, since the solids can be recycled back through the pump and filter system, unnecessarily increasing the load on the filter system and defeating its purpose. However, this problem can be minimized with this particular filter by locating the pump inlet above the bottom of the tank (close to mid-depth). Solids will eventually need to be removed when recycling significantly reduces the efficiency of the filter system.

[26] If spin screens are used, the elevation of the screen flush outlet must allow the flush water to flow by gravity back to the treatment works because the volume of flush water typically will not fill the return pipe.

that provide instantaneous flow rates and cumulative volume dosed (for multizoned systems), the data available from a control system using timers can also be used to evaluate the performance and troubleshoot a system (see section 7.2).

Floats are also used with time-dosed systems. One float is typically used to signal the controller that there is an adequate volume of water available to complete the dose (dose enable) and allows the system to override a scheduled cycle if sufficient volume is not available for a dose. Other floats are used that have identical functions to demand dosed systems. These include high- and low-water alarms and pump-on and -off overrides associated with high- or low-water conditions.

Representative control panels containing timers are shown in appendix E. In addition to the timer, other basic components include a NEMA 4X-rated enclosure, motor-start contactors, circuit breakers for pumps and controls, toggle switches, audio and visual alarms, a duplex alternator, and wiring terminals. Optional components that are very useful include the redundant off relay, elapsed time meter, event counter, and pump run light.

Control panels using a programmable logic controller or a personal computer are used to increase O&M flexibility and reliability. These panels accommodate multiple pump controls, multiple timer settings for changing flow conditions, differing audio/visual signals for different alarm conditions, and the capability of storing in memory registers a large amount of data about system performance. Elapsed time meters and event counters may also be included as either standard or optional items integrated in the panel. These panels are preprogrammed at the factory, but settings are easily modified in the field. When a telemetry board is included with the panel, system operators and maintenance organizations have the ability to remotely monitor and control the system’s performance, reducing (but not eliminating) the number of on-site trips that may be needed. If an alarm occurs, the system immediately notifies the system operator by pager or computer. Options include a preventive alert that warns operators of performance trends that could turn into an alarm condition if not addressed.

These panels also provide opportunities to optimize wastewater application to the drip field. For example, sensors could be strategically installed in three-dimensional networks within each zone or subzone of the drip field to provide data on soil moisture (or other key variables). The panel would be programmed to dose as needed to maintain predefined “optimal” soil moisture conditions for each zone or subzone of the system or to delay or bypass the dosing of a zone if its soils are already too wet. This type of control would provide a method for meeting performance-based standards that may be needed for difficult sites.

Manual overrides always need to be incorporated within the control panel for any electrical component to allow the operator the flexibility to test and troubleshoot the system and change preset values as needed. Additionally, the control panels should include programming with automatic default resets if remote communication is lost for any reason.

3.3.5 Supply Line and Manifold

The supply line and manifold provides the piping to deliver the filtered wastewater to the drip field. The design of the piping system should include several considerations. All pipe systems need to be based on velocity criteria and acceptable head losses for the system. Pipes that are too large will have very low velocities, resulting in a system that is not cost efficient and a system that cannot be properly flushed if needed. Pipes that are too small will have very high velocities with unacceptable head losses and other associated hydraulic problems such as water hammer. High head pumps may also be needed that are not efficient for the system.

Most PVC piping networks should be designed for flow velocities between 2 ft/s and 5 ft/s. This range results in networks that are stable with respect to cyclic surges, result in low friction losses, and are cost efficient.

For single-zone systems, the flow to the drip field is small, and the corresponding pipe sizes for the supply line and manifold are also small, typically 1 1/2 in or less. Many designers use the same pipe size for the supply line and manifold, since the cost of the manifold pipe is not significant. A smaller pipe (or series of pipes) could be designed for the manifold, since the flow drops rapidly as the number of laterals increase or if a center feed design is used to split flow to the drip field laterals.

For multiple zones, options need to be evaluated. Since isolation valves are needed to dose each zone separately, the supply pipe could be designed as a single pipe feeding each zone with a valve at the entrance to each zone, or the layout could place all zone valves near the filter system with separate supply pipes to each zone. For solenoid zone valves, the latter arrangement allows most of the system mechanical components to be sited close together, minimizing electrical and hydraulic lines and increasing protection and serviceability, but increasing the amount of pipe needed.

Most pipes used in drip systems are either Schedule 40 PVC or have a pressure rating of 200 psi. Many fittings used around the filter system are increased to Schedule 80.

For systems not designed to drain between doses, the supply pipe is buried below the frost depth. In areas with deep frost zones or very shallow soils where there is danger of the pipe freezing, special precautions are needed to minimize freezing problems. Experiences and opinions vary on how best to accomplish this. One leading designer advocates that the layout, design, and construction allow the pipe to drain completely between doses back to the dose tank [38]. Consequently, the system is not vulnerable to freezing, since there is no pipe containing water.[27]

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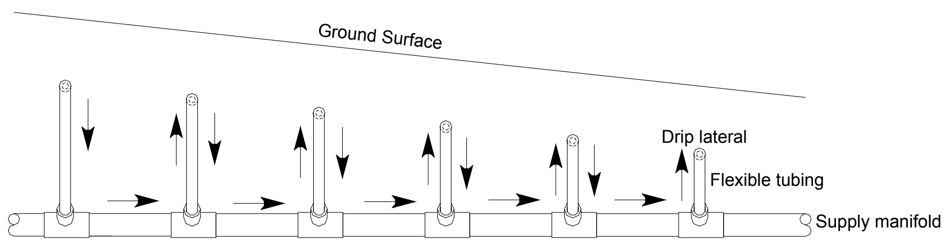
[27] There are hydraulic issues that must be adequately addressed during the design of draining systems. These include planning for additional surge capacity for the dose tank to accommodate the return flow, eliminating short-cycling field doses (all zone pressurization volumes and times must be carefully calculated and field verified), and controlling back-siphoning during pipe drainage (there's a greater need for air/vacuum release valves to be properly positioned and work properly, since there is a greater potential for some of the dosed wastewater to be sucked back into the emitters during pipe drainage). Consideration must also be given to the potential for the drip laterals to act as French drains. This can occur to a limited extent following each dose, since by the end of a dose, there is typically a saturated zone around the emitters. In tight soils, the hydrostatic pressure outside the emitter may be temporarily high following a dose. Saturated soils resulting from wet weather events are of even greater concern, since large volumes of extraneous water could reach the dosing and flush tanks. Additional issues include potential effects of

For nondraining systems, heavy insulation has been successful, and any problems that result from a power failure are handled as they occur.

The design of the supply manifold must also consider potential drain-back of wastewater after a dose from dripline laterals located at elevations higher than other laterals within the same zone. Wastewater may flow though the manifolds from laterals at higher elevations to laterals with lower elevations and drip from the tubing until empty[28] (see figure 3-10). This may hydraulically overload soils around the low-lying laterals. The problem can be minimized by placing the manifold lower than the lowest dripline,[29] placing as many driplines as possible on the same elevation (stairstepping), using subzones to limit the number of driplines that can drain to a particular low spot, using soil dams or humps at each end of each drip run, or rapidly draining back to the dose tank.[30]



The potential wastewater movement after a dose is shown by the arrows. In general, the relative movement of wastewater will be from higher elevations to lower elevations. Most of the wastewater in each drip lateral should drip from its emitters to the surrounding soil, resulting in relatively uniform distribution even during drain-down between doses. However, if the soil is saturated around the emitters at the end of a dose (which may be typical for clay soils), wastewater remaining in the drip tubing will follow the path of least resistance until all the laterals are empty. In severe cases, some of the wastewater dripped during a dose may even be sucked back into the emitters and tubing as the system drains. This may result in laterals at lower elevations receiving an excessive proportion of the draining wastewater. This is referred to as "drain-back". The design of the drip system must consider this potential problem and minimize it. With the supply manifold placed below the lowest drip line (either level as shown or at a slope similar to the surface), the volume of water contained in the manifold is not available to contribute to drain-back to the soil through the drip emitters. The potential problem can be further minimized by using short manifolds placed above the elevation of the highest lateral using flexible hose to isolate each lateral and completely stop movement of wastewater between laterals (see the next figure).

Figure 3-10
Drain-Back Potential and Manifold Design

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lowering the soil temperature due to the cold air that will enter the system during winter, increased slime growth in the pipes due to the oxygen that will be available, and the extra time needed for each dose cycle to pressurize the system (which may be difficult to provide in large systems).

[28] All emitters continue to drip wastewater until the lines are empty; consequently, only a portion of the wastewater remaining in the tubing when the pumps stop will drain to lower elevations. However, the amount can be significant without adequate precautions.

[29] This precludes only the volume of water contained in the manifold from contributing to the problem. The water contained in the drip tubing may still be available to drain from higher to lower drip laterals in the field through the manifold.

[30] See footnote 27 for factors that need to be considered for this procedure.

WWSI, in conjunction with Ayres Associates, has devised a very short supply and return manifold to eliminate this potential drainage problem. The manifolds are placed at the high end of the drip zone at an elevation above the highest lateral in a horizontal orientation that is parallel to the contour. Flexible PVC hose is used to connect the “top-feed” type of manifold to each drip lateral (see figure 3-11). This hydraulically isolates each drip lateral after a dose and precludes the tubing from acting as a French drain when soil becomes saturated (from precipitation or heavy dosing). Since the manifolds are short, they have little volume, which reduces the amount of air aspirated in after each dose, and they are quick to pressurize. These “top loading” manifolds are proprietary and are sold as a preassembled component of the Perc-Rite® system by WWSI and AMC. The vertical riser from the deeper supply pipe to the manifold is heavily insulated and/or heat-traced in cold areas.

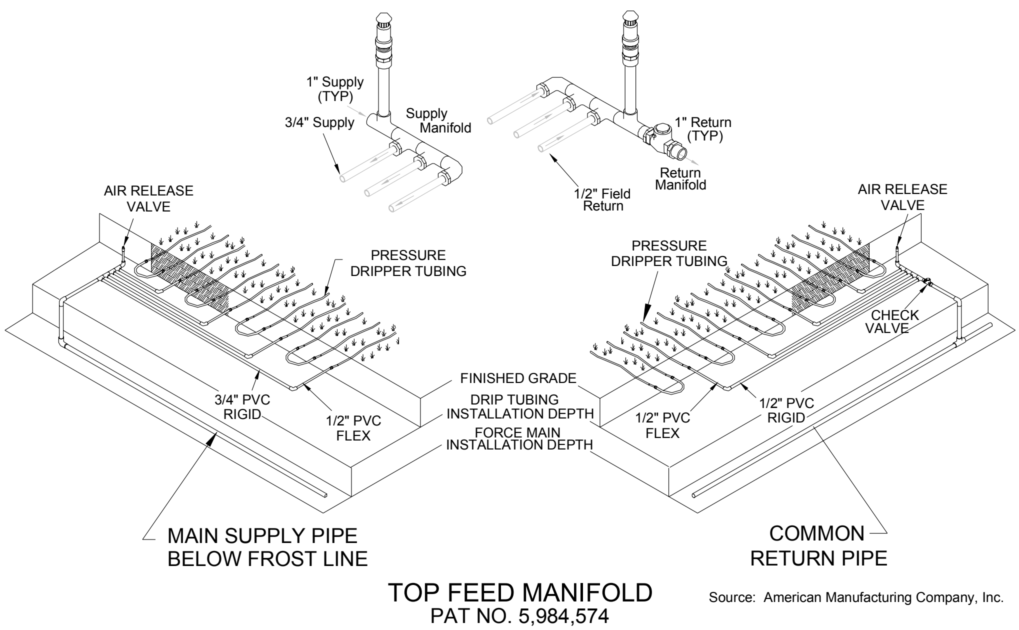

Figure 3-11
Top Feed Manifold Design

3.3.6 Return Manifold and Line

The return manifold and line provide piping to flush the drip field and return flush water to the treatment system or a settling tank for recycling. The same considerations are needed as for the supply piping system. Flow velocity needs to be maintained at flushing levels, since solids flushed from the drip field tubing will be returned to either the treatment system or a settling tank (which should be separate from the dose tank to prevent solids recycling through the filter system). Flow rates are smaller in the return piping, since the drip emitters are still working during the flushing cycle, requiring smaller pipes to maintain self-cleansing velocities. Pressure is also substantially reduced throughout the active portion of the drip field during flush cycles. Some of the cold weather systems are designed with a continuous partial flush using a cracked valve on the return line to allow the system to drain between doses.[31] To obtain a complete flush, the valve is completely opened periodically.

3.3.7 Flexible Hose

Iron pipe-size, flexible PVC pipe (from Agricultural Products, Inc., or other sources) is commonly used for connecting the drip tubing to the supply and return manifolds. The pipe is very flexible and durable and assembled using standard Schedule 40 PVC cement and fittings. It is ideal for making the transition between rigid supply and return piping and the flexible but stiff drip tubing, allowing the transition with minimal potential for kinking (which must be avoided) during construction and as the soil settles after construction. Flexible pipe also protects against line breaks, joint leaks, and kinking due to tubing expansion and contraction during construction. The pipe should typically be the same size as the drip tubing. If loops are used to extend the length of a drip lateral within an area with limited space, flexible pipe also provides a safer option to create the loops, particularly for line spacing of 24 in or smaller. Selection and proper use of barbed fittings is important to assure a watertight connection between the flexible hose and drip tubing under high or varying operating pressures.

Geoflow states that its dripline is not prone to kinking and most installations do not use the PVC flexible pipe.[32] If blank tubing is used for the connections, the tubing should be carefully bedded along its length to avoid kinking during backfilling or as the soil settles with time.

Flexible, heavy-wall PE is alternative tubing that could also be used for transition joints. It is stiffer than the flexible PVC pipe but is less prone to kinking than the drip tubing and has the advantage of using standard barbed fittings rather than solvent welding.

3.3.8 Air/Vacuum Relief Valves

Air/vacuum (A/V) relief valves are needed to release air at the start of a dose, so that the system is able to charge quickly and uniformly with wastewater, and to allow air to quickly enter the system at the end of a dose to minimize aspiration of fine soil particles into the drip emitters due to the vacuum that would otherwise be created as the driplines drain following a dose.

To be effective, the A/V relief valves need to be located at the highest elevation in each of the drip zones (above the highest dripline emitter). Standard practice has been to install the A/V relief valves on the upgradient ends of either the supply or return manifolds or both. However, most of the manifolds are installed deeper than the dripline laterals to minimize freezing if the system is not designed to drain or to facilitate better drainage of the driplines if the system is designed to drain following each dose. As a result, there is still potential for creating a vacuum

[31] The dose volume must include the additional volume needed for filling the system and the return flow through the partially open drain valve.

[32] Dripline for both manufacturers consists of linear, low-density PE tubing with the same thickness (0.045 in.). Geoflow tubing has a three-layer construction.

and drawing soil into the drip emitters at the end of the dose as the drip field drains.[33] Unless the A/V relief valves are located at the actual high point in the drip field or the manifolds are placed above the driplines, there is no source for air to enter the drip tubing except through the emitters, since the water in the manifolds acts like a P-trap for a sink, hydraulically isolating the driplines from the air entering the manifolds through the A/V relief valve. Similar problems can occur if the driplines have sags or humps where wastewater blocks airflow as the driplines drain. Locating the A/V relief valves at the actual high point(s) in the drip field is possible using blank tubing to connect each lateral at the high points or by placing an A/V relief valve on each lateral at its high point. Although it is not practical to have a perfect layout, quality design and construction based on these concepts will ensure a longer useful life of the drip field. Guidelines for minimizing dirt siphoning into the emitters are contained in Geoflow's design manual [1].

The major manufacturers or distributors will typically need to be contacted to obtain technical information on sizing A/V relief valves for wastewater drip systems. Geoflow lists only one model (1 in) in its wastewater guidelines, applicable for flows up to 50 gal/min. Netafim lists five models in its guidelines, ranging in size from 1/2 in to 2 in, and has a separate technical sheet with basic application information and design specifications. The 1/2-in model (TLAVRV by Netafim or the ARV-05 by Geoflow) is very inexpensive and is typically used directly on the dripline laterals. Basic design information for both the 1/2-in and 1-in valves can be found in table 5 of Geoflow's design guidelines for landscape irrigation (see Geoflow's Web page at www.geoflow.com). Using the nominal flow rate of 1/2 gal/h with 24-in emitter spacing and operating pressure of 20 psi, the 1/2-in and 1-in A/V relief valves can accommodate up to 1500 ft and 10,000 ft of dripline, respectively. Geoflow's technical drawings for the 1/2-in valve (drawings # 120A and 120B) indicate that the valve should only be used for zones of 7 gal/min or less (based on 750 emitters for 1500 ft of dripline with 24-in spacing and a drip rate of 0.5 gal/h, the zone flow would be 6.25 gal/min).

The valves are manufactured by three primary sources: Bermad (Evron, Israel), A.R.I. Flow Control Accessories (Kfar Charuv, Israel), and Agricultural Products, Inc. (Ontario, California, and Haines City, Florida). The Bermad Web site (www.bermad.com) provides a user guide for selecting, locating, troubleshooting, and installing and maintaining A/V relief valves (information for the 1/2-in valve is provided under "Irrigation Control Valves," while the larger valves are listed in the User Guide – *AR Series, Air and Vacuum Release Valves*). A.R.I. also has a sizing program that can be ordered (free) from Netafim (www.netafim-usa.com).

3.3.9 Flush Valve

Flushing the drip field is usually accomplished by opening a flush valve that is typically located near the flush return tank. Dosing occurs simultaneously during flushing (which means that for automatic flushing a sufficient volume of water must be available to dose while flushing is occurring). This valve may be a solenoid type of valve so that the flushing operation can be fully automated and programmed through the control panel. It can also be accomplished manually

[33] These systems are still functioning satisfactorily after several years of use although the extent of emitter clogging has not been quantified (see section 7 for information on quantifying the extent of emitter clogging).

using a standard ball or gate valve. For systems where the operating pressure is controlled with the flush valve, the valve is always kept slightly open, and fully opened manually during the flush cycle.

Manual flushing presents some practical difficulties that must be addressed. Since flushing requires a relatively large volume of water, the flushing cycles should be planned and scheduled when the required water volume is available and when the extra hydraulic load from the zone flush would not upset the pretreatment system. This requires staggering the various zone flushing cycles over a reasonable time period. For manual flushing, this requires the operator to be present at different times to properly flush each zone rather than consecutively flushing each zone during a single site visit.

3.3.10 Standard and Specialty Connectors and Fittings

There are various standard and specialty connectors and fittings that are used to connect the drip tubing and associated components together. These include:

- Reducer tees (standard Schedule 40 PVC with slip joints, typically supply and return manifold sizes by 1/2 in for the Schedule 40 flexible PVC tubing).
- Compression fittings: standard Schedule 40 PVC, with either slip, MIPT, or FIPT joints as needed, including adapters, tees, elbows, and couplings.
- Lock-slip fittings: adapters, tees, elbows, and couplings specifically manufactured for drip irrigation and types of flexible tubing. These fittings are typically more fragile than standard 40 PVC fittings and must be carefully handled during installation.
- Insert fittings: barbed adapters, tees, elbows, and couplings specifically sized for the various drip tubings. Recommended maximum system operating pressure is 45 psi (see Netafim USA brochure for BioLine Fittings & Accessories).
- Check valves and isolation valves are used to isolate separate field zones during normal dosing and flushing cycles and during system troubleshooting.

The Schedule 40 fittings with the slip (glue) joint are typically the most rugged and reliable and should always be used where practicable.

3.3.11 Valve Boxes

Any of the components that may need routine servicing should always be readily accessible. Access is typically provided by valve boxes of various sizes, shapes, and materials. The boxes also help locate buried components. Most boxes are high-density PE or polyolefin with fiber reinforcement, but depending on size and other factors, materials such as concrete and PVC are also used. Custom boxes are also commonly found, constructed from short segments of pipe with specialized lids. The list of available boxes is continuously growing to meet the expanding needs of the decentralized wastewater industry.

Selection of the proper type and size of box should consider the long-term need to service the drip system component. The box needs to be large enough to allow routine servicing, including periodic removal and replacement of the component as applicable. Many of the boxes need to be relatively long or deep to accommodate the depth of the component (which is typically based on freeze protection), requiring even larger boxes to improve serviceability. The bottom of the box needs to be designed to drain any rainwater or wastewater (from servicing the component) readily to the soil. The lid also needs to be easily removable with the proper tools but may also need to be tamperproof if access to the site is not restricted or tightly controlled. The overall strength of the boxes and lids must be able to withstand the weights of any mowers or other service equipment that may roll over the structure. If the boxes are not designed to withstand heavy weight, they need to be protected by appropriate types of guard structures.

3.3.12 Zones and Associated Components

For systems with more than one zone, there are additional components that are needed. These typically include zone valves, check valves, and pressure regulators.[34]

Zone valves are used to allow dosing of each zone independently or separately. Remote control valves are the most commonly used type of valve for large systems. These valves may be controlled by two basic methods: an individual electrical solenoid pilot valve or a hydraulic relay controlled by a remote solenoid pilot valve. The basic valve is the same for either control method. A diaphragm opens or closes based on hydraulic pressure differences between the two sides of the diaphragm. The solenoid pilot valve causes a plunger or piston to move, which opens an orifice through which wastewater passes into or from the control mechanism of the valve. Only the method of delivering the pressure differential varies. On small valves (e.g., 3/4 in and 1 in), the solenoid pilot valve is typically located directly on the main valve body with the hydraulic channels and orifices also located within the main valve body. Larger valves may have the solenoid pilot valve located either on the main valve body or remotely located on a manifold with hydraulic lines connected externally to the main valve body to each side of the diaphragm. The hydraulic source for most systems is filtered wastewater, but compressed air can also be used. Detailed descriptions of both types of valves and the various available options are provided at Web site www.bermad.com/pdf.asp (*Bermad Irrigation Catalog*, *200 Series Plastic Hydraulic/Electric Control Valves* and *5-Series Bermad Solenoid Valves Catalog*).

Netafim has developed the Aquanet® brand of solenoid valves. These are described in their guidelines contained in appendix D.

Solenoid valves are selected based on design flow rate and acceptable friction loss for the system. Another important design consideration includes the location of the valves. Options include locating the valves at the inlet to the supply manifold for each zone or locating the valves within the control building or structure. If the valves are placed at each zone, a single supply pipe can be used to feed all zones, but long electrical or hydraulic control lines may be needed for each valve, potentially increasing O&M requirements over the long term. Placing the valves near

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[34] Pressure regulators are also commonly used on Geoflow non-PC single-zone systems.

the control structure eliminates the problem with long electrical and hydraulic control lines but requires individual supply pipes to each drip zone and design to prevent drain-back, siphoning, and zone dose short cycling (which can be significant problems if the zone is at a lower elevation than the supply pipe so that the supply pipe drains to the zone between doses, see section 5.6.2).

An option to solenoid control valves is an automatic distributing valve. This valve, also known as a Hydrotek valve, has a proven track record for both agricultural and decentralized wastewater applications and is becoming common on multiple-zoned systems for high-quality aerobic effluents. The valve is typically not used for any application where the effluent quality may be poor. It is manufactured by K-Rain Manufacturing Corporation, Inc., Riviera Beach, Florida, and is distributed by many suppliers using different terminology. The valve can significantly lower the installation costs for a drip distribution system but increases the difficulty of troubleshooting the system. A single valve can dose up to six zones. The valve is hydraulically operated, contains only a few moving parts, requires no electricity, and alternates automatically each cycle. Models are available for a flow range of 10 to 70 gal/min. The valves have high head losses and must be carefully positioned on each site to function properly. Back pressure on the valve should not exceed 2 ft of head for the valve to rotate reliably. This may require a pressure relief hole or a separate drain line. Also, dosing cycles cannot occur too rapidly to allow pressure to dissipate between doses. A means to identify exactly which zone is being dosed at any time should also be incorporated into the design to facilitate troubleshooting. This can be done with transparent PVC pipe, Schrader valves, A/V relief valves, etc., added to the discharge lines to each zone. Design details are contained in an Orenco technical paper [39].

Most multizone drip systems recombine piping following the return manifold so that when each zone is flushed, a single pipe conveys the flush water back to the pretreatment system or settling tank (but not the dose tank). For this type of design, check valves are needed for each zone prior to repiping the zone to the return flush line. These valves hydraulically isolate the backsides of each zone and prevent wastewater from entering zones that are not scheduled to be dosed or flushed. Some designers prefer to use individual return pipes from each zone rather than combining the piping for all zones, in which case check valves are not needed. In addition to using check valves, the valve should be followed by an isolation valve (ball valve) so that a zone with a malfunctioning check valve or other problem can be positively shut down during system troubleshooting and repair.

The performance of these valves has not been good on several systems. Experience has found that the more expensive bronze swing-check valves are the most reliable for systems with 2-in or smaller piping. For piping larger than 2 in, wafer-style check valves have been reliable.

Flushing the dripline in each zone is typically accomplished by opening a flush valve (see section 3.3.9). For systems with only one common return line, a single flush valve can be used for the total system. If the zones are widely separated so that more than one return line is used, a flush valve may be located on each separate return line.

Pressure regulators are almost always found on non-PC dripline systems. The pressure regulators are located at the entrances to the supply manifolds so that each zone has the same inlet pressure (which is critical for uniform wastewater distribution in these types of systems). However, they may be omitted if the pressure in the zone is controlled by a valve on the outlet end of the zone or on the return flush line. This latter method is not common, and it is used only at sites operated by a trained, professional service provider. The method also increases the hydraulic load on the pretreatment and filter systems.

They are also used on PC drip systems whenever the design or site conditions result in pressures that exceed recommended limits for the drip tubing or fittings. This may occur in a multi-zoned system with large elevational differences.

When pressure regulators are included in the system, they need to be selected to allow sufficient pressure and flow for zone flushing. Older designs used a valved bypass around the pressure regulator to allow larger flows for zone flushing, but this practice is no longer considered to be needed.

3.4 System Design: Key Aspects to Consider

Detailed design information is provided in a subsequent section. However, there are many key factors that need to be considered and basic decisions that must be made before starting a detailed design for a site. It is assumed that an evaluation of alternatives has already been completed and a drip system is justified for the site. It is also assumed that at least a preliminary approval for use of drip technology has been obtained from the appropriate regulatory authority. As mentioned previously, the decision to use drip technology should not be made lightly, since the decision also involves a long-term commitment to the successful O&M of the system. Prior to starting the detailed design, decisions must be made concerning the following aspects:

- PC tubing versus non-PC tubing. Review the advantages and disadvantages of each type of tubing in relation to the site conditions (see section 3.3.1).
- Brand of drip tubing to be used and whether proprietary components will be included in the system. There are some major features and approaches that differ between the tubing manufacturers and their authorized dealers or distributors as explained in previous sections (see sections 3.3.1, 3.3.3, and 3.3.5). These differences may quickly guide the selection process. Customer support, proven expertise, economics, and specific design approaches and methods need to be key factors in wading through these options. Personalities and marketing strategies always seem to play an important function in this selection process as well. Use of proprietary or prepackaged components may be especially attractive to designers with little or no experience, since many of the design details have already been worked out and typically require minimal adaptation to the site. Long-term contractual arrangements may also be needed for lifetime system support. However, one of the goals of this manual is to provide sufficient information on the available technology and design concepts so that independent assessments can be more readily made on all key aspects of the system design.
- Level and type of pretreatment to be provided. Several factors need to be considered: regulatory requirements, site factors (including soil characteristics, the amount of available land, presence of adjacent water supply wells, and distance to property line), public access (which may affect the need for disinfection), owner preferences, how quickly service providers can respond to any alarm conditions, economics, and biases by key decision-makers.

Some regulatory agencies, particularly state health departments, will not allow drip systems for primary effluents. Other regulatory agencies allow the systems but may place relatively stringent limitations on their use. These issues need to be known and addressed prior to the detailed system design. Typically, systems designed for primary effluents under current regulatory guidelines require greater separation distances to the restrictive layer, smaller application rates (more land is needed), more frequent and aggressive flushing of both the filter system and the drip zones (automation ensures good performance for any type of system, especially if frequent flushing is needed or desired), and more importance on speedy responses by the service provider to any alarm or prealarm warning.[35,36] All of these aspects have costs associated with them that need to be evaluated and compared to those for an equivalent system where secondary or advanced pretreatment is provided prior to the drip system. An unresolved issue with drip systems following secondary or advanced pretreatment systems is the soil separation distance needed for fecal coliform removal. Without disinfection or high removals through the pretreatment system, the separation distance may need to be as large as or larger than that for anaerobic effluents (see section 3.2.3). Experience generally helps with these issues, but everyone needs to be aware of biases that may tend to glance over important factors that need to be more thoughtfully considered. Strongly held biases by key decision-makers are always an issue with application of any technology, particularly newer ones where track records are a key to the continued success of the technology. Other than regulators, strong biases may exist with system owners and designers. There are strong advocates for systems following only primary treatment as well as those for only systems following secondary or advanced pretreatment. Opinions are based on perceived as well as actual documented reasons; however, the issues related to which type of system is actually more cost effective and reliable over the long term are still largely

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[35] WWSI has vast experience with many variations of pretreatment systems including those that produce primary effluent. Their experience indicates that primary effluent systems do not require more frequent backwashing or tubing flushing. They report the opposite to be more typical. Their advanced or aerobic treatment systems experience more variation in effluent quality than their anaerobic treatment systems, and when the aerobic systems malfunction, suspended solids concentrations may be worse than that from septic tanks. Their approach is to design for the worst-case conditions to the extent practicable. This typically includes frequent filter backwashing and tubing flushing for either aerobic or anaerobic pretreatment systems. They firmly believe automation and routine maintenance are vital to good performance. Conversely, designers and operators of systems using recirculating sand filters (RSF) report that the RSF effluent quality is consistently very good and the need for flushing the filters and zones of the drip system is infrequent. Experience with systems regulated by the North Carolina Division of Environmental Health suggests that the rate of flushing is more critical for anaerobic than aerobic systems (primarily RSFs), resulting in recommended flushing velocities above 3 feet per second (ft/s) for anaerobic systems and 1.5 ft/s for aerobic systems. The higher velocities are needed for the anaerobic systems for long-term control of slimes (which are considered to be "aerobic" slimes, since the tubing drains between doses, providing aerobic conditions within the tubing). Without the higher design velocities, head losses were observed to increase to the extent that routine flushing was not adequate to maintain scouring flows and velocities (2 ft/s or larger) at the distal ends of the laterals.

[36] Although failed anaerobic drip systems are typically considered to represent greater environmental and health risks than aerobic systems, this is not necessarily true. "Failed" aerobic drip systems without disinfection can also have high pathogen levels. Any wet areas may not have the black, smelly characteristics of anaerobic effluent, which can lead to a false sense of security or lack of attention when corrective action is needed. Also, aerobic treatment units that are based on the activated sludge process are typically more prone to upset than treatment units based on anaerobic processes.

unresolved and need further study (see section 3.2.3). Both approaches have been successfully used on large and small projects. A comprehensive risk assessment is one approach that could be used to determine the level and type of treatment needed [34].

- Configuration and other considerations based on site conditions and constraints. After deciding the type and brand of tubing and related components to be used and the level and type of pretreatment to be provided (which is partly based on site conditions), continue the process of adapting the design to site conditions. Select conservative hydraulic footprint loading rates based on a detailed evaluation of the site soil characteristics. Evaluate the need for fill material based on both regulatory requirements and environmental concerns. For shallow soils above a restrictive layer, include an evaluation of the contour hydraulic loading based on horizontal flow considerations and landscape position. Adjust the design as needed.
- Extent of automation, monitoring, and timing of critical operation processes and procedures. Automation of the dosing cycles, filter flushing, and zone flushing reduces the amount of operator attention that is needed for the system and lowers the risk of long-term O&M problems, particularly if controls are flexible and can be modified based on either sensors or measurements and observations made during routine service calls. Technology is now available (and relatively economical) for remote monitoring and control of the system. Packages with different levels of sophistication are available from several sources based on design flows, number of zones and amount of tubing, and effluent quality. These packages are readily adaptable to specific design and site details. Although the degree of automation and monitoring depends partially on the relative size of the system (it is more affordable and cost effective for larger systems), some of the relatively simple and inexpensive aspects should be incorporated into the design of small systems including individual homes. These include dose timers, Schrader valves to allow pressure readings at critical locations such as before and after filters and on the supply and return manifolds (on the A/V relief valves), and flow meters (flow rates and dose volumes are needed) to compare actual performance and operation to design specifications. This information allows the operator to determine the overall status of the system and whether special O&M procedures may be needed to reverse undesirable trends or developing problems before they mature and require immediate corrective or emergency actions.

After these preliminary decisions are made, obtain detailed information needed to design the system competently around the selected components. As previously emphasized, the design should be approached as an integrated system rather than individual components. The design process may reveal the need to modify some of the components that were preliminarily selected.

3.5 System Installation: Key Aspects to Consider

There are also several important aspects to installing a system that will be critical to its long-term success. These are addressed in more detail in a subsequent section, but first, they are identified as key aspects that must be appropriately considered. They include:

- Helping the client select a quality installer. The best-designed drip system may not perform satisfactorily if the installation is poor. If possible, use a contractor that has a quality track record, preferably with some drip system experience. Quality is more important than experience, especially since the technology is still relatively new and may not have been used in many areas. If the contractor does not have experience with drip systems, the manufacturers and component vendors can provide the contractor with good information on how to install their components properly. It is also important to have the system designer and soil scientist on site during construction to ensure that the system is correctly installed and all components meet design specifications.

- Ensure that good construction practices are followed. These should be reviewed with the contractor prior to starting construction, and inspections during construction should be conducted to ensure adherence. These include:
  - Protecting the site prior to and after construction. There should be no activity on the drip field other than that needed to install and maintain the system. Site disturbance after soil surveys are completed can invalidate the soil evaluations and jeopardize the site's applicability for a drip system. Similarly, disturbance after the system is installed can modify soil structure and create a failing system. Heavy, rubber-tired equipment can easily compact soils when the ground is wet or damp and create significant problems before and after system installation. Drawings should designate traffic areas and areas acceptable for material stockpiling.
  - Clearing and grubbing should be performed based on site-specific plans that minimize disturbance and protect the overall soil characteristics. This can be a critical issue that needs close coordination between the designer, soil scientist, and installer. A surface that is smooth and debris-free is obviously the easiest from the installer's perspective. However, if heavy equipment is needed to cut and remove trees, or push over root balls, the harm to the site may be irreversible. Concerns are not as great if there is sufficient depth of suitable soils for the drip tubing to be placed, but this is often not the case at sites being considered for drip. Cutting trees flush with the ground and removing with only light track equipment, grinding out roots below proposed tubing depth, using nonperforated tubing to circumvent or pass through remaining obstructions, and using trenches instead of plows are techniques that may need to be considered to eliminate or minimize site disturbance. On heavily wooded sites, consideration may also be given to use of a surface drip system.
  - Never installing when soils are wet enough to easily compact or smear. Generally, this will occur when the moisture content is near the plastic limit where the soils would ribbon when performing the standard "texture-by-feel" analysis or would form a "wire" that does not easily crumble when a small amount of the soil is rolled between the thumb and fingers.
  - Laying the driplines on contour, minimizing sags and humps that would prevent the tubing from draining properly, and creating vacuums that might contribute to premature clogging of emitters.
  - Ensuring that the drip tubing is not crimped at any location, particularly at or near the connections to the supply and return pipes.
  - Using flexible heavy-wall PVC or PE tubing at each manifold connection to provide additional crimping protection and to prevent pulling the tubing out of the manifold as soils settle with time.

  - If blank tubing is used at the manifold connections, properly bedding the tubing along its entire length.
  - Meticulously protecting the ends of pipe and tubing from dirt and construction debris during installation, taking care to tape all open ends remaining after each interim installation day or period.
  - Using PVC pipe cutters that cleanly shear the pipe rather than sawing the pipe. This eliminates PVC fragments that may potentially clog the drip hose and emitters.
  - Completely flushing the system prior to performing start-up performance checks. Remove the vacuum release valves prior to flushing the system to prevent clogging or damage to the valves and to keep low pressures in the system until debris is removed.
  - Backfilling pipe trenches and tank excavations after leak testing is completed. Include specifications for ensuring that pipe and fittings are protected during backfill. Compaction specifications or regrading requirements are also needed to minimize problems associated with long-term soil settling/compaction.

- Perform start-up system checks with the contractor and operator to ensure that the system is performing as designed. Perform all of the operational functions that would be expected during routine operations and servicing to determine that the system is performing adequately, including timed dose periods, volume pumped, flow rates, pressures at the inlet and outlets of each zone and the filters, leak detection, flushing functions, alarms, etc. "Wet-spot analysis" is a key part of an installation inspection. Each zone should be dosed for at least a typical dose cycle, and any surfacing over any part of the field flagged. These spots must be further investigated to determine if they are caused by faulty connectors, faulty emitters, inadequate cover, or inclusion of unsuitable soils. Appropriate repairs or modifications need to be made to eliminate the wet spots.
- Establishment of vegetative cover is also critical. Final cover may not be possible until the proper season, but provisions for it must be agreed upon prior to approval of system start-up.

3.6 System O&M: Key Aspects to Consider

The critical O&M aspects that must be considered for a drip system include:

- O&M is a critical concept. A drip system is a relatively sophisticated mechanical system that is highly dependent on proper functioning of pumps, timers, filters, several types of valves, and alarms. Do not use a drip system without a quality commitment to its long-term O&M.
- The system must be periodically checked and serviced. The frequency of each action may depend on the extent of automation and may be adjusted with time, based on actual experience.
- Alarms resulting from mechanical problems must be resolved and repaired within the reserve holding time designed within the system. This will typically range from 12 to 24 hours at design flow. The operator should be fully aware of the reserve capacity available before overflows occur (information should be provided for actual flows as well as design flows). Critical spare parts should be inventoried or available from suppliers to allow replacement within this critical time period. In addition, procedures need to be available for guiding the

recovery operations after the mechanical problems are resolved or repaired. Preferably, the drip system has been designed to accommodate excess flows on a periodic basis and the control system has been automatically programmed to dose the fields for these conditions correctly. If not, a plan should be developed for periodically dosing the excess wastewater so that the fields are not "blown out."

- Detailed evaluation of the system's performance should be conducted at least semiannually and whenever system performance suggests a problem is developing. Dosing periods and frequencies, zone flow rates, system operating pressures (both manifolds and filters), and field flushing flow rates and pressures should be recorded and compared to design values.
- The designer and system manufacturers should provide a detailed O&M manual covering both routine and realistic nonroutine O&M activities that can be expected for the system.

3.7 System or Component Replacement Due to Aging: Key Aspects to Consider

With good design, installation, operation, and maintenance, drip systems are expected to have a useful life span of at least 20 years.[37] Most technology experts expect the system life expectancy to be unlimited because the technology has such good potential for matching design hydraulic and organic loading rates to allowable rates based on actual site conditions. However, our knowledge of cause and effect relationships need to be much improved, and the technology is not perfect. More detailed evaluations of systems that have been in use for long periods of time are needed.

A percentage of emitters can be expected to deviate from design drip rates significantly with time. This may be due to clogging (by microbial growth, roots, debris, soil, mineral precipitation, or combinations) or failed membranes on PC emitters. Several studies have documented clogging as a potentially significant problem based on both good and poor O&M [28,29,40]. In addition, the hydraulic characteristics of the soil itself may be significantly altered by wastewater [41]. The system should be designed and maintained based on potential degraded performance as the system ages. Key factors that need to be considered include:

- Ensure that flexibility exists to extend the length of dosing periods to mitigate the effects of clogged or partially clogged emitters or soil and to accommodate increased infiltration and inflow as the system ages. This is mostly applicable for larger systems with several zones (because dosing may be scheduled to occur most of the day). However, care must be used whenever dosing periods are increased, since there is danger of overloading the soil around the functioning emitters. In general, the design cumulative dosing during a day should not

[37] Non-PC emitters have been used since 1975 with many of the systems purported to be still working with the same degree of uniformity as when they were installed. Geoflow states that this type of emitter can almost always be brought back to the original performance standard unless root intrusion has caused the deterioration. The non-PC emitter is a very robust, proven technology. PC emitters have been used for wastewater since 1989. The first municipal PC drip system was installed in 1992 at Norwood, Georgia. This system continues to function successfully with routine O&M.

exceed 1080 minutes (18 hours) out of the available 1440 minutes. This also provides flexibility to add additional zones when needed (see next bullet).

- Consider the option of adding at least one extra zone to counter the effects of emitter or soil clogging and potential infiltration/inflow as the system ages. This ensures that the active portion of each zone is not hydraulically or organically overloaded as dosing times increase to counter the effects of clogged emitters or soil or extra flow due to infiltration/inflow. An extra zone provides flexibility to perform extensive maintenance or repairs on a problematic zone as needed without overloading other zones. An extra zone also facilitates sustainable performance of the system by allowing for long-term resting of alternate zones to break down potentially detrimental soil or tubing organic accumulations that may have formed while the zone was in service.
- Be aware that as part of a long-term maintenance function, chemical injection may be needed on a periodic basis to help restore hydraulic performance of a problem zone. Chemicals that may be needed include chlorine or industrial strength cleaners (to oxidize slimes and other organic material) and dilute acid (to dissolve minerals that may precipitate from the wastewater and clog the emitters). The PC diaphragm used by Geoflow and Netafim is silicone rubber, which has satisfactory resistance to these chemicals.[38]
- Each component of a drip system is relatively easy to repair or replace as needed. A failed drip zone or field represents the most critical component of the system, but methods are also available to mitigate this problem. If failure occurs on a limited basis, the specific spots can be addressed individually using such methods as replacement of faulty emitters, replacement of active tubing sections with blank tubing (no emitters), soil replacement, etc. For a zone or field where the failure is widespread, replacement with another new field may be needed, or the field may be renewed by installing new tubing runs between the old runs.

[38] Silicone rubber resists many chemicals including oxidizing chemicals, some acids, ammonia, and isopropyl alcohol. It is satisfactory for hydrochloric acid with strengths up to 10%. Concentrated acids, alkalines, and some solvents should not be used with silicones. Check a chemical resistance chart if there is any concern or doubt about resistance to a specific chemical. The potential impact of the chemical on soils should also be assessed.

4

CHAPTER 4—SITE ASSESSMENT

4.1 Type of Sites Where Drip Distribution is Commonly Used

Although drip distribution can be made to work on many types of sites, some sites and situations are much more appropriate than others are. In general, the technology should be used when it is important to get the best possible distribution of wastewater over an area. In many cases, the decision to use drip distribution should be based on its cost effectiveness relative to other appropriate distribution methods. Also, total system costs will be a critical factor since, while drip distribution may be technologically feasible, it may be too expensive to use for some sites. Some of the key factors that need to be considered are discussed below.

Drip distribution should be considered for sites where conventional septic drainfields cannot be used because of slowly permeable soils or a shallow depth to a restrictive layer. Drip distribution provides close to optimal dispersal of wastewater over the available soils. Drip tubing is also typically placed at much shallower depths than the trench bottom for conventional drainfields (6 to 12 in rather than 24 in deep). This 18- to 12-in difference in elevation between drip systems and conventional drainfields can be significant. The top soil layer normally has the highest permeability and the highest concentrations of fauna. In combination with better distribution of the wastewater, the soil has a better potential to attenuate remaining pollutants (primarily by aerobic processes) and move the water from the site. Water movement begins as saturated flow within a relatively small area around each emitter, progresses to unsaturated film flow as gravity and soil matric forces pull the water away from the emitters, and leaves the drip zone through either vegetative evapotranspiration or deep percolation to a perched or true groundwater table where saturated flow dynamics determine water movement from the site. Consequently, while a site may be borderline or not applicable for conventional drainfields, a drip distribution system may be applicable assuming it is affordable and managed properly. However, if the site contains soils with poor structure (see table 3-1) or very shallow soils, the improved performance resulting from drip distribution may still not be enough to overcome the soil conditions. Drip systems placed in elevated mounds with good soil characteristics combined with advanced treatment have been used in these difficult conditions but the costs may be prohibitive for some sites. This is an area where better information is needed to determine appropriate hydraulic and organic loading rates for soils with poor structure, clay mineralogy, and minimal depths and to identify practical limits for use of the technology.

Drip systems have also been placed directly on top of the soil surface, particularly in heavily wooded or landscaped areas. The tubing may either be left exposed or covered with mulch. This reduces the installation costs and may allow the technology to be used at sites without other suitable alternatives. These highly specialized systems or applications are outside the scope of these guidelines.

Drip distribution may also be a viable option for sites suitable for conventional septic systems where management is available, the system is affordable, and where minimization of environmental and public health risks is a primary objective. With long-term management, drip systems have the potential to be more sustainable over the long term than conventional septic systems. The good performance achieved with conventional septic systems in good soils can be expected to be even better using drip distribution where wastewater dispersal is much more uniform over the application area and the wastewater is applied closer to the surface.

Drip systems are finding an important niche for sites where point source discharges are either not allowed or would be controversial due to water quality issues for the receiving stream. These are typically classified as large drip distribution projects for small communities, subdivisions, or industrial or commercial property where conventional septic systems are not appropriate because of a large design flow or regulatory restrictions. Often the site may contain deep, permeable soils. This type of application is not unreasonably constrained by economics or the lack of an appropriate management entity. Performance standards are typically issued by the applicable state regulatory agency responsible for NPDES permits and large state land application permits based on both site and wastewater characteristics. This type of application is also the most appropriate for dispersing either primary or secondary/advanced quality effluents because the larger flows and system economics allow both approaches to be affordable with full automation. When anaerobic effluent systems are used, most designers prefer using them on the sites with relatively deep, permeable soils where the application is similar to conventional septic systems in good soils. As stated previously, the good performance achieved with conventional septic systems in good soils can be expected to be even better using drip distribution where wastewater dispersal is much more uniform over the application area and the wastewater is applied closer to the surface.

4.2 Sites Where SDD May Not Be the Most Appropriate

Drip distribution is a relatively expensive technology that requires a long-term commitment to proper O&M. The technology should generally not be used where other less expensive and more robust technologies[39] are appropriate. Conventional septic or alternative septic systems such as mounds or low-pressure pipe typically require less long-term O&M than drip distribution. However, there are exceptions as indicated in the previous section. Also, owner preferences concerning system aesthetics (mounds are typically unsightly) and reuse of the wastewater (drip systems allow irrigation of lawns and shrubs) may provide justification to consider drip distribution over conventional and alternative septic systems.

As mentioned in the preceding section, while drip distribution may be applicable for borderline sites, there are practical limits for use of the technology. Difficult sites will typically expose these limits. Caution is needed for any site with the following characteristics: small size, poor soils, shallow depth to limiting conditions, and steep woods.

[39] Robust refers to technologies that have stable or consistent performance with minimal operator attention for a wide range of influent wastewater characteristics.

Many drip systems have been installed in difficult terrain such as steep, wooded sites. These systems are expensive. Conventional machinery (e.g., dozers and tractors equipped with vibratory or static plows, backhoes, or trenching machines) typically cannot be used. Heavily wooded areas present several problems, including limiting the ability to uniformly space driplines between large trees, limiting the maneuverability of machinery, damage to trees from cut roots and bumps and scrapes, and damage to the soil structure from maneuvering machinery between trees. Installation is typically done by hand or small equipment. As with other types of systems, clearing or partially clearing a wooded area is always an installation option if costs are acceptable. If an area is to be grubbed, specific procedures and specifications need to be provided by the soil scientist and design engineer.[40] New or modified techniques are also being developed to improve installation of drip systems in difficult terrain, and many systems are now being installed on the surface in heavily wooded areas. Contact vendors or experienced designers to determine the viability of SDD or surface drip for these types of sites.

Problems most often occur with drip systems that are not professionally managed. Consequently, if long-term, quality management is lacking for any reason, the risk of failure or significant problems will be high as the drip system ages. However, this is not unique to drip systems and is generally applicable to any technology that needs quality management. The management issue needs to be resolved prior to allowing site development through the use of any advanced wastewater technology.

4.3 Site Soil Evaluation

One of the keys to a successful drip distribution system is carefully matching the zone details to the soil characteristics of the site. Drip rates, dosing duration and frequency, emitter and dripline spacing and burial depth are all variables that are dependent on soil texture and structure, depth to restrictive layer, slope, and other site conditions or constraints such as trees or other barriers and seasonal temperatures. Much of the information needed to design the system is obtained from a detailed soil survey or evaluation performed by a professional, certified soil scientist or engineer. Preferably, the soils expert should have experience with drip distribution systems and a good understanding of all the key concepts presented in this document to ensure that the information obtained is both relevant and extensive enough to provide the design engineer with the foundation needed for a competent system design.

Soils need to be mapped based on boundary concepts [42]. Boundaries are planes where conditions abruptly change. Key boundaries that need to be considered for design of drip distribution systems include those listed and described by Otis for any subsurface wastewater infiltration system. These are:

- The infiltration surfaces where the wastewater first contacts the soil.
- Secondary infiltration surfaces that cause percolating water to "perch" above an unsaturated zone created by changes in soil texture, structure, consistence, or bulk density.

[40] Using good grubbing practices, WWSI has generally found that grubbing does not negatively impact the hydraulic performance of drip systems.

- The groundwater table surface where the percolating water must drain from the site without excessive "mounding" or degradation of water quality.

Most of the information can be obtained from a detailed site evaluation. Several backhoe pits,[41] deep soil borings, soil permeability measurements, groundwater characterization, and other tests may be needed for large systems. Details are provided in other sources [43,15]. The Site Evaluation/Site Plan Checklist contained in the *EPA On-Site Wastewater Treatment Systems Manual* lists the appropriate surface and subsurface features that should be described and quantified [15]. This checklist is reproduced in table 4-1.[42] It should be modified as appropriate to include any additional items or to clarify features that may be important to the site evaluation.

Judgment is needed on the scope and amount of data needed for drip systems. At a minimum, all of the surface features listed in table 4-1 should be described for an area equal to about 200% of the estimated required drainfield area [15]. Drainage features and wells will probably need to be located and described within a radius of at least 100 ft beyond the perimeter of the proposed drip field for small systems and at least 500 ft for large systems. All of these values need to be adjusted based on applicable regulatory requirements.

Test pits or borings should be spaced sufficiently close together that conditions should be similar between adjacent pits or borings. Three to five pits or borings are typically sufficient for small projects. Depth of borings should typically be 4 ft below the proposed infiltrative surface.[43] If mounding or contour loading rates may be important for the site, deeper borings should be taken (assuming the restrictive layer is deeper than 4 ft below the proposed infiltrative surface) to allow a more detailed assessment of water movement in the soil.

Important soil properties that should always be obtained to describe a soil profile adequately include horizons, texture, structure, color, and redoximorphic features. Other properties that can be useful but not necessarily routinely required include moisture content, porosity, rupture resistance, penetration resistance, roots, clay mineralogy, boundaries, and coatings. Information on the value of these properties for determining water movement in the soil is provided in the *EPA On-Site Wastewater Treatment Systems Manual* [15].

The site evaluator should always provide the delineated area for the system, loading rate, and depth of installation on the soil map for the site.

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[41] Use of backhoe pits must be done judiciously and on a limited basis within the disposal area to avoid being detrimental to the performance of the drip field. When dug within the boundaries of the disposal site, the pit should be carefully backfilled following the recommendations of the soil scientist. Some soil scientists and engineers prefer that pits only be used around the periphery (outside) of the proposed disposal area to minimize disturbance of the actual disposal site.

[42] Table 4-1 is listed as a reference only. Additional information may be needed for a detailed design, particularly for difficult sites.

[43] Pits should not be deeper than Occupational Safety and Health Administration limits without adequate bank slopes or shoring.

Table 4-1
Site Evaluation/Site Plan Checklist

Owner/Client Information
Name____ Contact #s___________________________________
Address____
____
Projected design flow _______________________ (gal/d)
Existing use ______________________________________ Intended use ___________________________________
Legal description
____
____
____
Directions to site
____
____
____

Surface Features

______	Benchmark description	______	Assigned elevation _____ft.
______	Property boundaries	______	Surface water features
______	Existing/proposed structures	______	Existing/proposed water supply wells
______	Existing/proposed wastewater systems	______	Utility locations
______	Soil investigation points	______	Location of area of suitable soils
______	Contour elevations	______	Slope aspect & percent
______	Proposed system component locations	______	Other significant features
______	North arrow	______	Scale

Comments
____
____
____

Subsurface Features
______ Detailed soil descriptions (horizon depth, texture, color, structure, redoximorphic features, consistence, moisture, roots, and boundaries) (Use USDA nomenclature)
______ Depth and thickness of strong textural contrasts

______	Depth to seasonal saturation	______	Depth to perched water table
______	Soil testing results	______	Soil samples collected
______	Parent material	______	Soil formation factors
______	Depth completed	______	Depth
______	Depth to bedrock	______	Type of bedrock
______	Depth to permanent water table	______	Sample
______	Groundwater flow direction	______	Groundwater gradient

Comments
____
____
____

Site Evaluator ____ Date ____

Site Evaluation Type: Desktop ______________ Preliminary ___________ Detailed _______________

Source: *On-Site Wastewater Treatment Systems Manual* [15]

5
CHAPTER 5—DESIGN GUIDELINES

The basis for this document is the need for peer-reviewed design guidelines that provide a sound technical basis for the design, operation, and maintenance of drip distribution systems for wastewater applications. While visiting different sites with drip systems and discussing the design process and technology issues with various engineers, regulators, system owners and operators and equipment and component vendors and manufacturers, it became obvious that several approaches have been successfully used to design, operate, and maintain wastewater drip distribution systems. The following information should summarize the best of the design information, and as such, it should represent the current state-of-the-art for design of a subsurface wastewater drip system. However, with any document of this type, it should be considered as only a guide. The designer is always responsible for the appropriate use of the information and complying with applicable regulatory requirements. In addition, the manufacturers and their authorized representatives may have specific guidelines and recommendations that need to be followed for use of their components or systems.

5.1 Hydraulic Design Process

The detailed design process begins after the preliminary design decisions outlined in section 3.4 are completed, followed by the site evaluation process outlined in section 4.3 using boundary concepts. The basic information that will always be needed includes soil texture and structure, depth to restrictive layer, and surface slope at a sufficient number of locations to be representative of the site. This information must be documented by qualified professionals based on applicable regulatory requirements. Armed with this key information, drip application rates and dose volumes can be determined that are appropriate for the site conditions as described in section 3.2 and its subsections. The design process will be described through two examples starting with a relatively simple application for a home or residential system and ending with a relatively large system for a subdivision.

Pump-dosed, soil-based wastewater treatment systems operate in four distinct phases, and system designers must consider the operational characteristics of each phase. The initial phase of operation involves pressurizing the pipe network. Liquid distribution throughout the dosing network is not uniform until the entire system is pressurized. Optimal design will minimize the time required to pressurize a dosing network. All lines are fully pressurized and liquid distribution throughout the network is as designed during the second phase of the operation. With PC drip systems, this equilibrium phase of the operation is easily monitored. The equilibrium phase of the operation should be designed to supply liquid to the receiver site at the design rate. Following the dosing phase, the pump inactivates, and the system returns to a state of disequilibrium as the system depressurizes. During this depressurization phase of system operation, the liquid contained in the individual lines is redistributed to the lowest point in the network. Optimal design of a system will minimize the time required for the system to depressurize and minimize the volume of nonuniform distribution during depressurization. Following this depressurization phase is a resting and reaeration phase. Optimal design will allow maximum time between dose cycles for the system to rest and reaerate.

5.2 Example 1: Site that is Either Borderline or Unsuitable for a Conventional Residential Drainfield

The example used in chapter 5.7 of the EPA *On-Site Wastewater Treatment Manual* will be repeated here to provide a common reference to concepts and comparison of options that may be appropriate for this type of site [15]. Important site conditions that affect the design of the drip system are added to the EPA example as needed. Maximum allowable loadings and other limitations are based on GA EPD *Guidelines for Land Treatment of Municipal Wastewater by Drip Irrigation* [35]. Requirements for an actual site would be established by the local regulatory authority.

5.2.1 Site Description

A single-family residence with four bedrooms is proposed for a lot in Georgia with shallow, finely textured, slowly permeable soil over creviced bedrock. The soil is classified as a silty clay loam with a weak prismatic structure. No mottling or low chroma colors were observed within the soil profile. The soil depth is 2.5 ft. The slope of the lot is moderate (6%) and is controlled by bedrock. Groundwater is more than 5 ft below the bedrock surface. The available area is rectangular with dimensions of 150 ft along the contour or slope by 40 ft perpendicular to the contour. There are no large trees within the available area.

5.2.2 Design Boundaries

Four obvious design boundaries that will affect the system design are present: the infiltrative surface, the bedrock surface, the water table, and the downgradient area through which the wastewater flows. The site evaluation determined that no hydraulically restrictive layer is present in the soil profile above the bedrock.

5.2.3 Performance Requirements

The regulatory agency requires that the wastewater discharge remain below the ground surface at all times, that the groundwater contain no detectable fecal coliforms, and that the nitrate concentrations in the groundwater be less than 10 mg/l as nitrogen at the property boundary.

Maximum allowable design wastewater loadings are 2.8 in/wk and 0.30 inches per hour (in/h) (instantaneous).[44]

5.2.4 Design Based on Hydraulic Footprint Loading Rates

The application guidelines provided by the vendor or manufacturer of the brand of drip tubing to be used (tables 3-5 through 3-9) can be used as a guide for determining appropriate hydraulic loading rates, but the actual design value should be specified by an experienced professional soils evaluator based on key site conditions. For this example, the application rate (footprint loading rate) specified by the soils evaluator is 0.2 gal/d/ft^2. The footprint loading rate is not considered dependent upon effluent quality for typical residential wastewater (see section 3.2.3). Treatment levels may range from primary or septic to advanced.

The design flow for homes is typically based on the number of bedrooms. A typical design value is 150 gal/d per bedroom, resulting in a design flow of 600 gal/d for a four-bedroom house. Actual flow for new houses with standard water conservation devices should be closer to an average daily flow of 135 gal/d (based on 50 gallons per capita per day and 2.7 people per home) [15]. However, maximum or peak daily flows may be much higher due to weekend guests, clothes washing preferences, parties, or other factors. A peaking factor of 2.5 for peak daily flows is recommended for homes, resulting in a peak flow of 562.5 gal/d and an average flow of 225 gal/d for a four-bedroom home with five people with an average flow of 45 gallons per capita per day [34]. Since dosing tanks for either treatment or drip systems are typically designed to equalize flows during the day by providing storage capacity for peak and emergency flows and by using timed dosing that can be adjusted as needed to handle average and peak flows (see figure 3-6 and section 5.2.6), the design flow for the drip system can be reduced from the peak value. The amount depends on the details of the equalization plan. For this example, the peak flow is assumed to occur no more frequently than two consecutive days per week. For these conditions, a system designed for a maximum daily flow of 80% of the peak (450 gal/d) is adequate to process easily the total flow received throughout a week. Peak dosing would occur for the two days of high flow plus one additional day to return the water level to average or normal levels. Greater reductions in maximum daily flow may also be possible depending on the design of the equalization system and the actual maximum expected water use on a weekly basis. However, the treatment and drip systems should never be loaded in excess of the daily design flow. Peak flows that exceed the design flow must be stored and processed through the system over several days at the daily design flow rate.

For this example, the maximum design flow will be 450 gal/d and the average flow will be 225 gal/d. Equalization will be provided to process the peak daily flow of 562.5 gal/d that may occur during the week.

[44] These requirements are for illustrative purposes only and are not typical requirements for a home system in Georgia (which would be regulated by the Georgia Department of Human Resources, Public Health Division). The requirements are typical for larger systems (over 10,000 gal/d) in Georgia, which are regulated by the GA EPD.

Footprint area (A) required:

$A = 450 \text{ gal/d} \div 0.2 \text{ gal/d/ft}^2 = 2250 \text{ ft}^2$

Contour loading:

The site has a shallow restrictive layer (rock at a depth of 2.5 ft) and a moderate slope (6%). During the nongrowing season, most of the wastewater can be expected to seep deeply into the soil rather than evapotranspirate to the atmosphere. The wastewater will saturate the soil above the bedrock and begin to mound beneath the drip field as it moves horizontally along the top of the bedrock (see figure 3-3). If the bedrock is impermeable and solid (no significant fractures), mounding will need to be controlled to maintain a nonsaturated soil layer beneath the drip field. In this example, the rock formation is known to be extensively fractured and no significant mottles are present in the soil profile. Consequently, there is good potential for saturated vertical leakage to the rock layer. The minimum nonsaturated soil depth should be 12 in if the treatment system includes a disinfection unit and 24 in without disinfection (see section 3.2.3).[45] Since the total soil depth is only 30 in, the most cost effective option will probably be an advanced treatment system with disinfection rather than hauling in topsoil to maintain these suggested minimum unsaturated soil depths. To minimize the potential for water mounding and to provide a conservative design, the hydraulic contour loading rates suggested by Tyler (table 3-1) will be used. For a silty clay loam (SiCL) with a weak prismatic structure (shape “PR” and grade “1”) with a slope of 6% and an infiltration distance below the dripline of 12 to 24 in, the maximum suggested contour loading rate is 2.7 gal/d/ft. Since this is a total or cumulative value, the rate should be applied to the soil depth beneath the last dripline lateral on the downgradient edge of the system. This allows the following calculations.

Minimum length needed (L_{min}) along the contour:

$L_{min} = 450 \text{ gal/d} \div 2.7 \text{ gal/d/ft} = 167 \text{ ft}$

Since the site will accommodate a maximum of only 150 ft of dripline along the contour, options need to be reevaluated. One option is to recognize that the rates used are only recommended values based on conservative assumptions (use of the hydraulic contour loading rates suggested by Tyler assumes all flow moves horizontally in the permeable soil layers above the confining layer). A reasonable argument could be made that the system would function satisfactorily with laterals that are only 150 ft long rather than 167 ft and the design could be continued. For this example, we will adhere to the most conservative option, requiring that soil be added to the site to increase the infiltration distance between the bottom of the dripline and the rock. The dripline burial depth will be 9 in, and the minimum infiltration distance of 24 in will be maintained, requiring a total soil depth of at least 33 in. A total of 6 in of new topsoil (preferably a sandy loam or loamy sand) will be added to the site to provide an infiltration depth of 27 in and a total soil depth of 36 in. The added topsoil should be plowed into the original soil to minimize any textural or structural interface (which could act as another confining layer) between the original

[45] Actual requirements will be established by the local regulatory authority.

soil and the new topsoil.[46] Since some mounding may still occur over the fractured rock and the depth of unsaturated soil cannot be accurately estimated, advanced treatment with disinfection remains a conservative option for this site although a strong argument could be made for a septic effluent system (without disinfection), since Tyler's information is based on experience with both conventional septic tank effluent and higher quality effluents and an impermeable layer beneath the system rather than fractured rock.

The revised hydraulic contour loading rate based on an infiltration distance of 24 to 48 in is 3.2 gal/d/ft (table 3-1). The revised minimum length needed (L_{min}) along the contour is:

L_{min} = 450 gal/d ÷ 3.2 gal/d/ft = 141 ft

Since the site geometry will accommodate up to 150 ft of dripline along the contour, this value will be used, making the design more conservative by further reducing the contour loading rate for the site.

Emitter spacing and area coverage:

Typical emitter spacing is 2 ft along the tubing. Shorter spacing intervals (12 or 18 in) are sometimes used in difficult soils, but experience indicates that flow effectively moves along the emitter line.[47] Tubing with 2 ft emitter spacing will be used for this example.

Typical spacing between driplines is also 2 ft, resulting in area coverage of 4 ft^2 per emitter. Smaller spacing (either 12 or 18 in) may be used for special needs such as reducing the instantaneous loading rate (increasing the infiltration surface area) for septic effluents (see section 3.2.3).

Daily volume dosed per emitter:

Daily emitter volume = footprint application rate x emitter areal coverage = 0.2 gal/d/ft^2 x 4 ft^2/emitter = 0.8 gal/d/emitter

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[46] Use of fill in a drip system is controversial. Construction of a permeable interface or transition between the fill and natural soil may be difficult. Some practitioners believe that preparation of the site and placement or incorporation of fill may do more harm than good to the natural soil conditions, and the boundary or interface may impede vertical flow to the natural soil rather than enhancing it. Others have no problems using fill for drip systems and report good results. This example identifies several different design options.

[47] There is no consensus on this concept. Geoflow believes that flow along the tubing wall results from a reduction in capillary action around the emitter due to a combination of factors including application of anaerobic effluent, long application times, and application in heavy clays. There is consensus that capillary forces represent a major dispersion process as depicted in Figures 3.1 and 3.2; however, many of the reviewers also believe that one of the flow paths of least resistance is along the tubing wall regardless of effluent quality or soil type. The extent of movement along the tubing depends on several factors including saturation around the emitter (which depends on application time and soil characteristics) and gravity and surface tension along the drip tubing. This is another area where additional research may be needed to resolve the technical issues. See footnote 5 for additional information.

Emitter discharge rate:

For soils with low percolation rates or low permeability, emitters with small drip rates match the hydraulic characteristics of the soils better, minimizing the hydraulic pressure within the saturation zone around the emitter. Emitters with a nominal drip rate of 0.4 to 0.6 gal/h should typically be used.[48]

In addition, if there is an instantaneous loading rate restriction as is the case with the GA EPD regulations used to guide this example, the emitter rate must not exceed the instantaneous allowable rate. The instantaneous loading rate is calculated as follows:

Netafim PC emitter: 0.62 gal/h/emitter x 1 emitter/4 ft^2 x 1 cubic foot (ft^3)/7.481 gal x 12 in/ft = 0.25 in/h

Geoflow Wasteflow PC emitter: 0.53 gal/h/emitter x 1 emitter/4 ft^2 x 1 ft^3/7.481 gal x 12 in/ft = 0.21 in/h

Geoflow Wasteflow Classic emitter: 1.30 gal/h/emitter (at 20 psi) x 1 emitter/4 ft^2 x 1 ft^3/7.481 gal x 12 in/ft = 0.52 in/h

Both of the instantaneous rates for the PC emitters are less than the allowable 0.30 in/h, but the rate for the turbulent flow emitter is greater than the allowable instantaneous rate. For this example, only the PC emitters will be used.

Length of emitter tubing needed:

Tubing length = footprint surface area ÷ spacing between lines = 2250 ft^2 ÷ 2 ft = 1125 ft

Number of dripline runs:

Number of line runs = tubing length ÷ line length based on linear or contour loading = 1125 ft ÷ 150 ft = 7.5

Round up the number of lines to eight runs, resulting in a total of 1200 ft of drip tubing (spaced 2 ft apart) and 600 emitters.

If septic effluent was dosed, consideration may be given to decreasing the spacing of the driplines to 1 ft (resulting in 15 laterals, 2250 ft of drip tubing, and 1125 emitters) or 18 in (resulting in 10 laterals, 1500 ft of tubing, and 750 emitters). If this approach is used, the footprint size should remain the same. This increases the infiltrative surface (based on the value of 1 ft^2 per 5 linear ft of tubing; see section 3.2.1) and utilizes the available soils more efficiently

[48] Geoflow believes that emitters with a nominal drip rate of 1 gal/h are acceptable for soil application rates greater than 0.1 gal/d/ft^2 for aerobic effluents. For anaerobic effluent or soils with application rates of 0.1 gal/d/ft^2 or less, they would typically recommend the nominal 0.5 gal/h emitters.

for the stronger effluent.[49] The number of zones, flushing flows, dose frequencies, and pump sizes would need to be based on the larger number of drip laterals and emitters.

Configuration:

The driplines can be arranged in several configurations that have both advantages and disadvantages (see section 3.3.1 and figure 5-1). Since each line will need to be periodically flushed, reducing the number of laterals reduces the total flushing flow that will be needed. This is accomplished by looping the individual runs (defined as the dripline length between the manifolds for a zone without loops or the dripline length along the length of the zone if both manifolds are on the same end) to form a longer lateral (defined as the length of line from the supply to the return manifolds and may include two or more runs). Since this design has only eight runs, there should not be a problem with matching total flow requirements (drip flow plus flushing flow) with commonly available pumps. Consequently, each line will be tentatively configured as both a single run and lateral (no loops). If a problem occurs with matching total required pumping rates to available pumps, a single loop would be added to each run, resulting in the supply and return manifolds located in the same trench and reducing the number of laterals in half (from eight to four for this example). If the site was triangular shaped, adding loops to the configuration allows the drip field to better fit the site. In this case, the layout should be modified as necessary using several runs of varying lengths to obtain approximately the same overall length for each lateral. This will aid field flushing. Calculations will be based on the longest lateral. For larger systems, splitting the drip field into zones is another method for configuring the system to both site constraints and available pumps (see the next example).[50]

The layout of the drip field and manifolds should typically be configured to supply wastewater from the lowest elevation and flush the system from the highest elevation. This minimizes the contribution of the supply pipe to the potential drain-back volume within the field and improves distribution of wastewater and functioning of A/V relief valves during filling and draining of the field.[51] The supply and return manifolds should also be designed to minimize or eliminate any contribution to drain-back (see sections 3.3.5 and 5.6.2). The basic layout for the system is shown in figure 5-2.

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[49] This is considered a conservative approach for septic tank effluent; however, there is no consensus on the need for this approach. Many drip systems for septic tank effluents have been installed with the conventional 2-ft spacing for emitters and tubing using the application rate specified by the soils evaluator.

[50] Some practitioners never design for a single zone. Multiple zones allow more operational flexibility with the system, but this flexibility may significantly increase costs and complexity. The designer may need to evaluate the cost effectiveness of multiple zones for home systems in consultation with the system owner and operator to decide whether to incorporate them into the design.

[51] Care must be taken in rolling terrain to ensure that no portion of the supply or return mains is at a higher elevation than the drip field. If A/V release valves are used on the supply and return mains, some of the volume contained in the mains may be drained through the drip laterals.

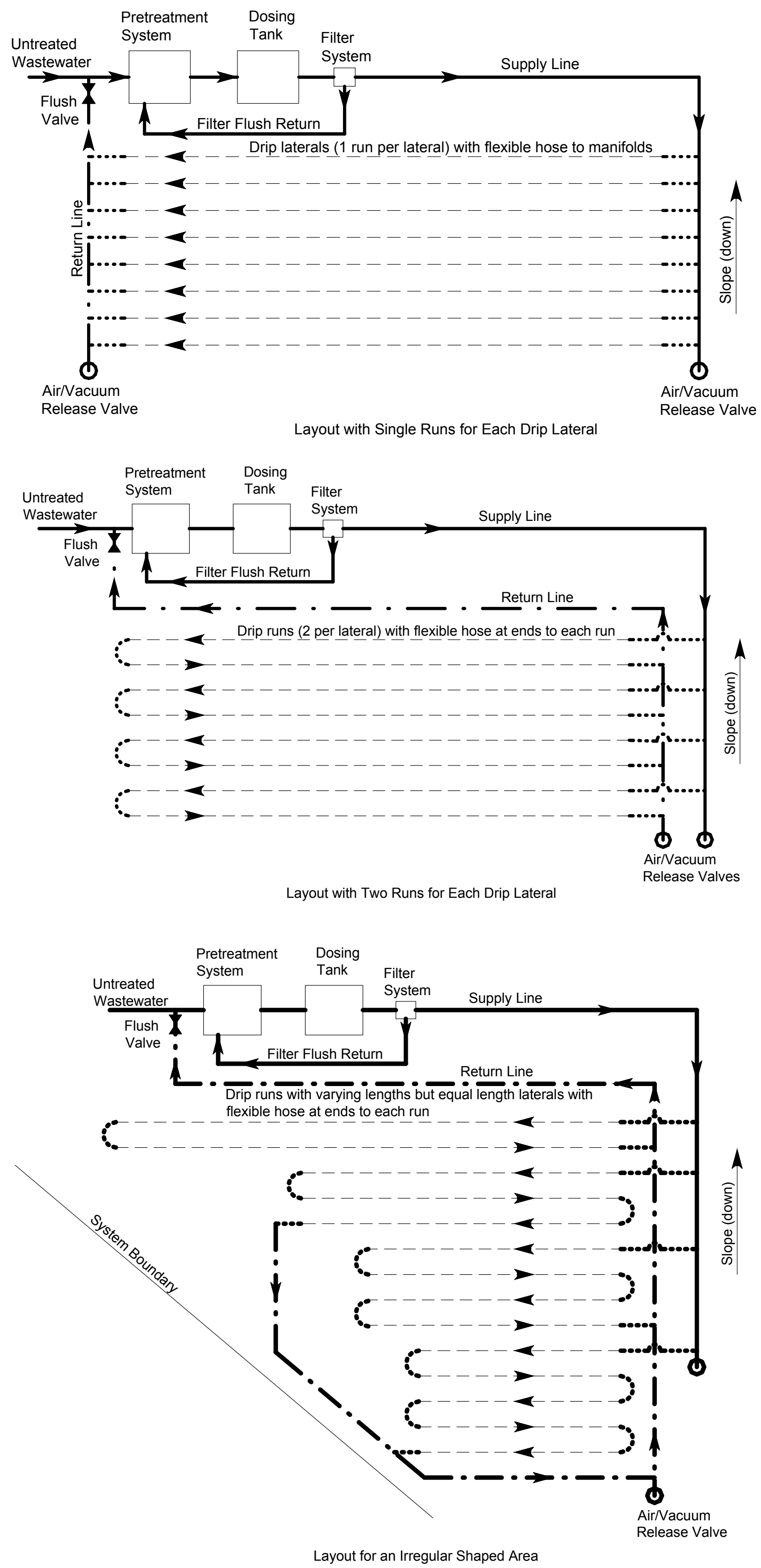

Figure 5-1
Layout Configurations for a Single-Zone System

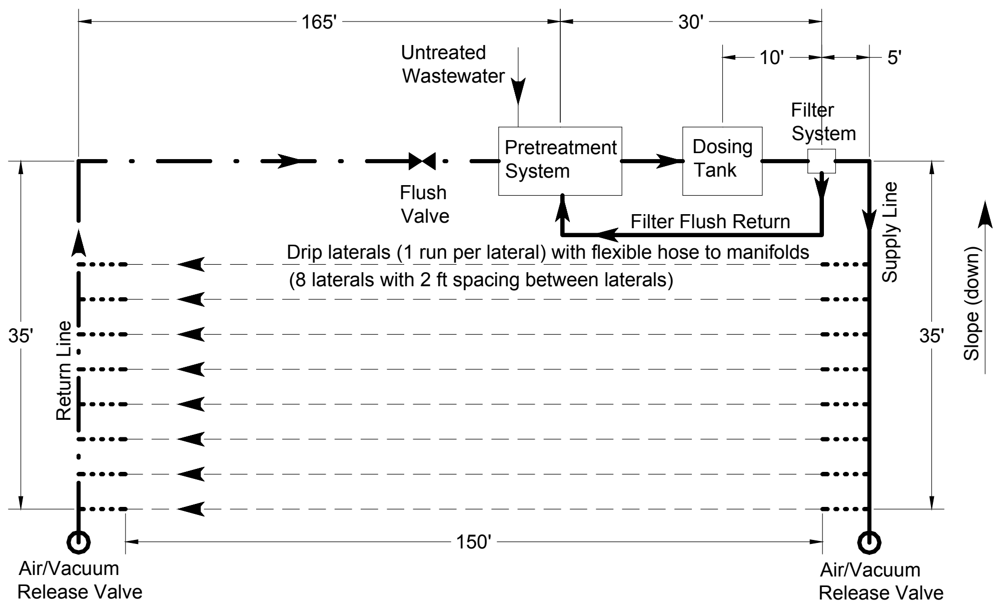

Figure 5-2
Layout for Design Example 1

5.2.5 Pumping Requirements

Dosing requirements:

The flow rate needed to dose the drip field is determined by the selected drip emitter, operating pressure (for non-PC emitters), and the number of emitters with the drip zone. For this example, there is only one zone. The design details will now depend on specific components to be used.

PC emitter dosing flow = emitter drip rate x number of emitters
= 0.62 gal/h/emitter (for the most commonly used Netafim BioLine emitter) ÷ 60 minutes per hour (min/h) x 600 emitters = 6.20 gal/min
= 0.53 gal/h/emitter (for Geoflow Wasteflow PC) ÷ 60 min/h x 600 emitters = 5.30 gal/min

The calculation would be similar for the Geoflow turbulent flow emitter after selecting the design operating pressure for the system and determining the corresponding drip emitter rate. If the Classic emitter is used, the design would assume the flow rate based on the design internal line pressure (typically 20 psi).

Flushing requirements:

Additional flow is needed to periodically flush the drip laterals and supply and return pipes. Flushing removes accumulated solids and controls microbial slimes that may be growing inside the tubing and other pipes. Although there is general agreement that tubing should be periodically flushed; there is no consensus on the required velocity needed to flush the laterals effectively. Turbulent flow is needed to keep solids in suspension, to resuspend particles that have settled between doses, to remove construction debris, or to scour biological growth from the wall of the tubing. The required velocities will vary depending upon the characteristics of the solids and the pipe. In general, for raw wastewater containing grit and other materials, minimum velocities of 2.5 ft/s and 3.5 ft/s are needed to keep solids in suspension and to resuspend solids, respectively [44]. For effluent following primary settling tanks, the equivalent velocities are lowered to 1.5 ft/s and 2 ft/s, respectively. For secondary effluent, the velocities are only 0.5 ft/s and 1 ft/s, respectively.[52] Since all drip systems should incorporate a filter system as a key integral component (regardless of the level of pretreatment), solids entering the drip system pipes and tubing will be very small, typically less than 100 to 130 microns. Generally, velocities on the order of 1 ft/s should be adequate to resuspend and flush any of the fine solids that exit these filters. However, there will be situations where higher velocities may be periodically needed. Biological growth or slimes may occur in some systems, requiring routine flushing to control them. These slimes are typically "sticky" in character and are more difficult to remove. Dirt and construction debris will need to be removed at system start-up and any time following a pipe or tubing failure or replacement (equivalent to grit contained in raw wastewater). Dirt can also enter the dripline during routine operations of on/off cycles and due to rainfall inflow. Chemical and biochemical reactions may also result in precipitation of solids within the pipe and tubing during operation. Consequently, velocities may need to be higher than 1 ft/s for these conditions or situations. However, high velocities increase the hydraulic friction loss for the pipe and require more pump energy. Velocities over 5 ft/s in PVC pipe also require special consideration for surge pressures and conditions [45].

Netafim recommends flushing velocities of at least 1 to 2 ft/s at the distal end of the laterals. All of the designers of Netafim tubing that were interviewed for this project used a design flushing velocity of 2 ft/s. Geoflow believes that a velocity of only 1 ft/s is adequate for tubing flushing because of the effectiveness of the biocide lining on the inside tubing wall and the high degree of treatment that typically precedes its systems. All of the states whose regulations were reviewed for this project require a minimum flushing velocity of 2 ft/s regardless of the brand of tubing used. Berkowitz reported that 3 ft/s or larger was needed to be effective for septic tank effluent and 1.5 ft/s or larger was needed for sand filter effluent [28].

For this example, supply and return pipes will be designed for self-cleaning velocities between 2 to 5 ft/s. A minimum drip tubing velocity of 2 ft/s at the distal end of the laterals will be used for Netafim tubing and 1 ft/s will be used for Geoflow tubing. In addition, calculations are also included for 2 ft/s flushing velocities for Geoflow Wasteflow tubing in tables 5-7, 5-8, and 5-9 to demonstrate the effect of the different velocities on the design. The flow needed for lateral flushing will be:

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[52] These velocities are appropriate for conventional sewer pipes that are typically larger than those needed for drip systems. Transition from laminar to turbulent flow in circular pipes typically occurs at Reynolds numbers between 2000 to 4000 or higher. Reynolds numbers depend on pipe diameter. Small diameter pipe requires larger velocities than large diameter pipes to achieve equivalent Reynolds numbers. For example, a nominal 1/2-inch pipe with a velocity of about 1 ft/s will have a Reynolds number of about 4000 (at a temperature of 70°F). A nominal 2-inch-diameter pipe would only need a velocity of about 0.25 ft/s for a Reynolds number of 4000. This indicates that higher velocities are needed in small diameter pipes to achieve an equivalent degree of turbulence (in terms of Reynolds numbers).

Flow needed per lateral = velocity x tubing cross-sectional area

Netafim tubing:

= 2 ft/s x 60 seconds per minute (s/min) x (π x (0.57 in)^2 ÷ 4) ÷ 144 square inch per square foot (in^2/ft^2) x 7.481 gal/ft^3
= 1.591 gal/min

Geoflow tubing:

= 1 ft/s x 60 s/min x (π x (0.55 in)^2 ÷ 4) ÷ 144 in^2/ft^2 x 7.481 gal/ft^3
= 0.741 gal/min

For the eight lateral zones:

Netafim tubing = 1.591 gal/min/lateral x 8 laterals = 12.73 gal/min[53]
Geoflow tubing = 0.741 gal/min/lateral x 8 laterals = 5.93 gal/min

The total flow required for both emitter operation and lateral flushing is the sum of the calculations.

Netafim tubing = 6.20 gal/min (600 emitters) + 12.73 gal/min = 18.93 gal/min
Geoflow tubing = 5.30 gal/min (600 emitters) + 5.93 gal/min = 11.23 gal/min

TDH for the system:

In addition to the system flow requirements, pump selection must be based on the TDH for the system. The TDH is the energy that the pump must supply to meet demands of the various drip system components and operating schemes. This requires the preliminary selection and design for all components to determine applicable head losses. If cumulative head losses result in a TDH that is too large for readily available pumps, components are reselected or resized to lower friction losses until the TDH for the system is within the range of commercially available pumps. The process is outlined below.

TDH = pressure head + velocity head + elevation head + friction head

The various heads are depicted in figures 5-3 and 5-4 for submersible turbine and centrifugal pumps, respectively. Since there will typically be different operating schemes within the system (i.e., dosing, dosing and flushing, and filter flushing) and the hydraulic conditions differ between each scheme, several TDHs will need to be calculated to determine the controlling value.

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[53] This method only works for drip fields or zones where all of the laterals are the same length. If the laterals are different lengths, the total friction losses will be different for each lateral, resulting in higher flows and velocities in the shorter laterals (relative to the longer laterals). This situation requires a Hardy-Cross type of analysis to determine incremental flow needed to assure 2 ft/s in all laterals. This type of analysis can be made using the DRIPNET program developed by Steven Berkowitz, North Carolina Department of Environment and Natural Resources; however, the program is currently only applicable for PC emitters [46].

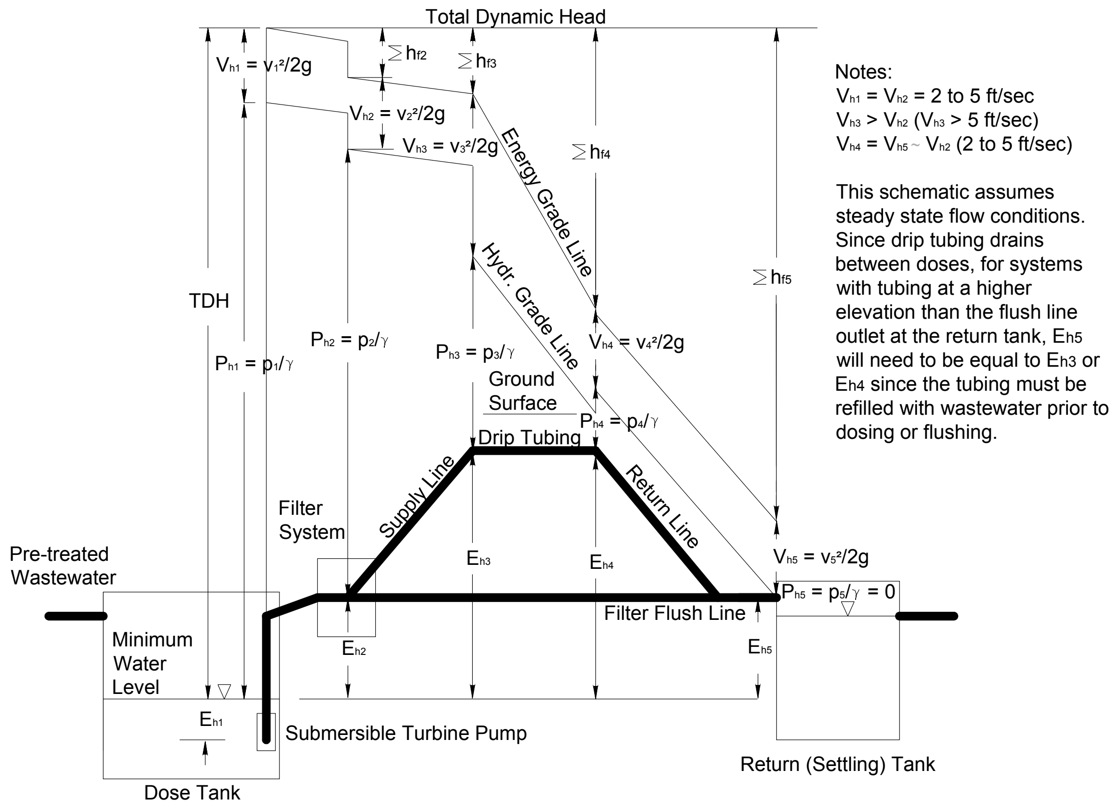

Figure 5-3
Hydraulic Energy Conditions for Submersible Turbine Pumps

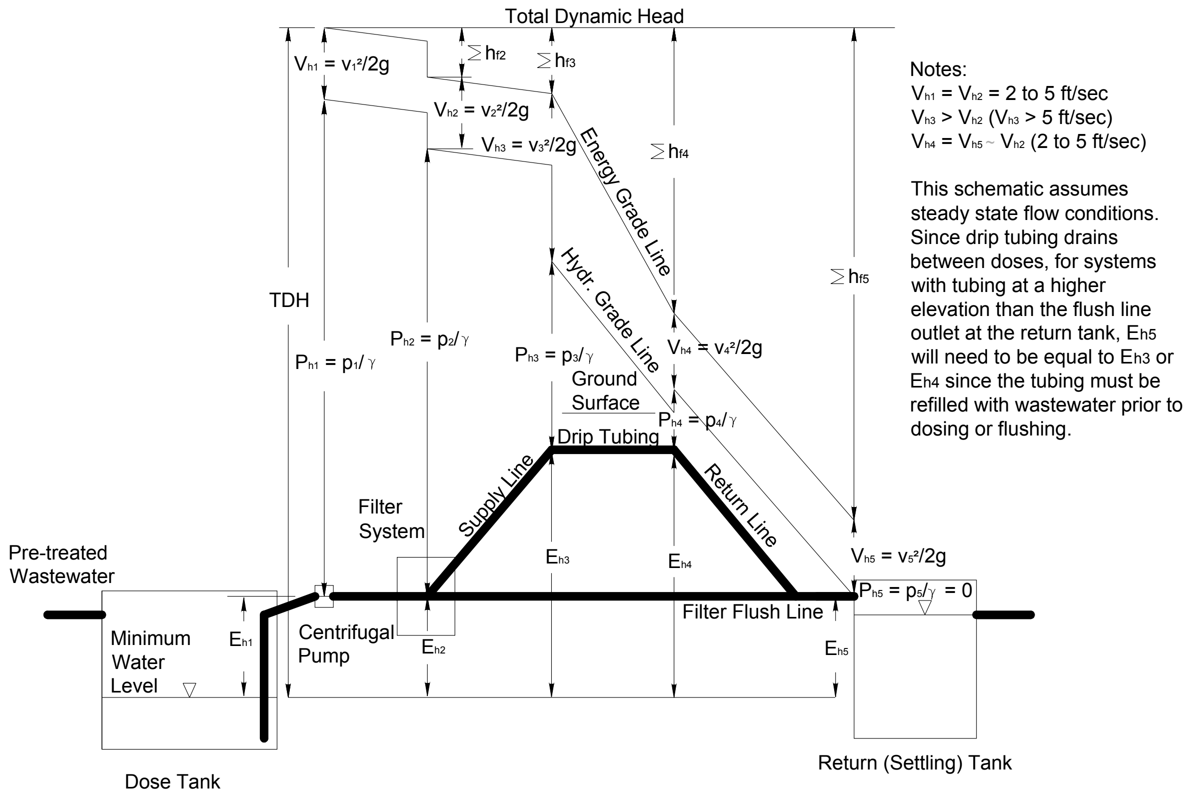

Figure 5-4
Hydraulic Energy Conditions for Centrifugal Pumps

Since the drip system is expected to dose uniformly even during flushing cycles, the flushing cycle will typically result in the highest energy demands for the drip field. If disk or sand filters are used, the TDH for dosing and flushing will typically need to be compared to the TDH required for filter back-flushing to determine the maximum energy required for the system. Spin or screen filters are flushed rather than back-flushed, and this operation requires less energy than that needed for dosing or flushing the drip field.

For Netafim BioLine, the recommended operating pressures for the drip tubing range from 25 to 40 psi. However, rather than specifying a minimum operating pressure, the design typically determines the required operating pressures based on specifications for minimum pressures needed for dosing or flushing for the longest length of drip lateral (so long as the resulting inlet pressures are within the manufacturer's acceptable range).

During the dosing cycle, the minimum inlet pressure for the drip field is determined based on the length of the longest drip lateral while maintaining a minimum operating pressure at the distal end for assuring uniform drip rates from the drip emitters (at least 7 psi). It is suggested that 10 psi be used as the minimum required target pressure at the distal end of the drip laterals rather than 7 psi. The friction loss for BioLine while dosing is only 0.43 psi for a lateral length of 150 ft, resulting in a required inlet pressure of 10.43 psi. During flushing, the required inlet pressure will need to be much higher to achieve the target flushing velocity. Netafim provides the required information in the chart "BioLine Flushing Velocity" on page 27 of the current Netafim Design Guide, reproduced in appendix D. For BioLine, the projected minimum head loss while flushing is about 7.25 psi based on a target flushing velocity of 2 ft/s (and 150 ft lateral) and a head loss while dosing of 0.43 psi. If the system is designed to dose uniformly during the flush cycle, a residual pressure of 10 psi is also needed at the distal end of the lateral as stated above, resulting in a total pressure needed at the inlet of 17.25 psi.[54] An important concept at this point is how to ensure that a pressure of 17.25 psi can actually be attained at the inlet to the drip laterals, since to flush the system, the flush valve is opened, allowing the system to be open to atmospheric pressure at the return settling tank. This will result in a pressure of 0 psi at the pipe outlet to the return tank. The actual pressure that can be achieved at the distal end of the drip system depends on the frictional losses that occur within the return piping system and any positive elevation head that may exist between the return manifold and the return tank. The design needs to ensure that the combination of frictional losses and elevation head total at least 10 psi (assuming the objective is to dose uniformly while the system is flushing). If the combined return energy components do not total 10 psi (based on the actual length of pipe, number and type of fittings and valves to be used, and elevation head), the flush valve will need to be partially closed or adjusted during flushing to ensure that 10 psi is available at the return manifold, resulting in the same energy needed for dosing and flushing under each scenario.

The TDH will need to be calculated for these various operating conditions to determine both controlling conditions and actual operating points for the pumps to be used. Additionally, when disk filters are used, the TDH must also be calculated for back-flushing the filter system. The disk filter corresponding to the maximum design flow of 19 gal/min (dosing and flushing) and 140 mesh filtration is the 1-in filter. This filter requires 15 gal/min at 40 psi to properly back-flush.[55] During back-flushing, the flush water is returned to the settling tank; consequently, the corresponding pressure at the pipe outlet to the return tank is 0 psi.

[54] There is not a consensus on the need for uniform dosing during flushing. Time needed for flushing is typically much shorter than that for dosing. Typically, at least one-pipe volume for the drip tubing should be flushed compared to at least four-pipe volumes for dosing. Flushing may also be very infrequent for drip systems distributing aerobic effluents (ranging from about once every 50 cycles to once per six months). For these types of systems (which are the most common), Geoflow believes that nonuniform dosing during flushing is not a concern, and the residual 10 psi pressure at the distal end is not necessary, which in combination with a 1 ft/s flushing velocity may result in a substantial reduction in capital and operating costs. The North Carolina Department of Environment and Natural Resources prefers to use at least two-pipe volumes for flushing (to both dislodge and scour clean) and at least five-pipe volumes while dosing (six-pipe volumes are needed to have 80% of the dose delivered under full pressurization).

[55] Only the Arkal 2-in (and larger) Spin Klin filters are designed to have adequate back-flushing capabilities for wastewater applications. The Arkal 1-in filter has been modified by JNM Technologies, Bryan, Texas, to provide equivalent back-flushing capability for wastewater. Wastewater Systems, Inc., has also found through experience that the 3/4-in manual filter can be successfully back-flushed (although they have modified the spring on the disk stack to allow the disks to separate with lighter pressure). This is due to its angular configuration. If another size of Arkal filter is used, the filter should be manually cleaned. Always check with the equipment representatives or manufacturers to obtain current information on any component.

The pressure heads (P_h) for the four conditions described above for the Netafim design are:

at the inlet of the drip laterals for dosing the drip field:	10.43 psi (24.1 ft)
at the return tank for dosing and flushing:	0 psi (0 ft)
at the inlet of the drip laterals for dosing and flushing:	17.25 psi (39.8 ft)
at the return tank for filter back-flushing:	0 psi (0 ft)

The velocity head is the energy associated with the moving water within the system. It is calculated by the following formula:

Velocity head (V_h) = $v_x^2/2g$

Where: v_x = mean flow velocity at location x

g = acceleration of gravity, 32.2 ft/s^2

Typically, this component of the energy equation can be ignored, since it is small relative to the other components. The flow velocity must be greater than 8 ft/s for the head to exceed 1 ft. Typically velocities for PVC pipe should be less than 5 ft/s to preclude excessive surge pressures (water hammer) and unnecessarily high friction head losses. For a velocity of 5 ft/s at any location in the drip system, the velocity head would be 0.39 ft as shown below:

$$V_h = (5 \text{ ft/s})^2/((2)(32.2 \text{ ft/s}^2)) = 0.39 \text{ ft}$$

For the design examples within this document, the flow velocities will always be less than 5 ft/s, and the velocity head will always be less than 0.5 ft.

The elevation head (E_h) is the energy that must be provided to pump the wastewater to the various elevations within the system. It is calculated as the difference in elevation between the critical locations within the drip system and water level within the dose tank. For this example, it is assumed that the ground surface at the drip field is 10 ft higher than the minimum water elevation in the dose tank (pump "off" float elevation), the drip laterals are buried 0.75 ft below the surface, and the return flush line discharges into the return tank at an elevation that is 3 ft above the minimum water level within the dose tank.[56] The corresponding elevation heads for these two critical locations are:

E_h at the inlet of the drip laterals = (10 ft – 0.75 ft) – 0 ft = 9.25 ft

[56] If the drip field was located at an elevation lower than the water in the pump tank, the elevation head would be a negative number. The elevation head would still be negative for this case if the supply pipe ran up a hill (at a higher elevation than the pump tank) and then downhill to the drip field assuming that the system included a zone valve that ensured that the supply pipe always remained filled between doses. However, if the difference in elevation is large, the designer would need to verify that the pump would be adequate to fill the supply pipe initially. Also, if this drip system consisted of a single zone without a solenoid zone valve (i.e., the portion of water in the supply pipe downhill from the peak could drain through the drip emitters between doses), the elevation head used in the calculation for either dosing or flushing would need to be the elevation difference between the high point in the supply piping system and the minimum water elevation in the pump tank since this part of the system must be refilled at the start of each dose.

E_h at the pipe outlet to the return tank = (3 ft) – 0 ft = 3 ft (for steady state flow assuming flow fills the return pipe[57])

Since friction loss depends on the flow velocity, the piping system needs to be preliminarily sized to allow calculation of friction losses at the critical locations within the system. Target velocities within the piping system should be within the range of 2 to 5 ft/s to prevent solids' deposition and to flush solids from the system while avoiding high surge pressures and friction losses. Typically, the supply and return manifolds are kept the same size as the supply and return pipes, respectively. Since the flow rate varies along the length of the manifolds due to dosing through the drip laterals, a target velocity in the upper portion of the velocity range should be used to size the manifold to achieve at least 2 ft/s in most of the length of the supply and return manifolds.

Using 4 ft/s as the target flow velocity for the maximum flow rate (dosing and flushing), the pipe size required for the supply line and manifold would be:

Pipe inside diameter (D_i) = $\sqrt{(4Q/\pi v)}$

Where Q = flow

v = velocity

D_i = $\sqrt{((4)(18.93 \text{ gal/min})(144 \text{ in}^2/\text{ft}^2)/(3.1417)(4 \text{ ft/s})(60 \text{ s/min})(7.481 \text{ gal/ft}^3))}$ = 1.390 in

PVC pipes with adequate pressure ratings, serviceability, and availability are typically either Schedule 40 or DR 21 (Class 200).[58] Using data for Schedule 40 pipe, the closest available pipe is nominal 1 1/4-in pipe with an inside diameter of 1.38 in. The actual velocity for this pipe would be 4.06 ft/s based on the design flow of 18.93 gal/min.

The pipe size required for the return manifold and line would be:

$D_i = \sqrt{((4)(12.73 \text{ gal/min})(144 \text{ in}^2/\text{ft}^2)/(3.1417)(4 \text{ ft/s})(60 \text{ s/min})(7.481 \text{ gal/ft}^3))}$ = 1.140 in

[57] Typically, the sizing of the return pipe and flush valve and the associated friction losses result in pressurization of the return pipe during flushing even if the drip field is located at a higher elevation than the return tank. However, the elevation head for flushing the system must be the based on the elevation of the drip laterals (or the supply pipe peak elevation if applicable) since the emitters allow the laterals to drain between doses, and the pump must refill the laterals at the beginning of each dose or flush cycle. For this example, the elevation head for flushing will be equal to the elevation head at the inlet to the drip laterals (9.25 ft) rather than the elevation head for the pipe outlet to the return tank (3 ft). The elevation head for back-flushing disk filters will be 3 ft since the piping for the filter system does not drain between cycles.

[58] Schedule 40 pipes are typically stocked in many plumbing stores for pipe diameters up to 2 in while larger pipes are typically stocked in DR 21 (Class 200) or SDR 21. DR is "dimension ratio" and SDR is "standard dimension ratio." Both are calculated by dividing the average outside pipe diameter by the minimum wall thickness. Several pipe series have been standardized under the SDR designation including 11, 13.5, 17, 21, 26, 32.5, and 41 series [47]. Schedule 80 pipe is often used around the control and filter system where the pressures are the highest.

The closest Schedule 40 pipe would be 1 in with an actual inside diameter of 1.049 in. The corresponding actual velocity for this pipe would be 4.72 ft/s based on the design flushing flow of 12.73 gal/min.

Using these pipe sizes, the friction head can now be calculated using the Hazen-Williams equation:

Friction loss (h_f) = $0.2083(100/C)^{1.85}(Q^{1.852}/D_i^{4.8655})$

Where: h_f = friction loss, ft of water per 100 ft of pipe

C = flow coefficient, 150 for PVC pipe (a conservative value for pipes in service)[59]

Q = flow rate, gal/min

D_i = pipe internal diameter, in

For the supply pipe for dosing and dosing and flushing flows, respectively:

$h_f = 0.2083(100/150)^{1.85}((6.20)^{1.852}/(1.38)^{4.8655}) = 0.60$ ft per 100 ft
= 0.30 ft for the 50 ft supply pipe used in this example

$h_f = 0.2083(100/150)^{1.85}((18.93)^{1.852}/(1.38)^{4.8655}) = 4.76$ ft per 100 ft
= 2.38 ft for the 50 ft supply pipe used in this example

The friction loss for the supply manifold will typically be small unless the manifold is designed to maintain velocities of 2 ft/s or more along its total length. For this example, it is assumed that the manifold size is the same as the supply pipe along its total length, and the flow is from the end of the manifold with drip run connections spaced every 2 ft.[60] The total head loss at the last drip lateral can be readily calculated using a spreadsheet. The calculations are tabulated in table 5-1 for the highest flow rate (dosing and flushing flow). A similar spreadsheet should be used for the return manifold (based on flushing flow only).

An alternate, shorter method for determining head losses for a multiple-outlet pipe is based on reduction coefficients. This method is described in the *National Engineering Handbook for Trickle Irrigation* [48]. The reduction coefficients are listed in table 5-2 for use with the Hazen-Williams' formula.

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[59] Some designers prefer to use 140 for the Hazen-Williams C Factor to be more conservative. However, research has established that the C Factor ranges from 155 to 165 for both new and used PVC pipe; therefore, a C value of 150 is considered a conservative value for the design of PVC piping systems [45].

[60] This will result in the highest friction losses. Center feed and "top loading" (see section 3.3.5) manifold designs would result in smaller head losses. Always place the supply pipe so that the drip field is fed through the manifold from the lowest elevation and the return pipe is fed through the return manifold at the highest elevation. This will help equalize lateral flows and velocities during flushing when pressures may be lower. Since the flow velocity will be less than 2 ft/s for a portion of the manifold near its end, a cleanout installed at the end of the manifold would allow the manifold to be completely flushed periodically at velocities greater than 2 ft/s. Optionally, the design can step-down the size of the manifold, using different size pipes to ensure velocities of 2 ft/s will be available along the entire length.

Table 5-1
Supply Manifold Friction Losses for the 450 gal/d Design Example (Netafim)

Manifold Segment No.	Manifold Length (ft)	Flow (gal/min)	Velocity (ft/s)	Pipe Friction Loss (ft)	Fitting (Tee) Friction Loss (ft)	Segment Friction Loss (ft)	Cumulative Friction Loss (ft)
1	2	18.93	4.06	0.095	0.333	0.428	0.428
2	4	16.56	3.55	0.074	0.260	0.334	0.763
3	6	14.20	3.05	0.056	0.196	0.251	1.014
4	8	11.83	2.54	0.040	0.139	0.179	1.193
5	10	9.46	2.03	0.026	0.092	0.119	1.312
6	12	7.10	1.52	0.015	0.054	0.070	1.382
7	14	4.73	1.02	0.007	0.026	0.033	1.415
8	16	2.37	0.51	0.002	0.007	0.009	1.424

Note: Calculations are based on a Hazen-Williams' Coefficient of 150 for dosing and flushing flow and a head loss attributable to 7.0 ft of equivalent length for a tee with flow through a branch (which will result in a conservative friction loss, since most of the flow will be through the run of the tees except for the last one).

Table 5-2
Reduction Coefficient (F) for Multiple-Outlet Pipeline Friction-Loss Computations

Number of Outlets	F
1	1.00
2	0.64
3	0.54
4	0.49
5	0.46
6	0.44
7	0.43
8	0.42
9	0.41
10-11	0.40
12-15	0.39
16-20	0.38
21-30	0.37
>31	0.36

For eight outlets used in this example (spaced 2 ft apart along a 16 ft long manifold), the reduction coefficient, F, is 0.42. The head loss is calculated by the formula:

$h_f = J'FL/100$

Where

J' = equivalent head-loss gradient of the manifold with laterals, ft per 100 ft

$= J((S_e + f_e)/S_e)$

Where

J = head loss gradient of the manifold with laterals, ft per 100 ft

= 4.76 ft/100 ft for 1 1/4-in Schedule 40 PVC pipe with an inlet flow velocity of 4.06 ft/s and a Hazen-Williams' C factor of 150

Se = spacing between laterals on the manifold, ft

= 2 ft for this example

fe = lateral-connection loss equivalent lengths, ft

= 7.0 ft/100 ft for flow through a branch of a tee

F = reduction coefficient to compensate for the discharge along the pipe

L = pipe length, ft

For the 1 1/4-in supply manifold with tees spaced 2 ft apart, J' = 4.76 ft/100 ft x ((2 ft + 7 ft/100 ft) ÷ 2 ft) = 21.42 ft/100 ft and h_f = 21.42 ft/100 ft x 0.42 x 16 ft ÷ 100 = 1.439 ft (compared to 1.424 ft using the spreadsheet method).

Losses for other components need to be included to determine the total friction losses. These are listed in table 5-3. The return pipe length is 200 ft.

Table 5-3
Friction Losses for the 450 gal/d Design Example (Netafim)

Component	Head Loss (ft)				Comments
	Dosing Flow (6.20 gal/min) (at the Inlet to Drip Laterals)	Dosing and Flushing Flow (18.93 gal/min) (at the Return Tank)	Dosing and Flushing Flow (18.93 gal/min) (at the Inlet to Drip Laterals)	Filter Flushing (15 gal/min) (at the Return Tank)	
Pump discharge assembly	1	2	2	1	From manufacturer's literature
Filter	11.6	11.6	11.6	92.4	Target value for flushing a dirty filter (max allowable loss: 5 psi pressure differential)
Filter valves	9.2	13.9	13.9	13.9	From manufacturer's literature x # valves
Flow meter	2.3	4.6	4.6	0	From manufacturer's literature
Supply pipe	0.3	2.4	2.4	0.3	Calculated using Hazen-Williams
Supply pipe fittings	1	1	1	1	Typically insignificant (use 1)
Supply manifold	0.2	1.4	1.4		Calculated using Hazen-Williams
Drip lateral (longest)		16.7			From manufacturer's literature
Return Manifold		2.2			Calculated using Hazen-Williams
Return pipe		17.3		0.9	Calculated using Hazen-Williams
Return pipe fittings		1		1	Typically insignificant (use 1)
Flush valve		6.9			From manufacturer's literature
Total friction head	**25.6**	**81.0**	**36.8**	**110.5**	Sum of individual losses

The TDH can now be calculated as summarized in table 5-4.

Table 5-4
TDH for the 450 gal/d Design Example (Netafim)

Component	Total Dynamic Head (ft)			
	Dosing Flow (6.20 gal/min) (at the Inlet to Drip Laterals)	Dosing and Flushing Flow (18.93 gal/min) (at the Return Tank)	Dosing and Flushing Flow (18.93 gal/min) (at the Inlet to Drip Laterals)	Filter Flushing (15 gal/min) (at the Return Tank)
Pressure head	24.1	0	39.8	0
Velocity head	0	0.4	0.1	0.2
Elevation head	9.3	9.3	9.3	3.0
Total friction head	25.6	81.0	36.8	110.5
Total dynamic head	**59.0**	**90.7**	**86.0**	**113.7**

The calculations show that the pressure needed for flushing the disk filters results in the highest head requirements. The calculations also show that the energy needed for dosing and flushing for getting the flush water to the return tank is slightly higher than that needed for dosing and flushing at the inlet to the drip laterals. This indicates that the friction losses in the return piping system exceeds the 10 psi needed at the return manifold during the flushing cycle, and the actual pressure at the return manifold should be slightly higher than 10 psi.[61]

A pump must be chosen that is capable of meeting the flow and pressure requirements for each of these key operating conditions. For this example, an OSI P300712 submersible turbine pump[62] would meet each operating condition as shown in figure 5.5. This is a 3/4 horsepower, 120-volt pump. Note that these head curves also provide an estimate of the actual operating pressures that will be produced for the various operating conditions. Also, note that flows will not be steady-state while the system is pressurizing.

The procedure is similar for determining the TDH for a system using Geoflow components. The recommended operating pressures for Geoflow Wasteflow PC are 10 to 45 psi. Using the same design procedure outlined above, the friction loss for Wasteflow PC while dosing is 0.59 psi for a lateral length of 150 ft (see appendix C), resulting in a required inlet pressure of 10.59 psi when 10 psi is used as the target operating pressure at the return manifold. Using Geoflow's recommended flushing velocity of 1 ft/s and maintaining a 10-psi operating pressure at the return manifold, the required inlet pressure while flushing is 13.73 psi (see appendix C). Using the more conservative flushing velocity of 2 ft/s, the inlet pressure needed while flushing is 19.47 psi.

[61] Some designers and regulators will use 10 psi as the minimum energy needed for the return piping for flushing. If the actual calculations show that the required energy is less than 10 psi, no additional energy is added to the required TDH, since 10 psi is already "built in" to the design (minimum pressure needed at the distal end of the drip laterals for either dosing or dosing and flushing). To actually attain 10 psi at the distal end of the laterals during flushing, the return valve may need to be slightly closed to increase the total frictional losses for the return piping or other methods will need to be used to increase the frictional losses to a total of 10 psi or more. If the calculations show that friction losses for the return piping exceed 10 psi, the additional energy above 10 psi (the total friction losses minus 10 psi) is added to the required energy for flushing. The method shown in these guidelines is intended as a more basic procedure, showing and instructing the user as to how each component or fitting affects the total energy that must be supplied and how the energy must be balanced for similar operating conditions. Also, note that the elevation head used for dosing and flushing at the return tank is 9.3 ft rather than 3 ft since, as noted earlier, the drip laterals must be refilled at the start of each dose or flushing cycle.

[62] Brand names for peripheral components are sometimes identified to provide specific information needed to demonstrate a complete design or specific points for each example. This does not reflect an endorsement of these brands. Other brands could also be used to meet the design requirements. Always check with equipment representatives or manufacturers to obtain current information on any component. Submersible turbine pumps are not designed for pumping solids; consequently, they should only be used within screened or filtered pump vaults or following treatment units that remove most of the suspended solids (see section 3.3.2 for information on different types of pumps).

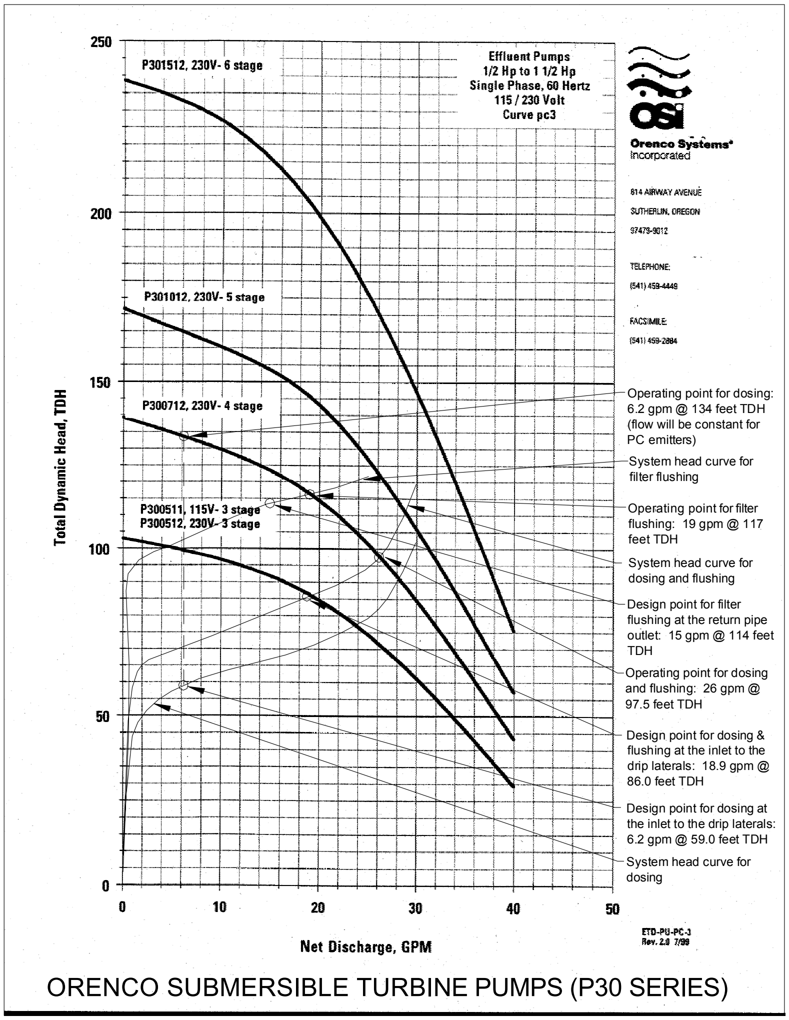

Figure 5-5
System Head Curves for the 450 gal/d Design Example (Netafim)

Supply and return pipes and manifolds are sized as explained previously. Calculations are summarized for both 1 and 2 ft/s flushing velocity for the driplines. A velocity of 1 ft/s results in substantially lower numbers (note that the supply and return pipes are still designed for a flushing velocity of at least 2 ft/s). The values can be compared in the following tables.

Table 5-5
Friction Losses for the 450 gal/d Design Example (Geoflow: 1 ft/s)

Component	Head Loss (ft)				Comments
	Dosing Flow (5.30 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (11.22 gal/min) (at the Return Tank)	Dosing and Flushing Flow (11.22 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (11.79 gal/min total flow with 0.56 gal/min used for flushing) (at the Return Tank)	
Pump discharge assembly	1	1	1	1	From manufacturer's literature
Filter	18.5	18.5	18.5	4.6	Based on a pressure differential of 8 psi across the filter with filtering and 2 psi pressure loss during flushing
Filter valves				2.8	Geoflow filters are not back-flushed so the typical filter package has only one valve on the flush line to the return tank.
Flow meter	2.3	4.6	4.6		From manufacturer's literature
Supply pipe	0.9	3.4	3.4	0.8	Calculated using Hazen-Williams
Supply pipe fittings	1	1	1	1	Typically insignificant (use 1)
Supply manifold	0.4	1.7	1.7		Calculated using Hazen-Williams
Drip lateral (longest)		8.7			From manufacturer's literature
Return Manifold		1.6			Calculated using Hazen-Williams
Return pipe		13.6		0	Calculated using Hazen-Williams
Return pipe fittings		1		1	Typically insignificant (use 1)
Flush valve		3.2			From manufacturer's literature
Total friction head	**24.1**	**58.3**	**30.2**	**11.2**	Sum of individual losses

The TDH can now be calculated as summarized in the following table.

Table 5-6
TDH for the 450 gal/d Design Example (Geoflow: 1 ft/s)

Component	Total Dynamic Head (ft)			
	Dosing Flow (5.30 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (11.22 gal/min) (at Return Tank)	Dosing and Flushing Flow (11.22 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (11.79 gal/min total flow with 0.56 gal/min used for flushing) (at the Return Tank)
Pressure head	24.5	0	31.8	0
Velocity head	0	0.2	0.1	0
Elevation head	9.3	9.3	9.3	3.0
Total friction head	24.1	58.3	30.2	11.2
Total dynamic head	**57.8**	**67.8**	**71.4**	**14.2**

Table 5-7
Friction Losses for the 450 gal/d Design Example (Geoflow: 2 ft/s)

Component	Head Loss (ft)				Comments
	Dosing Flow (5.30 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (17.15 gal/min) (at Return Tank)	Dosing and Flushing Flow (17.15 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (18.01 gal/min total flow with 0.86 gal/min used for flushing) (at Return Tank)	
Pump discharge assembly	1	1	1	1	From manufacturer's literature
Filter	18.5	18.5	18.5	4.6	Based on a pressure differential of 8 psi across the filter with filtering and 2 psi pressure loss during flushing
Filter valves				2.8	Geoflow filters are not back-flushed, so the typical filter package has only one valve on the flush line to the return tank
Flow meter	2.3	4.6	4.6		From manufacturer's literature
Supply pipe	0.2	2.0	2.0	0.4	Calculated using Hazen-Williams
Supply pipe fittings	1	1	1	1	Typically insignificant (use 1)
Supply manifold	0.1	1.2	1.2		Calculated using Hazen-Williams
Drip lateral (longest)		21.9			From manufacturer's literature
Return manifold		1.9			Calculated using Hazen-Williams
Return pipe		15.2		0	Calculated using Hazen-Williams
Return pipe fittings		1		1	Typically insignificant (use 1)
Flush valve		4.2			From manufacturer's literature
Total friction head	**23.1**	**72.5**	**28.3**	**10.8**	Sum of individual losses

Table 5-8
TDH for the 450 gal/d Design Example (Geoflow: 2 ft/s)

Component	Total Dynamic Head (ft)			
	Dosing Flow (5.30 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (17.15 gal/min) (at Return Tank)	Dosing and Flushing Flow (17.15 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (18.01 gal/min total flow with 0.86 gal/min used for flushing) (at Return Tank)
Pressure head	24.5	0	45.0	0
Velocity head	0	0.3	0.1	0
Elevation head	9.3	9.3	9.3	3.0
Total friction head	23.1	72.5	28.3	10.8
Total dynamic head	**56.9**	**82.1**	**82.7**	**13.8**

Table 5-9
Comparative Table for Flushing Velocity and System Components

Operating Function and System Location	Netafim: 2 ft/s flushing velocity	Geoflow: 2 ft/s flushing velocity	Geoflow: 1 ft/s flushing velocity
Dosing (at the Inlet to Drip Laterals)			
TDH, ft	59.3	56.9	57.8
Flow, gal/min	6.2	5.3	5.3
Dosing and Flushing (at the Return Tank)			
TDH, ft	90.7	82.1	67.8
Flow, gal/min	18.93	17.15	11.22
Dosing and Flushing (at the Inlet to Drip Laterals)			
TDH, ft	85.8	**82.7**	**71.4**
Flow, gal/min	18.93	**17.15**	**11.22**
Filter Flushing (at the Return Tank)			
TDH, ft	**113.7**	13.8	14.2
Flow, gal/min	**15**	18.01	11.79

Comparing these scenarios, the critical operating conditions are highlighted with **bold** fonts. The Netafim system requires the pump with the highest operating point based on the back-flushing requirements for the Arkal filters. Since the filters used on most Geoflow systems can only be flushed (not back-flushed), the hydraulic requirements are not as large. Also, smaller pumps potentially could be used if the chosen flushing velocity for the tubing is 1 ft/s rather than 2 ft/s. Note that the TDH for dosing the Geoflow system at 1 ft/s flushing velocity is slightly larger than for 2 ft/s. This is because larger supply and return pipes are used for the higher velocity system, resulting in smaller friction losses. As noted previously, there is strong divergence of opinions associated with the advantages and disadvantages of filter types, flushing velocities, and the need for uniform dosing during flushing. Also for the Geoflow systems, note that the TDH needed for dosing and flushing at the inlet to the drip laterals (while maintaining 10 psi at the return manifold to ensure uniform dosing during the flushing cycle) exceeds the corresponding TDH based on only the energy needed to dose and flush without maintaining the minimum desired 10 psi at the return manifold. Consequently, if the objective is to dose uniformly during the flush period, the return valve for each system will probably need to be adjusted slightly to ensure that the 10 psi will actually be available at the return manifold as noted previously. This will result in the same energy needed for each dosing and flushing scenario.

5.2.6 Dosing Considerations

Dosing design is the last critical step in the design process. This determines the wastewater volume that is applied to the soil during the duration of the dose cycle. This volume must be adequately matched to the soil to prevent excessive saturation and structural damage. As explained in sections 3.1.2 and 3.2.2, doses should be light enough that soils are saturated only in the zone immediately around each emitter and wetted along the drip tubing between emitters (the infiltrative surface area described in section 3.2.1). The objective is to “wet” as much soil as possible (to spread the hydraulic and pollutant load over as large an area as possible), but limit the amount of saturation. Between doses, the soil needs sufficient time to disperse the wastewater, eliminating any zone of saturation that exists at the end of the dose. This maintains aerobic soils and assures optimal dispersal of the wastewater by soil matric forces throughout the daily wastewater application process. However, consideration must also be given to potential drain-back problems, since increasing the number of doses increases the volume of water on a daily basis that will drain to low elevations within the drip field between each dose.

Soil textures containing clay need the most protection. For these soils, the recommended dosing time (after full system pressurization) should range from about 6 to 12 minutes with emitter discharge rates in the 0.4 to 0.6 gal/h range [2].[63] This is equivalent to about 0.04 to 0.12 gallon per emitter per dose for clays. For loams and silty soils without significant clay, the dosing time can be increased up to about 20 minutes (or up to 0.20 gallon per emitter per dose). For sandy soils, larger dosing times can be used if desired, since drainage will be rapid. Coarse sands are an exception, since the lack of capillary action makes it difficult to dose the area uniformly. Dosing time is typically shortened (similar to clays) and closer spacing of emitters and laterals (12 in by 12 in) may be used.

Using 10 minutes for dosing the silty clay loam for this example, the volume dosed per cycle and the number of doses per day would be:

Volume Dosed/Cycle	= Pump rate x dosing time
	= 6.20 gal/min x 10 minutes/dose = 62 gallons/dose
Doses/day (design flow)	= Design Daily Flow ÷ No. of Zones ÷ Volume Dosed/Cycle
	= 450 gal/d ÷ 1 zone ÷ 62 gallons/dose = 7.26 doses/day/zone
Doses/day (average flow)	= Average Daily Flow ÷ No. of Zones ÷ Volume Dosed/Cycle
	= 226 gal/d ÷ 1 zone ÷ 62 gallons/dose = 3.63 doses/day/zone

Before setting the timer, the time needed to fill and pressurize the drip laterals needs to be determined. Assuming that the supply pipe and manifold are designed to stay filled between doses and ignoring the volume of water dripped during the pressurization process, the time to fill the drip laterals will be:[64]

[63] Some designers and regulators prefer to establish dosing time based on dosing a minimum number of drip tubing volumes through the emitters (after pressurization). This ensures that the dosing cycle is long enough to get good distribution of the wastewater to the soil. The recommended minimum number of tubing volumes ranges from four to six (see footnote 54). For nominal 1/2-in diameter tubing and 1/2 gal/h emitters spaced 2 ft apart, the corresponding dose times needed for four-, five-, and six-pipe volumes are 10.3, 12.8, and 15.4 minutes for BioLine and 11.2, 14.0, and 16.8 minutes for Wasteflow PC.

[64] These are only approximate calculations. There are a couple of complicating factors. First, pump flow rates will be higher than design during the filling phase, since pressures will be much lower than design. This will tend to speed up the filling process. However, this will be at least partially offset by the fact that the emitters drip during pressurization, and the higher flow rates increase the friction losses through all of the supply line components.

Time to fill drip laterals	= Volume of laterals ÷ pump rate
For BioLine tubing	= π x (0.57 in)^2 ÷ 4 ÷ 144 in^2/ft^2 x 1200 ft x 7.481 gal/ft^3 ÷ 6.20 gal/min = 2.57 minutes
For Wasteflow PC tubing	= π x (0.55 in)^2 ÷ 4 ÷ 144 in^2/ft^2 x 1200 ft x 7.481 gal/ft^3 ÷ 5.30 gal/min = 2.79 minutes

Rounding up, the timer setting will be 13 minutes (10 minutes for the dose + 3 minutes for lateral pressurization).[65]

The total time between doses can also be calculated.

BioLine Dosing intervals (design flow)	= Minutes/day ÷ Doses/day/zone
	= 1440 min/day ÷ 7.26 doses/day/zone
	= 198 min/dose/zone
BioLine Dosing intervals (average flow)	= 1440 min/day ÷ 3.63 doses/day/zone
	= 397 min/dose/zone
Wasteflow PC Dosing intervals (design flow)	= 1440 min/day ÷ 8.49 doses/day/zone
	= 170 min/dose/zone
Wasteflow PC Dosing intervals (average flow)	= 1440 min/day ÷ 4.25 doses/day/zone
	= 339 min/dose/zone

The timer would typically be set for average flow conditions and the high-water float would be used to trigger extra doses for higher flows. Programmable control panels allow flexibility to vary the doses based on actual flows.

As mentioned in section 5.2.4, flows for small household systems can be highly variable. The wastewater system must be designed to handle periodic surge or emergency flows adequately. If these flows are not attenuated prior to the dose tank for the drip system, the dose tank must be designed with enough storage capacity to equalize the hydraulic load so that daily design flows are not exceeded. A typical storage capacity for homes ranges from 1/2 to 1 1/2 days of design flow. However, once stored, the excess volume of water must be processed through the system. This is best accomplished through programmable control panels that automatically adjust the dosing frequency based on high-water floats or sensors. The alternate dosing frequency must still be within design limits for the system. After the high-water level recedes, the dosing frequency is automatically adjusted back to its base value. The controller should also alert the management entity of the unusual event so that an investigation can be initiated to see if any corrective action is needed.

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[65] The pressurization period can be a significant portion of the dosing period as reflected here. It can also contribute a significant portion of the design dose volume for the reasons listed in the above footnote. Typically, adjustments to the dosing period are not made based on the extra wastewater dripped during pressurization; however, if saturation occurs over a large portion of the soil surface within the drip zones at the end of a dose, the problem may be partially caused by the extra wastewater dripped during the pressurization period, and the total dosing period should be reduced in an attempt to alleviate the problem. The flow meter should provide an accurate measure of the total volume actually dosed during each cycle. Adjustments to the dose period can be made until the flow meter indicates that only the design volume has been dosed.

Another calculation that may be needed is the volume of wastewater that could potentially drain back to a low elevation within the drainfield. Assuming that the supply manifold is designed so that it cannot contribute to drain-back (see figures 3-10 and 3-11), the maximum amount of wastewater that could be available is the volume contained in the laterals. These volumes are previously calculated for the time to fill the laterals, but they were not specifically listed. The volumes are 15.9 and 14.8 gallons for the BioLine and Wasteflow PC laterals, respectively.[66]

The last calculation that may be needed is the volume of wastewater that will be flushed to the return tank and recycled through the treatment system. This volume has the potential to upset the treatment process, depending on the type of treatment system used and the amount of equalization that may be available. Complete mix activated sludge processes are typically more likely to be adversely affected than plug flow fixed film processes. The return volume is equal to the flushing flow multiplied by the duration of the flushing cycle. When flushing is planned to occur simultaneously with a dose, the flushing duration is the same as that for dosing: 127 gallons (12.7 gal/min x 10 minutes) for the BioLine and 53 gallons (5.3 gal/min x 10 minutes) for Wasteflow PC for 1 ft/s flushing velocity and 119 gallons (11.9 gal/min x 10 minutes) for 2 ft/s flushing velocity. If the flushing occurs at the end of a dose or as a separate cycle, the duration is typically much shorter than the dose duration (the time needed to flush at least one- or two-pipe volumes through the zone). There will also be additional water recycled during each filter flush, but this volume is typically small because the time needed for filter flushing is normally less than a minute.

5.2.7 Design Based on Water and Nutrient Balances

Some state regulatory agencies require that design loading rates be based on water and nutrient balances. This approach should ensure that the loading rates never exceed the hydraulic capacity of the soil or the assimilative capacity of the site for nutrient uptake.

Using the procedure outlined by the GA EPD in its drip irrigation guidelines, water balance calculations are based on the average permeability of the most limiting soil layer, the Thornthwaite potential evapotranspiration, and the five-year return period monthly precipitation values for the site [35].

The maximum allowable monthly wastewater hydraulic loadings are determined from the following water balance equation:

$$Lwh = (PET + Perc) - Pr$$

Where Lwh = Maximum allowable hydraulic wastewater loading, inches per month (in/mo)

PET = Potential Evapotranspiration, in/mo

Perc = Design percolation rate, in/mo

[66] These volumes are 26% and 24% of the total dose. The drain-back potential can be lowered by using longer dosing times (or a higher number of pipe volumes for dosing, such as five or six). Trade-offs need to be considered based on actual experience and soil characteristics.

Pr	=	5-year (yr) return monthly precipitation, in/mo (80th percentile value in a 30-yr ranked listing of historical monthly precipitation data)
	=	30-yr average monthly rainfall + (0.85 x Standard Deviation)

Potential evapotranspiration is calculated using the Thornthwaite method. This method is only applicable for portions of the United States where soil moisture conditions do not limit evapotranspiration. It is not applicable for arid and semi-arid regions west of the Mississippi River. A 30-year record of historical climatic data is required to determine the monthly temperatures used in the equation. Climatic data can be obtained from the National Oceanic and Atmospheric Administration (NOAA) in Asheville, North Carolina.

$$PET = 0.63 \times S \times 50 \times [T - 32]^{A} / (9 \times I)$$

Where PET	=	30-day Thornthwaite Potential Evapotranspiration, in
S	=	Number of daylight hours in units of 12 hours
T	=	Mean (normal) monthly air temperature, °F
I	=	Annual heat index obtained by summing the 12 monthly heat indexes, i, where:
I	=	$(T-32)^{1.514}/9$
A	=	Power term derived from annual heat index, I,
	=	$0.000000675(I)^{3} - 0.0000771(I)^{2} + 0.01792(I) + 0.49239$

Assuming the example site is located in the Northwest Georgia Climatic Division, representative climatic data are listed in the following table:

Table 5-10
Climatic Data for the NOAA, Northwest Georgia Division, for 1971 –2000 [1]

Month	Daylight Hours @ 35° Latitude, 12-hour units[2]	Air Temperature, °F	30-yr Average Rainfall, in/mo	Monthly Rainfall Standard Deviation
Jan	0.87	40.0	5.39	1.79
Feb	0.85	43.9	4.88	2.19
Mar	1.03	51.8	6.10	3.05
Apr	1.09	59.0	4.48	2.32
May	1.21	66.8	4.20	1.73
Jun	1.21	74.3	4.20	1.86
Jul	1.23	78.2	4.44	1.92
Aug	1.16	77.1	3.83	1.52
Sep	1.03	71.1	4.07	2.38
Oct	0.97	59.9	3.24	2.01
Nov	0.86	50.9	4.46	1.83
Dec	0.85	42.9	4.49	2.13
Total			53.78	

[1] Source: *Climatography of the United States No. 85, Divisional Normals, 1971-2000* (and previous periods), sections 1 and 2, NOAA, Asheville, NC.

[2] Source: *Guidelines for Land Treatment of Municipal Wastewater by Drip Irrigation*, GA EPD, Atlanta, GA, February 1996.

Based on the climatic data and the above equations, the annual heat index, potential evapotranspiration, and the 5-year rainfall can be calculated. These values are listed below:

Table 5-11
Heat Index, Potential Evapotranspiration, and 5-Year Rainfall for Northwest Georgia

Month	Heat Index, I	Potential Evaporation (PET) in/mo	5-Year Rainfall, Pr in/mo
Jan	2.588	0.24	6.91
Feb	1.526	0.45	6.74
Mar	3.299	1.27	8.69
Apr	5.277	2.25	6.45
May	7.749	3.80	5.67
Jun	10.41	5.26	5.78
Jul	11.90	6.18	6.07
Aug	11.47	5.60	5.12
Sep	9.243	3.93	6.09
Oct	5.545	2.11	4.95
Nov	3.075	0.98	6.02
Dec	1.336	0.39	6.30
Total	73.43	32.46	74.80

It is assumed that the permeability of the soil will be determined by a professional soil evaluator. The GA EPD requires that saturated hydraulic conductivity (permeability) be determined for the most limiting soil horizon within the top 10 ft of the soil profile. For this example, the native soil depth is only 2.5 ft, and the vertical permeability is determined to be 0.15 in/h in the soil immediately above the creviced bedrock. Since the predominant drainage mechanism for this site will be horizontal, the horizontal permeability should also be determined. This value was found to be 0.30 in/h. GA EPD allows no more than 10% of the mean saturated vertical hydraulic conductivity for the design percolation rate for sites with seasonal high groundwater or impermeable layers between 2.5 and 5 ft from the surface. This site will just meet the minimum GA EPD requirement for at least 2.5 ft of soil above the restrictive layer for subsurface drip systems. The allowable design percolation rate is 0.015 in/h (10% of the saturated vertical hydraulic conductivity) or 0.36 in/day. Wastewater will be applied to the site every day of the month.

The allowed monthly hydraulic loading can now be calculated as listed in the following table.

Table 5-12
Allowable Monthly Hydraulic Loading, Lwh

Month	No. of Application Days	PET in/mo	Perc in/mo	PET + Perc in/mo	Pr in/mo	Lwh in/mo	Lwh in/day	Lwh in/wk
Jan	31	0.24	11.16	11.40	6.91	4.49	0.145	1.013
Feb	28	0.45	10.08	10.53	6.74	3.79	0.135	0.947
Mar	31	1.27	11.16	12.43	8.69	3.74	0.121	0.844
Apr	30	2.25	10.80	13.05	6.45	6.60	0.220	1.539
May	31	3.80	11.16	14.96	5.67	9.29	0.300	2.098
Jun	30	5.26	10.80	16.06	5.78	10.27	0.342	2.397
Jul	31	6.18	11.16	17.34	6.07	11.27	0.364	2.546
Aug	31	5.60	11.16	16.76	5.12	11.64	0.376	2.629
Sep	30	3.93	10.80	14.73	6.09	8.63	0.288	2.014
Oct	31	2.11	11.16	13.27	4.95	8.32	0.268	1.879
Nov	30	0.98	10.80	11.78	6.02	5.77	0.192	1.345
Dec	31	0.39	11.16	11.55	6.30	5.25	0.169	1.185
Total	365	32.46	131.40	163.86	74.80	89.06		

The critical hydraulic loading rate occurs in March and is 0.844 in/wk.[67] This is the maximum application rate that can be applied to the drip field based on hydraulics. **Note that this value is much less than that based on the soil classification (0.2 gal/d/ft^2 which is equivalent to 2.246 in/wk).**

Next, the maximum loading rate based on a nutrient balance is determined. These calculations are based on limiting the percolate to a maximum of 10 mg/l as nitrate nitrogen.[68] The concentration of the percolate depends on the nitrogen loading, type and management of cover crop, rainfall, and hydraulic loading.[69] If preliminary calculations indicate that the percolate will exceed 10 mg/l, options include selecting a cover crop with a greater nitrogen uptake rate, reducing the nitrogen loading through pretreatment, or increasing the footprint area. The calculations and assumptions are listed below:

[67] The daily and weekly rates are derived from the monthly estimates and are provided to allow comparisons with other loading values.

[68] This approach is recommended by the GA EPD. It results in a conservative evaluation, since dilution by other groundwater components and potential denitrification through reduced organic zones are ignored.

[69] Nutrient uptake by plants only occurs when plants are actively growing, primarily during the "growing season." The nutrient balance can be modified to reflect different uptake rates on a monthly basis to be more representative of the growing season for the site and the vegetation to be used. This approach is included in the spray irrigation guidelines provided by the Tennessee Division of Water Pollution Control [49]. Since a portion of the nutrients may be recycled if the vegetation is not properly harvested and removed from the site, this approach is dependent upon implementation of an appropriate management plan. Supplemental nutrient addition (potassium and trace elements) may also be needed to maintain agronomic growth for specific forage crops.

Assumptions:

Maximum daily design flow:	450 gal/d
Average daily design flow:	225 gal/d (used for the calculations)[70]
Wastewater total nitrogen concentrations:	20 mg/l (effluent from a denitrification system)
Nitrogen input from rainfall and fixation:	5 lbs/acre-year (from the GA EPD guidelines)
Ammonia volatilization:	0 lbs/acre-year (subsurface application)
Denitrification rate:	15% (representative value for row and forage crops)
Net plant nitrogen (N) uptake and storage:	200 lbs N/acre-year (representative value for grasses such as tall fescue, ryegrass, and Kentucky blue grass)
Precipitation:	74.80 in/year (from table 5-11)
Potential evapotranspiration:	32.46 in/year (from table 5-12)
Nitrogen allowed in percolate:	10 mg/l (as N)
Hydraulic loading based on soil classification:	0.2 gal/d/ft^2 (0.321 in/day, 2.25 in/wk, 117 in/yr)

Table 5-13
Estimated Total Nitrogen Concentrations

	Loading: Water Balance Storage	Maximum Loading: Nutrient Balance	Maximum Loading: EPD Weekly Limit	Loading: Soil Classification
Average Design Wastewater Loading (in/wk)	0.844	3.512	2.80	2.25
Wetted Area (acres)	0.13747	0.03303	0.04143	0.05165
Nitrogen Input from Wastewater (lbs/acre-year)	199.3	829.5	661.3	530.4
Total Nitrogen Input (lbs/acre-year)	204.3	834.5	666.3	535.4
Denitrification (lbs/acre-year)	30.6	125.2	100.0	80.3
Nitrogen Leached by Percolate (lbs/acre-year)	0.00	509.3	366.4	255.1
Wastewater Applied (in/year)	43.9	182.6	145.6	116.8
Percolate (in/year)	86.2	225.0	187.9	159.1
Estimated Percolate Total Nitrogen (mg/l)	0.00	10.00	8.61	7.08

Based on a maximum percolate concentration of 10 mg/l, these calculations reveal that nitrogen will not be limiting until the wastewater loading exceeds 3.51 in/wk. Since the GA EPD limits

[70] The average daily design flow is typically used for water and nutrient balance calculations, but the maximum design flow may also be used. So long as the user is consistent with which flow is used, the resulting nitrogen percolate concentrations will be identical. The wetted area depends on the design flow used, but the nitrogen loadings are on a per acre or unit basis, resulting in identical loadings per acre regardless of which design flow is used.

the maximum loading to 2.8 in/wk, nitrogen will not be a limiting factor in the system design.[71] The selected design loading rate will be 1.00 in/wk (0.089 gal/d/ft^2) based on a trial and error method for determining the maximum loading rate based on water balance storage criteria (see the spreadsheets on the attached computer disk for details).

To determine the wetted field area (the footprint area), storage requirements must be determined. Operational storage is needed if the drip field is operated less than seven days per week. Emergency storage is needed if equipment malfunctions. Wet weather storage is needed when severe weather causes wet soils. Water balance storage is needed if the design application rate exceeds that for the critical month determined through the water balance analysis. These storage requirements are met through increased drip area rather than holding tanks or reservoirs. This provides flexibility either to lower the overall application rate during routine operations by using all available drip fields or zones or to use only the additional area when needed based on the storage requirements.

The total storage requirement is the sum of these individual storage volumes:

A(wetted) = A(adf) + A(op) + A(ww/e) + A(wbs)

Where A(wetted) = Required total wetted field area (acres)
A(adf) = Area necessary to treat 7 days' average daily flow (acres)
A(op) = Area necessary to treat the operational storage (acres)
A(ww/e) = Area necessary to treat the wet weather/emergency storage (acres)
A(wbs) = Area necessary to treat the water balance storage (acres)

The areas are calculated as follows:

A(adf) = 225 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 1.0 in/wk
= 0.0580 acres

A(op) = 0 (7 days/wk operations; if operating only 5 days/wk, the area needed for treating 2 days' flow would be calculated)

A(ww/e):

Flow to be stored for subsurface drip systems is based on two GA EPD criteria:

Criterion 1: 3 days' average design flow (for subsurface drip systems)

Criterion 2: 1 day if 100% backup reliability is provided including standby power

The criterion selected is 3 days in order to avoid the need for standby power. The GA EPD allows 30 days to deplete this stored flow (90 days would be allowed if the amount of stored flow was 20 or more days).[72] A(ww/e) can now be calculated:

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[71] This would not be the case if septic tank effluent was applied to the site. Assuming a representative value for total nitrogen of 50 mg/l for residential septic tank effluent, the maximum loading rate would be only 0.76 in/wk.

[72] These are emergency storage requirements, which are met with increased drip area. Wet weather storage is not applicable for subsurface drip systems, since the system continues to operate during wet weather conditions. However, if the treatment component of the system is open and relatively large (such as an RSF), rainfall will affect the total volume of wastewater that must be pumped to the drip field. This extra volume should be managed by tank

A(ww/e) = 3 days x 225 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 30 days ÷ 1.0 in/wk

= 0.0058 acres

A(wbs):

To calculate this storage, another water balance is needed to determine the cumulative amount of wastewater that needs to be stored based on the monthly allowable hydraulic loads. These calculations are listed below:

The total storage area needed for the average design flow, operational storage, and wet weather/emergency conditions:

= 0.0580 acres + 0 acres + 0.0058 acres

= 0.0638 acres

The corresponding loading rate for this amount of storage:

= 225 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 0.0638 acres
= 0.9091 in/wk

This loading rate is used to calculate the monthly water balance storage:

Table 5-14
Water Balance Storage Requirements

Month	No. of Application Days/Mo	Hydraulic Loading Potential (in)	Hydraulic Loading Allowed (in)	Delta Hydraulic Loading (in)	Water Balance Storage (in)	Cumulative Water Balance Storage (in)
Jan	31	4.03	4.49	-0.46	0	0
Feb	28	3.64	3.79	-0.15	0	0
Mar	31	4.03	3.74	0.29	0.29	0.29
Apr	30	3.90	6.60	-2.70	0	0
May	31	4.03	9.29	-5.27	0	0
Jun	30	3.90	10.27	-6.38	0	0
Jul	31	4.03	11.27	-7.25	0	0
Aug	31	4.03	11.64	-7.62	0	0
Sep	30	3.90	8.63	-4.74	0	0
Oct	31	4.03	8.32	-4.30	0	0
Nov	30	3.90	5.77	-1.87	0	0
Dec	31	4.03	5.25	-1.22	0	0
Total	365	47.40	89.06			

storage and flow equalization. Also, during emergency conditions, actual flows would typically need tank storage based on the inability to use the drip system for some reason. The system design must account for and accommodate these conditions.

The maximum amount of storage needed is 0.29 in during March.

A(wbs) = 0.29 in x 0.0638 acres x 7 days/wk ÷ 30 days ÷ 0.9091 in/wk
= 0.00474 acres

A(wetted)= 0.0580 acres + 0 acres + 0.0058 acres + 0.0047 acres
= 0.0685 acres
= 2985 ft^2

The hydraulic loading rate (HLR) for the wetted area can now be calculated:

HLR = 225 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 0.0685 acres
= 0.8463 in/wk
= 0.0754 gal/d/ft^2 based on average design flow
= 0.1507 gal/d/ft^2 based on maximum design flow

Comparing these loading rates to that used in the conventional approach based on soil characteristics reveals that a larger wetted (footprint) area will be needed (2985 ft^2 versus 2250 ft^2, see section 5.2.4).

The process for the detailed system layout and design would be identical to that described previously (but using the revised hydraulic loading rate and the corresponding design flow).

5.3 Example 2: Site with Deep, Permeable Soils Suitable for Large Flows

This example is representative of that used for many decentralized wastewater systems servicing relatively large flows where an NPDES permit for a point source discharge is not appropriate or not preferred.

5.3.1 Site Description

A rural subdivision is being planned for a large parcel of land that contains deep, well-drained soils. Soils have been classified as a clay loam with moderate to strong structure. For simplicity, it is assumed that soils are uniform over the site; however, in reality most large sites will have several different soil types with corresponding application rates. The area has a slight slope, typically less than 2%, and has at least 700 ft available along the contours to place the drip system. There are no restrictive layers within 10 ft of the surface. The site is former agricultural land with few trees.

5.3.2 Design Boundaries

There are no significant boundary limitations for the site. The wastewater system will receive priority for use of the best soils on the site.

5.3.3 Performance Requirements

Performance requirements are the same as the previous example. The regulatory agency requires that the wastewater discharge remain below the ground surface at all times, that the groundwater contain no detectable fecal coliforms, and that the nitrate concentrations in the groundwater be less than 10 mg/l as nitrogen at the property boundary. Maximum allowable design wastewater loadings are 2.8 in/wk and 0.30 in/h (instantaneous).

5.3.4 Design Based on Hydraulic Footprint Loading Rates

The application rate (footprint loading rate) specified by the professional soils evaluator is 0.3 gal/d/ft^2. The footprint loading rate is not considered dependent upon effluent quality for typical residential wastewater (see section 3.2.3). Treatment levels may range from primary or septic to advanced. The soils evaluator has indicated that this loading rate is acceptable for actual anticipated flows.

The design flow for large subdivisions can be based on the average flow per home with applicable peaking factors applied. Actual flow for new houses with standard water conservation devices should average about 135 gal/d (based on 50 gallons per capita per day and 2.7 people per home) [15]. A peaking factor of 2.5 for peak daily flows is recommended for small communities, resulting in a design flow of 337.5 gal/d per home [34]. This results in a design flow of 50,000 gal/d for a 148-home subdivision. Average flow should be 20,000 gal/d.

Footprint Area (A) Required:

$A = 50{,}000 \text{ gal/d} \div 0.3 \text{ gal/d/ft}^2 = 166{,}667 \text{ ft}^2$

Contour loading:

The site has deep soils with a slight surface slope (<2%). Contour loading is typically not an issue for this type of site; however, it would still be prudent to take reasonable steps to minimize water mounding, such as long, narrow layouts, to the extent practicable. Some regulatory agencies will require mounding analysis for flows this large.

Emitter spacing and areal coverage:

The typical emitter and lateral spacing of 2 ft will be used for secondary or higher effluent quality. If the water and nutrient balance analyses indicated that septic effluent can be applied to the site, 1 ft spacing between driplines would be considered (while keeping the same footprint loading; see previous footnotes for example 1).

Daily volume dosed per emitter:

Daily emitter volume = footprint application rate x emitter areal coverage = 0.3 gal/d/ft^2 x 4 ft^2/emitter = 1.2 gal/d/emitter

Emitter discharge rate:

Emitters with standard drip rates will be used. These rates are 0.62 gal/h for BioLine, 0.53 gal/h for Wasteflow PC.

The nominal emitter rate for Wasteflow Classic is 1.3 gal/h at 20 psi, but the actual rate varies with pressure. To determine the design emitter rate, the average pressure for the drip laterals within each zone must be determined. The average pressure within a zone will depend on the lateral length, the number of laterals, and any elevation difference between the laterals. Typically, the maximum allowable flow variation between any two emitters within a zone is restricted to 10% or less. If the site is flat, the lateral length and number are typically the only design parameters restricted by the 10% criterion. In this case, the average emitter flow rate is based on the average of the inlet and outlet pressures. However, if the site is sloped, the pressure differential due to the elevation difference within each zone must also be determined. This results in an iterative design process to balance emitter lateral lengths and elevation changes within a zone to ensure that emitter drip rates do not vary by more than 10%.[73] Lateral lengths must be reduced from the maximum allowed for a flat site, since part of the allowable 10% variation in emitter flow must be accommodated by the elevation difference within the zone. The elevation difference depends on the site slope and the number of laterals within each zone (which also depends upon the total lateral length per zone). Pressure regulators are used at the entrance to each zone to ensure that the inlet pressures are the same.[74]

To allow a comparison of the different brands and types of drip tubing, the same design pressure will be used for the return manifold or outlet pressure (10 psi). The inlet pressure depends on the pressure loss for the longest drip lateral, which depends on the lateral length. As explained below, the maximum recommended lateral length for the Classic emitter is 210 ft (applicable for a flat site or no slope). The corresponding pressure loss is 2.53 psi for a 10-psi outlet pressure (from Geoflow's literature). Therefore, the inlet pressure needed is 12.53 psi. The average pressure for the lateral would then be 11.27 psi (most systems are probably designed around an average pressure of about 20 psi). The corresponding flow for this pressure is 0.96 gal/h (the flow rate will need to be adjusted for sites with a slope as explained below).

[73] In practice, these calculations have been rarely if ever done. They are provided here to demonstrate the process and method in the event they are required by the regulatory authority. As mentioned previously, it will be difficult if not impossible to meet the 10% criterion during pressurization and depressurization of the drip system. This is where the potential for unequal distribution and hydraulic overloading of the soil on a localized basis is much greater. Section 5.6.2 contains specific information on minimizing drain-back. During pressurization, the most practical approach to minimize unequal distribution is to run two pumps simultaneously to minimize the time needed to fill the tubing, followed by one pump for routine dosing.

[74] The system must also be designed to flush effectively. This may require the use of solenoid valves to bypass the pressure regulators during flushing in order to achieve the necessary flushing pressures and flows.

The instantaneous loading rate for each type of emitter needs to be checked with the allowable instantaneous rate if one is required. The instantaneous loading rate was previously calculated (see section 5.2.4) for each type and brand of emitter. Both PC emitters were less than the allowable 0.30 in/h; however, the instantaneous rate for the Wasteflow Classic depends on the emitter flow rate for the design pressure. For this example the rate is:

Wasteflow Classic emitter: 0.96 gal/h/emitter x 1 emitter/4 ft^2 x 1 ft^3/7.481 gal x 12 in/ft = 0.38 in/h

This rate exceeds the criterion of 0.30 in/h and to use the emitter, a request and justification for the higher loading rate must be made to the regulatory authority. For this example, it is assumed that the higher instantaneous loading rate is acceptable.

Length of emitter tubing needed:

Tubing length = footprint surface area ÷ spacing between lines = 166,667 ft^2 ÷ 2 ft = 83,333 ft

Drip lateral length:

Since the site is not limited by its configuration, lateral lengths depend on hydraulic considerations for the system. Long lateral lengths can be used along with a smaller number of laterals for each zone to reduce the overall pump rates needed for periodically flushing the lines, but this approach increases the TDH for the system. The first criterion that needs to be considered is the maximum allowable pressure loss for the tubing from the supply to the return end. This is typically specified as 10 psi. However, using the maximum tubing length based on this criterion may create TDHs that exceed the capacity of commercially available pumps.[75] This is a balancing problem that involves experience and multiple calculations to match system hydraulics to available pumps. The process is aided tremendously by using a spreadsheet to perform the basic calculations. Typically, for relatively flat sites, lateral lengths of 300 ft or less for PC driplines will result in system TDHs less than 150 ft, which are not difficult to match to available pumps. This length will be used for this example for BioLine and Wasteflow PC.[76, 77]

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[75] As mentioned for example 1, the importance of matching hydraulic requirements to commercially available pumps is not as critical for large systems, since custom pumps become affordable that can meet the design requirements exactly.

[76] Use of 300 ft laterals also results in flushing flow rates (for flushing velocities of 2 ft/s at the distal end and 2 ft emitter spacing) that are approximately the same as dosing flow rates. Flows needed for a flushing cycle are therefore about double that needed for a dosing cycle without flushing. Since the pumping capacity is available, this allows two zones to be dosed simultaneously. As shown later in the example, this is a significant advantage for large systems, since it optimizes pump operations and allows enough time to dose the daily flow with relatively small pumps.

[77] Geoflow states that they would approach this design differently. They would either use the nominal 1/2-in Wasteflow PC tubing with a supply manifold pressure of 45 psi and run across the field with 650 ft laterals, or they would look at the energy costs and if justified use the nominal 3/4-in Wasteflow PC tubing at 20 psi and run across the entire 700 ft that are available. This would reduce the number of trenches and connections and the corresponding installation costs. Geoflow says that the Classic dripline would not be economically appropriate for this example.

For non-PC tubing, the drip rate from each emitter must also be considered. Typically, the maximum allowable variation between any two emitters within a zone must not exceed 10%. This criterion will control the maximum lateral length. Also, the criterion is typically applied only to the dosing cycle and not the periodic flushing cycle. For Wasteflow Classic with 24-in emitter spacing, the corresponding maximum lateral length is 210 ft (see appendix C), but this uses all of the 10% allowable variation in emitter flow. For a sloped site, the maximum lateral length must be reduced to accommodate the variation in emitter flow rate due to elevation changes between laterals.[78] This results in an iterative design process to balance emitter lateral lengths and elevation changes within a zone to ensure that emitter drip rates do not vary by more than 10%. The process is complicated by the fact that the elevation difference with a zone depends on the number of laterals within each zone (which depends upon the lateral length).[79]

Number of dripline laterals:

BioLine and Wasteflow PC = tubing length ÷ lateral length = 83,333 ft ÷ 300 ft = 277.8

Round up the number of laterals to 278, resulting in a total of 83,400 ft of drip tubing (spaced 2 ft apart) and 41,700 emitters.

If septic effluent is dosed, consideration should be given to decreasing the spacing of the driplines to 1 ft, resulting in 556 laterals, 166,800 ft of drip tubing, and 83,400 emitters. As noted in the previous example, the footprint size should remain the same, resulting in a conservative approach that reduces the instantaneous loading rate and utilizes the available soils more efficiently for the stronger effluent. The number of zones, flushing flows, dose frequencies, and pump sizes would need to be based on the larger number of drip laterals and emitters.

For Wasteflow Classic, if the site was flat with no slope, the maximum lateral length would be 210 ft. This is based on the maximum friction loss for keeping the variation in emitter flow rate between the first and last emitters at 10%. However, this length must be reduced for a sloped site to account for the variance in emitter flow rate resulting from elevation changes. For the site used in this example, the slope is 2%. This will result in a pressure differential of 0.866 psi per 100 ft (2 ft/100 ft ÷ 2.31 ft/psi) of drip zone width. Although this appears to be a small pressure differential, it is significant for keeping the total variation in emitter flow rates to 10% or less. The calculations are iterative, beginning with a determination of the number of zones and laterals needed for a flat site. The preliminary number of laterals needed is:

Rather than delete the Classic dripline from the example, it is retained to illustrate the design steps and processes that are needed for its use.

[78] Geoflow recommends that the maximum elevation difference within a zone not exceed 6 ft for use of Classic tubing.

[79] The pressure differences for a sloped site and the corresponding differences in flows for each lateral also complicate flushing calculations.

Wasteflow Classic	= tubing length ÷ lateral length = 83,333 ft ÷ 210 ft = 396.8

Round up the number of laterals to 397, resulting in a total of 83,370 ft of drip tubing (spaced 2 ft apart) and 41,685 emitters.[80]

Number of zones:

If the entire system was dosed at one time, the flow rate needed for dosing would be:

BioLine:	41,700 emitters x 0.62 gal/h/emitter x 1 hr/60 min = 430.9 gal/min
Wasteflow PC:	41,700 emitters x 0.53 gal/h/emitter x 1 hr/60 min = 368.4 gal/min
Wasteflow Classic:	41,685 emitters x 0.96 gal/h/emitter x 1 hr/60 min = 666.9 gal/min

Since it is not practical to dose the entire system at the same time, the system needs to be divided into zones with associated hydraulic requirements that match readily available pumps.[81] Centrifugal pumps are readily available with pump rates from 60 to 140 gal/min for corresponding TDHs between 150 and 105 ft. Using 60 gal/min as a target, the number of zones needed would be:

BioLine:	431 gal/min ÷ 60 gal/min/zone = 7.2 zones (use 8 zones)
Wasteflow PC:	368 gal/min ÷ 60 gal/min/zone = 6.1 zones (use 8 zones)
Wasteflow Classic:	667 gal/min ÷ 60 gal/min/zone = 11.1 zones (use 12 zones)

To help balance the system hydraulically, some designers will adjust pumping rates or lateral lengths to obtain an even number of zones rather than an odd number (rounding up rather than down). Since larger systems should always use at least two pumps, the pumping capacity that is typically available allows two zones to be dosed simultaneously except during flushing cycles when both pumps are needed to provide the larger flow and corresponding TDH for each zone.[82] This also minimizes potential problems with having enough time within a day to complete all of the required dosing cycles for larger systems. If a problem occurs with one of the pumps, the controller automatically adjusts the operations to dose only one zone at a time rather than two until the pump problem is resolved.

[80] If septic effluent is dosed, the spacing of the driplines might be decreased to 1 ft, resulting in 794 laterals, 166,740 ft of drip tubing, and 83,370 emitters.

[81] For large systems, the need to use readily available pumps is not critical, since custom pumps can be provided by major pump suppliers that meet exact design specifications at reasonable costs.

[82] An alternate approach is to size the pumps so that one pump is capable of providing the maximum system flow (both dosing and flushing flows). This would allow complete system operation if one pump fails, and larger pumps may allow additional zones to be dosed simultaneously. Disadvantages include the extra expense of larger pumps, filter packages, pipes, and other components when smaller ones are adequate, particularly when flushing is relatively infrequent and repairs can be quickly completed when a failure occurs. The method would likely result in a smaller number of zones. The cost savings for a smaller number of control valves and other zone components may result in larger cost savings than the expense of larger components.

After establishing the number of zones, the number of laterals and emitters need to be recalculated to match the zones.

BioLine and Wasteflow PC:	278 laterals ÷ 8 zones	= 34.8 laterals/zone (use 35)
	35 laterals/zone x 300 ft/lateral	= 10,500 ft/zone
	10,500 ft/zone ÷ 2 ft/emitter	= 5250 emitters/zone
Wasteflow Classic:	397 laterals ÷ 12 zones	= 33.1 laterals/zone (use 34)
	34 laterals/zone x 210 ft/lateral	= 7140 ft/zone
	7140 ft/zone ÷ 2 ft/emitter	= 3570 emitters/zone

5.3.5 Pumping Requirements

The dosing and flushing flows for each zone and for multizone dosing can now be calculated:

Dosing Flow:

BioLine:	5250 emitters/zone x 0.62 gal/h ÷ 60 min/h = 54.3 gal/min/zone
Wasteflow PC:	5250 emitters/zone x 0.53 gal/h ÷ 60 min/h = 46.4 gal/min/zone
Wasteflow Classic:	3570 emitters/zone x 0.96 gal/h ÷ 60 min/h = 57.1 gal/min/zone

Flushing Flow:

BioLine:	35 laterals/zone x 1.59 gal/min/lateral = 55.7 gal/min/zone[83]
Wasteflow PC (1 ft/s):	35 laterals/zone x 0.741 gal/min/lateral = 25.9 gal/min/zone
Wasteflow PC (2 ft/s):	35 laterals/zone x 1.48 gal/min/lateral = 51.8 gal/min/zone
Wasteflow Classic (1 ft/s):	34 laterals/zone x 0.741 gal/min/lateral = 25.2 gal/min/zone
Wasteflow Classic (2 ft/s):	34 laterals/zone x 1.48 gal/min/lateral = 50.3 gal/min/zone

Maximum Zone Flow (Dosing and Flushing Flows):

BioLine:	54.3 gal/min + 55.7 gal/min = 110.0 gal/min
Wasteflow PC (1 ft/s):	46.4 gal/min + 25.9 gal/min = 72.3 gal/min
Wasteflow PC (2 ft/s):	46.4 gal/min + 51.8 gal/min = 98.2 gal/min
Wasteflow Classic (1 ft/s):	57.1 gal/min + 25.2 gal/min = 82.3 gal/min
Wasteflow Classic (2 ft/s):	57.1 gal/min + 50.3 gal/min = 107.4 gal/min

[83] Using DRIPNET (contact Steven Berkowitz at the North Carolina Department of Environment and Natural Resources) the required flow is 58 gal/min based on the Hardy-Cross analysis.

Dosing Flow for Simultaneously Dosing Two Zones:

BioLine:	54.3 gal/min x 2 = 108.6 gal/min
Wasteflow PC (1 ft/s):	46.4 gal/min x 2 = 92.8 gal/min
Wasteflow PC (2 ft/s):	46.4 gal/min x 2 = 92.8 gal/min
Wasteflow Classic (1 ft/s):	57.1 gal/min x 2 = 114.2 gal/min
Wasteflow Classic (2 ft/s):	57.1 gal/min x 2 = 114.2 gal/min

This design will be based on two-zone dosing using two pumps in parallel. This helps provide adequate time for completing all of the required doses during a day, while providing reserve time for increasing dose periods if needed due to clogged emitters as the system ages. It also ensures that the velocity in the supply pipe is similar during both the dosing and flushing cycles (above 2 ft/s), which would minimize slime growth and help keep the pipe clean.

Modifications to the Wasteflow Classic Design Based on Slope Considerations:

As previously stated, the above design would be applicable for a site with no slope. Since this site has a slope of 2%, the lateral length and number of laterals per zone must be adjusted to account for the variation in emitter flow rate caused by the elevation change. The total variation in flow between any two emitters within a zone is restricted to 10%.

There are 34 laterals needed for each zone for a flat site. With a uniform slope of 2% and standard spacing between laterals of 2 ft, there will be 68 ft (horizontally) between the high and low laterals within each zone. The corresponding elevation difference is 1.36 ft (68 ft x 0.02) and the pressure difference will be 0.59 psi (1.36 ft ÷ 2.31 ft/psi). Consequently, the design pressure at the distal end of the laterals will range from 10 psi for the high lateral to 10.59 psi for the low lateral. The emitter flow rates for these pressures are 0.907 gal/h and 0.932 gal/h. The difference in emitter flow rate is 2.66% based on the highest emitter rate of 0.932 gal/h.[84] Consequently, the total variance in emitter flow rate will be the 12.66% for the zone (based on the 10% variance for the lateral length of 210 ft and the 2.66% for the elevation change).

To keep the total variance to 10% or less, the lateral length must be shortened (see footnote 73). Since the elevation difference accounts for 2.66% of the allowable variance, the variance associated with the lateral length should not exceed 7.34%. The corresponding lateral length is 189 ft based on the following regression equation for Wasteflow Classic with emitter spacing of 2 ft and no flushing flow:

$$Y = -0.1275X^4+2.875X^3-22.566X^2+83.202X+27.52$$

Where Y = lateral length, ft

X = cumulative emitter flow variance, %

[84] The maximum difference in emitter flow rates will occur at the distal end of the laterals rather than the inlet ends. The change in emitter flow rate increases with decreasing pressures.

However, if this lateral length is used, it will result in a larger number of laterals and a corresponding increase in the elevation difference between the high and low laterals. The lateral length is arbitrarily reduced another 5% to 180 ft to reduce the number of calculations needed to keep the total variation in emitter flow rate to 10% or less. The corresponding pressure loss for 180 ft of drip lateral is 1.63 psi. The corresponding inlet pressures and drip emitter rates will be 11.63 psi (10 psi + 1.63 psi) and 0.975 gal/h for the high lateral and 12.22 psi (10.59 psi + 1.63 psi) and 1.000 gal/h for the low lateral. The corresponding variance in emitter flow rates is 9.29% using 1.000 gal/h as the base emitter rate. The average emitter flow rate for the zone is 0.953 gal/h based on the average emitter rate for the high lateral (0.941 gal/h) and the low lateral (0.966 gal/h).

Using the revised average zone emitter rate (0.953 gal/h), recalculations are needed for the total system and zones. The number of laterals will increase if the number of zones are not changed, resulting in a larger elevation change between the high and low laterals within each zone. The dosing flow for each zone will also change based on slight changes in the number of emitters and the average pressure for the zone. These calculations are listed below.

Preliminary number of laterals	= 83,333 ft ÷ 180 ft/lateral = 463.0 laterals
Number of zones	= 12 (retain the same number as calculated previously to reduce iterative calculations)
Actual number of laterals/zone	= 463 laterals ÷ 12 zones = 38.6 laterals/zone (round up to 39)
Actual ft of dripline/zone	= 39 laterals/zone x 180 ft/lateral = 7020 ft/zone
Number of emitters	= 7020 ft/zone ÷ 2 ft/emitter = 3510 emitters/zone
Dosing flow/zone	= 3,510 emitters/zone x 0.953 gal/h/emitter ÷ 60 min/h = 55.77 gal/min/zone
Zone width	= 39 laterals/zone x 2 ft/lateral = 78 ft/zone
Elevation difference/zone	= 78 ft/zone x 0.02 (slope) = 1.56 ft/zone
Pressure difference/zone	= 1.56 ft/zone ÷ 2.31 ft/psi = 0.675 psi/zone
Design outlet pressure for high lateral	= 10 psi
Emitter flow rate for high lateral (distal end)	= 0.9068 gal/h (from technical data for Wasteflow Classic)
Outlet pressure for low lateral	= 10 psi + 0.675 psi = 10.675 psi
Emitter flow rate for low lateral (distal end)	= 0.9353 gal/h (from technical data for Wasteflow Classic)
Difference in emitter flow rate (high to low)	= (0.9353 gal/h – 0.9068 gal/h) ÷ 0.9353 gal/h x 100= 3.04%
Available difference based on lateral length	= 10% - 3.04% = 6.96%
Revised max lateral length	$= -0.1275(0.0696)^4+2.875(0.0696)^3-22.566(0.0696)^2+83.202(0.0696)+27.52 =$ 184 ft
Lateral length to be used	= 180 ft (keep the same as previously selected to reduce the number of calculations)

Corresponding pressure loss	= 1.63 psi (from technical data for Wasteflow Classic)
Inlet pressure for high lateral	= 10 psi + 1.634 psi = 11.634 psi
Emitter flow rate at inlet of high lateral	= 0.9753 gal/h (from technical data for Wasteflow Classic)
Inlet pressure for low lateral	= 10.675 psi (from above) + 1.634 psi = 12.309 psi
Emitter flow rate at inlet of low lateral	= 1.0033 gal/h (from technical data for Wasteflow Classic)
Actual max variance in emitter flow rate	= (1.0033 gal/h – 0.9068 gal/h) ÷ 1.0033 gal/h x 100 = 9.61%
Average emitter flow rate for high lateral	= (0.9753 gal/h + 0.9068 gal/h) ÷ 2 = 0.9411 gal/h
Average emitter flow rate for low lateral	= (1.0033 gal/h + 0.9353 gal/h) ÷ 2 = 0.9693 gal/h
Average emitter flow rate for each zone	= 0.9693 gal/h + 0.9411 gal/h) ÷ 2 = 0.9552 gal/h

The revised flows for the Wasteflow Classic system are:

Dosing Flow: 3510 emitters/zone x 0.955 gal/h ÷ 60 min/h = 55.9 gal/min/zone

Flushing Flow:
1 ft/s: 39 laterals/zone x 0.741 gal/min/lateral = 28.9 gal/min/zone
2 ft/s: 39 laterals/zone x 1.48 gal/min/lateral = 57.7 gal/min/zone

Maximum Zone Flow (Dosing and Flushing Flows):
1 ft/s: 55.9 gal/min + 28.9 gal/min = 84.8 gal/min
2 ft/s: 55.9 gal/min + 57.7 gal/min = 113.6 gal/min

Dosing Flow for Simultaneously Dosing Two Zones:
1 ft/s: 55.9 gal/min x 2 = 111.8 gal/min
2 ft/s: 55.9 gal/min x 2 = 111.8 gal/min

Configuration:

Since this site has no constraints, the simplest layout will be used: rectangular zones placed side by side and end to end along the slope (to minimize potential water mounding). Since the available distance along the contour is 700 ft, the configuration for the PC systems would consist of two sets of zones placed end to end (using about 640 ft of the available 700 assuming each zone is separated by an arbitrary 20-ft buffer that would allow surface drainage swales and vehicular access between zones and would assist in zone separation and delineation for O&M purposes) and four zones deep (running down the slope). The basic layout is shown in figure 5.6. The configuration would be similar for the non-PC system but with more zones (three sets along the contour, covering about 580 ft with 20-ft buffers between the zones and four-zones deep down the slope).

As with the previous example, the layout of the drip field and manifolds should always be configured to supply wastewater from the lowest elevation (the supply line feeds the zone from the low end of the supply manifold) and flush the system from the highest elevation (the return or flush line receives flushing flow from the zone at the high end of the return manifold). This keeps the supply pipe from contributing to the potential drain-back volume within the field and improves distribution of wastewater and functioning of A/V relief valves during filling and draining of the field. Supply and return manifolds should also be designed to minimize or eliminate any contribution to drain-back (see sections 3.3.5 and 5.6.2).

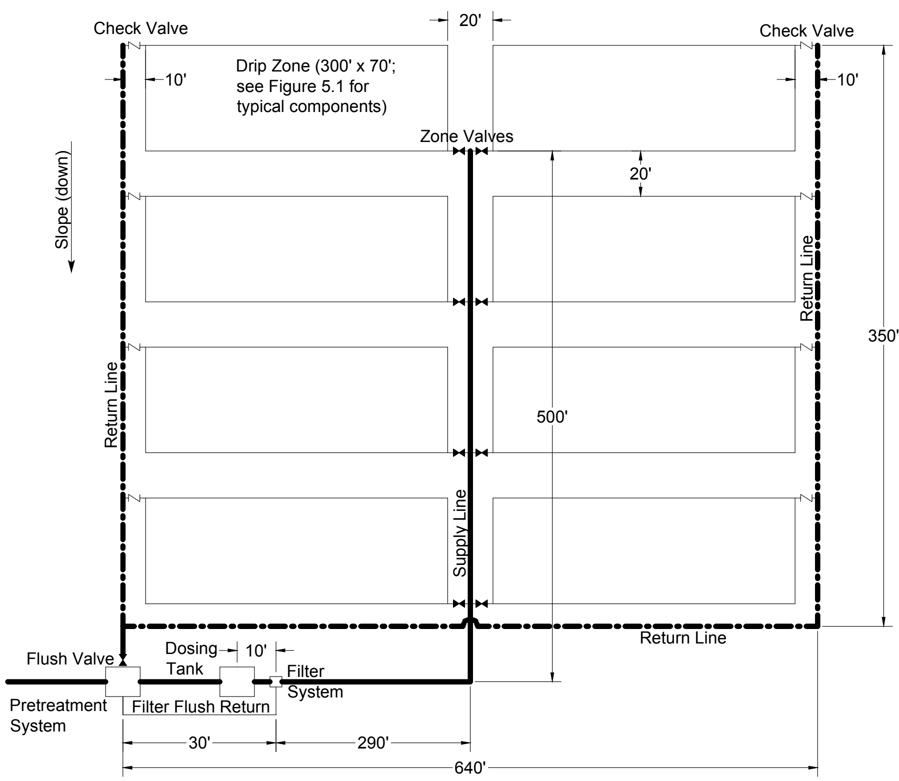

Figure 5-6
Typical Multizone Layout for Example 2

TDH for the system:

As noted previously, the TDH is the energy that the pump must supply to meet demands of the various drip system components and operating schemes. This requires the preliminary selection and design for all components to determine applicable head losses. If the cumulative head losses result in a TDH that is too large for readily available pumps, components are reselected, resized, or relocated to lower the friction losses and/or static lift until the TDH for the system is within the range of commercially available pumps. The key parts of the process are repeated below for this example.

TDH = pressure head + velocity head + elevation head + friction head

Based on Netafim information, the friction loss while dosing is 3.09 psi for a BioLine length of 300 ft. The required inlet pressure to maintain 10 psi at the return manifold is 13.09 psi. The minimum system pressure differential required to maintain at least 2 ft/s flushing velocity at the distal end of the drip lateral is 20.61 psi at the inlet (supply manifold). This also represents the friction loss occurring within the drip laterals while flushing. This design will be based on uniform dosing during the flush cycle, requiring a residual pressure of 10 psi at the distal end of the lateral.[85] The total pressure needed at the inlet for the flushing cycle is 30.61 psi. The actual pressure that can be achieved at the distal end of the drip system depends on the frictional losses that occur within the return piping system and any positive elevation head that may exist between the return manifold and the return tank. The design needs to ensure that the combination of frictional losses and elevation head total at least 10 psi. If the combined return energy components do not total 10 psi (based on the actual length of pipe, number and type of fittings and valves to be used, and elevation head), the flush valve will need to be partially closed or adjusted during flushing to ensure that 10 psi is available at the return manifold.

The TDH will need to be calculated for these various operating conditions to determine both controlling conditions and actual operating point for the pumps to be used. Additionally, when disk filters are used, the TDH must also be calculated for back-flushing the filter system. The disk filter corresponding to the maximum design flow of 110 gal/min (dosing and flushing) and 140-mesh filtration is a 2-in disk filter. This filter requires 35 gal/min at 50 psi to properly back-flush. During back-flushing, the flush water is returned to the primary tank; consequently, the corresponding pressure at the pipe outlet to the return tank is 0 psi.

The pressure heads (P_h) for the four primary conditions described previously are:

at the inlet of the drip laterals for dosing the drip field:	13.1 psi (30.2 ft)
at the return tank for dosing and flushing:	0 psi (0 ft)
at the inlet of the drip laterals for dosing and flushing:	30.6 psi (70.7 ft)
at the return tank for filter back-flushing:	0 psi (0 ft)

As noted previously, for design examples within this document, flow velocities will always be less than 5 ft/s, and the velocity head will always be less than 0.5 ft.

For this example, it is assumed that the ground surface at the drip field is 30 ft higher than the minimum water elevation in the dose tank (pump “off” float elevation), the driplines are buried 0.75 ft below the surface, and the return flush line discharges into the flush tank at an elevation that is 7 ft above the minimum water level within the dose tank. Corresponding elevation heads for these two critical locations are:

E_h at the highest drip lateral in the drip field = (30 ft – 0.75 ft) – 0 ft = 29.25 ft
E_h at the pipe outlet to the return tank = (7 ft) – 0 ft = 7 ft (for steady state flow assuming flow fills the return pipe)[86]

[85] See footnotes for example 1 for additional relevant information on these concepts. Without the extra 10 psi at the distal end of the drip laterals, the pressure would approach zero at the return manifold, and the emitters near the end of the lateral would not have the minimum pressure needed for pressure-compensated dosing.

[86] See footnotes 56 and 57 for the previous example.

Using 4 ft/s at the target flow velocity (see information for the first example for choosing flow velocities) for the maximum flow rate (dosing and flushing), the pipe size required for the supply line and manifold would be:

Pipe inside diameter (D_i) = $\sqrt{(4Q/\pi v)}$

Where Q = flow

V = velocity

$D_i = \sqrt{((4)(110 \text{ gal/min})(144 \text{ in}^2/\text{ft}^2)/(3.1417)(4 \text{ ft/s})(60 \text{ s/min})(7.481 \text{ gal/ft}^3))} = 3.35 \text{ in}$

PVC pipes with adequate pressure ratings, serviceability, and availability are typically either Schedule 40 or SDR 21 (Class 200).[87] Using data for Schedule 40 pipe, the closest available pipe is nominal 3-in pipe with an inside diameter of 3.068 in. The actual velocity for this pipe would be 4.77 ft/s based on the design flow of 110 gal/min.

The pipe size required for the return manifold and line would be:

$D_i = \sqrt{((4)(55.7 \text{ gal/min})(144 \text{ in}^2/\text{ft}^2)/(3.1417)(4 \text{ ft/s})(60 \text{ s/min})(7.481 \text{ gal/ft}^3))} = 2.38 \text{ in}$

The closest Schedule 40 pipe would be 2 in with an actual inside diameter of 2.067 in. The corresponding actual velocity for this pipe would be 5.32 ft/s based on the design flushing flow of 55.7 gal/min. Since this velocity exceeds the upper target of 5 ft/s (see information in the first example), the calculation is repeated using 3 ft/s rather than 4 ft/s.

$D_i = \sqrt{((4)(55.7 \text{ gal/min})(144 \text{ in}^2/\text{ft}^2)/(3.1417)(3 \text{ ft/s})(60 \text{ s/min})(7.481 \text{ gal/ft}^3))} = 2.75 \text{ in}$

The closest Schedule 40 pipe would be 2 1/2 in with an actual inside diameter of 2.469 in. The corresponding actual velocity for this pipe would be 3.73 ft/s based on the design flushing flow of 55.7 gal/min.[88]

Using these pipe sizes, the friction head can now be calculated using the Hazen-Williams' equation:

Friction loss (h_f) = $0.2083(100/C)^{1.85}(Q^{1.852}/D_i^{4.8655})$

Where: h_f = friction loss, ft of water per 100 ft of pipe

C = flow coefficient, 150 for PVC pipe (a conservative value for pipes in service)

Q = flow rate, gal/min

D_i = pipe internal diameter, in

For the supply pipe for dosing and dosing and flushing flows, respectively:

$h_f = 0.2083(100/150)^{1.85}((54.3)^{1.852}/(3.068)^{4.8655}) = 0.69$ ft per 100 ft

[87] SDR 21 PVC pipe would be a better choice than Schedule 40 for pipe sizes of 2 inches or larger because SDR 21 pipe has a larger inside diameter for equivalent pipe sizes. This results in lower velocities and less friction loss for the same design flows. SDR 21 pipe may also be more locally available in the larger pipe sizes than Schedule 40 pipe. Schedule 40 is used in this example to illustrate specific points.

[88] This second calculation would not have been needed using SDR 21 PVC pipe.

$= \quad 5.49$ ft for the 800 ft supply pipe used in this example

$h_f \quad = \quad 0.2083(100/150)^{1.85}((110)^{1.852}/(3.068)^{4.8655}) = 2.54$ ft per 100 ft

$= \quad 20.3$ ft for the 800 ft supply pipe used in this example

The friction losses for the supply manifold are calculated as described previously using a spreadsheet. Since the summary table for this example would be long, only the results will be provided here. The cumulative friction loss for the supply manifold is 2.92 ft based on a 70-ft manifold with drip laterals spaced 2 ft apart for dosing and flushing flow. The cumulative friction loss for the return manifold is 2.38 ft based on flushing flow only.

Losses for other components need to be included to determine the total friction losses. These are listed in the following table. The return pipe length is the same as the supply pipe (800 ft).

Table 5-15
Friction Losses for the 50,000 gal/d Design Example (Netafim)

Component	Head Loss (ft)				Comments
	Dosing Flow (2 zones) (108.5 gal/min) (at the Inlet to Drip Laterals)	Dosing and Flushing Flow (110 gal/min) (at the Return Tank)	Dosing and Flushing Flow (110 gal/min) (at the Inlet to Drip Laterals)	Filter Flushing (35 gal/min) (at the Return Tank)	
Pump suction line	2	2	2	1	From manufacturer's literature
Filter	11.6	11.6	11.6	115.5	Target value for flushing a dirty filter (max allowable loss: 5 psi pressure differential)
Filter valves	8.3	8.3	8.3	4.6	From manufacturer's literature x # valves
Flow meter	9.2	9.2	9.2		From manufacturer's literature
Supply pipe	19.8	20.3	20.3	<0.1	Calculated using Hazen-Williams
Supply pipe fittings	1	1	1	1	Typically insignificant (use 1)
Zone valve	2.3	4.2	4.2		From manufacturer's literature
Supply manifold	1.6	5.8	5.8		Calculated using Hazen-Williams
Drip lateral (longest)		47.6			From manufacturer's literature
Return manifold		4.0			Calculated using Hazen-Williams
Zone check valve		2.3			From manufacturer's literature
Return pipe		16.6		0.1	Calculated using Hazen-Williams
Return pipe fittings		1		1	Typically insignificant (use 1)
Flush valve		2.3			From manufacturer's literature
Total friction head	**55.8**	**136.2**	**62.4**	**123.2**	Sum of individual losses

The TDH can now be calculated as summarized in table 5-16.

Table 5-16
TDH for the 50,000 gal/d Design Example (Netafim)

Component	Total Dynamic Head (ft)			
	Dosing Flow (2 zones) (108.5 gal/min) (at the Inlet to Drip Laterals)	Dosing and Flushing Flow (110 gal/min) (at the Return Tank)	Dosing and Flushing Flow (110 gal/min) (at the Inlet to Drip Laterals)	Filter Flushing (35 gal/min) (at the Return Tank)
Pressure head	30.2	0	70.7	0
Velocity head	0.1	0.2	0.2	0.0
Elevation head	29.3	29.3	29.3	7.0
Total friction head	55.8	136.2	62.4	123.2
Total dynamic head	**115.4**	**165.7**	**162.6**	**130.2**

A pump must be chosen that is capable of meeting the flow and pressure requirements for each of these four key operating conditions.[89] If the combination of flow and TDH exceed the hydraulic range of off-the-shelf pumps, a custom pump will be needed, or the system will need to be redesigned to lower the hydraulic requirements. Centrifugal pumps are readily available for flows up to about 70 gal/min at heads up to 150 ft. At TDHs greater than 150 ft, custom pumps may be needed. Since the maximum TDH for this design exceeds the maximum target of 150 ft, pipes are resized to lower the friction losses and the TDH rather than ordering a custom pump.[90]

Lowering the target flow velocity from 4 ft/s to 3 ft/s, the pipe size required for the supply line and manifold would be:

Pipe inside diameter (D_i) = $\sqrt{(4Q/\pi v)}$

Where Q = flow

V = velocity

$D_i = \sqrt{((4)(110\text{ gal/min})(144\text{ in}^2/\text{ft}^2)/(3.1417)(3\text{ ft/s})(60\text{ s/min})(7.481\text{ gal/ft}^3))} = 3.87\text{ in}$

The closest available pipe is nominal 4-in pipe with an inside diameter of 4.026 in. The actual velocity for this pipe would be 2.77 ft/s based on the design flow of 110 gal/min.

The pipe size required for the return manifold and line would be:

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[89] As a general rule, it is better to over estimate the TDH rather than under estimate it, since the excess energy associated with a pump capable of providing the TDH can be easily dissipated, but if the calculations under estimate the TDH, the pump may not be able to meet the energy needs of the system. Also, as noted for example 1, the elevation head used for dosing and flushing at the return tank is the difference in elevation between the drip laterals and the water level in the pump tank (29.3 ft) rather than the difference is elevation between the return pipe outlet and the water level in the pump tank (7 ft) since the drip laterals must be refilled as the start of each dose or flushing cycle.

[90] If the TDH exceeded the upper target by 20 or more feet, other options would need to be used for lowering the TDH. Lowering the maximum lateral length provides the largest reductions. Increasing valve and flow meter sizes to the next available pipe size may also significantly lower the TDH. Using DR 21 pipe rather than Schedule 40 pipe would also lower the TDH.

D_i = •((4)(55.7 gal/min)(144 in^2/ft^2)/(3.1417)(3 ft/s)(60 s/min)(7.481 gal/ft^3)) = 2.75 in

Rounding up to the closest Schedule 40 pipe, a 3-in pipe with an actual inside diameter of 3.068 in would result in an actual velocity of 2.42 ft/s based on the design flushing flow of 55.7 gal/min.

The friction losses for these larger pipes for dosing and dosing and flushing flows will be:

h_f = $0.2083(100/150)^{1.85}((54.3)^{1.852}/(4.026)^{4.8655})$ = 0.183 ft per 100 ft
= 1.46 ft for the 800 ft supply pipe used in this example

h_f = $0.2083(100/150)^{1.85}((110)^{1.852}/(4.026)^{4.8655})$ = 0.68 ft per 100 ft
= 5.41 ft for the 800 ft supply pipe used in this example

The cumulative friction loss for the 4-in supply manifold is 2.1 ft based on a 70-ft manifold with drip laterals spaced 2 ft apart for dosing and flushing flow. The cumulative friction loss for the 3-in return manifold is 0.5 ft based on flushing flow only.

The revised losses for all components are listed in the following table.

Table 5-17
Revised Friction Losses for the 50,000 gal/d Design Example (Netafim)

Component	Head Loss (ft)				Comments
	Dosing Flow (2 zones) (108.5 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (110 gal/min) (at Return Tank)	Dosing and Flushing Flow (110 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (35 gal/min) (at Return Tank)	
Pump suction line	2	2	2	1	
Filter	11.6	11.6	11.6	115.5	Target value for flushing a dirty filter (max allowable loss: 5 psi pressure differential)
Filter valves	8.3	8.3	8.3	4.6	From manufacturer's literature x # valves
Flow meter	9.2	9.2	9.2		From manufacturer's literature
Supply pipe	5.3	5.4	5.4	<0.1	Calculated using Hazen-Williams
Supply pipe fittings	1	1	1	1	Typically insignificant (use 1)
Zone valve	2.3	4.2	4.2		From manufacturer's literature
Supply manifold	0.6	2.1	2.1		Calculated using Hazen-Williams
Drip lateral (longest)		47.6			From manufacturer's literature
Return manifold		1.7			Calculated using Hazen-Williams
Zone check valve		2.3			From manufacturer's literature
Return pipe		5.8		0.1	Calculated using Hazen-Williams
Return pipe fittings		1		1	Typically insignificant (use 1)
Flush valve		2.3			From manufacturer's literature
Total friction head	**40.3**	**104.5**	**43.8**	**123.3**	Sum of individual losses

The revised TDH values are summarized in table 5-18.

Table 5-18
Revised TDH for the 50,000 gal/d Design Example (Netafim)

Component	Total Dynamic Head (ft)			
	Dosing Flow (2 zones) (108.5 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (110 gal/min) (at Return Tank)	Dosing and Flushing Flow (110 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (35 gal/min) (at Return Tank)
Pressure head	30.2	0	70.7	0
Velocity head	0.1	0.1	0.3	0.0
Elevation head	29.3	29.3	29.3	7.0
Total friction head	40.3	104.5	43.8	123.3
Total dynamic head	**99.9**	**133.9**	**144.1**	**130.3**

The maximum TDH has been lowered to 144 ft. Also, note that the TDH at the return tank for dosing and flushing is less than the TDH needed at the inlet to the drip laterals (133.9 ft versus 144.1 ft). This indicates that the total friction losses with the return piping system are less than 10 psi (the minimum design outlet pressure at the distal end of the drip laterals). To actually attain 10 psi at the distal end of the laterals during flushing, the return valve may need to be slightly closed to increase the total frictional losses for the return piping or other methods will need to be used to increase the frictional losses to a total of 10 psi or more. This will result in the same TDH (144.1 ft) for each scenario. As shown in figure 5-7, a Sta-Rite Model DHJ self-priming centrifugal pump would meet each of these operating conditions. The Sta-Rite Model DHJ is a 5-horsepower, 230-volt pump.

Note that the operating points on figure 5-7 are estimates only. Conservative assumptions should typically be used for TDH calculations; consequently, the actual operating points, especially for zone dosing and flushing and filter back-flushing, may be different. Actual pressures for these operating conditions may be slightly less than calculated and actual flows may be slightly higher. This emphasizes the need to actually measure operating flows and pressures after the system is placed in operation to compare them to design values. This establishes a baseline that will be needed for troubleshooting the system, confirming design estimates, and ensuring that components actually installed meet design specifications. These are critical aspects for large systems.

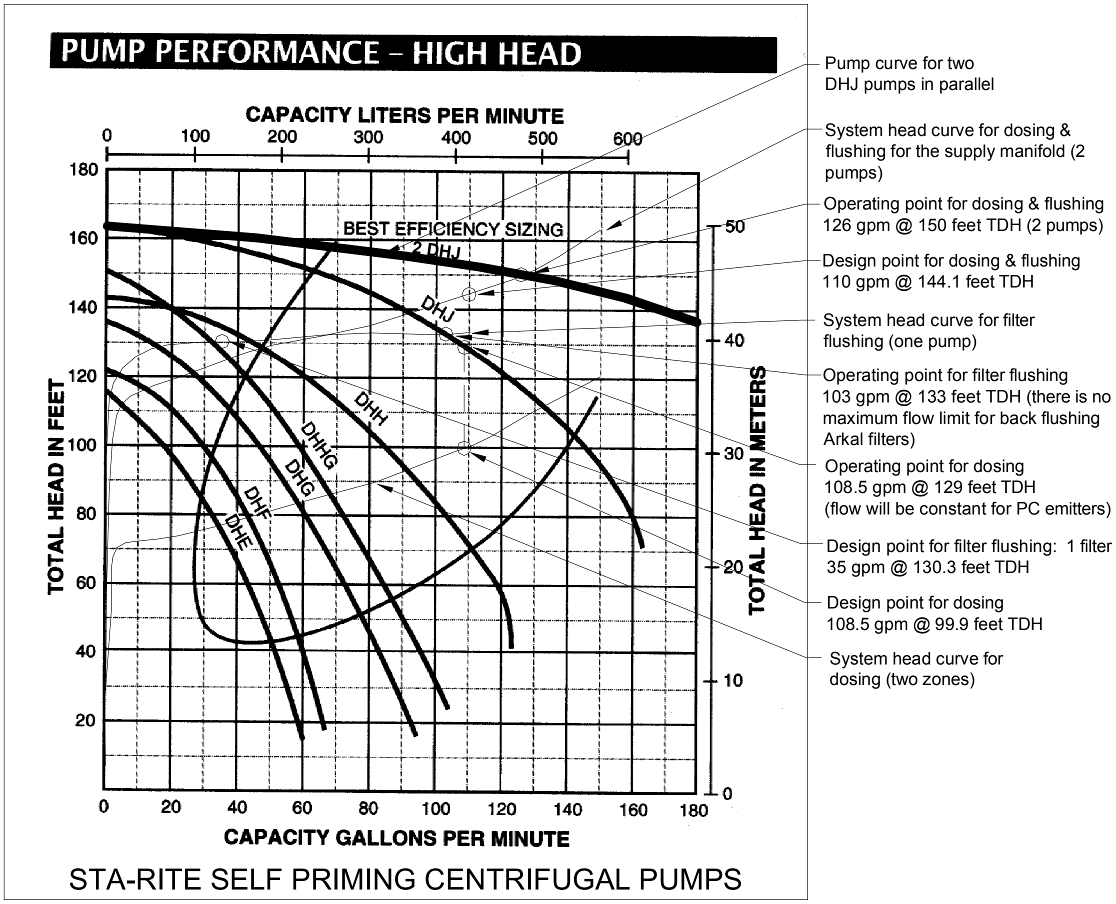

Figure 5-7
System Head Curves for the 50,000 gal/d Example (Netafim)

For Geoflow components, calculations will be summarized for Wasteflow PC and Classic driplines for 1 and 2 ft/s flushing velocity. Using the same design procedure outlined above, the friction loss for Wasteflow PC while dosing is 4.07 psi for a lateral length of 300 ft (see appendix C), resulting in a required inlet pressure of 14.07 psi when 10 psi is used as the target operating pressure at the return manifold. Using Geoflow's recommended flushing velocity of 1 ft/s and maintaining a 10-psi operating pressure at the return manifold, the required inlet pressure while flushing is 22.70 psi (see appendix C). Using the more conservative flushing velocity of 2 ft/s, the inlet pressure needed while flushing is 35.47 psi.

Supply and return pipes and manifolds are sized as explained previously. Calculations are summarized for both 1 and 2 ft/s flushing velocity for the driplines. A velocity of 1 ft/s results in substantially lower numbers (note that the supply and return pipes are still designed for a flushing velocity of at least 2 ft/s). The values can be compared in the following tables.

Calculations for flushing spin filters differ from disk filters. As discussed in section 3.3.3, spin filters cannot be back-flushed. Cleaning is accomplished by the centrifugal motion of the water being filtered. Gravity moves the debris downward to a flush valve, which is periodically opened for a short period of time during a routing dosing cycle to remove the debris. The amount of water used to flush the debris depends on the size of the flush valve and the time that the valve is open. Typically, only a small amount of water is needed to remove the debris from the filter. Since no hard numbers are typically provided for flushing, it is assumed for these calculations that 5% of the forward flow rate is used to flush the debris for the filter. The highest rate for either multiple-zone dosing or single-zone dosing and lateral flushing is used for these calculations to ensure that adequate pumping capacity is provided for the system. Consequently, the flow needed during filter flushing will always represent the maximum flow rate needed for the system. The TDH calculations for filter flushing represents the energy needed for pumping the maximum flow rate to the filter, followed by the relatively small amount of energy needed for flushing the debris to the trash tank.

Table 5-19
Friction Losses for the 50,000 gal/d Design Example (Geoflow PC: 1 ft/s)

Component	Head Loss (ft)				Comments
	Dosing Flow (2 zones) (92.75 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (72.3 gal/min) (at Return Tank)	Dosing and Flushing Flow (72.3 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (97.4 gal/min maximum system flow with 4.6 gal/min used for flushing) (at Return Tank)	
Pump suction line	2	2	2	2	
Filter	18.5	18.5	18.5	4.6	Based on a pressure differential of 8 psi across the filter while filtering and 2 psi pressure loss during flushing
Filter valves				3.2	From manufacturer's literature x # valves
Flow meter	6.9	4.2	4.2		From manufacturer's literature
Supply pipe	14.8	9.3	9.3	0.2	Calculated using Hazen-Williams
Supply pipe fittings	1	1	1	1	Typically insignificant (use 1)
Zone valve	5.8	7.9	7.9		From manufacturer's literature
Supply manifold	1.2	2.7	2.7		Calculated using Hazen-Williams
Drip lateral (longest)		29.3			From manufacturer's literature
Return manifold		5.1			Calculated using Hazen-Williams
Zone check valve		1.9			From manufacturer's literature
Return pipe		32.2			Calculated using Hazen-Williams
Return pipe fittings		1		1	Typically insignificant (use 1)
Flush valve		3.7			From manufacturer's literature
Total friction head	**50.2**	**118.8**	**45.6**	**12.0**	**Sum of individual losses**

The TDH can now be calculated as summarized in table 5-20.

Table 5-20
TDH for the 50,000 gal/d Design Example (Geoflow PC: 1 ft/s)

Component	Total Dynamic Head (ft)			
	Dosing Flow (2 zones) (92.75 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (72.3 gal/min) (at Return Tank)	Dosing and Flushing Flow (72.3 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (97.4 gal/min maximum system flow with 4.6 gal/min used for flushing) (at Return Tank)
Pressure head	32.5	0	52.4	0
Velocity head	0.1	0.3	0.1	0.0
Elevation head	29.3	29.3	29.3	7.0
Total friction head	50.2	118.8	45.6	12.0
Total dynamic head	**112.1**	**148.4**	**127.4**	**19.0**

The values are summarized in the following tables for a flushing flow of 2 ft/s.

Table 5-21
Friction Losses for the 50,000 gal/d Design Example (Geoflow PC: 2 ft/s)

Component	**Head Loss (ft)**				**Comments**
	Dosing Flow (2 zones) (92.75 gal/min) (at Inlet to Drip Laterals)	**Dosing and Flushing Flow (98.2 gal/min) (at Return Tank)**	**Dosing and Flushing Flow (98.2 gal/min) (at Inlet to Drip Laterals)**	**Filter Flushing (103.1 gal/min maximum system flow with 4.9 gal/min used for flushing) (at Return Manifold)**	
Pump suction line	2	2	2	2	
Filter	18.5	18.5	18.5	4.6	Based on a pressure differential of 8 psi across the filter while filtering and 2 psi pressure loss during flushing
Filter valves				3.2	From manufacturer's literature x # valves
Flow meter	6.9	7.4	7.4		From manufacturer's literature
Supply pipe	14.8	16.5	16.5	0.2	Calculated using Hazen-Williams
Supply pipe fittings	1	1	1	1	Typically insignificant (use 1)
Zone valve	5.8	12.0	12.0		From manufacturer's literature
Supply manifold	1.2	4.7	4.7		Calculated using Hazen-Williams
Drip lateral (longest)		58.8			From manufacturer's literature
Return manifold		7.2			Calculated using Hazen-Williams
Zone check valve		3.0			From manufacturer's literature
Return pipe		34.5			Calculated using Hazen-Williams
Return pipe fittings		1		1	Typically insignificant (use 1)
Flush valve		6.0			From manufacturer's literature
Total friction head	**50.2**	**172.6**	**62.1**	**12.0**	Sum of individual losses

Table 5-22
TDH for the 50,000 gal/d Design Example (Geoflow PC: 2 ft/s)

Component	Total Dynamic Head (ft)			
	Dosing Flow (2 zones) (92.75 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (98.2 gal/min) (at Return Tank)	Dosing and Flushing Flow (98.2 gal/min) (Supply Manifold) (at Inlet to Drip Laterals)	Filter Flushing (103.1 gal/min maximum system flow with 4.9 gal/min used for flushing) (at Return Manifold)
Pressure head	32.5	0	81.9	0
Velocity head	0.1	0.4	0.2	0
Elevation head	29.3	29.3	29.3	7.0
Total friction head	50.2	172.6	62.1	12.0
Total Dynamic Head	**112.1**	**202.3**	**173.5**	**19.0**

Since the maximum TDH exceeds the maximum target of 150 ft, pipes are resized to lower the friction losses and the TDH. The revised values are summarized in the following tables.

Table 5-23
Revised Friction Losses for the 50,000 gal/d Design Example (Geoflow PC: 2 ft/s)

Component	Head Loss (ft)				Comments
	Dosing Flow (2 zones) (92.75 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (98.2 gal/min) (at Return Tank)	Dosing and Flushing Flow (98.2 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (103.1 gal/min maximum system flow with 4.9 gal/min used for flushing) (at Return Manifold)	
Pump suction line	2	2	2	2	
Filter	18.5	18.5	18.5	4.6	Based on a pressure differential of 8 psi across the filter while filtering and 2 psi pressure loss during flushing
Filter valves				3.2	From manufacturer's literature x # valves
Flow meter	6.9	7.4	7.4		From manufacturer's literature
Supply pipe	7.3	8.1	8.1	0.1	Calculated using Hazen-Williams
Supply pipe fittings	1	1	1	1	Typically insignificant (use 1)
Zone valve	5.8	12.0	12.0		From manufacturer's literature
Supply manifold	0.7	2.7	2.7		Calculated using Hazen-Williams
Drip lateral (longest)		58.8			From manufacturer's literature
Return manifold		3.5			Calculated using Hazen-Williams
Zone check valve		3.0			From manufacturer's literature
Return pipe		14.5			Calculated using Hazen-Williams
Return pipe fittings		1		1	Typically insignificant (use 1)
Flush valve		6.0			From manufacturer's literature
Total friction head	**42.2**	**138.5**	**51.7**	**11.9**	Sum of individual losses

Table 5-24
Revised TDH for the 50,000 gal/d Design Example (Geoflow PC: 2 ft/s)

Component	Total Dynamic Head (ft)			
	Dosing Flow (2 zones) (92.75 gal/min) (at Inlet to Drip Laterals)	**Dosing and Flushing Flow (98.2 gal/min) (at Return Tank)**	**Dosing and Flushing Flow (98.2 gal/min) (at Inlet to Drip Laterals)**	**Filter Flushing (103.1 gal/min maximum system flow with 4.9 gal/min used for flushing) (at Return Manifold)**
Pressure head	32.5	0	81.9	0
Velocity head	0.1	0.2	0.2	0.0
Elevation head	29.3	29.3	29.3	7.0
Total friction head	42.2	138.5	51.7	11.9
Total Dynamic Head	**104.1**	**168.0**	**163.1**	**18.9**

The maximum TDH still exceeds the target value of 150 ft for a flushing flow of 2 ft/s. The required pressure head exerts a much greater influence on the TDH than the size of the supply pipe (most of the TDH reductions occurred with a larger return pipe, which does not affect the TDH calculations at the supply manifold). Options for this situation include finding a pump that can meet the TDH for the dosing and flushing flow or reducing the drip lateral lengths to reduce the required pressure head.

With Wasteflow Classic dripline, the maximum lateral length will be 180 ft for the sloped site based on an allowable difference of 10% for emitter drip rates. The corresponding values for a system based on the non-PC dripline are contained in the following tables. In addition, pressure regulators are needed at the entrance to each zone to ensure equivalent dosing for each zone (15 psi regulators would be needed for this example with a flow range from 55.9 gal/min while dosing to 84.8 gal/min for flushing at 1 ft/s to 113.6 gal/min for flushing at 2 ft/s).

Table 5-25
Friction Losses for the 50,000 gal/d Design Example (Geoflow Classic: 1 ft/s)

Component	Head Loss (ft)				Comments
	Dosing Flow (2 zones) (111.8 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (84.8 gal/min) (at Return Tank)	Dosing and Flushing Flow (84.8 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (117.3 gal/min maximum system flow with 5.6 gal/min used for flushing) (at Return Tank)	
Pump suction line	2	2	2	2	
Filter	18.5	18.5	18.5	4.6	Based on a pressure differential of 8 psi across the filter while filtering and 2 psi pressure loss during flushing
Filter valves				3.2	From manufacturer's literature x # valves
Flow meter	10.4	5.5	5.5		From manufacturer's literature
Supply pipe	10.3	6.2	6.2	0.3	Calculated using Hazen-Williams
Supply pipe fittings	1	1	1	1	Typically insignificant (use 1)
Zone valve	6.2	9.7	9.7		From manufacturer's literature
Pressure regulator	10.4	14.8	14.8		From manufacturer's literature (based on flow to one zone)
Supply manifold	1.1	2.1	2.1		Calculated using Hazen-Williams
Drip lateral (longest)		10.7			From manufacturer's literature
Return manifold		1.8			Calculated using Hazen-Williams
Zone check valve		2.1			From manufacturer's literature
Return pipe		11.7			Calculated using Hazen-Williams
Return pipe fittings		1		1	Typically insignificant (use 1)
Flush valve		4.4			From manufacturer's literature
Total friction head	**59.9**	**91.8**	**59.8**	**12.1**	Sum of individual losses

Table 5-26
TDH for the 50,000 gal/d Design Example (Geoflow Classic: 1 ft/s)

Component	Total Dynamic Head (ft)			
	Dosing Flow (2 zone) (111.8 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (84.8 gal/min) (at Return Tank)	Dosing and Flushing Flow (84.8 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (117.3 gal/min maximum system flow with 5.6 gal/min used for flushing) (at Return Tank)
Pressure head	26.9	0	33.8	0
Velocity head	0.1	0.1	0.2	0
Elevation head	29.3	29.3	29.3	7.0
Total friction head	59.9	91.8	59.8	12.1
Total Dynamic Head	**116.2**	**121.2**	**123.1**	**19.1**

The values are summarized in the following tables for a flushing flow of 2 ft/s.

Table 5-27
Friction Losses for the 50,000 gal/d Design Example (Geoflow Classic: 2 ft/s)

Component	Head Loss (ft)				Comments
	Dosing Flow (2 zones) (111.8 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (113.6 gal/min) (at Return Tank)	Dosing and Flushing Flow (113.6 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (119.3 gal/min maximum system flow with 6.0 gal/min used for flushing) (at Return Tank)	
Pump suction line	2	2	2	2	
Filter	18.5	18.5	18.5	4.6	Based on a pressure differential of 8 psi across the filter with filtering and 2 psi pressure loss during flushing
Filter valves				3.2	From manufacturer's literature x # valves
Flow meter	10.4	10.4	10.4		From manufacturer's literature
Supply pipe	5.6	5.8	5.8	0.1	Calculated using Hazen-Williams
Supply pipe fittings	1	1	1	1	Typically insignificant (use 1)
Zone valve	6.2	16.4	16.4		From manufacturer's literature
Pressure regulator	9.2	10.4	10.4		From manufacturer's literature (based on flow to one zone)
Supply manifold	0.7	2.1	2.1		Calculated using Hazen-Williams
Drip lateral (longest)		25.8			From manufacturer's literature
Return manifold		1.3			Calculated using Hazen-Williams
Zone check valve		3.7			From manufacturer's literature
Return pipe		6.2			Calculated using Hazen-Williams
Return pipe fittings		1		1	Typically insignificant (use 1)
Flush valve		6.5			From manufacturer's literature
Total friction head	**53.6**	**111.1**	**66.6**	**11.9**	Sum of individual losses

Table 5-28
TDH for the 50,000 gal/d Design Example (Geoflow Classic: 2 ft/s)

Component	Total Dynamic Head (ft)			
	Dosing Flow (2 zones) (111.8 gal/min) (at Inlet to Drip Laterals)	Dosing and Flushing Flow (113.6 gal/min) (at Return Tank)	Dosing and Flushing Flow (113.6 gal/min) (at Inlet to Drip Laterals)	Filter Flushing (119.3 gal/min maximum system flow with 6.0 gal/min used for flushing) (at Return Tank)
Pressure head	26.9	0	48.9	0
Velocity head	0.1	0.1	0.3	0
Elevation head	29.3	29.3	29.3	7.0
Total friction head	53.6	111.1	66.6	11.9
Total dynamic head	**109.9**	**140.5**	**145.1**	**18.9**

The maximum TDHs for the Classic system are 123 ft and 145 ft for 1 ft/s and 2 ft/s flushing velocities, respectively. As with the previous design scenarios, Sta-Rite Model DHJ self-priming centrifugal pumps operating in parallel would meet the conditions for each of these designs.

Table 5-29
Comparative Table for Flushing Velocity and System Components

Operating Function and System Location	Netafim: 2 ft/s flushing velocity	Geoflow PC: 2 ft/s flushing velocity	Geoflow Classic: 2 ft/s flushing velocity	Geoflow PC: 1 ft/s flushing velocity	Geoflow Classic: 1 ft/s flushing velocity
Dosing (at Inlet to Drip Laterals)					
TDH, ft	99.9	104.1	109.9	**112.1**	127.7
Flow, gal/min	108.5	92.75	111.8	**92.75**	111.8
Dosing and Flushing (at Return Tank)					
TDH, ft	133.9	**168.0**	140.5	**148.4**	121.2
Flow, gal/min	110	**98.2**	113.6	**72.3**	84.8
Dosing and Flushing (at Inlet to Drip Laterals)					
TDH, ft	**144.1**	163.1	**145.1**	127.4	**123.1**
Flow, gal/min	**110**	98.2	**113.6**	72.3	**84.8**
Filter Flushing (at return tank)					
TDH, ft	130.3	18.9	18.9	19.0	19.1
Flow, gal/min	35	103.1 and 4.9	119.3 and 6.0	97.4 and 4.6	117.3 and 5.6

Comparing these scenarios, the critical operating conditions are highlighted with **bold** fonts. As noted previously, the same pump could be used to meet all of the conditions except for the Geoflow PC design using 2 ft/s flushing velocity. This scenario needs to be redesigned to shorten the maximum lateral length and reduce the corresponding TDH. For each of the other designs using a flushing velocity of 2 ft/s, the energy needed at the inlet to the drip laterals for dosing and flushing control the design. For the designs using a flushing velocity of 1 ft/s, the energy needed at the inlet to the drip laterals for dosing two zones simultaneously controls the design for the non-PC emitter system, while the energy needed for both dosing and dosing and flushing need to be considered for the PC design (which has the overall lowest energy requirements).[91]

5.3.6 Dosing Considerations

As with the first example, dosing design is the last critical step in the design process. Using the rationale provided in the first example, 10 minutes is chosen as a reasonable dosing period for

[91] The design pressures must also be compared to the maximum allowable pressure for each individual component. Schedule 80 fittings are often used around the headworks. Pressure reducers may also be needed for large PC systems where there is a large elevation difference between the high and low zones.

the clay loam at the second site.[92] The volume dosed per cycle and the number of doses per day will be:

For BioLine:

Volume Dosed/Cycle	=	Pump rate x dosing time
	=	54.25 gal/min x 10 minutes/dose = 542.5 gallons/dose
Doses/day (design flow)	=	Design Daily Flow ÷ No. of Zones ÷ Volume Dosed/Cycle
	=	50,000 gal/d ÷ 8 zones ÷ 542.5 gallons/dose = 11.52 doses/day/zone
Doses/day (average flow)	=	Average Daily Flow ÷ No. of Zones ÷ Volume Dosed/Cycle/Zone
	=	20,000 gal/d ÷ 8 zones÷ 542.5 gallons/dose = 4.61 doses/day/zone

For Wasteflow PC:

Volume Dosed/Cycle	=	46.38 gal/min x 10 minutes/dose = 463.8 gallons/dose
Doses/day (design flow)	=	50,000 gal/d ÷ 8 zones ÷ 463.8 gallons/dose = 13.48 doses/day/zone
Doses/day (average flow)	=	20,000 gal/d ÷ 8 zones ÷ 463.8 gallons/dose = 5.39 doses/day/zone

For Wasteflow Classic:

Volume Dosed/Cycle	=	55.88 gal/min x 10 minutes/dose = 558.8 gallons/dose
Doses/day (design flow)	=	50,000 gal/d ÷ 12 zones ÷ 558.8 gallons/dose = 7.46 doses/day/zone
Doses/day (average flow)	=	20,000 gal/d ÷ 12 zones ÷ 558.8 gallons/dose = 2.98 doses/day/zone

Before setting the timer, the time needed to fill and pressurize the drip laterals needs to be determined. Assuming that the supply pipe and manifold are designed to stay filled between doses and ignoring the volume of water dripped during the pressurization process,[93] the approximate time to fill the drip laterals will be:

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[92] This dosing time results in about 3.9-lateral pipe volumes, which some designers and regulators believe is too small to assure uniform dosing. See footnotes 54 and 63.

[93] As indicated in a previous footnote for the first example, this is only an appropriate calculation due to complicating factors. Pump flow rates will be higher than design during the filling phase, since pressures will be

Time to fill drip laterals	=	Volume of laterals ÷ pump rate
For BioLine tubing	=	π x (0.57 in)^2 ÷ 4 ÷ 144 in^2/ft^2 x 10,500 ft x 7.481 gal/ft^3 ÷ 54.25 gal/min
	=	2.57 minutes
For Wasteflow PC tubing	=	π x (0.55 in)^2 ÷ 4 ÷ 144 in^2/ft^2 x 10,500 ft x 7.481 gal/ft^3 ÷ 46.38 gal/min
	=	2.79 minutes
For Wasteflow Classic tubing	=	π x (0.55 in)^2 ÷ 4 ÷ 144 in^2/ft^2 x 7020 ft x 7.481 gal/ft^3 ÷ 55.88 gal/min
	=	1.58 minutes

Rounding up, the timer setting will be 13 minutes (10 minutes for the dose + 3 minutes for lateral pressurization) for each of the PC tubing and 12 minutes (10 minutes for the dose + 2 minutes for the lateral pressurization) for the non-PC tubing.

The total time between doses will be as follows:

BioLine Dosing intervals (design flow)	= Minutes/day ÷ Doses/day/zone
	= 1440 min/day ÷ 11.52 doses/day/zone
	= 125 min/dose/zone
BioLine Dosing intervals (average flow)	= 1440 min/day ÷ 4.61 doses/day/zone
	= 312 min/dose/zone
Wasteflow PC Dosing intervals (design flow)	= 1440 min/day ÷ 13.48 doses/day/zone
	= 107 min/dose/zone
Wasteflow PC Dosing intervals (average flow)	= 1440 min/day ÷ 5.39 doses/day/zone
	= 267 min/dose/zone
Wasteflow Classic Dosing intervals (design flow)	= 1440 min/day ÷ 7.46 doses/day/zone
	= 193 min/dose/zone
Wasteflow Classic Dosing intervals (average flow)	= 1440 min/day ÷ 2.98 doses/day/zone
	= 483 min/dose/zone

The timer would typically be set for average flow conditions and the high-water float would be used to trigger extra doses for higher flows. Programmable control panels allow flexibility to vary the doses based on actual flows.

For large systems with many zones, sufficient time must be available to increase each cycle's dosing time as the system ages in response to clogged emitters (the design dose volume cannot be dripped during the allotted time if a significant number of emitters become clogged). Also, where disk filters are used, adequate time must be available for flushing the filters. With

much lower than design. This will tend to speed up the filling process. However, this will be at least partially offset by the fact that the emitters drip during pressurization.

programmable controllers, routine back-flushing of disk filters is programmed to occur automatically either at the start of a dosing cycle or between dosing cycles (following a predetermined number of doses). A rule-of-thumb is to restrict the cumulative design-dosing period to 1080 of the available 1440 minutes in a day (75% of the available time). If the cumulative dosing time exceeds 1080 minutes, the system is redesigned.

The total time needed for dosing all zones at design flow is as follows:

BioLine	= Minutes/dose (timer setting) x doses/day x zones ÷ zones dosed simultaneously
	= 13 min/dose x 11.52 doses/day x 8 zones ÷ 2 zones
	= 599 minutes/day
Wasteflow PC	= 13 min/dose x 13.48 doses/day x 8 zones ÷ 2 zones
	= 701 minutes/day
Wasteflow Classic	= 12 min/dose x 7.46 doses/day x 12 zones ÷ 2 zones
	= 537 minutes/day

Note that if only single-zone dosing was used, both of the PC designs would have exceeded the upper target limit of 1080 minutes available during the day for dosing a new system.

Another calculation that may be needed is the volume of wastewater that could potentially drain back to a low elevation within the drainfield. Assuming that the supply manifold is designed so that it cannot contribute to drain-back, the maximum amount of wastewater that could be available is the volume contained in the laterals. These volumes are previously calculated for the time to fill the laterals but they were not specifically listed. The volumes are 139, 130, and 88.1 gallons for the BioLine, Wasteflow PC, and Wasteflow Classic laterals, respectively.[94]

The last calculation that may be needed is the volume of wastewater that will be returned to the flush tank and recycled through the treatment system. As noted for the first example, this volume has the potential to upset the treatment process, depending on the type of treatment system used and the amount of equalization that may be available. It is equal to the flushing flow multiplied by the dosing period: 557 gallons for BioLine and 259 to 518 gallons for Wasteflow PC and 289 to 577 gallons for Wasteflow Classic depending on flushing velocity. Complete mix activated sludge processes are typically more likely to be adversely affected than plug flow fixed film processes. There will also be additional water recycled during each filter flush, but this volume is typically small because the time needed for filter flushing is normally less than a minute.

[94] These volumes range from 28% to 16% of the total dose. The drain-back potential for the PC designs can be lowered by using longer dosing times (or a higher number of pipe volumes for dosing, such as 5 or 6). Trade-offs need to be considered based on actual experience and soil characteristics.

5.3.7 Design Based on Water and Nutrient Balances

For this example, the native soil depth is deep (greater than 10 ft) so that the predominant drainage pattern is vertical. The vertical permeability is determined to be 0.40 in/h at a depth of 5 ft. GA EPD allows up to 12% of the mean saturated vertical hydraulic conductivity for the design percolation rate for sites with seasonal high groundwater or impermeable layers greater than 5 ft from the surface. Consequently, the allowable design percolation rate is 0.048 in/h (12% of the saturated vertical hydraulic conductivity) or 1.152 in/day. Wastewater will be applied to the site every day of the month.

Using the procedure outlined for the previous example and the climatic data for the Northwest Georgia Division (see tables 5-10 and 5-11), the allowed monthly hydraulic loading can now be calculated as listed in the following table.

Table 5-30
Allowable Monthly Hydraulic Loading, Lwh, (50,000 gal/d Example)

Month	No. of Application Days	PET in/mo	Perc in/mo	PET + Perc in/mo	Pr in/mo	Lwh in/mo	Lwh in/day	Lwh in/wk
Jan	31	0.24	35.71	35.95	6.91	29.04	0.937	6.557
Feb	28	0.45	32.26	32.71	6.74	25.96	0.927	6.491
Mar	31	1.27	35.71	36.98	8.69	28.29	0.913	6.388
Apr	30	2.25	34.56	36.81	6.45	30.36	1.012	7.083
May	31	3.80	35.71	39.51	5.67	33.84	1.092	7.642
Jun	30	5.26	34.56	39.82	5.78	34.03	1.134	7.941
Jul	31	6.18	35.71	41.90	6.07	35.82	1.156	8.090
Aug	31	5.60	35.71	41.32	5.12	36.19	1.168	8.173
Sep	30	3.93	34.56	38.49	6.09	32.39	1.080	7.558
Oct	31	2.11	35.71	37.82	4.95	32.88	1.060	7.423
Nov	30	0.98	34.56	35.54	6.02	29.53	0.984	6.889
Dec	31	0.39	35.71	36.10	6.30	29.80	0.961	6.729
Total	365	32.46	420.48	452.94	74.80	378.14	12.424	86.965

The critical hydraulic loading rate occurs in March and is 6.388 in/wk.[95] This is the maximum application rate that can be applied to the drip field based on hydraulics. Note that this value is much larger than that based on the soil evaluation (0.3 gal/d/ft^2 which is equivalent to 3.37 in/wk). It is also much larger than the maximum allowed by the GA EPD (2.8 in/wk).

Next, the maximum loading rate based on a nutrient balance is determined. As in the previous example, these calculations are based on limiting the wastewater percolate to a maximum of 10 mg/l as nitrate nitrogen. Two cases will be presented: one for septic tank effluent and one for denitrified effluent. The calculations and assumptions are listed below:

Assumptions for case 1 (septic tank effluent):

Maximum daily design flow:	50,000 gal/d
Average daily design flow:	20,000 gal/d
Wastewater total nitrogen concentrations:	50 mg/l (typical value for residential wastewater)
Nitrogen input from rainfall and fixation:	5 lbs/acre-year (from the GA EPD guidelines)
Ammonia volatilization:	0 lbs/acre-year (subsurface application)
Denitrification rate:	15% (representative value for row and forage crops)

[95] See footnotes for the first example.

Net plant uptake and storage:	200 lbs/acre-year (representative value for grasses such as tall fescue, ryegrass, and Kentucky blue grass)
Precipitation:	74.80 in/year (from table 5-11)
Potential evapotranspiration:	32.46 in/year (from table 5-12)
Nitrogen allowed in percolate:	10 mg/l (as N)
Hydraulic loading based on soil classification:	0.3 gal/d/ft^2 (3.37 in/wk)

Table 5-31
Estimated Total Nitrogen Concentrations (50,000 gal/d example for septic tank effluent)

	Loading: Water Balance Storage	Maximum Loading: Nutrient Balance	Maximum Loading: EPD Weekly Limit	Loading: Soil Classification
Average design wastewater loading (in/wk)	6.388	0.759	2.80	3.37
Wetted area (acres)	2.018	6.792	1.841	1.53
Nitrogen input from wastewater (lbs/acre-year)	3772	448.2	1653	1989
Total nitrogen input (lbs/acre-year)	3777	453.2	1658	1994
Denitrification (lbs/acre-year)	566.5	67.97	248.8	299.1
Nitrogen leached by percolate (lbs/acre-year)	3010	185.2	1210	1495
Wastewater applied (in/year)	332.2	39.47	145.6	175.2
Percolate (in/year)	374.5	81.81	187.9	217.5
Estimated percolate total nitrogen (mg/l)	35.49	10.00	28.42	30.35

Based on a maximum percolate concentration of 10 mg/l, these calculations reveal that nitrogen will be limiting unless the wastewater loading is less than 3/4 in/wk. Therefore, this is the selected loading rate.

To determine the wetted field area (the footprint area), storage requirements must be determined as outlined previously. The total storage requirement is the sum of the following storage volumes:

A(wetted) = A(adf) + A(op) + A(ww/e) + A(wbs)

Where A(wetted) = Required total wetted field area (acres)

A(adf) = Area necessary to treat 7 days' average daily flow (acres)

A(op) = Area necessary to treat the operational storage (acres)

A(ww/e) = Area necessary to treat the wet weather/emergency storage (acres)

A(wbs) = Area necessary to treat the water balance storage (acres)

The areas are calculated as follows:

A(adf) = 20,000 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 0.759 in/wk = 6.792 acres

A(op) = 0 (7 days/wk operations; if operating only 5 days/wk, the area needed for treating 2 days' flow would be calculated)

A(ww/e):

Flow to be stored for subsurface drip systems is based on the two GA EPD criteria:

Criterion 1: 3 days' average design flow (for subsurface drip systems)

Criterion 2: 1 day if 100% backup reliability is provided including standby power

The selected criterion is the first one (3 days) assuming that 100% backup power reliability will not be provided. The GA EPD allows 30 days to deplete this stored flow. A(ww/e) can now be calculated:

A(ww/e) = 3 days x 20,000 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 30 days ÷ 0.759 in/wk

= 0.679 acres

A(wbs):

To calculate this storage, another water balance is needed to determine the cumulative amount of wastewater that needs to be stored based on the monthly allowable hydraulic loads. These calculations are listed below:

The total storage area needed for the average design flow, operational storage, and wet weather/emergency conditions:

= 6.792 acres + 0 acres + 0.679 acres

= 7.472 acres

The corresponding loading rate for this amount of storage:

= 20,000 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 7.472 acres

= 0.690 in/wk

This loading rate is used to calculate the monthly water balance storage:

Table 5-32
Water Balance Storage Requirements

Month	No. of Application Days/Mo	Hydraulic Loading Potential (in)	Hydraulic Loading Allowed (in)	Delta Hydraulic Loading (in)	Water Balance Storage (in)	Cumulative Water Balance Storage (in)
Jan	31	3.06	29.04	-25.98	0	0
Feb	28	2.76	25.96	-23.20	0	0
Mar	31	3.06	28.29	-25.23	0	0
Apr	30	2.96	30.36	-27.40	0	0
May	31	3.06	33.84	-30.79	0	0
Jun	30	2.96	34.03	-31.08	0	0
Jul	31	3.06	35.82	-32.77	0	0
Aug	31	3.06	36.19	-33.14	0	0
Sep	30	2.96	32.39	-29.44	0	0
Oct	31	3.06	32.88	-29.82	0	0
Nov	30	2.96	29.53	-26.57	0	0
Dec	31	3.06	29.80	-26.74	0	0
Total	365	35.98	378.14			

No water balance storage is needed due to the high allowable hydraulic loadings.

A(wbs) = 0 acres

A(wetted) = 6.792 acres + 0 acres + 0.679 acres + 0 acres

= 7.472 acres

= 325,500 ft^2

The hydraulic loading rate (HLR) for the wetted area can now be calculated:

HLR = 20,000 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 7.472 acres

= 0.690 in/wk

= 0.0615 gal/d/ft^2 based on average design flow

= 0.154 gal/d/ft^2 based on maximum design flow

Assumptions for case 2 (denitrified effluent):

Maximum daily design flow:	50,000 gal/d
Average daily design flow:	20,000 gal/d
Wastewater total nitrogen concentrations:	20 mg/l (typical value following nitrification and denitrification treatment processes)
Nitrogen input from rainfall and fixation:	5 lbs/acre-year (from the GA EPD guidelines)
Ammonia volatilization:	0 lbs/acre-year (subsurface application)
Denitrification rate:	15% (representative value for row and forage crops)

Net plant uptake and storage:	200 lbs/acre-year (representative value for grasses such as tall fescue, ryegrass, and Kentucky blue grass)
Precipitation:	74.80 in/year (from table 5-11)
Potential evapotranspiration:	32.46 in/year (from table 5-12)
Nitrogen allowed in percolate:	10 mg/l (as N)
Hydraulic loading based on soil classification:	0.3 gal/d/ft^2 (3.37 in/wk)

Table 5-33
Estimated Total Nitrogen Concentrations (50,000 gal/d example for denitrified effluent)

	Loading: Water Balance Storage	Maximum Loading: Nutrient Balance	Maximum Loading: EPD Weekly Limit	Loading: Soil Classification
Average design wastewater loading (in/wk)	6.388	3.512	2.80	3.37
Wetted area (acres)	2.018	1.468	1.841	1.530
Nitrogen input from wastewater (lbs/acre-year)	1509	829.5	661.3	795.6
Total nitrogen input (lbs/acre-year)	1513	834.5	666.3	800.6
Denitrification (lbs/acre-year)	227.1	125.2	99.95	120.1
Nitrogen leached by percolate (lbs/acre-year)	1087	509.3	366.4	480.5
Wastewater applied (in/year)	332.2	182.6	145.6	175.2
Percolate (in/year)	374.5	225.0	187.9	217.5
Estimated percolate total nitrogen (mg/l)	12.81	10.00	8.61	9.75

Based on a maximum percolate concentration of 10 mg/l, these calculations reveal that nitrogen will not be limiting until the wastewater loading is 3 1/2 in/wk or greater. However, the GA EPD maximum allowable loading criterion is 2.80 in/wk, which will be used for determining the wetted field area.

To determine the wetted field area (the footprint area), storage requirements must be determined as outlined previously. The total storage requirement is the sum of the following storage volumes:

$$A(wetted) = A(adf) + A(op) + A(ww/e) + A(wbs)$$

Where A(wetted) = Required total wetted field area (acres)

A(adf) = Area necessary to treat 7 days' average daily flow (acres)

A(op) = Area necessary to treat the operational storage (acres)

A(ww/e) = Area necessary to treat the wet weather/emergency storage (acres)

A(wbs) = Area necessary to treat the water balance storage (acres)

The areas are calculated as follows:

A(adf) = 20,000 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 2.80 in/wk

= 1.841 acres

A(op) = 0 (7 days/wk operations; if operating only 5 days/wk, the area needed for treating 2 days' flow would be calculated)

A(ww/e):

Flow to be stored for a subsurface drip system is based on two criteria:

Criterion 1: 3 days' average design flow (for subsurface drip systems)

Criterion 2: 1 day if 100% backup reliability is provided including standby power

The selected criterion is the first criterion (3 days) assuming that 100% backup power reliability will not be provided. The GA EPD allows 30 days to deplete this stored flow. A(ww/e) can now be calculated:

A(ww/e) = 3 days x 20,000 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 30 days ÷ 2.80 in/wk

= 0.184 acres

A(wbs):

The total storage area needed for the average design flow, operational storage, and wet weather/emergency conditions:

= 1.841 acres + 0 acres + 0.184 acres

= 2.025 acres

The corresponding loading rate for this amount of storage:

= 20,000 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 2.025 acres

= 2.546 in/wk

This loading rate is used to calculate the monthly water balance storage:

Table 5-34
Water Balance Storage Requirements

Month	Number of Application Days/Month	Hydraulic Loading Potential (in)	Hydraulic Loading Allowed (in)	Delta Hydraulic Loading (in)	Water Balance Storage (in)	Cumulative Water Balance Storage (in)
Jan	31	11.27	29.04	-17.77	0	0
Feb	28	10.18	25.96	-15.78	0	0
Mar	31	11.27	28.29	-17.02	0	0
Apr	30	10.91	30.36	-19.45	0	0
May	31	11.27	33.84	-22.57	0	0
Jun	30	10.91	34.03	-23.13	0	0
Jul	31	11.27	35.82	-24.55	0	0
Aug	31	11.27	36.19	-24.92	0	0
Sep	30	10.91	32.39	-21.48	0	0
Oct	31	11.27	32.88	-21.60	0	0
Nov	30	10.91	29.53	-18.62	0	0
Dec	31	11.27	29.80	-18.53	0	0
Total	365	132.73	378.14			

No water balance storage is needed due to the high allowable hydraulic loadings.

A(wbs) = 0 acres

A(wetted) = 1.841 acres + 0 acres + 0.184 acres + 0 acres
= 2.025 acres
= 88,200 ft^2

The hydraulic loading rate (HLR) for the wetted area can now be calculated:

HLR = 20,000 gal/d x 7 days/wk x 12 in/ft ÷ 7.481 gal/ft^3 ÷ 43,560 ft^2/acre ÷ 2.025 acres
= 2.546 in/wk
= 0.227 gal/d/ft^2 based on average design flow
= 0.567 gal/d/ft^2 based on maximum design flow

Based on nitrogen limitations and using typical grasses for the vegetative crop, the area needed to apply septic tank effluent will be almost four times as large as that needed to apply denitrified effluent. Comparing the corresponding loading rates to that used in the conventional approach (based on soil texture and structure) reveals that a smaller wetted (footprint) area will be needed for a denitrified effluent (88,200 ft^2 versus 166,700 ft^2), while a larger area would be needed for septic tank effluent (325,500 ft^2 versus 166,700 ft^2).

As with the first example, the process for the detailed system layout and design would be identical to that described previously (but using the appropriate hydraulic loading rate calculated for the water and nutrient balances and the corresponding design flow).

If no specific design approach is required by the applicable regulatory authority, the designer must now decide between the various design options including types and brands of components. There is generally no one clear choice. Many options can result in many acceptable designs. The key factors that need to be considered have been summarized in sections 3.2.4, 3.4, and 4.

5.4 Spreadsheet Design Process

The design process outlined in the two examples is adaptable to spreadsheets. This type of application speeds the design process and reduces the potential for calculation errors. It also allows the designer to review the effect of key variables on system configuration and design quickly. However, to increase flexibility and automation, programming needs to be able to reference vendor specific details. These details may change with time as components are upgraded or replaced. TVA has developed Microsoft Excel spreadsheets based on commonly used equipment and components that should be useful for design of drip systems. The above examples were designed through the use of these spreadsheets. The Excel files on the attached computer disc are included as part of these design guidelines. The files will need to be modified to add vendor details for specific components or equipment not included; however, the design process and procedures should be generically applicable. The spreadsheets include water and nutrient balances based on GA EPD guidelines.

These files are not copyrighted or protected, so users may modify, improve, or use as needed to aid the design process for drip systems. All equations and specific values can be accessed and modified as needed. There may also still be errors, particularly for unusual combinations or design needs.

Each dripline manufacturer and some of their dealers or distributors also have design aids. Generally, these aids are not as detailed or as comprehensive as the programs contained on the attached computer disc. Contact them directly to determine what is available.

5.5 Other System Components

Selection, design, and specifications for other system components such as A/V relief valves, control valves, check valves, flow meters, control panels and instrumentation, flexible tubing, pressure regulators, access structures, etc., are addressed in chapter 3. Review this information for guidance on these components. Calculations are generally not needed for their selection, but each one needs to be sized and matched to components sized within this chapter.

5.6 Additional Design Considerations

Several key design aspects were listed in section 3.4. Some additional items that need to be considered are included below.

5.6.1 Design for Irregular Zones

If the site required irregular shaped or different size zones to fit available space properly or to accommodate different application rates based on different soil types, pumping requirements would be based on the combination of conditions that resulted in the largest dosing and flushing flows and corresponding TDH. Also, the combination of conditions that results in the largest TDH would need to be checked to see if it controlled the design. The process is similar to that outlined previously; however, several additional sets of calculations may be needed. Typically, the largest zone and the longest lateral within a zone would control. For a site using PC drip tubing, dosing will be uniform over all zones regardless of size or lateral length so long as the time per dose is equal. However, flow rates and pumping requirements for dosing and lateral flushing will vary based on the number of emitters and laterals in each zone with the largest numbers controlling the design. In triangular areas, create loops as necessary at the end of tubing runs to create laterals of roughly the same length within each zone. This will simplify and improve field flushing of the zone.[96] If different application rates are used for different soil types, the controller may need to be able to accommodate different dosing times associated with zones with different application rates. For non-PC tubing, calculations would need to be modified to include varying flow rates based on different pressures associated with various lateral lengths and number of laterals within each zone. A spreadsheet would aid the design process for any system with irregular zones. Consult the drip tubing manufacturers and their authorized representatives for additional guidance.

5.6.2 Design to Minimize Drain-Back Potential

Drip tubing drains after dosing and leaks during pressurization. The elevation head of water in the drip tubing results in higher drainage rates for runs and laterals at lower elevations. Also, water always follows the path of least resistance. The first path of least resistance will typically be the inside of the tubing and pipes. Another path is likely to be along the outside wall of the tubing and pipes. Any slope or grade for the tubing and pipe will carry water in the downgradient direction. If the soil is saturated and hydrostatic pressure is sustained after the dose, some of the wastewater distributed to the soil may also move back along these paths. This gravitational movement of water to low spots in each zone has the potential to saturate soils and cause breakout on the surface. The best way to minimize this potential problem is to minimize hydraulic pathways and the volume of water that is available along these pathways. This should be done as part of the design process, followed by good construction practices that meet design specifications. The most effective methods are:

- Keep the tubing and piping within each zone as level as possible.
- Keep as many of the runs and laterals on the same elevation as possible.
- Hydraulically isolate each drip lateral during draindown by using a “top loading” manifold design such as that described in section 3.3.5.

[96] Shorter lateral lengths within a zone will have larger flows and velocities at the end of the laterals during flushing than longer laterals because of smaller friction losses and numbers of emitters.

Less desirable methods include:

- If “bottom loading” manifold designs are used (see figures 3-5 and 3-10), if possible keep the highest elevation of the supply pipe and manifold below the elevation of the lowest drip lateral. The volume of water in the laterals will still be available to move by static pressure through the manifold to lower elevations, but the volume of water contained in the supply pipe and manifold cannot contribute to the total drain-back volume.
- Use seepage collars to block water migration around the outside periphery of the tubing and pipes.
- Reduce the number of doses per day per zone by increasing the time period of each dose (which increases risk of structural soil damage in tight soils unless drip tubing with emitters spaced 12 or 18 in are used, rather than the conventional 24-in emitter spacing).
- Reduce the size of each zone by increasing the number of zones or subzones. Each zone or subzone is served by a solenoid valve, providing the option to dose multiple areas simultaneously. Check valves may also be used instead of solenoid valves on branching supply pipes to submanifolds; however, check valves are only effective for controlling drain-back in locations where the drainage flow causes the valve to shut. If drainage is in the normal “dosing” direction, the valve will remain open. The check valves must also be capable of shutting for reverse flows with low flow rates and elevation heads.
- On a sloped site, reduce the number of laterals per zone by increasing the length of the laterals (which reduces the hydrostatic head on the lower laterals and increases the potential for each lateral to drain most of its static volume through its emitters). Increased spacing between zones on sloped sites may also help isolate or minimize drain-back effects between zones.
- Soil dams or humps at the end of each drip run.
- Check valves on the supply and return manifolds (see precautions in one of the preceding methods). Each check valve should be preceded by an A/V relief valve to ensure that airflow is not blocked as the laterals drain.

5.6.3 Cold Weather Design

There are two basic design approaches for providing freeze protection. The first approach uses the same basic design process outlined within this document. Any pipe that does not drain quickly after a dose is placed below frost depth or heavily insulated. The filter system is typically vulnerable to freezing if the power supply is lost for an extended period of time. The alternate approach is based on completely draining the system back to the wet well [38]. This approach is more practical for a system with only a few zones, since each zone is typically designed as an independent “system” with individual pumps, filters, and valves.[97] Filters are located in the pump

[97] Independent zones are considered a design preference by some advocates of this concept rather than an absolute requirement. The design could be modified to use a duplex pumping arrangement and a single filter system for multiple zones that drain after each dose. Others that have used draining system designs have found that bioslimes are more prevalent.

tank, typically within reach through access risers. A continuous flush is used to keep water moving throughout the system during a dose. After a dose, a motorized drain valve is used to drain the system within three minutes. A/V relief valves are heavily insulated and well-drained using gravel to below frost depth. Styrofoam insulation board is also used to protect supply and return headers that may be above frost depth.

Although drip tubing is typically buried at larger depths in cold climates (up to 24 in deep), the frost depth may be much greater, particularly during winters without significant snow coverage. Drip systems are capable of dosing wastewater to frozen soils without the system malfunctioning [27]. Drip tubing depths were less than 12 in for most systems included in this study.

Turf establishment should be a priority for cold weather design. Turf insulates and traps snow, which provides excellent insulation when present. During the first winter after construction, mulch (chopped straw, hay, etc.) should be spread over any system without an established turf.

Metal pins should be placed adjacent to or inside plastic valve boxes and other nonferrous access structures to help locate them when buried under snow.

5.6.4 Design for Maintainability

Drip systems require routine maintenance that includes periodic replacement of parts or components. This should be adequately recognized during the design process by incorporating features that make it easier to service and replace parts. Good access is needed to any component that may need to be periodically checked or replaced. Adequate disconnects are also needed for these components so that they can be readily removed and replaced. If there is a need for any electrical splices in the field, always provide a splice box. Housing to allow a maintenance person to work out of elements is important. For residential systems, mechanical components might be located in a garage or shed.

5.6.5 Electrical Grounding and Surge Protection

Electrical surges due to variations in power supply or thunderstorms can be particularly troublesome to electrical components of a drip system. The system and individual equipment must be adequately grounded and lightning arresters and surge protectors added to minimize electrical problems. The system should be routinely checked following any thunderstorm in the area. This can be easily done if the system employs telemetry.

6
CHAPTER 6—SYSTEM INSTALLATION

As listed in section 3.5, there are several important aspects to installing a system that are critical to its long-term success. Most of these items are covered in more detail below. Design specifications and details prepared by the system designer are assumed to address adequately special needs related to the specific applications (including freeze protection issues).

The initial step to installation of a drip system is site preparation. The area set aside for the system should be clearly marked and protected from other types of construction activities. In general, the area should not be disturbed prior to installation of the drip system. Using the area for other construction activities such as ingress or egress or storage of materials can compact the soils and invalidate the site for use of the drip system.

As applicable, the site should be mowed and cleared of brush and small trees that will not be part of the final landscaping plan. With areas containing only brush and small trees, clearing should be accomplished with minimal digging or grubbing to preclude significant changes to the soil structure and permeability. Large trees, boulders, or other obstacles should be bypassed and left as part of the landscape. In general, large trees should not be significantly impacted if the drip tubing is laid outside the dripline of the tree (the perimeter of the tree's branches). Details for bypassing these types of obstacles are typically determined in the field based on general specifications contained in the design drawings and specifications. Options include multiple short looped runs with the loops placed near the obstacle or blank tubing (no emitters) for long runs with the blank tubing portion of several runs laid close together or in the same trench around the perimeter of the obstacle. Remember that it is preferable to keep all laterals in a zone as close as possible in length to aid field flushing. Minor sags or humps with elevation differences of about 1/2 ft or less along the contour may be filled or leveled prior to installing the tubing. No construction should occur when the soils are wet enough to smear or compact easily.

If medium and large trees need to be removed, some designers prefer removing stumps and roots to a depth of about 18 in. Although this results in significant changes to soil structure and permeability, these designers believe that it is considered to be a better option than leaving the stumps and roots in place because the drip system will accelerate decay of any woody material left in place, potentially causing excessive organic loading to the soils (anaerobic conditions) and hydraulic short-circuiting along the decayed root system. Stump holes will need to be filled with topsoil (obtained outside the drip footprint area) and the site lightly compacted and smoothed after clearing and grubbing. Other designers believe that 18 in is too deep for removing all of the stumps and roots due to the damage to the soil structure.

Drip tubing for a subsurface system is typically installed using either vibratory or chisel plows with tubing reels mounted above the plows. For large systems, the number of parallel plow heads may be numerous. Pulling equipment must be matched to the number of plow heads and soil conditions.[98] For dry soils or sites with tree roots, preliminary passes without the tubing may be needed to obtain the correct installation depth. The tubing is then installed in the next pass over the preconditioned line routes. Geoflow recommends that dry soils be wetted one day prior to installation. Small systems may be installed using trenching methods (mechanical or manual). Trenching is also preferred for sites with gravelly soils containing chert or other sharp-edged gravels because there is less potential for the gravel to cut the tubing during installation and during routine dosing as it expands and contracts. Some designers highly recommend manual (hand) installation on steep slopes and wooded sites for erosion prevention, site protection, and safety.

Tubing should always be laid on contour in order to minimize potential drain-back problems, to allow A/V breakers to function properly, and to obtain uniform dosing for non-PC tubing. This typically requires marking the route for each run (or set of runs if multiple plow heads are used) using laser leveling equipment. There are no tolerance specifications for how level each run should be, but the objective should be to follow the same elevation for each run to the extent practicable using the typical state-of-the-art leveling and installation equipment.[99] For many sites, this means that the design tubing spacing between runs is a minimum rather than a typical value. As mentioned above, minor sags or humps may be graded to follow the contour prior to tubing installation. If large sags or humps occur in the terrain (defined as features with elevation differences along the tubing run approaching or exceeding the burial depth of the tubing), blank tubing should be used to cross the area to keep the tubing with emitters on the correct elevation, burial depth, and spacing. Tubing should never be placed in any area that ponds from rainfall. These site-specific features should always be considered in the system design and layout to ensure that the site has adequate space for installing each lateral and zone (the actual footprint area may need to be considerably larger than the calculated value because of these site features).

Both ends of each run should be marked to ensure that the correct length is obtained during installation. Allowances need to be added for any blank tubing used in the runs to obtain the design length of tubing containing emitters. The plow or trencher should always be kept to design depth until passing the marked end of each run. Tubing should always be extended beyond the end of each run with at least 1 ft sticking out of the ground at each end before cutting from the tubing coil or reel. Tape the ends of each run to prevent soil and debris from entering the tubing until final connections are made. It is also important to keep perforated drip tubing away from the supply and return manifolds, since effluent dripped from the emitters either could surface in these disturbed areas or flow preferentially along the manifold lines causing surfacing.

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[98] Experienced installers can install from 8,000 to 10,000 ft of tubing per day with a single shank vibratory plow on a “good” site. Up to 25,000 ft per hour can be installed with a four-shank plow.

[99] The target used by the North Carolina Department of Environment and Natural Resources is ± 2 in.

Kinks in the tubing as well as excessive stretching must be totally avoided as the tubing is inserted below the surface. Splices using standard barbed connectors can be confidently used as needed. Orientation of the emitters (up, down, sideways) cannot be controlled using plowing techniques and has not been a concern.

After the tubing is inserted below the ground surface, the exact location of the supply and return manifold trenches can be identified and cut. Install supply and return manifolds at design depth and run flexible PVC hose or any other type of flexible tubing that meets design specifications from manifold tees to each end of each drip lateral (cutting excess drip tubing to correct length). All pipes and tubing should be bedded according to design specifications, carefully avoiding actual or potential kinks, as trenches are backfilled. If laterals contain end loops, cut a trench for loops to the same depth as drip runs (or slightly higher to ensure drainage), cut excess lengths of drip tubing, and install flexible hose or tubing to connect each end of each run, again being careful to properly bed the tubing and avoid kinks.

If the design places the A/V relief valve at the high point within each zone rather than at the end of the manifolds, the blank tubing or piping used to connect each run to the valve must be carefully trenched and installed without damaging the drip tubing. Mechanical trenching can be used until approaching the tubing depth, followed by hand trenching to locate and uncover the tubing for each run and to complete the trench bottom to grade to allow air to move freely between each run and the valve (no sags or humps that would prevent complete drainage of water and block the free flow of air).

It is always good practice to tape or cap loose ends of all pipes that are not being actively worked on to minimize the amount of dirt, construction debris, insects, etc., that could get inside the piping before construction is completed.

Before backfilling around the manifolds for each zone, count the actual number of drip tubing connections to ensure that the correct number has been installed. There have been cases where one or more runs were missed and not discovered until start-up of the system.

After the drip zones are completed, cuts for the drip runs should be lightly compacted to minimize short-circuiting directly to the soil surface during the start-up phase. Also, if plows are used for the tubing installation, some hand dressing may be needed to replace voids left by “clods” that are cast to the side of the cut. If trenches are cut, water should be used to settle the backfill, followed by additional fill to level or slightly mound the cover relative to adjacent undisturbed soil. This will minimize settling of fill material with time and ponding over the tubing due to runoff.

It is also important to be aware of manufacturer’s recommendations and warranty conditions. For example, Geoflow’s tubing warranty requires that the dripline be stored out of direct sunlight in a cool place. This is because the herbicide used in the tubing is temperature sensitive.

The construction phase should include testing with clean water to ensure that all components are set properly and hydraulically functioning according to design specifications. The first step is flushing the system to remove construction debris. The A/V relief valves should be removed prior to flushing to prevent clogging or damage to the valves. In addition, the supply pipe and drip laterals should be initially flushed after connecting the laterals to the supply manifold but before connecting them to the flush manifold. This minimizes potential emitter clogging, since the laterals cannot be pressurized during this initial flushing procedure. After flushing the entire system, the A/V relief valves should be reinstalled and the system should be run through enough dosing cycles with sufficient permanent or temporary instrumentation (pressure gauges and flow meter) to adjust settings, verify that design specifications are being attained, and verify that all valves and components are functioning properly. Care is needed to ensure that the dose cycle and frequency do not exceed design specifications due to the danger of oversaturation of the soil and creating short-circuiting or piping channels directly to the soil surface. If design pressures and flows cannot be obtained for line dosing and flushing and filter flushing, troubleshooting is needed to discover the source of the problem and to fix it. All of this information needs to be adequately documented and certified by the design engineer and installer prior to initiating actual operation of the system with wastewater.

Although it should be obvious, people with responsibility for the proper installation of the system should make physical checks of the components being installed to ensure that they meet design specifications. There have been reports where installers used leftover material from previous jobs or other locally available materials that did not meet project specifications. This must not be allowed to occur.

It is important to be able to locate any pipe or component of the system after installation. Design specifications should always include access/location structures such as valve boxes for all valves (zone, check, A/V, and flush), pressure regulators, etc. Tracer wire or tape should also be used for pipes and manifolds. Before covering these components, a check should be made that these structures and wire or tape are used to allow components to be easily located.

7

CHAPTER 7—OPERATIONS AND MAINTENANCE (O&M)

Routine O&M of a drip system is critical for successful long-term performance. The mechanical and electrical components will need to be regularly serviced and periodically repaired or replaced. Some of the nonmechanical or nonelectrical components will also need regular inspections and servicing (such as flushing of pipes and filters). A proactive rather than a reactive maintenance program should allow potential problems to be detected and addressed early enough to minimize the need for major repairs or system failure (assuming the system was properly designed for the site and wastewater characteristics and installed according to design specifications). The major elements of a proactive O&M program are provided in sections 3.6, 3.7, and below. These services should be provided by a qualified and certified professional. Only the most commonly used components are covered in this discussion. Through a continuous O&M program, these systems can be considered permanent components of the infrastructure in a community.

7.1 Routine Operations

7.1.1 Pretreatment Systems

It is essential that the pretreatment facilities function according to design. Septic tanks need to be periodically pumped to keep quantities of scum and sludge within acceptable limits. Typically, this means that the top of the sludge layer should be at least 1 ft below the bottom of either the inlet or outlet tees, and the bottom of the scum layer should not be less than 3 in above the bottom of the outlet tee or baffle [15]. All septic tanks should include effluent filters to protect downgradient components from excessive suspended solids that may occur due to hydraulic surges (including return flow from zone flushing), toxic materials (cleansers, paints, pharmaceuticals, etc.), garbage disposals, water treatment regenerates, etc. Assuming filters were sized properly, they will need to be cleaned at least every three to five years (typically in conjunction with pumping the tank) or as needed due to septic tank upsets (malfunctioning of the septic tank due to overloading or toxics). It would also help to provide educational material to the people that produce the wastewater being treated to make them aware of their responsibilities for maintaining a “healthy” system. This should be done during system start-up and during each service call.

Aerobic, secondary, or advanced treatment systems must be operated and serviced on the frequency recommended by the manufacturer, as required by the regulatory agency, or in accordance with good management practices for nonproprietary systems (intermittent or RSFs, lagoons, wetlands, etc.). The effluent quality and flow should always be within the anticipated range for the treatment system. If not, the drip component will be at high risk.

7.1.2 Drip System Filters

The filter system should preferably be designed for automatic flushing or back-flushing. Disk filters are typically back-flushed based on a preset pressure differential (typically 5 psi) if pressure sensors are incorporated into the design and/or at a preset pumping time or number of dosing cycles based on anticipated pretreatment effluent quality. The time needed for back-flushing a disk filter is fast (typically about 15 to 30 seconds). The frequency of back-flushing is typically much less for higher quality effluents (e.g., once every one to three months) than for septic tank effluent (e.g., once every 20 cycles); however, the frequency may need to be periodically adjusted based on actual operating experience.[100] If pressure sensors are not available, pressure reading should be taken manually at least once per week to verify that the frequency is adequate or to provide data needed to revise the frequency based on actual operating conditions.[101] Spin filters are typically flushed each dosing cycle through the flush valve at the bottom of the filter on a continuous basis (for the dose period where the valve is either fully or partially open depending on its size) or a partial basis (typically for a preset time period at the start of a dose cycle using a solenoid valve). Pressure readings should be taken manually each week with spin filters to determine the effectiveness of the flushing. It is also good practice for any type of filter to periodically measure the pressure differential immediately following filter flushing to ensure that the flushing cycle was effective.

For small systems where filters are not automatically flushed, for the secondary “command” disk filters used to protect the hydraulic control system for remote control valves and for automatic filters where the frequency of flushing begins to be more frequent than normal, the filters must be periodically disassembled and manually cleaned following the manufacturer’s instructions. At a minimum, the filters are sprayed with water. Mineral scale or other hard to remove materials may require soaking the filter in a dilute acid or strong chlorine solution. The frequency of cleaning again depends on the quality and quantity of water that is filtered. Pressure readings can be taken before and after the filter to determine the pressure differential, and experience with the actual filter performance will determine how frequently the filter needs to be disassembled and cleaned. To ensure that the drip system remains operational, it is always good to have a spare filter cartridge available to replace the dirty cartridge while it is being manually cleaned. The original cleaned cartridge is typically used to replace the spare cartridge during the next manual cleaning operation.

[100] For automated systems (which are highly recommended), the back-flushing frequency should typically be very liberal (before it is needed), since there is no major disadvantage to the cleaning cycle.

[101] The design should always include either Schrader valves or pressure gauges before and after the filter system to allow pressure readings as needed. Schrader valves are considered a better option, since the same gauge may be used for determining the pressure differential across the filters. If the valves are not included as part of the design, the operator should drill, tap, and insert the valves to allow efficient O&M of the system.

7.1.3 Zone Dosing

To minimize drain-back potential and soil saturation, dosing of zones should be sequential beginning with the lowest elevation zone and ending with the highest elevation zone. This allows each zone to drain between doses with less potential for hydraulic interference or complications from upgradient zones (due to subsurface water movement).

7.1.4 Zone Flushing

Zone flushing should also be automated. Flushing is initiated during a dose cycle by opening the flush valve placed on the return line, typically near the tank where the flush water is routed to settle the solids and recycle the water. As with filters, the frequency depends on the number of doses and the characteristics of the wastewater; however, there may not be as clear a distinction between the frequency of flushing between septic and aerobic wastewaters. Some aerobic effluents have been reported to cause a more troublesome slime growth within the piping system than septic effluents. Even chlorinated effluents will typically have slimes that may need to be periodically removed. The flushing frequency may be based on the number of doses (ranging from 50 to 200 doses), time (ranging from once every two weeks to once per six months), or both and may be adjusted based on actual operating experience.[102] Flushing occurs simultaneously with a dose whenever the flush valve is opened. Consequently, the volume of flush water returned to the flush tank is equal to the time required for each dose multiplied by the incremental flow rate needed to flush the drip laterals at the design flushing velocity (unless limited to time to deliver one- to two-pipe volumes). It is typically not advisable to increase the flushing period or volume of flush water, since there would be a corresponding increase in the dosing volume to the drip zone (which in tight soils might increase the saturation zone and damage the soil structure). Depending on the volume of water contained in the supply and return pipes, the return flow may still be turbid at the end of the flush cycle. This is typically not an issue, since the remaining solids would be flushed out of the return pipe during the next flushing cycle (assuming the return pipe is properly sized to maintain at least 2 ft/s velocity during flushing). There could be an issue with inadequate flushing if the volume of the supply piping system was so large that the supply pipe is not adequately flushed during the flushing cycle. This would result in moving solids in the supply pipe to the drip laterals but not through them before the dose ended, potentially clogging emitters during subsequent dosing cycles. This should be avoided during the design of the system by comparing the volume of water contained in the supply pipe and manifold to the volume of water available during the flush cycle. The problem can also be avoided by designing the system for dosing two zones simultaneously so that dosing flows are similar to flushing flows, thereby assuring that flushing velocities in the supply pipe are available during every dose cycle. If there are multiple zones fed from a common supply pipe, the zone with the shortest supply pipe length should be flushed first and the furthest zone

[102] The Center for Irrigation Technology recommends at least monthly flushing of driplines for agricultural applications using **potable water** [50]. This emphasizes the need to flush frequently, especially with an automated system.

with the longest supply pipe should be flushed last. This should maintain a cleaner supply pipe with time.

7.1.5 Zone Isolation and Pressurization Valves

Each zone must be capable of being isolated and dosed independently of other zones. This is accomplished through the use of valves at the entrance and exit to each zone and by the flush valve on the return line. Typically, the valve on the supply line to each zone is a solenoid valve, and the valve on the return line for each zone is a check valve. The valve at the entrance to each zone is opened whenever the zone is to be dosed. Check valves on the return lines prevent water from entering the back side of a zone when another zone is being dosed.[103] The flush valve located on the return line typically always remains shut except during a flushing cycle. This allows each zone to pressurize properly when it is dosed. This valve is also typically a solenoid valve but may be a manual ball or gate valve on small systems.

Failure of any of these valves will lead to failure of one or more zones. Problems typically involve diaphragm or solenoid failure or poor sealing at the valve seat due to wear and tear or solids (e.g., microbial growth, sand and silt ingested through the emitters due to inadequate or faulty A/V relief valves, debris from construction or repairs, chemical scale, etc.). To detect potential problems early, dosing volumes and flow rates for each zone need to be routinely monitored, recorded, and compared to design values. Also, check pressure head losses across the network during flushing as a diagnostic tool. Any abnormal value should be investigated and resolved. Flows should typically be within 5% of design values after full pressurization of the system. Any variation from 5% should be investigated. As a rule-of-thumb, there will typically be a problem that needs to be fixed if the dose volume and flow rate for a zone are greater or less than 15-20% of design values. Problem valves need to be located and fixed or replaced. Additional information on locating or identifying which valve is causing the problem is provided in the troubleshooting section. Solenoid valves should typically be disassembled, cleaned, and inspected annually (most diaphragms have a warranty period of two years). Manual shutoff valves before and after the solenoid valves are also desirable to facilitate servicing of the valves and isolation of problematic zones. Solenoid function can be tested by "deadheading" dosing pumps when all valves are supposed to be shut off.

7.1.6 Zone Air/Vacuum Relief Valves

Air/vacuum (A/V) relief valves will also need to be serviced or replaced periodically. Typical problems include failure to completely seal (preventing the zone from pressurizing properly) or stick closed (preventing air from entering the pipe and tubing and creating a vacuum as the zone drains following a dose, sucking soil and water back through some of the emitters). The valves should be inspected monthly (increase to weekly or twice per month during winter in cold climates), removed and cleaned semiannually or annually, and periodically replaced (e.g., on about a three- to five-year cycle as recommended by WWSI or following failure of one or more

[103] A shutoff valve may also be used next to each check valve to help diagnose or locate a problem check valve and to enable the zone with a bad check valve to be isolated from other zones until the check valve is repaired.

of the valves, which increases the risk of clogging emitters). Internal seals and gaskets are typically only warranted for one year.

7.1.7 System Monitoring and Records

Each system component should be routinely inspected and observations and pertinent data recorded. Basic items that need to be checked have been previously identified for each major component. In particular, any manual operations that are needed should be documented with appropriate explanations. Critical control data need to be compared to design values and allowable tolerances or action levels. This may be automated with some of the control systems used for larger systems, but if so, the operator needs to check the data to be aware of important trends that may be occurring and to ensure that the data are compatible with what is actually occurring or observed within the system.

Maintenance forms and schedules should be provided by the system designer and equipment suppliers. The actions listed on these documents should be consistently performed and recorded.

As mentioned in section 5.6.5, thunderstorms are particularly troublesome to electrical components of a drip system. The system should be routinely checked following any thunderstorm in the area.

7.1.8 Additional Precautions

Additional precautions that may be needed to protect the drip system and increase its longevity include:

- Do not allow digging or driving stakes into the ground within any of the zones except for maintenance purposes.
- Do not allow any heavy (rubber-wheeled) vehicles or equipment within the drip zones. Compaction of the soil over the drip laterals may result in wastewater ponding at the surface. Also, machinery can damage valve boxes or other access structures that are not rated for heavy loads.

7.2 Basic Troubleshooting

Some precautions are needed when troubleshooting or any time the automatic control system for the drip system is bypassed. These include:

- Plan activities to the extent practicable to minimize impact to routine operations and ensure that adequate emergency storage is available if the system has to be "shut down." If necessary, arrange for "pump and haul" to dispose of excess wastewater.
- For manual operation or dosing, ensure that dosing times do not exceed design values; otherwise, the soil structure may be damaged.

- Check with the manufacturer or authorized representative if there is any question or concern that troubleshooting activities may damage system components.
- Be aware of basic safety and health issues and use appropriate safeguards and techniques. These include potential hazards from electricity, confined spaces, chemicals, and pathogens.

7.2.1 Filter System

Situation: The filters need flushing (based on observed pressure differential or manual check) or are flushing (automatically) more often than normal.

Potential Causes and Corrective Actions:

- If flushing restores the hydraulic performance of the filters to design specifications, the likely cause is poor effluent quality from the pretreatment system. Check the effluent for higher than normal total suspended solids, BOD, or oil and grease concentrations. Also, check for sludge accumulations in the bottom of the dosing tank. If the control system has data monitoring and storage capabilities, check the data to determine if unusual high flows may have occurred. Take corrective action based on the findings.
- If flushing does not restore the hydraulic performance of the filters to design specifications, the flushing is not effective. Potential causes and fixes include:
  - Organics and/or mineral scale may be clogging the screen (spin filters) or causing the disks to stick together (disk filters). Disassemble the filters and clean in chlorine or acid solution.
  - For disk filters, a leaky solenoid valve may be preventing backwash pressure from reaching design specifications. Check pressures before and after the filters during flushing and check (disassemble) and repair valves as needed.
  - For disk filters, a dirty "command" filter (the 3/4-in filter for hydraulic control lines to various solenoid valves for filters and drip zones) may preclude proper operation of solenoid valves. This filter is manually cleaned. Check the filter (disassemble) and clean as needed.
  - Pumps may not be providing design flow due to wear and tear or partially clogged inlets. Check flow rates and pressures for dosing and flushing the drip system and see if they are within specifications. If these flow rates check out satisfactorily and the flow rate for filter flushing is greater than drip system flow rates, install a temporary flow meter within the filter piping system and check flow rates during flushing. If filter design flushing flows are not achieved, check pipe inlets for potential clogging material and clean or repair or replace pumps as needed.

7.2.2 Zone Dosing

Situation: Average daily water levels in the dose tank are consistently rising and the high-water float triggers extra doses on a daily basis (i.e., there are more doses per day than expected for the daily flow).

Potential Causes and Corrective Actions:

- Increased flow to the dosing tank
    - There may be more people using the system, resulting in higher average and peak daily flows. Implement a study to quantify the number of users contributing wastewater to the system. Compare results to design average and peak population estimates and flows. Assuming results are still within design limits, modify control settings to accommodate the different flows. If results exceed design limits, the system needs to be upgraded and expanded. If the system is for a small number of users, check to see if new residents have moved in or if existing users have increased water usage for any reason.
    - If the number of users has not significantly changed, check the collection system for infiltration/inflow and for unplanned sources of water or wastewater. Leaky fixtures, broken collection pipes, or "illegal" connections or discharges may be present. If the system is a community system or a large commercial/industrial site, it may be necessary to conduct a comprehensive infrastructure analysis and evaluation [51].
    - If the system is designed to drain between doses, check to see if the volume of water returned to the settling or dosing tank from the drip system exceeds the design volume that should be returned based on pipe and tubing sizes and quantities. Larger than normal quantities of water indicate that the soil around the drip laterals may be saturated and water dripped during the dose is being sucked back into the emitters as the system drains. This would require that the affected zone be removed from service at least temporarily and the cause of soil saturation be determined and corrected.
- Reduced flow rates to one or more drip zones. If flow records indicate that one or more zones are not capable of receiving the design volume of wastewater during each dose period, there will be a problem within the affected zones. It will be necessary to check for the following conditions:
    - Clogged or partially clogged emitters and tubing: If the check of flow rates, dosing times, and pressures for the affected zones reveal that the zone is not disposing of the proper quantity of wastewater during each dose, the likely cause is clogged emitters. Increased pressures and reduced flow rates may also indicate that tubing is fouling, and it may not be possible to maintain design flushing velocities. Chemical cleaning should be used to clean the zone and restore emitter and tubing flow rates to the extent practicable. Contact the dripline manufacturer or authorized representative for specific guidance on cleaning the drip tubing and ensuring that any chemicals used are compatible with tubing materials. Typically, a strong chlorine or weak acid solution is injected into the zone during a dosing cycle. It is difficult to restore an emitter that is totally clogged, since the chemical cannot flow through the emitter; consequently, flushing and chemical treatment are most effective as preventive procedures to clean the emitters and tubing before they become severely clogged. If chemical treatment does not restore hydraulic performance to a satisfactory level, replacement of the drip tubing will be needed. Consideration must also be given to the potential effect of the chemicals on the soils, particularly clays that are subject to chemically induced structural changes.
- Clogged filters: Check each filter in the system and clean as needed. Some of the disk filter systems use a large "check" filter following the regular filters. The check filter uses a coarser

mesh size and should not need to be cleaned more than once per year; however, when it is cleaned, it must be done manually. Operators need to know if this type of filter is present in their system and if it is, to periodically check and clean it. In addition, as mentioned above, a dirty "command" filter may not allow solenoid zone valves to function properly. This is also a manually cleaned filter that must be serviced periodically for the system to function properly.

7.2.3 Wet Spots Within the Drip Zones

If the wet area is relatively small and localized near a specific system component, the problem is likely caused by a leak or break (from a broken or cut pipe or tubing or a loose connection), drain-back to a low area of the zone, faulty emitter(s), piping or channeling to the surface above an emitter(s), installation of a portion of a lateral at a depth less than design, or compacted soil around a portion of a drip lateral.[104] The corrective actions are summarized below.

Please note that excavation of any wet area will require that the area be allowed to dry before replacing soil to preclude soil smearing and compaction. Prior to replacing soil, any additional smeared or compacted soil in the bottom and sides of the excavated area should also be removed to minimize hydraulic differences in the soil layers. If the affected zone needs to be used during the time of repairs, temporary piping or solid drip tubing (no emitters) should be used to bypass the wet area until repairs are completed.

- Leak or break: A leak or break associated with a broken or cut pipe or tubing or a loose connection should be fairly obvious with soils saturated around the leak or break. Surface ponding and runoff may occur before the end of a dose. The area will need to be carefully excavated so that the failed pipe or tubing can be located and repaired. The zone may need to be pressurized to locate a leak after excavating the pipe and tubing around the wet area. Damage by rodents may require special actions to prevent recurrence of leaks, including harvesting the animals and injection of repellant chemicals such as butyric acid that discourage the animals from burrowing within the area.
- Drain-back: Generally, drain-back will be characterized with saturated zones around low elevation points within a zone. If necessary, use an engineering level to locate low spots within the zone and their relationship to the saturated area(s). If drain-back is suspected based on saturation in low spots, it may still be necessary to excavate the wet area to determine if there are any leaks or breaks in the pipe or tubing. Assuming no leaks or breaks are found, saturation caused by drain-back is a design or construction problem that can typically only be corrected through redesign or reconstruction of the affected zone to preclude drainage to low spots.
- Faulty emitter: An emitter that drips at a faster than normal rate can cause saturation at the soil surface. It is typically more practical to excavate and replace a suspect emitter than to determine or verify that it is faulty.

[104] Wet spots often occur during start-up before vegetation is established. By the time vegetation is established, some of these conditions are rectified; however, this needs to be fully addressed or verified prior to final approval of system installation.

- Clogged emitters (for volume controlled dosing systems): If the dose is controlled by volume (which should be avoided) rather than time, the total design dose volume will still be delivered through the unclogged emitters over a longer time period. The increased instantaneous loading may result in ponding at the soil surface. The tubing will need to be chemically cleaned. If this cleaning is not effective, the tubing will need to be replaced. For a system dosed by time, the frequency or number of doses per day will need to be increased to compensate for clogged emitters, but the volume per emitter per dose will not be affected.
- Piping or channeling above an emitter: Piping or channeling will also cause saturation at the soils surface. As with a faulty emitter, it is generally more practical to excavate the problem spot, replace the emitter(s) or tubing within the area, and lightly compact the soil as it is replaced above the tubing.
- Placement of tubing at a shallow depth: If the drip tubing trench is not completed to the full design depth for any reason, the shallow tubing may result in saturation of the soil at the surface. Excavation of the tubing below the saturated area should reveal if the tubing is installed at a depth less than design. The affected portion of the lateral would need to be lowered to design depth and the soil lightly compacted during backfill.
- Compacted soil around a portion of a drip lateral: If any type of heavy machinery or large livestock such as cows or horses are allowed within a zone (particularly when the soil is wet or damp), the soil may be compacted. The resulting change in structure may facilitate soil saturation at the surface. The affected area will need to be excavated and the soil carefully replaced.
- Root intrusion: Initial root intrusion in a PC emitter may push the diaphragm open, increasing flow. As the root progresses through the labyrinth, flow may be choked off. Both Geoflow and Netafim offer systems that use trifluralin to control root intrusion. The emitter may also be designed to provide an effective barrier to root intrusion. Chemical cleaning effectively controls root intrusion if used before the flow is totally blocked. If root intrusion progresses to the extent that flow is blocked, the affected emitters (and possibly the zone) will typically need to be replaced.

If the wet area is more widely spread or generalized within a drip zone, the source of the problem is probably related to increased flow to the zone, soil clogging, nonuniform distribution due to emitter clogging, or a high seasonal water table or other groundwater/runoff conditions. Applicable corrective actions include the following.

If measured daily flows to a zone(s) with saturated soils are found to be larger than design, the problem is likely to affect all or most zones. Daily flows probably exceed design values and the zones are hydraulically overloaded. The source of the excess flow needs to be determined and either eliminated or the system upgraded and expanded to accommodate the higher flows.

If daily flow to the affected zone(s) is found to be equal or less than design, the problem may be caused by one or more of the following factors.

- Faulty zone or check valves: Measured daily flow (and pressure) to the zone that is saturated will probably be normal; however, flow to other zones will exceed design (and pressure will be lower) due to the leaky zone or check valve for the zone that is experiencing problems.

Check valves can be particularly troublesome as previously discussed. When high flows are measured for a zone, the excess flow is typically routed to the back side of another zone containing a faulty check valve. The zone(s) with the apparent high flow is actually functioning normally, but one of the other zones is being partially dosed during each dosing event due to a leaky check valve, hydraulically overloading the soil. To determine if a check valve is leaky, check the A/V relief valve on the return manifold of the suspect zone while adjacent zones are being dosed. If the A/V relief valve seals or tries to seal, the check valve near it is faulty and needs to be replaced. The use of a manual shutoff valve following a check valve also facilitates troubleshooting and replacement of a failed check valve. More rarely, a zone valve may not close completely and allow water to enter its zone whenever other zones are dosed. Symptoms would be identical to a failed check valve. If replacement of the check valve does not correct the problem, replace or repair the zone valve. Pressure checks can also be used to isolate problem valves. Solenoid leaks can be identified by deadheading with all valves closed (no flow should be delivered to any zone with all valves closed).

- Soil clogging and/or saturation due to increased organics, grease, or salts in the dosed wastewater: Clogging may still occur with normal flows if the organic strength of the wastewater is high enough to cause a biomat around the emitters. Biomats can cause the soil around the emitters to drain slowly and still be saturated or nearly saturated by the time of the next dose. Similarly, high concentration of oil and grease or salts can either clog the soil or destroy the soil structure. Any of these conditions can lead to breakout of the wastewater on the soil surface. Generally, chemical analyses are needed to determine if effluent concentrations are higher than anticipated. If high concentrations are found, additional treatment will be needed to reduce concentrations to acceptable levels. Zones may be recovered or partially recovered by resting the zone for several months or by injection of appropriate chemicals (after consideration of potential effects on either the tubing or soil). However, if the soil structure is significantly changed, the application rate will need to be lowered to match the hydraulic capacity of the altered soil; otherwise, the zone will need to be totally replaced.
- Soil saturation due to an unusually high seasonal water table or other groundwater/runoff conditions: Temporary rises in the groundwater or soil saturation due to excessive rainfall or runoff can lead to surfacing of wastewater or soggy conditions within drip zones. Basically, the soil hydraulic capacity has been exceeded and there is no place for the water to drain. If the conditions are due to unusual climatic conditions, the problem should be temporary and self-corrective upon return to normal conditions. If the problem is caused by rerouting surface drainage or increased subsurface flows either on the site or upstream of the site, the excess water will need to be rerouted around the drip system.

8
CHAPTER 8—SYSTEM COSTS

The costs for a drip distribution system will be site specific. It will be much less difficult and less expensive to install a system on a field with uniform slopes and without obstacles such as trees and rocks.

The following ranges are provided as a general guide for installed costs for the drip component of a wastewater system. These costs are based on an experienced installer working on a cleared site with uniform slopes and a footprint wastewater application rate of 0.1 gal/d/ft^2.

Table 8-1
Representative Unit Installation Costs

Design Flow (gal/d)	Installed Cost ($/gal/d)
10,000	12
50,000	8 to 9
150,000	6 to 7
250,000	5
1,000,000	4 to 4.50

Converting these values to an acreage basis using the footprint loading results in the following range: $52,000/acre for the 10,000-gal/d system to $19,000/acre for the 1 million-gal/d system.

Actual costs for each case study site are included in appendix A. These include breakdown by major components including engineering and O&M.

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CHAPTER 9—RESEARCH NEEDS

During site visits and discussions with people responsible for the design and operation or advancement of the technology of drip systems across the United States, questions were asked concerning issues that were constraining the technology. Responses are summarized below. These represent aspects that need additional study or research (which may be stimulated through this listing).

Issues based on previous research at Texas A&M University [26,40]

- Define the optimum soil moisture content for effluent treatment and prevention of effluent surfacing. Should the optimum moisture content be less than saturation?
    - Define the alteration of soil hydraulic characteristics based on the effluent distribution system
        - Define the soil clogging mechanisms (chemical, biological, and physical) based on the wastewater and soil characteristics
        - Define the mechanisms that cause a reduction in saturated hydraulic conductivity around emitters.
            - Sodium-induced clay dispersion
            - Microbial activity: gas or organic production, decomposition of binding agents
            - Turbulent flow washing silt or clay particles from the saturated zone to the unsaturated zone
        - Define the relationships for hydraulic conductivity changes as a function of time.
        - Determine how these factors should be used to control proper sizing of subsurface drip systems under varying pretreatment/soil regimes.
- Evaluate emitter clogging for normal maintenance conditions
    - Evaluate the effect of improper location of A/V relief valves.
    - Evaluate the effect of design velocities on long-term clogging of emitters.
    - Evaluate the need for biocides (to control slimes) and herbicides (to control root intrusion) for systems properly designed and maintained.
    - Evaluate effectiveness/limitations of various cleaning techniques.
    - Evaluate how much soil is enough based on the level of pretreatment.

Additional issues:

- How much water spread occurs based on soil type (to address the striping issue); how much "suck" do you get at the start of a dose cycle?
- Better information on evapotranspiration rates for vegetation on a seasonal basis.
- Fate of pathogens for reuse applications (is disinfection needed?).
- Nitrogen issues: It is hypothesized that net nitrate transport could be less from drip systems receiving anaerobic effluent versus aerobic effluent with initially high nitrates due to the increased denitrification potential in the vicinity of emitters receiving septic tank effluent. Is this actually the case?
- Better design guidelines for dose per emitter, drain-back, and freeze resistance.
- Better design guidelines that differentiate between drip systems based on the level of pretreatment to be provided.
- Emitter dose rates that assure unsaturated flow for the various soil textures and structures and waste strength. Matching the emitter rate to soil texture and structure will result in soil tension pulling water away from the drip emitter, preserving soil structure. For fine textured soils, emitter rates that result in soil saturation "force" water through soil and may wash or move fines to the outer boundary of the saturated zone, possibly destroying soil structure with time, and creating a hardpan that would be roughly equivalent to a biomat created using primary treated effluent. Does saturated flow actually cause this progressive type of failure, and if so, are there design solutions to prevent the problem (such as new dripline options with lower emitter rates or use of sand as a secondary distribution method on top of fine textured soils)?
- Installation methods used in fine textured soils. Trenching or plowing during installation destroys structure of disturbed soil, increasing the potential for soil saturation and wastewater at the soil surface.
- Better installation standards for freeze protection.
- Representative detailed water balances and development of useful hydraulic and pollutant attenuation models. Very little information is available on daily, seasonal, or annual water budgets. To address contaminant fate and hydrologic issues from either a regulatory or an environmental perspective adequately, information is needed on typical proportions of water applied through the drip system that is stored near the surface (available for evapotranspiration), evapotranspirated, and percolated deep into soils (recharging groundwater or creating a perched water table). Key variables will include characteristics of the soil, system dosing (volume and intervals), vegetation, and weather and climate. For water that percolates deep into the soil, information is needed on attenuation of key contaminants that are relatively mobile, such as nitrates and pathogens.
- The effectiveness of A/V relief valves placed on supply and return manifolds that are located lower than the drip laterals.

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A
APPENDIX A—CASE STUDIES

Checklist of Information for Drip Irrigation Systems (Case Studies)

Basic Facts

System Name: James Cox/Blake House
Location: 5070 Green Drive West, Coden, AL 36523
USGS Quad sheet (with location pinpointed):
Owner: Blake (current homeowner)
Designer/Engineer: Kevin White, P.E., Univ. of South Alabama, Dept. of Civil Engineering, EGCB 280, Mobile, AL 36688-002, 251-460-6174
Operator/Management Entity: Homeowner
Date placed in operation: August 1994
Date of site visit: May 31, 2001

System Details

Treatment System:

Type: 1,000 gallon septic tank followed by dosing tank going into drip field
Manufacturer: Local tank manufacturer
Design Daily Flow: 450 gal/d (3 bedroom)
Actual Daily Flows (most recent 12-month period): Not available (private well for water supply)
Effluent Quality (concentrations and quantities for the most recent 12-month period): No monitoring data exists.
Summary of any compliance and operations problems: none noted

Drip System:

Dripline brand and model: PERC-RITE system by Waste Water Systems, Inc. (Netafim tubing)
Schematic or drawing of each zone with location, quantity, brand, and model or size of each component: Design drawings were provided for the system layout. See the following tables for details.
Monitoring Data (most recent 12-month period): None
Summary of any compliance and operations problems: None noted

Costs:

Design (not applicable for this demo project by the ADPH and the University of South Alabama Civil Engineering Department, but typically, cost would be $800-$1000)

Construction:

Equipment (Perc Rite pump, tubing, valves, floats, etc.)	$4815
Tanks (1000 gal. septic + 1000 gal dosing)	$1150
Electrical	$ 600
Installation	$2500
O&M (electrical cost, estimated)	$6/month
Monitoring (BOD, TSS, FC)	$60/sample

Special Design Objectives or Approaches: The drip system replaced a failed conventional septic system. 7 in. of loamy sand fill was used as a mound to obtain required minimum separation distance (18 in.) from bottom of tubing to restrictive layer (a seasonal water table).

Observations:

Wet soils around driplines: none noticeable

System Name: James Cox/Blake House, Coden, AL
Drip Field Details

	Zone 1
Number of dripline laterals	6
Total length of dripline laterals, ft.	1500
Number of loops per lateral	2 @ both the supply and return manifold
Longest lateral length, ft.	250
Dripper spacing, in.	24 in.
Ave. lateral burial depth, in.	6 in.
Installation method	chain trencher
Spacing of dripline laterals, in.	24 in.
Maximum elevation difference between laterals and pump-off float	~5 ft
Soil classification	loamy sand/sand
Depth to restrictive layer, in.	17 in. to SHWT Indicators
Design HLR, gal/d/ft^2	.15
Actual HLR, gal/d/ft^2	
Dosing flow rate, gal/min	7.6
Dosing time period, minutes	9.7
Doses per day at design flow (per zone)	6 (75 gal/dose)
Doses per day at average actual flow (per zone)	
Field flush flow rate, gal/min	10
Total zone flow rate, gal/min	18
Number of air/vacuum valves	1
Location of air/vacuum valves	on return manifold at high point
Model/Size of air/vacuum valves	ARI S-050 (1 in.)
Zone valves, type/model/size	not applicable
Elevation difference within zones, ft	<1 ft
Field flush valve type/model/number	solenoid valve/BERMAD/ 1 (in headworks enclosure)
Flushing criterion	at least 1 system volume
Flushing frequency	once per 200 dosing cycles
Disposal method for the flush water	septic tank
Supply pipe size & psi rating or sch, in./psi/sch	1.25/Schedule 40
Supply pipe length (max, to zone manifold), ft.	110
Supply pipe depth, in.	
Supply manifold length (max), ft.	58
Supply manifold depth, in.	
Supply manifold design pressure (flushing), psi	16.2
Return/flush manifold size and psi rating, in./psi	1.25/Schedule 40
Return manifold length (max), ft.	125
Return manifold depth, in.	
Return manifold pressure, psi	5
Type of valve on return line	See "field flush valve"
Primary species of vegetation.	Native landscaping grasses
Typical mowing frequency	weekly to twice per month
Striping severity	moderate
Degree of soil wetness	none noticeable
Type of fencing	chain length fence around property, but not specifically around drip field
Failures or sign. Problems (use "comments")	none

Comments:
This design was based on a minimum pressure of 5 psi at the distal end of the drip lateral and 2 ft/s flushing velocity with a listed friction loss of 11.2 psi for 250 ft of ½ in. Netafim tubing with emitters spaced 24 inches apart. Using current information, the friction loss would be 15.23 psi rather than the 11.2 psi used for this design.

System Name: James Cox/Blake House, Coden, AL
Dosing System Details

Tank		
	Inside dimensions (L:W:H) (in, to max water level)	
	Volume (gal)	1000
Risers		
	Type (inlet/outlet)	none/Polyethylene
	Number (inlet/outlet)	none/1
	Height (inlet/outlet)	not applicable/12 in.
	Diameter (inlet/outlet)	not applicable/22 in.
Pumps		
	Model	WWS OJS075
	Number of units	1
	Single, Series, or Alternating	Single
	Flow at design TDH for zone operation (gal/min)	18
	Design TDH for zone operation (ft)	69
	Flow for filter flushing (gal/min)	NA
	Design TDH for filter flushing (ft)	NA
	Depth of pump intake (relative to bottom, in)	~12
	Service or maintenance frequency	
	Failures or sign. problems (use “comments”)	
Floats		
	Red. off or low-water alarm/merc. or mech.	Red. off, alarm activation/mercury
	Timer override/merc. or mech.	Yes/mercury
	Pump off/mercury or mechanical	No
	Pump on/mercury or mechanical	No
	High-water mult. pumps on/merc. or mech.	No
	High-water alarm/mercury or mechanical	Yes/mercury
	Dose enable/merc. or mech.	Yes/mercury
	Failures or sign. problems (use “comments”)	
Timer		
	Model	Factory programmed computer chip
	Programmable	Requires reprogramming at the factory
	Design dosing interval, min.	14.05 minutes every 240 minutes
	Actual dosing interval, min.	
Control Panel		
	Model	WWS (PLC Model F1-130DR)
	Float functions (as listed/checked above)	As listed above
	Pump dosing cycles (timer or volume)	timer
	Motor-start contactor	yes
	Duplex alternator	yes
	Manual pump switch	yes
	Filter flush cycles	yes
	Field flush cycles (short: per cycle or zone)	no
	Field flush cycles (complete system)	yes
	Elapsed time meter for pumps	yes
	Cycle counter for pumps	yes
	Circuit breaker for controls power	yes
	Alarms (visual/audible/both)	both
	Alarm silence relay	yes
	Remote system monitoring (attach details)	no

Comments:

System Name: James Cox/Blake House, Coden, AL
Filter System Details

Filters		
	Model & size	Netafim 3/4 in. Disc Filter (115-micron)
	Number of units	2
	Manufacturer's specifications	see Netafim brochure in Appendix D
	Pressure loss at design flow, psi or ft	10.35 psi
	Flushing frequency	At the start of each dose and after every 5 minutes of pump run time; for ~ 15 seconds per filter
	Flushing criterion (max pressure loss, psi or ft)	not applicable
	Automatic or manual flushing cycles	automatic
	Continuous bleed flush? Rate (gal/min)	none
	Disposal method for the flush water	back to septic tank
	Failures or sign. problems (use "comments")	
Pressure Gauges		
	Model or type	none
	Locations (before/after filters)	
Valves		
	Model & size	BERMAD, 1 in.
	Solenoid or manual	Solenoid (electrically operated hydraulic valve)
	Number of units	4 (2 per filter)
	Schematic showing function of each unit	Available at www.bermad.com
	Pressure loss at design flow, psi or ft	
	Failures or sign. problems (use "comments")	
Air vent		
	Model & size	not applicable
	Location	

Comments:

System Name: James Cox/Blake House, Coden, AL
Pressure Regulator Details

Pres. Regulator		
	Model & size	None used
	Location(s)	
	Manufacturer's specifications provided?	
	Outlet pressure, psi	
	Failures or sign. problems (use "comments")	
Bypass valve		Not applicable
	Model & size	
	Solenoid or manual	
	Pressure loss at design flow, psi or ft	

Comments:

Flush Tank

Tank		Septic tank is used
	Inside dimensions (L:W:H) (in)	
	Volume (gal)	1000
Risers		
	Type (inlet/outlet)	Polyethylene
	Number (inlet/outlet)	1
	Height (inlet/outlet)	12 in.
	Diameter (inlet/outlet)	22 in.

Comments:

Checklist of Information for Drip Irrigation Systems (Case Studies)

Basic Facts

System Name: Odom/Ewing House
Location: 15355 Delta Port Road, Coden, AL 36523
USGS Quad sheet (with location pinpointed):
Owner: Ewing (current homeowner)
Designer/Engineer: Kevin White, P.E., Univ. of South Alabama, Dept. of Civil Engineering, EGCB 280, Mobile, AL 36688-002, 251-460-6174
Operator/Management Entity: Homeowner
Date placed in operation: August 1994
Date of site visit: May 31, 2001

System Details

Treatment System:

Type: 1000 gallon septic tank followed by dosing tank going into drip field
Manufacturer: Local tank manufacturer
Design Daily Flow: 600 gal/d (4 bedrooms)
Actual Daily Flows (most recent 12-month period): Not available (private well for water supply)
Effluent Quality (concentrations and quantities for the most recent 12-month period): No monitoring data exists.
Summary of any compliance and operations problems: Overflow of septic tank and flush tank in late winter of 2001. The homeowner had the septic tank pumped.

Drip System:

Dripline brand and model: PERC-RITE system by WWSI (Netafim tubing)
Schematic or drawing of each zone with location, quantity, brand, and model or size of each component: Design drawings were provided for the system layout. See the following tables for details.
Monitoring Data (most recent 12-month period): None
Summary of any compliance and operations problems: Overflow of septic tank and flush tank in late winter of 2001. The homeowner had the septic tank pumped.
Costs:

Design: (not applicable for this demo project by the ADPH and the Univ. of South Alabama Civil Engineering Department, but typically cost would be $800-$1000)

Construction (breakdown by major component if possible):

Equipment (Perc Rite pump, tubing, valves, floats, etc.)	$4815
Tanks (1000 gal. septic + 1000 gal dosing)	$1150
Electrical	$ 600
Installation	$2500
O&M (electrical cost, estimated)	$ 6/month
Monitoring (BOD, TSS, FC)	$ 60/sample

Special Design Objectives or Approaches: The drip system replaced a failed conventional septic system. 4 in. of loamy sand fill was used to obtain required minimum separation distance (18 inches) from bottom of tubing to restrictive layer.

Observations:

Wet soils around driplines: None noticeable; however, grass over the first segment of each dripline lateral was generally more lush than other areas and included patches of the wetland species, pennywort, indicating consistent dampness.

System Name: Odom/Ewing, Coden, AL
Drip Field Details

	Zone 1
Number of dripline laterals	7
Total length of dripline laterals, ft.	1400
Number of loops per lateral	1 at supply/return end; 2 @ opposite end
Longest lateral length, ft.	200 (4, 50 ft segments)
Dripper spacing, in.	24 in.
Ave. lateral burial depth, in.	6 in.
Installation method	chain trencher
Spacing of dripline laterals, in.	24 in.
Maximum elevation difference between laterals and pump-off float	~4 ft
Soil classification	loamy sand/sand
Depth to restrictive layer, in.	18 in. to SHWT indicators
Design HLR, gal/d/ft^2	0.4
Actual HLR, gal/d/ft^2	
Dosing flow rate, gal/min	7.12
Dosing time period, minutes	14.05
Doses per day at design flow (per zone)	6 (100 gal/dose)
Doses per day at average actual flow (per zone)	
Field flush flow rate, gal/min	11.2
Total zone flow rate, gal/min	18.32
Number of air/vacuum valves	1
Location of air/vacuum valves	on return manifold at high point
Model/Size of air/vacuum valves	ARI S-050 (1 in.)
Zone valves, type/model/size	not applicable
Elevation difference within zones, ft	
Field flush valve type/model/number	solenoid valve/BERMAD/ 1 (in headworks enclosure)
Flushing criterion	at least 1 system volume
Flushing frequency	once per 200 dosing cycles
Disposal method for the flush water	septic tank
Supply pipe size & psi rating or sch, in./psi/sch	1.25/Schedule 40
Supply pipe length (max, to zone manifold), ft.	155
Supply pipe depth, in.	
Supply manifold length (max), ft.	56
Supply manifold depth, in.	
Supply manifold design pressure (flushing), psi	13
Return/flush manifold size and psi rating, in./psi	1.25/Schedule 40
Return manifold length (max), ft.	200
Return manifold depth, in.	
Return manifold pressure, psi	5
Type of valve on return line	See “field flush valve”
Primary species of vegetation.	Native landscaping grasses with trees around perimeter - not in drip field
Typical mowing frequency	weekly to twice per month
Striping severity	moderate
Degree of soil wetness	none noticeable
Type of fencing	none
Failures or sign. Problems (use “comments”)	none

Comments:
This design was based on a minimum pressure of 5 psi at the distal end of the drip lateral and 2 ft/s flushing velocity with a listed friction loss of 8 psi for 200 ft of 1/2 in. Netafim tubing with emitters spaced 24 in. apart. Using current information, the friction loss would be 10.83 psi rather than the 8 psi used for this design.

System Name: Odom/Ewing, Coden, AL
Dosing System Details

Tank		
	Inside dimensions (L:W:H) (in, to max water level)	
	Volume (gal)	1000
Risers		
	Type (inlet/outlet)	none/Polyethylene
	Number (inlet/outlet)	none/1
	Height (inlet/outlet)	not applicable/12 in.
	Diameter (inlet/outlet)	not applicable/22 in.
Pumps		
	Model	WWS OJS075
	Number of units	1
	Single, Series, or Alternating	Single
	Flow at design TDH for zone operation (gal/min)	18
	Design TDH for zone operation (ft)	46
	Flow for filter flushing (gal/min)	NA
	Design TDH for filter flushing (ft)	NA
	Depth of pump intake (relative to bottom, in)	~12
	Service or maintenance frequency	
	Failures or sign. problems (use "comments")	
Floats		
	Red. off or low-water alarm/merc. or mech.	Red. off, alarm activation/mercury
	Timer override/merc. or mech.	Yes/mercury
	Pump off/mercury or mechanical	No
	Pump on/mercury or mechanical	No
	High-water mult. pumps on/merc. or mech.	No
	High-water alarm/mercury or mechanical	Yes/mercury
	Dose enable/merc. or mech.	Yes/mercury
	Failures or sign. problems (use "comments")	
Timer		
	Model	Factory programmed computer chip
	Programmable	Requires reprogramming at factory
	Design dosing interval, min.	9.87 minutes every 240 minutes
	Actual dosing interval, min.	
Control Panel		
	Model	WWS (PLC Model F1-130DR)
	Float functions (as listed/checked above)	As listed above
	Pump dosing cycles (timer or volume)	timer
	Motor-start contactor	yes
	Duplex alternator	yes
	Manual pump switch	yes
	Filter flush cycles	yes
	Field flush cycles (short: per cycle or zone)	no
	Field flush cycles (complete system)	yes
	Elapsed time meter for pumps	yes
	Cycle counter for pumps	yes
	Circuit breaker for controls power	yes
	Alarms (visual/audible/both)	both
	Alarm silence relay	yes
	Remote system monitoring (attach details)	no

Comments

System Name: Odom/Ewing, Coden, AL
Filter System Details

Filters		
	Model & size	Netafim 3/4-in. Disc Filter (115 micron)
	Number of units	2
	Manufacturer's specifications	see Netafim brochure in Appendix D
	Pressure loss at design flow, psi or ft	10.35 psi
	Flushing frequency	At the start of each dose and after every 5 minutes of pump run time; for ~ 15 seconds per filter
	Flushing criterion (max pressure loss, psi or ft)	not applicable
	Automatic or manual flushing cycles	automatic
	Continuous bleed flush? Rate (gal/min)	none
	Disposal method for the flush water	back to septic tank
	Failures or sign. problems (use "comments")	
Pressure Gauges		
	Model or type	none
	Locations (before/after filters)	
Valves		
	Model & size	BERMAD, 1 in.
	Solenoid or manual	Solenoid (electrically operated hydraulic valve)
	Number of units	4 (2 per filter)
	Schematic showing function of each unit	available at www.bermad.com
	Pressure loss at design flow, psi or ft	
	Failures or sign. problems (use "comments")	
Air vent		
	Model & size	not applicable
	Location	

Comments:

System Name: Odom/Ewing, Coden, AL
Pressure Regulator Details

Pres. Regulator		
	Model & size	None used
	Location(s)	
	Manufacturer's specifications provided?	
	Outlet pressure, psi	
	Failures or sign. problems (use "comments")	
Bypass valve		Not applicable
	Model & size	
	Solenoid or manual	
	Pressure loss at design flow, psi or ft	

Comments:

Flush Tank

Tank		Septic tank is used
	Inside dimensions (L:W:H) (in)	
	Volume (gal)	1000
Risers		
	Type (inlet/outlet)	none/Polyethylene
	Number (inlet/outlet)	none/1
	Height (inlet/outlet)	not applicable/12 in.
	Diameter (inlet/outlet)	not applicable/22 in.

Comments:

Checklist of Information for Drip Irrigation Systems (Case Studies)

Basic Facts

System Name: Bradley Harold
Location: 25740 E. Comfort Drive, Forest Lake, Minnesota 55025
Owner: Bradley Harold (homeowner)
Designer/Engineer: Scott D. Wallace, P.E., North American Wetland Engineering, 20 North Lake St., Suite 210, Forest Lake, MN 55025 (651-255-5065)
Operator/Management Entity: NAWE (annual sampling only)
Date placed in operation: November 1999
Date of site visit: June 26, 2001

System Details

Treatment System:

Type: Single-pass sand filter with Forced Bed Aeration (tubing installed but not used to date based on adequate natural aeration within the system)
Manufacturer: Custom system. Forced Bed Aeration trademarked and patented by NAWE
Design Daily Flow: 600 gal/d (4 bedrooms)
Actual Daily Flows (most recent 12 month period):
Average: 173 gal/d (based on homeowner meter readings 5/23 – 5/30/01
Effluent Quality (concentrations and quantities for the most recent 12 month period):

Sampling 5/23/01 (only sampling to date)

Parameter	Septic Tank Outlet (mg/l)	Drip Irrigation Tank (mg/l)
CBOD5	350	2.1
Fecal Coliform	>10,000	>10,000
TKN	59.5	0.1
Nitrate + Nitrite	<0.1	40.3
Total P	9.43	7.09
TSS	340	123
Total N	59.5	40.3

Summary of any compliance and operations problems: None

Drip System:

Dripline brand and model: Geoflow Wastewater PC (nominal flow of 1.02 gal/h) with 24 in. emitter spacing
Schematic or drawing of each zone with location, quantity, brand, and model or size of each component: Design drawings were provided for the system layout (as-builts were not available). See the following tables for details.
Monitoring Data (most recent 12-month period):
Summary of any compliance and operations problems: None
Costs:
Design: $1500
Construction (breakdown by major component if possible):

Tanks: $2400
Sand Filter: $6400
Drip Irrigation: $3000
O&M: No O&M Costs incurred to date
Monitoring: Approx $175/yr

Special Design Objectives or Approaches:

The system is designed to minimize the potential for freezing. The drainfield drains back to the dosing tank between cycles. Tubing is laid level (with no sags) or with a slight slope back to the supply line. Supply and return headers are also sloped to drain back to the tank and are insulated with 2 in. Styrofoam SB (min R-10 value) encasing granular backfill around the pipe. Air/vacuum relief valves are also heavily insulated with Perlite (Styrofoam beads: loose around the valve base and bagged on top) covering river gravel used for base drainage under the valve box. Antifreeze drain-back valves (solenoid) are used on the supply pipe inside the dosing tank. Continuous drainfield flushing and automatic drain-back of the return pipe occurs through a partially open ball valve inside the dosing tank. A 1 1/2 in. disk filter also has continuous flushing with automatic drainage between dosing cycles via a partially open ball valve on the bottom of the filter.

Observations:

System is nicely landscaped with decorative “fake boulders” and concrete blocks over the tanks. No visible problems. Site is adjacent to a lake with children swimming on day of site visit.

Wet soils around driplines:

None

System Name: Bradley Harold, Forest Lake, Minnesota
Drip Field Details

	Zone 1
Number of dripline laterals	9
Total length of dripline laterals, ft.	1330
Number of loops per lateral	0
Longest lateral length, ft.	76
Dripper spacing, in.	24
Ave. lateral burial depth, in.	12
Installation method	Chain trencher
Spacing of dripline laterals, in.	24
Maximum elevation difference between laterals and pump-off float	~8 ft
Soil classification	Sand fill over clay loam
Depth to restrictive layer, in.	Mottling from about 12 to 20 in.
Design HLR, gal/d/ft^2	0.451
Actual HLR, gal/d/ft^2	0.130
Dosing flow rate, gal/min	10
Dosing time period, minutes	10
Doses per day at design flow (per zone)	24
Doses per day at average actual flow (per zone)	6.9
Field flush flow rate, gal/min	Approx 2 gal/min
Total zone flow rate, gal/min	Approx 12 gal/min
Number of air/vacuum valves	2
Location of air/vacuum valves	Return & Supply Manifolds (1 @ each end at the high point)
Model/Size of air/vacuum valves	Geoflow (3/4 in.)
Zone valves, type/model/size	None (one zone)
Elevation difference within zones, ft	1
Field flush valve type/model/number	1 in. PVC ball valve for draining system after each dose (see comments)
Flushing criterion	not applicable
Flushing frequency	not applicable
Disposal method for the flush water	not applicable
Supply pipe size & psi rating or sch, in./psi/sch	2 in./Schedule 40
Supply pipe length (max, to zone manifold), ft.	10 ft
Supply pipe depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Supply manifold length (max), ft.	16 ft
Supply manifold depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Supply manifold design pressure, psi	
Return/flush manifold size and psi rating, in./psi	1 in./Schedule 40
Return manifold length (max), ft.	16 ft
Return manifold depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Return manifold pressure, psi	
Type of valve on return line	1 in. gate valve in dosing tank
Return pipe size & psi rating or sch, in./psi/sch	1 in./Schedule 40
Return pipe length (max, to zone manifold), ft.	80 ft
Return pipe depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Primary species of vegetation.	Fescue (native lawn grass)
Typical mowing frequency	Weekly to once every 2 weeks as needed
Striping severity	none
Degree of soil wetness	Same as surrounding soil (not wet)
Type of fencing	none
Failures or sign. Problems (use "comments")	none

System Name: Bradley Harold, Forest Lake, Minnesota
Dosing System Details

Tank		
	Inside dimensions (L:W:H) (in) (to high water)	150:60:60
	Volume (gal)	1,000
Risers		
	Type (inlet/outlet)	None on inlet/Concrete on outlet
	Number (inlet/outlet)	0/1
	Height (inlet/outlet)	0/3 ft
	Diameter (inlet/outlet)	0/48 in.
Pumps		
	Model	Myers 2NFL51-20E
	Number of units	1
	Single, Series, or Alternating	Single
	Flow at design TDH for zone operation (gal/min)	10
	Design TDH for zone operation (ft)	80
	Flow for filter flushing (gal/min)	not applicable
	Design TDH for filter flushing (ft)	not applicable
	Depth of pump intake (relative to bottom, in)	Pump is on bottom of tank
	Service or maintenance frequency	
	Failures or sign. problems (use “comments”)	
Floats		
	Red. off or low-water alarm/merc. or mech.	No redundant off
	Timer override/merc. or mech.	No timer override
	Pump off/mercury or mechanical	Pump off mercury float switch
	Pump on/mercury or mechanical	No
	High-water mult. pumps on/merc. or mech.	No
	High-water alarm/mercury or mechanical	HWL mercury float
	Failures or sign. problems (use “comments”)	
Timer		
	Model	SJE-Rhombus
	Programmable	yes
	Design dosing interval, min.	10 minutes every 30 minutes
	Actual dosing interval, min.	10 minutes every 30 minutes (off float permitting)
Control Panel		
	Model	SJE-Rhombus TD1W914H4E18A
	Float functions (as listed/checked above)	As listed above
	Pump dosing cycles (timer or volume)	timer
	Motor-start contactor	yes
	Duplex alternator	no
	Manual pump switch	yes
	Filter flush cycles	no
	Field flush cycles (short: per cycle or zone)	no
	Field flush cycles (complete system)	no
	Elapsed time meter for pumps	no
	Cycle counter for pumps	no
	Circuit breaker for controls power	yes
	Alarms (visual/audible/both)	both
	Alarm silence relay	yes
	Remote system monitoring (attach details)	no

Comments:

System Name: Bradley Harold, Forest Lake, Minnesota
Filter System Details

Filters		
	Model & size	Netafim 1 1/2 in. ↓ 80-mesh filter w/ball valve on drain
	Number of units	1
	Manufacturer's specifications	see Netafim brochure in Appendix D
	Pressure loss at design flow, psi or ft	
	Flushing frequency	annually unless a problem is observed
	Flushing criterion (max pressure loss, psi or ft)	not applicable
	Auto or manual hydraulic flushing cycles or manual disassembly	manual disassembly and cleaning
	Continuous bleed flush? Rate (gal/min)	continuous @ ~ 0.25 gal/min
	Disposal method for the flush water	back to dosing tank
	Failures or sign. problems (use "comments")	
Pressure Gauges		
	Model or type	none
	Locations (before/after filters)	
Valves		
	Model & size	not applicable
	Solenoid or manual	
	Number of units	
	Schematic showing function of each unit	
	Pressure loss at design flow, psi or ft	
	Failures or sign. problems (use "comments")	
Air vent		
	Model & size	not applicable
	Location	

Comments:

System Name: Bradley Harold, Forest Lake, Minnesota
Pressure Regulator Details

Pres. Regulator		None used
	Model & size	
	Location(s)	
	Manufacturer's specifications provided?	
	Outlet pressure, psi	
	Failures or sign. problems (use "comments")	
Bypass valve		Not applicable
	Model & size	
	Solenoid or manual	
	Pressure loss at design flow, psi or ft	

Comments:

Flush Tank

Tank		Dosing tank is used
	Inside dimensions (L:W:H) (in)	
	Volume (gal)	
Risers		See dosing tank
	Type (inlet/outlet)	
	Number (inlet/outlet)	
	Height (inlet/outlet)	
	Diameter (inlet/outlet)	

Comments:

Checklist of Information for Drip Irrigation Systems (Case Studies)

Basic Facts

System Name: Scott Stewart residence
Location: 20125 West 105th St, Olathe, KS 66061
Owner: Scott & Colleen Stewart
Designer/Engineer: Tom Fritts, Vice-President, Residential Sewage Treatment, 12800 Second St Grandview, MO 64030 (RST) (Note: this is a repair or replacement system for a failed conventional drainfield.)
Operator/Management Entity: Residential Sewage Treatment, 12800 Second St., Grandview, MO 64030 (816-966-8885)
Date placed in operation: July 1997
Date of site visit: September 19, 2001

System Details

Treatment System:

Type: Septic tank to a JET Model J-500 BAT Aerobic Unit
Manufacturer: JET, Inc., 750 Alpha Drive, Cleveland, OH 44143
Design Daily Flow: 600 gal/d
Actual Daily Flows (most recent 12-month period):
Average: Not available
Max:
Min:
Effluent Quality (concentrations and quantities for the most recent 12-month period): No data available – regulatory monitoring is not required
Summary of any compliance and operations problems: There are no compliance requirements. No operational problems have occurred to date.

Drip System:

Dripline brand and model: Geoflow WASTEFLOW Classic (non-PC dripperline with a 0.55 in. I.D. and a nominal flow of 1.3 gal/h at 20 psi) with 24 in. emitter spacing.
Schematic or drawing of each zone with location, quantity, brand, and model or size of each component: Design drawings were provided. Details are summarized below and in the following tables.
Dosing system: tanks, pumps, controllers, timers (including settings), valves
Simplex timed dosing system (see the following tables for details)
Filter system: filters, valves, housing, flushing details
A 1 in. Geoflow Vortex filter is installed inside the dosing tank on the supply line to the drip field. The filter is manually serviced during routine 6 month service calls; however, it is designed to be self cleaning and is equipped with a continuous bleed within the dose tank.
Drip system:
Design and actual hydraulic loading rates: design soil loading rate is 0.3 gal/d/ft^2
Soil classifications: not specified in soil report
Soil depths: not specified in soil report
Supply manifold (including trench depth), zone valves, pressure regulators, driplines (including burial depth and installation method), air/vacuum valves, return manifold and valves, flush valves, vegetation (species, striping, general

health, mowing/harvesting), elevation difference across zone, flushing details: See details in drip & filter dosing sections

Settling tank: flushing flow is returned to the dose tank

Monitoring Data (most recent 12-month period):

No samples have been analyzed; however, service information including pressure readings are recorded and logged at 6 month intervals by RST.

Summary of any compliance and operations problems: The only operational problem has been associated with the custom-made flow inducer for the dosing pump (a Goulds Model 12EB06 high head turbine pump). The inducer could not supply enough wastewater to match the pumping rate, resulting in pumping air during the dose cycle. The flow inducer is no longer used.

Costs:

Engineering: $ in total price
Construction (breakdown by major component if possible): $12,115.62
O&M: $175.00/yr
Monitoring: None

Special Design Objectives or Approaches:

This drip system was used to replace an existing failed conventional drainfield. The drip system represents RSTC's original design approach to home drip systems. Several features are no longer used. These include eliminating the pressure reducer and bypass at the inlet to each zone, replacing the air/vacuum valves with models that contain a Schrader valve that allow direct pressure readings and quick adjustment of operating pressures, eliminating the pump flow inducer, eliminating an air/vacuum valve at the end of the return line (which was ineffective for draining the line after a dose), and relocating the pressure adjusting valve from the end of the return line to the beginning of the return line. The system is fully automated to minimize the need for daily operator attention. Routine service calls occur on a 6 month basis where all components are checked and serviced. All drip systems follow aerobic treatment units that provide 20/20 effluent or better.

Observations: Wastewater was visible in an apparent tire rut caused by vehicles running over the drip field near the garage area.

System Name: Stewart Residence, Olathe, KS
Drip Field Details

	Zone 1
Number of dripline laterals	10
Total length of dripline laterals, ft.	1250
Number of loops per lateral	none
Longest lateral length, ft.	125
Dripper spacing, in.	24
Ave. lateral burial depth, in.	10
Installation method	Geoflow tubing insertion plow
Spacing of dripline laterals, in.	24
Maximum elevation difference between laterals and pump-off float, ft	N/A
Soil classification	Not specified in soil report
Depth to restrictive layer, in.	Not specified in soil report
Design HLR, gal/d/ft2	.3
Actual HLR, gal/d/ft2	.24
Dosing flow rate, gal/min	13.75
Dosing time period, minutes	5 minutes every 1 hr*
Doses per day at design flow (per zone)	24
Doses per day at average actual flow (per zone)	
Field flush flow rate, gal/min	20
Total zone flow rate, gal/min	13.75
Number of air/vacuum valves	2
Location of air/vacuum valves	end of supply & return manifolds (high point: set above highest dripper line)
Model/Size of air/vacuum valves	Geoflow APVBK-1 (ARI 1 in.)
Zone valves, type/model/size	Not applicable
Elevation difference within zones, ft	~2
Field flush valve type/model/number	1 1/4 in. Gate Valve
Flushing criterion	None
Flushing frequency	Once every 6 months
Disposal method for the flush water	Return to dose tank
Supply pipe size & psi rating or sch, in./psi/sch	1 1/4 in. Schedule 40
Supply pipe length (max, to zone manifold), ft.	287
Supply pipe depth, in.	12 in.
Supply manifold length (max), ft.	18
Supply manifold depth, in.	12 in.
Supply manifold pressure, psi	20
Return pipe size & psi rating or sch, in./psi/sch	1 1/4 in. Schedule 40
Return pipe length (max, to zone manifold), ft.	~350
Return pipe depth, in.	12 in.
Return/flush manifold size and psi rating, in./psi	1 1/4 in. Schedule 40
Return manifold length (max), ft.	18
Return manifold depth, in.	12 in.
Return manifold pressure, psi	19
Type of valves on return line	1 1/4 in. Gate Valve
Primary species of vegetation.	native lawn grasses
Typical mowing frequency	Weekly to biweekly
Striping severity	None
Degree of soil wetness	Spots (see comments)
Type of fencing	None
Failures or sign. Problems (use “comments”)	

Comments
* Fill time or the amount of time to charge the drip field is added to the dose time. This is typically about 4 minutes, resulting in a typical total dose period of about 5 1/2 minutes.

Geoflow WASTEFLOW Classic is always used on RST projects. The drip emitter rates vary with pressure changes, resulting in slightly higher loading rates on lower laterals. At the Stewart site, the elevation difference is only about 2 to 2 1/2 ft within the drip field. This results in only about 1 psi difference between operating pressures within the drip field. This small difference is typically considered insignificant.

Wastewater was visible in an apparent tire rut caused by vehicles running over the drip field near the garage area.

System Name: Stewart Residence, Olathe, KS
Dosing System Details

Tank		
	Inside dimensions (L:W:H) (in, to max water level)	68:44:52
	Volume (gal)	1000
Risers		
	Type (inlet/outlet)	Not applicable/PVC (OSI Ribbed Riser)
	Number (inlet/outlet)	0/1
	Height (inlet/outlet)	Not applicable/18 in.
	Diameter (inlet/outlet)	Not applicable/26 in.
Pumps		
	Model	Goulds 12EB06
	Number of units	1
	Single, Series, or Alternating	single
	Flow at design TDH for zone operation (gal/min)	13.75
	Design TDH for zone operation (ft)	101
	Flow for filter flushing (gal/min)	N/A
	Design TDH for filter flushing (ft)	N/A
	Depth of pump intake (relative to bottom, in)	~16
	Service or maintenance frequency	semiannually
	Failures or sign. problems (use "comments")	
Floats		
	Red. off or low-water alarm/merc. or mech.	N/A
	Timer override/merc. or mech.	N/A
	Pump off/mercury or mechanical	mercury
	Pump on/mercury or mechanical	N/A
	High-water mult. pumps on/merc. or mech.	N/A
	High-water alarm/mercury or mechanical	mercury
	Dose enable/merc. or mech.	N/A
	Failures or sign. problems (use "comments")	None
Timer		
	Model	Omron H3CR-F
	Programmable	Yes
	Design dosing interval, min.	~1.5 minutes every 60 minutes*
	Actual dosing interval, min.	~1.5 minutes every 60 minutes*
Control Panel		
	Model	SJE-Rhombus TD123
	Float functions (as listed/checked above)	As listed above
	Pump dosing cycles (timer or volume)	timer
	Motor-start contactor	yes
	Duplex alternator	Not applicable
	Manual pump switch	yes
	Filter flush cycles	N/A
	Field flush cycles (short: per cycle or zone)	N/A
	Field flush cycles (complete system)	N/A
	Elapsed time meter for pumps	N/A
	Cycle counter for pumps	N/A
	Circuit breaker for controls power	20AMP
	Alarms (visual/audible/both)	both
	Alarm silence relay	yes
	Remote system monitoring (attach details)	N/A

Comments
* Time to fill or charge the system is added to the dosing interval.

The drip field is flushed during each semiannual maintenance visit. The gate valve on the return line is closed enough to increase the system pressure from 20 psi to 30 psi to flush the emitters (increasing the nominal flow rate from 1.30 gal/h to 1.62 gal/h). The valve is then opened to increase flow and velocity to flush the driplines.

System Name: Stewart Residence, Olathe, KS
Filter System Details

Filters		
	Model & size	1 in. Vortex Spin Filter (AP4E100)
	Number of units	1
	Manufacturer's specifications	See Geoflow design guidelines
	Pressure loss at design flow, psi or ft	7
	Flushing frequency	N/A
	Flushing criterion (max pressure loss, psi or ft)	Not applicable
	Automatic or manual flushing cycles	Manual
	Continuous bleed flush? Rate (gal/min)	N/A
	Disposal method for the flush water	back to dosing tank
	Failures or sign. problems (use "comments")	
Pressure Gauges		
	Model or type	OCI liquid filled 0-30 PSI
	Locations (before/after filters)	
Valves		
	Model & size	Not applicable
	Solenoid or manual	
	Number of units	
	Schematic showing function of each unit	
	Pressure loss at design flow, psi or ft	
	Failures or sign. problems (use "comments")	
Air vent		
	Model & size	not applicable
	Location	

Comments:
The Vortex Spin filter is manufactured by API (Agricultural Product, Inc.). The 3/4 in. filter is undersized for the design flow. Geoflow guidelines indicate that the 3/4 in. filter should be used for flows from 4 to 11 gal/min. The head loss for 11 gal/min is approximately 13 psi. The 1 in. filter should be used for flows from 7 to 28 gal/min).

System Name: Stewart Residence, Olathe, KS
Pressure Regulator Details

Pres. Regulator		
	Model & size	N/A
	Location(s)	Bypassed
	Manufacturer's specifications provided?	
	Outlet pressure, psi	N/A
	Failures or sign. problems (use "comments")	
Bypass valve		
	Model & size	1 1/4 in. gate valve
	Solenoid or manual	manual
	Pressure loss at design flow, psi or ft	

Comments:

Flush Tank

Tank		Dose tank is used as the flush tank
	Inside dimensions (L:W:H) (in)	
	Volume (gal)	
Risers		
	Type (inlet/outlet)	
	Number (inlet/outlet)	
	Height (inlet/outlet)	
	Diameter (inlet/outlet)	

Comments:
A separate flush tank is not used. The drip system flush water is routed back to the dose tank.

Checklist of Information for Drip Irrigation Systems (Case Studies)

Basic Facts

System Name: Mick Warnock residence
Location: 28225 S. State Rt. O, Freeman, MO
Owner: Mick Warnock
Designer/Engineer: Robert E. Quick, P.E., 16719 Bel Ray Blvd., Belton, MO 64012, using design information provided by Residential Sewage Treatment (RST)
Operator/Management Entity: Residential Sewage Treatment, 12800 Second St., Grandview, MO 64030 (816-966-8885)
Date placed in operation: Summer 2001
Date of site visit: September 19, 2001

System Details

Treatment System:

Type: Interon grinder pump to a NORWECO Singulair Aerobic Unit
Manufacturer: Norweco, Inc., 220 Republic St., Norwalk, OH 44857
Design Daily Flow: 600 gal/d
Actual Daily Flows (most recent 12-month period):
Average: Not available
Max:
Min:
Effluent Quality (concentrations and quantities for the most recent 12-month period): No data available – regulatory monitoring is not required
Summary of any compliance and operations problems: There are no compliance requirements. The system is new and no operational problems have occurred to date.

Drip System:

Dripline brand and model: Geoflow WASTEFLOW Classic (non-PC dripperline with a 0.55 in. I.D. and a nominal flow of 1.3 gal/h at 20 psi) with 24 in. emitter spacing.
Schematic or drawing of each zone with location, quantity, brand, and model or size of each component: Design drawings were provided. Details are summarized below and in the following tables.
Dosing system: tanks, pumps, controllers, timers (including settings), valves
Simplex timed dosing system (see the following tables for details)
Filter system: filters, valves, housing, flushing details
A GAG Sim Tech filter provides primary filtering, followed by a 1 in. Geoflow Vortex spin filter. Both filters are located in the pump tank immediately above the pump and within reach through the access riser. The filters must be manually serviced. Although the spin filter is designed to be self-cleaning when the continuous bleed option is used, experience has shown that the continuous bleed is not necessary with the Sim Tech filter preceding the spin filter.
Drip system:
Design and actual hydraulic loading rates: design soil loading rate is 0.2 gal/d/ft^2
Soil classifications: soils were mapped using 3 pits. Soils were classified as ranging from silt loam to silty clay loam with the layer next to the surface layer being extremely gravelly. Structure ranged from 2fsbk (moderate fine

subangular blocky) to 2msbk (moderate medium subangular blocky) to 3mabk (strong medium angular blocky). Slopes ranged from 10% to 28%.

Soil depths: Bedrock depth ranged from 48 in. to 60 in. Drainage classifications ranged from moderately well to well drained with no seasonal high water within the top 48 in. An average of 2 inches of topsoil was spread over the drip field area to meet regulatory minimum separation distances.

Supply manifold (including trench depth), zone valves, pressure regulators, driplines (including burial depth and installation method), air/vacuum valves, return manifold and valves, flush valves, vegetation (species, striping, general health, mowing/harvesting), elevation difference across zone, flushing details: See details in drip & filter dosing sections

Settling tank: flushing flow is returned to the dose tank

Monitoring Data (most recent 12-month period):

No samples have been analyzed; however, service information including pressure readings are recorded and logged at 6-month intervals by RST.

Summary of any compliance and operations problems: None

Costs:

Engineering: $661.53

Construction (breakdown by major component if possible): $12,659.62 + $4000 for Grinder pump station

O&M: $185/yr

Installation of all components and field top soil work: $ 7995.00

Monitoring: None

Special Design Objectives or Approaches:

The design used on this site incorporates both standard features that have proven to be successful and modifications based on RST's experience with these types of systems since the first one installed in 1997. The system is fully automated to minimize the need for daily operator attention. Routine service calls occur on a 6 month basis where all components are checked and serviced. All drip systems follow aerobic treatment units that provide 20/20 effluent or better. Pressure in each drip zone is set to 20 psi using a ball valve on the return line. This eliminates the need for a pressure reducer at the inlet to each zone and allows the system to drain between doses (which minimizes overloading lower trenches due to drain-back and prevents freezing). The model of air/vacuum valve contains a Schrader valve for direct pressure readings and quick adjustment of operating pressures. For multiple zone systems, individual return lines are used for each zone to eliminate the need for check valves. Return lines for multiple zones are recombined following a down-gradient elevation difference of 1 foot, which is considered adequate to prevent back-flow to other zones based on low pressure gravity drainage following the ball valve. A GAG Sim Tech filter has been added to increase filtering capacity prior to the drip field and reduce reliance on the smaller spin filter.

Observations:

Wet soils around driplines: None

System Name: Warnock Residence, Freeman, MO
Drip Field Details

	Zone 1
Number of dripline laterals	15
Total length of dripline laterals, ft.	1500
Number of loops per lateral	none
Longest lateral length, ft.	100
Dripper spacing, in.	24
Ave. lateral burial depth, in.	10
Installation method	Vibratory plow
Spacing of dripline laterals, in.	24
Maximum elevation difference between laterals and pump-off float, ft	~25
Soil classification	Silt loam over silty clay loam
Depth to restrictive layer, in.	60 in. seasonal high-water table
Design HLR, gal/d/ft2	0.20
Actual HLR, gal/d/ft2	
Dosing flow rate, gal/min	16.5
Dosing time period, minutes	~1.52 minutes every 1 hr*
Doses per day at design flow (per zone)	24
Doses per day at average actual flow (per zone)	
Field flush flow rate, gal/min	20 gal/min
Total zone flow rate, gal/min	16.5 gal/min
Number of air/vacuum valves	2
Location of air/vacuum valves	end of supply & return manifolds (high point: set above highest dripper line)
Model/Size of air/vacuum valves	Geoflow APVBK-1 (ARI 1 in.)
Zone valves, type/model/size	Not applicable
Elevation difference within zones, ft	~8
Field flush valve type/model/number	1 1/4 in. PVC Ball Valve
Flushing criterion	None
Flushing frequency	Once every 6 months
Disposal method for the flush water	Return to dose tank
Supply pipe size & psi rating or sch, in./psi/sch	1 1/4 in. Schedule 40
Supply pipe length (max, to zone manifold), ft.	20
Supply pipe depth, in.	12 in.
Supply manifold length (max), ft.	~30 ft
Supply manifold depth, in.	12 in.
Supply manifold pressure, psi	20 in.
Return pipe size & psi rating or sch, in./psi/sch	1 1/4 in. Schedule 40
Return pipe length (max, to zone manifold), ft.	~110
Return pipe depth, in.	12 in.
Return/flush manifold size and psi rating, in./psi	1 1/4 in. Schedule 40
Return manifold length (max), ft.	~30 ft
Return manifold depth, in.	12 in.
Return manifold pressure, psi	20 (measured)
Type of valves on return line	1 1/4 in. PVC Ball Valve
Primary species of vegetation.	native grasses
Typical mowing frequency	typically not mowed
Striping severity	None
Degree of soil wetness	None
Type of fencing	None
Failures or sign. Problems (use “comments”)	

Comments

System Name: Warnock Residence, Freeman, MO
Dosing System Details

Tank		
	Inside dimensions (L:W:H) (in, to max water level)	68:44:52
	Volume (gal)	1000 gallon
Risers		
	Type (inlet/outlet)	HDPE (Zabel ZEUS)
	Number (inlet/outlet)	2
	Height (inlet/outlet)	Not applicable/12 in.
	Diameter (inlet/outlet)	Not applicable/26 in.
Pumps		
	Model	Goulds 20EB0722 Blaster
	Number of units	1
	Single, Series, or Alternating	single
	Flow at design TDH for zone operation (gal/min)	16.5
	Design TDH for zone operation (ft)	86 ft
	Flow for filter flushing (gal/min)	N/A (filters are manually cleaned)
	Design TDH for filter flushing (ft)	N/A
	Depth of pump intake (relative to bottom, in)	16 in.
	Service or maintenance frequency	semiannually
	Failures or sign. problems (use "comments")	
Floats		
	Red. off or low-water alarm/merc. or mech.	N/A
	Timer override/merc. or mech.	N/A
	Pump off/mercury or mechanical	MERCURY
	Pump on/mercury or mechanical	N/A
	High-water mult. pumps on/merc. or mech.	N/A
	High-water alarm/mercury or mechanical	mercury
	Dose enable/merc. or mech.	N/A
	Failures or sign. problems (use "comments")	None
Timer		
	Model	OMRON H3CR-F
	Programmable	Yes
	Design dosing interval, min.	~1.5 minutes every 60 minutes*
	Actual dosing interval, min.	~1.5 minutes every 60 minutes*
Control Panel		
	Model	BIO INC. 240D
	Float functions (as listed/checked above)	As listed above
	Pump dosing cycles (timer or volume)	timer
	Motor-start contactor	yes
	Duplex alternator	Not applicable
	Manual pump switch	yes
	Filter flush cycles	N/A
	Field flush cycles (short: per cycle or zone)	N/A
	Field flush cycles (complete system)	N/A
	Elapsed time meter for pumps	N/A
	Cycle counter for pumps	N/A
	Circuit breaker for controls power	20 AMP
	Alarms (visual/audible/both)	YES BOTH
	Alarm silence relay	YES
	Remote system monitoring (attach details)	N/A

Comments
* Time to fill or charge the system is added to the dosing interval.

The drip field is flushed during each semiannual maintenance visit. The ball valve on the return line is closed enough to increase the system pressure from 20 psi to about 30 psi to flush the emitters (increasing the nominal flow rate from 1.30 gal/h to 1.62 gal/h). The valve is then opened to increase flow and velocity to flush the driplines.

System Name: Warnock Residence, Freeman, MO
Filter System Details

Filters		
	Model & size	GAG Sim/Tech: STF-100A3 (2 in.), followed by a 1 in. Vortex Spin Filter (AP4E100)
	Number of units	1 of each type
	Manufacturer's specifications	
	Pressure loss at design flow, psi or ft	less than 0.21 psi for the GAG filter; about 7 psi for the spin filter
	Flushing frequency	Semi annually during routine service visit
	Flushing criterion (max pressure loss, psi or ft)	N/A
	Automatic or manual flushing cycles	Manual
	Continuous bleed flush? Rate (gal/min)	N/A (not needed with the Sim/Tech in front of the spin filter)
	Disposal method for the flush water	back to dosing tank
	Failures or sign. problems (use "comments")	
Pressure Gauges		
	Model or type	OCI LIQUID FILLED 0-30
	Locations (before/after filters)	
Valves		
	Model & size	Not applicable
	Solenoid or manual	
	Number of units	
	Schematic showing function of each unit	
	Pressure loss at design flow, psi or ft	
	Failures or sign. problems (use "comments")	
Air vent		
	Model & size	not applicable
	Location	

Comments:
The Vortex Spin filter is manufactured by API (Agricultural Product, Inc.).

System Name: Warnock Residence, Freeman, MO
Pressure Regulator Details

Pres. Regulator		None used
	Model & size	
	Location(s)	
	Manufacturer's specifications provided?	
	Outlet pressure, psi	
	Failures or sign. problems (use "comments")	
Bypass valve		Not applicable
	Model & size	
	Solenoid or manual	
	Pressure loss at design flow, psi or ft	

Comments:

Flush Tank

Tank		Dose tank is used as the flush tank
	Inside dimensions (L:W:H) (in)	
	Volume (gal)	
Risers		
	Type (inlet/outlet)	
	Number (inlet/outlet)	
	Height (inlet/outlet)	
	Diameter (inlet/outlet)	

Comments:
A separate flush tank is not used. The drip system flush water is routed back to the dose tank.

Checklist of Information for Drip Irrigation Systems (Case Studies)

Basic Facts

System Name: Nasonville Elementary School
Location: Wood County, Wisconsin (near Marshfield)
Owner: School District of Marshfield
Designer/Engineer: S. Kunze, P.E., Ayres Associates, 2445 Darwin Road, Madison, WI 53704-3186
Operator/Management Entity: Paul Rodenbeck, Director of Buildings & Grounds, School District of Marshfield, 1010 East Fourth St, Marshfield, WI 54449 (715-387-1101, ext. 108)
Date placed in operation: August 1998
Date of site visit: July 26, 2001

System Details

Treatment System:

Type: Septic tank & recirculating gravel filter (RGF)
Manufacturer: Not applicable
Design Daily Flow: 2500 gal/d
Actual Daily Flows (most recent 12-month period): Sept 13 through Oct 15, 2001
  Average: 547 gal/d or 3.65 gal/student
  Max: Unknown
  Min: Unknown
Effluent Quality (concentrations and quantities for the most recent 12-month period): No data available – regulatory monitoring is not required
Summary of any compliance and operations problems: The RGF uses drip tubing for wastewater distribution within two zones. During the winter of 1999, the RGF supply line froze, probably due to a failed return valve, and the filter was removed from service. For the winter of 2000, maintenance staff installed a manually set timer on the sand filter, which shuts the filter off at night and on the weekends. Since then, there have been no problems with freezing. Also, the system is designed for 350 students and a kitchen (the school capacity after expansion during the summer of 2001). Enrollment during the first three years of operation was approximately 100 (with no kitchen). Consequently, the system has been very lightly loaded. Enrollment for the fall of 2001 is 150 students.

Drip System:

Dripline brand and model: Netafim BioLine (PC dripperline with a 0.57 in. I.D. and a nominal flow of 0.61 gal/h) with 24 in. emitter spacing
Schematic or drawing of each zone with location, quantity, brand, and model or size of each component: Design drawings were provided. Details are summarized below and in the following tables.
  Dosing system: tanks, pumps, controllers, timers (including settings), valves
    With the exception of the manual timer on the RSF, all other timed events are set in the computerized controller
  Filter system: filters, valves, housing, flushing details
    Automatically back-flushes filters prior to a dosing event and every 5 minutes during the dose
  Drip system:

Design and actual hydraulic loading rates: design soil loading rate is 0.2 gal/d/ft2 and the actual loading rate is approximately 0.09 gal/d/ft2

Soil classifications: the soils on the site are mapped as Santiago silt loam. In reality, it is transitional between the Santiago and Withee Silt Loams. Soil descriptions show the solum to be higher in clay content than what is typical for the Santiago series. The specific soils on the site would be defined as somewhat poorly drained, formed in loess deposits over dense glacial till.

Soil depths: the surficial soil (A & B Horizons) is silt loam that is mottled at between 18 in. and 27 in. The solum, generally greater than 24 in, varies between sandy clay loam and clay loam till.

Supply manifold (including trench depth), zone valves, pressure regulators, driplines (including burial depth and installation method), air/vacuum valves, return manifold and valves, flush valves, vegetation (species, striping, general health, mowing/harvesting), elevation difference across zone, flushing details: See details in drip & filter dosing sections

Settling tank:

Monitoring Data (most recent 12-month period): contact Paul Rodenbeck @ 715-305-0940

Summary of any compliance and operations problems: None except replacement of failed solenoid valves due to diaphragm rupture. Only two of the four zones are used due to small flows. This situation will change during the 2001/2002 school year since the school was enlarged during the summer of 2001. The system is not used during the summer.

Costs:

Engineering:

Design: $11,800

Construction Services: $5530

Construction (breakdown by major component if possible): Lump Sum Bid of $49,000

O&M: Estimated $300/yr

Monitoring: None required other than operational (contact Paul Rodenbeck @ 715-305-0940)

Special Design Objectives or Approaches:

The system is fully automated to minimize the need for daily operator attention. Flow meters have been installed for each supply line and on the return line. A pressure gauge has also been installed on both the supply header prior to the solenoid valves and on the return line prior to the flow meter and solenoid valve. These were installed by the University of Wisconsin to study the winter performance of the system. The system is shut down during summer since the school is not in use.

Observations:

Wet soils around driplines:

No unusual conditions were noted but the system was not operational at the time of the site visit since school was not in session. The operator reported that the drip component of the system has performed very well.

System Name: Nasonville Elementary School, Wood County, Wisconsin
Drip Field Details

	Zone 1	Zone 2
Number of dripline laterals	5	5
Total length of dripline laterals, ft.	1560	1560
Number of loops per lateral	1 @ each end	1 @ each end
Longest lateral length, ft.	312	312
Dripper spacing, in.	24	24
Ave. lateral burial depth, in.	8 to 14 in.	8 to 14 in.
Installation method	Vibratory plow	Vibratory plow
Spacing of dripline laterals, in.	24	24
Maximum elevation difference between laterals and pump-off float, ft	~7	~8
Soil classification	Silt loam over sandy clay loam / clay loam(slowly permeable)	Silt loam over sandy clay loam / clay loam(slowly permeable)
Depth to restrictive layer, in.	~ 18 in	~27 in.
Design HLR, gal/d/ft2	0.20	0.20
Actual HLR, gal/d/ft2	0.09 gal/d/ft^2	0.09 gal/d/ft^2
Dosing flow rate, gal/min	8.5	8.5
Dosing time period, minutes	~18.3 minutes every 1.5 hrs	~18.3 minutes every 1.5 hrs
Doses per day at design flow (per zone)	4	4
Doses per day at average actual flow (per zone)	1.76 w/ 2 zones operating	1.76 w/ 2 zones operating
Field flush flow rate, gal/min	10.0	10.0
Total zone flow rate, gal/min	18.5	18.5
Number of air/vacuum valves	2	2
Location of air/vacuum valves	end of supply & return manifolds (high point: set above highest dripper line)	end of supply & return manifolds (high point: set above highest dripper line)
Model/Size of air/vacuum valves	ARI Guardian, 1 1/2 in.	ARI Guardian, 1 1/2 in.
Zone valves, type/model/size	Solenoid valve/DH SOL NC	Solenoid valve/DH SOL NC
Elevation difference within zones, ft	<1	<1
Field flush valve type/model/number	Solenoid valve/DH SOL NC	Solenoid valve/DH SOL NC
Flushing criterion	2 gal/min x # manifold connections	2 gal/min x # manifold connections
Flushing frequency	Once every 150 doses	once every 150 doses
Disposal method for the flush water	inlet pipe to recirc tank	inlet pipe to recirc tank
Supply pipe size & psi rating or sch, in./psi/sch	1 1/2 in. Schedule 40	1 1/2 in. Schedule 40
Supply pipe length (max, to zone manifold), ft.	170	205
Supply pipe depth, in.	24	24
Supply manifold length (max), ft.	~2 ft (prefabricated by WWSI; see comments)	~2 ft (prefabricated by WWSI; see comments)
Supply manifold depth	1 1/2 ft to 3 ft deep; sloped for drain-back to the pump tank, starting with a vertical drop pipe from the supply manifold (see comments)	1 1/2 ft to 3 ft deep; sloped for drain-back to the pump tank, starting with a vertical drop pipe from the supply manifold (see comments)
Supply manifold pressure, psi	25-26 (measured, dosing)	25-26 (measured, dosing)
Return pipe size & psi rating or sch, in./psi/sch	2 in. Schedule 40	2 in. Schedule 40
Return pipe length (max, to zone manifold), ft.	85	135
Return pipe depth	2 to 3 ft deep; sloped for drain-back to the settling tank, starting with a vertical drop pipe from the return manifold (see comments)	2 to 3 ft deep; sloped for drain-back to the settling tank, starting with a vertical drop pipe from the return manifold (see comments)
Return/flush manifold size and psi rating, in./psi	2 in. Schedule 40	2 in. Schedule 40
Return manifold length (max), ft.	~2 ft (prefabricated by WWSI; see comments)	~2 ft (prefabricated by WWSI; see comments)
Return manifold depth, in.	8	8
Return manifold pressure, psi	20-22 (measured)	20-22 (measured)

	Zone 1	Zone 2
Type of valves on return line	2 in. check valve per zone and 1 in. solenoid field flush valve in the control building	2 in. check valve per zone and 1 in. solenoid field flush valve in the control building
Primary species of vegetation.	native grasses	native grasses
Typical mowing frequency	typically not mowed	typically not mowed
Striping severity	None	none
Degree of soil wetness	None	none
Type of fencing	None	none
Failures or sign. Problems (use "comments")		

Comments

Supply and return manifolds are prefabricated by WWSI. Flex IPS tubing (3/4 in. for the supply and 1/2 in. for the return) is used from the manifolds to the dripper lines. The supply manifold is located below the lowest dripper line in the zone, and the return manifold is located above the highest dripper line in the zone. This design isolates each dripper line to eliminate drain-back between doses to lower runs. Vertical risers are insulated to minimize freezing. Only two of the 4 zones are active at any time due to the low system flow. All four zones will be used beginning in the fall of 2001 due to school expansion. The system is shut down during the summer since no school activities occur.

The minimum bury depth for the supply and return lines is 18 in. All lines are sloped to drain back through the control building; however, the supply lines contains both solenoid and check valves, effectively precluding automatic drain-back. The combined return lines also contain the solenoid field flush valve (normally closed) which would also preclude automatic drain-back. No freezing problems have been reported for the drip system.

During the first year of operation, three check valves failed, one on the suction line to one of the pumps and two on return lines, one to the RSF and another to zone 2. All were subsequently replaced, and have worked without a problem since.

The diaphragm ruptured on several of the BERMAD solenoid valves, requiring replacement.

System Name: Nasonville Elementary School, Wood County, Wisconsin
Drip Field Details

	Zone 3	Zone 4
Number of dripline laterals	5	5
Total length of dripline laterals, ft.	1560	1560
Number of loops per lateral	1 @ each end	1 @ each end
Longest lateral length, ft.	312	312
Dripper spacing, in.	24	24
Ave. lateral burial depth, in.	8 to 14 in.	8 to 14 in.
Installation method	Vibratory plow	vibratory plow
Spacing of dripline laterals, in.	24	24
Maximum elevation difference between laterals and pump-off float, ft	~7	~8
Soil classification	Silt loam over sandy clay loam / clay loam (slowly permeable)	Silt loam over sandy clay loam / clay loam (slowly permeable)
Depth to restrictive layer, in.	~18 in	~27 in.
Design HLR, gal/d/ft2	0.20	0.20
Actual HLR, gal/d/ft2	0.09 gal/d/ft^2	0.09 gal/d/ft^2
Dosing flow rate, gal/min	8.5	8.5
Dosing time period, minutes	~18.3 minutes every 1.5 hrs	~18.3 minutes every 1.5 hrs
Doses per day at design flow (per zone)	4	4
Doses per day at average actual flow (per zone)	1.76 w/ 2 zones operating	1.76 w/ 2 zones operating
Field flush flow rate, gal/min	10.0	10.0
Total zone flow rate, gal/min	18.5	18.5
Number of air/vacuum valves	2	2
Location of air/vacuum valves	end of supply & return manifolds (high point: set above highest dripper line)	end of supply & return manifolds (high point: set above highest dripper line)
Model/Size of air/vacuum valves	ARI Guardian, 1 1/2 in.	ARI Guardian, 1 1/2 in.
Zone valves, type/model/size	Solenoid valve/BERMAD DH SOL NC 1 in.	Solenoid valve/BERMAD DH SOL NC 1 in.
Elevation difference within zones, ft	<1	<1
Field flush valve type/model/number	Solenoid valve/BERMAD DH SOL NC 1 in.	Solenoid valve/BERMAD DH SOL NC 1 in.
Flushing criterion	2 gal/min x # manifold connections	2 gal/min x # manifold connections
Flushing frequency	once every 150 doses	once every 150 doses
Disposal method for the flush water	inlet pipe to recirc tank	inlet pipe to recirc tank
Supply pipe size & psi rating or sch, in./psi/sch	1 1/2 in. Schedule 40	1 1/2 in. Schedule 40
Supply pipe length (max, to zone manifold), ft.	175	215
Supply pipe depth	1 1/2 ft to 3 ft deep; sloped for drain-back to the pump tank, starting with a vertical drop pipe from the supply manifold (see comments)	1 1/2 ft to 3 ft deep; sloped for drain-back to the pump tank, starting with a vertical drop pipe from the supply manifold (see comments)
Supply manifold length (max), ft.	~2 ft (prefabricated by WWSI; see comments)	~2 ft (prefabricated by WWSI; see comments)
Supply manifold depth, in.	24	24
Supply manifold pressure, psi	25-26 (measured, dosing)	25-26 (measured, dosing)
Return pipe size & psi rating or sch, in./psi/sch	2 in. Schedule 40	2 in. Schedule 40
Return pipe length (max, to zone manifold), ft.	335	375
Return pipe depth	2 to 3 ft deep; sloped for drain-back to the settling tank, starting with a vertical drop pipe from the return manifold (see comments)	2 to 3 ft deep; sloped for drain-back to the settling tank, starting with a vertical drop pipe from the return manifold (see comments)
Return/flush manifold size and psi rating, in./psi	2 in. Schedule 40	2 in. Schedule 40
Return manifold length (max), ft.	~2 ft (prefabricated by WWSI; see comments)	~2 ft (prefabricated by WWSI; see comments)
Return manifold depth, in.	8	8

	Zone 3	Zone 4
Return manifold pressure, psi	20-22 (measured)	20-22 (measured)
Type of valves on return line	2 in. check valve per zone and 1 in. solenoid field flush valve in the control building	2 in. check valve per zone and 1 in. solenoid field flush valve in the control building
Primary species of vegetation.	native grasses	native grasses
Typical mowing frequency	typically not mowed	typically not mowed
Striping severity	None	none
Degree of soil wetness	none except in the sag area noted in previous comment	none
Type of fencing	None	none
Failures or sign. Problems (use "comments")		

Comments
Supply and return manifolds are prefabricated by WWSI. Flex IPS tubing (3/4 in. for the supply and 1/2 in. for the return) is used from the manifolds to the dripper lines. The supply manifold is located below the lowest dripper line in the zone, and the return manifold is located above the highest dripper line in the zone. This design isolates each dripper line to eliminate drain-back between doses to lower runs. Vertical risers are insulated to minimize freezing. Only two of the 4 zones are active at any time due to the low system flow. All four zones will be used beginning in the fall of 2001 due to school expansion. The system is shut down during the summer since no school activities occur.

The minimum bury depth for the supply and return lines is 18 in. All lines are sloped to drain back through the control building; however, the supply lines contains both solenoid and check valves, effectively precluding automatic drain-back. The combined return lines also contain the solenoid field flush valve (normally closed) which would also preclude automatic drain-back. No freezing problems have been reported for the drip system.

During the spring following system construction, a broken elbow at the supply manifold of Zone 3 was found. It is unclear whether the damage occurred during construction, from freezing, or from some other event. The fitting was replaced by the contractor.

Also, during the first year of operation, three check valves failed, one on the suction line to one of the pumps and two on return lines, one to the RSF and another to zone 2. All were subsequently replaced, and have worked without a problem since.

The diaphragm ruptured on several of the BERMAD solenoid valves, requiring replacement.

System Name: Nasonville Elementary School, Wood County, Wisconsin
Dosing System Details

Tank		
	Inside dimensions (L:W:H) (in, to max water level)	152:72:49
	Volume (gal)	2000
Risers		
	Type (inlet/outlet)	concrete/concrete
	Number (inlet/outlet)	1/1
	Height (inlet/outlet)	30 in./30 in.
	Diameter (inlet/outlet)	24 in./24 in.
Pumps		
	Model	WWS OJS Aermotor 3/4 hp, HNAS75
	Number of units	2
	Single, Series, or Alternating	alternating
	Flow at design TDH for zone operation (gal/min)	8.5
	Design TDH for zone operation (ft)	66 ft
	Flow for filter flushing (gal/min)	8.0 gal/min flush / Total flow = 22.4 gal/min
	Design TDH for filter flushing (ft)	66 ft
	Depth of pump intake (relative to bottom, in)	8
	Service or maintenance frequency	Inspect & calibrate semiannually
	Failures or sign. problems (use “comments”)	
Floats		
	Red. off or low-water alarm/merc. or mech.	Low-Level - Pump-off / mercury
	Timer override/merc. or mech.	No
	Pump off/mercury or mechanical	No
	Pump on/mercury or mechanical	No
	High-water mult. pumps on/merc. or mech.	No
	High-water alarm/mercury or mechanical	Yes/mercury
	Dose enable/merc. or mech.	Yes/mercury
	Failures or sign. problems (use “comments”)	None
Timer		
	Model	Factory programmed computer chip
	Programmable	Requires new computer chip
	Design dosing interval, min.	~18.3 minutes every 90 minutes
	Actual dosing interval, min.	Should be same as above
Control Panel		
	Model	WWS W15C
	Float functions (as listed/checked above)	As listed above
	Pump dosing cycles (timer or volume)	timer
	Motor-start contactor	yes
	Duplex alternator	yes
	Manual pump switch	yes
	Filter flush cycles	yes
	Field flush cycles (short: per cycle or zone)	no
	Field flush cycles (complete system)	yes
	Elapsed time meter for pumps	yes but internal in controller*
	Cycle counter for pumps	yes but internal in controller*
	Circuit breaker for controls power	yes
	Alarms (visual/audible/both)	both
	Alarm silence relay	yes
	Remote system monitoring (attach details)	no

Comments
* Pump use requires download from computer

System Name: Nasonville Elementary School, Wood County, Wisconsin
Filter System Details

Filters		
	Model & size	Netafim 3/4-in. Disc Filter (115 micron)
	Number of units	3
	Manufacturer's specifications	see Netafim brochure in Appendix D
	Pressure loss at design flow, psi or ft	
	Flushing frequency	At the start of each dose and after every 5 minutes of pump run time; for ~ 15 seconds per filter
	Flushing criterion (max pressure loss, psi or ft)	not applicable
	Automatic or manual flushing cycles	Automatic
	Continuous bleed flush? Rate (gal/min)	None
	Disposal method for the flush water	back to settling tank
	Failures or sign. problems (use "comments")	
Pressure Gauges		
	Model or type	None
	Locations (before/after filters)	
Valves		
	Model & size	Solenoid valve/BERMAD DH SOL NC 1 in.
	Solenoid or manual	Solenoid (electrically operated hydraulic valve)
	Number of units	6 (2 per filter)
	Schematic showing function of each unit	available at www.bermad.com
	Pressure loss at design flow, psi or ft	
	Failures or sign. problems (use "comments")	
Air vent		
	Model & size	not applicable
	Location	

Comments:
The diaphragm ruptured on several of the BERMAD solenoid valves, requiring replacement.

System Name: Nasonville Elementary School, Wood County, Wisconsin
Pressure Regulator Details

Pres. Regulator		None used
	Model & size	
	Location(s)	
	Manufacturer's specifications provided?	
	Outlet pressure, psi	
	Failures or sign. problems (use "comments")	
Bypass valve		Not applicable
	Model & size	
	Solenoid or manual	
	Pressure loss at design flow, psi or ft	

Comments:

Flush Tank

Tank		
	Inside dimensions (L:W:H) (in)	152:72:49
	Volume (gal)	2000
Risers		
	Type (inlet/outlet)	Concrete/concrete
	Number (inlet/outlet)	1/1
	Height (inlet/outlet)	30 in. / 30 in.
	Diameter (inlet/outlet)	24 in./24 in.

Comments:
A separate flush tank is not used. The drip system flush water is routed back to the dose tank.

Checklist of Information for Drip Irrigation Systems (Case Studies)

Basic Facts

System Name: North Ten Mile Lake Subordinate Sanitary District
Location: Cass County, Minnesota (near Hackensack)
Owner: North Ten Mile Lake Subordinate Sanitary District
Designer/Engineer: K. Scallon, P.E., Ayres Associates, 2445 Darwin Road, Madison, WI 53704-3186
Operator/Management Entity: Nick Pond, North Ten Mile Lake Subordinate Sanitary District
Date placed in operation: November 1999
Date of site visit: July 25, 2001

System Details

Treatment System:

Type: Primary treatment by septic tanks (STEP collection system)
Manufacturer: Not applicable
Design Daily Flow: 4700 gal/d
Actual Daily Flows (most recent 12-month period): Not available
Effluent Quality (concentrations and quantities for the most recent 12-month period): Not available
Summary of any compliance and operations problems:
A couple of service lines from the septic tank to the street collection main froze and burst during the winter of 2001 due to homeowners cutting power to the line heat trace while they were living at other locations.

Drip System:

Dripline brand and model: Netafim BioLine (PC dripperline with a 0.57 in. I.D. and a nominal flow of 0.61 gal/h) with 24 in. emitter spacing
Schematic or drawing of each zone with location, quantity, brand, and model or size of each component: As-built drawings were provided. Details are summarized below and on the following tables.

Dosing system: tanks, pumps, controllers, timers (including settings), and valves.
The number of doses, dose sequencing, and dose duration are controlled by input of design data to the system controller.

Filter system: filters, valves, housing, flushing details.
The system automatically back-flushes filters prior to a dosing event and every 5 minutes during the dose.

Drip system: design and actual hydraulic loading rates, soil classifications, soil depths, supply manifold (including trench depth), zone valves, pressure regulators, driplines (including burial depth and installation method), air/vacuum valves, return manifold and valves, flush valves, vegetation (species, striping, general health, mowing/harvesting), elevation difference across zone, flushing details.

Details are listed in the following tables. Soils on the site are mapped by the USDA-NRCS as Warba sandy loam. This soil is described as very deep, moderately well drained soil formed in loamy calcareous till on moraines. Permeability is moderate to moderately rapid in the upper part and moderately slow in the lower part. A typical soil profile consists of a surface of 7 in of fine sandy loam, a sandy loam to loamy sand subsoil from 7 to 21 in, and a C horizon of generally weakly structured clay loam.

Discontinuous inclusions of clay and coarse sandy loam were observed within the C horizon. The northeast area of the site exhibited mottled conditions greater than 34 in. Although textures were similar to the descriptions for Warba sandy loam, drainage characteristics suggest that the site is better drained.

Settling tank: see detailed tables

Monitoring Data (most recent 12-month period): not available

Summary of any compliance and operations problems: Localized soil saturation occurs in a low (sag) area within Zone 3. This is believed to be caused by dripline drainage after a dosing cycle. During the winter of 2002, the active drip zone used during winter froze up and pumping and hauling was used. Freezing was reported to be a common problem within the county during 2002 for all types of septic systems including conventional, at-grades and mounds, due to lack of snow. Freeze-up at Ten Mile was attributed to a combination of weather, poor cover over the drip field, and low wintertime flows resulting in lower effluent temperatures.

Costs:

Engineering

- Preliminary Engineering Study: $ 3,000
- Facility Plan: $ 8,500
- Design: $20,000
- Construction Services: $55,000

Total $86,500

Construction (breakdown by major component if possible):

- Tanks: $48,000
- Step Components: $63,000
- Step Laterals & Sewer Connections: $25,000
- Force Main: $74,200
- Settling Tank: $ 1,200
- Dose Tank: $ 1,500
- Control Building: $10,000
- Pump, Valves & Control Unit: $ 5,000
- Drip Supply Lines: $ 3,000
- Drip Return Lines: $ 3,800
- Drip Dispersal Zones: $25,000
- Electrical – Collection: $ 8,000
- Electrical – Treatment: $ 2,500
- Access Road: $15,000
- Site Restoration: $10,000
- Misc: $ 4,800

Total $300,000

O&M: $ 6,000/yr

Monitoring:

- None Required

Special Design Objectives or Approaches:

The system is fully automated and includes telemetry equipment for remote dial-up capability to check system status and modify control settings as needed.

Monitoring includes the following functions: pump start control, timed back-flush of filters, automatic flushing of drip system, flow variance, and all alarms (high water, low water, power out). The system monitors and records flow rates, individual zone dose volumes, total daily dose and flush volumes, and alarm conditions. This information is downloaded from the panel daily (at 12:01 am) to the computer. Through the remote telemetry, system status can be monitored, tested, and some aspects such as dose volumes can be changed. Float and pump status can be determined and pumps can be engaged and zone and filter backwash operations initiated. During winter, only Zone 4 is keep functional because only a couple of residences are routinely occupied.

Observations:

Wet soils around driplines:

Soil is wet in the sag area within Zone 3. No other wet areas were noticed. No vegetative stripping was noticeable.

System Name: Ten Mile Lake, Cass County, Minnesota

Drip Field Details

	Zone 1	**Zone 2**
Number of dripline laterals	7	7
Total length of dripline laterals, ft.	2100	2100
Number of loops per lateral	1	1
Longest lateral length, ft.	300	300
Dripper spacing, in.	24	24
Ave. lateral burial depth, in.	6 to 8 in.	6 to 8 in.
Installation method	vibratory plow	vibratory plow
Spacing of dripline laterals, in.	24	24
Maximum elevation difference between laterals and pump-off float, ft	~21	~23
Soil classification	Sandy loam over clay loam (slowly permeable)	Sandy loam over clay loam (slowly permeable)
Depth to restrictive layer, in.	none	none
Design HLR, gal/d/ft^2	0.28	0.28
Actual HLR, gal/d/ft^2		
Dosing flow rate, gal/min	11.4 gal/min	11.4 gal/min
Dosing time period, minutes	9.75 minutes every 6 hours	9.75 minutes every 6 hours
Doses per day at design flow (per zone)	4	4
Doses per day at average actual flow (per zone)		
Field flush flow rate, gal/min	14 gal/min	14 gal/min
Total zone flow rate, gal/min	25.4	25.4
Number of air/vacuum valves	2	2
Location of air/vacuum valves	end of supply & return manifolds (high point: set above highest dripper line)	end of supply & return manifolds (high point: set above highest dripper line)
Model/Size of air/vacuum valves	ARI Guardian, 2 in.	ARI Guardian, 2 in.
Zone valves, type/model/size	solenoid valve/BERMAD/ 1 in.	solenoid valve/BERMAD/ 1 in.
Elevation difference within zones, ft	8	10
Field flush valve type/model/number	solenoid valve/1 in. BERMAD/ 1 for the system on the return line	solenoid valve/1 in. BERMAD/ 1 for the system on the return line
Flushing criterion	at least 1 system volume	at least 1 system volume
Flushing frequency	once every 15 days	once every 15 days
Disposal method for the flush water	settling tank before the dosing tank	settling tank before the dosing tank
Supply pipe size & psi rating or sch, in./psi/sch	1 1/2 in. Schedule 40	1 1/2 in. Schedule 40

	Zone 1	Zone 2
Supply pipe length (max, to zone manifold), ft.	193	170
Supply pipe depth, in.	24	24
Supply manifold length (max), ft.	~3 ft (prefabricated by WWSI; see comments)	~3 ft (prefabricated by WWSI; see comments)
Supply manifold depth	typically 5 to 6 ft deep; sloped for drain-back to the pump tank, starting with a vertical drop pipe from the supply manifold (see comments)	typically 5 to 6 ft deep; sloped for drain-back to the pump tank, starting with a vertical drop pipe from the supply manifold (see comments)
Supply manifold design pressure (flushing), psi	30.41	30.41
Return pipe size & psi rating or sch, in./psi/sch	2 in. Schedule 40	2 in. Schedule 40
Return pipe length (max, to zone manifold), ft.	Common rtn line of 461 ft	Common rtn line of 461 ft
Return pipe depth	typically 5 to 6 ft deep; sloped for drain-back to the settling tank, starting with a vertical drop pipe from the return manifold	typically 5 to 6 ft deep; sloped for drain-back to the settling tank, starting with a vertical drop pipe from the return manifold
Return/flush manifold size and psi rating, in./psi	1 1/2 in. Schedule 40	1 1/2 in. Schedule 40
Return manifold length (max), ft.	~3 ft (prefabricated by WWSI; see comments)	~3 ft (prefabricated by WWSI; see comments)
Return manifold depth, in.	5	5
Return manifold pressure, psi	10	10
Type of valves on return line	1 1/2 in. check valve per zone and 1 in. solenoid field flush valve in the control building	1 1/2 in. check valve per zone and 1 in. solenoid field flush valve in the control building
Primary species of vegetation	native grasses	native grasses
Typical mowing frequency	not mowed	not mowed
Striping severity	none	none
Degree of soil wetness	none	none
Type of fencing	none	none
Failures or sign. Problems (use “comments”)		

Comments

Supply and return manifolds are prefabricated by WWSI. Flex 3/4 in. IPS tubing is used from the manifolds to the dripper lines. The supply manifold is located below the lowest dripper line in the zone, and the return manifold is located above the highest dripper line in the zone. This design isolates each dripper line to eliminate drain-back between doses to lower runs. Vertical risers are insulated to minimize freezing. Only Zone 4 is used for winter operation. Zones 1, 2, and 3 are drained prior to winter to prevent freeze damage.

All lines are sloped to drain back through the control building; however, the supply lines contains both solenoid and check valves, effectively precluding automatic drain-back. The combined return lines also contain the solenoid field flush valve (normally closed) which would also preclude automatic drain-back. During the winter of 2002, the active drip zone used during winter froze up and pumping and hauling was used. Freezing was reported to be a common problem within the county during 2002 for all types of septic systems including conventional, at-grades and mounds, due to lack of snow. Freeze-up at Ten Mile was attributed to a combination of weather, poor cover over the drip field, and low wintertime flows resulting in lower effluent temperatures.

System Name: Ten Mile Lake, Cass County, Minnesota
Drip Field Details

	Zone 3	Zone 4
Number of dripline laterals	7	7
Total length of dripline laterals, ft.	4200	4200
Number of loops per lateral	3 (2 opposite the manifolds and 1 adjacent to manifolds)	3 (2 opposite the manifolds and 1 adjacent to manifolds)
Longest lateral length, ft.	300	300
Dripper spacing, in.	24	24
Ave. lateral burial depth, in.	6 to 8 in.	6 to 8 in.
Installation method	vibratory plow	vibratory plow
Spacing of dripline laterals, in.	24	24
Maximum elevation difference between laterals and pump-off float, ft	~26	~30
Soil classification	Sandy loam over clay loam (slowly permeable)	Sandy loam over clay loam (slowly permeable)
Depth to restrictive layer, in.	none	35 in, part of this zone only
Design HLR, gal/d/ft^2	0.28	0.28
Actual HLR, gal/d/ft^2		
Dosing flow rate, gal/min	11.4 gal/min	11.4 gal/min
Dosing time period, minutes	17.2 minutes every hour	9.75 minutes every 6 hours
Doses per day at design flow (per zone)	4	4
Doses per day at average actual flow (per zone)		
Field flush flow rate, gal/min	14 gal/min	14 gal/min
Total zone flow rate, gal/min	25.4	25.4
Number of air/vacuum valves	2	2
Location of air/vacuum valves	end of supply & return manifolds (high point: set above highest dripper line)	end of supply & return manifolds (high point: set above highest dripper line)
Model/Size of air/vacuum valves	ARI Guardian, 2 in.	ARI Guardian, 2 in.
Zone valves, type/model/size	solenoid valve/BERMAD/ 1 in.	solenoid valve/BERMAD/ 1 in.
Elevation difference within zones, ft	4.5	5
Field flush valve type/model/number	solenoid valve/1 in. BERMAD/ 1 in. for the system on the return line	solenoid valve/1 in. BERMAD/ 1 in. for the system on the return line
Flushing criterion	at least 1 system volume	at least 1 system volume
Flushing frequency	once every 15 days	once every 15 days
Disposal method for the flush water	settling tank before the dosing tank	settling tank before the dosing tank
Supply pipe size & psi rating or sch, in./psi/sch	1 1/2 in. Schedule 40	1 1/2 in. Schedule 40
Supply pipe length (max, to zone manifold), ft.	163	302
Supply pipe depth	typically 5 to 6 ft deep; sloped for drain-back to the pump tank, starting with a vertical drop pipe from the supply manifold (see comments)	typically 5 to 6 ft deep; sloped for drain-back to the pump tank, starting with a vertical drop pipe from the supply manifold (see comments)
Supply manifold length (max), ft.	~3 ft (prefabricated by WWSI; see comments)	~3 ft (prefabricated by WWSI; see comments)
Supply manifold depth, in.	24	24
Supply manifold design pressure (flushing), psi	30.41	30.41
Return pipe size & psi rating or sch, in./psi/sch	2 in. Schedule 40	2 in. Schedule 40
Return pipe length (max, to zone manifold), ft.	Common rtn line of 461 ft	Common rtn line of 461 ft
Return pipe depth	typically 5 to 6 ft deep; sloped for drain-back to the settling tank, starting with a vertical drop pipe from the return manifold (see comments)	typically 5 to 6 ft deep; sloped for drain-back to the settling tank, starting with a vertical drop pipe from the return manifold (see comments)
Return/flush manifold size and psi rating, in./psi	1 1/2 in. Schedule 40	1 1/2 in. Schedule 40
Return manifold length (max), ft.	~3 ft (prefabricated by WWSI; see comments)	~3 ft (prefabricated by WWSI; see comments)
Return manifold depth, in.	5	5
Return manifold pressure, psi	10	10
Type of valves on return line	1 1/2 in. check valve per zone and	1 1/2 in. check valve per zone and 1

	Zone 3	Zone 4
	1 in. solenoid field flush valve in the control building	in. solenoid field flush valve in the control building
Primary species of vegetation	native grasses	native grasses
Typical mowing frequency	not mowed	not mowed
Striping severity	none	none
Degree of soil wetness	none except in the sag area noted in previous comment	none
Type of fencing	none	none
Failures or sign. Problems (use "comments")		

Comments
Supply and return manifolds are prefabricated by WWSI. Flex 3/4 in. IPS tubing is used from the manifolds to the dripper lines. The supply manifold is located below the lowest dripper line in the zone, and the return manifold is located above the highest dripper line in the zone. This design isolates each dripper line to eliminate drain-back between doses to lower runs. Vertical risers are insulated to minimize freezing. Only Zone 4 is used for winter operation. Zones 1, 2, and 3 are drained prior to winter to prevent freeze damage.

All lines are sloped to drain back through the control building; however, the supply lines contains both solenoid and check valves, effectively precluding automatic drain-back. The combined return lines also contain the solenoid field flush valve (normally closed) which would also preclude automatic drain-back. During the winter of 2002, the active drip zone used during winter froze up and pumping and hauling was used. Freezing was reported to be a common problem within the county during 2002 for all types of septic systems including conventional, at-grades and mounds, due to lack of snow. Freeze-up at Ten Mile was attributed to a combination of weather, poor cover over the drip field, and low wintertime flows resulting in lower effluent temperatures.

System Name: Ten Mile Lake, Cass County, Minnesota
Dosing System Details

Tank		
	Inside dimensions (L:W:H) (in, to max water level)	141:52:48
	Volume (gal)	2,000
Risers		
	Type (inlet/outlet)	none/concrete
	Number (inlet/outlet)	0/1
	Height (inlet/outlet)	Not applicable/48 in.
	Diameter (inlet/outlet)	Not applicable/24 in.
Pumps		
	Model	WWS OJS
	Number of units	2
	Single, Series, or Alternating	alternating
	Flow at design TDH for zone operation (gal/min)	10.7
	Design TDH for zone operation (ft)	38 psi w/ 10 suction lift
	Flow for filter flushing (gal/min)	11.2
	Design TDH for filter flushing (ft)	
	Depth of pump intake (relative to bottom, in)	8
	Service or maintenance frequency	Annual Inspection / Maintenance required
	Failures or sign. Problems (use “comments”)	
Floats		
	Red. off or low-water alarm/merc. or mech.	None
	Timer override/merc. or mech.	None
	Pump off/mercury or mechanical	Emergency Pump-Off - Mercury
	Pump on/mercury or mechanical	No
	High-water mult pumps on/merc. or mech.	No
	High-water alarm/mercury or mechanical	Yes/mercury
	Dose enable/merc. or mech.	Yes/mercury
	Failures or sign. problems (use “comments”)	
Timer		
	Model	Factory programmed computer chip
	Programmable	Requires new computer chip
	Design dosing interval, min.	17.2 minutes every hour
	Actual dosing interval, min.	Same as design
Control Panel		
	Model	WWS 15C
	Float functions (as listed/checked above)	As listed above
	Pump dosing cycles (timer or volume)	timer
	Motor-start contactor	Yes
	Duplex alternator	yes
	Manual pump switch	yes
	Filter flush cycles	yes
	Field flush cycles (short: per cycle or zone)	no
	Field flush cycles (complete system)	yes
	Elapsed time meter for pumps	No – Run time is accumulated in controller
	Cycle counter for pumps	No – Events accumulated in controller
	Circuit breaker for controls power	yes
	Alarms (visual/audible/both)	both
	Alarm silence relay	yes
	Remote system monitoring (attach details)	no

Comments:

System Name: Ten Mile Lake, Cass County, Minnesota
Filter System Details

Filters		
	Model & size	Netafim 3/4 in. Disc Filter (115-micron)
	Number of units	3
	Manufacturer's specifications	see Netafim brochure in appendix D
	Pressure loss at design flow, psi or ft	
	Flushing frequency	At the start of each dose and after every 5 minutes of pump run time; for ~ 15 seconds per filter
	Flushing criterion (max pressure loss, psi or ft)	not applicable
	Automatic or manual flushing cycles	automatic
	Continuous bleed flush? Rate (gal/min)	none
	Disposal method for the flush water	back to settling tank
	Failures or sign. problems (use "comments")	
Pressure Gauges		
	Model or type	none
	Locations (before/after filters)	
Valves		
	Model & size	BERMAD 1 in.
	Solenoid or manual	Solenoid (electrically operated hydraulic valve)
	Number of units	6 (2 per filter)
	Schematic showing function of each unit	Available at www.bermad.com
	Pressure loss at design flow, psi or ft	
	Failures or sign. Problems (use "comments")	
Air vent		
	Model & size	not applicable
	Location	

Comments:

System Name: Ten Mile Lake, Cass County, Minnesota
Pressure Regulator Details

Pres. Regulator		None used
	Model & size	
	Location(s)	
	Manufacturer's specifications provided?	
	Outlet pressure, psi	
	Failures or sign. Problems (use "comments")	
Bypass valve		Not applicable
	Model & size	
	Solenoid or manual	
	Pressure loss at design flow, psi or ft	

Comments:

Flush Tank

Tank		
	Inside dimensions (L:W:H) (in)	60 in. diameter, 65 in. to outlet pipe
	Volume (gal)	500
Risers		
	Type (inlet/outlet)	None/concrete
	Number (inlet/outlet)	None/1
	Height (inlet/outlet)	Not applicable/48 in.
	Diameter (inlet/outlet)	Not applicable/24 in.

Comments:

Checklist of Information for Drip Irrigation Systems (Case Studies)

Basic Facts

System Name: City of Spring Hill
Location: Spring Hill, Minnesota
Owner: City of Spring Hill
Designer/Engineer: Scott D. Wallace, North American Wetland Engineering, 20 N. Lake Street Suite 210, Forest Lake, MN 55025
Operator/Management Entity: City of Spring Hill
Date placed in operation: October 1999

System Details

Treatment System:

Type: Constructed Wetlands with Forced Bed Aeration™
Manufacturer: Custom constructed wetlands design by NAWE; patented Forced Bed Aeration™ by NAWE
Design Daily Flow: 9,200 gal/d
Actual Daily Flows (most recent 12-month period): Approximate flows are
Average 10,000 gal/d
Max 20,000 gal/d + (due to unresolved I&I)
Min 6,000 gal/d
Effluent Quality (concentrations and quantities for the most recent 12-month period): Average (mean or median as applicable), Max, & Min for each parameters monitored:

Sampling from 10-30-2000

Influent	Wetland Effluent
CBOD 317.5 mg/l	CBOD 51.7 mg/l
	Fecal Coliform 2200 cfu/100 ml
Total Phosphorus 7.9 mg/l	Total Phosphorus 4.2 mg/l
TSS 100.0 mg/l	TSS 29.0 mg/l

Summary of any compliance and operations problems: Higher than design flows and high sediment loads resulting from storm water inflow after a farmer knocked off the top section of a manhole in the collection system (a new conventional 8 in. gravity sewer). Fine sediment coated all fixtures and components within the drip dosing tanks. The affected portion of the collection system had to be hydraulically cleaned and the manhole repaired.

Drip System:

Dripline brand and model: Geoflow Wastewater PC (nominal flow of 1.02 gal/h) with 24 in. emitter spacing
Schematic or drawing of each zone with location, quantity, brand, and model or size of each component: Design drawings provided for the system layout (as-builts were not available). See the following tables for details.
Monitoring Data (most recent 12-month period): None available

Summary of any compliance and operations problems: No compliance problems. Most significant maintenance problem has been gophers cutting the driplines. Gopher control is a necessity. Localized effluent surfacing occurs in the dripfield where soil structure has been destroyed by a contractor truck traversing the field this past spring.

Costs:

Design $32,550 (including construction observation & wetland system design)

Construction (breakdown by major component if possible): From Bid Tabulation:

Item	Quantity	Unit Price	Amount
6,000-gallon Drip Irrigation Tank (inc. hatches)	1 LS	$9,270.00	$9,270.00
Drip Irrigation Pumps & Controls	1 LS	$13,300.00	$13,300.00
3 in. Sch. 40 PVC Pipe (inc. valves & fittings)	2700 lf	$2.60	$7,020.00
Drip Irrigation Tubing	21,000 lf	$2.15	$45,150.00
1 in. Schedule 40 PVC Pipe (inc. valves & fittings)	4300 lf	$2.05	$8,815.00
Pipe Insulation (inc. common trench piping)	1400 lf	$3.40	$4,760.00
Drip Irrigation Field Planting	1 LS	$8,830.00	$8,830.00
Site Seeding	3 acres	$2,520.00	$7,560.00
Fence	1950 LF	$4.40	$8,580.00
			$113,285.00

O&M Monitoring: Quarterly monitoring of wetland required under County operating permit. Cost not available.

Special Design Objectives or Approaches:

The system is designed to minimize the potential for freezing. The drainfield drains back to the dosing tanks between cycles. Tubing is laid level (with no sags) or with a slight slope back to the supply line. Supply and return headers are also sloped to drain back to the tank and are insulated with 2 in. Styrofoam SB (min R-10 value) encasing granular backfill around the pipe. Air/vacuum relief valves are also heavily insulated with Perlite (Styrofoam beads: loose around the valve base and bagged on top) covering river gravel used for base drainage under the valve box. Antifreeze drain-back valves (solenoid) are used on the supply pipe inside the dosing tanks. Continuous drainfield flushing and automatic drain-back of return pipes occurs through a partially open ball valve inside the dosing tanks. The 3-in. Netafim super filters also have continuous flushing with automatic drainage between dosing cycles via a partially open ball valve on the bottom of each filter.

Observations:

Each dosing tank was coated with sediment/silt from storm water inflow during the time that one of the collection system manholes was damaged by a farm tractor (see previous comments under the treatment system section. The high flows surcharged the wetlands treatment system as well as the DI dosing tanks. The 3-in. super filters would filter material coarser than 80 mesh (200 microns), but finer material would have been circulated through the drip system during high flow periods.

The air blowers for the constructed wetlands cells were inoperable during the site visit.

Wet soils around driplines:

Soil is saturated around tire ruts from a contractor's truck traversing the drip field during spring 2001. No other wet areas were noticed.

System Name: City of Spring Hill, Spring Hill, Minnesota
Drip Field Details

	Zone 1	Zone 2
Number of dripline laterals	18	18
Total length of dripline laterals, ft.	4200	4200
Number of loops per lateral	0	0
Longest lateral length, ft.	250	250
Dripper spacing, in.	24	24
Ave. lateral burial depth, in.	14 to 16 in.	14 to 16 in.
Installation method	chain trencher	chain trencher
Spacing of dripline laterals, in.	24	24
Maximum elevation difference between laterals and pump-off float, ft	21.5	17.5
Soil classification	clay	clay
Depth to restrictive layer, in.	mottling @ 55 to 57 in.	mottling @ 55 to 57 in.
Design HLR, gal/d/ft^2	0.2381	0.2381
Actual HLR, gal/d/ft^2		
Dosing flow rate, gal/min	40	40
Dosing time period, minutes	10 minutes every 30 minutes	10 minutes every 30 minutes
Doses per day at design flow (per zone)	24	24
Doses per day at average actual flow (per zone)		
Field flush flow rate, gal/min	not applicable	not applicable
Total zone flow rate, gal/min	40	40
Number of air/vacuum valves	2	2
Location of air/vacuum valves	end of supply & return manifolds (high point)	end of supply & return manifolds (high point)
Model/Size of air/vacuum valves	Geoflow 3/4 in.	Geoflow 3/4 in.
Zone valves, type/model/size	none	none
Elevation difference within zones, ft	6	4
Field flush valve type/model/number	1 in. gate valve for draining system after each dose (see comments)	1 in. gate valve for draining system after each dose (see comments)
Flushing criterion	not applicable	not applicable
Flushing frequency	not applicable	not applicable
Disposal method for the flush water	not applicable	not applicable
Supply pipe size & psi rating or sch, in./psi/sch	3 in. Schedule 40	3 in. Schedule 40
Supply pipe length (max, to zone manifold), ft.	330	290
Supply pipe depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Supply manifold length (max), ft.	34	34
Supply manifold depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Supply manifold design pressure, psi		
Return pipe size & psi rating or sch, in./psi/sch	1 in. Schedule 40	1 in. Schedule 40
Return pipe length (max, to zone manifold), ft.	570	520
Return pipe depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Return/flush manifold size and psi rating, in./psi	1 in. Schedule 40	1 in. Schedule 40
Return manifold length (max), ft.	34	34
Return manifold depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Return manifold pressure, psi		
Type of valve on return line	1 in. gate valve	1 in. gate valve
Primary species of vegetation.	Native grasses (Big Bluestem, Side	Native grasses (Big Bluestem,

	Zone 1	Zone 2
	Oats Grama, Indian Grass, Switchgrass) plus trees (~15 species with majority Hybrid Poplar DN34)	Side Oats Grama, Indian Grass, Switchgrass) plus trees (~15 species with majority Hybrid Poplar DN34)
Typical mowing frequency	3 times per growing season for first 3 years	3 times per growing season for first 3 years
Striping severity	slight	slight
Degree of soil wetness	Low except around tire ruts	Low except around tire ruts
Type of fencing	3 ft tall steel wire	3 ft tall steel wire
Failures or sign. Problems (use "comments")		

Comments

Most significant maintenance problem has been gophers cutting the driplines. Gopher control is a necessity.

Localized effluent surfacing occurs in the dripfield where soil structure has been destroyed by a contractor truck traversing the field this past spring (Zones 1, 2 and 3).

Each drip zone is designed to drain following the wastewater dose cycle. The supply line is drained using a 1 in. solenoid valve following the 3 in. Super Filter. The electric actuator for each valve was removed at the time of the visit so that drain-back was not occurring. The actuators would be replaced before winter to allow drain-back and prevent freezing. The return line is drained through the 1 in. gate valve at the end of the line (in the dosing tank). This valve is always cracked open so that flushing also occurs during dosing. Design operating pressure for the drip zone is obtained by adjusting this gate valve.

System Name: City of Spring Hill, Spring Hill, Minnesota
Drip Field Details

	Zone 3	Zone 4
Number of dripline laterals	18	18
Total length of dripline laterals, ft.	4200	4200
Number of loops per lateral	0	0
Longest lateral length, ft.	250	250
Dripper spacing, in.	24	24
Ave. lateral burial depth, in.	14 to 16 in.	14 to 16 in.
Installation method	chain trencher	chain trencher
Spacing of dripline laterals, in.	24	24
Maximum elevation difference between laterals and pump-off float, ft	14.5	27.5
Soil classification	clay	clay
Depth to restrictive layer, in.	mottling @ 55 to 57 in.	mottling @ 55 to 57 in.
Design HLR, gal/d/ft^2	0.2381	0.2381
Actual HLR, gal/d/ft^2		
Dosing flow rate, gal/min	40	40
Dosing time period, minutes	10 minutes every 30 minutes	10 minutes every 30 minutes
Doses per day at design flow (per zone)	24	24
Doses per day at average actual flow (per zone)		
Field flush flow rate, gal/min	not applicable	not applicable
Total zone flow rate, gal/min	40	40
Number of air/vacuum valves	2	2
Location of air/vacuum valves	end of supply & return manifolds (high point)	end of supply & return manifolds (high point)
Model/Size of air/vacuum valves	Geoflow 3/4 in.	Geoflow 3/4 in.
Zone valves, type/model/size	none	none
Elevation difference within zones, ft	2.5	10
Field flush valve type/model/number	1 in. gate valve for draining system after each dose (see comments)	1 in. gate valve for draining system after each dose (see comments)
Flushing criterion	not applicable	not applicable
Flushing frequency	not applicable	not applicable
Disposal method for the flush water	not applicable	not applicable
Supply pipe size & psi rating or sch, in./psi/sch	3 in. Schedule 40	3 in. Schedule 40
Supply pipe length (max, to zone manifold), ft.	250	590
Supply pipe depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Supply manifold length (max), ft.	34	34
Supply manifold depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Supply manifold design pressure, psi		
Return pipe size & psi rating or sch, in./psi/sch	1 in. Schedule 40	1 in. Schedule 40
Return pipe length (max, to zone manifold), ft.	480	850
Return pipe depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Return/flush manifold size and psi rating, in./psi	1 in. Schedule 40	1 in. Schedule 40
Return manifold length (max), ft.	34	34
Return manifold depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold
Return manifold pressure, psi		
Type of valve on return line	1 in. gate valve	1 in. gate valve
Primary species of vegetation.	Native grasses (Big Bluestem, Side	Native grasses (Big Bluestem,

	Zone 3	**Zone 4**
	Oats Grama, Indian Grass, Switchgrass) plus trees (~15 species with majority Hybrid Poplar DN34)	Side Oats Grama, Indian Grass, Switchgrass) plus trees (~15 species with majority Hybrid Poplar DN34)
Typical mowing frequency	3 times per growing season for first 3 years	3 times per growing season for first 3 years
Striping severity	slight	slight
Degree of soil wetness	Low except around tire ruts	Low except around tire ruts
Type of fencing	3 ft tall steel wire	3 ft tall steel wire
Failures or sign. Problems (use "comments")		

Comments

Most significant maintenance problem has been gophers cutting the driplines. Gopher control is a necessity.

Localized effluent surfacing occurs in the dripfield where soil structure has been destroyed by a contractor truck traversing the field this past spring (Zones 1, 2 and 3).

Each drip zone is designed to drain following the wastewater dose cycle. The supply line is drained using a 1 in. solenoid valve following the 3 in. Super Filter. The electric actuator for each valve was removed at the time of the visit so that drain-back was not occurring. The actuators would be replaced before winter to allow drain-back and prevent freezing. The return line is drained through the 1 in. gate valve at the end of the line (in the dosing tank). This valve is always cracked open so that flushing also occurs during dosing. Design operating pressure for the drip zone is obtained by adjusting this gate valve.

System Name: City of Spring Hill, Spring Hill, Minnesota
Drip Field Details

	Zone 5	
Number of dripline laterals	18	
Total length of dripline laterals, ft.	4200	
Number of loops per lateral	0	
Longest lateral length, ft.	250	
Dripper spacing, in.	24	
Ave. lateral burial depth, in.	14 to 16 in.	
Installation method	chain trencher	
Spacing of dripline laterals, in.	24	
Maximum elevation difference between laterals and pump-off float, ft	23.5	
Soil classification	clay	
Depth to restrictive layer, in.	mottling @ 55 to 57 in.	
Design HLR, gal/d/ft^2	0.2381	
Actual HLR, gal/d/ft^2		
Dosing flow rate, gal/min	40	
Dosing time period, minutes	10 minutes every 30 minutes	
Doses per day at design flow (per zone)	24	
Doses per day at average actual flow (per zone)		
Field flush flow rate, gal/min	not applicable	
Total zone flow rate, gal/min	40	
Number of air/vacuum valves	2	
Location of air/vacuum valves	end of supply & return manifolds (high point)	
Model/Size of air/vacuum valves	Geoflow 3/4 in.	
Zone valves, type/model/size	none	
Elevation difference within zones, ft	9	
Field flush valve type/model/number	1 in. gate valve for draining system after each dose (see comments)	
Flushing criterion	not applicable	
Flushing frequency	not applicable	
Disposal method for the flush water	not applicable	
Supply pipe size & psi rating or sch, in./psi/sch	3 in. Schedule 40	
Supply pipe length (max, to zone manifold), ft.	550	
Supply pipe depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	
Supply manifold length (max), ft.	34	
Supply manifold depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	
Supply manifold design pressure, psi		
Return pipe size & psi rating or sch, in./psi/sch	1 in. Schedule 40	
Return pipe length (max, to zone manifold), ft.	820	
Return pipe depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	
Return/flush manifold size and psi rating, in./psi	1 in. Schedule 40	
Return manifold length (max), ft.	34	
Return manifold depth, in.	Varies; sloped for drain-back to tank, starting at ~18 to 24 in. deep at the A/V value on the manifold	
Return manifold pressure, psi		
Type of valve on return line	1 in. gate valve	
Primary species of vegetation.	Native grasses (Big Bluestem, Side Oats Grama, Indian Grass,	

	Zone 5	
	Switchgrass) plus trees (~15 species with majority Hybrid Poplar DN34)	
Typical mowing frequency	3 times per growing season for first 3 years	
Striping severity	slight	
Degree of soil wetness	Low except around tire ruts	
Type of fencing	3 ft tall steel wire	
Failures or sign. Problems (use "comments")		

Comments

Most significant maintenance problem has been gophers cutting the driplines. Gopher control is a necessity.

Each drip zone is designed to drain following the wastewater dose cycle. The supply line is drained using a 1 in. solenoid valve following the 3 in. Super Filter. The electric actuator for each valve was removed at the time of the visit so that drain-back was not occurring. The actuators would be replaced before winter to allow drain-back and prevent freezing. The return line is drained through the 1 in. gate valve at the end of the line (in the dosing tank). This valve is always cracked open so that flushing also occurs during dosing. Design operating pressure for the drip zone is obtained by adjusting this gate valve.

System Name: City of Spring Hill, Spring Hill, Minnesota
Dosing System Details

Tank		
	Inside dimensions (L:W:H) (in, to max water level)	211:86:80
	Volume (gal)	6000
Risers		
	Type (inlet/outlet)	none/concrete
	Number (inlet/outlet)	none/3
	Height (inlet/outlet)	not applicable/36 in.
	Diameter (inlet/outlet)	not applicable/48 in.
Pumps		
	Model	Myers J1035BE
	Number of units	5
	Single, Series, or Alternating	Single to each zone
	Flow at design TDH for zone operation (gal/min)	40
	Design TDH for zone operation (ft)	80
	Flow for filter flushing (gal/min)	NA
	Design TDH for filter flushing (ft)	NA
	Depth of pump intake (relative to bottom, in)	~12
	Service or maintenance frequency	
	Failures or sign. problems (use "comments")	
Floats		
	Red. off or low-water alarm/merc. or mech.	Red. off, alarm activation/mercury
	Timer override/merc. or mech.	Yes/mercury
	Pump off/mercury or mechanical	No
	Pump on/mercury or mechanical	No
	High-water mult. pumps on/merc. or mech.	No
	High-water alarm/mercury or mechanical	Yes/mercury
	Failures or sign. problems (use "comments")	
Timer		
	Model	SJE-Rhombus
	Programmable	yes
	Design dosing interval, min.	10 minutes every 30 minutes
	Actual dosing interval, min.	
Control Panel		
	Model	SJE-Rhombus TD (custom)
	Float functions (as listed/checked above)	As listed above
	Pump dosing cycles (timer or volume)	timer
	Motor-start contactor	yes
	Duplex alternator	yes
	Manual pump switch	yes
	Filter flush cycles	no
	Field flush cycles (short: per cycle or zone)	no
	Field flush cycles (complete system)	no
	Elapsed time meter for pumps	yes
	Cycle counter for pumps	yes
	Circuit breaker for controls power	yes
	Alarms (visual/audible/both)	both
	Alarm silence relay	yes
	Remote system monitoring (attach details)	no

Comments

System Name: City of Spring Hill, Spring Hill, Minnesota
Filter System Details

Filters		
	Model & size	Netafim 3 in. ↓ Super Filter (80-mesh) w/ball valve on drain
	Number of units	1 for each zone
	Manufacturer's specifications	see Netafim brochure in Appendix D
	Pressure loss at design flow, psi or ft	
	Flushing frequency	quarterly unless a problem is observed
	Flushing criterion (max pressure loss, psi or ft)	not applicable
	Automatic or manual flushing cycles	manual disassembly and cleaning
	Continuous bleed flush? Rate (gal/min)	continuous @ ~ 5 gal/min
	Disposal method for the flush water	back to dosing tank
	Failures or sign. problems (use "comments")	
Pressure Gauges		
	Model or type	none
	Locations (before/after filters)	
Valves		
	Model & size	not applicable
	Solenoid or manual	
	Number of units	
	Schematic showing function of each unit	
	Pressure loss at design flow, psi or ft	
	Failures or sign. problems (use "comments")	
Air vent		
	Model & size	not applicable
	Location	

Comments:

System Name: City of Spring Hill, Spring Hill, Minnesota
Pressure Regulator Details

Pres. Regulator		None used
	Model & size	
	Location(s)	
	Manufacturer's specifications provided?	
	Outlet pressure, psi	
	Failures or sign. problems (use "comments")	
Bypass valve		Not applicable
	Model & size	
	Solenoid or manual	
	Pressure loss at design flow, psi or ft	

Comments:

Flush Tank

Tank		Dosing tank is used
	Inside dimensions (L:W:H) (in)	
	Volume (gal)	
Risers		See dosing tank
	Type (inlet/outlet)	
	Number (inlet/outlet)	
	Height (inlet/outlet)	
	Diameter (inlet/outlet)	

Comments:

B

APPENDIX B—GLOSSARY AND ACRONYMS

The following terms are used in or are relevant to this document. The definition or meaning for most of the terms has been copied or adapted from existing sources. Where applicable, copied terms include the reference for each source at the end of each term. Each source is identified at the end of this appendix.

Activated sludge process: A biological wastewater treatment process in which biologically active sludge is agitated and aerated with incoming wastewater. The activated sludge is subsequently separated from the treated wastewater (mixed liquor) by sedimentation, and most of it is returned to the process. The rest is wasted as needed. [1]

Advanced treatment: Removal of dissolved and suspended materials remaining after normal biological treatment when required for water reuse or for the control of eutrophication in receiving waters. [5]

Aerobic: Having molecular oxygen as a part of the environment, or growing or occurring only in the presence of molecular oxygen, as in “aerobic organisms.” [1]

Aerobic treatment unit (ATU): A mechanical on-site treatment unit that provides secondary wastewater treatment by mixing air (oxygen) and aerobic and facultative microbes with the wastewater. ATUs typically use a suspended growth treatment process (similar to activated sludge extended aeration) or a fixed film treatment process (similar to trickling filter). [1]

Air/Vacuum (A/V) relief valve: A valve that automatically lets air out of or into a liquid-carrying pipe (provides vacuum or air release) as needed in response to changes in system pressure. [2]

Alternative on-site wastewater treatment system: An on-site treatment system that includes components different from those used in a conventional septic tank and drainfield system. An alternative system is used to achieve acceptable treatment and dispersal/discharge of wastewater where conventional systems may not be capable of meeting established performance requirements to protect public health and water resources (e.g., at sites where high ground water, low-permeability soils, shallow soils, or other conditions limit the infiltration and dispersal of wastewater or where additional treatment is needed to protect ground water or surface water quality). Components that might be used in alternative systems include sand filter, aerobic treatment units, disinfection devices, and alternative systems such as mounds, gravelless trenches, and pressure and drip distribution. [1]

AMC: American Manufacturing Company, Inc.

Anaerobic: Characterized by the absence of molecular oxygen, or growing in the absence of molecular oxygen (as in "aerobic bacteria"). [1]

Backwash: The process of flow reversal to clean a filter and to restore it to the normal clean condition for filtering with a minimum resistance to flow through the media or screen. [2]

Biochemical Oxygen Demand (BOD): A commonly used gross measurement of the concentration of biodegradable organic impurities in wastewater. The amount of oxygen, expressed in milligrams per liter (mg/l), required by bacteria while stabilizing, digesting, or treating organic matter under aerobic conditions is determined by the availability of material in the wastewater to be used as biological food and the amount of oxygen used by the microorganisms during oxidation of matter in a wastewater. [1]

Biomat: The layer of biological growth and inorganic residue that develops at the wastewater-soil interface and extends up to about 1 inch into the soil matrix. The biomat controls the rate at which pretreated wastewater moves through the infiltrative surface/zone for coarse- to medium-textured soils. This growth may not control fluxes through fine clay soils, which are more restrictive to wastewater flows than the biomat. [1]

CAD: Computer-aided design

Clay: A textural class of soils consisting of particles less than 0.002 millimeters in diameter. [1]

Coliform: One type of bacteria. The presence of coliform-type bacteria is an indication of possible pathogenic bacterial contamination. Fecal coliforms are those coliforms found in the feces of various warm-blooded animals, whereas the term coliform also includes other environmental sources. [5]

Consistence: Attribute of soil expressed in degree of cohesion and adhesion, or in resistance to deformation or rupture. Consistence includes the resistance of soil material to rupture; resistance to penetration; the plasticity, toughness, or stickiness of puddled soil material; and the manner in which the soil material behaves when subjected to compression. General classifications of soil consistence include loose, friable, firm, and extremely firm. [1]

Constituent: Individual components, elements, or biological entities such as suspended solids or ammonia nitrogen. [5]

Contaminants: Constituents added to the water supply through use. [5]

Contour loading rate: The cumulative linear loading for all of the driplines placed along the contours of the site (the linear loading rate multiplied by the number of driplines). This rate needs to be considered for sites with a shallow restrictive layer where horizontal flow may be important.

Control panel: An electronic control panel that controls the quantity and time of dose. This can also control the zone receiving effluent, automatically flushes the lines, flushes the filters, monitors the flow rate into a drip zone and pump run times. [4]

Conventional on-site system: A wastewater treatment system consisting of a septic tank and subsurface wastewater infiltration system. [1]

Decentralized system: On-site and/or cluster wastewater systems used to treat and disperse or discharge small volumes of wastewater, generally from dwellings and businesses that are located relatively close together. Decentralized systems in a particular management area or jurisdiction are managed by a common management entity. [1]

Demand dosing: A dosing method based on starting and stopping a pump using floats in the dosing tank. The pump is started when the wastewater level rises sufficiently to activate the pump "on" float and ends when the wastewater level drops sufficiently to activate the pump "off" float. The volume of water pumped or dosed depends on tank dimensions, float elevation levels, and the amount of any inflow to the tank during a dose cycle.

DEP: Delta Environmental Products, Inc.

Depressurized flow: Water exiting the emitters after the pump has ceased to operate. [4]

Denitrification: The biochemical reduction of nitrate or nitrate to gaseous molecular nitrogen or an oxide of nitrogen. [1]

Detention time: The period of time that a water or wastewater flow is retained in a basin, tank, or reservoir for storage or completion of physical, chemical, or biological reaction. [5]

Disk filter: A type of filter that utilizes a series of grooved rings that overlay each other to from a network of very small openings to trap contaminants. [2]

Dissolved oxygen (DO): The oxygen dissolved in water, wastewater, or other liquid, usually expressed in milligrams per liter (mg/l), parts per million (ppm), or percent of saturation. [1]

Distributing valve: A valve that distributes flow to multiple drainfield laterals, zones, or locations by automatically rotating upon each pump cycle. [2]

Dosing tank: A tank that collects treated effluent and periodically discharges it into another treatment/disposal component, depending upon the needs and design of the particular on-site sewage system. [3]

Drainfield: Shallow, covered, excavation made in unsaturated sol into which pretreated wastewater is discharged through distribution piping for application onto soil infiltration surfaces through porous media or manufactured (gravelless) components placed in the excavations. The soil accepts, treats, and disperses wastewater as it percolates through the soil, ultimately discharging to groundwater. [1]

Drain-Back: The process of effluent draining along the laterals and manifolds after the pump shuts off. Drainage occurs both inside and outside of the drip tubing and manifolds to lower elevations in the drip field. The additional water may saturate the soil and cause breakout of effluent on the surface.

Draindown: The action of effluent left in the distribution system, after the pump shuts off, that drains by gravity to the lower lines in the system. [3]

Dripline: The dripline is a polyethylene tube that comes in large coils. Internal emitters are embedded regularly along the length of the tube. Typical emitter spacings include 12, 18, and 24 inches. [4]

Effluent: Sewage, water, or other liquid, partially or completely treated or in its natural state, flowing out of a septic tank, subsurface wastewater infiltration system, aerobic treatment unit, or other treatment system or system component. [1]

Emitters: Small diameter openings in dripline that can dissipate pressure and allow a slow, controlled discharge (rated in gallons per hour). [2]

EPA: Environmental Protection Agency

Evapotranspiration: The combined loss of water from a given area and during a specified period of time by evaporation from the soil or water surface and by transpiration from plants. [1]

Failure: A condition of an on-site sewage system that threatens the public health by inadequately treating sewage or creating a potential for direct or indirect contact between sewage and the public. Examples of failure include:

(a) Sewage on the surface of the ground.

(b) Sewage backing up into a structure caused by slow absorption of septic tank effluent.

(c) Sewage leaking from a septic tank, pump chamber, holding tank, or collection system.

(d) Cesspool or seepage pits where evidence of groundwater or surface water quality degradation exists.

(e) Inadequately treated effluent contaminating groundwater or surface water.

(f) Noncompliance with standards stipulated on the permit. [2]

Fats, oils, & greases (FOG): FOG is a measure of the amount of fatty matter from animal and vegetable sources and hydrocarbons from petroleum products and waxes, such as from lotions, shampoos, and tanning oils. High levels of fats, oils, and greases in the wastewater stream may interfere with wastewater treatment efficiency. [3]

Fecal coliform: Indicator bacteria common to the digestive systems of warm-blooded animals that is cultured in standard tests to indicate contamination form sewage or level of disinfection. Generally measured as colonies/100 ml. [5]

Field flush: Water is passed through the drip laterals for the purpose of removing particles from the inside of the drip tubing. Water is carried through the return manifold and return line back to the pretreatment device. [4]

Filter: A device or structure for removing suspended solid or colloidal material from wastewater. [2]

Fixed-film wastewater treatment system: A biological wastewater treatment process that employs a medium such as rock, plastic, wood, or other natural or synthetic solid material that will support biomass on its surface. Fixed-film systems include those in which the medium is held in place and is stationary relative to fluid flow (trickling filter), those in which the medium is in motion relative to the wastewater (e.g., rotating biological disk), and dual process systems that include both fixed and suspended biomass together or in a series. [1]

Flow equalization: Storage of effluent peak flows to provide for even time dosing of dripper lines. It is designed into system by the distance between the enable float and the alarm float. [3]

Footprint loading rate: The hydraulic or contaminant loading rate applied to the area containing the drip field. The hydraulic rate is typically expressed in terms of gallons per day per square foot and the contaminant rate is expressed in terms of pounds per day per square foot.

French drain: An underground passageway for water through the interstices among stones placed loosely in a trench. [5]

GA EPD: Georgia Department of Natural Resources, Environmental Protection Division

Groundwater: When determining the presence of groundwater in the soil treatment area, it is at a depth where saturated soil exists or where the soil exhibits signs of seasonal saturation. [4]

Hydraulic conductivity: As applied to soils, the ability of the soil to transmit water in liquid from through pores. [1]

Hydraulic loading rate (HLR): An empirically derived design and operating parameter that relates to ponding, surface shearing rate, and hydraulic detention time. Usually reported in units of volume of wastewater (including recycle) per unit cross-sectional area per day. [5]

Infiltration: The flow or movement of water through the interstices of pores of soil or other porous medium. [5]

Infiltrative surface: The area where free water meets the soil surface.

Infiltrative loading rate: The hydraulic or contaminant loading rate applied to the infiltrative surface area. The hydraulic rate is typically expressed in terms of gallons per day per square foot and the contaminant rate is expressed in terms of pounds per day per square foot.

Influent: Wastewater, partially or completely treated, or in its natural state (raw wastewater), flowing into a reservoir, tank, treatment unit, or disposal unit. [2]

Inorganic: The minerals, salts, etc. present in wastewater not attributed to carbon molecules of the organic. Examples include iron, silver, lead, sodium. [5]

Instantaneous loading rate: The rate at which the wastewater is dripped to the available infiltrative surface of the soil. This is the drip emitter rate divided by the infiltrative surface with units of gallons per hour per square foot or inches of water per hour. If the rate is higher than the soil can move away from the emitter by gravity and matrix potential, the soil will saturate. The volume of soil that saturates depends on the amount of time that the emitter continues to discharge. In general, short dose times or smaller emitter discharge rates (i.e., smaller instantaneous loading rates) are needed to minimize saturation in fine soils. The total instantaneous loading is the instantaneous loading rate multiplied by the dose time (gal/ft^2). The infiltrative surface area used in the calculations has not been standardized. Some use the footprint area for each emitter while others estimate the actual wetted surface.

Lateral: One run or a series of runs connected at one end to a supply manifold and the other end connected to a return manifold. [3]

Limiting factor: The condition that limits treatment capacity usually either groundwater or bedrock. [5]

Linear loading rate: The quantity of effluent applied along the length of the drip field or zone along the contour expressed in gallons per day per linear foot of system. [4]

Management entity: An entity similar to a responsible management entity, but managing a limited set of management activities (e.g., homeowners association, contracted provider of management services). [1]

Matric potential: the attraction of the soil solids (matric) for water. There is an inverse relationship between soil moisture and matric potential: higher matrix potentials correspond to lower moisture content, but the relative difference is based on particle size. [6]

Mesh: A parameter used to describe the size of screen openings or the size of particles that can be passed through a screen, usually in terms of the number of openings occurring per linear inch. [2]

Monitoring: Periodic inspection of system for performance. [3]

Mottling: Spots or blotches of different colors or shades of color interspersed with the dominant soil color caused in part by exposure to alternating unsaturated and saturated conditions. [1]

Nitrification: The biochemical oxidation of ammonium to nitrate. [1]

NOWRA: National On-Site Wastewater Recycling Association

NPDES: National Pollutant Discharge Elimination System

Nutrients: The minerals and other materials that provide food for living organisms. Traditionally, nitrogen, phosphorus, and potassium are thought of as the most important elemental nutrients for streams and lakes. [5]

O&M: Operation and maintenance

Organic: The molecules, cells, etc. in wastewater from living organisms based on elemental carbon. [5]

Organic soil: A soil that contains a high percentage (more than 15 to 20 percent) of organic matter throughout the soil column. [1]

Orifice: Discharge hole in the drip tubing.

Package plant: Term commonly used to describe an aerobic treatment unit serving multiple dwellings or an education, health care, or other large facility. [1]

Parameter: A measurable factor such as temperature. [5]

Particle size: The effective diameter of a particle, usually measured by sedimentation or sieving. [1]

Pathogens: Microorganisms that cause infectious diseases.

PE: Polyethylene

Percolation: The flow or trickling of a liquid downward through a contact or filtering medium. [1]

Performance-based management program: A program designed to preserve and protect human health and environmental resources by focusing on the achievement of specific, measurable performance requirements based on site assessments. [1]

Performance boundaries: The point at which a wastewater treatment performance requirement corresponding to the desired level of treatment at that point in the treatment sequence is applied. Performance boundaries can be designated at the discharge point of the pretreatment system (e.g., septic tank, package plant discharge to surface waters), at physical boundaries in the receiving environment (impermeable strata, ground water table), at a point of use (ground water well), or at a property boundary. [1]

Performance requirement: Any requirement established by the regulatory authority to ensure future compliance with the public health and environmental goals of the community. Performance requirements can be expressed as numeric limits (e.g., pollutant concentrations, mass loads, wet weather flows, structural strength) or narrative descriptions of desired performance, such as no visible leaks or no odors. [1]

Permeable: Having pores or openings that permit liquids or gases to pass through. [5]

Permeability: The ability of a porous medium such as soil to transmit fluids or gases. [1]

pH: A measure of the acid or base quality of water that is the negative log of the hydrogen ion concentration. The scale ranges from 1 – 14. A pH of 7.0 is neutral with 13.0 being very basic and 1.0 being very acidic. [5]

Platy structure: Laminated or flaky soil aggregate developed predominantly along the horizontal axes. [1]

Pressure compensating (PC) emitters: Drip emitters that allow a constant discharge over a wide range of applied pressures. A pressure regulator is not needed with this type of emitter when system pressure is maintained (determined by pump selection) within the range recommended by the manufacturer. [2]

Pressure distribution: A system of small diameter pipes equally distributing effluent through a trench or bed. [5]

Pressure regulator: A device used to regulate and maintain pressure within a specified range in a piping system. Required to control discharge with turbulent flow emitters. [2]

Pretreatment: Conditioning of effluent prior to dispersal by drip system. [3]

PRT: Peer review team

Primary treatment: Removal of a portion of the suspended solids and organic matter from the wastewater. [5]

Primary treatment tank: A passive method of treating wastewater that involves physical processes such as screening and sedimentation to remove floating and settling solids such as occurs in a septic. [2]

PVC: Polyvinyl chloride

Raw wastewater: Wastewater before it receives any treatment. [2]

Reduced conditions: Zones in a soil that do not contain free oxygen and that exhibit chemical reduction of mineral elements, particularly iron and manganese. These areas typically have a bleached, grayish hue and include areas with mottling.

Residual sewage: Sewage having the consistency and strength typical of wastewater from domestic households. [2]

Restrictive layer: A stratum impeding the vertical movement of water, air, and growth of plant roots, such as hardpan, clay pan, fragipan, caliche, some compacted soils, bedrock and unstructured clay soils. [2]

Return line: The return line connects the return manifold to the pretreatment unit for the purpose of carrying flush water from the drip field. [4]

Return manifold: A collection manifold or the piping that returns liquid and debris to the primary treatment tank during system flushes. [2]

Robust technology: A technology that has stable or consistent performance with minimal operator attention for a wide range of influent wastewater characteristics.

Routine servicing: Servicing all system components as needed, including product manufacturer's requirements/recommendations for service. [2]

RSF: Recirculating sand filter

Run: One continuous length of tubing run across contour connected to a supply line or return line or another run. [3]

Sand filter: A biological and physical wastewater treatment component consisting (generally) of an under drained bed of sand, to which pretreated effluent is periodically applied. Filtrate collected by the under drains is then disposed of by an approved soil absorption system. Pretreatment can be provided by a septic tank or another approved treatment component. An Intermittent Sand Filter is a sand filter in which pretreated wastewater is applied periodically providing intermittent periods of wastewater application, followed by periods of drying and oxygenation of the filter bed. A Recirculating Sand (Gravel) Filter is a sand (gravel) filter that processes liquid waste by mixing filtrate with incoming septic tank effluent and recirculating it several times through the filter media before discharging to a final treatment/disposal unit. Sand-Lined Drainfield Trench is a combination of a pressure distribution drainfield and an intermittent sand filter consisting of a 2-foot layer of intermittent sand filter media placed directly below the drain rock layer in the pressure distribution drainfield trench. A Bottomless Sand Filter is a special case of a sand-lined drainfield trench installed in a containment vessel and is usually used to utilize more suitable soils high in the soil profile for disposal. [2]

SDD: Subsurface drip distribution

Secondary treatment: A method of treating wastewater in which biological and chemical processes are used to remove most of the organic matter. [2]

Septic tank: A watertight pretreatment receptacle receiving sewage discharge from a building sewer, designed and constructed to permit separation of settleable and floating solids from the liquid, detention, and anaerobic/facultative digestion of organic matter prior to discharge of the liquid. [2]

Sewage: Any urine, feces, and the water carrying human wastes including kitchen, bath, and laundry wastes from residences, buildings, industrial establishments or other places. For the purposes of this document, "sewage" is generally synonymous with domestic wastewater. Also see "residential sewage." [2]

Silt: A textural class of soils consisting of particles between 0.05 and 0.002 millimeters in diameter. [1]

Soil horizon: A layer of soil or soil material approximately parallel to the land surface and different from adjacent layers in physical, chemical, and biological properties or characteristics such as color, structure, texture, consistence, and pH. [1]

Soil map: A map showing the distribution of soil types or other soil mapping units in relation to the prominent physical and cultural features of the earth's surface. [1]

Soil morphology: The physical constitution, particularly the structural properties, of a soil profile as exhibited by the kinds, thickness, and arrangement of the horizons in the profile and by the texture, structure, consistence, and porosity of each horizon. [1]

Soil structure: The combination or arrangement of individual soil particles into definable aggregates, or peds, which are characterized and classified on the basis of size, shape, and degree of distinctness. [1]

Soil survey: The systematic examination, description, classification, and mapping of soils in an area. [1]

Soil texture: The relative proportions of the various soil separates (e.g., silt, clay, sand) in a soil. [1]

Soil water: A general term emphasizing the physical rather than the chemical properties and behavior of the soil solution. [1]

Solenoid valve: An electric valve actuated by a solenoid, used for controlling the flow of liquid in pipes. [2]

Spin filter: Spin filters consist of a screen cylinder enclosed in a casing. For small drip systems, the filters range in size from 3/4 in. to 1 1/2 in. with a typical mesh size of 150 and micron rating of 104. Other sizes and openings are available. [4]

Static plow: A static plow is a dripline plow with a shank that remains at a given depth as the plow is pulled through the soil. [4]

Subsoil: In general, that part of the soil below the depth of plowing. [1]

Supply line: The supply line extends from the pump/hydraulic unit to the supply manifold of a given zone. [4]

Supply manifold: The supply manifold connects the supply line to a series of drip laterals. [4]

TDH: Total dynamic head

Telemetry system: Transmits system performance information measured by sensors to a remote location by means of wires or electromagnetic waves. [2]

Timer controlled system: A pressure distribution system where pump on and off times are preset, discrete time periods. [2]

Topsoil: The layer of soil moved in agricultural cultivation. [2]

Total Suspended Solids: Suspended solids refer to the dispersed particulate matter in a wastewater sample that may be retained by a filter medium. Suspended solids may include both settleable and unsettleable solids of both inorganic and organic origin. This parameter is widely used to monitor the performance of the various stages of wastewater treatment, often used in conjunction with BOD_5 to describe wastewater strength. The test consists of filtering a known volume of sample through a weighed filter membrane that is then dried and reweighed. [2]

Toxicity: The adverse effect that a biologically active substance has at some concentration on a living entity. [5]

Treatment system: Any technology or combination of technologies (treatment trains or unit processes) that discharges treated wastewater to surface waters, ground water, or the atmosphere. [1]

Turbulent flow emitters: Drip emitters that allow a varying discharge depending on the pressure applied (flow rate increases as system pressure increases). A pressure regulator is required with this type of emitter to ensure discharge is in accordance with design. [2]

TVA: Tennessee Valley Authority

Unsaturated flow: Movement of water in a soil that is not filled to capacity with water. [1]

Vertical separation: The depth of unsaturated, original, undisturbed soil between the bottom of a disposal component and the highest seasonal water table or a restrictive layer. [2]

Vibratory plow: A vibratory plow is a dripline plow with a shank that oscillates vertically as the plow is pulled through the soil. [4]

Wastewater: Water-carried human excreta and/or domestic waste from residences, buildings, industrial establishments or other facilities (see sewage). [2]

Water table: The level in saturated soil at which the hydraulic pressure is zero. [1]

WWSI: Waste Water Systems, Inc.

Zero discharge: Complete recycling of water; discharge of essentially pure water; discharge of a treated effluent containing no substance at a concentration higher than that found normally in the local environment. [5]

Zone: A group of laterals dosed at the same time. [3]

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C

APPENDIX C—GEOFLOW GUIDELINES

GEOFLOW

Wastewater
Design, Installation
and Maintenence Guidelines

(800) 828-3388

www.geoflow.com

Updated Sept. 2003

GEOFLOW

Design, Installation and Maintenance Guidelines

Subsurface Drip for Onsite Wastewater Reuse and Dispersal

October 2003

INTRODUCTION

Geoflow's WASTEFLOW®[1] drip system disperses effluent below the ground surface through 1/2″ pressurized pipes. It is designed using the grid concept with supply and flush manifolds at each end creating a closed loop system. The grid design provides a complete subsurface wetted area.

The objective with effluent dispersal is usually to disperse the effluent using the minimum area as quickly and safely as possible at an approximately uniform rate throughout the year. If the main purpose of the Geoflow system is to irrigate, then please use the standard irrigation manual for landscape available from Geoflow, Inc.

Subsurface drip is a highly efficient method to dispose of effluent. Small, precise amounts of water are uniformly applied under the soil surface from multiple points.

The main advantages of Geoflow's subsurface drip system for effluent dispersal are:

- Human and animal contact with effluent is minimized, reducing health risks.
- Correctly designed systems will not cause puddling or runoff.
- It can be used under difficult circumstances of high water tables, tight soils, rocky terrain, steep slopes, around existing buildings, trees or other vegetation, and on windy sites.
- Disposal of water is maximized by means of evapotranspiration.
- The system requires no gravel. It is easy to install directly into indigenous soils and the natural landscape can be maintained.
- Minimizes deep percolation.
- Consumption of nitrates by the plant material is increased.
- Invisible and vandal proof installations.
- Ten-year warranty for root intrusion, workmanship and materials. Systems are durable with a long expected life.
- Non intrusive. It allows use of the space while operating.
- Easily automated.
- Effluent can be re-used for irrigation.

NOTES

- These guidelines are for secondary treated effluent When using primary treated effluent, Geoflow recommends automating all the self flushing valves, and increasing the number of emission points in the dispersal field. For more information on septic tank dispersal, please check our website at www.geoflow.com or telephone Geoflow at 800-828-3388.
- Please follow your State and County Regulations for onsite wastewater dispersal. This manual is intended to be a guide to users of the Geoflow drip system and should be used only as a supplement to your local regulations

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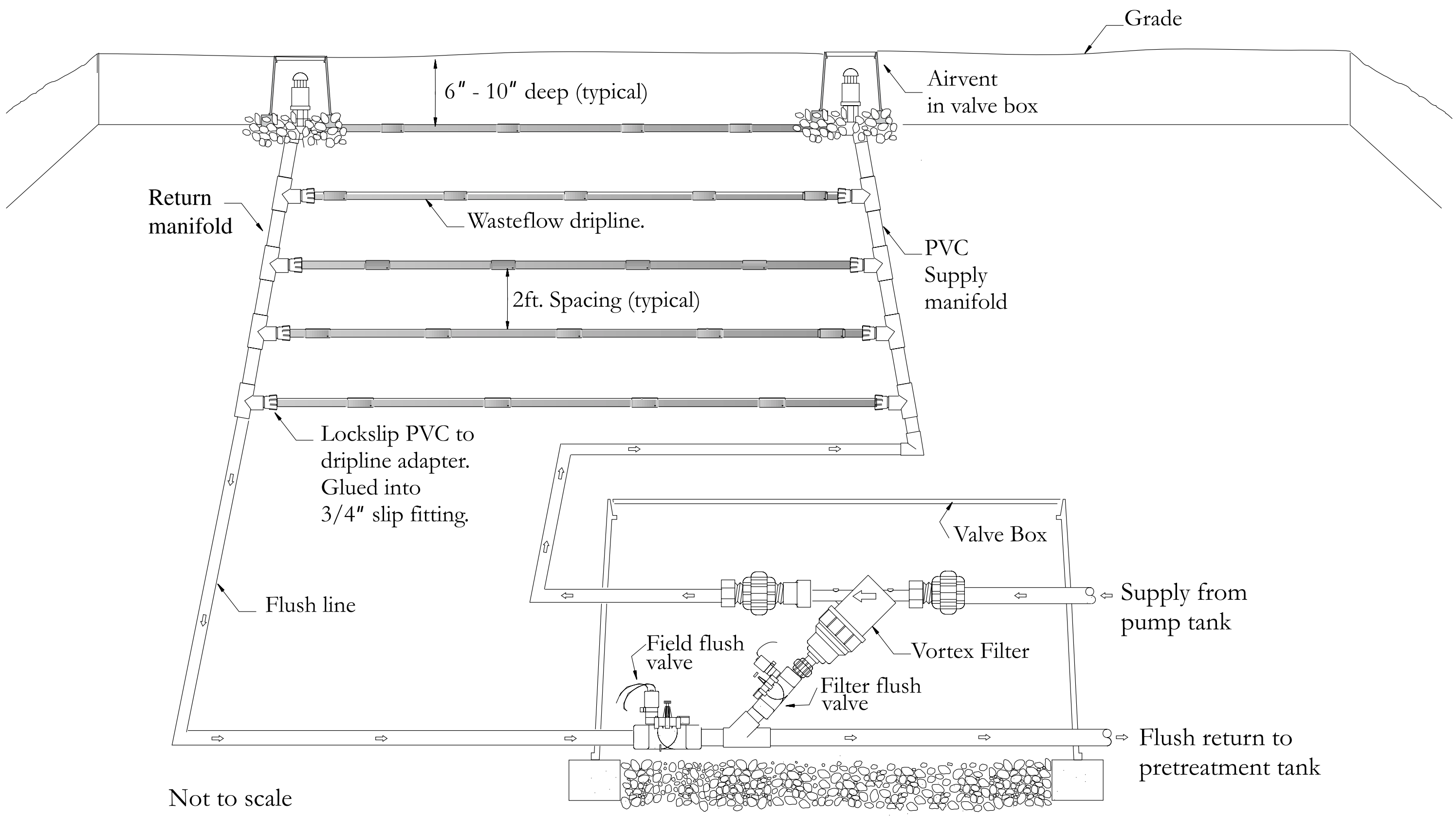
[1] WASTEFLOW® is a registered trademark of A.I. Innovations.

Diagram 1: Typical Dripfield layout



Not to scale

SYSTEM COMPONENTS:

See Diagram 1 on page 3.

A typical drip system installation will consist of the elements listed below:

1. WASTEFLOW® DRIPLINE

(See Appendix 1 for product specification)

WASTEFLOW dripline carries the water into the dispersal/reuse area. The dripline is connected to the supply and return manifolds with Compression or Lockslip fittings. Typical spacing between each dripline and between drip emitters is 24″ on center. 12″ spacing is used regularly for soils with very low or high permeability. The pipe has no joints that may pull apart during installation and is ideal for tractor mounted burying machines. It is sold in 500-ft rolls. For export 400-m rolls are available. Rolls of alternative lengths, diameters and dripper spacings may be special ordered.

WASTEFLOW dripline features:

a) ROOTGUARD®[2]

The risk of root intrusion with an emitter slowly releasing nutrient rich effluent directly into the soil is well known to anyone who has observed a leaking sewer pipe. All Geoflow drip emitters are guaranteed to be protected against root intrusion with ROOTGUARD. This patented process fuses the root-growth inhibitor, TREFLAN®[3] into each drip emitter during manufacturing. Treflan is registered with the United States EPA for this application. The ROOTGUARD technology slowly releases Treflan in minute quantities to prevent root cells from dividing and growing into the barrier zone. It is chemically degradable, non-systemic, and virtually insoluble in water (0.3 ppm). ROOTGUARD carries a 10 year warranty against root intrusion.

b) Bactericide protection

Geoflow's WASTEFLOW has an inner lining impregnated with a bactericide, Ultra Fresh DM-50, to inhibit bacterial growth on the walls of the tube and in the emitter. This minimizes the velocity required to flush WASTEFLOW dripline. The velocity only needs to move out the fine particles that pass through the 100 micron filter that, if not flushed, will ultimately accumulate at the distal end of each lateral. It is not necessary to scour growth off the inside wall of WASTEFLOW tubing. Since all pumps deliver more volume given less resistance to flow, just opening the flush valve will usually achieve this degree of flushing.

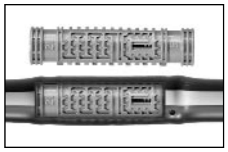
When a minimum flushing velocity is requested, 0.5 feet per second is used with Wasteflow dripline to get the settled particles at the bottom of the pipe back into suspension. This equates to 0.375 gpm per dripline.

c) Turbulent Flow Path

WASTEFLOW drip emitters are pre-inserted in the tube 6″, 12″ or 24″ apart with 24″ being the most popular. Angles in the emitter flow path are designed to cause turbulence in order to equalize flow between emitters and keep the emitters clean. Geoflow emitters boast large flow paths, which, coupled with turbulent flow, have proven over the years to be extremely reliable and dependable

[2] ROOTGUARD® is a registered trademark of A.I. Innovations

[3] Treflan is a registered trademark of Dow Agro Sciences



WASTEFLOW Classic

WASTEFLOW PC

d) WASTEFLOW Classic and WASTEFLOW PC Dripline
Both WASTEFLOW Classic and WASTEFLOW PC have turbulent flow path emitters with ROOTGUARD and bactericide protection. The WASTEFLOW PC has the added element of a silicone rubber diaphram that moves up and down over the emitter outlet to equalize flows regardless of pressure between 7 and 60 psi. To ensure a long life the recommended operating range is 10 to 45 psi.
For WASTEFLOW Classic the flow rate delivered by the emitter is a function of the pressure at the emitter. The Classic dripline has the advantage of no moving parts or rubber that may degrade over time. Also, when minimum flushing velocities are required, the flows during a dosing cycle and flushing cycle are very similar with the Wasteflow Classic because when the flush valve is opened, the pressure is reduced, causing the flows from the emitters to decline. PC driplines require significantly higher flow for flushing than dosing as the emitter flow does not go down during the flushing cycle.
We recommend that WASTEFLOW PC be used when the advantages are of substantial economic value.

i) WASTEFLOW PC can be run longer distances than WASTEFLOW Classic.
ii) Steep slopes. Systems should be designed for the dripline lateral to follow the contour. When this is practical, the extra cost of installing pressure regulators required for WASTEFLOW Classic would likely be less than the incremental cost of WASTEFLOW PC.
iii) Rolling terrain. If the difference in height from trough to peak exceeds six feet then WASTEFLOW PC should be used. Vacuum relief valves must be placed at the top of each rise.

2. CONTROLLERS
(See Appendix 3)

Controllers are used for time dosing and time flushing of the filter and dripfields. GEO controllers include a programmable logic control interface for field modifications. They can be used on systems ranging in size from one to eight zones at the time this manual was printed. All controllers include a surge arrestor, elapsed time meter and counter. For larger systems please inquire about our Wasteflow Manager controller which has monitoring and telemetry capabilities.

3. PUMPS AND PUMP TANKS

WASTEFLOW dripfields depend on pumps to dose effluent under pressure to the field. These must be sized according to flow and pressure requirements. Look for submersible effluent pumps from a dependable source. Geoflow does not endorse a single manufacturer, but does advocate you use a pump that is readily serviced in your area. Pump tanks should be sized according to your local rules and regulations.

4. FILTERS

Geoflow systems use a self-cleaning Vortex Filter with a stainless screen 150 mesh / 100 micron filter element. The self-cleaning action is efficient over a range of flow rates depending on the filter size. The clean-out port is at the base and can be opened and closed manually or automatically. If using a manual flush valve, please keep the valve cracked open slightly at all times for continuous flushing. The controller will fully open automatic filter flush valves.

5. SUPPLY MANIFOLD

This carries the water from the dosing tank to the dispersal area. Rigid PVC is usually used and must be designed to slope back to the pump tank in freezing conditions. The velocity in the manifold should be between 2 feet per second and 5 feet per second (fps). Refer to PVC pipe sizing chart in the appendix to determine the best diameter for your application.

6. RETURN MANIFOLD

In order to help clean the system, the ends of the drip lines are connected together into a common return line, most often made of rigid PVC. This line will help equalize pressures in the system. Flushing should be done frequently during the installation period. Periodic flushing will help to keep the manifolds clean. The return manifold should be installed to self-drain back to the pump or pretreatment tank in freezing climates.

7. PRESSURE REGULATOR

(See Appendix 6 for product specification)

Pressure regulators fix the inlet pressure at a given rate and are recommended with WASTEFLOW Classic. Under normal operating conditions, pressure in the drip lines should be 10 psi to 45 psi.

8. AIR VACUUM BREAKER

(See Appendix 5 for product specification)

Air vacuum breakers are installed at the high points to keep soil from being sucked into the emitters due to back siphoning or backpressure. This is an absolute necessity with underground drip systems. They are also used for proper draining of the supply and return manifolds in freezing conditions. One is used on the high end of the supply manifold and one on the high point of the return manifold. Additional air vents may be required in undulating terrain. Freezing conditions require the air vacuum breaker be protected with insulation.

9. FILTER FLUSH VALVES

(See Appendix 4 for product specifications)

Used to flush debris from the filter cleanout port back to the pretreatment tank, this can be an electronically activated solenoid valve or a manual valve. If manual, it should be opened for a full flushing at least every six months and left cracked open slightly to flush continuously. Cracking open a manual valve may be used to increase flow through the system to be within the efficient flow rate of the filter and/or pump, if necessary. Certain States may require automated electronic flushing. Please refer to your State codes.

10. FIELD FLUSH VALVES.

(See Appendix 4 for product specifications)

Used to flush out fine particles that have passed through the filter and accumulated on the bottom of the tube at the end of each lateral, the field flush valve can be manual or electronic. If manual, it should be opened for full flushing at least every six months and left cracked open slightly to flush continuously and provide for drainage of the flush line in freezing conditions. Cracking open a manual valve can also be used to; increase the flow through the system to be within the efficient flow rate of the filter and/or pump, or to set system pressure instead of a pressure regulator. Certain States do require automated electronic flushing. Please refer to your State codes.

11. ZONE VALVES

Used to divide single dispersal fields into multiple zones, these can be hydraulic activated index valves or solenoid valves.

12. WASTEFLOW HEADWORKS

(See Appendix 7 for product specifications)

WASTEFLOW Headworks is a pre-assembled unit including the filter, valves and pressure gauge in a jumbo box. It is installed between the pump and the field. Be sure to insulate the box in freezing climates.

DESIGN PARAMETERS:

1. SELECT AREA

Select the area with careful consideration of the soil, the terrain and your State and County regulations. Be sure the field is not in a flood plain or bottom of a slope where excessive water may collect after rain. Surface water should be directed away from the proposed field area.

2. WATER QUALITY

Determine the quality of the water entering the system. Is it secondary treated or primary treated? If using primary treated effluent, please refer to Geoflow's article for direct septic found at www.geoflow.com or call 800-828-3388 for a copy. Be aware of water conditions intrinsic to the area. If iron or iron bacteria is prevalent, please be sure to eliminate it upstream of the drip system with ozone, ultraviolet or chemical treatment. Iron can be recognized as orange stain on plumbing fixtures and may be treated prior to entering the facility.

3. SOIL APPLICATION DESIGN

Note: This section based on Subsurface Trickle Irrigation System for On-Site Wastewater Disposal And Reuse by B. L. Carlile and A. Sanjines. The basis of the information is from the Texas Health Department regulations. The rules in your County and State may vary.

The instantaneous water application rate of the system must not exceed the water absorption capacity of the soil. A determination of the instantaneous water absorption capacity of the soil is difficult, however, since the value varies with the water content of the soil. As the soil approaches saturation with water, the absorption rate reduces to an equilibrium rate called the "saturated hydraulic conductivity." Wastewater application rates should be less than 10 percent of this saturated equilibrium.

Even though the trickle irrigation system maximizes the soil absorption rate through the low rate of application, thus keeping the soil below saturation, there will be times when the soil is at or near saturation from rainfall events. The design must account for these periods and assume the worst case condition of soil saturation. *By designing for a safety factor of 10 or 12, based on the saturated hydraulic conductivity, the system will be under-loaded most of the time but should function without surface failure during extreme wet periods.*

By applying wastewater slowly for a few hours daily, particularly if applied in "pulses" or short doses several times per day near the soil surface where the soil dries the quickest would keep the soil absorption rate at the highest value and minimize the potential of water surfacing in poor soil conditions.

As stated previously, this design criterion will under-load the system at all times except when the soil is at or near saturation from rainfall. If designing for an efficient irrigation system, the water supply may not be sufficient to meet the demands of a lawn or landscaped area during peak water demand months. This problem can be overcome by either of two solutions: add additional fresh-water make-up to the system during the growing season to supply the needed water for plants in question; or split the system into two or more fields with necessary valves and only use one of the fields during the peak water demand months and alternate the fields during winter months or extremely wet periods, or use both fields simultaneously if the pump capacity will so allow.

TABLE 1. MINIMUM SURFACE AREA GUIDELINES TO DISPOSE OF 100 GPD OF SECONDARY TREATED EFFLUENT

		Soil Absorption Rates		Design	Total
Soil Class	Soil Type	Est. Soil Perc. Rate minutes/in	Hydraulic Conductivity inches/hr	Hydraulic Loading Rate gal/sq. ft. per day	Area Required sq. ft./100 gallons per day
I	Coarse sand	<5	>2	1.400	71.5
I	Fine sand	5 - 10	1.5 - 2	1.200	83.3
II	Sandy loam	10 - 20	1.0 - 1.5	1.000	100.0
II	loam	20 - 30	0.75 - 1.0	0.700	143.0
III	Clay loam	30 - 45	0.5 - 0.75	0.600	167.0
III	Silt - clay loam	45 - 60	0.3 - 0.5	0.400	250.0
IV	Clay non-swell	60 - 90	0.2 - 0.3	0.200	500.0
IV	Clay - swell	90 - 120	0.1 - 0.2	0.100	1000.0
IV	Poor clay	>120	<0.1	0.075	1334.0

Dispersal field area calculation:
Total square feet area of dispersal field = Design flow divided by loading rate

Table 1 shows the recommended hydraulic loading rates for various soil conditions, using a safety factor of at least 12 with regard to the equilibrium saturated hydraulic conductivity rate of the soil. These loading rates assume a treated effluent with BOD and TSS values of less than 30 mg/l is produced in the pre-treatment system and that any anomalies such as iron bacteria have been removed prior to dosing.

NOTES

1) The above chart is provided as a guide only. States and Counties may have regulations that are different. Check your State guidelines and consult with your local health department.

2) Problems with drip dispersal fields occur when soils are misinterpreted. If in doubt, choose the more restrictive soil type from the table above.

3) “Soil type” should be based on the most restrictive layer within two feet of the dripline. In many soils 1-ft. vertical separation from the limiting layer has proven successful with secondary treated effluent. Geoflow recommends you follow State and Local guidelines.

4) Table 1 above, with only minor modifications over the years, has served us well since 1990 with tens of thousands of systems operating successfully based upon this data. However, thanks to work by Jerry Tyler and his associates at the University of Wisconsin-Madison soil structure has become better understood and can now be used as a comprehensive tool to determine optimal hydraulic loading rates.

Soil Textures	Soil Structure	Maximum Monthly Average BOD5> 30mg/L<220mg/L TSS>30 mg/L<150 mg/L (gallons/ft2/day)	BOD5<30mg/L TSS<30mg/L (gallons/ft2/day)
Course sand or coarser	N/A	0.4	1.6
Loamy coarse sand	N/A	0.3	1.4
Sand	N/A	0.3	1.2
Loamy sand	Weak to strong	0.3	1.2
Loamy sand	Massive	0.2	0.7
Fine sand	Moderate to strong	0.3	0.9
Fine sand	Massive or weak	0.2	0.6
Loamy fine sand	Moderate to strong	0.3	0.9
Loamy fine sand	Massive or weak	0.2	0.6
Very fine sand	N/A	0.2	0.6
Loamy very fine sand	N/A	0.2	0.6
Sandy loam	Moderate to strong	0.2	0.9
Sandy loam	Weak, weak platy	0.2	0.6
Sandy loam	Massive	0.1	0.5
Loam	Moderate to strong	0.2	0.8
Loam	Weak, weak platy	0.2	0.6
Loam	Massive	0.1	0.5
Silt loam	Moderate to strong	0.2	0.8
Silt loam	Weak, weak platy	0.1	0.3
Silt loam	Massive	0.0	0.2
Sandy clay loam	Moderate to strong	0.2	0.6
Sandy clay loam	Weak, weak platy	0.1	0.3
Sandy clay loam	Massive	0.0	0.0
Clay loam	Moderate to strong	0.2	0.6
Clay loam	Weak, weak platy	0.1	0.3
Clay loam	Massive	0.0	0.0
Silty clay loam	Moderate to strong	0.2	0.6
Silty clay loam	Weak, weak platy	0.1	0.3
Silty clay loam	Massive	0.0	0.0
Sandy clay	Moderate to strong	0.1	0.3
Sandy clay	Massive to weak	0.0	0.0
Clay	Moderate to strong	0.1	0.3
Clay	Massive to weak	0.0	0.0
Silty clay	Moderate to strong	0.1	0.3
Silty clay	Massive to weak	0.0	0.0

TABLE 2 DRIP LOADING RATES CONSIDERING SOIL STRUCTURE.
Table 2 (above) is taken from the latest State of Wisconsin code and reflects Jerry Tylers work.

4. DEPTH AND SPACING

WASTEFLOW systems usually have emitter lines placed on 2 foot (600 mm) centers with a 2 foot emitter spacing such that each emitter supplies a 4 sq. ft (0.36 m^2) area. These lines are best placed at depths of 6-10 inches (150 - 250 mm) below the surface. This is a typical design for systems in sandy and loamy soils with a cover crop of lawn grass. Closer line and/or emitter spacing of 12 inches is used on heavy clay soils or very coarse sands where lateral movement of water is restricted. Using closer spacing should not reduce the size of the field.

5. SOIL LAYERS AND TYPES

The shallow depth of installation is an advantage of the subsurface dripfield since the topsoil or surface soil is generally the most biologically active and permeable soil for accepting water. The topsoil also dries the fastest after a rainfall event and will maintain the highest water absorption rate. The quality and homogeneity of the soil may present a problem. If the soil was not properly prepared and there are pieces of construction debris, rocks and non-uniform soils, it is very difficult to obtain uniform water spread. In many cases, particularly if the soil is compacted, soil properties can be greatly improved by ripping and disking.

6. ADDING FILL TO THE DISPERSAL FIELD

Some dispersal sites require additional soil be brought in for agronomic reasons or to increase separation distances from the restrictive layer. Restrictive layers stop or greatly reduce the rate of downward water movement, as a result surfacing may occur during part of the year. In soils with high water tables treatment is minimized due to a lack of oxygen.

Placing drip lines in selected fill material above the natural soil provides an aerated zone for treatment. Dispersal however still occurs in the natural soil and the field size must be based on the hydraulic capability of the natural soil to prevent hydraulic overload.

Any time fill material is to be used, the area to receive the fill should have all organic material removed or it must be incorporated into the natural soil to prevent an organic layer from forming and restricting downward water movement.

The fill material should be applied in shallow layers with the first 4 to 6 inches incorporated into the natural soil to prevent an abrupt textural interface. Continue this process until all fill has been incorporated.

The fill area should be left crowned to shed surface water and may need diversion ditches or some other devices to prevent surface water from infiltrating. The entire fill area should have a vegetative cover to prevent erosion. If possible allow the fill to set at least seven to ten days before installing WASTEFLOW dripline.

It is generally agreed that fill should not be used on slopes greater than 20%.

7. HIGH POINTS, SIPHONING AND SLOPES

A potential problem with buried drip lines is siphoning dirt into the emitters when the pump is switched off. For this reason:

a. Drip lines should have a fairly constant slope. Run dripline along a contour.

b. At least one vacuum breaker should be installed at the highest point in each zone.

c. Avoid installing lines along rolling hills where you have high and low points along the same line. If this is the case, connect all the high points together and install a vacuum breaker on the connecting line. (See Geoflow detail 602).

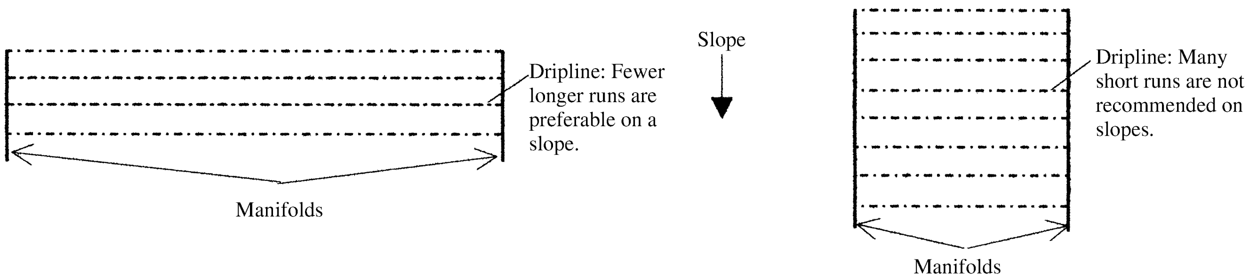
d. Drip lines should be connected at the end to a common return line with a flush valve.

8. EXCESSIVE ELEVATION DIFFERENCES

WASTEFLOW Classic If the level variation within a WASTEFLOW Classic zone exceeds six feet, individual pressure regulators should be placed for each six-foot interval.

WASTEFLOW PC WASTEFLOW PC can tolerate very large height variations provided the pressure remains within the 7 to 60 psi range, and preferably within 10 to 45 psi.

At the end of each dosing cycle, water in the dripline will flow down to the bottom lines within the drip zone. This is called “lowhead drainage”. On a slope site Geoflow recommends installing short manifolds with fewer lines and longer dripline runs. If unsure, a maximum of 1500 ft of Geoflow dripline within each zone or sub-zone can be used as a rule of thumb. Do not exceed 5 lines in a single zone or sub-zone with a slope greater than 10%. Be sure to open valves fully so manifolds drain rapidly.



9. HILLY SITE

Concentrate drip lines at the top of the hill with wider spacing towards the bottom. In the case of compound slopes consult a professional irrigation designer or engineer.

10. MULTIPLE ZONES

Drip dispersal fields can be divided into multiple zones or subzones with solenoid valves or index valves for the following reasons:

a. Steep slopes with a risk of lowhead drainage can be subdivided to distribute the water at system shut-down more uniformly in the field.

b. Smaller zones reduce the required flow per minute which consequently reduces the size of the pump5, valves, filters, supply and return lines.

c. Subdividing the field is a tool used to achieve the optimum ranges required to efficiently operate the Vortex filters.

d. If the dispersal field is located in multiple areas on the property.

e. To accommodate varying soils or vegetation on a single site.

Note. On multiple zones, a single Wasteflow Headworks can be used for filtration and flushing by placing zone valves downstream of the Headworks box. All zones would require a check valve on the individual flush lines upstream of each line joining a common flush line to keep flush water from one zone entering any other zone during the flush cycle. (See Geoflow Design Detail No. 588)

If the effluent has not been through secondary treatment, then each zone should have a dedicated filter or Wasteflow Headworks.

11. REUSE FOR IRRIGATION

A good vegetative cover is an advantage to prevent erosion from the field and utilize water applied to the rooting zone. Sites should be planted or seeded immediately after installation. Grasses are particularly suitable for this application. Most lawn grasses will use 0.25″ to 0.35″ (6.3-8.9mm) of water per day during the peak growing season. This calculates to be about 0.16 to 0.22 gal/ft^2/day. By over-seeding lawns with winter ryegrass, this use efficiency can be continued through much of the year. For vegetation using 0.16 to 0.22 gal/ft^2/day by evapotranspiration, a sewage flow of 1000 gallons per day would supply the water needs of a landscaped area of 4600 to 6400 sq. ft. without having to add fresh water. For areas larger than this, the plants will suffer water stress during the hot months unless additional fresh water is applied.

12. WATER APPLICATION FORMULA

To determine the rate of application for various drip irrigation designs, use the following formula:

Water application (inches per hour) = (231 x (emitter flow rate gph)) / ((Emitter spacing inches) x (dripline spacing inches))

Example: Dripline with 1.3 gph flow rate emitters spaced 24" apart and dripline spaced 24" apart.

Water application = (231x1.3)/(24x24) = 0.52 inches of water per hour.

WORKSHEET:

The following worksheet is available on an Excel spreadsheet and can be downloaded from Geoflow's homepage at www.geoflow.com. If you would like a copy sent to you at no charge phone 800-828-3388.

To calculate the area required for your drip dispersal system you must know:

1. the quantity of effluent to be disposed of (in gallons per day) and
2. the soil acceptance rate (i.e. gallons per day per square foot).

Make a sketch of the dispersal area with contour lines.

WORKSHEET 1 - DISPERSAL FIELD DESIGN FOR SINGLE ZONE SYSTEM

Worksheet	Formula
A) Quantity of effluent to be dispersed per day ______________ *gpd*	
B) Soil type or hydraulic loading rate ______________ *loading rate (gal/sq. ft./day)*	*Based on soil analysis*
C) Determine the total area required ______________ *square ft*	*Refer to State or Local regulations.* *If none, refer to Table 1, page 8 and* *Divide gpd by loading rate. (A)/(Bii)*
D) Choose the spacing between each WASTEFLOW line and each WASTEFLOW emitter i) ______________ *ft. between WASTEFLOW lines* ii) ______________ *ft. between WASTEFLOW emitters*	*Standard spacing is 2 ft.*
E) How many linear feet of dripline in the total area? ______________ ft	*(Area / 2) for 2ft. line spacing. (C)/2.0 or* *(Area / 1) for 1 ft. line spacing. (C)/1.0 or* *(Area / 0.5) for 6" line spacing. (C)/0.5*
F) Calculate the number of emitters ______________ emitters	*(Linear ft. of dripline/2) for 2 ft emitter spacing. (E)/2 or* *(Linear ft. of dripline/1) for 1 ft emitter spacing. (E)/1 or* *(Linear ft. of dripline/0.5) for 6" emitter spacing (E)/0.5*

G) Choose pressure compensating or Classic dripline ☐ *WASTEFLOW Classic dripline or* ☐ *WASTEFLOW PC dripline*	*See page 4 and Appendix 1, page 28*
H) Determine dripfield pressure ______________ *psi*	*Standard pressure is 20 psi.* *WASTEFLOW Classic systems need between 15 and 45 psi (34.7 and 104 ft.) at the start of the dripfield.* *WASTEFLOW PC systems need between 10 and 45 psi (23.1 ft. to 104 ft.) at the start of the dripfield.*
I) Determine feet of head required at dripfield ______________ *ft. of head*	*Multiply pressure above by 2.31 to get head required.* *(H) x 2.31*
J) What is the flow rate per emitter?__________ *gph / emitter*	*See WASTEFLOW flow rates in Appendix 1.*
K) Determine total flow for the area ______________ *gpm* ______________ *gph*	*Number of emitters multiplied by the emitter flow rate at the design pressure.* *Gph = (F)x(J) Gpm = gph/60*
L) Select pipe diameters for manifolds and submains ______________ *inches*	*Based on total flow from (K) above, in gpm.* *See schedule 40 friction loss charts on page 44* *Optimum velocity is between 2 and 5 ft. per second.*
M) Select size of Vortex filter or WASTEFLOW Headworks __________ Vortex filter or __________ WASTEFLOW Headworks	*Based on total flow from (K) above, in gpm. See minimum and maximum flow requirements for each filter in Appendix 2.*
N) Sketch a layout of the WASTEFLOW lines in the dispersal plot to make sure that the maximum lateral length of each WASTEFLOW line is not exceeded.	*See Maximum Length of Run table in Appendix 1*

WORKSHEET 2 - SELECT PUMP

Worksheet		Formula
O) Minimum pump capacity	_______ gpm	*From (K) above*
P) Header pipe size	_______ inches	*From (L) above*
Q) Pressure loss in 100 ft. of pipe	_______ psi	*Refer to PVC charts on page 34.*
R) Friction head in 100 ft. of pipe	_______ ft. of head	*Multiply psi from (Q) above by 2.31*
S) Static head		
i) Height from pump to tank outlet.	_______ ft.	*Number of ft.*
ii) Elevation increase or decrease	_______ ft.	*Height changes from pump to dripfield.*
T) Total static head	______________ ft.	*Add (Si) + (Sii)*
U) Friction head		
i) Equivalent length of fittings	_______ ft.	*Estimate loss through fittings - usually inconsequential for small systems.*
ii) Distance from pump to field.	_______ ft.	*Measure length of sub-main*
iii) Total equivalent length of pipe.	_______ ft.	*Add (Ui) + (Uii)*
iv) Total effective feet.	______________ ft.	*(Uiii) / 100 x (R)*
v) Head required at dripfield	______________ ft.	*See line (I) in Worksheet 1 above.*
vi) Head loss through filter or Headworks	______________ ft.	*See pressure loss for filters in Appendix 2 or see pressure loss for Headworks box in Appendix 7. Multiply pressure by 2.31 to get head loss.*
vii) Head loss through zone valves	______________ ft.	*See pressure loss in Appendix 4 for electric valves. For manual or index valves check with the manufacturer. Multiply pressure loss in psi by 2.31 to get head loss.*
V) Minimum Total friction head	______________ ft.	*Add (Uiv) + (Uv) + (Uvi) + (Uvii)*
W)Minimum Total Dynamic Head	______________ ft.	*Add (T) + (V)From line item (O) above*
X) Minimum pump capacity	______________ gpm	
NOTE: Some States and Counties require additional flow for flushing. Please check your local regulations. If you need help on flushing design, see Geoflow's flushing worksheet at www.geoflow.com or call Geoflow at 800-828-3388.		
Y) Choose the pump. ____________________ Model Number ____________________ Manufacturer		*Based on pressure from line (W) above and flow from line (X) above.*

SYSTEM INSTALLATION

1. INSTALLATION GUIDELINES

All Geoflow drip systems require:
100 micron / 150 mesh filter
Filter flush valve
Field flush valve and
Air vent in each zone
All Wasteflow Classic drip systems require pressure regulation

Handle your dripline and components with care. ROOTGUARD® is temperature sensitive. To assure a long life store the drip line out of direct sunlight in a cool place. This should be a consideration when installing the system in very hot and sunny areas. Your system life span will be increased if it is buried an extra two or three inches below the soil surface, to avoid the warm temperature extremes.

a) All dripfield construction shall be done in accordance with Local rules and regulations.

b) No utilities, cable wire, drain tile, etc shall be located in dripfield.

c) Fence off entire dripfield prior to any construction.

d) System is not to be installed when ground is wet or frozen.

e) Divert all downspouts and surface waters away from dripfield or into curtain drains.

f) Excavation, filling and grading should have been finished before installation of the subsurface drip system.

g) Be sure you have everything required for the installation before opening trenches. Pre-assemble as many sets of components as practical above ground and in a comfortable place. Compression or Lockslip adapters should be glued to PVC tees, riser units should be pre-assembled, the sub-main manifold with tees can be pre-assembled and used to mark the beginning and end of WASTEFLOW lines.

h) For particularly tough soil conditions moisten the soil the day before opening trenches or installing WASTEFLOW. Remember it is much easier to install the system in moist soil. The soil should be moist but still should allow the proper operation of the installation equipment and not cause smearing in the trenches. The soil surface should be dry so that the installation equipment maintains traction.

i) Mark the four corners of the field. The top two corners should be at the same elevation and the bottom two corners should be at a lower elevation. In freezing conditions the bottom dripline must be higher than the supply and return line elevation at the dosing tank.

j) Install a watertight dosing tank. In freezing conditions the dosing tank should be at the lowest elevation of the entire system. Install a watertight riser on the dosing tank if necessary.

k) Determine the proper size for the supply and return manifolds. See Worksheet line (L).

l) Install the PVC supply line from the dosing tank, up hill through one lower and one upper corner stake of the dispersal field. Please refer to your State guidelines for depth of burial.

m) Paint a line between the two remaining corner stakes.

n) Install the Geoflow WASTEFLOW dripline from the supply line trench to the painted line, approximately 6″ to 10″ deep as specified. Upon reaching the painted line, pull the plow out of the ground and cut the dripline 1′ above the ground. Tape the end of the dripline to prevent debris from entering. Continue this process until the required footage of pipe is installed. Geoflow dripline must be spaced according to specification (2 ft. is standard). Depth of burial of dripline must be consistent throughout the field. Take care not to get dirt into the lines.

o) Install the supply header with tees lined up at each Geoflow line. Hook up the Geoflow lines to the supply header. Do not glue WASTEFLOW dripline.

    Installing Lockslip fittings

    a) Hold the fitting in one hand and position the tubing with the other hand.
    b) Move the sleeve back, and push the tubing onto the exposed stem as far as possible.
    c) Push the sleeve out over the tubing and thread the sleeve onto tubing, as though tightening a nut to a bolt. Hand tighten. Do not use tools.

p) Install the Vortex filter and filter flush valve, or install the pre-assembled Headworks between the field and the pump tank on the supply line. *Insulate the box in freezing conditions.

q) If using a pressure regulator, install it downstream of the filter or Headworks, just ahead of the dispersal field, on the supply line. Although the pressure regulator can be buried directly into the soil, it is preferable to install it inside a small valve box for easy access. *Insulate the box in freezing conditions.

r) Install the floats in the dosing tank and wire up to the timer control. The timer control should be set to pump no more than the design flow, do not set to match the treatment capacity.

s) Install the pump. Fill the dosing tank with fresh water and turn on the pump. Check for flow out the ends of all of the Geoflow lines. Let the pump run for about five minutes to flush out any dirt. Shut off the pump and tape the ends of the lines.

t) Dig the return header ditch along the line painted on the ground and back to the pre-treatment tank. Start the return header at the farthest end from the dosing tank. The return line must have slope back to the treatment tank or septic tank.

u) Install the return header and connect all of the Geoflow lines. Care must be taken not to kink the dripline.

v) Install air vacuum breakers at the highest points in the dispersal field. Use pipe dope or Teflon tape and hand tighten.

w) Install a ball or solenoid field flush valve on the return line to the pretreatment or pump tank unless a pre-assembled Wasteflow Headworks is being used. If a Headworks was installed on the supply line, connect the return line back through the Headworks box. Open the field flush valve and turn on the pump to flush lines then close the valve and check the field and all piping and connections for leaks. Turn off the system

x) Turn on the pump and check the pressure at the air vacuum breaker(s). It should be between 15 to 45 PSI. Check the pressure in the WASTEFLOW Headworks if used. It should be five psi or higher. If using a manual valve for field flushing, crack it open until at least one PSI is lost or design pressure is reached and leave in that position.

y) Check the filter for construction debris and clean.

z) Provide owner with final as-built diagrams, flow measurements and pressure readings at startup.

d) Test the connection to make sure the sleeve threads have gripped the tubing tightly.

Valve Installation and Operation

a) Wrap male adapters with 2 wraps of Teflon tape and thread the adapters into the valve inlet and outlet 1 turn past hand tight. CAUTION: over tightening may cause damage to the valve. The solenoid is located on the downstream side of the valve.
b) Using watertight connectors, connect the valve common and an individual output wire to the solenoid leads.
c) Flush the laterals by opening the internal manual bleed lever on the downstream side of the solenoid. Turn the flow control stem fully open (counterclockwise)for flow control models.
d) Close the internal manual bleed after flushing the system.

WORKSHEET 3- AS BUILT SYSTEM DESCRIPTION.

1. Site name: ______________________
2. Site address including State: ______________________
3. Dripfield designed by: ______________________
4. Dripfield installed by: ______________________
5. Date of installation: ____________
6. Daily design flow: ____________ gpd.
7. Soil percolation rate: ____________
8. Is there secondary treatment on this job site? ________ Yes ________ No

   If "Yes" to question 8 above, please name manufacturer and model number: ____________
9. Number of zones in dripfield: ______________ . If more than one zone, please describe valve (size, manufacturer, part number, type): ______________
10. Amount of dripline installed in each zone:

    Zone 1 ________ ft. Zone 2 ________ ft. Zone 3 ________ ft. Zone 4 ________ ft.
11. Wasteflow dripline model number &/or description: ______________
12. Flow rate per zone:

    Zone 1 ______ gpm. Zone 2 ______ gpm. Zone 3 ______ gpm. Zone 4 ______ gpm.
13. Depth dripline installed below grade: ____________ inches
14. Pump manufacturer, model number and number of pumps: ______________
15. Vortex filter model number &/or description: ______________

    If more than one zone, do the zones (a) share one filter or (b) each have their own filter? ______
16. Pressure in each zone:

    Zone 1 ________ psi Location pressure measured: ______________

    Zone 2 ________ psi Location pressure measured: ______________

    Zone 3 ________ psi Location pressure measured: ______________

    Zone 4 ________ psi Location pressure measured: ______________
17. Size (diameter) of feed manifold: ______ inches. Depth of feed manifold: ______ inches.
18. Size (diameter) of flush manifold: ______ inches. Depth of flush manifold: ______ inches.
19. Size of filter flush valve: ______ inches. Is filter flush valve manual or automatic? ______
20. Size of field flush valve: ______ inches. Is the field flush valve manual or automatic? ______

    If more than 1 zone, do the zones (a) share 1 flush valve or

    (b) does each zone have it's own flush valve? ______
21. Was any fill material supplied on the dripfield? ____________

If "yes" to 21 above describe fill quality and quantity added. ______________

____

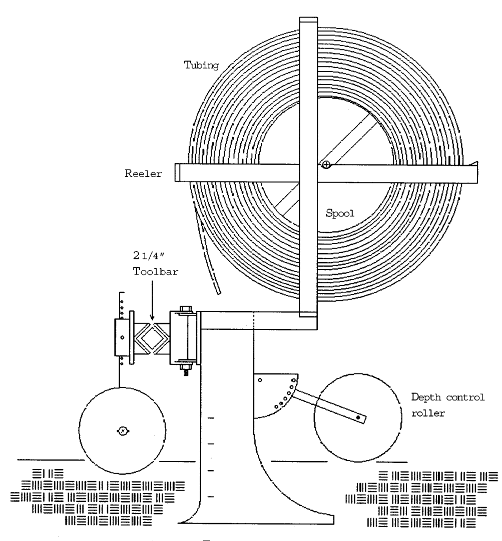
22. Please provide owner with as-built drawings, including but not limited to direction of drip lines, location of air vents, pressure regulators if applicable, Headworks (filter and valves) and pump tank.

TABLE 3. SUBSURFACE DRIP INSTALLATION METHODS

NOTE: Disturbing the soil may effect the pore structure of the soil and create hydraulic conductivity problems. Please consult with your soil scientist or professional engineer before making the installation technique decision.

INSERTION METHOD	ADVANTAGES	DISADVANTAGES
a) Hand Trenching	• Handles severe slopes and confined areas • Uniform depth	• Slow • Labor intensive • Disrupts existing turf and ground • Back fill required
b) Oscillating or vibrating plow. Use the type that inserts the dripline directly in place, not one that pulls the dripline through the soil.	• Fast in small to medium installations • Minimal ground disturbance • No need to back fill the trench	• Depth has to be monitored closely • Cannot be used on steeper slopes(>20%) • Requires practice to set and operate adequately • Tends to “stretch” pipe. Shorter runs are required
c) Trenching machine	• Faster than hand trenching • May use the 1″ blade for most installations • Uniform depth	• Slower, requires labor • Disrupts surface of existing turf • Back fill required
d) Tractor with dripline insertion tool - see diagram 2. below.	• Fast • Little damage to existing turf because of the turf knife • Minimal ground disturbance • Does not stretch drip line • Adaptable to any tractor	• The installation tool is designed specifically for this purpose.
e) Tractor mounted 3-point hitch insertion implement	• Fastest. Up to four plow attachments with reels • A packer roller dumps back soil on top of the pipe	• Suitable for large installations only

Diag. 2 Installation Tool



2. WINTERIZATION

Buried drip systems are not prone to frost damage because, in their design, vacuum release and drain valves are provided. The dripline itself is made of polyethylene and not susceptible to freezing. It drains through the emitters so will not be full of water after pumps are turned off. Please follow these precautions:

a) Manifolds, supply lines and return lines must be sloped back to their respective dosing or treatment tanks. These lines need to drain rapidly. Under extreme conditions return and supply manifolds must be insulated or buried below frost-line. Be sure drain valve on flush line remains open long enough for entire field to drain.

b) Remove the check valve at the pump.

c) Insulate equipment boxes, including Headworks box or filter and field flush valve boxes as well as zone dosing valves, pressure regulator and air vacuum relief valves. Use closed-cell insulation such as Perlite in a plastic bag.

d) In severe freezing conditions, use heat tape or small heater in the Headworks box.

d) The top of air vacuum relief valves must be no higher than soil surface.

e) If using an index valve to split field zones, be sure it is capable of self-draining.

f) WASTEFLOW lines will self-drain through the emitters into the soil. If the cover crop over the dripfield is not yet adequately established, add hay or straw over the field for insulation.

g) Mark the valve box with a metal pin so you can find it in the winter when covered in snow.

h) If using manual filter flush valves or manual field flush valves, they should be left cracked open slightly to provide for rapid drainage of the flush line in freezing conditions.

i) Fields dosed with relatively small quantities of effluent are more likely to freeze than those dosed with design quantities. If winter use is less than summer use, then only use proportional number of fields to maintain water application rates in the field being dosed.

SYSTEM MAINTENANCE:

The best way to assure years of trouble free life from your system is to continuously monitor the system and to perform regular maintenance functions. For large systems or systems with a BOD > 30 mg/l automation of maintenance is essential. For smaller systems with a BOD < 30 mg/l inspection and maintenance should be performed every six months.

ROUTINE AND PREVENTATIVE MAINTENANCE

1) Remove the spin filter and install a clean cartridge. Clean the used filter cartridge back at the shop with a pressure hose. The filter cartridge should be cleaned from the outside inwards. If bacteria buildup is a problem we advise first trying lye, and if the problem persists, soak the filter cartridge in a chlorine bath - a mixture of 50% bleach and 50% water.

2) Open the field flush valve and flush the field for 3-5 minutes by activating the pump in “manual” position. Close the flush valve. On automatic solenoid valves the manual bleed lever should always be in the horizontal position and the dial on top should be free spinning. Clockwise rotation closes valve

3) With the pump in the “manual” position, check the pressure in the drip field by using a pressure gauge on the schraeder valve located on the air vents and by reading the pressure gauge located in the Wasteflow Headworks box. The pressure should be the same as shown on the initial installation records. On systems with manual flush valves, close the field flush valve completely and then open the valve slightly until there is a 1-2 psi drop or design pressure is reached. This will allow the field to drain after each dose to prevent the manifold lines from freezing.

4) Remove the lids on the vacuum breaker and check for proper operation. If water is seen leaking from the top of the vacuum breaker, remove the cap of the vacuum breaker and press down on the ball to allow any debris to be flushed out. Be careful not to come in contact with the effluent.

5) Turn off the pump and reset the controller for auto mode.

6) Periodically remove and clean the air vents, field flush and filter flush valves.

7) Visually check and report the condition of the drip field, including any noticeable wetness.

8) Treatment and distribution tanks are to be inspected routinely and maintained when necessary in accordance with their approvals.

9) Record the elapsed time meter, pump counter, override counter, high-level alarm and power failures. This information can be obtained from the controller.

HOME OWNERS GUIDE FOR CARE AND MAINTENANCE OF GEOFLOW DRIP DISPERSAL FIELD

A drip dispersal system has been installed on your property for the subsurface dispersal of the effluent from your home.

The drip dispersal system consists of a series of 1/2″ diameter drip tubing installed at a shallow depth of 8-10″ below the ground surface. It is designed to effectively disperse of the treated effluent in the ground with a combination of soil absorption and plant uptake. Your drip dispersal system will function for many years with only minimal maintenance being required, provided the following recommendations are followed:

- ❏ Establish landscaping (preferably a grass cover) immediately. This will stabilize the soil and allow for the vegetation to take up the water.
- ❏ Do not discharge sump pumps, footing drains or other sources of clear water to the system, except for the effluent discharge from your treatment system.
- ❏ Maintain all plumbing fixtures to prevent excess water from entering the dispersal system.
- ❏ Do not drive cars, trucks or other heavy equipment over the drip dispersal field. This can damage the drip components or the soil and cause the system to mal-function. Lawn mowers, rubber wheeled garden tractors and light equipment can be driven over the drip field.
- ❏ Do not drive tent stakes, golf putting holes, croquet hoops etc., into the dispersal field
- ❏ Contact your service company if your high water alarm should sound. The pump chamber is sized to allow additional storage after the high water alarm sounds but you should refrain from excessive water usage (i.e., laundry) until the system has been checked.
- ❏ After a temporary shut down due to a vacation or other reason, the treatment plant ahead of the drip field filter, initially may not function effectively, resulting in the filter blocking.

Contact your service company if you notice any areas of excessive wetness in the field. In most cases, this is usually caused by a loose fitting or a nicked dripline and can be easily repaired. Note: There may be some initial wetness over the driplines following the system's installation. This should cease once the ground has settled and a grass cover is established

TROUBLE SHOOTING GUIDE:

Symptom: High water alarm activates periodically (1-2 times/week). During other times the water level in the pump chamber is at a normal level.

Possible cause: Peak water usage (frequently laundry day) is causing a temporary high water condition to occur.

Remedy: Set timer to activate the pump more frequently. Be sure to not exceed the total design flow. To avoid this, reduce the duration of each dose.

Remedy: Provide a larger pump tank to accommodate the peak flow periods.

Symptom: High water alarm activates during or shortly after periods of heavy rainfall.

Possible cause: Infiltration of ground/surface water into system.

Remedy: Identify sources of infiltration, such as tank seams, pipe connections, risers, etc. Repair as required.

Symptom: High water alarm activates intermittently, including times when it is not raining or when laundry is not being done.

Possible cause: A toilet or other plumbing fixture may be leaking sporadically but not continuously. Check water meter readings for 1-2 weeks to determine if water usage is unusually high for the number of occupants and their lifestyle. Also determine if water usage is within design range.

Remedy: Identify and repair fixture.

Symptom: High water alarm activates continuously on a new installation (less than 3 months of operation). Inspection of the filter indicates it is plugged with a gray colored growth. Water usage is normal.

Possible cause: Slow start-up of treatment plant resulting in the presence of nutrient in the effluent sufficient to cause a biological growth on the filter. This is typical of lightly loaded treatment plants that receive a high percentage of gray water (i.e., from showers and laundry).

Remedy: Remove and clean filter cartridge in a bleach solution. Add a gallon of household bleach to pump tank to oxidize organics. Contact treatment plant manufacturer for advice on speeding up the treatment process possibly by "seeding" the plant with fresh activated sludge from another treatment plant.

Symptom: Water surfaces continuously at one or more isolated spots, each one foot or more in diameter.

Possible cause: Damaged drip line or a loose connection is allowing water be discharged under pressure and therefore at a much greater volume than intended.

Remedy: Dig up drip line. Activate pump and locate leak. Repair as required.

Possible cause: If water is at base of slope, can be caused by low-head drainage.

Remedy: Install check valves and airvents in the manifolds to redistribute water in the system after pump is turned off. This is not advised for freezing climates where manifold drainage is required.

Symptom: A portion of the drip field closest to the feed manifold is saturated while the rest of the field is dry.

Possible cause: Insufficient pump pressure. A pressure check at the return manifold indicates pressure of less than 10 psi.

Remedy: Check filter and pump intake to insure they are not plugged. If they are, clean as required.

Remedy: Leaks in the system may be resulting in loss of pressure. Check for water leaks in connections and fittings or wet spots in the field. Also check air vents to insure they are closing properly. Repair as necessary.

Remedy: Pump is worn or improperly sized. Pressure at feed manifold in less than 15 psi. Verify pressure requirements of system and provide a new or larger pump. As an alternate approach, the drip field may need to be divided into two or more zones.

Possible cause: The duration of each dose is of insufficient length to allow the drip field to become pressurized before the pump shuts off (or runs for only a brief time before turning off).

Remedy: Increase the pump run time and decrease the frequency of doses. Always calculate (or observe during field operation) how long the system takes to fully pressurize and add this time to the design dosing duration.

Symptom: High water alarm begins to activate continuously after a long period (1-2 years) of normal operation. Inspection of the filter indicates it is plugged with a heavy accumulation of sludge.

Possible cause: A buildup of solids in the pump tank due to carryover from the treatment plant.

Remedy: Replace the filter cartridge with a clean cartridge. Check the pump tank and if an accumulation of solids is noted, pump the solids out of the pump tank. Also, check the operation of the treatment plant to insure it is operating properly.

Symptom: Water surfaces at several spots in drip field during dosing periods. Installation is recent, less than 6 months of usage and the soil is a moderate to heavy clay. Possibly, the installation was completed using a non-vibratory plow.

Possible cause: Smearing of the soil may have occurred during installation of drip line. Also, the “cut” resulting from the installation allows an easy path for the water to surface during dosing.

Remedy: In most cases the sod will compact naturally around the drip line and the surfacing will diminish and ultimately cease. To help, reduce the duration of each dose and increase the number of doses/day. Also, it will help to seed the area to encourage the development of a good root zone.

Symptom: Entire area of drip field is wet, soft and spongy. It appears to be totally saturated with water. Situation occurs during dry season when there is little rainfall.

Possible cause: Water being discharged to drip field exceeds design. Excess water may be a result of infiltration, plumbing leaks or excessive water usage.

Remedy: Check water meter, elapsed time meter, pump counter, override counter or high level alarm counter to determine if water usage is in excess of design. Check for leaks or infiltration. Repair leaks as required. Reduce water usage by installing water saving fixture.

Remedy: If water usage cannot be reduced, enlarge drip field as required.

Possible cause: Area of drip field was inadequately sized and is too small.

Remedy: Provide additional soil analysis to verify sizing and enlarge as required.

Valve Troubleshooting

Symptom: Valve will not open manually

Check water supply and any possible master or gate valves to insure they are open.

Check that the valve is installed with the arrow pointing in the downstream direction.

Check that the flow control is fully open, counterclockwise.

Turn off the water supply. Remove the solenoid and check for debris blocking the exhaust port.

Turn off the water supply. Remove the cover. Inspect the diaphragm for damage and replace if necessary.

Symptom: Valve will not open electrically

Check voltage at controller for 24 VAC station.

Check voltage across the solenoid lead wires for minimum 21 VAC.

Make sure handle on top of valve is free spinning. Not all the way open or all the way closed.

If the valve still does not operate electrically, replace the solenoid.

Symptom: Valve will not close

Insure the manual bleed lever is in the closed position.

Check for leaks around the flow control, solenoid or between valve cover and body.

Turn off the water supply. Remove the solenoid and check for debris or damage to the exhaust port.

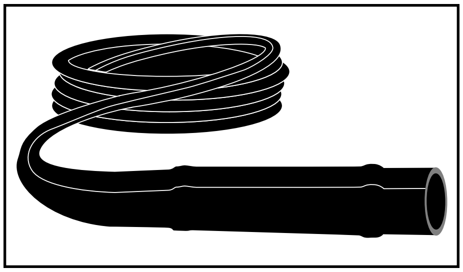
Turn off the water supply. Remove valve cover and inspect for debris under diaphragm or debris in diaphragm ports.

Symptom: Slow leak

Check for dirt or gravel embedded in the diaphragm seat.

Check actuator and exhaust fitting for proper seating.

APPENDIX



WASTEFLOW DRIPLINE

DESCRIPTION

The flexible 1/2″ polyethylene dripline has large emitters regularly spaced in the line. With the dripline hidden about six inches below ground effluent is distributed slowly and uniformly, reducing ponding, even in difficult soils and hilly terrain.

WASTEFLOW is built to last. It is guaranteed to be trouble-free from root intrusion with built-in *ROOTGUARD*® protection, and the dripline wall is protected from organic growth with a bactericide lining.

WASTEFLOW provides uniform distribution. The emitters have a Coefficient of variation (Cv) of less than .05.

Different flow rates, dripline diameters and emitter spacings can be special ordered.

Use 600 series compression adapters or lockslip fittings to connect the dripline to PVC pipe.

ROOTGUARD® PROTECTION

WASTEFLOW dripline features patented *ROOTGUARD*® technology to prevent roots from clogging the emission points. The pre-emergent, Treflan®, is bound into *WASTEFLOW* emitters when they are molded to divert roots from growing into the emitter outlet. The system is guaranteed against root intrusion for 10 years.

BACTERICIDE PROTECTION

Ultra-Fresh DM50 is incorporated into the inner lining and emitters of *WASTEFLOW* dripline to prevent bacteria from forming and eliminates the need to scour the tubing. It is a tin based formula that defeats the energy system of microbial cells.

WHEN TO USE WASTEFLOW PC VS. WASTEFLOW CLASSIC

Geoflow, Inc. offers WASTEFLOW dripline in both pressure compensating (WASTEFLOW PC) and non-compensating (WASTEFLOW Classic) models.
We recommend that WASTEFLOW PC be used when the advantages are of substantial economic value.

a) Very long runs.
b) Steep slopes. Systems should be designed for the dripline lateral to follow the contour. If this is possible, the extra cost of pressure regulators required for WASTEFLOW Classic would likely be less than the incremental cost of WASTEFLOW PC.
c) Rolling terrain. If the difference in height from trough to peak exceeds six feet then WASTEFLOW PC should be used. Vacuum relief valves must be placed at the top of each rise.

WASTEFLOW PC and WASTEFLOW Classic can be interchanged to meet filter and zone flow requirements.

WASTEFLOW dripline is available in 20mm diameter. Please see Geoflow website for specifications.

- WASTEFLOW is manufactured under US Patents 5332160,5116 414 and Foreign equivalents.
- WASTEFLOW is a registered trademark of A.I.Innovations.
- TREFLAN is a registered trademark of Dow Agro Chemicals.

WASTEFLOW Classic

Available in 2 standard models:

WF16-4-24 WASTEFLOW Classic 24″/ 1.3gph

WF16-4-12 WASTEFLOW Classic 12″/ 1.3gph

Alternate flow rates, diameters and spacing available upon request.

Flow Rate vs. Pressure (+/- 5%)
Wasteflow Classic

Pressure	Head	WF16-4-24	WF16-4-12
10 psi	23.10 ft	0.90 gph	0.90 gph
15 psi	34.65 ft.	1.13 gph	1.13 gph
20 psi	46.20 ft.	1.30gph	1.30gph
25 psi	57.75 ft.	1.47 gph	1.47 gph
30 psi	69.30 ft.	1.62 gph	1.62 gph
35 psi	80.85 ft.	1.76 gph	1.76 gph
45 psi	103.95 ft	1.89 gph	1.89 gph

Maximum Length of Run vs. Pressure
Wasteflow Classic
Flow variation +/- 5%

Total loss taken in dripline. No allowance for loss in the manifolds.

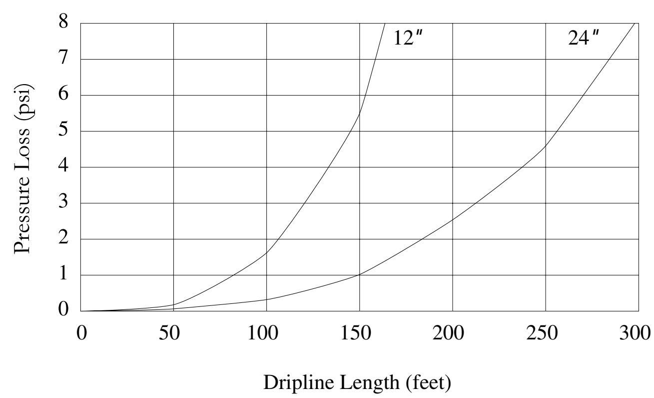
Pressure	Head	WF 16-4-24	WF 16-4-18	WF 16-4-12
10-45 psi	23 - 104 ft.	210 ft.	208 ft.	120 ft.

Allows 25% of loss in manifold

Pressure	Head	WF 16-4-24	WF 16-4-18	WF 16-4-12
10-45 psi	23 - 104 ft.	170 ft.	165 ft.	100 ft.

Kd = 0.9

Wasteflow Classic
Pressure Loss vs. length of Dripline



WASTEFLOW Classic Specification

The dripline shall consist of nominal sized one-half inch linear low density polyethylene tubing, with turbulent flow, drip emitters bonded to the inside wall. The drip emitter flow passage shall be 0.053″ x 0.053″ square. The tubing shall have an outside diameter (O.D.) of approximately .64-inches and an inside diameter (I.D.) of approximately .55-inches. The tubing shall consist of three layers; the inside layer shall be a bactericide protection, the middle layer shall be black and the outside layer shall be purple striped for easy identification. The dripline shall have emitters regularly spaced 24″ (or 12″) apart. The turbulent flow emitters shall be molded from virgin polyethylene resin. The turbulent flow emitters shall have nominal discharge rates of 1.3 gallons per hour at 20 psi. The emitters shall be impregnated with Treflan® to inhibit root intrusion for a minimum period of ten years and shall be guaranteed by the manufacturer to inhibit root intrusion for this period. WASTEFLOW Classic dripline shall be Geoflow model number WF16-4-24 (or WF16-4-12).

WASTEFLOW PC 0.53 GPH

WFPC16-2-24 WASTEFLOW PC 24″/ .53gph

WFPC16-2-18 WASTEFLOW PC 18″/ .53gph

WFPC16-2-12 WASTEFLOW PC 12″/ .53gph

Alternative spacing, flow rates and diameters available upon request

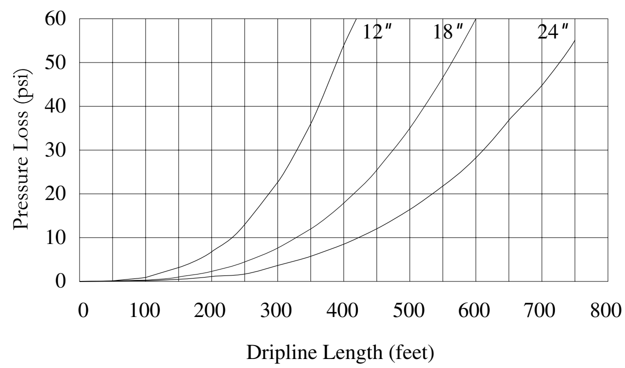
Pressure	Head	WFPC16-2-24 WPFPC16-2-18 WFPC16-2-12
7-60 psi*	16 -139 ft.	0.53 gph

Maximum Length of Run vs. Pressure
Wasteflow PC
Allows a minimum of 10 psi in the line
*Recommended operating pressure is 10-45 psi

Pressure	Head	WFPC 16-2-24	WFPC 16-2-18	WFPC 16-2-12
10 psi	23.10 ft.	—	—	—
15 psi	34.65 ft.	321 ft.	260 ft.	174 ft.
20 psi	46.20 ft.	423 ft.	330 ft.	228 ft.
25 psi	57.75 ft	478 ft.	377 ft.	260 ft.
30 psi	69.30 ft.	535 ft.	415 ft.	288 ft.
35 psi	80.85 ft	576 ft.	448 ft.	313 ft.
40 psi	92.40 ft.	613 ft.	475 ft.	330 ft.
45 psi	103.95 ft	651 ft.	501 ft.	354 ft.
50 psi *	115.50 ft	675 ft.	523 ft.	363 ft.
55 psi *	127.50 ft	700 ft.	544 ft.	377 ft.
60 psi *	138.60 ft	727 ft.	563 ft.	403 ft.

Kd = 2.070

Wasteflow PC 0.53 gph.
Pressure Loss vs. length of Dripline



WASTEFLOW PC Specification

The dripline shall consist of nominal sized one-half inch linear low density polyethylene tubing, with turbulent flow, drip emitters bonded to the inside wall. The drip emitter flow passage shall be 0.032″ x 0.045″ square. The tubing shall have an outside diameter (O.D.) of approximately .64-inches and an inside diameter (I.D.) of approximately .55-inches. The tubing shall consist of three layers; the inside layer shall be a bactericide protection, the middle layer shall be black and the outside layer shall be purple striped for easy identification. The dripline shall have emitters regularly spaced 24″ (or 18″ or 12″) apart. The pressure compensating emitters shall be molded from virgin polyethylene resin with a silicone rubber diaphragm. The pressure compensating emitters shall have nominal discharge rates of 0.53 gallons per hour. The emitters shall be impregnated with Treflan® to inhibit root intrusion for a minimum period of ten years and shall be guaranteed by the manufacturer to inhibit root intrusion for this period. 0.53 gph WASTEFLOW PC pressure compensating dripline shall be Geoflow model number WFPC16-2-24 (or WFPC16-2-18 or WFPC16-2-12)

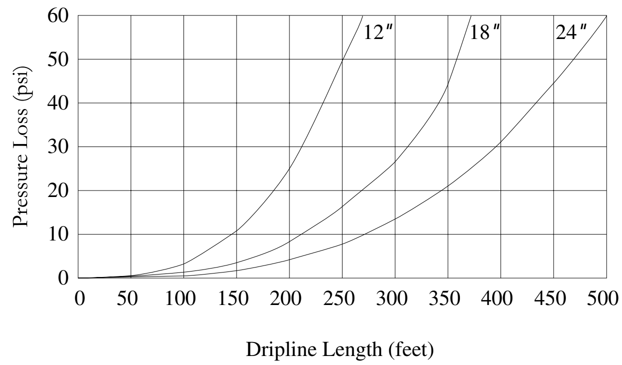
WASTEFLOW PC 1.02 GPH

WFPC16-4-24 WASTEFLOW PC 24″/ 1.02gph
WFPC16-4-12 WASTEFLOW PC 12″/ 1.02gph
Alternate spacing available upon request.

Flow Rate vs. Pressure

		Dripline
Pressure	Head	WFPC16-4-24 WFPC16-4-12
7 - 60 psi*	16 - 139 ft.	1.02 gph

Wasteflow PC 1.02 gph.
Pressure Loss vs. length of Dripline



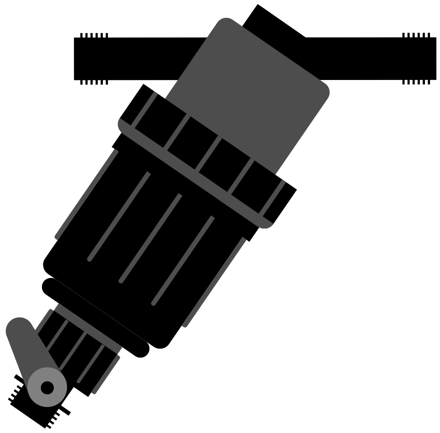
Maximum Length of Run vs. Pressure
Allows a minimum of 10 psi in the line
*Recommended operating pressure is 10 - 45 psi

Pressure	Head	WFPC 16-4-24	WFPC 16-4-18	WFPC 16-4-12
10 psi	23.10 ft.	—	—	—
15 psi	34.65 ft.	211 ft.	172 ft.	115 ft.
20 psi	46.20 ft.	265 ft.	210 ft.	146 ft.
25 psi	57.75 ft.	315 ft.	242 ft.	171 ft.
30 psi	69.30 ft.	335 ft.	266 ft.	180 ft.
35 psi	80.85 ft.	379 ft.	287 ft.	199 ft.
40 psi	92.40 ft.	385 ft.	305 ft.	211 ft.
45 psi	103.95 ft.	429 ft.	321 ft.	222 ft.
50 psi*	115.50	431 ft.	334 ft.	232 ft.
55 psi*	127.05	449 ft.	347 ft.	240 ft.
60 psi*	138.60	465 ft.	360 ft.	249 ft.

Kd = 2.070

WASTEFLOW PC 1.02 GPH Specification

The dripline shall consist of nominal sized one-half inch linear low density polyethylene tubing, with turbulent flow, drip emitters bonded to the inside wall. The drip emitter flow passage shall be 0.032″ x 0.045″ square. The tubing shall have an outside diameter (O.D.) of approximately .64-inches and an inside diameter (I.D.) of approximately .55-inches. The tubing shall consist of three layers; the inside layer shall be a bactericide protection, the middle layer shall be black and the outside layer shall be purple striped for easy identification. The dripline shall have emitters regularly spaced 24″ (or 12″) apart. The pressure compensating emitters shall be molded from virgin polyethylene resin with a silicone rubber diaphragm. The pressure compensating emitters shall have nominal discharge rates 1.02 gallons per hour. The emitters shall be impregnated with Treflan® to inhibit root intrusion for a minimum period of ten years and shall be guaranteed by the manufacturer to inhibit root intrusion for this period.
1.02 gph WASTEFLOW PC pressure compensating dripline shall be Geoflow model number WFPC16-4-24 (or WFPC16-4-12).



VORTEX FILTERS

Description

The filters are placed between the pump and dripfield to screen out any debris.

Body - Two-piece threaded housing with O-ring seal. Molded from high heat ABS and chemical resistant glass reinforced plastic.

Screen - Sintered stainless steel. Sintering is a process in which three pieces of stainless steel mesh are transformed into one; a perforated plate, 30m then 150 mesh. Screen collars molded from vinyl for long life and durability.

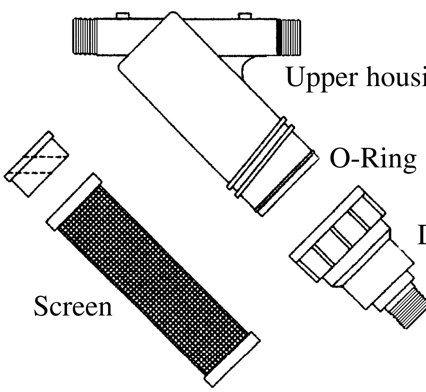
Spin Plate and drain - Directional spin plate is molded of PVC or fiberglass.

Vortex Spin Action - Incoming water is forced through a directional nozzle plate onto the inside of the stainless steel screen. A centrifugal motion starts inside the screen chamber, throwing organic and inorganic particles outward against the screen. Gravity, moves the debris down the screen wall to the 3/4″ flush outlet at the base of the Vortex Filter.

To stay clean, two criteria must be met:

a. Flow into the filter must be within the specified range to produce a 5 to 8 psi pressure differential across the filter.

b. The filter flush valve must be partially to fully open allowing debris to flush away.



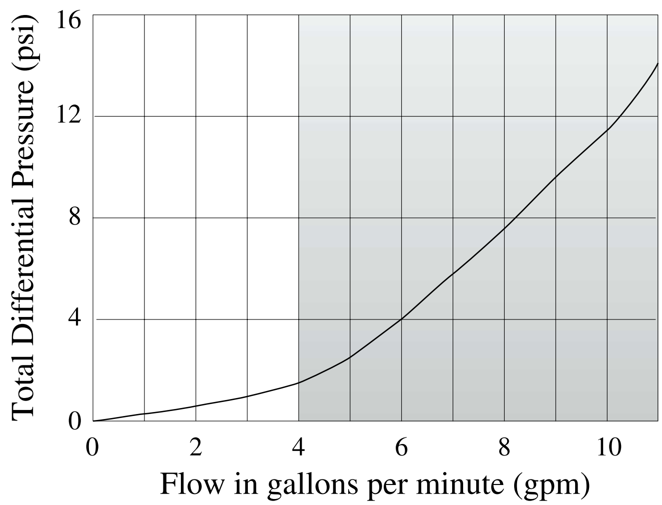
ITEM NUMBER	SIZE (MIPT)	FLOW (GPM)	MAX. PRESSURE	WIDTH (thread to thread)	HEIGHT (with flush port)	SIZE OF FLUSH PORT	AREA OF FILTRATION
AP4E-75	3/4″	04 - 11	80 psi	6.0″	12.0″	3/4″ MPT	23.4 inches^2
AP4E-100	1.0″	07 - 28	80 psi	6.5″	13.0″	3/4″ MPT	28.4 inches^2
AP4E-150-3	1.5″	34 - 42	100 psi	12.0″	15.5″	3/4″ MPT	60.8 inches^2
AP4E-150-4	1.5″	45 - 55	100 psi	12.0″	15.5″	3/4″ MPT	60.8 inches^2
AP4E-200-3	2.0″	68 - 84	80 psi	12.0″	16.0″	3/4″ MPT	60.8 inches^2
AP4E-200-4	2.0″	90 - 110	80 psi	12.0″	16.0″	3/4″ MPT	60.8 inches^2

AP4E-75 3/4″ Filter

Specification

The Y filter body shall be molded from glass reinforced engineering grade black plastic with a 3/4 inch male pipe thread (MIPT) inlet and outlet. The two piece body shall be capable of being serviced by untwisting and shall include an O-ring seal. An additional 3/4 inch MIPT outlet shall be capable of periodic flushing. The 150-mesh filter screen is all stainless steel, providing a 23.4 square inch filtration area. The screen collar shall be molded from vinyl. The 3/4″ filter shall be Geoflow Vortex Filter model number AP4E-75.

Flow vs. Pressure



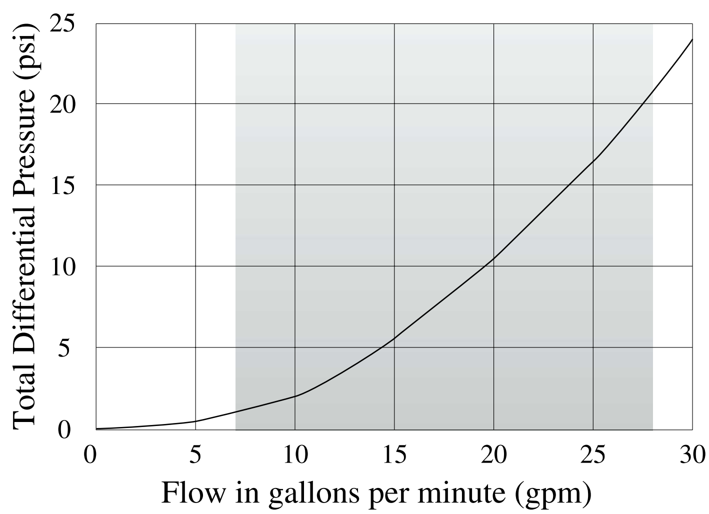
Self cleaning action occurs in shaded area. (4-11gpm)

AP4E-100 1″ Filter

Specification

The Y filter body shall be molded from glass reinforced engineering grade black plastic with a 1 inch male pipe thread (MIPT) inlet and outlet. The two piece body shall be capable of being serviced by untwisting and shall include an O-ring seal. An additional 3/4 inch MIPT outlet shall be capable of periodic flushing. The 150 mesh filter screen is all stainless steel, providing a 28.4 square inch filtration area. The screen collar shall be molded from vinyl. The 1″ filter shall be Geoflow Vortex Filter model number AP4E-100.

Flow vs. Pressure



Self cleaning action occurs in shaded area (7-28gpm)

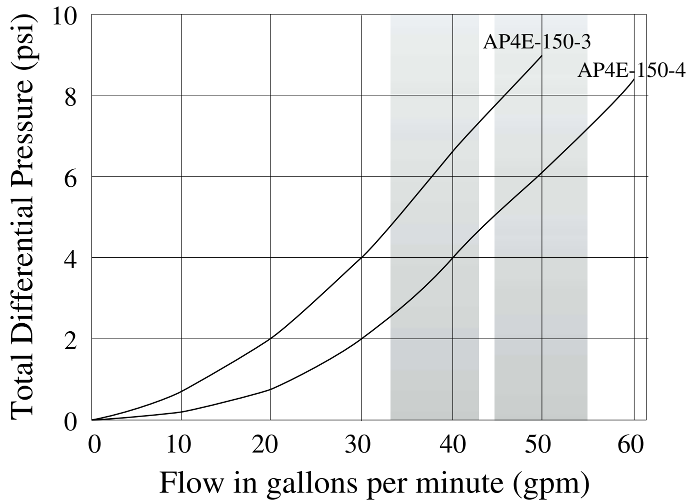
Note: Two or three 1″ Vortex filters can be used side by side to deliver higher flow rates or to decrease pressure loss through the filters.

AP4E-150 1.5″ Filter

Specification

The Y filter body shall be molded from glass reinforced engineering grade black plastic with a 1.5 inch male pipe thread (MIPT) inlet and outlet. The two piece body shall be capable of being serviced by unscrewing and shall include an O-ring seal. An additional 3/4‰ MIPT outlet shall be capable of periodic flushing. The 150 mesh filter screen is all stainless, providing a 60.8 square inch filtration area. The outer support shell shall be woven stainless steel wire, and the inner screen shall be made of stainless steel cloth. The inner and outer screens shall be soldered together. The screen collar shall be molded from vinyl. The 1½″ filter shall be Geoflow model number AP4E-150-3 or AP4E-150-4

Flow vs. Pressure



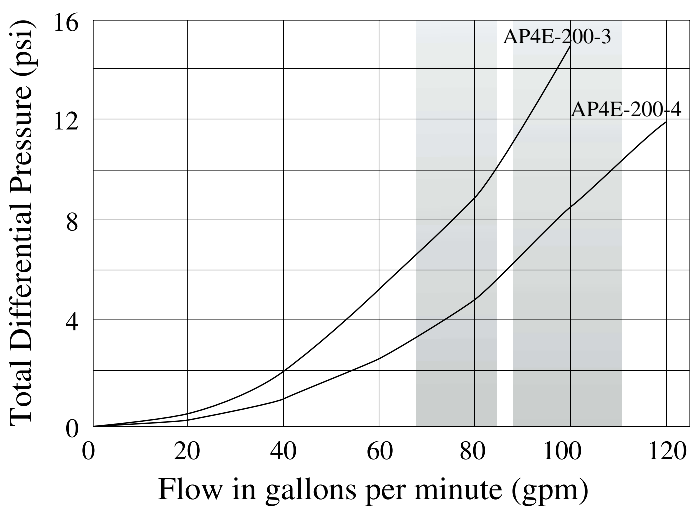
AP4E-150-3 at 34-42 gpm & AP4E-150-4 at 45-55 gpm

AP4E-200 2″ Filter

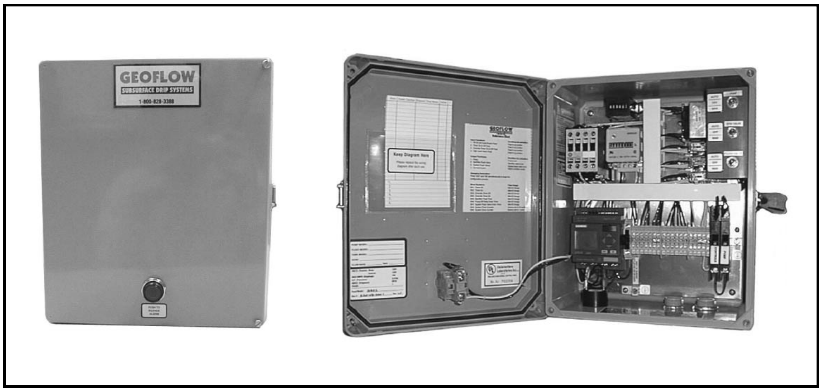
Specification

The Y filter body shall be molded from glass reinforced engineering grade black plastic with a 2 inch male pipe thread (MIPT) inlet and outlet. The two piece body shall be capable of being serviced by unscrewing and shall include an O-ring seal. An additional 3/4‰ MIPT outlet shall be capable of periodic flushing. The 150 mesh filter screen is all stainless, providing a 60.8 square inch filtration area. The outer support shell shall be woven stainless steel wire, and the inner screen shall be made of stainless steel cloth. The inner and outer screens shall be soldered together. The screen collar shall be molded from vinyl. The 2″ filter shall be Geoflow model number AP4E-200-3 or AP4E-200-4.

Flow vs. Pressure



AP4E-200-3 at 68-84 gpm & AP4E-200-4 at 90-110gpm



GEO CONTROLLERS

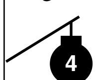
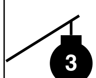
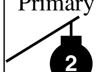
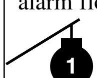
Geo controllers are the brain in the system, utilizing a programmable logic controller (PLC) to activate the pumps cycles, zone valves and flush valves when needed. See the table below for the control panel that fits your application.

All Geo controllers have the following built-in log functions:

- Elapsed time meter (ETM)
- Pump events
- Peak timer events
- High level alarm events
- Power failure events

Note: ETM and pump events are recorded whenever contactor is energized.

Float Functions GEO Controllers

Floats	Functions
High Level Alarm Float 	Float raised - Alarm enable. Activates the audible and visual alarm when lifted. Audible alarm may be silenced by pressing the illuminated "PUSH TO SILENCE" button. The audible alarm reactivates after 12 hours if the alarm condition is not resolved. The alarm light will remain on until the float is lowered.
Secondary Timer On/Off Float 	Float raised - Peak Timer enable. The Peak timer will cycle the pump(s) more frequently. The Peak Timer function will remain active until the Primary Timer enable float lowers. When the Peak Timer function has been completed and the Primary Timer enable float is reactivated, normal timer operation will resume.
Primary Timer On/Off Float 	Float raised - Timer enable. The Primary Timer will control pump cycles, beginning with the off cycle. Note: On duplex panels the pumps will alternate with each timer cycle.
Redundant Off & Low Level alarm float 	Float raised - Pump enable. Float lowered - Pump disable. Flashing visual & audible alarm enable. This is a secondary off float that will prevent the operation of the pump if the water level in the tank gets too low. Pumping will be disabled in both the automatic and manual modes. This float also activates the visual and audible alarms. Audible alarm may be silenced by pressing the illuminated "PUSH TO SILENCE" button. The audible alarm reactivates after 12 hours if the alarm condition is not resolved. The flashing alarm light will remain on until the float is raised. When raised, this float will enable operation of the pump.

Choose a GEO controller:

Step 1: Number of zones in dispersal field.

Single zone. - Go to GEO1 table below.
Two to four zones. - Zones activated hydraulically with indexing valves. Go to GEO1 table.
- Zones activated electrically with solenoid valves. Go to GEO4 table.
Five to eight zones. - Zones activated hydraulically with indexing valves. Go to GEO1 table.
- Zones activated electrically with solenoid valves. Go to GEO8 table.
More than 8 zones. - Zones activated hydraulically with indexing valves. Go to GEO1 table.
- Zones activated electrically with solenoid valves. Special order.
- Zones activated with index & solenoid valve combinations can be accommodated. Please call Geoflow, Inc.

Step 2: Voltage.

Determine the required pump voltage.
115vac (max 3/4hp; 1phase pump) or 230vac (max 2hp; 1phase pump).
Pumps must have internal capacitors. Any pumps requiring external capacitor kits will be special order. Capacitor kits and dimensions must be provided by pump manufacturer.

Step 3: Number of pumps.

Choose one pump (simplex) or two pumps (duplex).

Step 4: Flushing operation.

Choose manual or electronic field and filter flushing. Geoflow requires all direct septic systems use electronic flushing. (Manual flushing not available on GEO4 or GEO8 panels).

GEO 1 Table

Step 1	Step 2	Step 3	Step 4	Part Number
GEO1	115vac	Simplex	Manual	Geo1-115v-Sim-Man
			Auto	Geo1-115v-Sim-Aut
		Duplex	Manual	Geo1-115v-Dup-Man
			Auto	Geo1-115v-Dup-Aut
	230vac	Simplex	Manual	Geo1-230v-Sim-Man
			Auto	Geo1-230v-Sim-Aut
		Duplex	Manual	Geo1-230v-Dup-Man
			Auto	Geo1-230v-Dup-Aut

GEO 4 Table

Step 1	Step 2	Step 3	Step 4	Part Number
GEO4	115vac	Simplex	Auto	Geo4-115v-Sim-Aut
		Duplex	Auto	Geo4-115v-Dup-Aut
	230vac	Simplex	Auto	Geo4-230v-Sim-Aut
		Duplex	Auto	Geo4-230v-Dup-Aut

GEO 8 Table

Step 1	Step 2	Step 3	Step 4	Part Number
GEO8	115 vac	Simplex	Auto	Geo8-115v-Sim-Aut
		Duplex	Auto	Geo8-115v-Dup-Aut
	115 vac	Simplex	Auto	Geo8-230v-Sim-Aut
		Duplex	Auto	Geo8-230v-Dup-Aut

GEO1 *MANUAL* CONTROLLERS

The Primary Timer (float 2-activated) controls the pump dose cycle during normal operating conditions. During high flow conditions the pump dosing cycles will be controlled by the Peak Timer (float 3 - activated). The Peak Timer off is typically set to trigger more frequent flow than the Primary Timer off setting.

If *duplex pump* option is chosen, the pumps are alternated every pump cycle and never operate simultaneously. There is a selection switch for pump 1, pump 2 or alternation. This allows one pump to be taken out of service for maintenance without affecting the operation of the system.
Pump dosing cycles are controlled by the timers when the H-O-A switch is in the auto position. Under normal conditions the Primary Timer (float 2) will control the pump(s). During high flow conditions, the Peak Timer (float 3) will control the pump(s). The Peak Timer will cycle the pump more frequently than the Primary Timer (field adjustable). The pump will dose for the same amount of time as it does when operated by the Primary Timer but the time in between doses, or the Peak timer "off time", will be 75% of that of the Primary Timer "off time". Factory settings (field adjustable) are 1 hr 55 minutes off and 5 minutes on for Primary Timer and Peak Timer is set to 1 hr 25 minutes off (1 hr 55 mins x 75%) and 5 minutes on. Consequently peak doses are more frequent than normal.
Hydraulically activated zone valve(s) will index each time the PLC calls for a dose. Each time the pump is called for another zone is dosed. The controller does not dose all zones sequentially as "one" dose and ignores the fact that there are multiple zones for the purpose of dosing. For example if the Primary Timer is programmed to be off for 1 hour, on for 5 minutes and there are four zones, each zone will get 6 doses - five minutes in length - in a 24-hour period. The controller will dose a single zone every hour and will not dose all zones every hour.

GEO *AUTOMATIC* CONTROLLERS

The Primary Timer (float 2 activated) controls the pump dose cycle during normal operating conditions. During high flow conditions the pump dosing cycles will be controlled by the Peak Timer (float 3 activated).
If *duplex pump* option is chosen, the pumps are alternated every pump cycle and never operate simultaneously. There is a selection switch for pump 1, pump 2 or alternation. This allows one pump to be taken out of service for maintenance without affecting the operation of the system. *The Vortex Filter flush* valve will open for 15 seconds (field adjustable) at the end of the pump cycle to allow the filter to self-flush. When the vortex filter flush is complete, the filter flush valve will close and the system drain function will begin.
Pump dosing cycles are controlled by the timers when the H-O-A switch is in the auto position. Under normal conditions the Primary Timer (float 2) will control the pump. During high flow conditions, the Peak Timer (float 3) will control the pump. The Peak Timer will cycle the pump more frequently than the Primary Timer . The pump will dose for the same amount of time as it does when operated by the Primary Timer but the time in between doses, or the Peak Timer "off time", will be 75% that of the Primary Timer "off time". Factory settings (field adjustable) are 1 hr 55 minutes off and 5 minutes on for Primary Timer and Peak Timer is set to 1 hr 25 minutes off (1 hr 55 mins x 75%) and 5 minutes on.
Zone valve(s) will open when the PLC calls for a dose or flush. These can be electrically operated solenoid valves (requires GEO4 or GEO8) or hydraulically activated index valves (used with GEO1). Each time the pump is called for another zone is dosed. The controller does not dose all zones sequentially as "one" dose but rather ignores the fact that there are multiple zones for the purpose of dosing. The total doses of all zones in a 24-hour period must be considered when setting the "off" timer(s). After the pump is deactivated the electrically activated solenoid flush valve will remain open for five minutes (field adjustable) to allow for drainage of the supply line and return line.
If hydraulically activated index valve is used, be sure to drain the supply line in freezing climates.

If hydraulically activated index valves are used in combination with a solenoid field flush valve, a field setting for number of zones and number of zone valves is available.
Field flush valve will open at the end of the dosing cycle. The pump will continue to run for 5 seconds (field adjustable) to accommodate the opening of this valve. After the pump is deactivated the field flush valve will remain open for five minutes (field adjustable) to allow for drainage of the return line in freezing conditions. It is best to clock the length of time it takes the return flush line to drain and use this to set your drain time.
The activated zone valve remains open at the end of the dose for same " # " minutes as return flush and filter flush valves to accommodate drainage of supply line.
To periodically *flush the dripfield*, after 10 dosing cycles (field adjustable) the pump will operate for 5 minutes (field adjustable) with the field flush valve open. The field flush cycle will repeat until all zones have been flushed. This operation will also occur after a power outage. This is achieved by correctly inputting number of zone valves (if applicable) and number of zones during setting of the controller values.

GEO Panel Components:

- Siemen's Logo programmable logic module for timing and controls.
- Contactor and circuit breaker for pump (115VAC; max 3/4hp; 1E pump or 230VAC; max 2hp; 1E pump). Pumps must have built in capacitors. (External capacitor kits are special order).
- Hand-Off-Auto (H-O-A) switches for pump(s) and valve(s) operation.
- Connections/contacts for normally closed 24 VAC valves. (Contacts for normally open valves may be special ordered.)
- Elapsed time meter and cycle counter for pump monitoring built in to PLC.
- Circuit breaker for control power.
- Surge arrestor.
- NEMA 4 X fiberglass enclosure.
- UL listed control panel.

GEO Wiring

- Control voltage input is 115 VAC for all GEO1 and GEO4 panels.
- Output to valve(s) is 24 VAC.

Telemetry and SCADA control systems available. Please contact Geoflow for custom panel information.

SOLENOID VALVES

Description

The Solenoid Valve is electrically operated and used as zone valves and to flush the dripfield and Vortex filter. It is normally closed, and in the event of a power failure the valve closes.

Features

Unique Dual Ported Diaphragm greatly minimizes clogging. In operation, the diaphragm ports constantly flex, inhibiting sand, silt and debris from blocking the valve action.

The porting design also permits equal pressure on both sides of the diaphragm wall, regardless of line pressure when valve is not operating, and nearly equal pressure across the wall when operating. This feature prevents diaphragm "stretching", a common cause of valve failure in valves that are ported through the seat.

The DW Valve diaphragm is made of nylon fabric reinforced Buna-N rubber; a grooved rib interlocks with cover and body to prevent leakage.

Nylon exhaust orifice is non-corrosive and has an opening sized larger than the diaphragm ports so that any pieces of sand or silt passing through the diaphragm will not be trapped beneath the solenoid actuator.

Solenoid is constructed of molded epoxy resin having no carbon steel components exposed thereby eliminating possible external corrosion and deterioration. Solenoid is completely waterproof, with an O-ring seal, and complies with NEC Class II circuit requirements for 24V a.c. operation (also operates on 12 volts d.c. up to 75 psi).

The actuator is teflon coated stainless steel and brass with a molded-in place rubber exhaust port seal; a stainless steel spring assures positive seating.

High strength plastic glass-filled body and cover designed to operate in heavy duty commercial applications. Stainless steel 1/4 inch cover bolts and mating brass body inserts make re-assembly easy.

Shock cone on diaphragm seat eliminates water hammer in all except extreme cases.

Flow control. A brass, non-rising type flow control stem for throttling the valve from full open to close positions.

Manual bleed lever. An easy-to-use, hand operated control bleeds valve to downstream; has stops for open and closed positions.

Operating Data

Cold water working pressure: 150 psi

The DW Valve has excellent low flow characteristics ideally suited for dripfield and Vortex filter applications.

Installation

Teflon tape is recommended. 1 inch FIP can be bushed to 3/4 inch. 1-1/2 inch FIP can be bushed to 1-1/4 inch. International threads. (Specify ISO).

The manual bleed lever should always be in the horizontal position and the dial on top should be free spinning for valve to operate automatically. Clockwise rotation closes valve.

S O L E N O I D V A L V E S

ELECTRICAL

Wiring requires a single lead from the controller to each solenoid valve, plus a common neutral to all solenoids. Type UF wire, UL listed, is recommended for all hookups.

24 VAC/60 Hz	24 VAC/50 Hz
Inrush: 9.86 VA	Inrush: 10.7 VA
Holding: 5.69 VA	Holding: 7.5 VA

Pressure loss through Valves (in psi)

GPM	SVLV-100	SVLV-150	SVLV-200
0-4	1.2 max.		
6	1.4 psi		
8	1.6		
10	1.7		
12	1.8		
14	1.9		
16	2.0		
18	2.1		
20	2.3	1.3 psi	
22	2.5	1.4	
24	2.8	1.5	
26	3.2	1.6	
28	3.7	1.7	
30	4.3	1.9	
32	4.9	2.1	
34	5.6	2.3	
36	6.3	2.5	
38	7.0	2.8	
40	7.7	3.0	2.3 psi
42	8.4	3.3	2.3
44	9.1	3.6	2.4
46	9.9	3.9	2.4
48	10.7	4.2	2.5
50	11.5	4.6	2.6
52		5.0	2.6
54		5.4	2.7
56		5.8	2.7
58		6.2	2.8
60		6.7	2.9
70		9.5	3.3
80		13.0	3.4
90			4.2
100			5.2
110			6.7
120			7.7
130			8.8

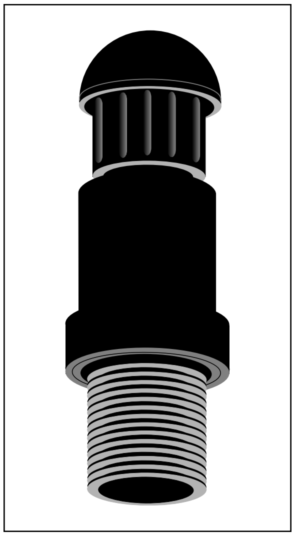
Note. Wire sizes that are too small can cause voltage to drop below the minimum required to operate controllers and valves.
Do not use nominal voltage ratings listed above for sizing of valve wire. See wire-sizing tables below based on operating pressure and wire length.

Wire Size—1 valve per station.
Input to controller is 115 Va.c.

Maximum length of wire run in feet from control to valve

AWG size		Static pressure not exceeding				
Diameter No.	In.	75 psi	85 psi	100 psi	125 psi	160 psi
18	0.040′	2200′	2000′	1600′	1,100′	700′
16	0.051′	3600′	3200′	2500′	1800′	1100′
14	0.064′	5700′	5000′	4000′	3000′	1700′
12	0.081′	9000′	8000′	6400′	4700′	2800′
10	0.102′	14000′	12700′	10200′	7400′	4400′
8	0.129′	22700′	20200′	16200′	11800′	7000′
MULTIPLYING FACTOR: 2 valves per station *		0.43	0.40	0.41	0.38	0.31

* Use this multiplying factor only in the event two valves will be operating simultaneously.

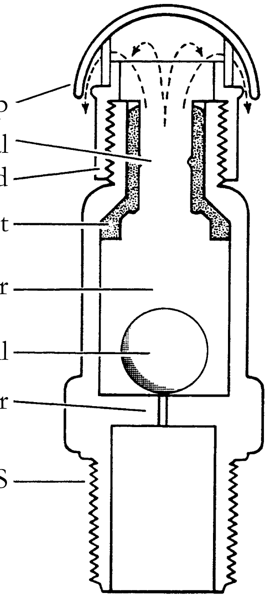


AIR VACUUM BREAKERS

Description

Air Vacuum Breakers are installed at the high points of the WASTEFLOW dripfield to keep soil from being sucked into the drip emitters due to back siphoning or backpressure. This is an absolute necessity with underground drip systems. They are also used for proper draining of the supply and return manifolds in freezing conditions. Use one on the high end of the supply manifold and one at the high point of the flush manifold and any other high points in the system.

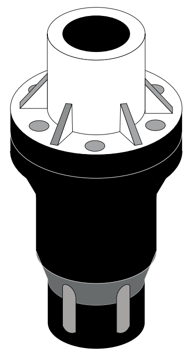
- Instant and continuous vacuum relief
- Non-continuous air relief
- Seals tight at 5 psi
- Durable, weather resistant
- Readily accessible pressure test point
- Easy to install
- Removable dirt cover
- Maximum flow of 50 gpm



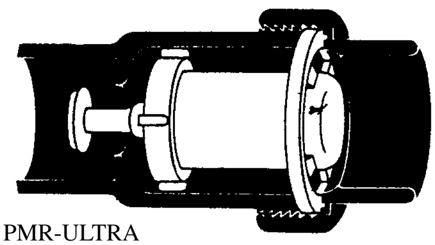
Air Vacuum Specification

The air vacuum relief valve provides instant and continuous vacuum relief and non-continuous air relief. Both the body and the removable dirt cover shall be constructed of molded plastic. The body and the dirt cover shall be connected with a 3/4 inch hose thread. The ball shall be constructed of low density plastic and the internal seat shall be constructed of vinyl. The air vacuum relief valve shall seal at 5 psi. Inlet size shall be a 1 inch male pipe thread. The air vent shall be Geoflow item number APVBK-1.

AIR VACUUM BREAKERS



PMR 20 & PMR 50



PMR-ULTRA

P R E S S U R E R E G U L A T O R

Description

The regulators are preset to regulate pressure to the field. These are recommended with Wasteflow Classic and optional with Wasteflow PC. This is the first component of the supply manifold. Under normal operating conditions, pressure in the drip lines should be:

10 psi to 45 psi for WASTEFLOW Classic and WASTEFLOW PC Dripline.

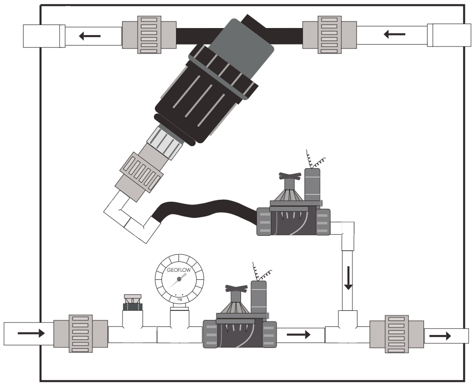
ITEM NUMBER	OUTLET PRESSURE	FLOW RANGE	MAX. INLET PRESSURES	INLET SIZE	OUTLET SIZE
PMR-20LF	20 psi	1/10 - 8 gpm	150 psi	3/4" FIPT	3/4" FIPT
PMR-20MF	20 psi	2 - 20 gpm	150 psi	1" FIPT	1" FIPT
PMR-20HF	20 psi	10 - 32 gpm	150 psi	1.25" FIPT	1" FIPT
PMR-50MF	50 psi	2 - 20 gpm	150 psi	1" FIPT	1" FIPT
PMR-50HF	50 psi	10 - 32 gpm	150 psi	1.25" FIPT	1" FIPT
PMR-ULTRA	20 psi	12 - 75 gpm	20 - 75 psi	1.5" socket	1.5" socket

PMR 20 and PMR 50 Specification

Pressure regulator shall be designed to handle steady inlet pressures of 150 psi and withstand severe water hammer extremes. It shall handle flow rates between ___ and ___ gpm. Flow restriction shall be negligible until the factory preset operating pressure of ___psi is reached. Regulating accuracy shall be within +/- 6%. Inlet size shall be ___ FIPT. Outlet size shall be ___FIPT. Pressure regulator shall be constructed of high impact engineering grade thermoplastics. Regulator shall be accomplished by a fixed stainless steel compression spring enclosed in a chamber separate from the normal water passage. Each regulator shall be water tested for accuracy. Preset pressure regulators shall be Geoflow model no. PMR -___.

PMR ULTRA Specification

Pressure regulator shall be designed to handle steady inlet pressures of 150 psi and withstand severe water hammer extremes. It shall handle flow rates between 12 and 75 gpm. Flow restriction shall be negligible until the factory preset operating pressure of 20 psi is reached. Regulating accuracy shall be within +/- 6%. Inlet and outlet size shall be 1.5" socket. Pressure regulator shall be constructed of high impact ABS and delrin materials. Each regulator shall be water tested for accuracy. Pressure regulators shall be Geoflow model number PMR-ULTRA.



Automatic Headwork

HEADWORKS

Description

Geoflow accessory parts are now available pre-assembled with either manual or automatic flush configurations. Each headwork box includes the following:

- Vortex filter
- Field flush valve
- Headwork air vent
- Filter flush valve
- Pressure gauge
- Headwork box

Wasteflow Headworks Super includes flow meter and pressure gauges across the filter and can be special ordered with zone valves pre-assembled in the box.

Note: Air vents, dripline, and fittings are required to complete the Geoflow disposal system. Pressure regulators are recommended with Wasteflow Classic.

Operation

Field and filter flushing can be done manually or automatically.

Manual Headworks

Both valves should be cracked open slightly at all times to allow a constant flush. Make sure pressure at the Headwork gauge is at least 3 psi, and if not, close the valves slightly to increase pressure. The valves need to be open fully for a complete system flush twice a year.

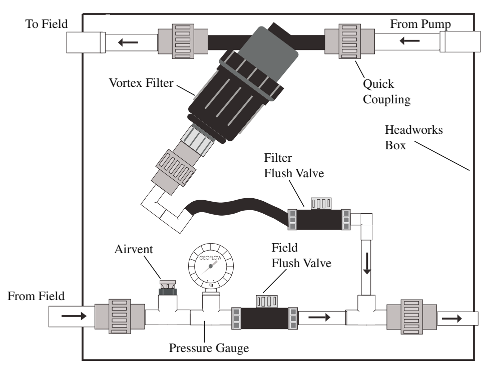
Automatic Headworks

Both valves are activated electrically. Geoflow recommends using a GEO controller to activate your flush cycles in the Automatic Headworks.

Flow Rates

Wasteflow Headworks and Wasteflow Headworks Ultra

Model No.	Min. Flow	Max. Flow
WHW-.75-Aut/Man	4 gpm	11 gpm
WHW-1.0-Aut/Man	10 gpm	28 gpm
WHW-1.5-3Aut	34 gpm	42 gpm
WHW-1.5-4-Aut	45 gpm	55 gpm
WHW-2.0-3-Aut	68 gpm	84 gpm
WHW-2.0-4-Aut	90 gpm	110 gpm



Manual Headwork

Pounds per square inch (psi) per 100 ft. of pipe

	1/2"		3/4"		1"		1 1/4"		1 1/2"	
Flow GPM	Velocity FPS	Pressure Drop PSI	Velocity FPS	Pressure Drop PSI	Velocity FPS	Pressure Drop PSI	Velocity FPS	Pressure Drop PSI	Velocity FPS	Pressure Drop PSI
1	1.05	0.43	0.60	0.11	0.37	0.03				
2	2.11	1.55	1.2	0.39	0.74	0.12	0.43	0.03		
3	3.17	3.27	1.8	0.83	1.11	0.26	0.64	0.07	0.47	0.03
4	4.22	5.57	2.41	1.42	1.48	0.44	0.86	0.11	0.63	0.05
5	5.28	8.42	3.01	2.15	1.86	0.66	1.07	0.17	0.79	0.08
6	6.33	11.81	3.61	3.01	2.23	0.93	1.29	0.24	0.95	0.11
8	8.44	20.10	4.81	5.12	2.97	1.58	1.72	0.42	1.26	0.20
10	10.55	30.37	6.02	7.73	3.71	2.39	2.15	0.63	1.58	0.30
15			9.02	16.37	5.57	5.06	3.22	1.33	2.36	0.63
20					7.42	8.61	4.29	2.27	3.15	1.07
25					9.28	13.01	5.36	3.42	3.94	1.63
30					11.14	18.22	6.43	4.80	4.73	2.27
35							7.51	6.38	5.52	3.01
40							8.58	8.17	6.30	3.88
45							9.65	10.16	7.09	4.80
50							10.72	12.35	7.88	5.83
60									9.46	8.17
70									11.03	10.87

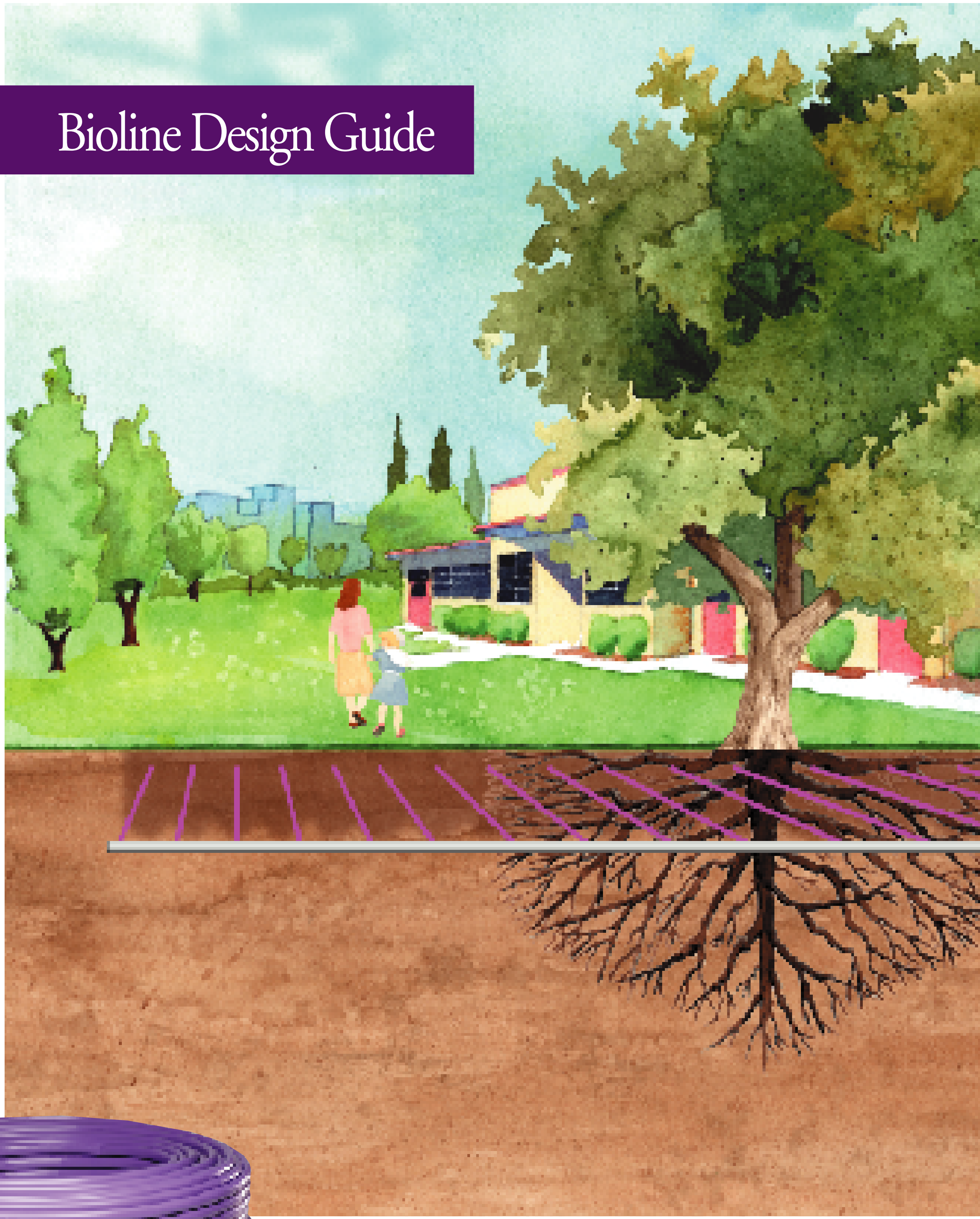
	2" Pipe		2 1/2"" Pipe		3" Pipe		4" Pipe		6" Pipe	
Flow GPM	Velocity FPS	Pressure Drop PSI	Velocity FPS	Pressure Drop PSI	Velocity FPS	Pressure Drop PSI	Velocity FPS	Pressure Drop PSI	Velocity FPS	Pressure Drop PSI
6	0.57	0.03								
8	0.76	0.06	0.54	0.02						
10	0.96	0.09	0.67	0.04						
15	1.43	0.19	1.01	0.08	0.65	0.03				
20	1.91	0.32	1.34	0.13	0.87	0.05				
25	2.39	0.48	1.67	0.20	1.08	0.07				
30	2.87	0.67	2.01	0.28	1.30	0.10				
35	3.35	0.89	2.35	0.38	1.52	0.13	0.88	0.03		
40	3.82	1.14	2.64	0.48	1.73	0.17	1.01	0.04		
45	4.30	1.42	3.01	0.60	1.95	0.21	1.13	0.05		
50	4.78	1.73	3.35	0.73	2.17	0.25	1.26	0.07		
60	5.74	2.42	4.02	1.02	2.60	0.35	1.51	0.09		
70	6.69	3.22	4.69	1.36	3.04	0.47	1.76	0.12		
80	7.65	4.13	5.36	1.74	3.47	0.60	2.02	0.16		
90	8.60	5.13	6.03	2.16	3.91	0.75	2.27	0.20		
100	9.56	6.23	6.70	2.63	4.34	0.91	2.52	0.24	1.11	0.03
125	11.95	9.42	8.38	3.97	5.42	1.38	3.15	0.37	1.39	0.05
150			10.05	5.56	6.51	1.93	3.78	0.51	1.67	0.07
175					7.59	2.57	4.41	0.68	1.94	0.09
200					8.68	3.40	5.04	0.90	2.22	0.12

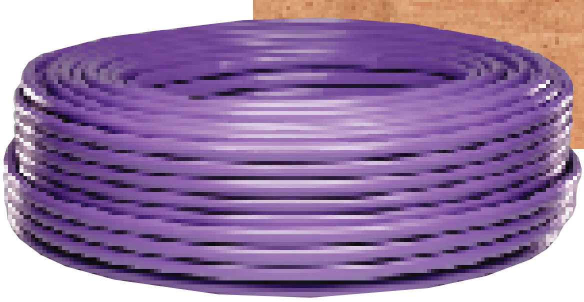
Optimum velocity is 2 - 5 ft. per second.
The pipe is Schedule 40
ASTM D 1785, D2672, D1784 Cell Class 12454-A

D
APPENDIX D—NETAFIM GUIDELINES

NETAFIM USA

Bioline Design Guide





NETAFIM USA

Table of Contents

Table of Charts & Illustrations

Introduction

The purpose of this design guide is to detail the equipment and design considerations necessary for the effective application of drip technology to onsite wastewater.

Drip technology was originally developed for the agriculture industry as a technique to improve the efficiency of water delivery to plants, especially in environments where water supply is limited. The technique involves delivering only water that plants actually use into the root zone, and relying on horizontal as well as vertical movement through the soil to disperse the water. Netafim is a world leader in drip applications. Netafim drippers, filters, valves and other products have become industry standards in over 80 countries.

Drip technology is very well suited for the wastewater industry. The ability of drip disposal to deliver effluent in the shallow subsurface and in the root zone of plants, enables the wastewater designer to take advantage of evapotranspiration, plant uptake for nutrient removal and slow dispersal in the soil medium.

Within the last few years, the Environmental Protection Agency (EPA) has recognized that on-site treatment and disposal of domestic wastewater is a permanent alternative rather than a temporary solution for wastewater treatment and disposal when centralized collection systems are not feasible. Increasing public concern about issues related to the effective and reliable treatment and disposal of wastewater on-site has created a climate for change beyond septic tanks and drainfields. The on-site industry has responded with improved technology for wastewater treatment and regulations have become more explicit and scientifically based. These are key reasons why interest in drip disposal within the on-site wastewater treatment and disposal industry has rapidly increased.

As the demand increases for residential development in rural areas and in sub-optimal conditions for traditional onsite wastewater disposal, the significance of alternative technologies increases. Advanced on-site wastewater treatment with drip disposal is the most effective strategy for a wide variety of the most demanding on-site wastewater design parameters.

In addition to simply "getting rid of" wastewater, drip disposal has a number of benefits:

- With proper design, drip technology can be applied in almost any climate or soil conditions
- Installation does not require major disruption to the drain field, taking advantage of natural or modified landscape strategies
- Water can often be re-used for irrigation of lawns, shrubs, or trees
- Beneficial wastewater nutrients are available for plant uptake.

This design manual provides basic guidelines for drip system design, installation, maintenance, and operation. However, because such designs are subject to state and local regulatory requirements for on-site wastewater systems, any regulatory specification must be given precedence over the recommendations included here. If local regulations allow design parameters which are more liberal than those expressed in this manual, the designer should bear in mind that the following recommendations are based on actual design experience and analysis of both properly functioning and failed on-site systems.

Basic Assumptions

This Design Guide assumes highly pre-treated effluent, 30/30 BOD/TSS or lower with fats, oils, and grease of domestic strength (FOG less than 20) and a design flow less than 1500 gallons per day (GPD). This quality of effluent can be produced by a number of advanced on-site treatment technologies, including fixed-film systems, bio filters, constructed wetlands, mechanical aeration systems, peat filters, rotating biological contactors, sand filters, trickling filters, etc. This design guide is not intended for filtered septic tank effluent or lesser levels of treatment.

Effluent normally leaves one of the above mentioned treatment devices and enters into an adequately designed storage tank. Storage tanks should allow for both a working level and reserve capacity above the high water level alarm. The drip system is designed to distribute the wastewater uniformly over the drip field and throughout 24 hour day.

The drip control system regulates this flow and can provide for filter and field flushing, zone shifting, and alarms whenever operational conditions are exceeded.

Since drip tubing requires pressure to operate, this design manual is built around commonly available pressure pumps, that run at 12-20 GPM and generally utilize 110 volts with 1/2 horse power motors. Pressure is also required to operate filters (automatic or manual back flush), which are necessary to remove organic and inorganic suspended solids. Multiple zones may be necessary to keep pumps small and inexpensive. Yet pump capacity should allow for adequate flushing of the drip tubing during manual or automatic field flush cycles. Design considerations derived from these principles are detailed in the following chapters.

Drip tubing is frequently installed at a depth of 6", but 10" to 12" depths are recommended to minimize human contact potential. Cold climates may require even deeper burial, or additional cover based on local conditions. Installation below the soil freeze depth is generally safe, but there are examples of satisfactory installations at relatively shallow depths in cold climates ***with appropriate design and routine time dosing.***

Most critical to a proper design is matching the soil capacity to absorb water with the demand for disposal of the design flow. In this regard, the designer must take into account:

- water flow over, into, and through the soil
- storage of water in the soil column
- the loss of water to the air through evaporation
- exchange to the air through plant transpiration

This design guide shows how accurate information about daily wastewater flow, along with proper soil analysis and site evaluation, can lead to a properly sized complete, successful, and cost-effective drip system.

A simple spreadsheet to do the quantitative design analysis based on wastewater loading, soil characteristics, and size of the drip field required is available on our website, or by request. The following discussions provide a context for these calculations.

Wastewater Flow Determination

A drip disposal system must accommodate the amount of wastewater effluent generated. The following table can be used for estimating the daily wastewater production rate for various activities. Actual water usage data or other methods of calculating wastewater usage rates must be used by the system designer if it is determined that, for whatever reason, quantities may exceed standard estimates. In any case, estimates used for on-site wastewater treatment designs must be approved by local regulatory authorities. The following table from the EPA is widely used for wastewater flow estimation.

Typical Wastewater Flows

SOURCE	UNIT	WASTE WATER FLOW RANGE	(GPD / Unit) TYPICAL
Recreational			
Apartment, Resort	Person	52.8 - 74	58.1
Cabin, Resort	Person	34.3 - 50.2	42.3
Cafeteria	Customer	1.1 - 2.6	1.6
	Employee	7.9 - 13.2	10.6
Campground (developed)	Person	21.1 - 39.6	31.7
Cocktail Lounge	Seat	13.2 - 26.4	19.8
Coffee Shop	Customer	4.0 - 7.9	5.3
	Employee	7.9 - 13.2	10.6
Country Club	Member Present	66 - 132	106.0
	Employee	7.9 - 13.2	10.6
Day Camp (no meals)	Person	10.6 - 15.9	13.2
Dining Hall	Meal Served	4.0 - 13.2	7.9
Dormitory, bunkhouse	Person	19.8 - 46.2	39.6
Hotel, resort	Person	39.6 - 63.4	52.8
Store Resort	Customer	1.3 - 5.3	2.6
	Employee	7.9 - 13.2	10.6
Swimming Pool	Customer	5.3 - 13.2	10.6
	Employee	7.9 - 13.2	10.6
Theater	Seat	2.6 - 4.0	2.6
Visitor Center	Visitor	4.0 - 7.9	5.3

Typical Wastewater Flows

SOURCE	UNIT	WASTE WATER FLOW RANGE	(GPD / Unit) TYPICAL
Residential			
Residence	Person	22 - 75	45.0
Commercial			
Airport	Passenger	2.1 - 4.0	2.6
Automotive Service Station	Vehicle Served	7.9 - 13.2	10.6
	Employee	9.2 - 15.8	13.2
Bar / Lounge	Customer	1.3 - 5.3	2.1
	Employee	10.6 - 15.8	13.2
Hotel	Guest	39.6 - 58.0	50.1
	Employee	7.9 - 13.2	10.6
Factory (excluding industry and cafeteria)	Employee	7.9 - 17.2	14.5
Laundry (self-service)	Machine	475 - 686	580.0
	Wash	47.5 - 52.8	50.1
Motel	Person	23.8 - 39.6	31.7
Motel with Kitchen	Person	50.2 - 58.1	52.8
Office	Employee	7.9 - 17.2	14.5
Restaurant	Meal	2.1 - 4.0	2.6
Rooming House	Resident	23.8 - 50.1	39.6
Store, Department	Toilet room	423 - 634	528.0
	Employee	7.9 - 13.2	10.6
Shopping Center	Parking Space	0.5 - 2.1	1.1
	Employee	7.9 - 13.2	10.6
Hospital, Medical	Bed	132 - 251	172.0
	Employee	5.3 - 15.9	10.6
Hospital Mental	Bed	79.3 - 172	106.0
	Employee	5.3 - 15.9	10.6
Prison	Inmate	79.3 - 159	119.0
	Employee	5.3 - 15.9	10.6
Nursing Home	Resident	52.8 - 119	92.5
	Employee	5.3 - 15.9	10.6
School, Day:			
with Cafeteria, Gym, Showers	Student	15.9 - 30.4	21.1
with Cafeteria Only	Student	10.6 - 21.1	15.9
without Cafeteria, Gym, Showers	Student	5.3 - 17.2	10.6
School, Boarding	Student	52.8 - 106	74.0

Before doing any detailed design specification, it is necessary to evaluate specific site features. This assessment should include the following:

A. Site Boundaries: Most state rules will have regulations on how close drip lines may be placed to property lines, home foundations, and other permanent property features. Follow local rules for set backs from these boundaries.

B. Special Features: Community water distribution lines, property and utility easements, wells, treatment systems, water lines from wells etc. require setbacks; 50 to 100 feet is typical. Surface waters, including ditches, ponds, lakes, streams and even intermittent water courses also require specific setbacks. Follow local regulations for set backs.

C. Prior Land Use: Research should be conducted to determine if there were any prior activities on the proposed site that would affect soil characteristics. These effects include compaction, foreign soils, buried materials, etc.

D. Future Land Use Restrictions: The drip field can be installed under a permanent lawn, among trees, or other landscape features, provided set backs are followed. Any future permanent structures that will affect soil texture and water flow through the soil must be avoided over a drip field, including but not limited to the following: out-buildings, parking areas, swimming pools, tennis courts, home additions, decks, etc. The designer should consult with the property owner regarding any anticipated improvements to the property, and avoid these areas.

E. Precipitation and Landscape Position: If the site is in an area that experiences seasonal, intense, or even short duration precipitation events which cause collection of water from surrounding areas or ponding of water on the soil surface, then special attention should be directed toward regrading the soil surface to encourage direct precipitation run off.

F. Slopes: Drip disposal encourages lateral, not just vertical movement throughout the soil. This does not restrict disposal fields to level areas, especially with the use of pressure compensating emitters and flow zoning. However, it may increase the amount of land needed depending on the severity of the slope The "Suggested Absorbtion Area Increase" chart, adapted from the State of Virginia, demonstrates that considerations of slope should include information about the soil depth.

Additional considerations about slopes include:

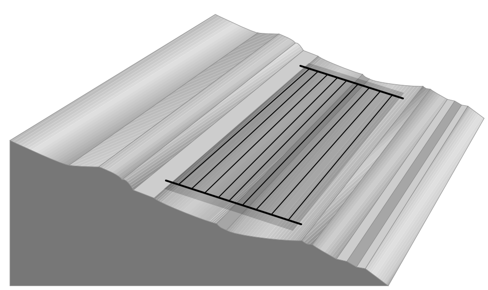
1) whether there is a natural or artificial barrier down-slope from the proposed site that might provide opportunities for water to surface (such as hillside cuts or walls)

2) whether the drip tubing can be laid out on the contours of the slope

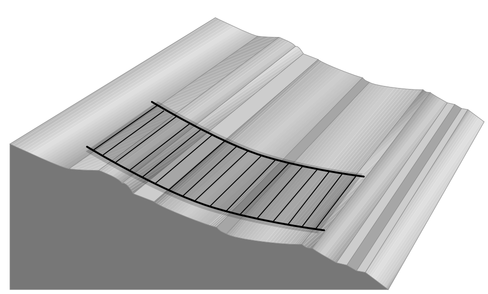
3) whether system geometry can be used that minimizes linear loading rate

Minimizing Linear Loading by Selection of System Geometry

More Desirable Layout



Less Desirable Layout



4) whether the design can incorporate air release valves, check valves, zones, and other means to equalize flow and to prevent drainbacks (See the design and layout discussions which follow.)

With consideration of the above issues, and any similar issues that the designer believes may affect soil absorption rates, the designer is now ready to evaluate the specific soil characteristics.

Suggested Absorption Area Increase on Slopes

	Slope of Site			
Depth to Impervious Strata	**10% to 20%**	**20% to 30%**	**30% to 40%**	**40% to 50%**
Shallow Soil	15%	35%	50%	65%
Deeper Soil	0%	15%	35%	50%

After the drip disposal area has been identified, the designer must undertake a thorough study of the specific soil characteristics of the proposed field. Particular focus must be given to:

- Texture
- Site uniformity
- Compaction
- Native vs. disturbed soils
- Soil depth to restictions or water table
- Clay minerology

A. Sample Collection

An accurate representation of the overall site conditions requires a determination of the underlying soil characteristics. A minimum of two samples per proposed zone is strongly recommended. The sample should be a three dimensional soil core sample which if possible extends into the soil a minimum of two feet deeper than the proposed location for the drip tubing. The analysis of the soil core should be not only for the texture, but should include a morphological analysis for presence of ground water, seasonal high water tables, restrictive layers, etc.

USDA/NRCS Soils Maps or other locally available geological maps should be consulted to determine consistency between observed and referenced conditions. Any inconsistencies should lead the designer to undertake further investigations of the site particulars and history.

B. Determining Soil Texture

Accurate analysis of several samples collected across the proposed site area is critical to determining the absorptive capacity of the soil. If the samples from the different locations of the proposed site are different, the design must be based on the most restrictive sample. The system designer should always consult with a registered soil scientist, site evaluator or soils structure laboratory for assistance in determining an accurate soil texture classification.

The following USDA Soil Texture Triangle chart should serve as an outline to determine soil composition and texture, leading to suggested loading rates.

SOIL PARTICLE SIZE:

Clay: Smaller than 0.002mm in diameter

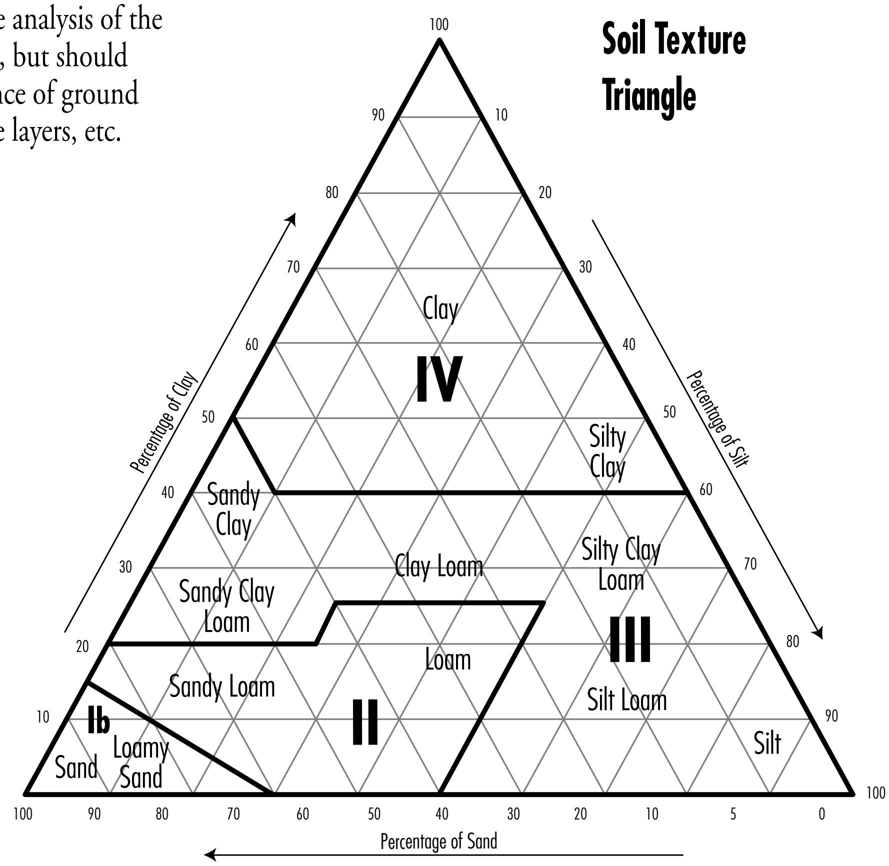
Silt: 0.05 to 0.002mm in diameter

Sand: 2.0 to 0.05mm in diameter

Gravel: Greater than 2.0mm in diameter

Note 1: Sand shall be free of organic matter and shall be composed of silica, quartz, mica or any other stable mineral.

Note 2: Class 1a soils contain more than 30% gravel, therefore, they are not portrayed on the soil triangle.



C. Restrictive Layers

Many soil environments are surrounded by other soils with less desirable characteristics. It should be recognized that water movement through multiple soil types will be determined by the characteristics of the most restrictive types. Therefore, whenever these restrictive types are encountered in a proposed drip field, they should provide the operative design criteria. In particular, soil absorptive capacities should be based on those of restrictive layers rather than those of the more absorptive soils. If restrictive layers are present within two feet below the drip line, then the designer should use the reduced loading rates of the restrictive layer. The greater the soil depth to a restrictive layer, the better.

In the two to four foot range below the drip tubing, if there is a change in the soil classification of one class or more, or if a boundary layer is present (rock, tight clays, etc.), then the disposal area should be increased.

D. Native vs. Disturbed Soils

Native, non-disturbed soils are always the most desirable medium for drip application. However, if the soils are very poor, or the site conditions (e.g., available space) are so limited, then the designer may consider the introduction of fill material, if regulations permit.

If the proposed drip field employs soil fill material, artificially compacted soils, or mixed soils, special considerations apply. Although the fill material may have a greater soil absorptive capacity, a design should not rely on the better soil classification if the underlying poor soil is still present and utilized in the drip system design. Mixing or tilling of the soils may increase the soil absorptive capacity. However, adding Class II soils to a Class IV site does <u>NOT</u> yield a class III absorptive capacity. A proper analysis by a soils laboratory (engineering rather than agricultural focus) is necessary to determine the new soil characteristics. Any time a drip field is constructed with added soil, the overall field should be larger than otherwise called for in the design, and the loading rate should be determined by the restrictive layers and other site conditions rather than by the constructed soils.

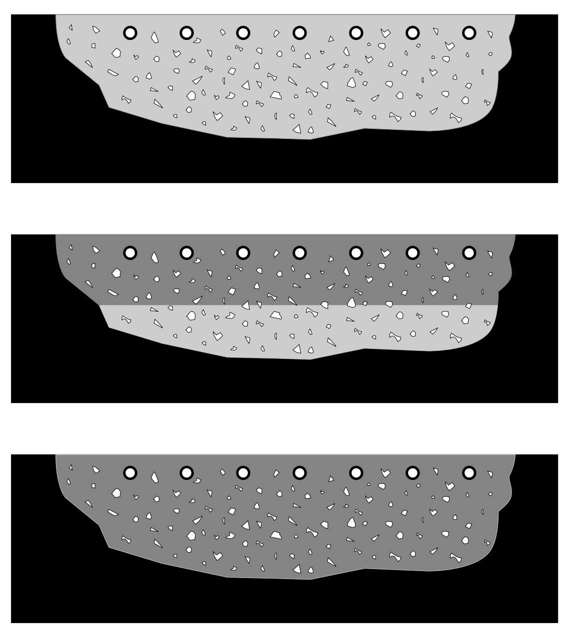
The "soup bowl" graphic demonstrates the problem. If the bowl area is scooped out and replaced with more absorptive soils, system failures may still occur because the water will be trapped in the bowl. Conversely, if the situation is reversed, in a "mound" configuration, water will tend to escape at the interface between the imported and native soils.

With the above constraints used to define the overall characteristics of the proposed drip disposal site, the designer is now prepared to establish a loading rate for the soil.

E. Soil Hydraulic Loading Rate

The maximum hydraulic loading per unit area of soil should be determined by many different factors, including structure, slope, depth to restriction, and soil texture. As an estimation, we will consider soil texture and structure classification as the determinant for soil hydraulic loading rate. However, it is urged that a more thorough analysis, including depth and slope, be incorporated into design considerations. Different soil textures have different porosities and therefore enable different quantities of water to pass through the soil. In drip disposal, the goal is shallow disposal, not deep percolation or surfacing. Therefore soil textures both at the surface and below are important to enable wastewater flow both horizontally and vertically. Load the soil at an even rate in the biologically active zone near the surface. This will enhance treatment (through better oxygenation), and enhance plant uptake through evapotranspiration. The recommended loading rates for each soil classification are in the "Soil Loading Rate" table on page 11.

Soup Bowl Effect of Soil Addition



Soil Loading Rate

Soil Texture	Soil Structure	Maximum Monthly Average Loading Rate (gallons/ft.^{2}/day)	Area Required (per 1,000 GPD)
Coarse Sand; Loamy Coarse Sand	n/a	1.50	667
Sand	n/a	0.80	1,250
Loamy Sand; Fine Sand; Loamy Fine Sand; Very Fine Sand; Loamy Very Fine Sand	moderate to strong massive or weak	0.80 0.50	1,250 2,000
Sandy Loam	moderate to strong weak to massive	0.50 0.30	2,000 3,333
Loam; Silt Loamy	moderate to strong weak, weak platy massive	0.50 0.20	2,000 5,000
Sandy Clay Loam; Clay Loam; Silty Clay Loam	moderate to strong weak, weak platy massive	0.30 0.20 0.15	3,333 5,000 6,667
Sandy Clay; Clay; Silty Clay	moderate to strong massive to weak	0.10 0.05	10,000 20,000

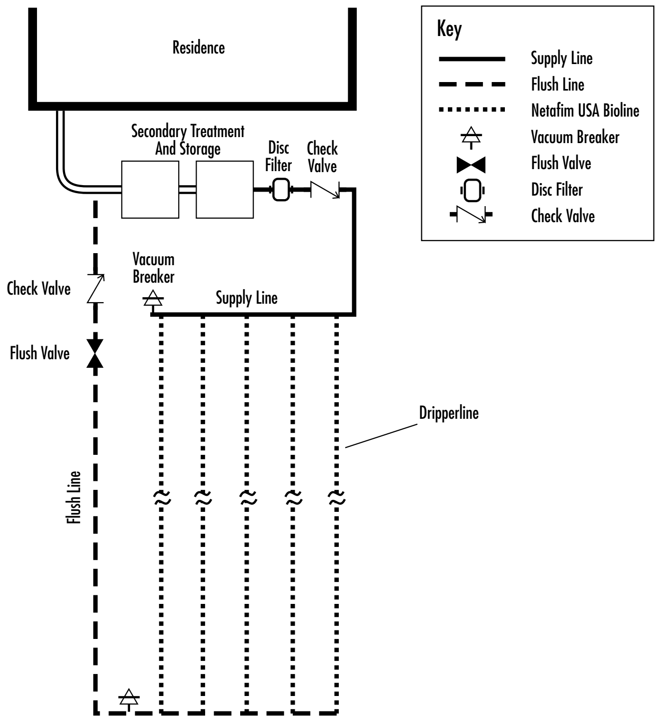
Some states have regulations specifying loading rates that are sometimes more and sometimes less restrictive than the above. The designer must follow regulations, but otherwise should opt for more conservative designs.

The basic rule for drip disposal area is:

Application Area = Daily Flow / Loading Rate

The designer should take into account that the proposed loading rates are for optimal soil conditions, and any site special circumstances including but not limited to: special features, precipitation, slopes, prior and adjacent land uses, impervious boundaries, depth to limitation, vegetation, etc. must be considered in the design. When it comes to design, the more conservative the approach, the better. Remember, the least expensive part of the overall drip system is the tubing.

A simple schematic design for onsite wastewater disposal using drip follows:



A. Components

Pumps: Systems can be designed to use any type of commercially available pressure pump. However, utilizing pressure pumps that produce 12-20 GPM and generally utilize 110 volts with 1/2 horse power motor will normally be the most cost effective strategy for domestic size drip fields.

Storage: It is recommended that operating storage capacity within the system be created in the storage tank behind the treatment unit and/or before the treatment unit to allow for flow equalization and emergency storage. The operating capacity should be designed to hold a minimum of 18 hours of average flow to allow for even distribution to the drip field throughout the day. Additionally, an emergency or reserve capacity should be established which will allow for temporary excess flow, or in the case of equipment failure, time for service or repair personnel to arrive. A minimum of one-quarter to one-half day storage above the high water alarm is recommended. Local regulations may also relate to the amount of storage required.

Filtration: Every drip system must include a filter to prevent introduction of sediments and suspended organic materials into the drip tubing. Without proper filtration, sediment can accumulate over time and cause plugging. A 100-130 micron disc filter (120 or 140 mesh) is strongly recommended for all Netafim USA Bioline dripperlines.

Zone Valves: When multiple zones are used, automatic valves are customarily used to turn zones on and off. Many automatic valves designed for irrigation will not withstand the more rigorous demands of effluent. Be certain the valves you select are appropriate for the application.

Locate zone valves at equal or higher elevations than the disposal field, when possible. Placement of Air/Vacuum Relief valves downstream of the zone valves will then allow proper drainage of the drip field without creating suction on the drippers.

Locate the zone valves at elevations higher than the pump or dosing tank.

Air/Vacuum Relief: Drip system design should include a minimum of two vacuum relief valves per zone. Their purpose is to prevent soil particles from being sucked back into the drip emitters when the system is depressurized. They should be located at the highest points on both the supply and flush manifolds. They should be located in a valve box lined with a pea gravel bed at least 6” deep.

Properly placed Air/Vacuum Relief Valves also serve to exhaust the air in the PVC pipes at the beginning of each dosing event. This allows the driplines to fill more quickly which helps produce a more uniform dosing, especially when short dosing intervals are used.

Pressure Regulation: With the use of pressure compensating drip emitters and appropriately sized pumps, it is not normally necessary to regulate pressure. Normal field operating pressure should be within the recommended range of 25-40 psi. Netafim USA Bioline is designed to provide uniform drip output rates with pressures of 7 to 70 psi at the emitter, but at pressures exceeding 45 psi, stainless steel clamps are recommended on all barbed Bioline fittings.

Pressure Regulators should be considered to limit pressure when severe slopes are encountered or when pressures higher than 45 psi are present. Pressure regulators are typically located at the manifold of each zone where varying topographies exist.

Check Valves: Check valves are necessary to prevent backflow and to isolate zones. Every zone should have a check valve at the supply and flush manifolds.

Loops and Flex Connects: Bioline can usually be made to turn at 180 degrees for 24" pipe spacing. However, maximum long-term protection against kinking, especially in freeze-thaw conditions, is assured by installing a flex-connect whenever a loop of 45 degrees or more is made. These flex connects are used to prevent kinking of Bioline tubing. Kinking can completely shut off flow through the drip tube, therefore eliminating its usefullness. Flex connects are made of flexible PVC with a Bioline connector. Flex connects should be used between the Bioline tubing and the manifolds to allow for shrink and swell and the movement and settling of the soils.

The flex connect tube also prevents dripperline flow from entering the trench of the supply and flush manifolds. Because these trenches often run against slope contour, they can become drains, with the potential for effluent surfacing at the downstream end. It is therefore highly desirable that the dripperline not drip into the trench.

Supply Line: The standard design is a pressure line made of schedule 40 PVC from the filter to the supply manifold. It should contain a minimum of one check valve to prevent back flow into the tank.

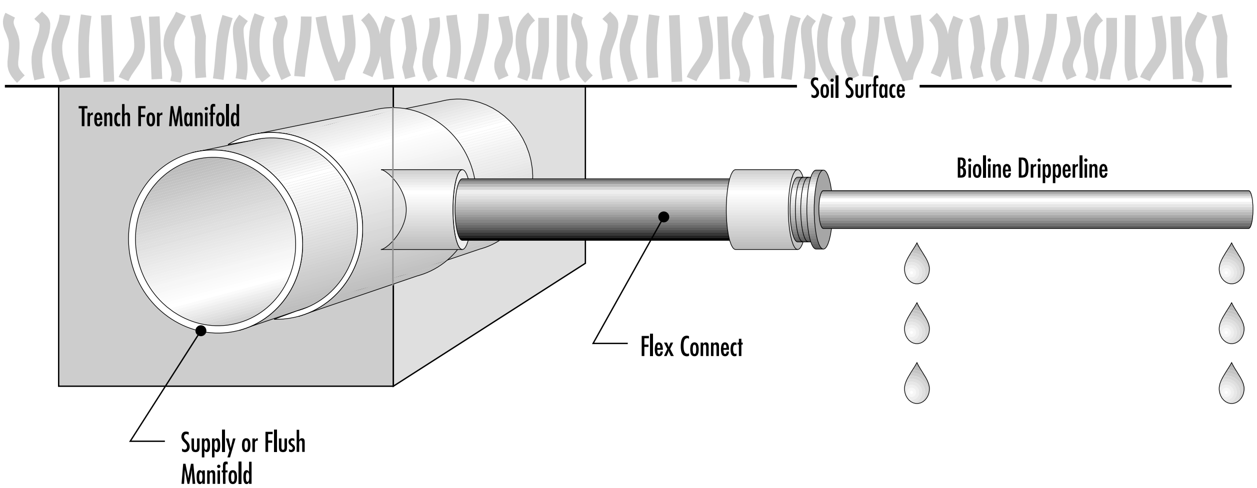
Supply Manifold: The standard design is PVC piping where the effluent supply enters and is distributed to the Bioline tubing via the flex connections. To maintain both a volume and pressure of effluent to achieve sufficient velocity for field flushing, the number of connections to the manifolds should be limited. See Zone Size, Flush Velocity & Number of Connections chart for recommendations.

Effluent flows through the Bioline dripperline, and out into the soil through emitters (drippers). These emitters each have a specific flow rate of 0.4, 0.6, or 0.9 gallons per hour (GPH). These limited flow rates are designed to prevent overloading of the soil.

Flush Manifold: The characteristics of the flush manifold are the same as the supply, with a limited and equal number of connections. It is typical to use the same diameter pipe size as the supply manifold.

Flush Line: This component should typically be the same diameter pipe as the flush manifold. It terminates at the front end of the treatment system. If chemical disinfecton is utilized on the system, the flush line should return to the pump tank, or the treatment system may be disrupted by the disinfection agents. The flush line should have, at a convenient location, a manual or electric valve to enable field flushing.

Bioline Connection To Supply Manifold

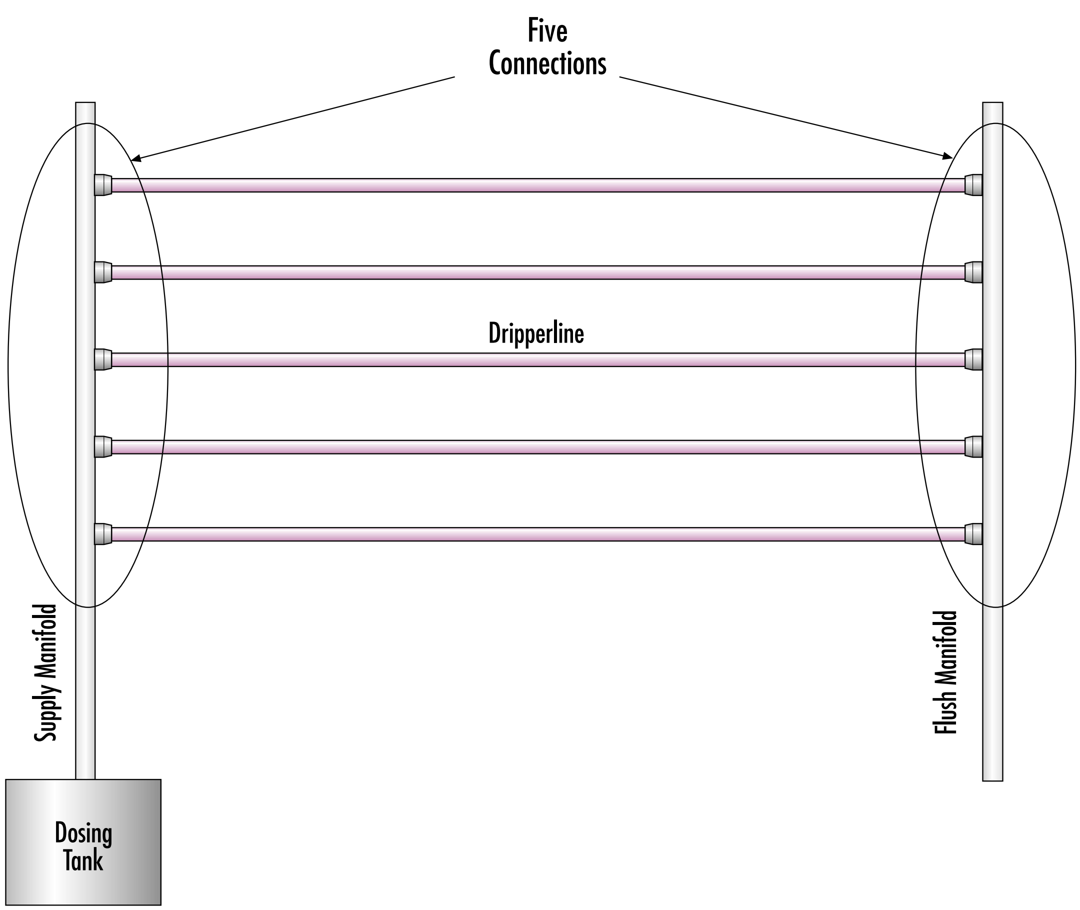


Zone Size, Flush Velocity & Number of Connections

(With 18 GPM pump)

	Bioline .4 GPH @ 18" and Bioline 0.6 GPH @ 24"			Bioline .9 GPH @ 24"		
Flush Velocity (ft./sec.)	1	1.5	2	1	1.5	2
Number of Connections to Flush Manifold	Maximum Total Length of Dripperline (feet)			Maximum Total Length of Dripperline (feet)		
2	1,000	1,000	1,000	800	800	800
3	1,500	1,500	1,500	1,200	1,200	1,200
4	2,000	2,000	2,000	1,600	1,700	1,500
5	2,800	2,400	2,000	1,800	1,600	1,300
6	2,600	2,100	1,700	1,700	1,400	1,100
7	2,500	1,900	1,400	1,600	1,300	900
8	2,300	1,700	1,000	1,500	1,100	700
9	2,100	1,400	700	1,400	900	500
10	2,000	1,200	400	1,300	800	300

Example of Connection Count



B. Zone Requirements

Maximum Zone Size: If total system flows exceed 10 GPM per pump, or if there are significant topographic or other site constraints, it is recommended that multiple zones be considered in order to have sufficient system capacity for field flushing. For the most cost effective results, the designer should consider the use of mechanical or solenoid valves to dose different zones.

When using multiple zones, try to balance the zoned disposal fields to equalize flows for both dosing and flushing.

There is a direct relationship between the total length of tubing per zone, the number of connections, and the field flush velocity. Increases in number of connections require a decrease in the number of feet of tubing in a zone in order to maintain a field flush velocity of 1-2 feet per second. See field flush section under Operations for more detail. The "Zone Size, Flush Velocity, and Number of Fittings" chart provides a recommendation for maximum tube length per zone.

This chart assumes the use of a typical 1/2 HP high head pump producing 18-20 GPM. Naturally, other pumps can be used, but the designer must make the necessary hydraulic calculations.

This chart provides the linkage between the design flush capacity, maximum Bioline length, and the number of manifold connections. While lesser velocities may be acceptable for cleaner water, 2 ft./sec. provides a thorough flush which adds an additional measure of protection against unexpected contaminants.

Disposal flows exceeding 10 GPM per zone usually require specialized pumps, higher voltage, contactors and motor starters. These pumps are not addressed in this design guide for domestic wastewater effluent.

C. Piping Layout

The basic principle of field layout is to arrange the tubing so that drip tube lengths are roughly equal and approximately 300-400 feet in length (please refer to page 27 for maximum length runs for specific Bioline models). Lengths greater than these will require pumps to create more head and flow than are typically available from 1/2 horse power pumps. Horizontal spacing between tubes of 24 inches is standard practice, although if the soil is capable of handling higher infiltration rates, there is no reason that the tubes cannot be spaced more closely.

A standard, recommended pipe size to optimize flow and friction loss for drip distribution systems up to 1500 gallons per day is 1 1/4 inch PVC for distribution lines, supply and return manifolds, and return lines.

D. Drainback Considerations

When the irrigation cycle ends, much of the effluent which remains in the system will drain out through the drip tubing. Effluent will drain to the lowest elevations of the system, and even on nominal (1 percent) slopes this can cause local soil overloading. Therefore it is important to anticipate where the effluent will flow when the dosing event is completed and pressure is released, and to design the system accordingly. There are a variety of design approaches that address this issue, several of which follow:

Installed with the contour: Tubing must be installed along the contour of the slope (as level as possible), not up and down the slope! Otherwise, all the effluent in the drip tube will drain rapidly to the lowest elevation emitters, which can overload the soil.

Feed from the bottom of the field: As a general rule, drip fields on a slope should be fed from the bottom and flushed from the top. This strategy will prevent the main lines and manifolds from draining to the field during rest periods. This strategy assumes that the field is uphill from the supply line. The supply manifold should "stair step" though a series of check valves, with a limited number of lines between each check valve. Check valves limit the down gradient flow of the water when the pump shuts down.

Increase the spacing between drip lines at bottom of slope: By increasing the spacing beween drip lines, there will be a decrease in the loading rate of the soil , therefore providing additional absorbtion potential for the water that does drain through the lower elevaton drip lines.

Increase drip field sizing: Where allowed, decreasing the overall loading rate by increasing the drip field size will actually result in the lower elevations receiving closer to their actual maximum daily loading rate once drainback flow is considered. The state of Virginia has provided some guidelines for drip field up-sizing on slopes (see chart page 7).

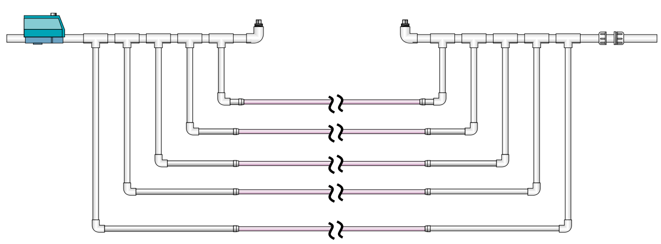
Less frequent, longer doses: In more highly permeable soils, with no restrictive conditions, longer dosing duration and decreased frequency of dosing can minimize the effects of drainback by a reduction in the number of cycles per day.

Zone valves: To prevent main line and sub main drainage into dosing fields, zone valves can be installed as close as possible to the disribution field to minimize the volume of water subject to drainback. Zoning prevents water from mains and sub mains from draining into the drip fields during periods of rest.

Deeper line burial: In the context of drain back issues, deeper tubing can be a strategy to minimize surfacing.

Top Loading: The best design strategy for steep slopes (but sometimes more costly) feeds each lateral or group of lateral lines individually. Manifolds in this instance are located at the top of the drip field and are operated by zone valves. Each drip lateral, on the contour of the slope is fed by an individual, small diameter feed line from the supply manifold. An air relief valve must be located on both the supply and return manifolds. The illustration below shows how this system is set up.

Top Loading



In addition to describing the key system components, it is necessary to discuss fundamental operational principles. These pertain to dosing, filtration, field flushing, and control of root intrusion. This is a general discussion. Other methodologies and engineering practices may achieve the goals of these operational principles.

A. Dosing and Controls

The fundamental principle of drip distribution is to take full advantage of the entire application area, over the course of the entire day. Although most wastewater flows have peaks and valleys, the goals of effective distribution are to:

- Keep soil moist
- Encourage lateral (i.e., capillary) rather than gravitational flow
- Spread the effluent out over the field,
- Utilize the entire day (18-24 hours)

All of these goals are accomplished through effective dosing controls. A sophisticated dosing system is especially important on tight, shrink-swell clay soils, since they are very sensitive to overloading.

The function and complexity of the control system will be determined both by the wastewater demand and the limitations of the soil. The control system needs to take into account:

- Unusual loading conditions
- Storage capacity
- Emergency storage/malfunction

A simple demand system configuration will generally not be adequate; for example, a float switch with a 100 gallon tether. The system must have adequate capacity to receive the flow and distribute it evenly over the course of the day, rather than merely distribute the effluent as it enters the system. This is the essence of time dosing, rather than demand dosing: pumping the effluent out at specified intervals throughout the day rather than simply letting it flow out for disposal at the same time it is generated.

Historically, the cause of most drip system failures is not improperly designed drip fields, but rather an inadequate soil loading schedule. Experience has shown that even a flow as little as 200 gallons, dosed intensively, can cause a system failure in the same field that could accept 500 gallons, if dosed evenly throughout the day.

How to Dose

The following analysis provides the conceptual basis for sizing the drip field, setting up zones, and designing the pump control system for delivering the desired quantities of wastewater to the desired places over the desired time periods. A basic spreadsheet program is also available on our web site www.netafimusa.com to make these calculations a simple 'fill in the blank' task.

1. How many Gallons Per Day (GPD) is the wastewater load?
   - *reference Table pg. 5*
2. What is the Soil Loading Rate in gallons per sq. ft. per day?
   - *Check local rules*
   - *Soil Loading Rate Chart pg. 10*
3. Calculate Disposal Area
   - *GPD/Loading Rate = Application Area (sq. ft.)*
4. Calculate Total Linear Length of Tubing
   - *Divide the Application Area by two to get the total linear length of drip tubing. (This assumes 2 feet between the dripperlines; divide by 3 for 3 foot spacing, etc.)*
5. Select Dripper Flow Rate and spacing based on soil type.
   - *Bioline is available in 0.4 gallons per hour (GPH), 0.6 GPH, and 0.9 GPH.*
   - *Heavier soils usually indicate lower flow drippers, either 0.4 GPH or 0.6 GPH.*
6. Calculate Total Flow Rate of all tubing.
   - *Use the chart Flow Rate per Length of Tubing on page 27, or the following formula.*

- *Flow rate of dripper x Total Linear Length of Tubing ÷ Dripper Spacing (ft.)*
- *For example - Bioline with 0.6 GPH drippers at 2 ft. spacing between drippers: for each 1,000 feet of drip tubing, the flow would be:*

  0.6 x 1000 ÷ 2 = 300 gallons per hour (GPH)

  = 5 gallons per minute (GPM)
  [GPH ÷ 60 = GPM]

7. Determine Number of Zones needed by pump size consideration.
   - *Zones should generally not exceed half the rated volume of the pump.*
8. Calculate Total Flow Rate per Zone in gallons per minute (GPM).
   - *Total Flow Rate of all tubing ÷ number of zones.*
9. Calculate Number of Minutes of Total Run Time based on daily flow.
   - *Total Daily Load (GPD) ÷ Zone Flow Rate (GPM)*
10. Calculate Number of Minutes per Zone
    - *Total minutes ÷ number of zones*
11. Select Dosing Duration based on soil conditions (6 to 12 minutes).
    - *Typically, heavier soils should have shorter dosing durations*
12. Determine Number of Dosing Events.
    - *Number of minutes of total run time ÷ dose duration (minutes)*
13. Calculate Time Between Dosing Events.
    - *Based on an 18 hour day (to be conservative)*
    - *Time between dosing events = 18 ÷ number doses + 1.*

In addition to turning the pump on and off at specified times to achieve the desired distribution of water, the Control System can enable cleaning of filters and field flush.

B. Filter Cleaning

The filter on the system is designed to capture particles larger than that which can safely pass through the drip emitter. Over time, particles will build up and cause the filter to clog. There are several filtration systems and methods that can be used to clean and restore the filter to normal flow.

Manual Filter: a filter in the supply line coming from the treatment system. Cleaning it requires the filter cartridge to be removed, and the discs and housing to be manually flushed with water.

Timed back flush: This is a more sophisticated filtration system which normally has several filters and valves used in a configuration to clean one another automatically. The frequency of the back wash is controlled using a time clock or dosing counter to automatically flush the filter. Filtered water is sent through another filter backwards, therefore dislodging particles captured between the filter discs. This backwash water is then returned to the treatment system and reprocessed.

Pressure differential back flush: This system is similar to the Timed Back Flush system, but has an added component, a pressure differential switch or sensor. As a filter starts to clog, the pressure differential across the filter increases. A pre-set pressure difference across the filter triggers an automatic back flush. This can be the primary trigger for the system back flush, or a back-up option for a regularly timed back flush.

If the system has a timed or pressure differential back flush, manual cleaning of the disc filter cartridge may still be needed occasionally. Especially as a treatment and disposal system is first started up, cleaning may be necessary to insure that construction debris is removed.

Filter cleaning: All filters from time to time require that the filter be taken apart, inspected, and cleaned if necessary. Each disc surface has grooves that capture particles as they try to pass through the filter. Therefore, it is necessary to separate the discs and clean the entire filter element using a garden hose, or other pressurized stream of water. If deposits form on the discs that cannot be removed by mechanical means, muriatic acid can be used (in a 10:1 ratio of water to acid, following safety instructions on the acid container).

C. Field Flush

Drip tubing is designed to last the lifetime of the system (twenty years, or more). Although filtration is taking place, small particles (under 130 microns) can still enter the tubing. Over time these particles may accumulate. Therefore, it is recommended to field flush the system.

Field flushing is accomplished by periodically opening the flush line from the drip field to the pre-treatment tank. In this process, the velocity of water moving through the tubing should be at least 1-2 feet per second. The dirtier the water, the higher should be the recommended flush velocity. To prevent an accumulation of debris in the dripperline, it is recommended that field flushing take place on a regular basis. Field flushing should be done at least several times per year, but may be as frequently as every day. The required rate will depend on many factors. Among these are:

- Effluent quality and characteristics
- Filtration efficiency
- Length of tubing in each zone
- Local regulations for maintenance

D. Root Intrusion

The characteristics of the Bioline dripperline provides an effective physical barrier to root intrusion in most waste water disposal applications. However, some applications may require chemical preventative treatment. For those applications, we recommend the use of a Techfilter System.

The techfilter incorporates a replaceable filter element embedded with trifluralin. As water passes through this filter, a very low concentration of trifluralin (parts per billion) passes through the system This technology provides very precise and even distribution of trifluralin throughout the piping network and effectively inhibits root growth into the Bioline dripper outlets. This approach to root intrusion prevention eliminates skin irritation from chemicals during installation, does not require that tubing be stored out of the sun, and is indefinately renewable as needed.

The Techfilter System has a limited LIFETIME WARRANTY against root intrusion.

A. Site Preparation

The drip field should be viewed as a wastewater disposal field, and many of the considerations for conventional septic drain fields should apply. These limitations should include:

- No future expectation of building(s), decks, or other impervious surfaces
- No long term storage of equipment or vehicles over the site
- A permanent vegetative cover.

Winter dormant grasses should be over seeded with winter grasses when possible.

B. Drip Tubing Installation

The drip tubing should be installed 8 to 12 inches below the soil surface with an absolute minimum of 6 inches. Colder climates may require deeper placement or additional cover to avoid freezing during periods of inactivity.

Where winter temperatures and other conditions allow, the depth of the manifold trenches should be the same as the tubing depth in order for the vacuum release valves to work most effectively.

Dig the maifold trenches wide enough to provide sufficient working room to cut and fit tees and to insert the flex connectors between the manifolds and the tubing. Give yourself enough room to work.

There are three common ways to install the Bioline Drip tubing. They are:

1. **Plowing:** Installed the same way as TV cable, plowing refers to the method of knifing, or using a vibratory plow, to insert the drip tubing. This method is increasingly common as the equipment becomes more widely available. The use of a foot pulled by a small tractor to open a narrow trench ahead of the Bioline tubing is an alternative to the vibrating plow.
2. **Trenching:** This method uses a commonly available chain trenching machine to cut narrow trenches for tubing installation. The advantages of this method are that these machines are widely available and easy to use. The disadvantages are that the trench may leave wall surfaces that are "slicked" and therefore less receptive to horizontal water flow. The trench must be filled with original materials and watered in from the top down.
3. **Fill:** In this method, tubing is laid on the ground and fill material is placed over it. If there is any vegetative cover, it should be removed and the original soil scarified (plowed or deep-raked) to minimize any inhomogeneity between soil types. If soils of different textures are used, the constraints discussed in the Soils Section must apply. It is recommended that the fill material be the same as the original, if possible.

For all methods of drip tube installation, it is very important that the disturbed soil above the dripperline be the approximate texture and compaction as the soil around the dripperline to avoid creating a preferrential pathway of the effluent to the surface. Some careful, manual compaction of the soil above the dripperline may be advisable when the tube has been trenched or plowed in (local codes permitting).

Every effort must be made to avoid excessive mechanical stress on the tubing before, during, and after installation.

C. Piping Hook-Up

The supply and flush lines, and the supply and flush manifolds are installed using standard techniques for PVC piping. A medium body (not fast drying) PVC cement is generally preferred. Use the cement as recommended by the manufacturer.

The installer should use a good quality ratcheting type PVC cutter to prevent the introduction of PVC filings to the distribution lines.

Start-up

The designer should take special precautions to troubleshoot the system and insure that it is working properly over an initial startup period, typically 2-3 weeks.

Do not start the system with a massive dose! This can create preferrential water passages, or chimneys, to the surface that can be difficult to block.

- Construction debris (e.g. PVC scraps, glue remnants, or soil) found in the pipe network after intial assembly need to be flushed. Try not to exceed the scheduled dosing program in this flushing process.
- The pump tank or treatment system may be full of water after installation. Do not simply run it out through the drip tube. Either use the dosing schedule to empty the tank, or set up a sprinkler.
- If the dosing field is extremely dry, it can be advantageous to run a sprinkler on the surface for a while to intially dampen the field.

Routine Maintenance

Other service and maintenance of the system can be coordinated with regulatory requirements for monitoring of the on-site wastewater treatment system. Most states have regulations that specify a routine maintenance schedule for advanced on-site wastewater treatment systems.

When a drip distribution system is properly sized, designed, and installed, it should operate with little maintenance and easy monitoring. In addition to the fundamental design considerations already outlined, several other installation steps will simplify maintenance. These are as follows:

1. Provide nipples for Schrader valves (tire gauge stems) on critical piping elements (pump output, supply and flush manifolds, etc.) in irrigation boxes to provide easy measurement of system pressure.
2. Maintain access to a short length of drip tubing for inspection.
3. Keep a detailed plot plan, system diagram, and wiring diagram readily accessible in the control panel.
4. Establish a service record chart to record–

   Pressure at:

   - pump
   - supply line or manifold
   - flush line or manifold
   - other critical points

   Schedule

   - dosing
   - filter flushing
   - field flushing
5. Monitor any changes in the number, activities, and water usage patterns of members of the household.

With this information framework, a system inspector can quickly and easily determine if the system is operating within specifications. If problems are identified by changes in pressure or flow, they can be located and corrected easily using information in the plans and locations of irrigation boxes.

Typical Layouts for Residential and Small Commercial Systems

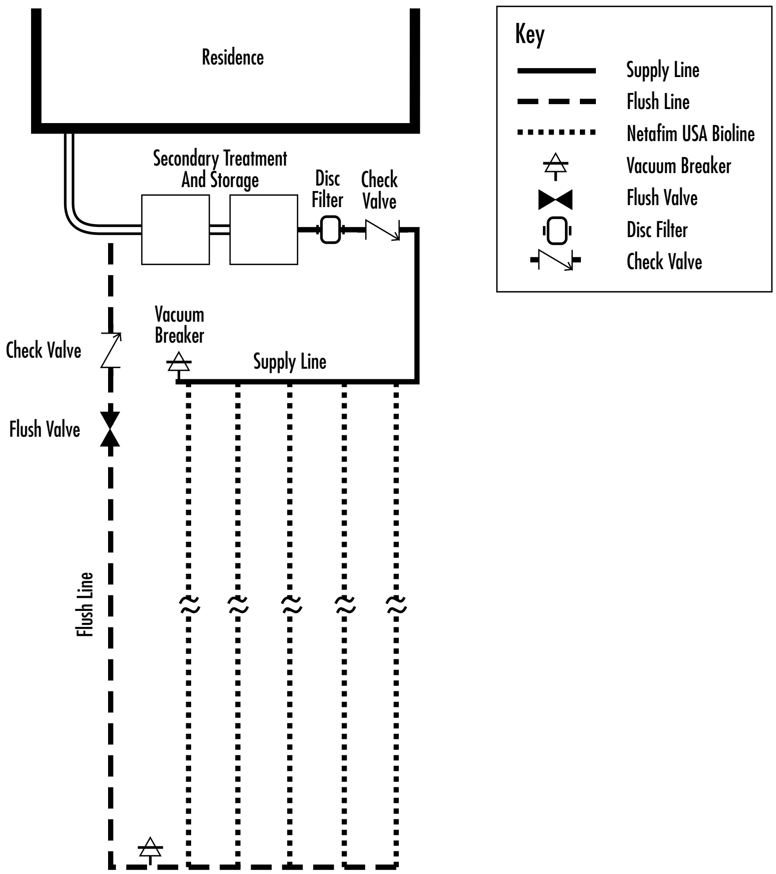
The layout for a typical residential or small commercial system is made-up of several components. In the following illustrations, each design scenario will contain all or part of the following components and systems.

- Treatment system - aeration treatment unit, recirculating sand filter, peat system, fixed film, or wetland system, etc.
- Pump or dosing tank with water level sensors
- Dosing pump
- System controller for pump operations, zone control, dosing scheduling, dosing tank monitoring, filter backflushing, field flushing and alarms
- Automatic or manual disc filter (130 micron) set in a buried access box that is capable of automatic backflushing or manual cleaning
- Air-vacuum relief valves
- Zone control valve - water actuated, motor driven or solenoid activated hydraulic valve
- Underground PVC piping, typically 1 $^{1}/_{4}$ inch mainline, header and return lines
- Flexible PVC connectors and loops
- Mainline and supply header
- Flush manifold and return line
- Check valves
- Bioline drip tubing

The following layouts illustrate the various ways that drip disposal fields might be laid out at a residence or small commercial complex. These are to be used as guides only. Each individual system will have special requirements that will require the designer to modify these typical layouts in order to adapt to the site. The following are basic considerations that should be taken prior to beginning any design.

- Shape of the proposed drain field
- General slope or direction of rise and fall of the site
- Location of property lines, buildings, trees, wells, water lines, gas lines, buried power lines, swimming pools, etc.
- Soil type including profiling to determine depth to most restrictive layer and or water table
- Location of treatment system
- Location of power outlets or breaker
- Location of old drain field if new system is a retrofit

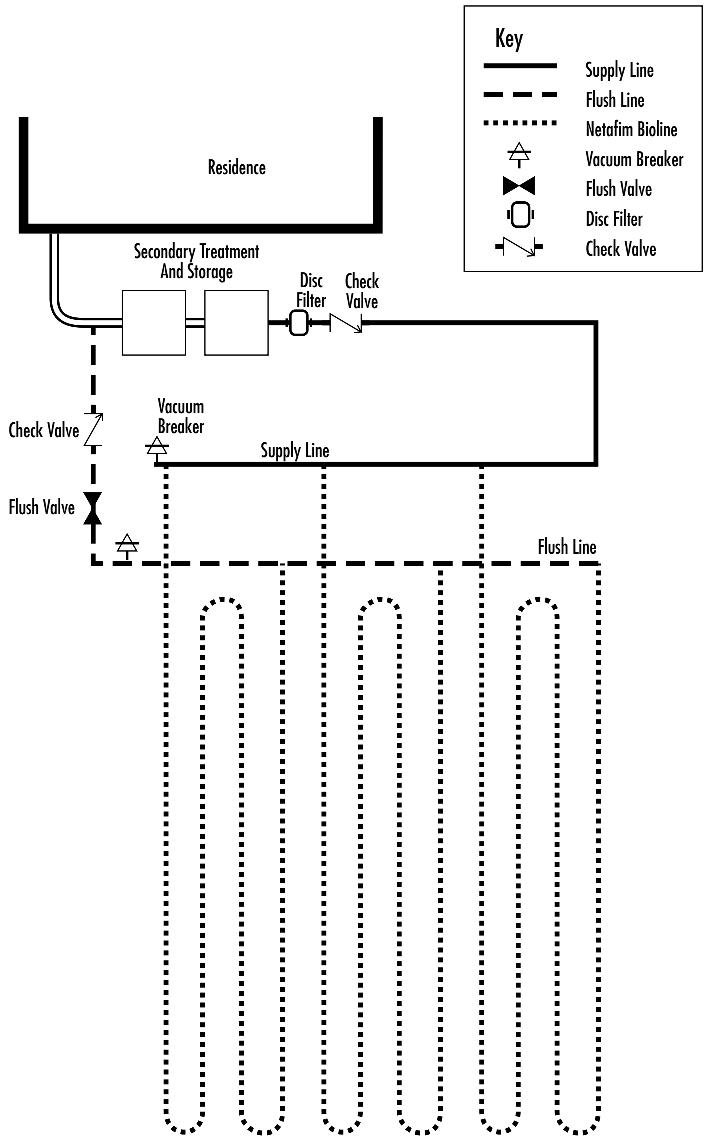
Opposing Manifold Layout



Rectangular field with supply and flush manifold at opposite ends of dripperlines;

- Can be used where Bioline lengths will be long and drip field is narrow

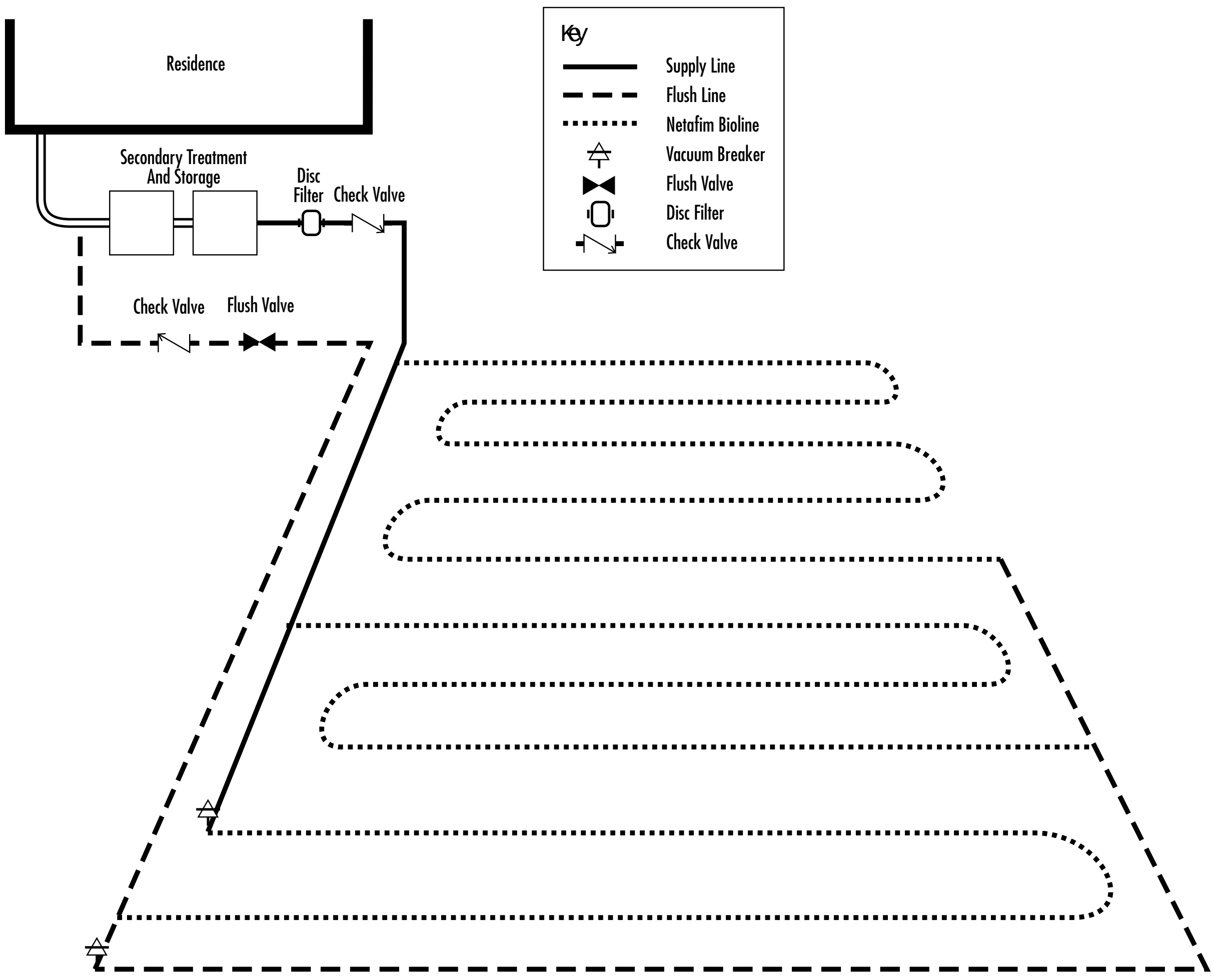
Single Trench Layout



Rectangular field with supply and flush manifold on same side and in same trench;

- Locate supply and flush manifold in same trench
- Dripperlines are looped at the end opposite the supply and flush manifolds
- The longest Bioline length should not exceed 400 ft. Drip fields 200 ft. in length might loop the Bioline once; drip disposal fields under 100 ft. might be looped twice, as illustrated.

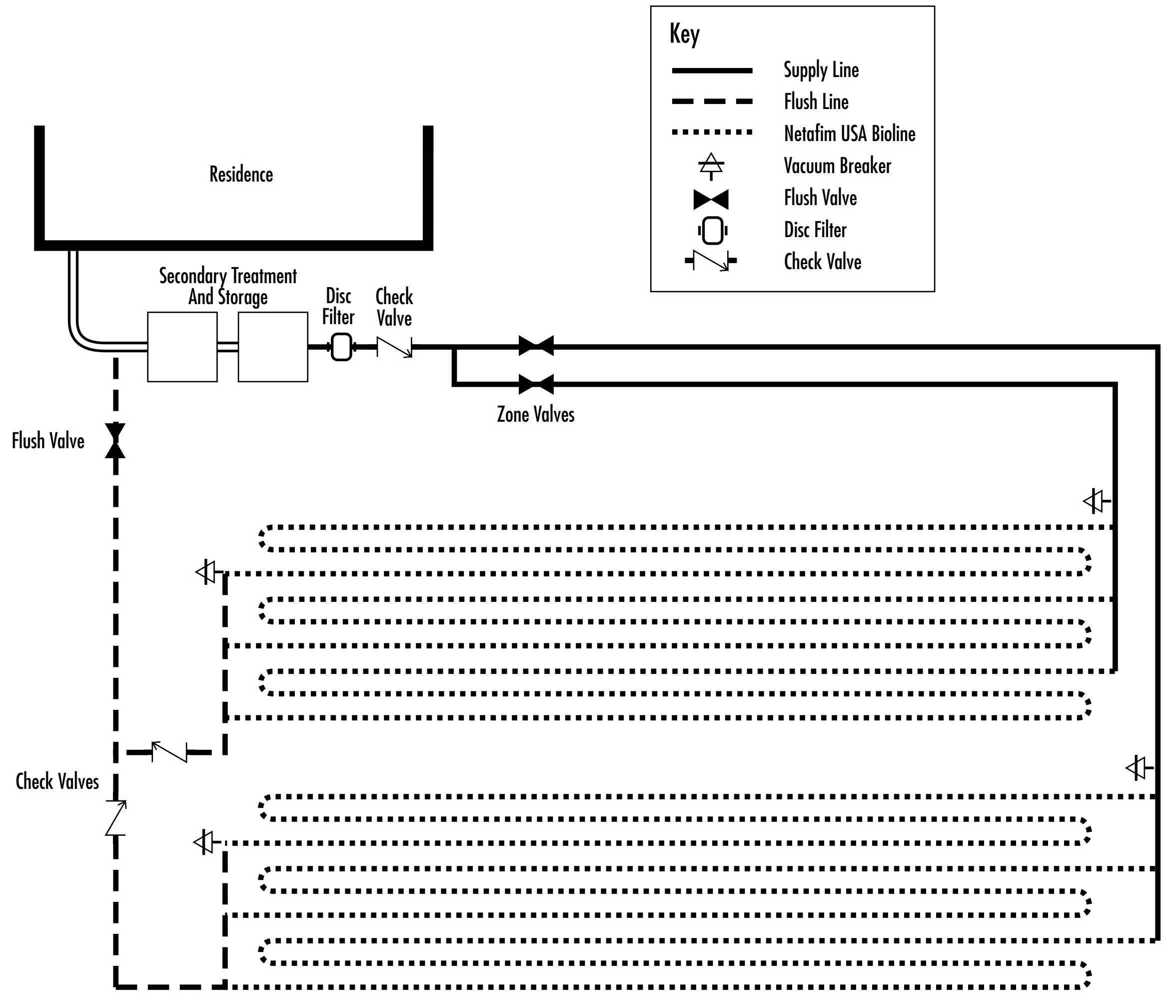
Irregular Field Shape Layout



Triangular field with looping and varied positioning of flush maifolds;

- Can be used when site limitations dictate unequal dripperline length with respect to disposal field length.
- Loop Bioline tubes in order to increase tube length and reduce the number of connections. Attempt to equalize all Bioline run lengths in order to provide an equal field flush.
- Flush Manifold may be located on the same or opposite side of supply manifold. In some cases it may be necessary to make one or more distal end connection to the flush line on an opposing side in order to balance dripperline lengths and limit the number of connections.

Multiple Zone Layout



Multi-zone system with looping laterals;

- Should be used when single zone accumulated Bioline lengths exceed 2000 ft.
- Should be used when soils require additional resting time between dosings.
- Should be used when there is a potential need for expansion of the system, which is common in commercial systems. Second zone may be left out until needed.
- Additional check valves are needed to isolate each zone on the flush line side. An additional air-vacuum relief valve should also be installed before the check valve on each zone.
- Zone changes are typically accomplished using an electrical valve with a controller.
- Zone layouts may be parallel systems or may follow any of the scenarios discussed.
- Zones should be have similar flows when possible.
- Controller must be capable of operating multi-zone system.

Bioline Self-Cleaning, Pressure Compensating Dripperline

Description

Bioline is a low-volume dripperline with integral and evenly spaced pressure compensating drippers at specified intervals. Bioline emitters have a discharge rate of 0.4, 0.6, or 0.9 gallons per hour (GPH). Bioline is available in 500' and 1000' coils.

Construction

Individual dripperlines shall be of extruded linear low density polyethylene with an inside diameter (I.D.) of .057 inches and an outside diameter (O.D.) of .067 inches. The entire polyethylene pipe is to be purple throughout to designate its use for wastewater. The tubing is to have fully pressure compensating drippers integral with the inner wall of the tubing. These drippers shall be constructed of plastic with a hard plastic diaphragm retainer and a self-flushing/ cleaning elastomeric diaphragm extending the full length of the dripper. The drippers shall be impregnated with the anti-microbial agent Vinyzene® to prevent the attachment of microbial slime to the dripper[1]. Each dripper will have an individual filter at the inlet to the dripper; this filter shall have a cross sectional area not less than five times larger than the minimum cross sectional area of the dripper flow path[2].

Operation

The dripper must be capable of flushing potential clogging particles throughout its operation cycle[3]. The drippers are to have a nominal discharge rate of 0.42, 0.62, or 0.92 gallons per hour (GPH) with an inlet pressure of five to seventy (5-70) pounds per square inch (PSI). The flow from any individual dripper in a dripperline may not vary more than ±10% from the designated nominal flow over a pressure range of 5-55 psi. At no point, from 0 to 55 psi, can the dripper have a flow exceeding 10% of the nominal flow of the dripper[4]. The dripper flow shall be ± 10% of the nominal flow for any single pressure within the temperature range of 25°C to 50°C (73°F to 124°F)[5]. The dripper shall have a Cv of 3% or lower[6]. The Kd for the dripper must be 1.0 or less[7]. The recommended operating pressure shall be between 5-45 PSI. Filtration shall be 120 mesh or finer.

Bending radius shall be 7" or greater.

For on-surface or under mulch installations, 6" metal wire staples (TLS6) shall be installed 3' to 5' on center, and two staples installed at every change of direction.

Bioline shall be Netafim Model Number

Bioline Dripperline .4 gph Flow

08WRAM.4-12V – .4 gph Flow, 12" Dripper Spacing, 1,000 Foot Coil
08WRAM.4-18V – .4 gph Flow, 18" Dripper Spacing, 1,000 Foot Coil
08WRAM.4-24V – .4 gph Flow, 24" Dripper Spacing, 1,000 Foot Coil

Bioline Dripperline .6 gph Flow

08WRAM.6-12V – .6 gph Flow, 12" Dripper Spacing, 1,000 Foot Coil
08WRAM.6-18V – .6 gph Flow, 18" Dripper Spacing, 1,000 Foot Coil
08WRAM.6-24V – .6 gph Flow, 24" Dripper Spacing, 1,000 Foot Coil

Bioline Dripperline .9 gph Flow

08WRAM.9-12V – .9 gph Flow, 12" Dripper Spacing, 1,000 Foot Coil
08WRAM.9-18V – .9 gph Flow, 18" Dripper Spacing, 1,000 Foot Coil
08WRAM.9-24V – .9 gph Flow, 24" Dripper Spacing, 1,000 Foot Coil

(Other spacings & flows available. Contact Netafim USA Customer Service for Details.)

[1] Vinyzene® , also known as OBPA, is commonly used in household products, such as shower curtains, to prevent the growth of bacteria.

[2] This is to ensure that debris which makes its way into the polyethylene lines (possibly by a breached system due to mechanical breakage of a mainline) has a significant barrier to each emitter, hence promoting the reliable operation of each dripper under temporarily adverse conditions.

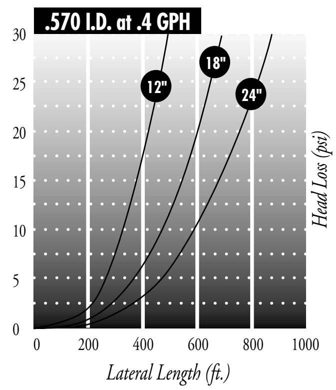
[3] The dripper flushing capability throughout the irrigation cycle ensures that the designed dripper flow will be maintained at all times. Drippers which flush only at the beginning and/or at the end of each operation cycle may have an extremely reduced flow for the majority of time they are operating.

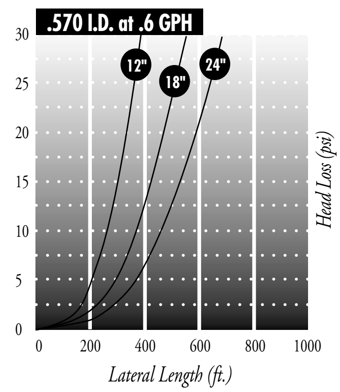
[4] This defines the flow characteristic of a pressure compensating dripper, and ensures the dripper will not have spikes in its flow curve. Flow spikes, even when present outside the designed operating pressure for the system, may require the entire system (pumps, valves, mainlines, etc) to be up-sized to the maximum flow of the dripper, thereby increasing the cost of the system without enhancing its design performance.

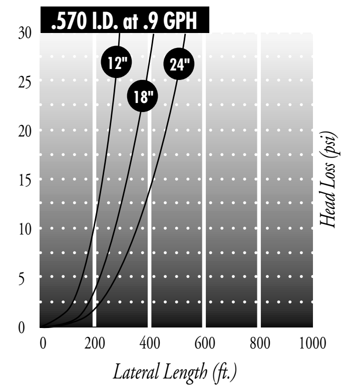
[5] Drip systems will encounter a wide range of temperatures. Drippers in which the flow is significantly affected by temperature are less capable, in some cases incapable, of producing a highly uniform system flow.

[6] Cv is a measure of the consistency of manufacturing. It measures the deviation from the specified flow for a random sampling of drippers. In order for a waste dispersal system to operate with an EU (Emission Uniformity) in the mid 90% range, the Cv must be not more than 3%.

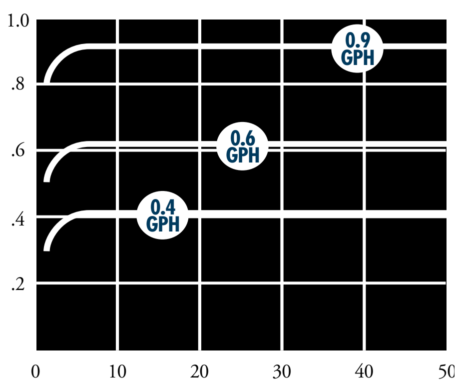
[7] Kd is a measure of the friction loss within a pipe caused by the portion of the dripper which protrudes into the flow path. A high Kd requires a higher pump pressure to create proper line flushing.



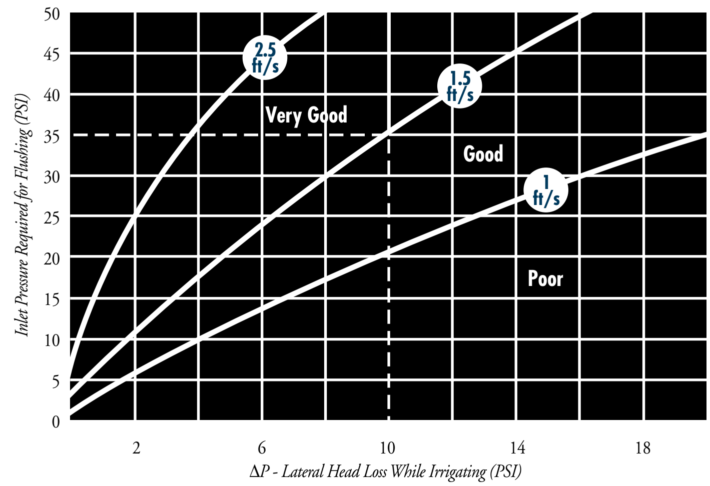




BIOLINE Flow Rate vs. Pressure



BIOLINE Flushing Velocity



Flow Rate per Length of Tubing (Gallons Per Minute)

Dripper Flow Rate (GPH)	Dripper Spacing (inches)	Total Length of Bioline Dripperline (feet)									
		500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
0.42	12	4	7	11	14	18	21	25	28	32	35
	18	2	5	7	9	12	14	16	19	21	23
	24	2	4	4	7	9	11	12	14	16	18
0.62	12	5	10	16	21	26	31	36	41	47	52
	18	3	7	10	14	17	21	24	28	31	34
	24	3	5	8	10	13	16	18	21	23	26
0.92	12	8	15	23	31	38	46	54	61	69	77
	18	5	10	15	20	26	31	36	41	46	51
	24	4	8	12	15	19	23	27	31	35	38

Bioline 17mm Fittings

Description

Bioline 17mm fittings shall be constructed in one of the following end configurations:

- Barbed insert fittings only
- Male pipe threads (MPT) with barbed insert fittings
- Female pipe threads (FPT) with barbed insert fittings

Construction

All fittings shall be constructed of molded brown plastic having a nominal outside dimension (I.D.) of 17mm (0.57"). Female and male threaded ends shall be capable of mating to standard PVC pipe with tapered threads.

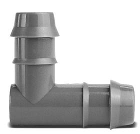
Operation

Bioline 17mm fittings shall be mated with Netafim USA Bioline 17mm dripperline by pushing the fitting into the tubing while twisting side to side until the tubing abuts to either adjoining tubing or a fitting stop.

Bioline 17mm fittings shall be Netafim USA model numbers TLTEE, TLCOUP, TL2W075MA, TLELL, TLCROS, TL050MA, TL075MA & TL075FTEE.

TLCOUP
Insert Coupling

TLCROS
Insert Cross



TLELL
Insert Elbow

TL075FTEE
Combination Tee
Ins. x Ins. x 3/4" FPT

TL2W075MA
3/4" MPT
"V" 2-way Insert

TL050MA
1/2" Male Adapter

TL075MA
3/4" Male Adapter

TLTEE
Insert Tee

TLSOV
Shut-Off Valve
Ins. x Ins.

TLFIG8
Figure 8 Line End

Techfilter® Systems

Description

The Techfilter system combines the Techfilter with a length of Bioline. Techfilter is a disc filter with a chemical root intrusion preventer (trifluralin). Techfilter is available in 5 filter sizes, (2", 1 1/2" Long, 1" Long, 1" and 3/4"). The mesh rating is 120, and maximum system pressure is 140 PSI.

Construction

Filter: The filter shall be a multiple disc filter with trifluralin incorporated into the replaceable disc ring assembly inside the filter housing. The disc filter body shall be molded of black plastic with male pipe threads for both inlet and outlet. The disc filter shall be capable of periodic servicing and replacement of the chemically-treated disc ring set by unscrewing a threaded cap or unlatching the band.

Dripperline: Individual dripperlines shall be of extruded linear low density polyethylene with an inside diameter (I.D.) of .057 inches and an outside diameter (O.D.) of .067 inches. The entire polyethylene pipe is to be purple throughout to designate its use for wastewater. The tubing is to have fully pressure compensating drippers integral with the inner wall of the tubing. These drippers shall be constructed of plastic with a hard plastic diaphragm retainer and a self-flushing/cleaning elastomeric diaphragm extending the full length of the dripper. The drippers shall be impregnated with the anti-microbial agent Vinyzene® to prevent the attachment of microbial slime to the dripper. Each dripper will have an individual filter at the inlet to the dripper; this filter shall have a cross sectional area not less than five times larger than the minimum cross sectional area of the dripper flow path.

Operation

When water passes through the filter, a very low concentration of trifluralin (parts per billion) is transmitted throughout the Bioline piping network. This provides for precise and even distribution of trifluralin throughout the piping network and effectively inhibits root growth into the dripper outlets.

The trifluralin-treated filter ring set shall be replaced every two (2) years, or two hundred (200) hours of operation, whichever occurs first.

The Techfilter system shall be Netafim USA Model Number
TFB075924-1000 – 3/4" Techfilter w/ 1000' .9 gph 24" Bioline,
TFB075624-1000 – 3/4" Techfilter w/ 1000' .6 gph 24" Bioline,
TFB10924-1000 – 1" Techfilter w/ 1000' .9 gph 24" Bioline,
TFB10624-1000 – 1" Techfilter w/ 1000' .6 gph 24" Bioline,
TFB10L924-1000 – 1" Long Techfilter w/ 1000' .9 gph 24" Bioline,
TFB10L624-1000 – 1" Long Techfilter w/ 1000' .6 gph 24" Bioline,
TFB15L924-1000 – 1 1/2" Techfilter w/ 1000' .9 gph 24" Bioline,
TFB15L624-1000 – 1 1/2" Techfilter w/ 1000' .6 gph 24" Bioline,
TFB20924-1000 – 2" Techfilter w/ 1000' .9 gph 24" Bioline,
TFB20624-1000 – 2" Techfilter w/ 1000' .6 gph 24" Bioline,

2″ Model **1 1/2″ Long** **1″ Long** **1″** **3/4″** **Techfilter Tool**

Air/Vacuum Relief Valve

Description

The Air/Vacuum Relief Valve serves two purposes:

- To evacuate air from the Bioline and PVC tubing during system start-up and
- To prevent a vacuum from occurring after the remote control valve has closed, thus avoiding debris intrusion into the drippers.

Construction

The Air/Vacuum Relief Valve shall be constructed of black, grey, and/or orange plastic with a pipe thread capable of mating with an NPT threaded PVC fitting.

Operation

Subsurface Bioline design and installation techniques require that air/vacuum relief valves be installed at the highest elevation in each zone (some zones may require more than one) in order to expel air and relieve vacuum. In a zone where the highest elevation occurs between the intake and exhaust headers (such as a mound or berm), an air/vacuum relief lateral shall interconnect the Bioline dripperlines to avoid the necessity of installing one air/vacuum relief valve on each Bioline lateral. Air/vacuum relief valves can be installed below grade in valve boxes to allow for periodic inspection.

The Air/Vacuum Relief Valve shall be:

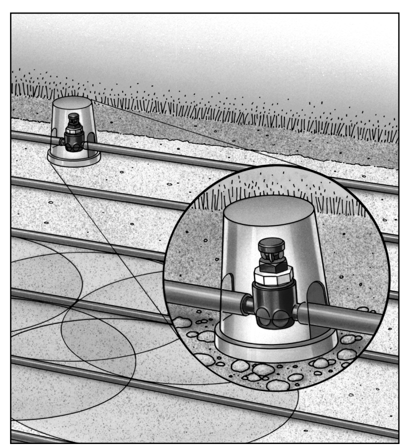
TLAVRV – 1/2" Air/Vacuum Relief
65ARIB2 – 2" Combination
65ARIB1 – 1" Combination,
65ARIA2 – 2" Guardian
65ARIA100 – 1" Guardian,
65ARIA075 – 3/4" Guardian

1" Combination,

3/4" & 1" Guardian

2" Combination

2" Guardian



Air/Vacuum Relief

Pressure Regulator

Description

The purpose of the Pressure Regulator is to control downstream pressure at or below the specified system operating pressure. Unregulated pressures in excess of the recommended operating ranges can cause the integrity of the Bioline fittings connection to weaken and/or fail.

1 1/2"

Construction

The Pressure Regulator shall be a Netafim USA spring-operated piston-type regulator with an externally accessible regulation unit that can be serviced without removing the valve body from the piping. The body shall be molded of black plastic with a combination of male/female pipe threaded inlet and outlet. Removable and interchangeable springs shall be color-coded to denote varying pressure ranges.

3/4"

Operation

The Pressure Regulator shall have a built-in indicator that indicates when it is operating. It shall be able to respond immediately to any inlet pressure variation. The regulator shall be capable of regulating 20 PSI, or 45 PSI.

The Pressure Regulator shall be a Netafim USA Model Number:

PRV075HF20 – 3/4" MPT x FPT 20 psi, 3.5 to 22 GPM
PRV075HF45 – 3/4" MPT x FPT 45 psi, 3.5 to 22 GPM
PRV15020 – 1 1/2" MPT x MPT 20 psi, 7 to 44 GPM
PRV15045 – 1 1/2" MPT x MPT 45 psi, 7to 44 GPM

Disc Filter

Description

The purpose of the Disc Filter is to capture and retain water-transported debris or sediments that could reduce the efficiency of the Bioline drippers.

Construction

The filter shall be a multiple disc filter with color-coded filter elements indicating the mesh size of the element being used. The discs shall be constructed of chemical-resistant thermoplastic for corrosion resistance.

The disc filter body shall be molded of black plastic with male pipe threads for both inlet and outlet. The disc filter shall be capable of periodic servicing by unscrewing a threaded cap or unlatching the band.

Disc filter ring color-coding shall be: Red (120 Mesh) or Black (140 Mesh).

Operation

Installation of the Disc Filter shall be as detailed. Disc filters can be installed downstream of the remote control valve to allow for periodic servicing when the remote control valve is not operating. It can be installed upstream of the remote control valve when a line size shut-off valve is also specified to allow for periodic servicing with a pressurized main line. Recommended installation of disc filters shall be below grade positioned in a valve box large enough to remove the disc filter cap and internal disc element. A gravel sump in the bottom of the valve box is recommended to drain water during periodic maintenance.

The Disc Filter shall be a Netafim Model USA Number:

DF075-120 – 3/4" MPT x MPT 120 Mesh
DF075-140 – 3/4" MPT x MPT 140 Mesh
DF100-120 – 1" MPT x MPT 120 Mesh
DF100-140 – 1" MPT x MPT 140 Mesh
DF150-120 – 1 1/2" MPT x MPT 120 Mesh
DF150-140 – 1 1/2" MPT x MPT 140 Mesh
DF150S-120 – 1 1/2" Super x MPT 120 Mesh
DF150S-140 – 1 1/2" Super x MPT 140 Mesh
DF200-120 – 2" MPT x 120 Mesh
DF200-140 – 2" MPT x 140 Mesh

2″ | 1 1/2″ *Super* | 1 1/2″ | 1″ | 3/4″

Stainless Steel Clamps

(for operating pressures in excess of recommendations)

Description

Stainless steel clamps are used to secure Bioline to barbed insert fittings. Clamps shall be manufactured by "Oetiker" and shall be one "ear" type. Nominal size that is recommended for use with Bioline 17mm is 13/16", Part No. 210SS.

Construction

Oetiker clamps shall be constructed of 304 AISI stainless steel. Clamps shall be one "ear" type and formed with a "dimple", allowing for thermal expansion and contraction properties without loosening the clamp.

Interior clamp wall shall be smooth to prevent crimping or pinching of tubing. Wall thickness of clamps shall be .0236" (0.6 mm) with an overall band width of ˘" (7 mm).

Operation

Stainless steel clamps are used to secure Bioline over barbed insert fittings when design-operating pressures exceed 45 PSI. Clamps are to be slipped over the tubing before being fitted to barbed insert fittings. Place the clamp between the first and second ridge of the barbed insert fittings. Crimp the "ear" of the clamp tightly with an Oetiker pincer tool. Crimp twice to ensure proper seating.

NETAFIM USA's LIMITED WARRANTY/LIMITATION OF BUYER'S REMEDIES

(A) BASIC MANUFACTURER'S LIMITED WARRANTY:

Except as to products described in subsections (B), (C), (D), and (E) below, products sold and/or manufactured by Netafim Irrigation, Inc. (Netafim USA) are warranted to be free from original defects in material and workmanship for a period of one (1) year from the date of delivery to the buyer unless (i) otherwise specified by and subject to the terms and conditions of any Warranty Supplements pertaining to specific products or, (ii) expressly disclaimed in writing by Netafim USA. Within the warranty period, Netafim USA at its sole discretion shall have the option to repair or replace part or all of a defective product, or refund part or all of the original purchase price, if any part proves to be defective in material or workmanship after return of such product at customer's expense and after such return has been authorized in writing by Netafim USA.

THIS BASIC MANUFACTURER'S LIMITED WARRANTY IS SUBJECT TO THE TERMS AND PROVISIONS IN SUBSECTION (F), (LIMITATION OF REMEDIES AND DISCLAIMER OF WARRANTIES) SET FORTH BELOW. IN THE EVENT OF ANY INCONSISTENCY BETWEEN SUBSECTION (A) and SUBSECTION (F) OF THIS PRODUCT WARRANTY, THE PROVISIONS OF SUBSECTION (F) SHALL PREVAIL.

(B) BIOLINE DRIPPERLINES:

Bioline dripperlines are warranted to be free from original defects in materials and workmanship for a period of seven (7) years. This warranty shall apply only to products with a wall thickness of 35 mil or greater.

(C) FILTERS:

Disc filters are warranted to be free from original defects in materials and workmanship for a period of five (5) years. AGF media tanks are warranted to be free from original defects in material and workmanship for a period of ten (10) years. This warranty specifically excludes gaskets, seals and o-rings, which are subject to the basic one (1) year warranty.

(D) VALVES:

Valve bodies are warranted to be free from original defects in materials and workmanship for a period of five (5) years. Valve diaphragms are warranted for a period of two (2) years.

(E) AIR VENTS:

Air vent bodies are warranted to be free from original defects in materials and workmanship for a period of five (5) years. This warranty specifically excludes internal seals, gaskets or o-rings which are subject to the basic one (1) year warranty.

(F) LIMITATION OF REMEDIES AND DISCLAIMER OF WARRANTIES:

EXCEPT AS EXPRESSLY PROVIDED HEREIN, ALL WARRANTIES EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR USE, ARE HEREBY EXCLUDED AND DISCLAIMED.

THE REMEDIES PROVIDED HEREIN SHALL BE THE EXCLUSIVE AND SOLE REMEDY OF THE BUYER. NO OTHER EXPRESS WARRANTY IS GIVEN AND NO AFFIRMATION BY NETAFIM USA, BY WORDS OR ACTION, WILL CONSTITUTE A WARRANTY. NO OTHER EXPRESS WARRANTY NOR ANY OTHER REMEDY SHALL BE AVAILABLE TO THE BUYER AND NETAFIM USA SHALL NOT BE RESPONSIBLE OR LIABLE FOR ANY DAMAGES, INCLUDING ANY LOSS OF PROFIT, LOST SAVINGS, LOSS OF SALES, OR OTHER DIRECT, INDIRECT, INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES, INJURY OR DAMAGES TO ANY PERSON OR PROPERTY ARISING OUT OF THE USE OR INABILITY TO USE THE PRODUCTS OR THE BREACH OF ANY EXPRESS WARRANTY, EVEN IF NETAFIM USA HAS BEEN ADVISED OF THE POSSIBILITY OF THOSE DAMAGES OR CLAIMS. NETAFIM USA SHALL NOT BE RESPONSIBLE FOR THE AFORESAID DAMAGES, CLAIMS OR LOSSES DUE TO LATE DELIVERY OR DELIVERY OR NON-DELIVERY, OR OTHERWISE.

THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION AS SET FORTH HEREIN. IF NETAFIM USA SHALL FURNISH TECHNICAL ADVICE OR ASSISTANCE WITH RESPECT TO THE PRODUCTS SOLD HERE UNDER, IT SHALL BE GIVEN WITHOUT CHARGE TO BUYER AND SHALL BE GIVEN AND ACCEPTED AT BUYER'S SOLE RISK WITHOUT ANY EXPRESS OR IMPLIED WARRANTY AND NETAFIM USA SHALL NOT BE REPSONSIBLE OR LIABLE FOR THE ADVICE OR THE RESULTS THEREOF. BUYER ASSUMES ALL RISK AND LIABILITY RESULTING FROM USE OF THE PRODUCT PURCHASED.

This warranty is expressly conditioned upon proper storage, installation, application and normal wastewater use and services as recommended by Netafim USA. Such recommendations may be updated from time to time. Any misuse, neglect, modifications, unauthorized repairs or replacement or uses of the product and/or any of its components for non-wastewater purposes not recommended by Netafim USA, including but not limited to the following, shall completely void this warranty.

(I) Wastewater which has not been filtered or treated to the levels specified for individual components of the product by Netafim USA;

(II) Chemical concentrates used, or applied internally or externally to the product, or mechanical abuse which is harmful to the product or its components;

(III) Operating pressures greater than those specified by Netafim USA's individual component specifications;

(IV) Damage or plugging caused by insects, rodents, other animals, improper installation or other mechanical damage.

THE EXPRESS WARRANTY PROVIDED HERE IN IS EFFECTIVE ONLY IF CLAIM IS MADE BY WRITTEN NOTICE WITHIN THE APPLICABLE WARRANTY PERIOD AND POSTMARKED WITHIN THRITY (30) DAYS AFTER DISCOVERY OF THE DEFECT ON WHICH THE CLAIM IS BASED. SUCH NOTICE SHALL BE DELIVERED TO NETAFIM USA AT THE FOLLOWING ADDRESS:

NETAFIM USA
5470 E. HOME AVENUE
FRESNO, CALIFORNIA 93727
ATTN: PRODUCT MANAGEMENT

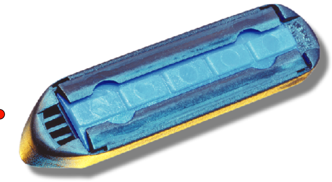
The buyer shall, together with its notice of claim, offer Netafim USA in writing prompt opportunity to examine the defective product and correct the defect, if possible. This warranty shall be void unless buyer delivers the defective product to Netafim USA at buyer's sole cost and in accordance with Netafim USA's instructions.

Netafim USA is not liable for damage or loss occurring during shipment. Shipments are FOB Netafim USA's warehouse. Responsibility for safe deliver of the product is assumed by the freight carrier at the time of shipment. Claims for such damages must be filed with the freight carrier.

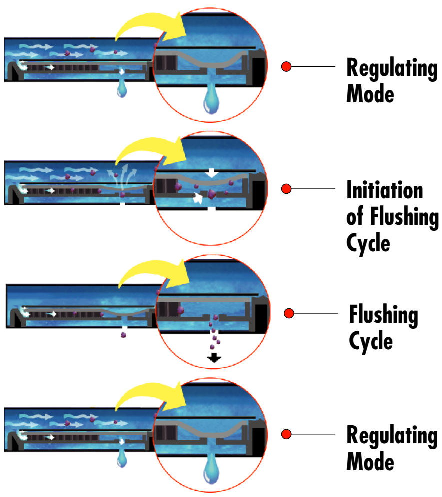
5470 East Home Avenue • Fresno, CA 93727
(888) NETAFIM (638-2346) • FAX (800) 695-4753
WEB SITE – www.netafimusa.com

NETAFIM USA

Bioline® Dripperline



Pressure Compensating Dripperline for Wastewater



BioLine's Self-Cleaning, Pressure Compensating Dripper is a fully self-contained unit molded to the interior wall of the dripper tubing.

As shown at left, BioLine is continuously self-cleaning during operation, not just at the beginning and end of a cycle. The result is dependable, clog free operation, year after year.

Applications

- For domestic strength wastewater disposal.
- Installed following a treatment process.
- Can be successfully used on straight septic effluent with proper design, filtration and operation.
- Suitable for reuse applications using municipally treated effluent designated for irrigation water.

Specifications

Wall thickness (mil): 45*

Nominal flow rates (GPH): .4, .6, .9*

Common spacings: 12", 18", 24"*

Recommended filtration: 120 mesh

Inside diameter: .570*

Color: Purple tubing indicates non-potable source.

*Additional flows, spacings, and pipe sizes available by request. Please contact Netafim USA Customer Service. for details.

Product Advantages

The Proven Performer

- Tens of millions of feet used in wastewater today.
- Bioline is permitted in every state allowing drip disposal.
- Backed by the largest, most quality-driven manufacturer of drip products in the U.S.
- Preferred choice of major wastewater designers and regulators.
- Proven track record of success for many years of hard use in wastewater applications.

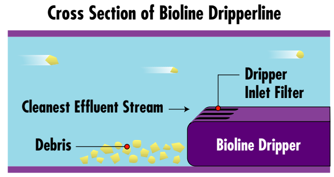
Quality Manufacturing with Specifications Designed to Meet Your Needs

- Pressure compensating drippers assure the tightest application uniformity - even on sloped or rolling terrain.
- Excellent uniformity with runs of 400 ft. or more reduce installation costs.
- Highest quality-control standards in the industry: Cv of 0.25 (coefficient of manufacturer's variation).
- A selection of flows and spacings to satisfy the designer's demand for almost any application rate.

Long-Term Reliability

- Protection against plugging:
  - Dripper inlet raised 0.27" above wall of tubing to prevent sediment from entering dripper.
  - Drippers impregnated with Vinyzene to prevent buildup of microbial slime.
  - Unique self-flushing mechanism passes small particles before they can build up.

Cross Section of Bioline Dripperline

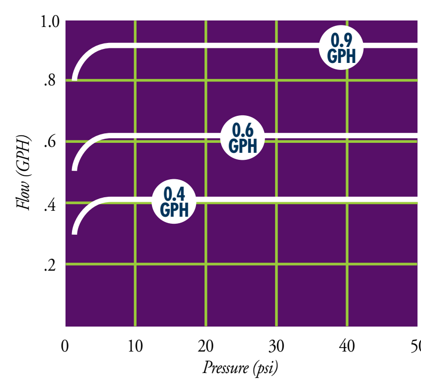


Root Safe

- A physical barrier on each BioLine dripper helps prevent root intrusion.
- Protection never wears out - never depletes - releases nothing to the environment.
- Working reliably for up to 15 years in subsurface wastewater installations.
- Additional security of chemical root inhibition with Techfilter - supplies Trifluralin to the entire system, effectively inhibiting root growth to the dripper outlets.

TECHFILTER LIFETIME EXTENDED WARRANTY

BIOLINE Flow Rate vs. Pressure



NETAFIM USA
PRECISION IRRIGATION™
5470 E. Home Ave. • Fresno, CA 93727
(888) 638-2346 • FAX (800) 695-4753
www.netafimusa.com

Bioline Technical Information

DRIPPER FLOW PATH DIMENSIONS

Dripper	Length	Depth	Width
0.4 GPH	.75"	.037"	0.040"
0.6 GPH	.75"	.045"	0.044"
0.9 GPH	.75"	.047"	0.060"

DRIPPER HYDRAULIC PERFORMANCE

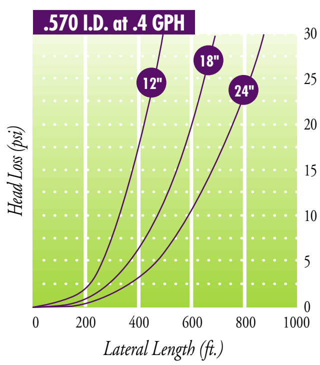
Dripper	Kd	Exponent (x)	Constant (K)
0.4 GPH	.9	0	.42
0.6 GPH	.9	0	.61
0.9 GPH	.9	0	.92

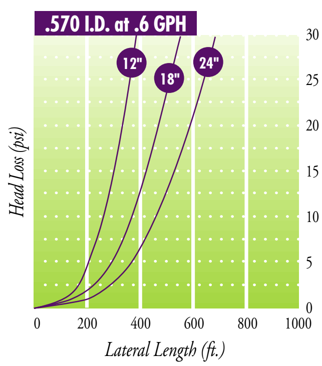
UNIFORMITY

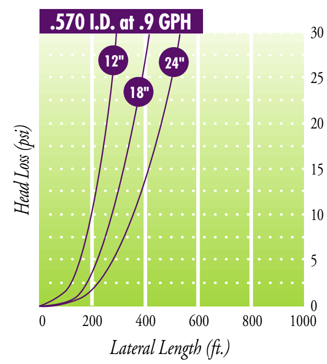
Dripper	Cv
0.4 GPH	0.25
0.6 GPH	0.25
0.9 GPH	0.25

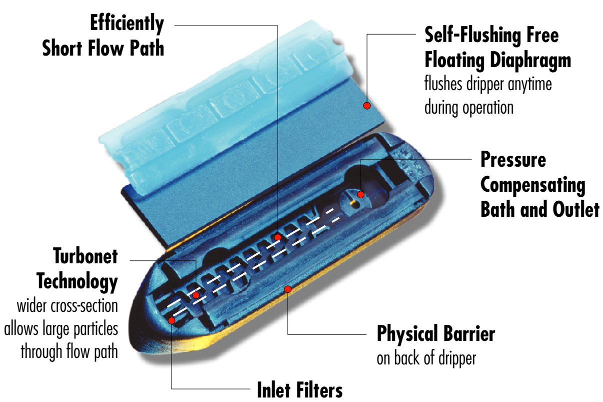
OPERATING RECOMMENDATIONS

Dripper	Minimum Pressure	Maximum Pressure	Minimum Filtration
0.4 GPH	10 psi	60 psi	120
0.6 GPH	10 psi	60 psi	120
0.9 GPH	10 psi	60 psi	120

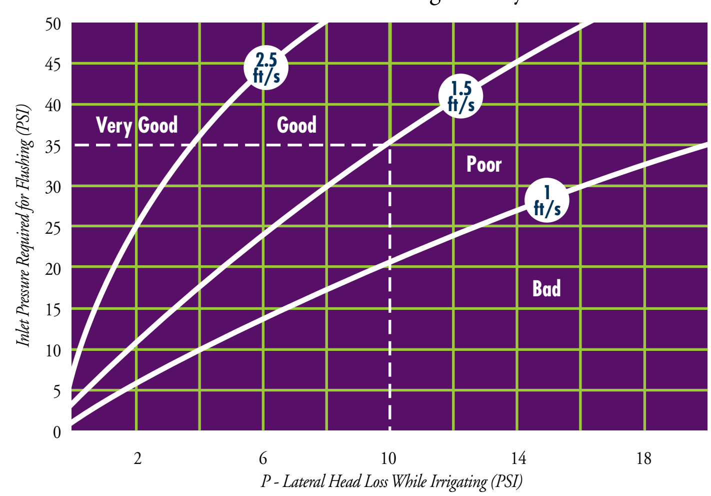








BIOLINE Flushing Velocity



Netafim USA – Delivering Total Growing Solutions

• Dripperlines • Filters • Valves • Air Vents • Sprinklers • Automation • Technical Education

For Wastewater, Agriculture, Landscape, Greenhouse & Nursery

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For more information call your Authorized Netafim USA Dealer or call Netafim USA Customer Service at (888) 638-2346.

NETAFIM USA

DF Series Disc Filters

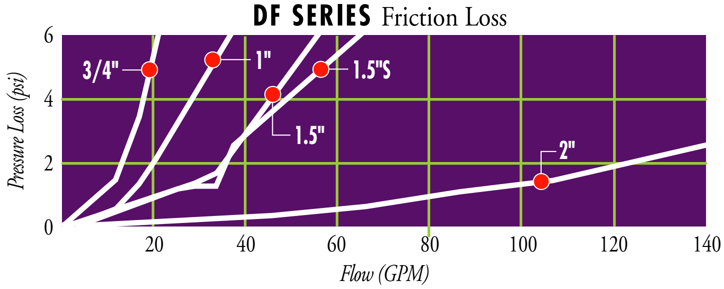
2"   1 1/2" Super   1 1/2"

1"   3/4"   3/4" *with Shut-Off Valve*

Reliable, Efficient Plastic Discs Create Superior Filtration

Disk Filter Technology was originally developed to keep the hydraulic lines on military aircraft clean. Each filter element is a stack of grooved rings, or discs. Clean water must pass through the grooves in the stack of discs from the outside to the inside of the disc stack. The grooves on adjacent discs run cross-ways to each other, so the effluent must pass through a labyrinthine passageway on its way through the filter element. The debris is deposited in the grooves as the effluent makes its way through the filter element. Because the grooves have depth (a 3-dimensional volume vs. a 2-dimensional surface like a screen filter), they are able to hold a larger amount of debris than screen filters.

DF SERIES Friction Loss



Applications

- All domestic wastewater applications

FILTER SIZE

Filter	GPM
3/4"	13
1"	22
1 1/2"	35
2"	132

Netafim USA offers filters up to 4000 GPM - please call for more information.

Product Advantages

- Extremely Reliable
  Unlike screen elements, the stack of discs that comprise the filter unit cannot tear or collapse. Organic material won't get pushed through as the filter loads.
- Higher Capacity for Holding Debris Means Less Frequent Cleaning
  The 3-dimensional nature of disc filtration enables the filter to safely hold more debris without clogging or 'sliming over' as can happen with screen filters used on water sources with organic loads.
- Simple, Easy and Thorough Filter Cleaning
- Low Friction Loss
- 100% Thermoplastic Discs Provide Extremely High Corrosion Resistance
- Color-coded Replacement Filter Rings Available

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DF Series Disc Filters Technical Information

PRESSURE LOSS (psi)

Filter Size	Filter Volume (cu. in.)	Filtration Area (sq. in.)	Flow Rate (GPM)												
			4.4	8.8	13	17	22	26	31	35	44	66	88	110	132
3/4"	6	25	0.40	1.46	3.40										
1"	27	48	0.14	0.54	1.34	2.10	3.24								
1 1/2"	27	48					1.10	1.30	1.70	2.30					
1 1/2" Super	34	61					1.10	1.20	1.20	2.50	3.60				
2"	74	146.5									0.30	0.63	1.03	1.47	2.13

Ordering Information

MANUAL FILTERS

Model Number	Description	Flow Range (GPM)
DF075-120	3/4" MPT x MPT-120 mesh	1 - 12
DF075-140	3/4" MPT x MPT-140 mesh	1 - 12
DF100-140	1" MPT x MPT-120 mesh	5 - 26
DF100-140	1" MPT x MPT-140 mesh	5 - 26
DF150-140	1 1/2" MPT x MPT-120 mesh	10 - 35
DF150-140	1 1/2" MPT x MPT-140 mesh	10 - 35
DF150S-140	1 1/2" Long MPT x MPT-120 mesh	10 - 35
DF150S-140	1 1/2" Long MPT x MPT-140 mesh	10 - 35
DF200-140	2 MPT x MPT-120 mesh	10 - 50
DF200-140	2 MPT x MPT-140 mesh	10 - 50

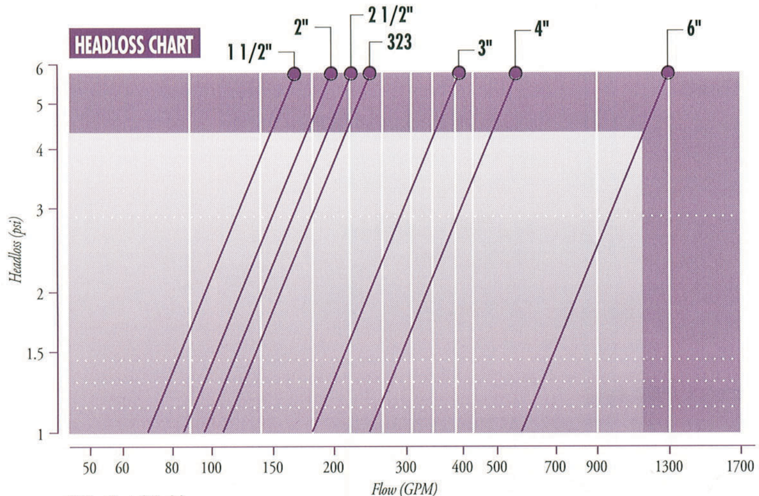
FILTER BATTERIES

Model Number	Description	Flow Range (GPM)
26ASKWWA2A2-120	2 x 2" Disc-Kleen - 120 mesh	30 - 180
26ASKWWA2A2-140	2 x 2" Disc-Kleen - 140 mesh	30 - 180
26ASKWWA2A3-120	3 x 2" Disc-Kleen - 120 mesh	150 - 260
26ASKWWA2A3-140	3 x 2" Disc-Kleen - 140 mesh	150 - 260
26ASKWWA2A4-120	4 x 2" Disc-Kleen - 120 mesh	200 - 350
26ASKWWA2A4-140	4 x 2" Disc-Kleen - 140 mesh	200 - 350

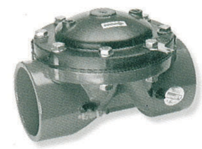
NETAFIM USA

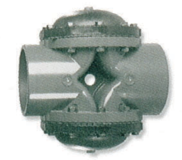
Nylon and PVC Valves

Engineered to Perform Reliably in Wastewater Applications



3-Way Control Model
Light brown area indicates recommended operating range.





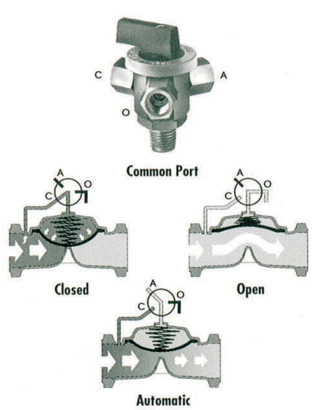
Applications

- Ideal for water control in PVC networks.
- Surface or Sub-surface installations.
- **Functions:** Manual, Electrical or Hydraulic Remote Control, Pressure Reducing, Pressure Sustaining, Pressure Relief, Pump Control, Check Valve, Surge Anticipating.

Specifications

Maximum water temperature: 140° at maximum pressure.

- **Operating Pressure (psi):**
  Nylon - 12 minimum, 145 maximum
  PVC - 12 minimum, 115 maximum

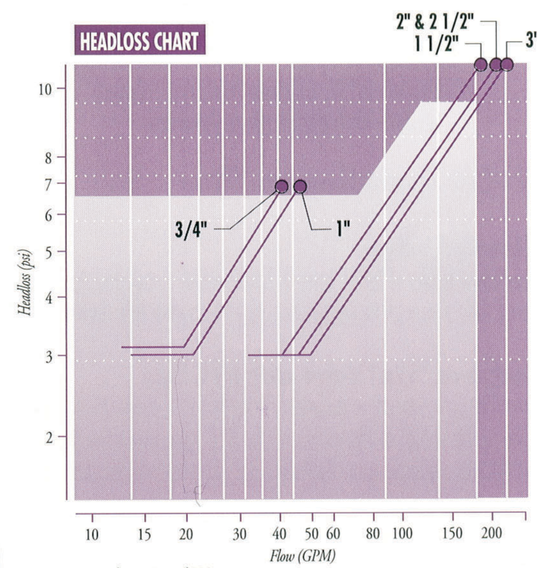


Netafim USA's Basic Valve can be operated manually through the use of a 3-way selector. Selector options are:

Closed (C): Upstream pressure or pressure from an external source is applied to the control chamber. Initiated by the spring, the diaphragm is pressed down to close the valve drip-tight.

Open (O): Relieving the water or air pressure to the atmosphere from the control chamber causes the valve to open.

Automatic (A): The automatic port of the 3-way selector is connected to a solenoid, hydraulic relay or pilot, which controls the valve. The common port of the 3-way selector connects the control chamber to either A, O or C, depending on the direction the selector is pointed.



2-Way Electric Control PBI
Light brown area indicates recommended operating range.

RECOMMENDED Cv $H\ (psi) = \left(\frac{Q\ (GPM)}{Cv}\right)^2$

SIZES	1"	1 1/2"	2"	323	3"	4"	6"
	18	66	83	103	175	250	554

Product Advantages

- Superb hydraulic performance.
- Simple to install with slip or threaded PVC connections.
- Simple design - diaphragm is the only moving component, no shaft, seals or bearings are located within the water passage way. Completely serviceable in-line.

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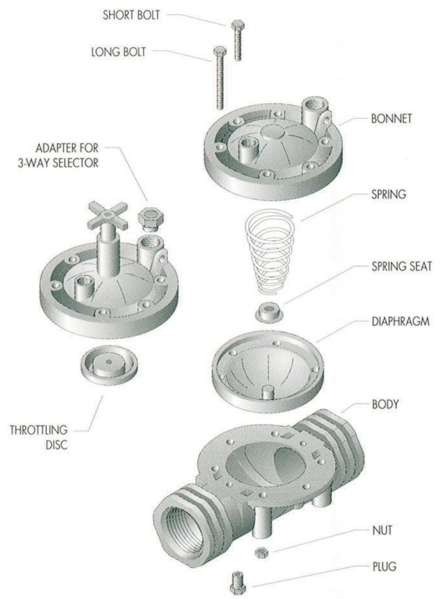
Nylon and PVC Valves Specifications



(Nylon valve shown above)

VALVE DATA

	Nylon				PVC			
	Threaded				Threaded	Slip		
Size	1"	1 1/2"	2"	323"	3"	3"	4"	6"
Length (in.)	4 7/8	7 3/8	7 7/8	9 1/4	10 1/8	10 1/8	11	14
Height (in.)	2 7/8	4 3/8	4 3/8	4 3/4	7 5/8	7 5/8	8	15
Weight (lbs.)	0.4	2	2.2	3.1	9.3	9.3	9.5	20
Max. Pressure (psi)	115	140	140	140	115	115	115	150

OPTIONS

REMOTE CONTROL	**Electric Hydraulic**	Specify normally open or closed for main valve pressure rating and voltage. Order Catalog #61GALIT
BONNET	**Standard**	Nylon Valves are available with a throttling feature.
HOOK-UP	**Standard**	1/4" Nylon Tubing

MODELS AVAILABLE

	CONNECTION	Nylon	PVC	
	MATERIAL	Threaded	Threaded	Slip
SIZES	1"	●		
	1 1/2"	●		
	2"	●		
	323	●		
	3"		●	●
	4"			●
	6"			●

Materials

Nuts, bolts and washers: Zinc coated steel/BS 5216
Nylon Valves only: Body, Bonnet and Seat: 30% Glass Reinforced Polyamide (GRP)
PVC: Body - uPVC
Spring: Stainless steel AISI 302
Connections: Threaded - ANSI (NPT Female)
Socket - IPS, PVC Standard
Diaphragm Materials: Standard - Natural Rubber
Special - EPDM (Ethylene Proplylene Polymer)
Special - Nitril (Butadiene Acrylonitrile)

Valve Installation Tips

Threaded Valves
Use a few layers of Teflon tape or Teflon sealer compound on the adapter and tighten by hand. Use a wrench to tighten the adapter another half revolution.

Socket or "Slip" Valve with PVC Pipe
Use the same procedure as when cementing PVC pipes. Mark the pipe first, then apply glue to the socket of the valve and the PVC pipe. Insert the pipe until reaching the mark and rotate a quarter turn. Hold the joint in place until the cement hardens.

Installation Above Ground
When installing a manifold above ground the length of the manifold should be kept as short as possible, (this eliminates the need for additional support). For longer lengths a firm support under the horizontal pipes is recommended. Always install the valve with the bonnet exposed to the sun.

Diaphragm Replacement
Loosen bolts, remove old diaphragm and install new diaphragm. Tighten the bolts, applying even pressure in a diagonal pattern, until the diaphragm is firmly pressed between the body and the bonnet. Do not over tighten. If leakage occurs between the bonnet and valve, tighten until leakage stops.

Underground
For underground installations use thrust blocks where needed, allow sufficient space and keep the area around the valve free from rough objects and stones. Cover the valve with clean soil – up to 24" is recommended for protection against heavy equipment. The controls for the valve, like the pilot, 3-way valve, should be positioned above ground. Be sure to mark the control tubing by color or number and put a protective poly or PVC tubing around the control tubing.

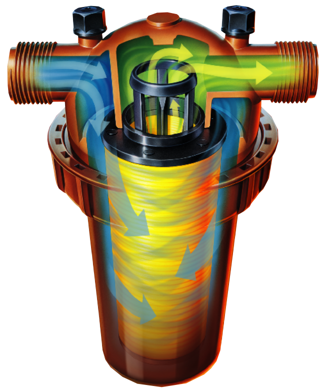
W069 10/01

NETAFIM USA

Techfilter

The Guaranteed Root Intrusion Terminator

Our revolutionary Techfilter protects against roots invading the system. Here's how it works: Trifluralin is incorporated into the replaceable disc ring assemblies inside the filter housing. When water passes through the filter, a very low concentration of trifluralin (parts per billion) is transmitted throughout the system. This technology provides very precise and even distribution of trifluralin throughout the piping network and effectively inhibits root growth into the dripper outlets.



2" Model

1 1/2" Long

1" Long

1"

3/4"

Techfilter Tool

Product Advantages

- Prevents root intrusion.
- Replaceable Techfilter cartridge allows system to remain protected throughout its lifetime.
- Renewable warranty, activated when filter cartridges are installed and registered, gives the opportunity for a lifetime of protection.
- Delivers a low concentration of trifluralin evenly to all drippers throughout the system.
- Sealed packaging dramatically extends shelf life and adds to filter replacement convenience.
- Easy, no-touch installation and replacement of trifluralin filter.
- Provides efficient water filtration with performance far superior to screen-type filters.

Applications

- Recommended wherever chemical protection against root intrusion is desired.

Specifications

Maximum pressure: 140 psi

Mesh: 120

Exclusive Netafim USA Techfilter Lifetime Extended Warranty

- Every Netafim USA Techfilter carries an up-to-lifetime warranty. Proper use and timely replacement of the cartridge keep the Lifetime Extended Warranty in force.
- Replaceable Techfilter disc cartridges come in convenient sealed packages which have two benefits:
  - Extended shelf life.
  - Clean and simple replacement of the complete cartridge without having to touch the rings.

TECHFILTER MINIMUM AND MAXIMUM FLOW RATES

Techfilter	Minimum Flow	Maximum Flow
3/4"	1	7
1"	3	22
1" Long	8	40
1 1/2" Long	8	40
2"	14	90

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Techfilter Technical Information

TECHFILTER SPECIFING INFORMATION

TFB	XXX	X	XX	XXXX
Techfilter	Filter Size	Dripper Flow	Dripper Spacing	Quantity of Techline
TFB	075 = 3/4" 10 = 1" 10L = 1" Long 15L = 1 1/2" Long 20 = 2"	6 = 0.6 GPH 9 = 0.9 GPH	24 = 24"	1,000'

TECHFILTER MODEL NUMBER DESCRIPTIONS

	Filter Size					Dripper Flow (GPH)		Techfilter	
Model Number	3/4"	1"	1" Long	1 1/2" Long	2"	0.6	0.9	Minimum Flow	Maximum Flow
TFB075924-1000	X						X	1	7
TFB075624-1000	X					X		1	7
TFB10924-1000		X					X	3	22
TFB10624-1000		X				X		3	22
TFB10L924-1000			X				X	8	40
TFB10L624-1000			X			X		8	40
TFB15L924-1000				X			X	8	40
TFB15L624-1000				X		X		8	40
TFB20924-1000					X		X	14	90
TFB20624-1000					X	X		14	90

All Techfilters come in 1,000' rolls with 24" dripper spacing standard. Additional spacing options available.

NETAFIM USA

Bioline Fittings & Accessories

Applications

- Fits 17mm Bioline Dripperlines

Product Advantages

- Barbed fittings for secure fit and easy installation without glue, tools or clamps
- Maximum recommended system operating pressure: 45 psi
- UV resistant for surface or subsurface applications
- Durable one-piece construction
- Allows for easy on-site inspection of proper fitting installation

TLCOUP
Insert Coupling

TLCROS
Insert Cross

TLELL
Insert Elbow

TL075FTEE
Combination Tee
Ins x Ins x 3/4" FPT

TL075MA
3/4" Male Adapter

TL2W075MA
3/4" MPT
"V" 2-way Insert

TL050MA
1/2" Male Adapter

TLTEE
Insert Tee

TLSOV
Shut-Off Valve
Ins x Ins

TLFIG8
Figure 8 Line End

Other Bioline Accessories

TLTIP
Dripperline Tubing Insert Plow

WBTD
Wheelbarrow Dripperline Tubing Dispenser (250' and 1,000' coils)

GAUGE 100

GAUGE 30

TLS6 Soil Staple
On-surface applications should use one TLS6 for approximately every 4' of tubing, plus two on each tee, elbow or cross

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Operation/Pressure Indicator Stake

For Use with All Drip Irrigation Systems

10-F-01
Operation/Pressure Indicator Stake

The set includes: pressure indicator flag, anchoring stake and tubing/adapter. When the zone is on, pressure causes the flag to rise. At a pressure of 10 psi or higher, it is at a 90˚ angle. At 7 psi, it is at a 45˚ angle. When the pressure either drops below 4.5 psi or the system is off, the flag is in a down position.

Applications

- For Bioline drip systems

Specifications

Flag position: 45˚ = 7 psi, 90˚ = 10 psi, closed position = 4.5 psi and lower

Product Advantages

- Provides quick visual confirmation of system operation
- Flag rises to indicate system operation and minimum 10 psi system operation
- Answers the question "Is the system working?'

W066 3/01

E
APPENDIX E—CONTROL PANELS

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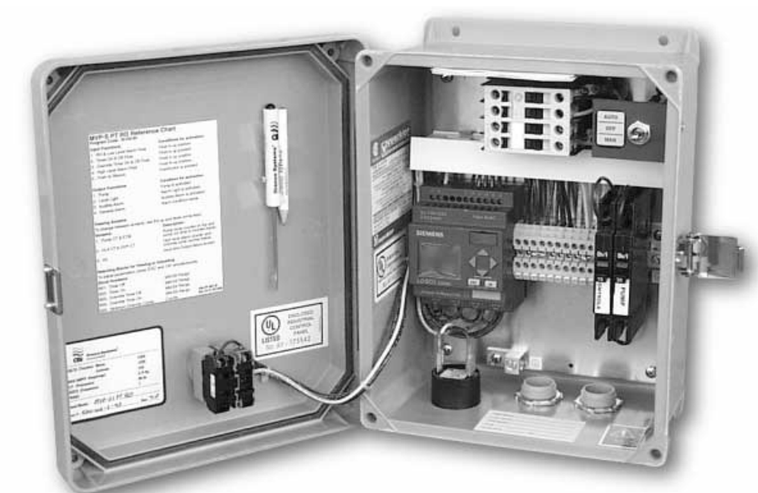
MVP-Simplex Control Panels

Technical Data Sheet

Applications

Orenco's MVP line of control panels is specifically engineered for water and onsite wastewater treatment systems and is especially suited for applications that require a programmable timer. The MVP Simplex Panels are ideal for timed dosing in single pump systems.

The programmable logic module is the brain of the MVP line of control panels



Model shown is MVP-S1 PTRO

The enclosure is NEMA 4X rated

Features/Unique Specifications

To specify this panel for your installation, require the following:

- Digital timing accurate within 1%
- Multiple timer settings for optimum dosing during normal **and** peak flow conditions
- Built-in programming keys for adjusting timer settings in the field without a portable computer
- Built-in elapsed time meter and counters
- Port on logic unit for easy insertion of EEPROM card to change panel functions
- High and low-level alarm conditions differentiated by steady or blinking light
- Silenced alarms automatically reactivated after 12 hours if condition is not corrected
- Timed delays on float inputs to prevent chattering
- Ability to use one model of float for all functions
- Visual indicators of float position
- UL 508 listing in U.S. and Canada

Standard Models

MVP-S1 PTRO, MVP-S2 PTRO

Nomenclature

MVP-S□□□□ PTRO□□□□

Indicates additional options:
HT = heater
CS = current sensor
PRL = pump run light

Indicates number of Intrinsically safe relays

Indicates IR option (Intrinsically safe relays)

Indicates voltage:
1 = 120 VAC
2 = 240 VAC

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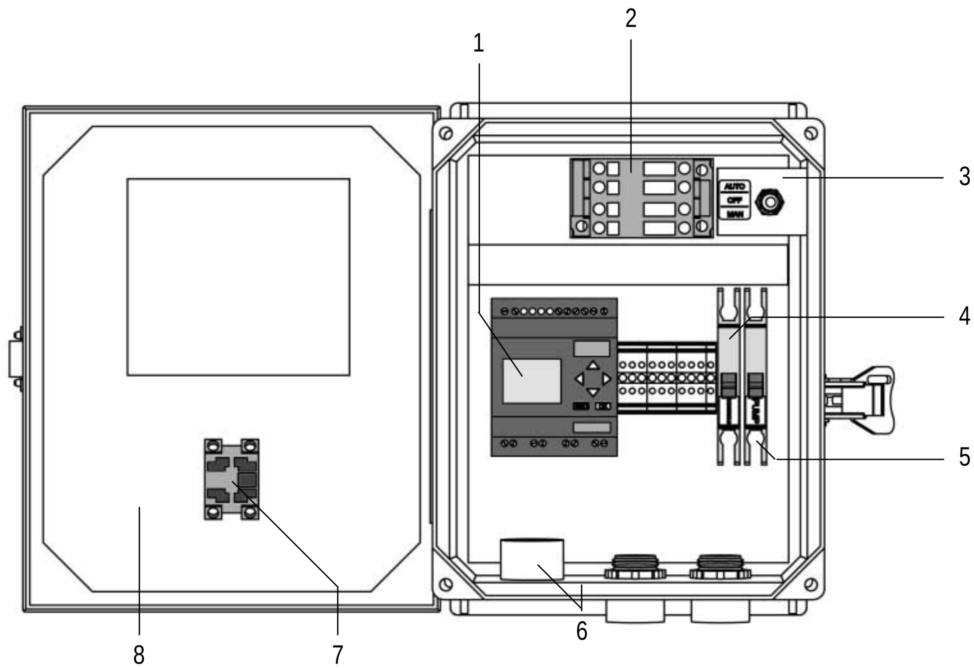


Standard Components

Feature	Specification(s)
1. Programmable Logic Unit	120/240 VAC programmable logic unit with built-in LCD screen and programming keys. Provides control functions and timing for panel operation.
2. Motor-Start Contactor	120 VAC: 14 FLA, 3/4 hp, 60 hz; 2.5 million cycles at FLA (10 million at 50% of FLA). 240 VAC: 14 FLA, 2 hp, 60 hz; 2.5 million cycles at FLA (10 million at 50% FLA).
3. Toggle Switch	Single-pole, double-throw HOA switch. 20 amps, 1hp.
4. Controls Circuit Breaker	10 amps, OFF/ON switch. Single pole 120 VAC. DIN rail mounting with thermal magnetic tripping characteristics.
5. Pump Circuit Breaker	20 amps, OFF/ON switch. Single-pole 120 VAC, double-pole 240 VAC. DIN rail mounting with thermal magnetic tripping characteristics.
6. Audio Alarm	80 dB at 24", warble-tone sound.
7. Visual Alarm	7/8" diameter red lens, "Push-to-silence." NEMA 4, 1 Watt bulb, 120 VAC.
8. Panel Enclosure	Measures 11.52" high x 9.31" wide x 5.43" deep. NEMA 4X rated. Constructed of UV-resistant fiberglass; hinges and latch are stainless steel. Conduit couplings provided.
MVP-S1 PTRO Panel Ratings	120 VAC, 3/4 hp, 14 amps, single phase, 60 Hz.
MVP-S2 PTRO Panel Ratings	240 VAC, 2 hp, 14 amps, single phase, 60 Hz.

Optional Components

Feature	Specification(s)	Product Code Adder
Pump Run Lights	7/8" green lens. NEMA 4, 1 Watt bulb, 120 VAC.	PRL
Heater	Anti-condensation heater. Self-adjusting: radiates additional wattage as temperature drops.	HT
Intrinsically Safe Control Relays	120 VAC. Listed per UL 698A, for Class 1 Div. 1, Groups A, B, C, D hazardous locations. Larger enclosure required.	IR
Current Sensor	120 VAC. Go/no-go operation. Pump fail indicator light on panel. Manual reset switch.	CS

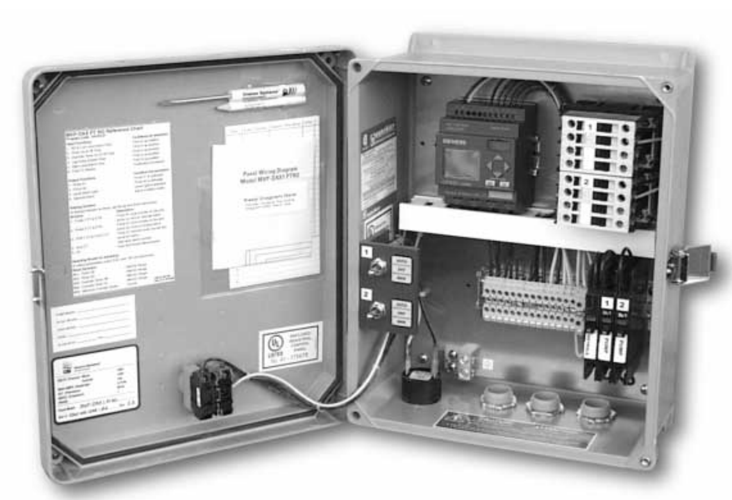
MVP-Duplex Control Panels

Technical Data Sheet

Applications

Orenco's MVP line of control panels is specifically engineered for demand and timed dosing of onsite wastewater and water treatment systems and is especially suited for applications that require a programmable timer. The MVP Duplex Panels are ideal for timed dosing in two-pump alternating systems.

The programmable logic module is the brain of the MVP line of control panels



Model shown is MVP-DAX1 PTRO

The enclosure is NEMA 4X rated

Features/Unique Specifications

To specify this panel for your installation, require the following:

- Digital timing accurate within 1%
- Multiple settings for optimized dosing during normal and peak flow conditions
- Pump alternation continues during override conditions
- Built-in programming keys for adjusting timer settings in the field without a portable computer
- Built-in elapsed time meters and counters
- Port on logic unit for easy insertion of EEPROM card to change panel functions
- High and low-level alarm conditions differentiated by steady or blinking light
- Silenced alarms automatically reactivated after 12 hours if condition is not corrected
- Timed delays on float inputs to prevent chattering
- Ability to use one model of float for all functions
- Visual indicators of float position
- UL 508 listing in U.S. and Canada

Standard Model

MVP-DAX1 PTRO, MVP-DAX2 PTRO, MVP-DAX1 RO, MVP-DAX2 RO

Nomenclature

MVP-DAX□□□□ □□RO □□□□

Indicates additional options:
HT = heater
CS = current sensor
PRL = pump run light

PT = indicates timed dosing
Blank = indicates demand dosing

Indicates number of Intrinsically safe relays

Indicates IR option (Intrinsically safe relays)

Indicates voltage:
1 = 120 VAC
2 = 240 VAC

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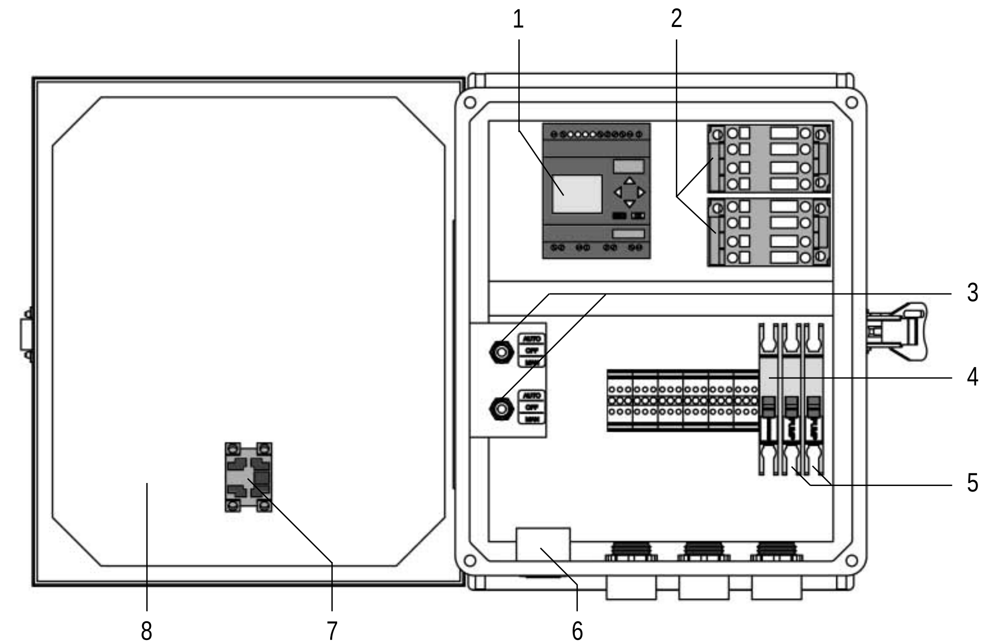


Standard Components

Feature	Specification(s)
1. Programmable Logic Unit	120/240 VAC programmable logic unit with built-in LCD screen and programming keys. Provides control functions and timing for panel operation.
2. Motor-Start Contactors	120 VAC: 14 FLA, 3/4 hp, 60 hz; 2.5 million cycles at FLA (10 million at 50% of FLA). 240 VAC: 14 FLA, 2 hp, 60 hz; 2.5 million cycles at FLA (10 million at 50% FLA).
3. Toggle Switches	Single-pole, double-throw HOA switch. 20 amps, 1hp.
4. Controls Circuit Breaker	10 amps, OFF/ON switch. Single pole 120 VAC. DIN rail mounting with thermal magnetic tripping characteristics.
5. Pump Circuit Breakers	20 amps, OFF/ON switch. Single-pole 120 VAC, double-pole 240 VAC. DIN rail mounting with thermal magnetic tripping characteristics.
6. Audio Alarm	80 dB at 24", warble-tone sound.
7. Visual Alarm	7/8" diameter red lens, "Push-to-silence." NEMA 4, 1 Watt bulb, 120 VAC.
8. Panel Enclosure	Measures 13.51" high x 11.29" wide x 5.58" deep. NEMA 4X rated. Constructed of UV-resistant fiberglass; hinges and latch are stainless steel. Conduit couplings provided.
MVP-DAX1 PTRO Panel Ratings	120 VAC, 3/4 hp, 14 amps, single phase, 60 Hz.
MVP-DAX2 PTRO Panel Ratings	240 VAC, 2 hp, 14 amps, single phase, 60 Hz.

Optional Components

Feature	Specification(s)	Product Code Adder
Pump Run Lights	7/8" green lens. NEMA 4, 1 Watt bulb, 120 VAC.	PRL
Heater	Anti-condensation heater. Self-adjusting: radiates additional wattage as temperature drops.	HT
Intrinsically Safe Control Relays	120 VAC. Listed per UL 698A, for Class 1 Div. 1, Groups A, B, C, D hazardous locations. Larger enclosure required.	IR
Current Sensor	120 VAC. Go/no-go operation. Pump fail indicator light on panel. Manual reset switch.	CS

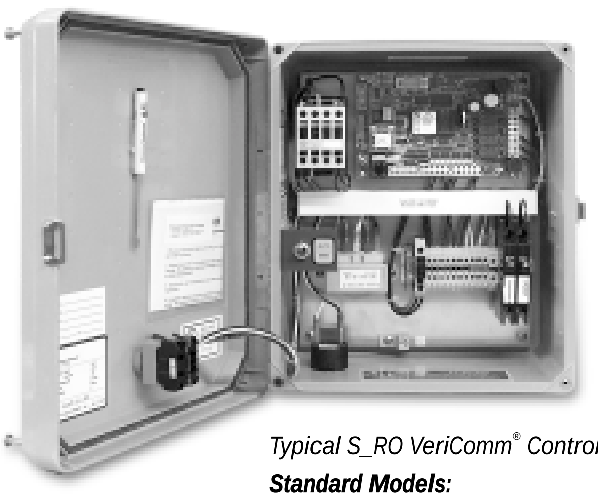
For On-Demand Applications

VeriComm® S_RO Control Panels

Technical Data Sheet

Applications

VeriComm S1RO and S2RO remote telemetry control panels are used with on-demand simplex pumping operations. Coupled with the VeriComm web-based Monitoring System, these affordable control panels give water/wastewater system operators and maintenance organizations the ability to monitor and control each individual system's performance remotely, with real-time efficiency, while remaining invisible to the homeowner.



Typical S_RO VeriComm® Control Panel

Standard Models:
VCOM S1RO, VCOM S2RO

To Specify...

To specify this panel for your installation, require the following:

Basic Control Logic: Three Operating Modes

- A "Start-up Mode" for the initial 30 days, during which the system collects trend data to establish operating standards for future reference.
- A "Normal Mode" that manages day-to-day functions.
- A "Test Mode" that suspends data collection and alarm reporting during installation and service.

Data Collection and Utilization

- Data logs of system conditions and events, such as pump run time, pump cycles, and alarm conditions.

Troubleshooting and Diagnostic Logic

- Troubleshooting capabilities that can report suspected failed components and/or negative trends in operating data, which then trigger Alarms.

Advanced Control Logic

- Advanced control logic that activates during float malfunctions to diagnose the situation and use pre-established trend data, if necessary, to keep the system operating normally until servicing.

Communication and Alarm Management

- Remote telemetry capabilities coupled with a web-based monitoring application (see *VeriComm Monitoring System*, ATD-WEB-VCOM-1) for communication and alarm management. Updating of point values and receipt of queued changes during each communication session with host. Communication sessions that occur monthly, at a minimum, and more frequently during alarm conditions.
- Multiple methods of communication, as follows:

  Call-In to VeriComm® Host

  – Automatic notification to host of "Alarms," which signal fault conditions that need to be addressed immediately (e.g., pump failure).

  – Automatic notification to host of "Alerts," which signal less critical fault conditions and which trigger the panel's troubleshooting logic and alternative operating mode (e.g., stuck float switch).

  – Automatic notification to host of "Updates," which include alarm updates or all-clear notifications following Alarms/Alerts, as well as normally scheduled monthly panel reports.

  – Manual, forced communication from panel to host to effect an updating of point values and receipt of queued changes.

  Real-Time Direct Connection to Panel

  – Manual, direct connection at the site via RS-232 serial port, to allow a local operator real-time access to detailed logged data and the ability to change point values from a laptop.

  – Manual, forced communication by local operator/homeowner at the site to initiate an auto-answer mode, allowing a remote operator real-time access to detailed logged data and the ability to change point values.

  During real-time, manual connections, software with open architecture (and password security) is used; no proprietary software is required. VT100 protocol allows access and control from any computer modem (Mac or PC) with a simple communication program (e.g., Windows® HyperTerminal); multilevel password protection in panel ensures that only qualified personnel can access the panel's data.

Additional Features

- Status light indicators on the board, including . . .
  – Flashing green LED for normal operation
  – Yellow LEDs for status of digital inputs
  – Red LEDs for status of digital outputs and modem activity
- UL-recognized and FCC-approved

For more information, try our online demo at www.vericomm.net (no password required).

Orenco Systems®
Incorporated

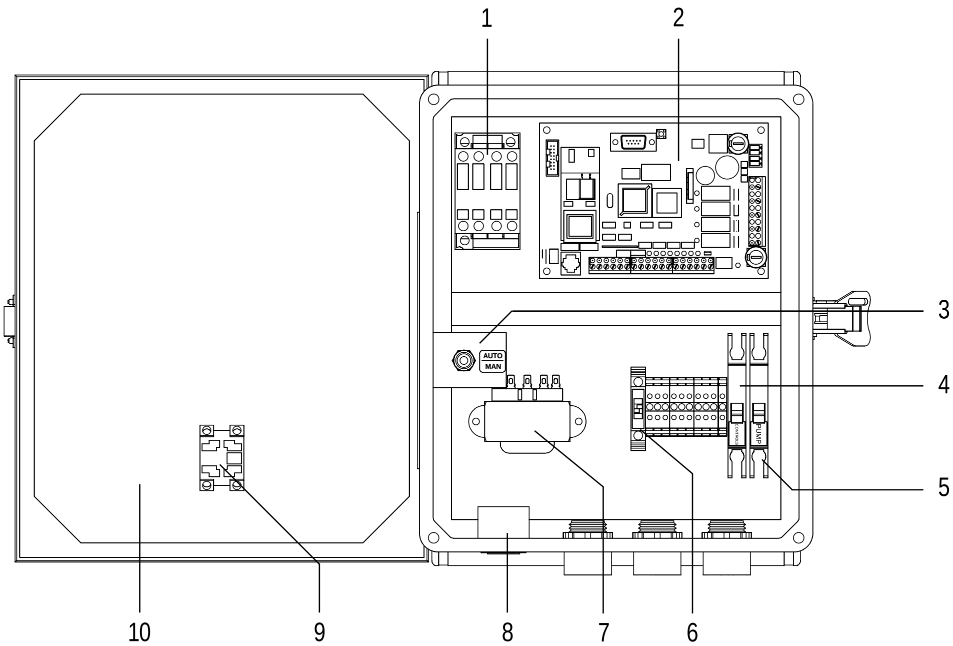
Changing the Way the World Does Wastewater®

www.orenco.com

ATD-CP-VCOM-4
Rev. 2.0 © 06/02

VeriComm® S_RO Control Panels

1. Motor-Start Contactor
2. VeriComm® Remote Telemetry Board
3. Toggle Switch
4. Control Circuit Breaker
5. Pump Circuit Breaker
6. Fuse
7. Transformer
8. Audio Alarm
9. Visual Alarm
10. Panel Enclosure



Standard Components

Feature	Specifications
1. Motor-Start Contactor	120 VAC: 14 FLA, 3/4 hp, 60 Hz; 2.5 million cycles at FLA (10 million at 50% of FLA). 240 VAC: 14 FLA, 2 hp, 60 Hz; 2.5 million cycles at FLA (10 million at 50% of FLA).
2. VeriComm® Remote Telemetry Unit*	ATRTU-100: 36/18 VAC (center tap transformer), 8 digital inputs, 4 analog inputs, 4 digital outputs, 0 analog outputs, on-board modem (2400 baud), LED input and output indicators, 1-year battery backup of data and program settings.
3. Toggle Switch	Single-pole switch, automatic On, with spring-loaded, momentary, manual On. 20 amps, 1 hp.
4. Control Circuit Breaker	10 amps, OFF/ON switch. Single-pole 120 VAC, double-pole 240 VAC. DIN rail mounting with thermal magnetic tripping characteristics.
5. Pump Circuit Breaker	20 amps, OFF/ON switch. Single-pole 120 VAC, double-pole 240 VAC. DIN rail mounting with thermal magnetic tripping characteristics.
6. Fuse	120 VAC Primary, 36 VCT @ 0.85A Secondary.
7. Transformer	250 VAC, 1A.
8. Audio Alarm	80 dB at 24”, warble-tone sound.
9. Visual Alarm	7/8” diameter red lens, “Push-to-silence.” NEMA 4, 1 Watt bulb, 120 VAC.
10. Panel Enclosure	Measures 13.51” high x 11.29” wide x 5.58” deep. NEMA 4X rated. Constructed of UV-resistant fiberglass; hinges and latch are stainless steel. Conduit couplings provided.
VCOM-S1 RO	120 VAC, 3/4 hp, 14 amps, single-phase, 60 Hz.
VCOM-S2 RO	240 VAC, 2 hp, 14 amps, single-phase, 60 Hz.

Optional Components

Feature	Specifications	Product Code Adder
Pump Run Light	7/8” diameter green lens. NEMA 4, 1 Watt bulb, 120 VAC.	PRL
Heater	Anticondensation heater. Self-adjusting: radiates additional Wattage as temperature drops.	HT

* *See VeriComm® Remote Telemetry Unit (ATD-CP-VCOM-1) and VeriComm® Monitoring System (ATD-WEB-VCOM-1) for more detail.*

Sand Filter Control Panels

Submittal Data Sheet

Orenco Systems® Incorporated
1-800-348-9843

Applications

Orenco Sand Filter Control Panels are used to control STEP (Septic Tank Effluent Pump) and sand filter pumps, alarms, and other equipment as specified in onsite septic systems.

General

Orenco Sand Filter Control Panels are specifically engineered for onsite septic treatment systems. Standard features include circuit breakers, automatic/manual/off toggle switches for each pump, automatic motor control operation, an audio/visual high level alarm, and automatic reset. Other standard features and options are listed on page 2. The design includes an automatic shutoff of the septic tank pump should a high water condition occur in the sand filter. Orenco Panels are designed for use with mechanical and/or mercury float switches. Listed per UL 508; a UL-Canada listing is available.

Standard Models

SSF1, SSF2

Nomenclature

SSF☐ ☐☐☐/☐☐☐

Indicates selected options (see page 2). Options listed before the slash are for septic tank pump; options listed after the slash are for the sand filter pump.

Indicates voltage
1 = 120 VAC
2 = 240 VAC

Specifications

Feature	Specification(s)
Panel Enclosure:	Measures 15.5" high x 13.3" wide x 6.7" deep. NEMA 4X rated. Constructed of UV resistant fiberglass; hinge and latch are stainless steel.
SSF1 Panel Ratings:	120 VAC, 3/4 hp, 14 amps, single phase, 60 Hz.
SSF2 Panel Ratings:	240 VAC, 2 hp, 14 amps, single phase, 60 Hz.

Sand Filter Control Panels (continued)

Standard Features

Feature	Specification(s)
Motor-Start Contactor	120 VAC: 14 FLA, 3/4 hp, 60 hz; 2.5 million cycles at FLA (10 million at 50% of FLA). 240 VAC: 14 FLA, 2 hp, 60 hz; 2.5 million cycles at FLA (10 million at 50% FLA).
Pump Circuit Breaker	20 amps, OFF/ON switch. Single pole 120 VAC, double pole 240 VAC. DIN rail mounting with thermal magnetic tripping characteristics.
Controls Circuit Breaker	10 amps, OFF/ON switch. Single pole 120V. DIN rail mounting with thermal magnetic tripping characteristics.
Toggle Switch	Single pole-double throw HOA switch rated at 20 amps.
Audio Alarm	95 dB at 24", warble-tone sound.
Audio Alarm Silence Relay	120 VAC, automatic reset. DIN rail mount.
Visual Alarm	7/8" diameter red lens, "Push-to-silence." NEMA 4X, 1 Watt bulb, 120 VAC.

Optional Features

Feature	Specification(s)	Product Code Adder
Intrinsically Safe Control Relays	120 VAC. Listed per UL 698A, for Class 1 Div. 1, groups A, B, C, D hazardous locations. Larger enclosure required.	IR
Programmable Timer	120 VAC, Repeat cycle from 0.05 seconds to 30 hours. Separate variable controls for OFF & ON time periods.	PT
Redundant Off Relay	120 VAC, provides a secondary off. Sounds alarm on low level condition. DIN rail mount.	RO
Heater	Anti-condensation heater. Self-adjusting: radiates additional wattage as temperature drops.	HT
Elapsed Time Meter	120 VAC, 7-digit, non-resettable. Limit of 99,999 hours; accurate to 0.01 hours.	ETM
Event Counter	120 VAC, 6-digit, non-resettable.	CT
Pump Run Light	7/8" green lens. NEMA 4X, 1 Watt bulb, 120 VAC.	PRL

MODEL TD Control Panel

Single phase, simplex timed dosing pump control.

The Model TD control panel provides a reliable means of controlling one single phase pump in onsite septic installations. A programmable timer activates a magnetic motor contactor to turn the pump on and off. A low level cutout float overrides the timer to prevent the pump from running dry. An alarm float activates the audio/visual alarm system indicating a high liquid level. Common applications include sand filter systems, pressure distribution systems, mound systems, or any application requiring a timed dose.

PANEL COMPONENTS

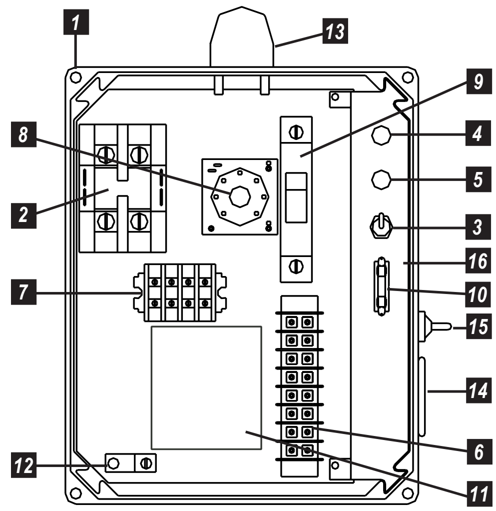
1. **Enclosure** measures 10 x 8 x 4 inches (25.40 x 20.32 x 10.16 cm) NEMA 4X (ultraviolet stabilized thermoplastic with removable flanges for outdoor or indoor use).
2. **Magnetic Motor Contactor** controls pump by switching electrical lines.
3. **HOA Switch** for manual pump control.
4. **Control Fuse**
5. **Alarm Fuse**
6. **Float Switch Terminal Block**
7. **Incoming Power Terminal Block**
8. **Programmable Timer** with separate variable controls allows for setting the on and off times from .05 seconds to 30 hours.
9. **Circuit Breaker** provides pump disconnect and branch circuit protection.
10. **Spare Fuse**
11. **Backplate Label** includes diagram of float, pump, and power connections.
12. **Ground Lug**

NOTE: Timer Installation Label and Pump/Float Switch Installation Specification Label are located inside the panel on enclosure cover.

STANDARD ALARM PACKAGE

13. **Red Alarm Beacon** provides 360° visual check of alarm condition.
14. **Alarm Horn** provides audio warning of alarm condition (83 to 85 decibel rating).
15. **Exterior Alarm Test/Normal/Silence Switch** allows horn and light to be tested and horn to be silenced in an alarm condition. Alarm automatically resets once alarm condition is cleared.
16. **Horn Silence Relay** (mounted under bracket).

NOTE: other options available.



Model Shown TD1W914X

FEATURES

- Entire control system (panel and switches) is UL Listed to meet and/ or exceed industry safety standards
- Dual safety certification for the United States and Canada
- Standard package includes one 20' SJE PumpMaster® pump switch and one 20' Sensor Float® control switch
- Complete with step-by-step installation instructions
- Three-year limited warranty

c UL us LISTED

SJE Rhombus® CONTROLS

PO Box 1708, Detroit Lakes, MN 56502
1-888-DIAL-SJE • 1-218-847-1317
1-218-847-4617 Fax
email: sje@sjerhombus.com
www.sjerhombus.com

SEE BACKSIDE FOR COMPLETE LISTING OF AVAILABLE OPTIONS.

TD		W			4		

MODEL TD

ALARM PACKAGE

☐ 0 = select option (If you select "0", you must select option 1F)

☐ 1 = alarm package (includes test/normal/silence switch, red beacon, horn)

ENCLOSURE RATING

✔ W = Weatherproof, NEMA 4X (engineered thermoplastic)

STARTING DEVICE

☐ 1 = magnetic motor contactor 120/208/240V

☐ 9 = magnetic motor contactor 120V only

PUMP FULL LOAD AMPS

☐ 0 = 0-7 FLA

☐ 1 = 7-15 FLA

☐ 2 = 15-20 FLA

PUMP DISCONNECTS

✔ 4 = circuit breaker

FLOAT SWITCH APPLICATION

☐ H = 20' low level cutout (20' SJE PumpMaster®, gray), high level alarm floats (20' Sensor Float® Mini, black)

☐ X = no floats

OPTIONS *Listed below*

If additional features are required, call the factory for a quote on either a SJE-Rhombus Pro-Line or Engineered Custom control panel system.

	CODE	DESCRIPTION
☐	1F	Door mounted alarm indicator with horn and test/normal/silence switch *(must select "0" as an alarm package)*
☐	4B	Redundant off, alarm activation, red indicator light *(must select option "4D" if floats included)*
☐	4D	Redundant off float (20' Sensor Float® Mini)
☐	4E	Redundant off float, alarm activation (20' SJE PumpMaster® SPDT)
☐	6A	Normally open dry auxiliary alarm contacts
☐	8A	Elapsed time meter
☐	8C	Event (cycle) counter
☐	10E	Lockable latch
☐	10K	Anti-condensation heater
☐	16A	10' cord in lieu of 20' *(per float)*
☐	16B	15' cord in lieu of 20' *(per float)*
☐	16C	30' cord in lieu of 20' *(per float)*
☐	16D	40' cord in lieu of 20' *(per float)*
☐	18A	Timer override float (20' SJE PumpMaster®)
☐	19X	Externally mounted pump run indicator
☐	21E	SJE PumpMaster® in lieu of Sensor Float® Mini *(per float)*

SAMPLE

MODEL	TD	1	W	9	1	4	H	4E 18A

Alarm Package — 1
Enclosure Rating — W
Starting Device — 9
Pump Full Load Amps — 1
Pump Disconnect — 4
Float Switch Application — H
Option: Redundant off float, Timer override float — 4E 18A

MODEL DTD Control Panel

Single phase, duplex timed dosing pump control.

The Model DTD control panel provides a reliable means of controlling two single phase 120, 208, or 240 VAC pumps in onsite septic installations. A programmable timer, in conjuction with an alternating circuit board, alternately activates the magnetic contactors to turn the pumps on and off and equalize pump wear. A low level cutout float overrides the timer to prevent the pump from running dry. An alarm float activates the audio/visual alarm system indicating a high liquid level. Common applications include sand filter systems, pressure distribution systems, mound systems, or any application requiring timed dose control.

PANEL COMPONENTS

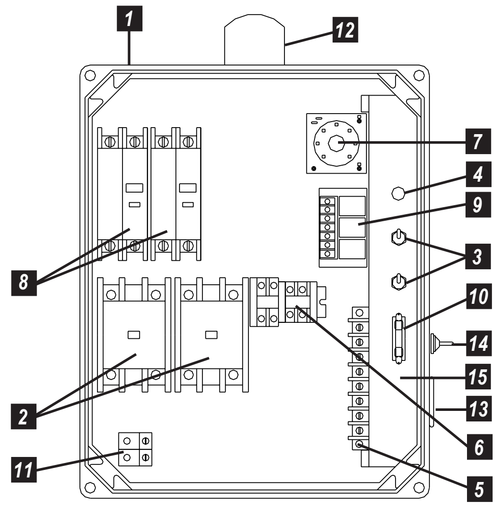
1. **Enclosure** measures 14 x 12 x 6 inches (35.56 x 30.48 x 15.24 cm); NEMA 4X (ultraviolet stabilized thermoplastic with removable flanges for outdoor or indoor use).
2. **Magnetic Motor Contactors** control pumps by switching electrical lines.
3. **HOA Switches** for manual pump control.
4. **Control/Alarm Fuse**
5. **Float Switch Terminal Block**
6. **Incoming Power Terminal Block**
7. **Programmable Timer** with separate variable controls allows for setting the on and off times from .05 seconds to 30 hours.
8. **Pump Circuit Breakers** provides pump disconnects and branch circuit protection.
9. **Alternating Circuit Board** provide pump control and alternation (U.S. Patent 5,909,352).
10. **Spare Fuse**
11. **Ground Lugs**

NOTE: Timer Installation Label, Field Wiring Diagram and Pump/Float Switch Installation Specification Label are located inside the panel on enclosure cover.

STANDARD ALARM PACKAGE

12. **Red Alarm Beacon** provides 360° visual check of alarm condition.
13. **Alarm Horn** provides audio warning of alarm condition (83 to 85 decibel rating).
14. **Exterior Alarm Test/Normal/Silence Switch** allows horn and light to be tested and horn to be silenced in an alarm condition. Alarm automatically resets once alarm condition is cleared.
15. **Horn Silence Relay** (mounted under bracket).

NOTE: other options available.



Model Shown DTD1W104X

FEATURES

- Entire control system (panel and switches) is UL Listed to meet and/ or exceed industry safety standards
- Dual safety certification for the United States and Canada
- Standard package includes one 20' SJE PumpMaster® pump switch and one 20' Sensor Float® control switch
- Complete with step-by-step installation instructions
- Three-year limited warranty

c UL us LISTED

SJE Rhombus® CONTROLS

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1-218-847-4617 Fax
email: sje@sjerhombus.com
www.sjerhombus.com

SEE BACKSIDE FOR COMPLETE LISTING OF AVAILABLE OPTIONS.

DTD		W			4		

MODEL DTD

ALARM PACKAGE

- ☐ 0 = select option (If you select "0", you must select option1F)
- ☐ 1 = alarm package (includes test/normal/silence switch, red beacon, horn)

ENCLOSURE RATING

- ✔ W = Weatherproof, NEMA 4X (engineered thermoplastic)

STARTING DEVICE

- ☐ 1 = magnetic motor contactor 120/208/240V
- ☐ 9 = magnetic motor contactor 120V only

PUMP FULL LOAD AMPS

- ☐ 0 = 0-7 FLA
- ☐ 1 = 7-15 FLA
- ☐ 2 = 15-20 FLA
- ☐ 3 = 20-30 FLA

PUMP DISCONNECTS

- ✔ 4 = circuit breaker

FLOAT SWITCH APPLICATION

- ☐ H = 20' low level cutout (20' SJE PumpMaster®, gray), high level alarm float (20' Sensor Float®, black)
- ☐ X = no floats

OPTIONS *Listed below*

If additional features are required, call the factory for a quote on either a SJE-Rhombus Pro-Line or Engineered Custom control panel system.

CODE	DESCRIPTION
1F	Door mounted alarm indicator with horn and test/normal/silence switch *(must select "0" for alarm package)*
4B	Redundant off, alarm activation, red indicator *(must select option 4D if floats included)*
4D	Redundant off float (20' Sensor Float®)
4E	Redundant off float, alarm activation (20' SJE PumpMaster® SPDT)
6A	Normally open dry auxiliary alarm contacts
8A	Elapsed time meters
8C	Event (cycle) counters

CODE	DESCRIPTION
10E	Lockable latches
10K	Anti-condensation heater
16A	10' cord in lieu of 20' *(per float)*
16B	15' cord in lieu of 20' *(per float)*
16C	30' cord in lieu of 20' *(per float)*
16D	40' cord in lieu of 20' *(per float)*
18A	Timer override float (20' SJE PumpMaster®)
19X	Externally mounted pump run indicators
21E	SJE PumpMaster® in lieu of Sensor Float® *(per float)*

SAMPLE

MODEL DTD 1 W 9 1 4 H 4E 18A

- **Alarm Package** — 1
- **Enclosure Rating** — W
- **Starting Device** — 9
- **Pump Full Load Amps** — 1
- **Pump Disconnect** — 4
- **Float Switch Application** — H
- **Option: Redundant off float, Timer override float** — 4E 18A

Program:
Municipal Water and Wastewater

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EPRI creates science and technology solutions for the global energy and energy services industry. U.S. electric utilities established the Electric Power Research Institute in 1973 as a nonprofit research consortium for the benefit of utility members, their customers, and society. Now known simply as EPRI, the company provides a wide range of innovative products and services to more than 1000 energy-related organizations in 40 countries. EPRI's multidisciplinary team of scientists and engineers draws on a worldwide network of technical and business expertise to help solve today's toughest energy and environmental problems.

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