Utah Guidance for Performance, Application, Design, Operation & Maintenance

Pressure Distribution Systems

Revised Draft

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Utah On-Site Wastewater Treatment Training Program
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Introduction

Gravity flow is a frequently used method for distributing effluent. It is also the simplest. It allows wastewater to flow by gravity through large diameter pipes into a subsurface soil absorption field. Distribution is usually localized in a few areas within the field, which results in overloading of the infiltrative surface in those areas until a mature biomat develops. The disadvantage of this method is that overloading can lead to groundwater contamination in coarse granular soils due to insufficient treatment, or to more rapid clogging in finer-textured soils.

Pressure distribution, on the other hand, is a method used to apply effluent *uniformly* over an entire absorption area. Each square foot of an infiltrative surface receives approximately the same amount per dose. The rate of distribution is less than the receiving capacity of the soil or media.

The advantage to pressure distribution is that in soil-based or alternative (mound, and packed bed) on-site systems, treatment performance is improved by maintaining vertical unsaturated flow. In finer-textured soils or media the degree of clogging is reduced.

Research evidence indicates that wastewater traveling vertically through 2 to 4 feet of suitable, unsaturated soil provides adequate treatment of the wastewater. Research also indicates that the method of distribution of septic tank effluent within the soil absorption field, mound, or packed bed system will affect the treatment performance of the system.

Pressure distribution is usually used in locations where it is either desirable or required to:

- **Achieve uniform application** of wastewater throughout a soil absorption field or on the infiltrative surface of pressurized alternative systems, including mound or packed bed systems
- **Treat and disperse** effluent higher in the soil profile
- **Improve the treatment performance** and **extend the life expectancy** of a soil absorption field, a mound, or a packed bed system

A pressure distribution system consists of:

- A **septic tank** to separate the major solid materials from the raw wastewater entering the tank
- A **screening device** to protect the pump and distribution lateral orifices from solids
- A **means to deliver specified doses** of effluent, under pressure, to the distribution system. The distribution system consists of small (typically 1 to 2 inches in diameter, based on hydraulic calculations) laterals with small discharge orifices. A pressure head is created within the laterals, usually by means of a pump

As regulated by Utah Administrative Code R317-4, pressure distribution is applicable to any system that uses soil as a treatment medium where pressure distribution may improve long-term performance of those systems.

Pressure distribution is a required component of alternative systems that include the mound system and packed bed systems. It is also appropriate for larger soil absorption and packed bed systems that are regulated by Utah Administrative Code R317-5.

1.0 System Components / Process Summary

Pressure distribution systems require the following basic components:

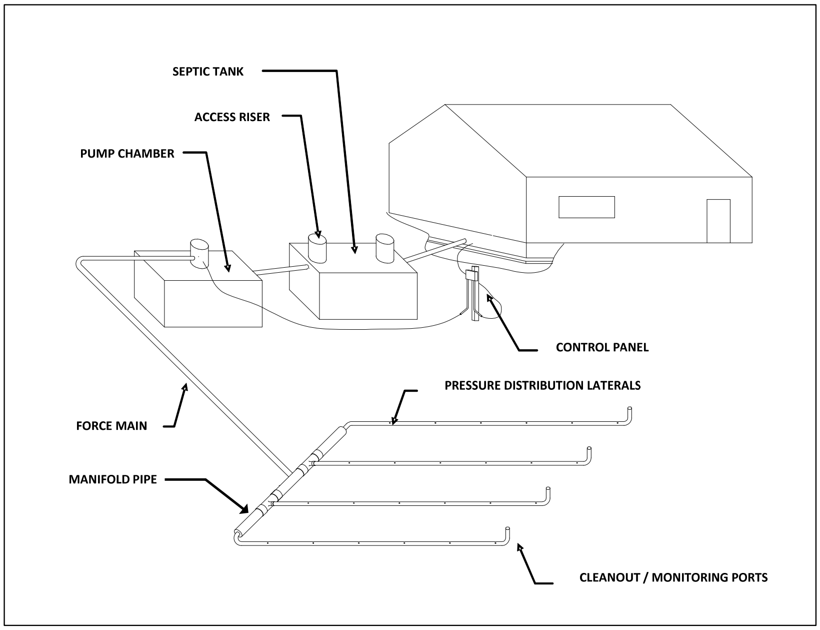

Figure 1: Major components of a typical pressure distribution system

Component:	Primary function:
Septic tank	Solids separation and storage.
Effluent filter	Protection of pump and distribution network orifices from solids.
Pump chamber	Transport of a specific volume of effluent from the pump chamber to the distribution network. Accumulate effluent between pump cycles and during malfunction.
Force main (transport pipe)	Pipeline that connects the pump to the manifold.

Component:	Primary function:
Manifold	Piping network connecting the force main to the various laterals.
Control Panel	NEMA-rated box containing all the controls for the pumping system, dose cycle counter, pump run time meter, and alarm controls.
Laterals	Small diameter pipes with orifices that distribute effluent over the infiltrative surface of an absorption area.
Absorption treatment area	Native soil or other receiving media where various biological and physical processes provide additional treatment of septic tank effluent; Consists of a soil absorption field or the infiltrative surface of a mound or packed bed system.

Table 1: Major components of a typical pressure distribution system

1.1. Septic Tank

A pressure distribution system must be preceded by a properly sized septic tank:

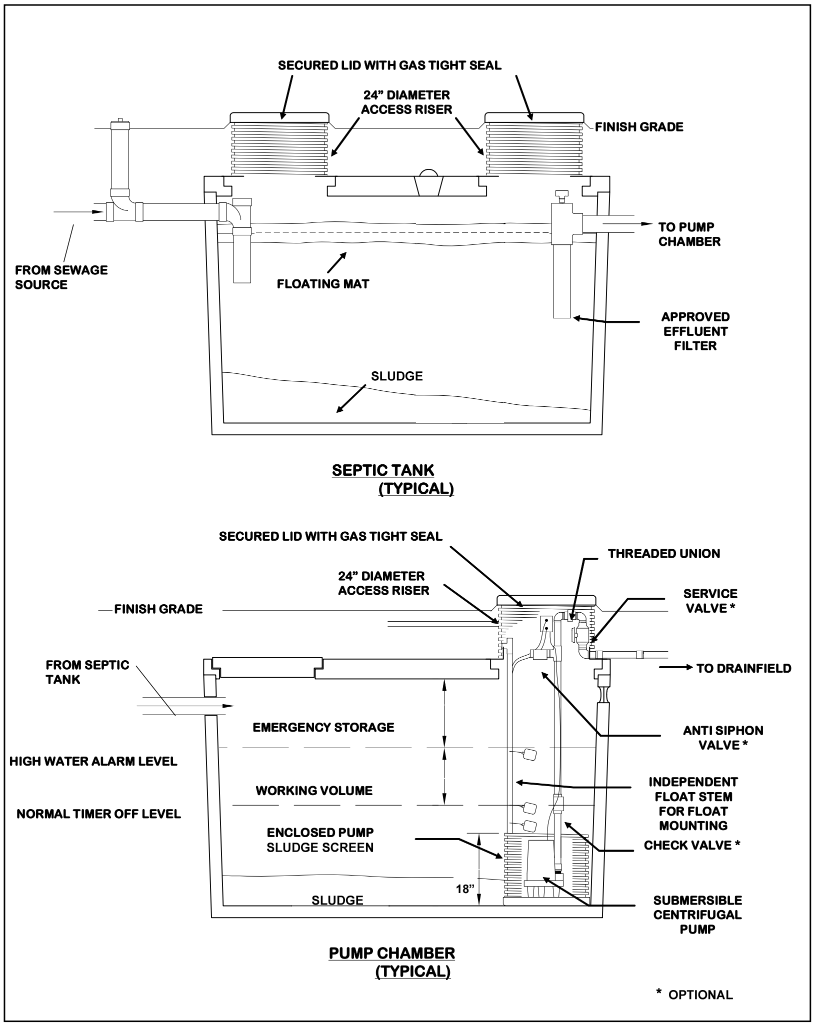

Figure 2: Typical septic tank and pump chamber

The septic tank must be designed in compliance with the guidelines given in Utah Administrative Code R317-4.

All septic tanks should:

Septic tank must:	Requirement:
Be tested for water tightness	Be water tight to a level above any possible seasonal ground water. Each tank must be tested for water tightness according to the procedures outlined in Utah Administrative Code R317-4.
Retain solids	Have functioning outlet baffle or tees. May include screening of the effluent with an effluent filter that is located in the septic tank or in a separate pump chamber. Screening around the pump in a pump vault can also be used to protect the pump; however also using an effluent filter in the septic tank can provide extra protection.
Be accessible	Have service access manholes and monitoring ports for the inlet and outlet.
Have water tight risers that meet requirements	Risers must be placed to facilitate pumping both sides of the tank. Multiple risers may be necessary. Covers must be gasketed and securely fastened by screws or some other lockable means. Risers must be constructed of durable, structurally sound materials and designed to withstand expected physical loads and corrosive forces. If soil cover is more than 24 inches, risers must extend to within 6 inches of the surface of the ground. The riser should preferably be brought up to the finished grade to encourage periodic servicing and maintenance.

Table 2: Septic tank requirements

Some or all of the following materials can be used to aid in achieving water tightness of the tanks:

Material:	Use:
Cast-in-place flexible rubber gaskets	Used for inlet and outlet openings with stainless steel clamps to seal the rubber to the pipes.
Flexible rubber gaskets	Seal to the inlet and outlet openings with a ratcheted expansion seal and stainless steel clamps.
Expanding grout material	Used to seal tanks and risers. Some grouts will shrink and crack over time and thus allow tanks to leak after the tank is backfilled.
Bentonite backfill	Used around the tank seams and pipe entrances to help provide a water tight tank.
Epoxy	Another effective method of sealing some kinds of joints, but the weather conditions must be ideal and there is no capacity for flex.
Rubber grommets	Used around smaller inlet and discharge pipes, conduit and junction box penetrations, can be effective in controlling leaks.

Table 3: Materials used for water tightness

1.2. Outlet Effluent Filter

An effluent filter or screen is a removable, cleanable device installed on the outlet piping of a septic tank for the purpose of retaining solids larger than a specific size (1/8 inch or greater) and/or modulating the effluent flow rate out of the tank.

The effluent filter should provide an open area flow capacity at least equal to the flow capacity provided by a 4-inch diameter PVC pipe. However, using the minimum area will very likely require a high frequency of cleaning. In standard practice a much larger flow area should be used. Larger flow areas will result in longer intervals between services for the same hydraulic and organic strength loadings.

An effluent filter is required in all pressure distribution systems.

The effluent filter should meet the following performance criteria:

Function:	Filter must:
Positioning	Draw liquid from the “clear zone” of the septic tank.
Durability	Be constructed of durable, non-corroding materials. Be securely fastened to prevent dislodging or misalignment.
Protection	Prevent discharge orifices from plugging by particles larger than the orifices. Protect the effluent pump from damage due to particles that exceed the pump’s capacity to pass (may be an issue with some types of pumps).
Service	Avoid loss of performance between routine service events. Should not require frequent routine servicing. Be designed, constructed and installed for easy and thorough cleaning. Have an access riser for cleaning over the septic tank opening above the effluent filter. The typical concrete riser and lid common on tanks that are buried below finished grade are not acceptable for extending to the surface. They are not water tight and will not keep odors and gases within the tank. Although concrete lids are heavy, they are not necessarily heavy enough to keep children out of a septic tank.

Table 4: Effluent filter performance requirements

1.3. Pump Tanks, Vaults, and Basins

Pump Tanks

A pump tank is a chamber used to house the pump, floats, and miscellaneous equipment required for the pumping system. Pump tanks receiving septic tank effluent will accumulate sludge and scum. The sludge level should not be allowed to accumulate to levels above the intake of the pump.

Pump tank must:	Requirement:
Be structurally sound	Be water tight to a level above any possible seasonal ground water. Leak testing is required. Be equipped with a water tight riser with a secured lid that extends to the ground surface. Lids must be equipped with an airtight gasket to eliminate nuisance odors and be secured from accidental or intentional removal by unauthorized persons, especially children.
Have sufficient internal volume of the pump chamber	Design must accommodate: The operating volume. Dead space below the pump inlet to provide for full time pump submergence and to ensure that the pump intake is above accumulated sludge levels. Emergency storage volume for periods of power outage, mechanical failure, or equipment malfunctions. This may be achieved by relying on the full volume of the septic tank and pump tank (up to the bottom of the lids), provided that the elevation of the top of the highest lid is below the lowest floor drain in the building served by the septic system to prevent backup into the building. Reductions in emergency pump chamber volume may be considered when "duplex" or redundant pumps are used. Time-dosed systems may require additional surge tank capacity. Surge volume may be a concern for time-dosed systems that may periodically experience higher influent flow rates into the pump tank than discharge flow rates from the pump tank. Failure to size the tank for surge flows could result in nuisance high level alarms, leading to the need to use shorter timer settings to accommodate periods of high flow. Using shorter time settings during surge flow conditions simulates a demand dosing configuration and limits the benefits of a timed-dosing system.

Table 5: Pump tank requirements

Pump Vaults

Pump vaults may be used to house the pumping equipment within a septic tank, a pump tank or a pump basin. A pump vault usually consists of either one (Simplex) or two (Duplex) pumps, discharge assembly(ies), filter or screens around the pump(s), a float switch assembly, and a float stem bracket.

Pump vault must:	Requirement:
Be accessible	The pump vault must be designed and constructed to facilitate removal and maintenance of the vault screen, pumps, and floats.
Have adequate volume	The minimum storage and pump working volumes in the septic tank must be equivalent to the volume required in a septic tank. The minimum volumes include: • Sufficient volume to handle the functions of a septic tank and to keep the pump submerged, when required • Additional reserve storage for emergency situations as appropriate for protection of public health and the environment.
Not interfere with the septic tank	If a pump vault is installed within a septic tank the vault must not interfere with the main function of the septic tank, which is to provide for the separation of scum and settleable solids. The use of two compartment septic tanks is recommended although not required when a pump vault is used. To prevent interference, the pump vault should be installed such that: • The entry point of the wastewater into the pump vault is at the level of the clarified effluent in the middle of the tank. The elevation of the pump vault is based on the tank dimensions and the maximum allowable levels of scum and sludge before the tank requires pumping • The liquid level changes caused by operation of the pump system are minimized to reduce the disturbance of the scum layer. This change will generally be less than two inches, but may vary depending on the specific tank dimensions • The amount of wastewater pumped out of the tank during each dosing event is equal to the required dose volume. When the influent flow rate temporarily exceeds the effluent flow rate during a 24 hour period, surge volume is required to accommodate these temporary high flow periods

Pump vault must:	Requirement:
	• Timer-based pump control systems may also require surge volume capacity in the tank • The pumping rate should always be less than 30 gallons per minute, and preferably less than 20 gallons per minute. If higher pumping rates are required, the pumping system should be installed in a separate pump tank after the septic tank and not in a pump vault in the septic tank • Reserve volume must be provided within the septic tank for emergency storage in the event of a power outage or mechanical failure. The reserve volume may be achieved by relying on the full volume of the septic tank (up to the bottom of the lid), provided that the elevation of the top of the lid is below the lowest floor drain in the building served by the septic tank, to ensure that backup into the building does not occur during emergency events • The pump vault must not interfere with the pumping of solids from the tank. If the pumping vault access riser is the same access riser used for pumping of solids and scum from the tank, the pump vault and the associated pumping equipment should be installed so that they can be easily removed when the tank is being pumped. Preferably the septic tank should have other access openings for solids removal.

Table 6: Pump vault requirements

Pump Basins

A pump basin is a separate pumping chamber located within a packed bed system or after a packed bed system. Because wastewater is time-dosed into a packed bed system, demand dosing from the pump basin after the packed bed system can be used because the amount of flow for pumping will be controlled by the timed-dosing of the effluent to the packed bed system.

A pump basin may also be used to lift effluent from a septic tank to a gravity-flow absorption field or to an at-grade system. Demand dosing may also be used in other situations, if the design is approved by the regulatory authority.

Pump basin issues:	Considerations:
Volume	A pump basin has little to no storage volume and must be used only in demand dosing.

Pump basin issues:	Considerations:
Off-line provisions	The designer must account for periods when the pump is off-line by considering corrective action response times and activities. If there will be a backup or overflow condition created during a power outage or a mechanical failure, and if the flows cannot be stopped or minimized until the problem is corrected, a pump basin with more storage volume should be used. However, if the facility generating the flows can be closed or other temporary arrangements made to reduce wastewater flow, or if a drinking water pump can also not be used during a power outage, then a pump basin with little emergency storage volume can be used.

Table 7: Pump basin design issues

1.4. Pumps, Dosing Options, Controls, Fittings, and Valves

Pumps

The effluent pumps used for pressurizing the distribution networks are either centrifugal effluent pumps or turbine effluent pumps, which are slightly modified well pumps. The centrifugal pump is a higher capacity/ lower head pump with a relatively flat performance curve and the turbine pump is a lower capacity/higher head pump with a relatively steep performance curve. Turbine pumps probably have a longer life. They may be the preferred choice for time dosing because of their longevity relative to stop/starts.

Pumps and pump installations must meet the following requirements:

Requirement:	Pump must:
Pump effectively	Be able to pump effluents containing solids up to 1/8 inch in diameter when following an effluent filter, and solids up to 1/2 inch in diameter when an effluent filter is not used. Be capable of meeting the minimum design hydraulic flow and head requirements of the proposed pressure distribution system. Pumps must be able to withstand the wet, corrosive environment found within the pump chamber, vault, or basin. Only pumps that are specified for use in wastewater should be used.

Requirement:	Pump must:
Be accessible	Pumps must be installed so that they can be easily removed and/or replaced from the ground surface. Under no circumstances should pump replacement and/or repair require service personnel to enter the pump tank. Pumps must be fitted with unions, valves, and electrical connections necessary for easy pump removal, servicing, and repair.
Have a protective filter	Pumps must be protected by an approved outlet effluent filter in the chamber preceding the pump chamber or by pump screens, as described in previous sections.
Comply with electrical requirements	Pumps and associated controls should have gas-tight junction boxes or splices and have electrical disconnects (as per National Electric Code) appropriate for the installation. The boxes should be placed so that they do not interfere with the servicing and/or removal of other components installed in the system. Pumps and electrical hook-ups must conform to all state and local electrical codes. Depending on the size of the system and/or location of the pumping equipment, specialized equipment for explosion may be required by fire codes. The appropriate regulatory authority will determine whether specialized equipment is required.

Table 8: Pump requirements

Pump Performance Curve

A pump performance curve is a graphical representation that describes the relationship between flow rate and head for a specific model of pump (Figure 3). The bottom axis is labeled “gallons per minute”, and the left side is labeled “total dynamic head”. These values are calculated in the Pressure Distribution Design Process (section 3.0 of this manual). The flow rate and total dynamic head needed to operate a specific pressurized distribution system is noted by a point on a specific pump performance curve that represents the combination of flow rate and head at which the system must perform. This point should be on the pump performance curve or just below the curve. If the point is about the curve, a different pump must be selected.

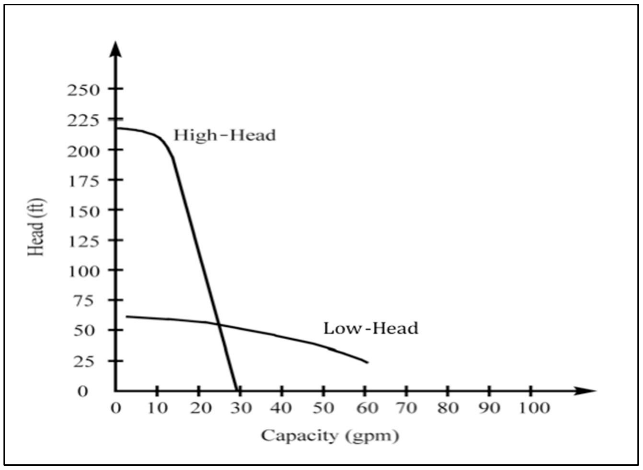

Figure 3: Examples of pump curves

Dosing Options

There are two different options for delivering doses of effluent to the receiving component of a pressurized distribution system: demand dosing and timed-dosing.

Demand Dosing

In demand dosing, the dose is delivered to the receiving component whenever a dose volume accumulates in the pump chamber. The effluent is not metered out uniformly over a 24-hour period.

Demand dosing is the least complex method of dosing and therefore least costly to install and easiest to understand.

Demand dosing is not sensitive to heavy use days and therefore will not activate the alarm circuit with weekend guests, large laundry days or parties.

Additionally, demand dosing does not protect the soil absorption field, mound or packed bed system from hydraulic surges and overload.

Effluent distribution is based on the pattern of water use in the particular system. For example, in residential systems, most of the effluent is distributed during the periods of household water use, that is, usually in morning, evening and weekend surges.

When demand dosing is used, the dose volumes should be minimized to provide smaller and more frequent doses to the system, with large doses avoided as much as possible.

Timed Dosing

In timed dosing, the effluent is metered to the receiving component in discrete, evenly spaced doses.

This method of dosing allows more frequent, smaller doses to be pumped to the receiving component, thereby promoting unsaturated flow through the soil or filter media while protecting the receiving component from hydraulic overload.

Timed dosing is strongly recommended on all pressure distribution systems, for this type of system enhances performance and reliability.

Timed dosing means that both the length of each dose (which determines the gallons per dose) and the interval between doses (which determines the number of doses per day) is controlled by a timing device whenever a dose volume is in the pump chamber.

The number of pump cycles should be adjustable and in sufficient number to meet the design needs of the system.

However, timed dosing is sensitive to heavy use days and therefore the high water alarm may be activated when the volume of wastewater exceeds the design flow. Some causes of excessive flow are weekend guests, large laundry days, parties, leaking fixtures, and ground water leaking into the septic tank or pump chamber.

With timed dosing, dose volumes pumped to the receiving component are often smaller and more frequent, with intervening resting and aeration periods, thereby assuring unsaturated flow through the soil or filter media. These smaller doses may require smaller orifices, smaller transport and lateral pipes, check valves, and orifices in the 12 o'clock position to maintain the system full of effluent between doses.

When timed-dosing is used, the timer settings should be set such that the system doses equal amounts of effluent evenly during the day by delivering 12 to 24 doses per day. Some systems may even be dosed 100 to 200 times in a 24-hour period, resulting in improved treatment performance. The timer settings should be set so that no more than the daily design flow is delivered to the infiltrative service during a 24-hour period.

Surge analysis is especially important when timed-dosing is used, that is, when many small doses are being applied over time. Enough surge volume is required to avoid high level alarms during the short duration, higher flows that are commonly observed in the mornings and evenings in residential applications.

Timed dosing is not required for pressure distribution soil absorption fields following treatment components that are timed-dosed. The flow is already time-dosed to the treatment component, and therefore the pump chamber after the treatment component may be demand-dosed.

Controls

For all pumping systems, the appropriate controls system must be specified. The controls system must have the proper functionality for the proposed design.

Requirement:	Controls system must:
Meet Code and safety requirements	Meet the applicable code requirements for the installed location. This may include NEMA 4, or NEMA 4X, or other standards depending on where the controls are mounted. Be Underwriters Laboratories (UL) listed or other accepted equivalent.
Functionality	Deliver prescribed doses uniformly to the orifices in the distribution network. Have controls located within sight of the pumping system. Where this is not possible, it may be necessary to provide electrical disconnects. The local electrical codes should be consulted for specific requirements. Have default settings for timed-dose controls to assure that the flows do not exceed the maximum design capacity without entering alarm condition. Record and store pump run times and number of pumping events using built in cycle counters and elapsed time meters. A water meter may also be used to track and record system flows. Should not be installed directly to the outside wall of the house or structure where the system may create nuisance complaints. The contact motor switching sound may transfer through the wall and create nuisance complaints. Noise can be reduced by mounting the controls on a post next to the wall of the structure or by installing the controls on the garage or non-bedroom walls.
Alarms	Provide an audible alarm. The audible alarm may have a silencing switch. Provide a visible alarm. This must continue to show until the condition is corrected. Provide a remote alarm in a conspicuous place for systems where the alarm condition may go undetected.

Requirement:	Controls system must:
	The alarm circuit must be independent of the pump circuit, including a separate breaker from the house supply. This is to ensure that an alarm sounds if the pump breaker or the breaker supplying power to the control panel is tripped. The designer must clearly specify this requirement in the design documentation and the inspectors must check for this separate alarm circuit.

Table 9: Controls system requirements

Fittings

Pipe fittings include the range of components that are used to connect pipe ends for in-line, multi-port, offset and mounting configurations.

Pipe fitting cross sections are mostly, but not always, circular in shape to match with the pipe section with which they are connected.

Pipe fittings are used for various purposes. They can be used to extend or terminate pipe runs, change a pipe's direction, to connect two or more pipes and to change the pipe size.

The amount of friction loss associated with fittings must be accounted for in the design of the pressure distribution system.

A discharge assembly is composed of all of the piping and fittings between the point of pump discharge to the point at which the force main exits the tank. The friction loss associated with the discharge assembly is a critical component of system design and must be accounted for in system design.

Valves

Valves are mechanical devices used to close off, regulate, or divert the flow of fluids, including liquids and gases.

Valve type:	Uses:
Check valve	A check allows flow in only one direction by closing when the flow direction reverses. Common uses of check valves in onsite systems are to keep the force main pipe from draining between doses, and in duplex pumping applications.

Valve type:	Uses:
	When the force main pipe is not allowed to drain, a check valve should be installed just above the pump in the discharge piping. This will increase the pumping efficiency, as all the effluent pumped will be discharged to the pumping chamber without returning a portion at the end of each cycle. In cold weather installations the force main pipe with a check valve must be installed below the frost depth or insulated to prevent freezing. Duplex pumping systems are often used or required on larger or non-residential applications to provide pump redundancy. Duplex pumps are usually connected into a single supply or force main pipe. Each pump must have a check valve installed so that when a pump is operational, the effluent does not discharge into the tank through the other pump. The check valve should be located as close to the pump as possible. When a duplex pump system is installed in a cold weather application with drain back, the drain back orifice must be located above the check valve so that the pipe can drain between dose cycles. A check valve will require maintenance and therefore should be installed so that it can be removed for servicing or replacement. Unions placed at the check valve are a common means to allow servicing of the check valves while avoiding destroying of the valve. Some check valves can be disassembled without removing them from the line. If possible, check valves should be installed such that they are accessible from the surface. The location of check valves must be well documented and marked. Preferably check valves should be located in a structure that is accessible from the surface.
Air/vacuum valve	Air/vacuum valves release air buildup within the pipe as well as let air into the pipe to prevent a siphon or vacuum condition. They are needed when pipes are installed to pump over a hill and back down the other side to an open discharge point. There are multiple options for location of the air/vacuum valve. It is often installed at the high point of the system. However, in smaller residential systems, it can be installed in the discharge assembly within the pump access riser. The air/vacuum valve will open and allow air to enter the system under a vacuum condition created when the effluent drains down the backside of the hill, releasing the vacuum within the pipe. The opening of the valve will also stop the vacuum from siphoning effluent from the pump tank.

Valve type:	Uses:
	For larger systems, the air/vacuum valve should be installed at the high point of the pipe system. For installations where the elevation drop from the high point to the low point is significant, the vacuum within the pipe could result in collapse of the pipe without an air/vacuum valve. When this is a concern, the designer should specify that the valve must be located at the high point and not in the discharge tank.
Air release valve	Air release valves only let air buildup out of the pipe. They are used where there is a high point in the piping that can accumulate air and gas buildup. The air release valve is a simpler valve than the air/vacuum combination valve. When the downhill side of the piping system will remain full and there is no risk of draining that would create a vacuum within the pipe, an air release valve is adequate to release any buildup of air within the pipe.
Vacuum release valve	Vacuum release valves only allow air into the pipe, and while under pressure they are closed. They are used most often in drip dispersal systems to immediately release the vacuum after the pump shuts off. They are installed at the high point of the system. Vacuum release valves open when the pump shut offs, releasing vacuum and decreasing potential for pulling soil into the tubing.

Table 10: Types of valves and their uses

1.5. Floats (or Other Types of Liquid Sensors)

A float is a sensor installed in a pump vault, chamber, or basin that opens or closes an electrical circuit in response to changing liquid levels, thereby controlling equipment operation.

Floats installed in a pumping system should not be installed on the pump discharge piping. They should be installed on a separate pipe or mechanism (for example, a float tree, which is a removable device located within a pump vault or pump tank to which floats are attached) so that they can be easily removed for servicing, adjustment, and maintenance without removing the pump.

The minimum requirements for timed pump cycle controls are a timer actuator float for the pump and a high liquid level alarm.

In addition, a low liquid level off float is highly recommended.

For pump chambers serving single-family residences, the necessary floats or liquid level sensors are to actuate and turn off the pump control system, and a high water alarm float.

Redundant “off” controls are optional, but are highly recommended and may be required by the regulatory authority.

Commercial and multi-family applications may require redundant “off” and special ratings on installed motors and equipment.

1.6. Force Main

The force main (main transport pipe) must be sized based on hydraulic calculations for flow (gallons per minute) and total head (in feet) for the proposed layout.

Where potential for freezing exists, the line must be buried below the frost depth, insulated, or installed with drain back orifices such that the water does not remain in the pipe between doses.

When the drain back option is used, the smallest acceptable diameter of pipe should be selected to increase the pumping efficiency and minimize unnecessary pumping of effluent.

Whenever a pump is used to pump effluent to an elevation lower than the pump, pump fittings, or force main, an air/vacuum release or similar anti-siphon device must be installed to prevent siphoning.

1.7. Manifold

The primary function of the manifold is to deliver equal flow to all laterals while minimizing system friction losses.

The most common configurations are the center and the end manifolds.

End manifolds may be used when the system utilizes short laterals, but center manifolds allow for use of smaller lateral pipe sizes.

The laterals may be connected to the manifold in several ways. Manifold to lateral connection must be appropriate for the site conditions and the specific use.

Manifold designs for sloping sites are particularly critical. Laterals at different elevations will have different residual pressures, with the lowest lateral having the highest residual. In addition, if the manifold is not designed correctly, the lowest lateral will receive pressure before the top lateral and system backflow will continue to the lower laterals after the pumping cycle has ended. In this instance, the lowest trench will receive more flow than the others, with the potential for overload. While there may be several solutions to these problems, Figures 4A and 4B illustrate two methods for resolving them. The check valves and flow control valves shown in Figures 7A and 7B are assumed to be an integral part of the manifold.

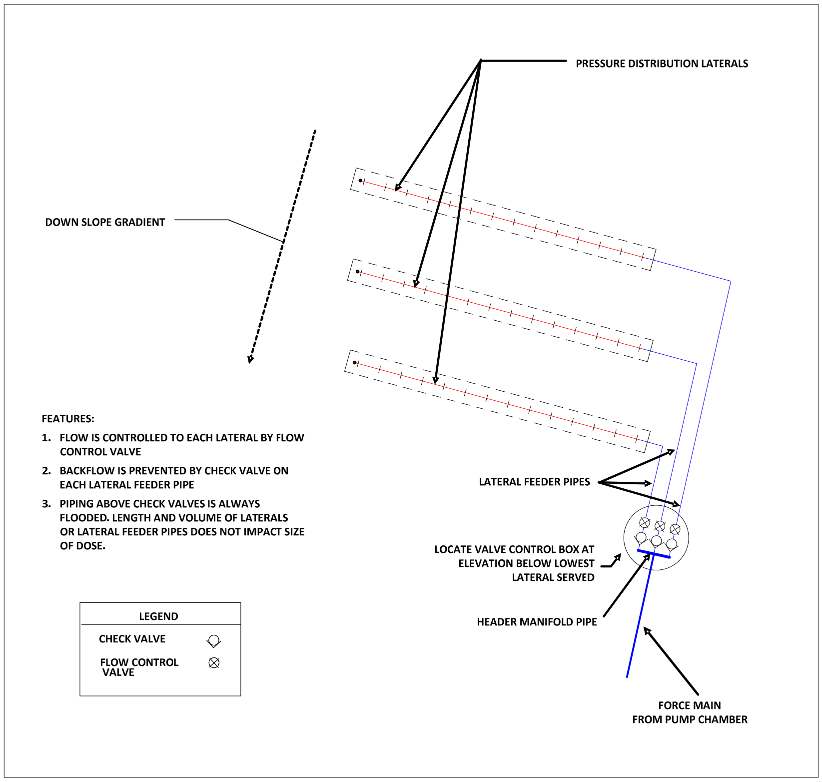

Figure 4A: Pressure distribution drainfield (sloping ground)

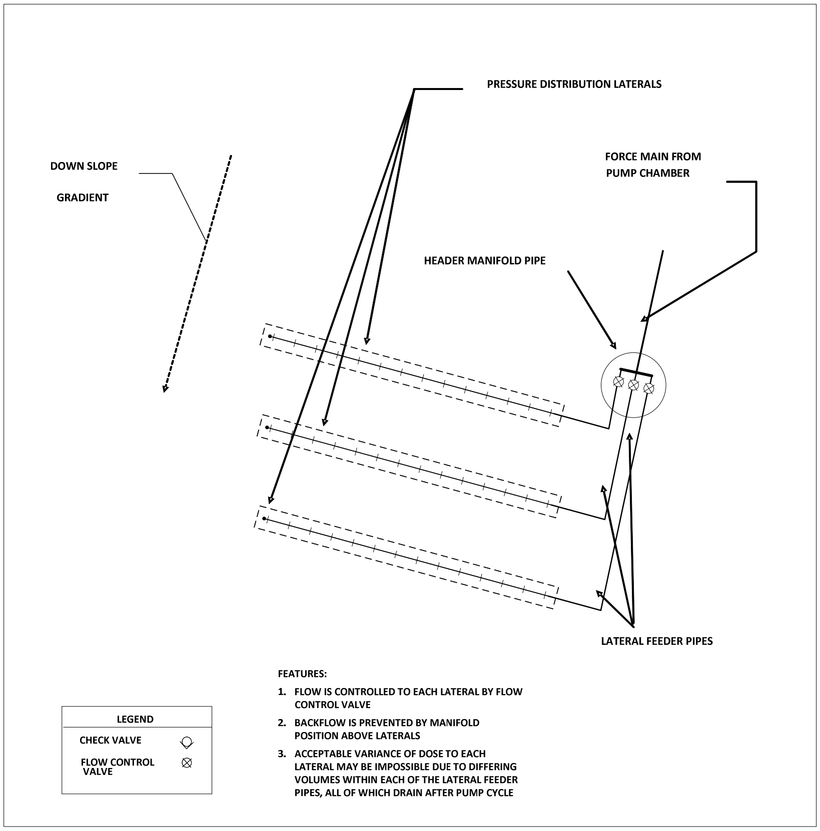

Figure 4B: Pressure distribution drainfield (sloping ground)

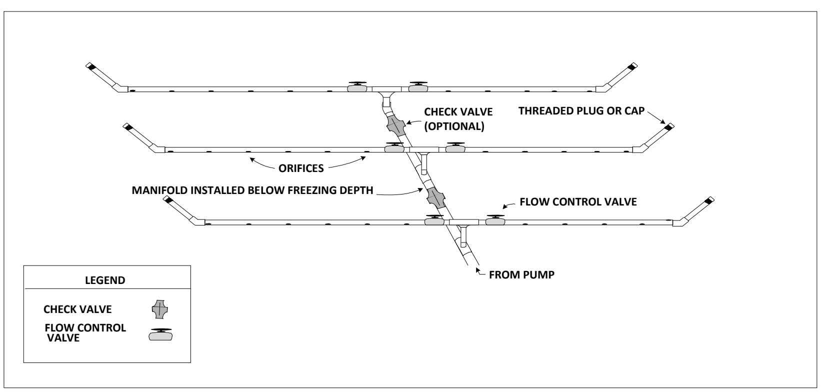

Figure 5: Pressure drainfield tee to tee

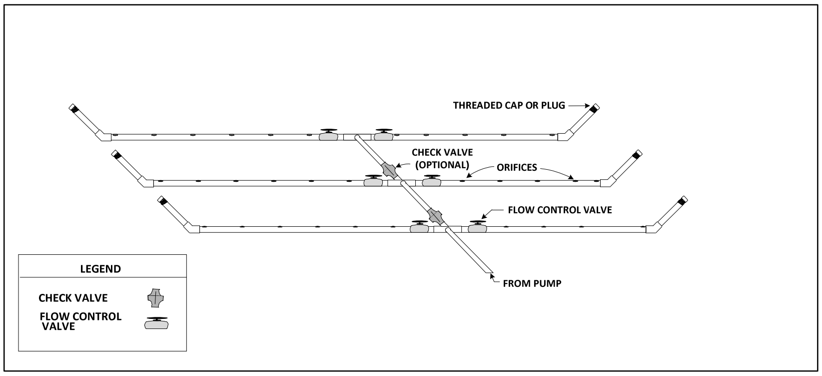

Figure 6: Pressure drainfield cross construction

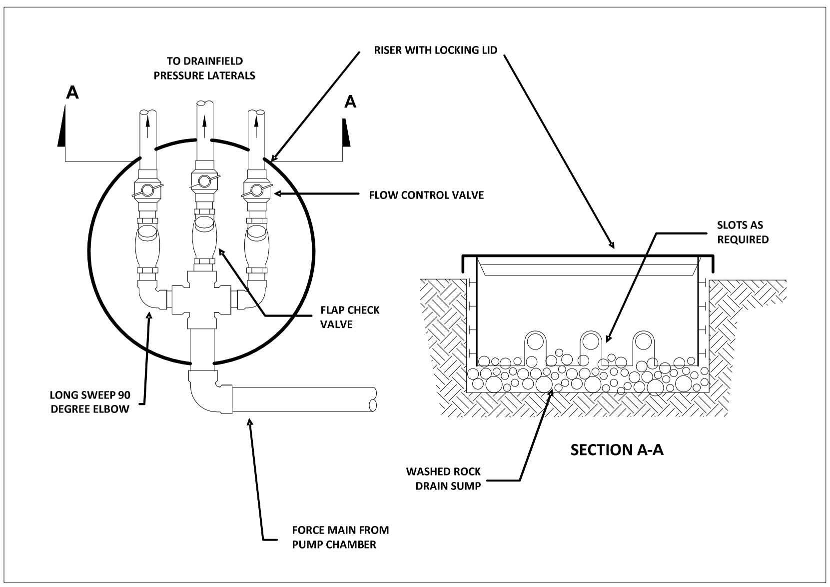

Figure 7A: Drainfield control box (sloping ground, manifold below laterals)

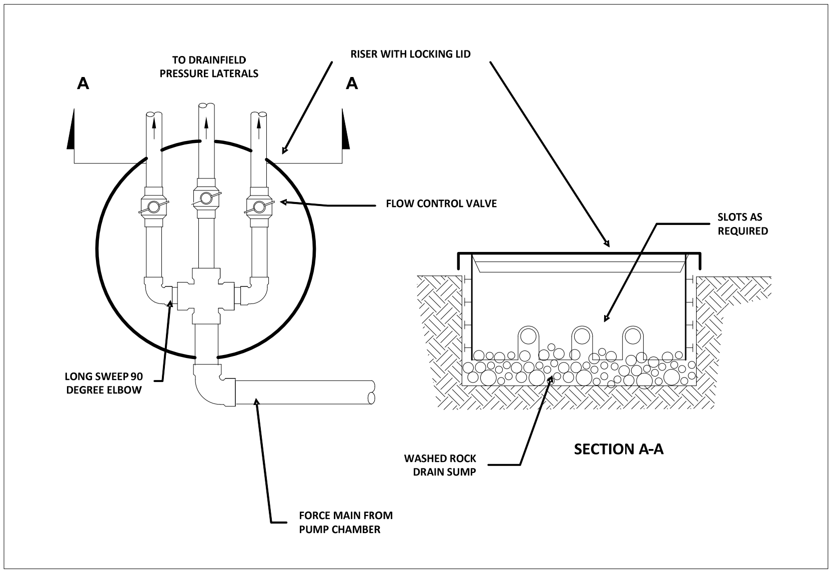

Figure 7B: Drainfield control box (sloping ground, manifold above laterals)

Examples of possible manifold configurations are given below. Other configurations than those described may also be used.

Configuration:	Uses:
Header manifold with check valves	A header manifold is positioned at an elevation below the laterals (Figure 4A), with check valves, flow control valves and feeder lines to each lateral. This configuration will maintain the manifold, feeder lines and laterals full between doses, will not allow drain back, and can be adjusted at one location to equalize residual head in all laterals. This arrangement can deliver small volumes per dose, allowing many doses per day, if desired. Caution should be taken to minimize the potential for effluent freezing in the laterals and manifold.

<table>
<tr><th>Configuration:</th><th>Uses:</th></tr>
<tr><td>Header manifold without check valves</td><td>A header manifold is placed at an elevation above the laterals (Figure 4B) without check valves, with flow control valves and feeder lines to each lateral.

The measured flows from an orifice in each lateral are nearly equal without the use of check valves and without maintaining the system full between doses.</td></tr>
<tr><td>Tee-to-tee with manifold below</td><td>Tee-to-Tee with manifold below (Figure 5) - When freezing and sloping site conditions are not a concern, this method of construction can be used to allow a very rapid pressurization of the system, especially if the transport line remains full between doses.

When check valves are used in the manifold just downstream of each lateral, the manifold (and laterals too, when orifices are in the 12 o'clock position) stays full of effluent between doses.

With this layout:

• There is no drain back from the upper laterals and manifold into the lower lateral

• The system is completely charged within just a second or two after the pump is turned on

• The system can be dosed with very small volumes per dose.</td></tr>
<tr><td>Cross construction</td><td>Cross construction (Figure 6) - If the lateral orifices are drilled in the 6 o'clock position, this design will allow the laterals and a portion of the manifold to drain between doses, assuming the transport line remains full between doses.</td></tr>
</table>

Configuration:	Uses:
Tee-to-tee with manifold above	If the lateral orifices are drilled in the 6 o'clock position, the entire distribution network will drain after each dose. This may be desirable on a sloping site (where check valves are not installed in the manifold), to prevent upper laterals from draining back through the manifold to the lowermost laterals, thereby overloading them. If the orifices are drilled in the 12 o'clock position, the laterals will remain full between doses. This may be desirable when the objective is to pressurize the distribution network quickly without the use of check valves. Caution should be taken to minimize the potential for effluent freezing in the laterals.

Table 11: Possible manifold configurations

1.8. Laterals

Laterals are perforated pipes used to deliver effluent equally over the infiltrative surface of the pressure distribution system.

Lateral Spacing

Uniform distribution of effluent is accomplished through lateral spacing and orifice spacing. The following minimum spacing of orifices and laterals is recommended:

1 orifice/6 sq. ft. - Mounds

1 orifice/4 sq. ft. - Intermittent sand filter

1 orifice/4 sq. ft. or less - Recirculating sand filter, Recirculating gravel filter, Textile filter

Closer orifice spacing should be considered for use when small doses are specified and where the infiltrative surface is in highly structured soils or has large macropores.

For pressurized drain fields, each trench will usually have a single lateral. In this case, it is recommended that the orifices be as close to each other as is practical, preferably one orifice every 2 to 4 feet, on center.

Orifice spacing is also used to determine the maximum spacing between the outside laterals and the edge of the trench or bed, which is 1/2 of the selected orifice spacing, ±0.5 feet.

Lateral Orifices

Orifices (holes in the laterals of a specified diameter) are a critical element of a successful pressurized distribution system. They are used to deliver equal amounts of effluent over a given area.

Care must be given to how the orifices are drilled in the pipe. Even with a good design, use of a dull drill bit and a sloppy process for drilling the holes can lead to a failed inspection by the regulatory authority or unequal distribution of effluent through the system.

Orifices should be drilled in a manufacturing setting so that the holes are lined up correctly and are clean and free from debris. Additionally, the orifices must be drilled with a properly sized, sharp drill bit. Accurate hole diameters may also require the use of jigs or other drill stabilizing tools to prevent wobble and to drill the hole perpendicular to the pipe. Proper layout and control will ensure that the correct numbers of orifices are actually drilled in each lateral.

Orifices can be drilled in the top of the pipe (12 o'clock position) or in the bottom of the pipe (6 o’clock position).

Orifice position:	Considerations:
12 o’clock up position	Orifices drilled in the 12 o’clock position will maintain the laterals full or partially full and therefore reduce the amount of effluent needed to pressurize the system. Maintaining effluent in the lines will promote biological growth, which may accelerate clogging of the orifices and buildup of sludge and slime in the lines. It also makes the laterals subject to freezing in areas where this is a concern. The laterals may be drained by putting a few orifices in the 6 o’clock position, or by designing the systems such that the force main and laterals drain back to the surge tank. However, these practices will increase the dose volume required. When using gravelless chambers with pressure distribution, the orifices must be oriented in the 12 o’clock position. If one or two orifices are placed in the 6 o’clock position to facilitate draining after each pump cycle (to prevent freezing in areas of the state where that may occur or to prevent build-up of microbial growth inside the laterals), they must have some mechanism to break the flow (an orifice shield that drains, a pad of gravel, etc.).

Orifice position:	Considerations:
6 o'clock down position	When some or all of the orifices are in the 6 o'clock, or "down" position, the laterals will drain between dose cycles, thus retarding biological growth and reducing freeze up potential. Although systems with some or all of the orifices in the "down" position may be less prone to clogging, they also will require a larger dose volume to pressurize the system, due to laterals draining between pump cycles.

Table 12: Lateral orifice positions

Lateral Orifice Diameters

In general, smaller orifices are preferred for onsite systems.

The minimum orifice diameter is 1/8 inch. Larger orifices may be used, but caution should be used when designing systems with larger orifices. They will increase flow rates, thus requiring the use of larger pipes and larger pumps. Larger pipes and pumps increase the initial cost of the system and result in systems that are more expensive to operate.

The following orifice diameters are suggested:

Orifice diameter:	Uses:
1/8 inch	Used in all alternative systems & pressurized trenches
5/32 inch	Typically used in pressurized trenches
3/16 inch	Used in mounds or pressurized trenches
1/4 inch	Can be used in mounds (but generally not recommended for use)

Table 13: Lateral orifice diameters

Residual Pressure (Head) Requirements

Residual pressures are determined by measuring squirt height, that is, the height achieved by the liquid in a pressurized lateral when an orifice is positioned such that the discharge is vertical into the atmosphere, typically expressed in feet of height.

The following residual pressures are recommended, based on orifice diameters:

Orifice diameter:	Residual pressure:
1/8 inch	3 to 5 ft
5/32 inch	2 to 4 ft
3/16 inch	2 to 3.5 ft
1/4 inch	2 to 2.5 ft

Table 14: Residual pressure (head)

Lateral Orifice Flow Rate

The actual flow rate from each orifice is represented by the equation:

$Q_o = 11.79\ d^2\ h^{0.5}$

where:

Q_o is the orifice flow in gallons per minute

d is the orifice diameter in inches

h is the discharge head in feet (also called residual pressure or head)

There are other factors that affect accurate calculation of the orifice flow rate, such as accurate drilling of holes, class of pipe, size of pipe, and slight variations in the friction coefficients used for fittings.

The choice of coefficient to use in a design can vary, depending on the experience of the designer in being able to predict accurately and control for the friction losses and other variables of construction and manufacture. The two most common coefficients used are 11.79 and 12.38.

For many designs, experience has shown that use of a slightly higher coefficient in the equation more accurately predicts the actual flow.

For whichever coefficient is selected, it is critically important that the same coefficient be used throughout the design.

Examples of orifice flow rates in gallons per minute (gpm), using 11.79 as the coefficient, include:

Orifice diameter:	Squirt:	Flow rate:
1/8 inch	5 ft	0.41 gpm
5/32 inch	3.5 ft	0.54 gpm
3/16 inch	3.5 ft	0.78 gpm
1/4 inch	2.5 ft	1.17 gpm

Table 15: Flow rate calculations

Lateral Orifice Shields

Orifice shields are devices used to protect orifices from external blockages and to deflect the squirt over a wider surface area, thus spreading the effluent over more of the infiltrative surface.

The use of shields is recommended, even when the system is installed in gravel, and especially when orifices are oriented in the 12 o-clock position. The shields must be strong enough to withstand the weight of the backfill and large enough to protect the orifice from being plugged by pieces of gravel.

Orifice shields may be the half pipe design, the local cap type, or another design that accomplishes the same end result (Figure 8).

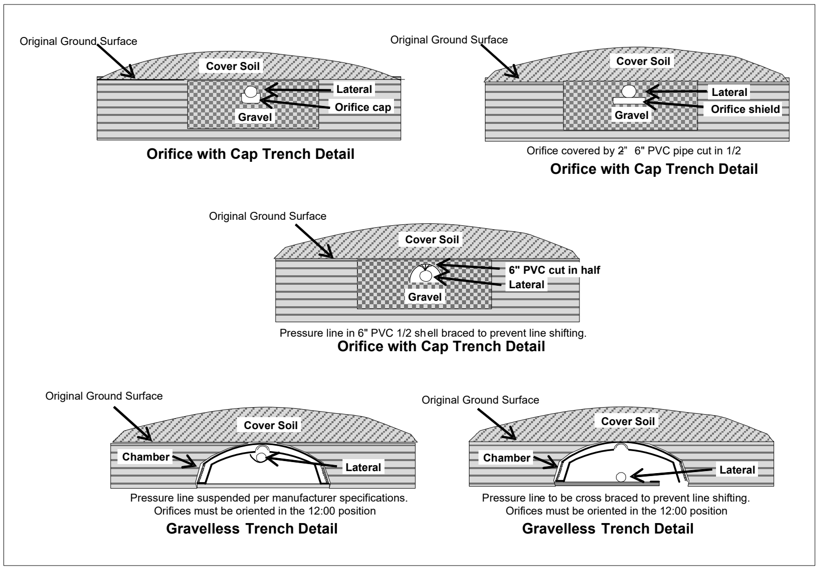

Figure 8: Orifice caps and shields

Cleanout and Monitoring of Laterals

All laterals must have access for cleanouts and monitoring ports to the lateral ends from the ground surface, such as through a small landscaping box (Figures 9A and 9B). Designs must include details of monitoring and cleanout ports and explain how they accomplish the respective tasks.

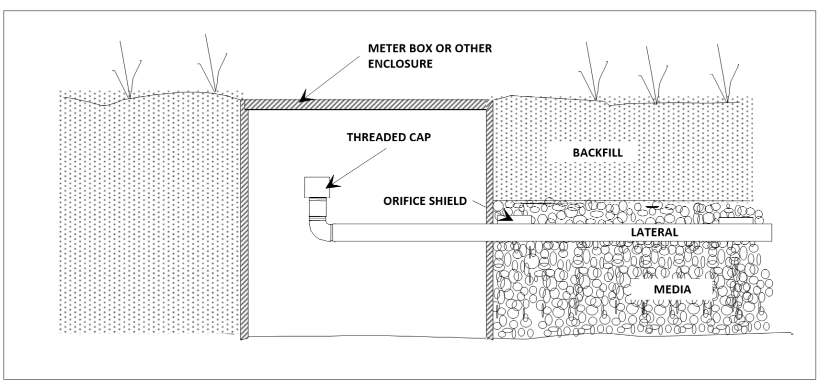

Figure 9A: Cleanout port

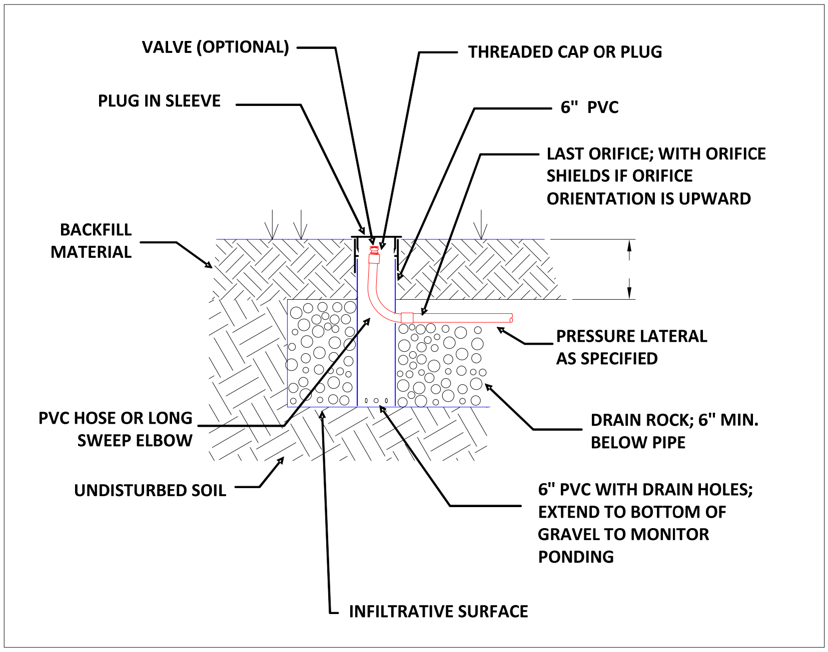

Figure 9B: Cleanout port (example)

Components:	Considerations for cleanout and monitoring:
Lateral access	Some local health departments have specific requirements for lateral access. The designer should consult with the local permitting authority and specify the appropriate fittings in the design. The access box should be large enough to allow access to caps, plugs, or valves with hands, tools, etc.
Wide swing fittings	Laterals must have wide swing fittings towards the surface for the installations of a pipe brush or other maintenance tools. The use of two 45-degree elbows or wide sweeping 90-degree elbows at the lateral ends is recommended.
Plug or cap	The ends must have a plug or cap that is easily removed for maintenance and for monitoring lateral residual pressure (squirt height).

Components:	Considerations for cleanout and monitoring:
Monitoring ports	Monitoring ports should be open and slotted at the bottom and be void of gravel to the infiltrative surface to allow visual monitoring of possible standing water on the infiltrative surface.
Shut off valve	A shut off valve is often installed at the lateral ends. In some cases, there may also be a shut off valve located at the beginning of the laterals. This may be done in the individual trench or in a valve box. The benefit of installing the valves on the inlet side of the laterals is to facilitate maintenance and troubleshooting and to assist in controlling flows on sloping sites. They do increase the overall cost of the system and are not mandatory.

Table 16: Cleanout and monitoring of laterals

2.0 Pressure Distribution Design for Special Conditions

Special care must be taken when designing pressure distribution systems for use under freezing conditions or on sloping sites.

2.1. Freezing Conditions

Many locations in Utah have freezing conditions during the winter months. Depending on the specific location, the frost depth can range from a few inches to several feet. Traffic areas and areas that are clear of snow will have deeper frost depths than areas with good snow cover.

All designs installed in freezing conditions require proper design and engineering to ensure that the system does not freeze. The following recommendations are provided as a guide to assist the designer.

Recommendation:	Considerations:
Avoid standing water	One of the best protections against freezing is designing the system so that it does not hold standing water for prolonged periods of time. This is usually accomplished with drain back holes in pipe in the pumping tank. The piping system should be installed with the appropriate slope back to the pump tank and adequate bedding to prevent sagging of the pipe, which could result in effluent accumulating and freezing in the area of sagging. The orifices in the laterals should also be installed for drainage after each dose. For systems with the orifices installed pointing downward, drainage should occur naturally. Orifice shields should be used to keep the orifices clear and free to drain after each dose event. Laterals may be installed with orifices pointing upward (12 o'clock position) provided that there are several orifices pointing downward (6 o'clock position). Depending on the size of the system, adequate drainage may be accomplished with the first, middle and last orifice pointed downward. Longer laterals may require more downward pointing orifices to ensure drainage after each cycle.
Install below frost depth	Deeper burial is especially recommended for systems that have a long force main or for systems with larger pipe diameters that require more volume of water to fill the system.

Recommendation:	Considerations:
Insulate	Piping that is installed within the frost depth and that may retain water must be insulated. Insulation must be adequate for the appropriate frost depth. Where rigid insulation board is to be used above an installed pipe, it must extend beyond each side to protect the pipe from freezing.
Manifold position	Installing the manifold at the high point in the system may also be helpful in cold weather installations. This configuration will allow effluent in the transport pipe and some of the effluent in the manifold to drain back to the pump tank. The remaining water in the manifold and the laterals would then drain into the receiving system. This design can be accomplished with the use of vertically mounted tees in the manifold and lateral piping. With systems that are very shallow, within the frost depth, such as a shallow drip dispersal system, the manifold should be installed below the drip tubing at a deeper depth to protect against freezing.
Heating	Although a heating system (heat tape, light bulbs, etc.) may be designed to maintain temperature along the pipes, this design is usually not recommended.

Table 17: Recommendations for freezing conditions

2.2. Sloping Sites

Sloping sites can be challenging for both gravity and pressurized distribution systems. One of the main concerns is making sure that the sloping site receives equal amounts of effluent throughout the absorption area. Specifically, lower areas should not receive more effluent than the upper areas, resulting in overloading or surfacing of effluent.

One of the most common methods for dosing multiple trenches on sloping sites is the drop box method of serial distribution. With serial distribution, the upper trench reaches a saturated condition before overflowing to the lower trenches. With pumping to the high point of the system, a simple manifold or splitter mechanism can be installed that will equally split the flow into equal volumes that can be directed to the individual trenches.

If a pump is required to lift the effluent to the higher elevation of the absorption trenches, the pumping system could also be used to pressurize the entire distribution system of laterals. Research has shown that equal distribution over the entire infiltrative area promotes improved performance of the system, a longer life of the system, and better treatment of the effluent.

Where pressurized trenches are installed on a sloping site, the system must be sized to lift the effluent to the highest point and meet the required squirt height. When laterals are installed at varying elevations, the lower trenches may discharge effluent at higher flow rates, and depending on the difference in elevation, the lower trenches can be easily overloaded.

There are several methods for adjusting distribution of effluent to the different elevations of laterals.

- Valves at the beginning of the laterals may be used, with gate valves less likely to change due to system cycling
- Pipe diameters may be adjusted to equalize flows at the different elevations
- Flow control discs may also be used. However, it may be difficult to calculate the correct size of orifices for the discs to ensure that equal distribution between trenches occurs. Additionally, construction changes in elevation will require recalculation of the flow control disc orifice sizes
- Delivering the effluent to the high point of the system (Figure 4B) will minimize overloading of the trenches because the effluent from the upper trenches cannot drain to the lower trenches.

3.0 Pressure Distribution Design Process

The pressurized distribution system must be sized appropriately for the design flows of the system.

Critical design flows that will affect the appropriate design for a particular system include the daily design flow and the operational design flow. Operational design flows are a function of the proposed distribution system. There are many correct design approaches for a particular situation, provided that some simple design steps are followed.

Overall, the design flow and the total dynamic head are calculated and used to design the critical components of a pressurized distribution system. The design flow is the estimated volume of wastewater per unit of time for which the system is designed, and the total dynamic head is the measure of the cumulative energy that a pump must impart to a liquid to move it from one point to another, consisting of the sum of friction head (as based upon piping diameter, system configuration, and flow rate) and the static head (the sum of elevation head and operating pressure).

Many pump and onsite system manufacturers offer software that will perform the design calculations for the designer using the hydraulic equations and the hydraulic performances of their particular system components that are given in the Design Worksheet.

To facilitate the appropriate design approach, the Pressurized Distribution Design Worksheet in Appendix A may be used. A summary of the Worksheet design process is included in this section, with supplemental explanations for each step.

Design step:	Discussion:
Step 1: **Determine the daily flow rate**	The daily flow rate is the maximum flow of wastewater that the system will receive in a 24-hour period. Onsite wastewater systems for single-family residences using conventional absorption systems are sized based on the number of bedrooms in the home. In pressurized systems, the daily design flow is defined as gallons per day distributed through the system. Additionally, the design flow rate must also be determined. The design flow rate is not the same as the daily design flow but is the flow rate of the pumping system while in operation. The daily design flow for packed bed systems, according to Utah Administrative Code R317-4, is estimated as 300 gallons per day (gpd) for the first two bedrooms, plus an additional 100 gpd for each additional bedroom. Absorption systems and mound systems are designed using 150 gpd/bedroom. For systems other than single-family residences, the daily flow rate is determined using the procedures outlined in Utah Administrative Code R317-4. For pressurized systems, flow patterns throughout the day and particularly throughout the week can be an important consideration in system design. The use of a surge or equalization tank may be required to handle peak flows.

Design step:	Discussion:
Step 2: **Determine the maximum loading rate**	The loading rate is defined as the rate at which the wastewater is applied onto the absorption treatment area. For pressurized trenches for residential and non-residential systems, select the loading rate using guidance from R317-4. For the alternative wastewater treatment systems defined in Utah Administrative Code R317-4, the maximum loading rate is based on the particular treatment technology: • Mound systems = 1.0 gal/sq. ft./day • For packed bed systems, select from: o Intermittent sand filter: Sand media = 1.0 gal/sq. ft./day; Sand fill = 1.2 gal/sq. ft./day o Recirculating sand filter = 5.0 gal/sq. ft./day o Recirculating gravel filter = 15.0 gal/sq. ft./day o Textile filter = 30 gal/sq. ft./day o Peat filter = 5.0 gal/sq. ft./day o Synthetic polystyrene media filter = 21 gal/sq. ft./day o Synthetic open cell foam media filter: 16 gal/sq. ft./day and 6 gal./cu. ft./day

Design step:	Discussion:
Step 3: **Determine the required absorption treatment area**	The required absorption treatment area is specific to the treatment medium that receives the wastewater. 1) For pressurized trenches in systems without pretreatment of effluents in packed bed or membrane bioreactor systems, the required size of the absorption treatment area is determined using the sizing tables in R317-4. 2) When pressurized trench systems are used to disperse effluent from packed bed or membrane bioreactor systems systems, they may be reduced in size according to the guidelines given in R317-4. 3) In mound systems, the absorption treatment area is the gravel bed in which the distribution pipes are placed. For mound systems the required treatment area is defined as *A x B*, where A = absorption area width and B = absorption area length. 4) For a packed bed system, the treatment area is the surface area of the system. The treatment area may consist of sand, gravel, textile, peat, synthetic polystyrene media, or synthetic open cell foam media, depending on the type of packed bed system. The daily design flow is used to determine the required area for mounds, packed bed systems, and pressurized trenches for non-residential systems. The minimum required surface area is calculated using the following equation: Minimum Required Surface Area = Daily Flow Rate, gpd (Step 1) / Maximum Loading Rate, gpd/sq. ft (Step 2)

Design step:	Discussion:
Step 4: **Sketch the dimensions of the treatment area from site-specific information obtained from the site evaluation process**	The configuration and size of the soil treatment/infiltrative surface is dependent on the soil and site criteria and limitations of the specific site. Once the dimensions have been established, the distribution network can be designed. For pressurized trenches and packed bed systems, use: Length x Width = Absorption Treatment Area The layout will be dependent of the characteristics of the specific site. For mound systems, use the values of A and B from the Mound Design Worksheet (available from the Utah Onsite Wastewater Treatment Training Program). Sketch should include critical systems details: • Sizing dimensions (length, width) • Pipe layout (number of laterals, pipe spacing) • Piping (diameter, orifice diameter, orifice spacing) • Manifold (diameter, length, orientation) • Force main (diameter, length) • etc.

Design step:	Discussion:
Step 5: **Select the orifice diameter**	The orifice diameter will directly impact the design flow rate. Larger orifices will result in larger flow rates per orifice, even with a lower squirt height. Historically, larger orifices were recommended as a result of concerns that wastewater would either plug orifices with solids, and/or growth on the inside of the pipe would plug the orifices. Pressurized designs that use low head pumps will not be able to deliver the necessary pressure even if only minimal plugging occurs. However, routine maintenance of the system prevents clogging problems. Additionally, using smaller orifices often offsets the concern of plugging of orifices because smaller orifices allow smaller doses, which improves the life and performance of the system. Guidelines for the selection of orifice diameters include: • 1/8 inch orifices are acceptable for all of the approved alternative wastewater systems. • 5/32 inch orifices are typically used for pressurized drain field trenches. • 3/16 inch orifices can be used in mounds or pressurized trenches, especially when low head pumps are installed. • 1/4 inch or larger orifices are not recommended for most onsite systems. Historically were used in mounds.
Step 6: **Select the squirt height**	The squirt height recommendations were developed to ensure that the system will dose the correct amount each cycle and to minimize cleaning of the orifices. The following squirt heights are recommended based on orifice diameter: • 1/8 inch orifice = 5 ft. (equal to or greater than 3 ft. okay for inspection) • 5/32 inch orifice = 4 ft. (equal to or greater than 2 ft. okay for inspection) • 3/16 inch = 3.5 ft. (equal to or greater than 2 ft. okay for inspection) • 1/4 inch = 2.5 ft. (equal to or greater than 2 ft. okay for inspection)

Design step:	Discussion:
Step 7: **Determine the orifice flow rate**	The orifice flow rate can be calculated using the following equation: $Q = 11.79*d^2*(h)^{½}$ Where: Q = Orifice flow rate, gallons per minute (gpm) d = Orifice diameter, inches h = Squirt height, ft. Another commonly used coefficient used instead of 11.79 is 12.38. Using the above equation with 11.79 as the coefficient, the following flow rates correspond to the orifice diameters as follows: 1/8 inch orifice with 5 ft. squirt = 0.41 gpm 5/32 inch orifice with 4.0 ft. squirt = 0.58 gpm 3/16 inch orifice with 3.5 ft. squirt = 0.78 gpm 1/ 4 inch orifice with 2.5 ft. squirt = 1.17 gpm Additional flow rates for orifice diameters and squirt heights are given in Appendix B, *Table B-5: Orifice flow rates*.

Design step:	Discussion:
Step 8: **Select the orifice spacing**	Orifice spacing determines the application rate over a given surface area. For trenches, the orifice spacing will likely be greater than for mounds and packed bed systems. However, the designer should space the orifices as close together as practical to provide equal loading throughout the entire system. Most trench designs will have an orifice every 2 feet to 4 feet along the pressurized lateral. For mounds and packed bed systems, the orifice spacing should be set to provide for equal distribution within the area of influence of each orifice. The proper application of this principle will result in square areas of influence, that is, equal or close to equal spacing between the orifices and the laterals. These recommendations are provided as a guide for setting the spacing for each type of alternative system: 1 orifice /6 – 9 sq. ft. preferred for mound systems, less than 12 sq. ft. recommended 1 orifice /2 - 4 sq. ft. typical for intermittent sand filter systems, less than 4 sq. ft. recommended 1 orifice /1 - 2 sq. ft. typical for recirculating sand filter, recirculating gravel, and textile systems, less than 4 sq. ft. recommended For pressurized trenches, orifices are typically placed every 2 to 6 lineal feet along each pressurized lateral (based on pump calculations)

Design step:	Discussion:
Step 9: **Determine the number and length of laterals**	The number and length of laterals are dependent on the space available for the system and are site-specific. Using the sketch of the system created in Step 4 and the orifice spacing, the designer should select lateral placement that promotes equal distribution. When multiple laterals are used within the same infiltrative surface, the laterals and orifices should be placed to provide equilateral distribution (equal spacing of the laterals and orifices) of the effluent. The number of laterals is all of the laterals in the system. The number of laterals dosed by pump is the number of laterals dosed when the pump runs. It is the same as all of the laterals when zones are not used. It is the number of laterals within the zone when zones are used. This number is used for determining the design flow rate of the pump in Step 14. For end feed: Lateral length = Absorption length minus 0.5 to 1 foot For center feed: Lateral length = Absorption length divided by 2 minus 0.5 to 1 foot Laterals should extend to within 6 inches to 1 foot of the end of the absorption area. The distance from the laterals to the edge of the infiltrative area should be 6 inches to 1 foot for bed areas and 1 foot to 1.5 feet for trenches.
Step 10: **Determine the number of orifices in each lateral**	The number of orifices in each lateral is a function of the orifice spacing and the lateral length. The following equation should be used to determine the number of orifices in each lateral. From Step 8 and Step 9: Number of orifices = (lateral length /orifice spacing) + 1 A fraction remaining as a result of the calculation is accounted for by disregarding the fraction and adding an additional orifice.

Design step:	Discussion:
Step 11: **Determine the lateral flow rate**	The orifice flow rate is multiplied by the total number of orifices in a lateral to determine the lateral flow rate. The following equation is used: From Step 7 and Step 10: (Orifice flow rate) x (Number of orifices) = Lateral flow rate (gpm) The lateral flow rate is the amount of water needed to provide each orifice with the flow necessary to provide the design squirt height.

Design step:	Discussion:
Step 12: **Determine the lateral pipe diameter**	Lateral sizing is a critical step in the design process. Failure to size the lateral correctly can result in uneven distribution. The laterals must be sized large enough to provide flows that are equal throughout the length of the lateral. The orifices at the beginning of a pressurized lateral will discharge at a higher rate than at the end of the same lateral. The properly sized lateral will minimize this difference to promote equal distribution. The maximum difference between the first and last lateral orifice should be less than 10% of the orifice flow rate, or 21% of the squirt height. The following table gives the actual squirt height distances corresponding to a 10% flow difference for selected squirt heights: **Residual Squirt Height** — **10% Flow Difference** 2 feet — 5 inches 2.5 feet — 6.3 inches 3 feet — 7.6 inches 3.5 feet — 8.8 inches 4 feet — 10 inches 5 feet — 12.6 inches Graphs B-1 to B-8 in Appendix B are used to select the minimum lateral pipe diameter size. Selection of the appropriate graph is dependent on the orifice sizing: 1/8 inch orifices — Use Graph B-1A or B-1B 5/32 inch orifices — Use Graph B-2A or B-2B 3/16 inch orifices — Use Graph B-3A or B-3B 1/4 inch orifices — Use Graph B-4A or B-4B

Design step:	Discussion:
Step 13: **Determine the lateral head loss**	There are multiple methods for determining the head loss within each lateral. Simplified methods produce results accurate enough for onsite systems. The two methods described below allow an approximate solution without the use of more complex hydraulic calculations. Other methods may be acceptable provided that adequate information is provided for the reviewing authority to verify the design. **Method 1**: Use 1/3 of the squirt height (in ft.) selected in Step 6. This will usually be a conservative approach, provided that the other steps are each followed correctly. **Method 2**: Calculate the head loss based on a solid pipe 1/3 of the length of the perforated lateral pipe determined in Step 9 using the lateral flow rate from Step 11 and the diameter of the lateral from Step 12. See Appendix B *Table B-6: Frictional head loss per 100 feet of solid pipe.* This approach is conservative when compared to the actual head losses within the perforated pipe.
Step 14: **Determine the design flow rate**	The design flow rate in gallons per minute (gpm) is the combined lateral flow for all of the laterals that are dosed at a given time. For the typical single-family system, the design flow rate will usually be the flow from all of the laterals in the system. For larger systems that are divided into zones, the design flow rate includes all of the laterals in a zone. (Number of laterals from Step 9) x (Lateral flow rate from Step 11) = Design flow rate The design flow rate is used in pump selection.

Design step:	Discussion:
Step 15: **Determine the diameter of the manifold**	The manifold diameter should be large enough to supply flow to all of the laterals. For small systems, such as a typical single-family residential system, the manifold may be the same diameter as the laterals, or it may be the same size as the force main pipe. When the manifold pipe lengths are relatively short compared to the overall pipe lengths used for the force main, it may be acceptable to simplify the manifold pipe sizing to specify that the manifold be the same pipe diameter as the force main pipe. For some systems, the manifold diameter may be between the size of the force main and lateral pipes. Two acceptable simple methods for determining the manifold pipe diameter are: **Method 1**: Use the same diameter of pipe used for the force main in Step 18. **Method 2**: Because the flow is being dispersed into each lateral across the length of the manifold, it is acceptable to use a flow rate equal to ½ of the total design flow rate from Step 14 when calculating the manifold head loss. Calculate for multiple pipe sizes and select the best fit. Use Appendix B *Table B-6: Frictional head loss per 100 feet of solid pipe.* The total manifold head losses should always be less than 40% of the total dynamic head (TDH) from Step 23, and the diameter should be as small as possible that works for the pump selected. Where this is not the case, a larger pipe size should be used.
Step 16: **Determine the manifold pipe head loss**	The head loss in a manifold pipe is the same as for a solid pipe, such as a force main. The head loss is a function of the flow rate, the pipe size diameter, and the pipe smoothness coefficient (c-value). The Hazen-Williams equation for water may be used to determine this frictional loss. Use the pipe size and corresponding head loss selected in Step 15 to simplify the process.

Design step:	Discussion:
Step 17: **Determine the force main length**	The force main length is the total pipe length from the pump discharge to the beginning of the manifold. This length is not the same as the horizontal distance from the pump vault to the discharge point. This length is site-specific and is determined for each proposed system as part of the overall system layout. Add manifold length if Method 1 was selected in Step 15: Force main length + Manifold length = Total length
Step 18: **Determine the force main diameter**	The diameter of the force main is a function of the design flow rate and the force main length. The designer should select the smallest acceptable pipe size diameter, for smaller pipe diameters will provide higher velocities during a dose. Smaller pipe diameters will also reduce the amount of pumping for systems with drain back orifices that protect against freezing. Additionally, the smaller pipes will fill with water quicker during a dose and will come to pressure quicker, which leads to faster equal distribution throughout a system. The limiting factor in selecting small pipe diameters is the head loss through the force main. For small systems that have short force main lengths, the higher head loss per lineal foot of pipe is more acceptable than for a system that has a very long pipe length at the same head loss per lineal foot. The designer should also be aware of the available head loss that a typical pump has capacity to deliver. For some designs this available head loss will be critical. Other designs may be able to experience high head loss with minimal impact on pump selection. Once the design flow rate is known and the length of the force main is determined, Appendix B *Table B-6: Frictional head loss per 100 feet of solid pipe* is used to select the smallest pipe size diameter that will still maintain an acceptable overall head loss. This may be an iterative process.

Design step:	Discussion:
Step 19: **Determine the force main head loss**	The Hazen-Williams equation for water may be used to determine this frictional loss. To simplify this process, *Appendix B Table B-6: Frictional head loss per 100 feet of solid pipe* may be used for pipe size selected, based on Step 18.
Step 20: **Determine miscellaneous head losses**	Every system has a number of fittings and valves that increase the head loss to the system as a whole. These fittings and valves must be included in the miscellaneous head loss total. There are two methods that can be used to determine these losses: **Method 1:** Add 50% of the force main head loss from Step 19 to account for fittings, valves, etc. This is a conservative approach for most typical, single-family residential systems. Caution should be employed in using this approach for larger systems or for systems that have a large number of fittings. When concerns arise regarding the applicability of this approach, it is recommended that Method 2 be used. **Method 2:** Determine the “equivalent” pipe lengths for each of the fittings in the design and use Appendix B *Table B-7: Frictional losses through plastic fittings* to determine the head loss associated with the fittings. Frictional head losses associated with a particular fitting can be represented as an equivalent pipe length. This method assigns a length of straight pipe of the same diameter that equals the head loss that occurs through the fitting. Manufacturer of fittings can provide this information. Additionally, there are tables that contain this information for the typical fittings used in an onsite system. Appendix B *Table B-7: Frictional losses through plastic fittings* provides head losses for some of the most commonly used fittings. The two examples presented below can be used as a guide for determining how to best account for miscellaneous head losses: Example 1: A smaller force main pipe diameter results in greater head loss. If the force main pipe length is long and the diameter is small, the higher head loss for the pipe and the long length will both increase the head loss calculated for the force main pipe. When using the 50% method above, it is possible that the head loss calculated in Method 1 will be much higher than desired.

Design step:	Discussion:
	Example 2: Some systems will have several fittings due to the site-specific conditions. For a system with many fittings, the use of Method 1 or 2 may not accurately account for the fittings in the design. Changes made by a contractor during installation may also increase the number of fittings in a particular design. When either of these conditions occurs, and if the fittings create head loss above what is estimated, the system may not perform as designed. A manufactured, pre-assembled discharge assembly, which consists of all piping and parts between the point of pump discharge to the point at which the supply line exits the tank and used to convey effluent from a pump to the exterior of a riser or pump basin or chamber, may be used in a pressurized system. When using a manufactured discharge assembly, information on head loss through the discharge assembly can be obtained from the manufacturer. Using this information will provide a more accurate head loss measurement than using either of the two simplified methods described above.
Step 21: **Determine head loss associated with a zone valve**	If the proposed system will use multiple zones, then the system will likely require the use of one or more zone valves. Dividing the distribution area into zones is used to maintain a reasonably small pump size when many orifices are to be dosed. Dividing the distribution system into zones will also distribute the hydraulic load over time as well as space, allowing for longer resting times. A zone valve may be a mechanical rotating valve, a solenoid valve, or other mechanism for controlling the flow from one zone to another. This valve will have a head loss associated with the flow passing through the valve. The head loss through the valve will be more than the amount accounted for in the miscellaneous head losses step discussed in Step 20. Therefore, when a system utilizes one or more zone valves, the head loss for the valve(s) must be calculated and added to the total head loss. The manufacturer of a specific valve will have an equation and/or a chart for determining the head loss. The head loss will be a function of the valve size and the design flow rate that will pass through the valve each time the system doses.

Design step:	Discussion:
Step 22: **Determine the elevation head difference**	The elevation head difference is the difference (in ft.) in elevation from the low water level in the pump tank to the discharge point and is site-specific. This is usually a positive value, but for systems with a discharge point below the pump, it may be a negative value. If the discharge is below the pump, the use of an anti-siphoning device is necessary.
Step 23: **Determine the Total Dynamic Head (TDH)**	The total dynamic head (TDH) (in ft.), which is used to size and select the pump, is the sum of the following head losses: Squirt height (Step 6) Lateral head loss (Step 13) Manifold head loss (Step 16) Force main head loss (Step 19) Miscellaneous head loss (Step 20) Zone valve head loss (Step 21) Elevation head difference (Step 22) Sum in ft.= TDH
Step 24: **Select the appropriate pump sizing criteria**	The pump specified and installed in the system must be sized based on the design flow rate and the calculated TDH for the system. If changes to the design are made during installation, they will likely change the system calculations for flow and/or TDH. Therefore, the designer should clearly document the design basis and all calculations. The design flow rate (in gpm) determined in Step 14 is used for pump selection. The TDH (in ft.) required for the pump is determined in Step 23. Use pump curves to select the correct pump.

Design step:	Discussion:
Step 25: **Determine the applicable dose volume**	The system dose volume is the amount of effluent that the pump will deliver during a single cycle event. This volume will include the dose applied to the absorption area as well as any volume required to fill the pipe network. System Dose Volume + Pipe Volume = Total Dose Volume The maximum dose volume for any pump event should be no greater than 10% of the daily design flow. Smaller dose volumes are preferred (1/48 – 1/24 preferred). Appendix B *Table B-8: Void volume for various diameter pipes* is used to calculate pipe volumes based on pipe diameter. When timed-dosing is used, it would be appropriate to have more frequent doses applied during the day. Smaller doses will provide more doses during a 24-hour period and may result in better performance of the onsite wastewater system, which may lead to a longer design life. Therefore, the system should be able to provide doses that are small enough to provide multiple dosing events, spread evenly over time, during the day. For most systems, this will be a dose volume of 5% or less for each dosing event. Once the targeted dose volume has been chosen, the actual pumping dose volume must be determined. For systems installed in cold weather conditions, with drain back orifices, the force main piping and manifold network will need to be filled during each pump cycle. The volume of these pipes should be added to the dose volume. Pipe volumes are provided in Appendix B *Table B-8: Void volume for various diameter pipes*. For a demand-controlled system, the floats are set in the dose tank with the appropriate spacing between the pump on position and the pump off position to deliver the selected dose volume. For timer-controlled systems, the pump rate needs to be determined by means of a draw down test or meter. Using the pump flow rate of the installed system, the timer “on” setting can be determined to deliver the selected dose volume for each pumping event.

Design step:	Discussion:	
	Using the total dose volume from Step 25 and the design flow rate from Step 14, determine the pump run time per dose. From Step 25 and Step 14 ______ **(total dose volume) / (design flow rate)**	**26. Pump Dose Run Time** **_______ min**
Step 27: **Develop a system performance curve**	The system performance curve predicts how the distribution system will perform under various flow rates and heads. The flow rate is a result of the total head that the pump works against. As the head increases, the flow rate decreases. The flow rate determines the network pressure and thus the relative uniformity of discharge throughout the distribution network. The best way to select the pump is to evaluate the system performance curve vs. the pump performance curve. Where the two curves cross is where the system will operate relative to flow rate and head. System evaluation involves calculations that are explained step by step in Appendix A. Pump performance curves are supplied by pump manufacturers. Plot the system head curve and pump curve together to determine: 1. Where the pump will operate on its curve 2. What changes will occur if the system head curve or the pump performance curve changes	

Table 18: Design steps

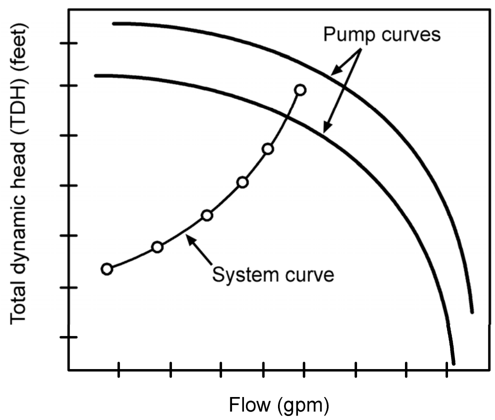

Figure 10: System and pump performance curves

4.0 Pressure Distribution Design Submittal Requirements

Suggested information that should be provided in the system design plans includes:

- **All pump calculation and results** necessary to document that the system is designed and sized for the appropriate flows must submitted. Information on **how the daily flow rate was estimated** should also be included.
- The design should clearly show **the placement of the equipment** to be installed.
- **Components that are critical to the operation of the system**, such as pumps, floats, control panels, effluent filters, etc., should be clearly specified in the design to ensure that the proper equipment is installed. Adequate information should be provided for the contractor to understand what is to be installed as well as the inspector to verify.
- Pumping systems require access from the finished ground surface. Knowledge of appropriate equipment needed for a safe installation that protects the environment and public health may be unfamiliar to the contractor and the inspector. The designer should include details and drawings in the design that **address how the access to ground surface is to be achieved** in a safe manner to prevent unauthorized access, especially by children.
- **Electrical requirements** for the installed equipment should also be specified in the design.
- Many of the sites where pressurized systems or alternative systems will be used have site conditions that limit the installation of a conventional system. In many cases there may only be one acceptable solution for the site; therefore the **design plans must be followed**. Details regarding the location of the system should be clear to all who review the plans.
- When pumping assemblies are installed in a tank, the dimensions of the tank will dictate the location of the pump and/or the floats. Therefore, the designer must provide **the size and dimensions of the pump chamber, basin, or vault, designate specific components to be used, and specify the spacings that are to be used for pump and float placement**. If alternative components are proposed for use, the designer and regulatory authority must be consulted to ensure proper installation of the equipment. This requirement should be clearly noted on the plans.
- At a minimum, the pump specifications should also include the following information:
  - Pump manufacturer
  - Model number
  - Horsepower
  - Voltage and phase
  - Amperage (run amps, starting amps, full load amps)
  - Capacity: Number of gpm at the specified feet of TDH
  - Pump curve with system curve

- If alternative equipment is used**, documentation of the approved change**, including who approved the change, must be provided to the property owner and included in the record file at the regulatory office.
- **Details of system design that were calculated** using the design spreadsheet (or design software) should also be provided, including:
  - Septic tank size, location and outlet invert elevation
  - Pump elevation and location
  - Force main length, location, highest elevation, and diameter
  - All valves, other components and fittings in the system
  - Manifold diameter, location, length, and orientation
  - Lateral diameter, location, length, orientation, and elevations
  - Orifice diameter, spacing, and orientation
  - Dose volume and frequency
  - Location and detail of access ports on the laterals.
- **A user's manual for the pressure distribution system** should be provided to the homeowner/system user and the local health department. This document may be developed in conjunction with the installer and submitted with the as-built information, but the designer is responsible for preparation of the manual. The contents of the user's manual should include, at a minimum:
  - Diagrams of the system components.
  - Explanation of general system function, operational expectations, owner responsibilities, etc.
  - Specifications of all electrical and mechanical components installed (occasionally components other than those specified on the plans are used).
  - Names and telephone numbers of the system designer, local health department, component manufacturers, supplier/installer, and/or the management entity or service provider to be contacted in the event of a failure.
  - Information on the periodic maintenance requirements of the various components of the onsite system.
  - Information on troubleshooting common operational problems that might occur. This information should be as detailed and complete as needed to assist the system owner or user to make accurate decisions about when and how to attempt corrections of operational problems and when to call for professional assistance.

5.0 Testing and Inspection of Pressure Distribution System after Installation

Testing and inspection of a pressure distribution system should be conducted to verify that distribution is uniform with the required minimum residual pressure, that the system is dosed at the proper volume and frequency, and that the alarms are functioning properly.

If problems are encountered during testing, the installer should notify the designer or engineer.

Specifically, the following components of a pressure distribution system should be inspected and verified, prior to backfill, by the regulatory authority, the contractor and/or the designer.

In preparation for inspection, the pump chamber, vault, or basin should be filled with water.

- **Water tight tanks must be inspected and verified as water tight after installation**, as this is a critical component in pressurized systems. If the tank allows infiltration of water into the tank, excessive quantities of ground water will be pumped onto the receiver infiltrative surface and will overload the system, leading to an early failure. Infiltration can also cause high water use alarms. These problems can be exacerbated during wet periods of seasonally high ground water, snowmelt, or heavy rainfall. Ex-filtration of effluent out of the tank can cause low water alarms under low or no flow conditions.
- The **pump must deliver the correct dose** to the absorption area. For demand-dose systems, verification that "dry" float settings will send the correct dose to the dispersal area when floats are in water must be made. Minor adjustments of float placement may be required. The drawdown per dose measurements should be recorded.
- **All floats must be inspected** for proper operation. Common installation errors include incorrect wiring of floats. Care should be taken to ensure that when the float is moved from the up or down position that the correct signal occurs at the control panel.
- The **floats should turn on and off at the correct water elevations** for the high water alarm, “on” level, “off” level, and “redundant off” level as identified on the design plan. For simplicity and accuracy, these adjustments should be made with the float tree out of the water (“dry” float settings).
- The audible and visual alarm functions of the control panel should be confirmed.
- In some regulatory jurisdictions, a system must be designed such that the high water alarm does not turn the pump on. If the high water alarm turns the pump on, the system will not be approved. **High water levels that set off alarms should be investigated as to the cause of the condition**. If the cause is due to temporary periods of high water use, the excess water will be pumped out through the

system. If the high water levels are due to on-going conditions, such as leaky fixtures or toilets, those problems should be corrected.

- **The installed piping should be pressurized** to verify that it does not leak prior to backfill.
- Drain back systems require reverse slope back to the dose tank in order to ensure proper drainage between pump events. Bedding around the pipe must be adequate to prevent sagging of pipes, which may retain water and freeze during low or no flow conditions. **Any dip in the piping must be leveled** prior to backfill.
- The **squirt height must meet design specifications**. The uniformity of squirt height along the length of the laterals should be evaluated. The actual squirt heights at both ends of each lateral at the time of inspection should be recorded if possible. If the squirt height varies from inlet to outlet end of the lateral, the height difference must be evaluated to ensure that the flow from the orifices is within 10% from the first orifice to the end orifice.

  Squirt height can be measured by attaching a clear PVC standpipe to the end of the lateral. The initial squirt height at time of installation will be used during periodic inspections over the life of the system by the O&M service provider. The residual head is measured from the top of the lateral pipe to the top of the water column.
- All access risers, including lids and lid bolts must be inspected to verify that they are secure and safe.
- **All installed valves should be inspected** and verified to be working as designed.
- **Other standard inspection requirements** must also be confirmed, such as component sizing, locations, elevations, etc.

Timed-dose testing

For timed-dose systems, the timer run times provided by designers must be field-tested to see if these run times will send a full dose to the receiving component. This determination can be accomplished by running the system in manual and measuring the time interval required for a full dose to be pumped. There must be sufficient water in the pump chamber to run these tests.

- Using the time required to pump a full dose, it must be verified that **when the system runs automatically, that it runs for the time required** to send the proper dose to the receiving component. Timers can be difficult to set, i.e., setting a timer to 2.2 minutes may not ensure a run time of 2.2 minutes.
- The timer “off “time should be the same as that specified in the plan or should be able to dose the system the correct number of times per day. For instance, if the receiving component is to receive 4 doses per day, the “off” time should be approximately 6 hours.

Post-inspection follow-up

Problems encountered during an inspection must be resolved by the certified designer and the regulatory authority.

Wiring problems should be referred to the electrician who installed the electrical components.

Any approved changes to the design submittal document should be recorded.

Information from the final inspection should be recorded in an as-built construction document. This information should be provided to the regulatory authority, the system owner, and to the operation and maintenance (O&M) service provider.

6.0 Operation and Maintenance (O&M) Criteria & Recommendations

Permit requirements

Most of the permitted systems that utilize pressurized distribution require an operating permit from either the State of Utah Division of Water Quality or from a local health department.

Specific O&M requirements for a particular system should be identified during the permitting and approval process.

Maintenance requirements

The typical pressurized system must be maintained on a regular basis. Alternative treatment systems using pressurized distribution systems as defined in R317-4 require a semi-annual inspection.

During the semi-annual inspection, maintenance observations and activities should be logged and reviewed. Often small changes in system performance, if observed and documented, can be used to initiate preventative maintenance that can reduce or eliminate future problems and expenses.

O&M activities may include the following:

- Conduct a **walkthrough** of the area where the system is installed. Look for any indication of surfacing effluent and also look for changes to the site from the previous visit to ensure that the system integrity remains intact.
- Check all tanks and measure and record sludge and scum levels.

Pump tanks when necessary. Guidelines for when to pump a tank are found in R317-4.

Check for signs of leaking in tanks and risers. Lids of risers must be secure.

- **Check the inlet and outlet of the tanks**, including the baffles or tees, to ensure that they are not damaged, broken, clogged, or missing.
- Remove and **clean the effluent filter** if necessary. Re-install after inspection and cleaning.
- **Inspect and verify valves** to ensure that they are working as designed.
- **Inspect floats** for proper operation. Float failure is a common cause of system failures. Movement of the floats should not be restricted, and the floats should be positioned correctly and provide positive instrumentation signals.
- **Measure pump run time per cycle and drawdown**. Compare these values with those recorded in the construction record and previous inspection records. If the values are different, evaluate the system for improperly set timer controls or float settings, clogged laterals, or plugged orifices.

- **Check and verify connections in splice or junction boxes** to ensure that when the float is moved from the up or down position, the correct signal occurs at the control panel. Test alarms for proper functioning at high and low liquid levels.
- Check and verify the control panel functions according to the approved design.
- **Measure and record squirt height** and compare to previous recordings and initial measurements. Increasing squirt heights indicate the need to flush or clean a lateral pipe. Lower squirt heights usually indicate a problem with the pipe network but may also be a result of a problem with the pump system.

Squirt height can be measure by attaching a clear PVC standpipe to the end of the lateral. The true residual head is measured from the top of the lateral pipe to the top of the water column.

- Confirm that the **audible and visual alarm functions** of the control panel are operational.

All findings and repairs made during the semi-annual O&M inspections should be recorded and filed for easy access and reports sent to the local health department or the Utah Division of Water Quality, as required.

Step 26: System Performance Curve and Pump Selection

Calculate a system performance curve by completing the worksheet on the following page:

- **a)** **In Column 1 Row C, enter the Design Flow Rate from Step 14. Then select two flow rates above the Design Flow Rate and two below and enter in rows A, B, D and E. Column 1 should now be completed.**
- **b)** **In Column 2, calculate the Orifice Flow by dividing the Total Flow Rate from Column 1 by the number of orifices in the network from Step 10.**
- **c)** **In Column 3, enter the Elevation Head Difference from Step 22.**
- **d)** **In Column 4, use *Table B-6: Frictional head loss per 100 feet of solid pipe* to calculate the Force Main Head Loss.**
- **e)** **In Column 5, calculate the Network Head using:**

  $H = 1.3(Q/(11.79d^2))^2$

  H is for head in ft.
  Q is for orifice flow rate from column 2
  d is orifice diameter in inches from Step 5
  The 1.3 is an adjustment factor for friction loss in laterals.

  Example:
  The equation for a 3/16” orifice is $H = 1.3(Q/0.4145))^2$
- **f)** **In Column 6, calculate the Total Head. Add the Elevation, Force Main and Network heads.**
- **g)** **To develop the system performance curve, plot the Total Flow from Column 1 vs. the Total Head from Column 6.**
- **h)** **Using manufacturers’ Pump Performance Curves, select one that intersects the System Performance Curve above the Total System Flow Rate.**

System Performance Curve Worksheet

	1. Total Flow (gpm)	2. Orifice Flow (gpm)	3. Elevation Head Difference (ft)	4. Force Main Head Loss (ft)	5. Network Head (ft)	6. Total Head (ft)
A						
B						
C						
D						
E						
	Design Flow Rate from Step 14 in Row C. Select higher and lower rates in rows A,B,D,E	Divide the Total Flow Rate from Column 1 by the number of orifices in the network from Step 10	Elevation Head Difference from Step 22	Use Table B-6: Frictional head loss per 100 feet of solid pipe	See Step 26 e)	Add the Elevation, Force Main and Network heads

Appendix A: Pressurized Distribution Design Worksheet

Please enter the results of your calculations for each step.

Absorption Area Design

Absorption Area Design Notes:	Step:
For residential systems, determine the number of bedrooms for design. For **non-residential systems**, determine the number of gallons per day using guidance from R317-4. For **absorption systems** and **mound systems**, use 150 gallons per day per bedroom. For **packed bed systems**, use: A minimum of 300 gallons per day for two bedrooms 100 gallons per day for each additional bedroom.	**1. Daily flow rate** **Number of bedrooms:** **______** **Total gallons per day:** **______**
For **pressurized trenches for residential** and **non-residential systems**, select the loading rate using guidance from R317-4 For **mound systems**, use 1.0 gal/sq. ft./day For **packed bed systems**, select from: Intermittent sand filter: Sand media = 1.0 gal/sq. ft./day; Sand fill = 1.2 gal./sq. ft./day Recirculating sand filter = 5.0 gal/sq. ft./day Recirculating gravel filter: 5.0 gal/sq. ft./day Textile filter: 30.0 gal/sq. ft./day Peat filter: 5.0 gal/sq. ft./day	**2. Maximum loading rate** **______ gal/sq. ft./day**

Absorption Area Design Notes:	Step:
For **pressurized trenches**, use absorption area sizing tables from R317-4 For **pressurized trenches after packed bed systems**, use absorption area sizing tables from R317-4 and allowable reduction factors. For **mound systems**, use values of A (absorption area width) and B (absorption area length) from Mound Design Worksheet For **packed bed systems**, use: Daily flow rate (from Step 1)/maximum loading rate (from Step 2) = required treatment absorption area.	**3. Required absorption treatment area** **______ sq. ft.**
For **pressurized trenches** and **packed bed systems**, use: Length x width = absorption treatment area The layout will be dependent on the characteristics of the specific site. For **mound systems**, use the values of A and B from the Mound Design Worksheet (available from the Utah On-Site Wastewater Treatment Training Program).	**4. Sketch a proposed absorption treatment area for the system being designed, using the required absorption area**

Pressure Network Design

Pressure Network Design Notes:	Step:
Select based on system layout configuration and pump calculations. 1/8 inch – U~~Can be u~~sed on all **alternative systems & pressurized trenches** 5/32 inch – ~~Typically used~~Common in **pressurized trenches** 3/16 inch – Common~~an be used~~ in **mounds** or **pressurized trenches** 1/4 inch – ~~Can be~~Historically used in **mounds** (but generally not recommended for use in pressurized system design).	**5. Orifice diameter** **______ inch**
Select the squirt height using orifice diameter (Step 5) 1/8 inch: ~~3 –~~5 ft (>3 ft ok for inspection) 5/32 inch: ~~2 –~~4 ft. (>2 ft ok for inspection) 3/16 inch: ~~2 –~~3.5 ft. (>2 ft ok for inspection) 1/4 inch: ~~2 –~~2.5 ft. (>2 ft ok for inspection)	**6. Minimum squirt height** **______ ft.**
Determine the orifice flow rate (See Appendix B *Table B-5: Orifice flow rates*) using the orifice diameter (Step 5) Examples of orifice flow rates include: 1/8 inch with 5 ft squirt = 0.41 gpm 5/32 inch with 3.5 ft squirt = 0.54 gpm 3/16 inch with 3.5 squirt = 0.78 gpm 1/4 inch with 2.5 ft squirt = 1.17 gpm	**7. Orifice flow rate in gallons per minute (GPM)** ______

Pressure Network Design Notes:	Step:
Select the orifice spacing: **Mounds** 1 orifice/6 – 9 ft² Preferred, < 12 ft² recommended – **Mounds** **Intermittent sand filter** 1 orifice/2 – 4 ft² Typical, < 4 ft² preferred - **Intermittent sand filter** **Recirculating sand filter, recirculating gravel filter, textile filter** 1 orifice/1 – 2 4 ft² Typical, < 4 ft2 preferred or less - **Recirculating sand filter, recirculating gravel filter, textile filter** For **pressurized trenches** 1 orifice / 2 to 6 Lineal feet along trench (based on pump calcs), orifices are typically placed every 2 to 4 feet along each pressurized lateral.	**8. Orifice spacing** ______ **ft.**
Based on orifice spacing and shape of distribution area (from Step 4 sketch), determine number and length of laterals: **Number of laterals** is all laterals in the system **Number of laterals dosed by pump** is the number of laterals dosed when the pump runs. It is the same as above when zones are not used. It is the number of laterals within the zone when zones are used. This number is used for determining the design flow rate of the pump in Step 14. **For end feed**: lateral length = Absorption length minus 0.5 to 1 foot **For center feed**: lateral length = Absorption length divided by 2 minus 0.5 to 1 foot Laterals should extend to within 6 inches to 1 foot of the end of the absorption area. The distance from the laterals to the edge of the infiltrative area should be 6 inches to 1 foot for bed areas and 1 foot to 1.5 feet for trenches.	**9. Number and length of laterals** **Number of laterals:** ______ **Number of laterals dosed by pump** ______ **Length of laterals** ______ **ft.** **Add the laterals to the sketch in Step 4**

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Pressure Network Design Notes:	**Step:**
From Step 8 and Step 9: Number of orifices = (lateral length/orifice spacing) + 1 If the calculation results in a fraction, add the one then disregard the fraction and add one.	**10. Number of orifices in each lateral** ______
From Step 7 and Step 10: (Orifice flow rate) x (Number of orifices)	**11. Lateral flow rate** ______ **GPM**
Size the lateral diameter to ensure flow within the lateral is within 10%. Use orifice diameter from Step 5. Use Graphs B1 through B8 in Appendix B to determine minimum lateral diameters: Use Graph B-1 or B-2 for 1/8 inch orifice Use Graph B-3 or B-4 for 5/32 inch orifice Use Graph B-5 or B-6 for 3/16 inch orifice Use Graph B-7 or B-8 for 1/4 inch orifice	**12. Lateral sizing** ______ **in.**
Determine lateral head loss using Method 1 or 2: **Method 1**: Use 1/3 of the squirt height from Step 6: (squirt height) x (0.33) **Method 2**: Calculate the head loss based on solid pipe 1/3 the length of the perforated lateral from Step 9, using the lateral flow rate from Step 11 and the diameter of the lateral from Step 12. See Appendix B *Table B-6, Frictional Head Loss per 100 feet of Solid Pipe.*	**13. Lateral head loss** ______ **ft.**
Calculate flow rate from all laterals dosed at one time. This will be the total flow rate for all laterals or all laterals within a zone: (No. of laterals from Step 9) x (Lateral flow rate from Step 11) = Design Flow Rate.	**14. Design flow rate** ______**GPM**

Pressure Network Design Notes:	Step:
Determine the size of the manifold using Method 1 or 2: **Method 1:** Use the same size pipe used for the force main in Step 18. **Method 2:** Use ½ of the total design flow from Step 14 to c~~C~~alculate the head loss within the manifold~~ using various sizes of pipe and using 1/2 of the total design flow from Step 14.~~. Calculate for multiple pipe sizes then select best fit. Use Appendix B *Table B-6: Frictional Head Loss per 100 feet of Solid Pipe.* Select an "acceptable" head loss - usually select the smallest possible pipe. Manifold head loss should be <40% of total dynamic head (TDH) from Step 23.	**15. Manifold sizing** **______ in.**
Based on Step 15, use head loss for pipe size selected.~~Determine manifold head loss using Appendix B *Table B-6: Frictional Head Loss per 100 feet of Solid Pipe*~~	**16. Manifold head loss** **______ ft.**
Length of pipe from the pump discharge to the beginning of the manifold (site-specific).	**17. Force main length** **______ ft.**
Use Appendix B *Table B-6: Frictional Head Loss per 100 feet of Solid Pipe* to determine the pipe diameter. Pick a pipe diameter with an acceptable range of head loss. May be an iterative process.	**18. Force main diameter** **______ in.**
Based on Step 18, use head loss for pipe size selected.~~Determine the force main head loss from Appendix B *Table B-6: Frictional Head Loss per 100 feet of Solid Pipe* using the force main pipe size diameter from Step 18.~~	**19. Head loss in force main** **______ ft.**

Pressure Network Design Notes:	Step:
Estimate additional head loss for fittings, valves, etc. Use Method 1 or 2 Method 1: Use~~Add~~ 50% of the force main head loss from Step 19 to account for fittings, valves, etc. Method 2: Determine the "equivalent" pipe lengths for fittings, valves, etc. and determine the head loss from Appendix B *Table B-7: Frictional losses through plastic fittings.*	**20. Miscellaneous head loss** **______ ft.**
Determine the head loss through automatic distributing valve. This information is usually supplied by the manufacturer.	**21. Head loss for systems with multiple zones (if used)** **______ ft.**
The vertical distance (elevation difference) from the water level in the pump tank to the water level at the discharge point (site-specific).	**22. Elevation head difference** **______ ft.**
To determine the Total Dynamic Head (TDH), add together: Squirt Height (Step 6) __________ Lateral Head Loss (Step 13) __________ Manifold Head Loss (Step 16) __________ Force Main Head Loss (Step 19) __________ Miscellaneous Head Loss (Step 20) __________ Zone Valve Head Loss (Step 21) __________ Elevation head difference (Step 22) __________ Result in feet = TDH __________	**23. Total Dynamic Head (TDH)** **______ ft.**

Pressure Network Design Notes:	Step:
Design Flow Rate (Step 14) gpm__________ Total Dynamic Head (Step 23) ft.__________	**24. Pump Selection** **USE PUMP CURVES TO SELECT THE CORRECT PUMP**
The dose volume should not exceed 10% of the daily design flow. Smaller dose volumes are preferred. 1/48 – 1/24 preferred (based on one dose per half hour or hour) For systems that drain back to the pump tank after each cycle, the volume of the force main should be added to the dose volume. Pipe volumes are calculated using Appendix B *Table B-8: Void volume for various diameter pipes.*	**25. Dose Volume** **System Dose Volume** **______ gal.** **Pipe Volume** **______ gal.** **Total Dose Volume** **______ gal.**
Using the total dose volume from Step 25 and the design flow rate from Step 14, determine the pump run time From Step 25 and Step 14 ______(total dose volume) / (design flow rate)	**26. Pump Dose Run Time** **_______ min**

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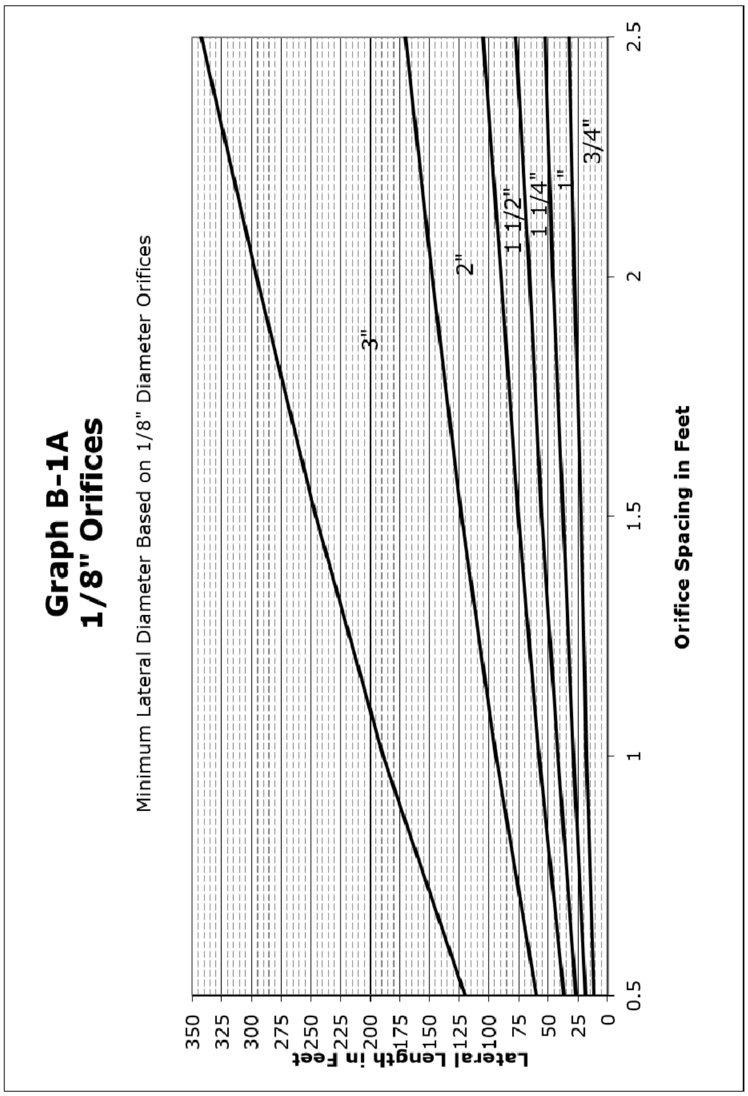
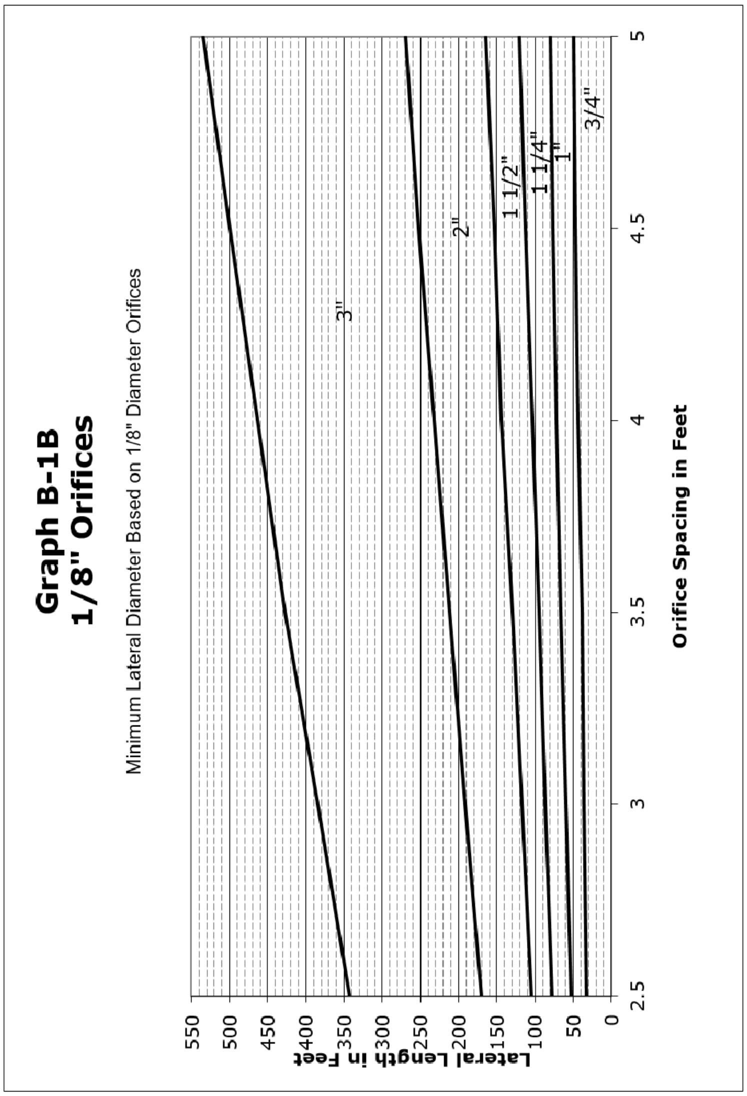
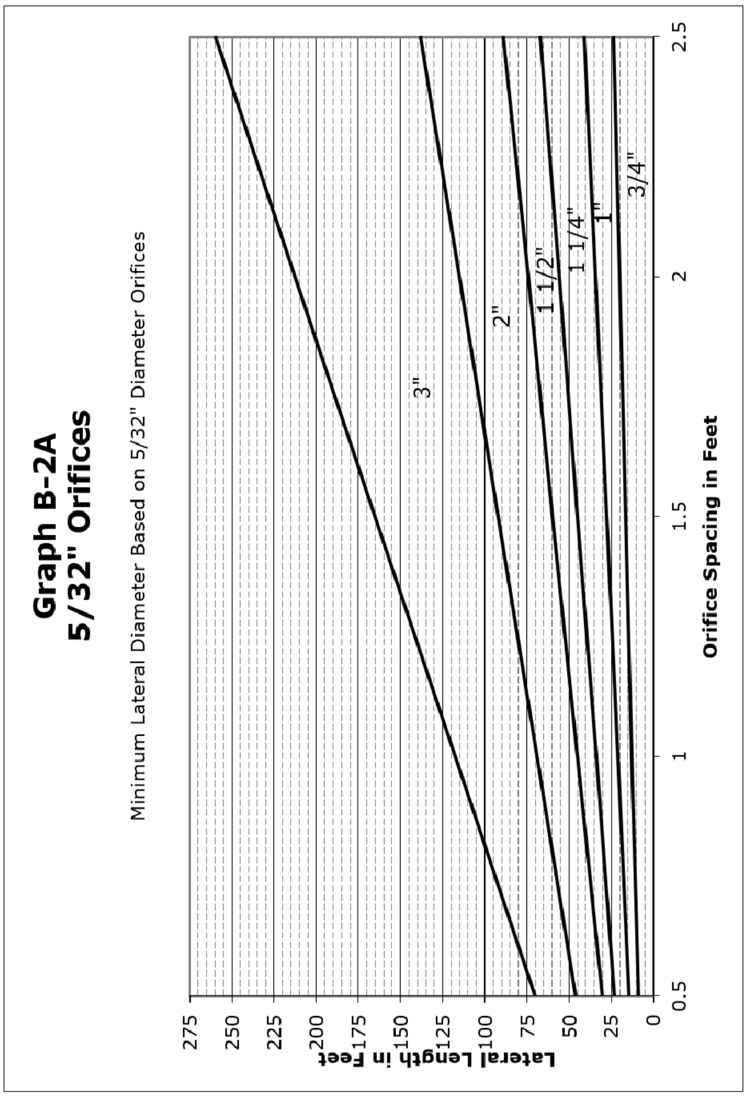
Pressure Network Design Notes:	Step:
Calculate a system performance curve by completing the worksheet on the following page: **a) In Column 1 Row C, enter the Design Flow Rate from Step 14. Then select two flow rates above the Design Flow Rate and two below and enter in rows A, B, D and E. Column 1 should now be completed.** **b) In Column 2, calculate the Orifice Flow by dividing the Total Flow Rate from Column 1 by the number of orifices in the network from Step 10.** **c) In Column 3, enter the Elevation Head Difference from Step 22.** **d) In Column 4, use *Table B-6: Frictional head loss per 100 feet of solid pipe* to calculate the Force Main Head Loss.** **e) In Column 5, calculate the Network Head using:** **$H = 1.3(Q/(11.79d^2))^2$** **H is for head in ft.** **Q is for orifice flow rate from column 2** **d is orifice diameter in inches from Step 5** **The 1.3 is an adjustment factor for friction loss in laterals.** **Example:** **The equation for a 3/16" orifice is $H = 1.3(Q/0.4145))^2$** **f) In Column 6, calculate the Total Head. Add the Elevation, Force Main and Network heads.** **g) To develop the system performance curve, plot the Total Flow from Column 1 vs. the Total Head from Column 6.** **h) Using manufacturers' Pump Performance Curves, select one that intersects the System Performance Curve above the Total System Flow Rate.**	~~26.~~27. **System Performance Curve and Pump Selection**

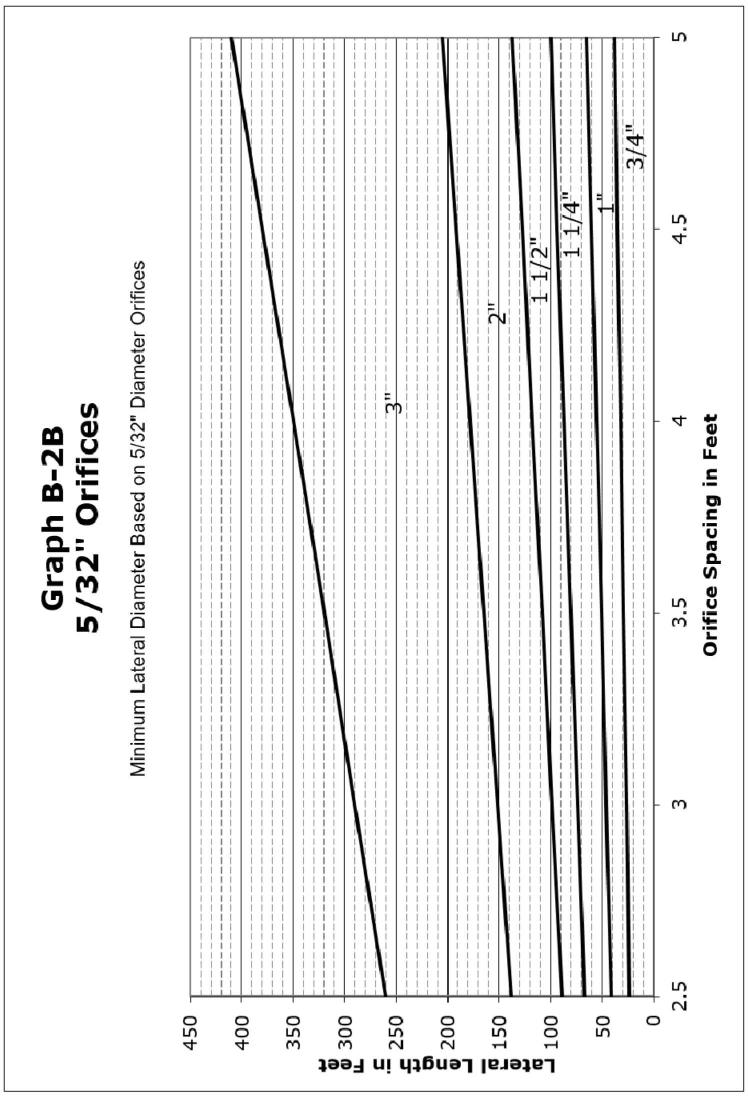
Appendix B

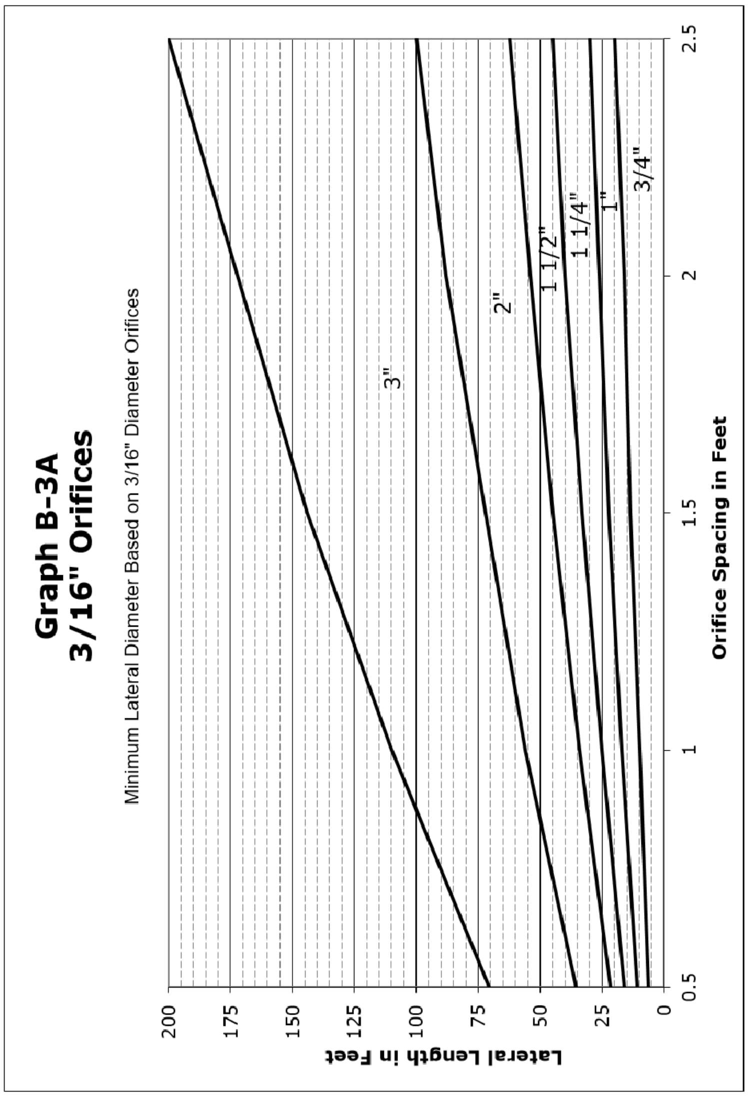


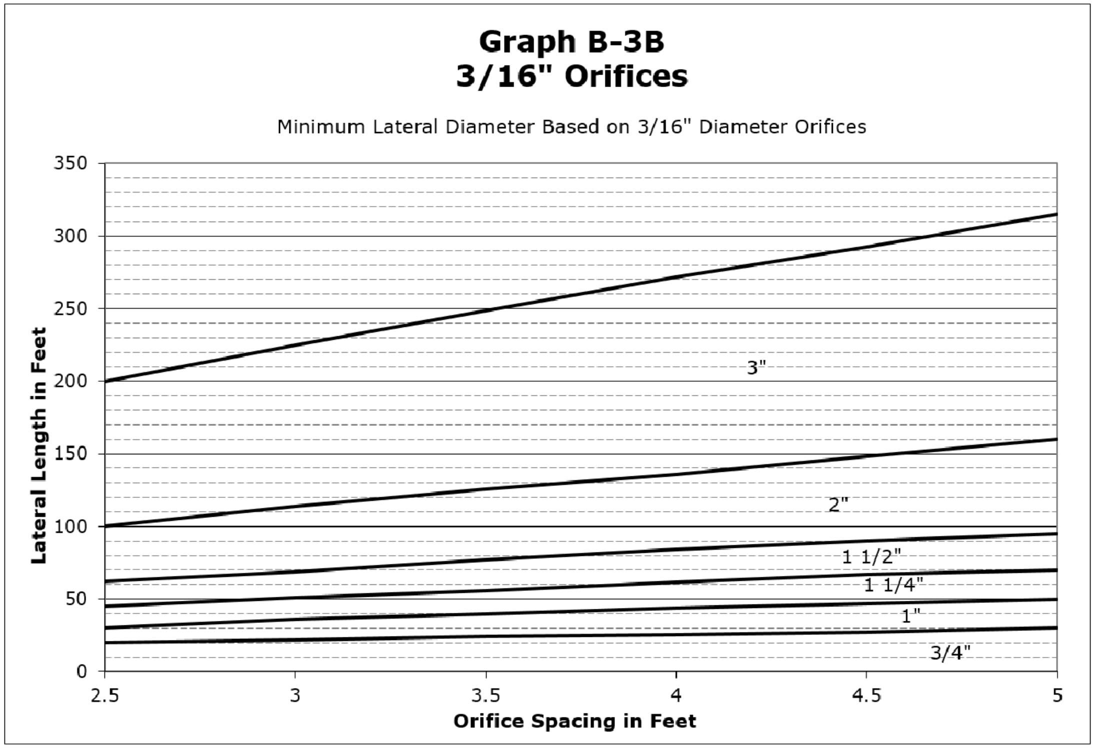
Graph B-1A
1/8" Orifices
Minimum Lateral Diameter Based on 1/8" Diameter Orifices
Lateral Length in Feet
Orifice Spacing in Feet
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
0.5
1
1.5
2
2.5
3"
2"
1 1/2"
1 1/4"
1"
3/4"

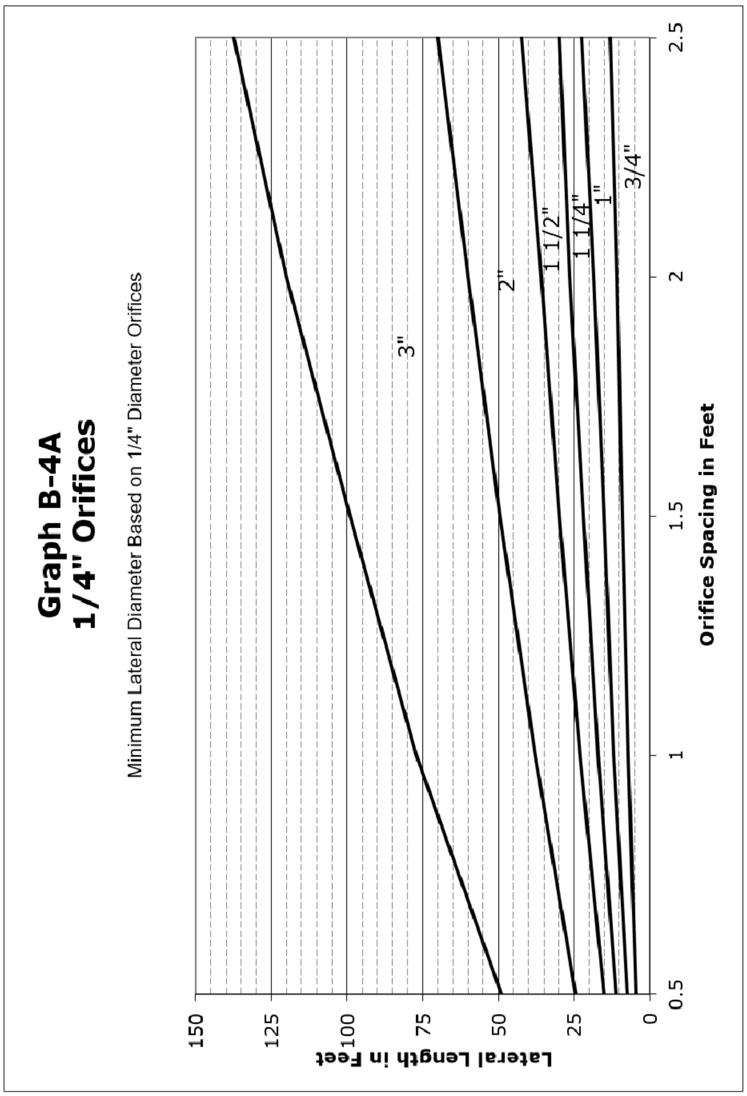

Graph B-1B
1/8" Orifices
Minimum Lateral Diameter Based on 1/8" Diameter Orifices
Lateral Length in Feet
550
500
450
400
350
300
250
200
150
100
50
0
2.5
3
3.5
4
4.5
5
Orifice Spacing in Feet
3"
2"
1 1/2"
1 1/4"
1"
3/4"

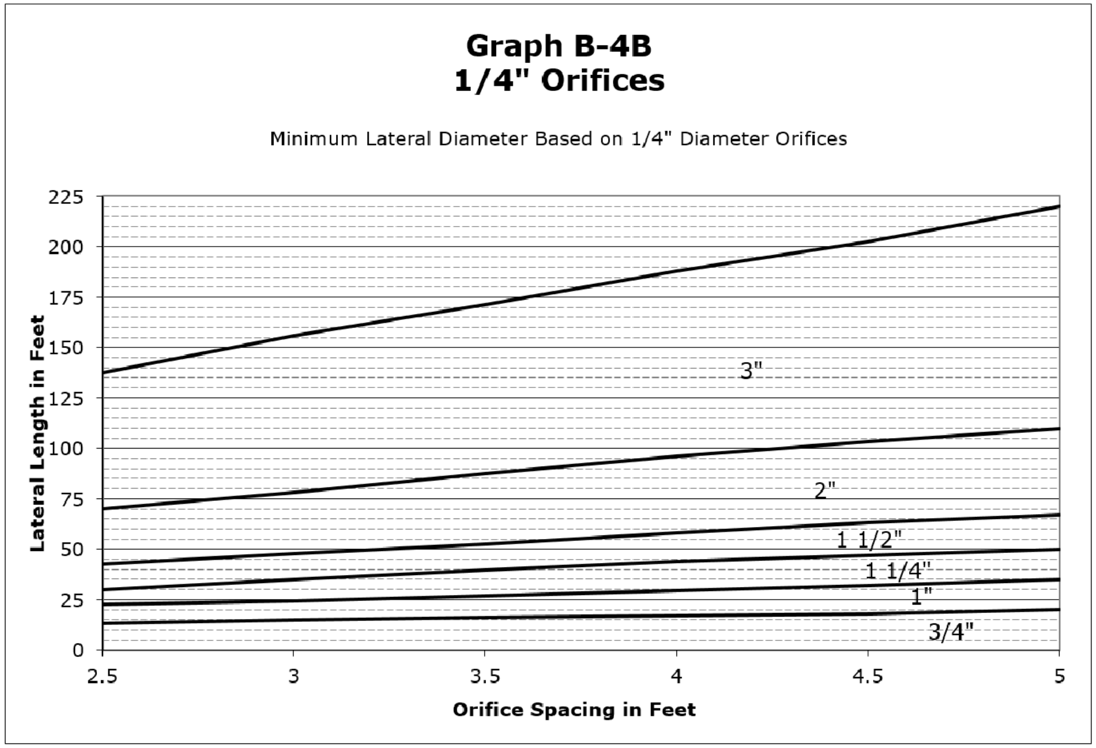

Graph B-2A
5/32" Orifices
Minimum Lateral Diameter Based on 5/32" Diameter Orifices
Lateral Length in Feet
Orifice Spacing in Feet
275
250
225
200
175
150
125
100
75
50
25
0
0.5
1
1.5
2
2.5
3"
2"
1 1/2"
1 1/4"
1"
3/4"


Graph B-2B
5/32" Orifices
Minimum Lateral Diameter Based on 5/32" Diameter Orifices
Lateral Length in Feet
Orifice Spacing in Feet
450
400
350
300
250
200
150
100
50
0
2.5
3
3.5
4
4.5
5
3"
2"
1 1/2"
1 1/4"
1"
3/4"


Graph B-3A
3/16" Orifices
Minimum Lateral Diameter Based on 3/16" Diameter Orifices
Lateral Length in Feet
Orifice Spacing in Feet
0
25
50
75
100
125
150
175
200
0.5
1
1.5
2
2.5
3"
2"
1 1/2"
1 1/4"
1"
3/4"


Graph B-3B
3/16" Orifices
Minimum Lateral Diameter Based on 3/16" Diameter Orifices
Lateral Length in Feet
Orifice Spacing in Feet
350
300
250
200
150
100
50
0
2.5
3
3.5
4
4.5
5
3"
2"
1 1/2"
1 1/4"
1"
3/4"


Graph B-4A
1/4" Orifices
Minimum Lateral Diameter Based on 1/4" Diameter Orifices
3"
2"
1 1/2"
1 1/4"
1"
3/4"
Lateral Length in Feet
150
125
100
75
50
25
0
0.5
1
1.5
2
2.5
Orifice Spacing in Feet



Graph B-4B
1/4" Orifices
Minimum Lateral Diameter Based on 1/4" Diameter Orifices
Lateral Length in Feet
225
200
175
150
125
100
75
50
25
0
Orifice Spacing in Feet
2.5
3
3.5
4
4.5
5
3"
2"
1 1/2"
1 1/4"
1"
3/4"

Orifice Flow Rates in Gallons Per Minute (GPM				
Pressure in Feet	**Orifice Diameter**			
	1/8"	**5/32"**	**3/16"**	**1/4"**
2.0	0.26	0.41	0.59	1.04
2.5	0.29	0.46	0.66	1.17
3.0	0.32	0.50	0.72	1.28
3.5	0.34	0.54	0.78	1.38
4.0	0.37	0.58	0.83	1.47
4.5	0.39	0.61	0.88	1.56
5.0	0.41	0.64	0.93	1.65
5.5	0.43	0.68	0.97	1.73
6.0	0.45	0.71	1.02	1.80
6.5	0.47	0.73	1.06	1.88
7.0	0.49	0.76	1.10	1.95
7.5	0.50	0.79	1.14	2.02
8.0	0.52	0.81	1.17	2.08
8.5	0.54	0.84	1.21	2.15
9.0	0.55	0.86	1.24	2.21
9.5	0.57	0.89	1.28	2.27
10.0	0.58	0.91	1.31	2.33

Table B-5: Orifice flow rates

Frictional Head Loss per 100 feet of Solid Pipe							
Gallons Per Minute	**Nominal Pipe Size**						
	3/4”	**1”**	**1 ¼”**	**1 ½”**	**2”**	**3”**	**4”**
3	3.24	0.80	0.27	0.11	0.03	0.00	0.00
4	5.51	1.36	0.46	0.19	0.05	0.01	0.00
5	8.34	2.05	0.69	0.28	0.07	0.01	0.00
6	11.68	2.88	0.97	0.40	0.10	0.01	0.00
7	15.55	3.83	1.29	0.53	0.13	0.02	0.00
8	19.91	4.90	1.65	0.68	0.17	0.02	0.01
9	24.76	6.10	2.06	0.85	0.21	0.03	0.01
10	30.09	7.41	2.50	1.03	0.25	0.04	0.01
11	35.90	8.84	2.98	1.23	0.30	0.04	0.01
12	42.18	10.39	3.50	1.44	0.36	0.05	0.01
13	48.92	12.05	4.06	1.67	0.41	0.06	0.01
14	56.12	13.82	4.66	1.92	0.47	0.07	0.02
15	63.77	15.71	5.30	2.18	0.54	0.07	0.02
16	71.87	17.70	5.97	2.46	0.60	0.08	0.02
17	80.40	19.80	6.68	2.75	0.68	0.09	0.02
18	89.38	22.01	7.42	3.06	0.75	0.10	0.03
19	98.80	24.33	8.21	3.38	0.83	0.12	0.03
20	108.64	26.76	9.02	3.71	0.91	0.13	0.03
25	164.24	40.45	13.64	5.61	1.38	0.19	0.05
30	230.21	56.70	19.12	7.87	1.94	0.27	0.07
35	306.27	75.43	25.44	10.47	2.58	0.36	0.09
40	392.20	96.60	32.58	13.40	3.30	0.46	0.11
45		120.14	40.52	16.67	4.11	0.57	0.14
50		146.03	49.25	20.26	4.99	0.69	0.17
60		204.68	69.03	28.40	7.00	0.97	0.24
70		272.31	91.84	37.79	9.31	1.29	0.32
80		348.71	117.61	48.39	11.92	1.65	0.41
90			146.28	60.19	14.82	2.06	0.51
100			177.80	73.16	18.02	2.50	0.62
125			268.78	110.59	27.24	3.78	0.93
150				155.01	38.18	5.30	1.30
175				206.23	50.79	7.05	1.74

Table B-6: Frictional head loss per 100 feet of solid pipe

Based on Hazen-Williams equation hL = L*(Q/(0.285*C*d^2.63))^1.852 where C = ~145, L= 100, Q = GPM

Head loss in table must be corrected for pipe length:

(head Loss from table) x (pipe length/100) = head loss in pipe

Frictional Losses through Plastic Fittings in terms of Equivalent Length of Solid Pipe								
	Nominal Pipe Diameter							
Type of Fitting	**1/2"**	**3/4"**	**1"**	**1 ¼"**	**1 ½"**	**2"**	**3"**	**4"**
90° STD Elbow	2	2	3	4	4	6	8	12
45° Elbow	1	1	2	2	2	3	4	5
STD Tee	4	5	6	8	9	12	16	22
Check Valve	4	6	7	9	11	14	19	25
Quick Disconnect	1	1	1	1	1	1	2	3
Angle Valve	8	12	15	19	22	28	40	55
Globe Valve	15	22	27	35	45	60	80	110
Gate Valve - Open	1	1	1	1	1	1	2	3
1/4 Closed	2	3	4	5	6	7	10	14
1/2 Closed	10	14	17	22	25	35	50	70
3/4 Closed	40	55	70	90	105	140	200	300

Table B-7: Frictional losses through plastic fittings

Pipe Volumes	
Nominal Pipe Diameter	**Volume (gal./LF)**
1/2"	0.010
3/4"	0.023
1"	0.041
1-1/4"	0.064
1-1/2"	0.092
2"	0.163
3"	0.367
4"	0.652

Table B-8: Void volume for various diameter pipes