

SUBSURFACE DRIPLINE GUIDE



 **NETAFIM**™
Landscape & Turf Division

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A CULTURE OF CONSERVATION

In 1965, Netafim made history with the unique concept of drip irrigation that not only revolutionized traditional irrigation practices but gave us a way to beautify the environment without wasting precious resources. Today, together with over 45 years of experience and ambitious, dedicated Research and Development, Netafim continues to take irrigation technology and performance, along with conservation to new heights.

Among its accomplishments, Netafim developed products that have been used successfully in turfgrass since the 1980's. They are a popular choice for a variety of residential and commercial, general and specialized-use turf areas, and have been used very successfully in sports turf as well as composition and grass tennis courts.

There are many myths surrounding the issue of dripline in subsurface, or below grade applications, especially in turf. That is the reason for this guide. It is time to realize that subsurface irrigation works and works very well. Landscape irrigation contractors are in the business of maximizing the beauty of a property, and drip and dripline does it better than overhead sprinklers. They do it faster, and they do it while saving water.

As with so many new ideas, we have perfected the fine art of filling in the blanks with negatives. We've all done it. A frequent response is to sidestep potential problems by maintaining the status quo and leaving well enough alone. But there's another twist to it. It's the "If I'm not familiar with it, it must be bad" syndrome. For example, you walk into a store and ask a question about a product or service. Instead of the salesperson admitting that the product isn't sold there, or that they simply don't know the answer, you hear phrases like, "You don't want that," or "That'll never work." Let's be clear, the question was legitimate, it's the answer that wasn't.

Many people imagine that there are no problems with overhead irrigation. To believe that, you must also believe:

- Nozzles are never pointed in the wrong direction
- Sprinkler heads don't break
- Hardscapes, plants and trees aren't battered, stained and ruined by spray
- Spray always reaches into the garden, and the coverage is always perfect.

The following pictures illustrate common problems associated with overhead sprinklers.



Figure 1 - Broken sprinkler floods street and hardscape causing damage.



Figure 2 - Sprinklers out of adjustment and wind drift.



Figure 3 - Sprinkler damage to trees.



Figure 4 - Misplaced sprinklers and trenches not properly compacted.

A CULTURE OF CONSERVATION
(continued)



Figure 5 - Wood fence bleached by sprinkler spray.



Figure 6 - Sprinkler hit by lawnmower.



Figure 7 - Examples of how people struggle to keep vegetation from blocking a sprinkler's throw.



A CULTURE OF CONSERVATION (continued)

Here are a few words and phrases that describe the advantages of drip irrigation and dripline. They appear in no particular order of importance and they help set the stage for what we are going to discuss in this guide:

- Increases efficiency
- Uses less water
- Less likely to be banned during droughts
- Lower water pressures needed
- Reduces maintenance
- Lower lifetime system cost
- Smaller water tap or meter
- Increases plant growth
- Delivers outstanding uniformity
- Increases water window
- Less evaporative loss
- Hardscapes remain undamaged
- Wind issues are eliminated
- Plant obstruction issues removed
- No water-stained buildings or windows
- No damage to trees or fences
- Out of sight, out of mind
- Reduces plant disease
- No sprinkler “donuts”
- Dry streets and sidewalks increases safety
- No nozzles to break, steal or misalign
- Reduces liability
- Less water runs down the street and into the storm sewers
- Conforms to any landscape shape
- Reclaimed or recycled water can be used
- Check valves in emitters
- Works with fertigation
- Larger zones are possible
- Smaller station-count controllers
- Fewer valves
- Happier neighbors
- Great on slopes
- Curved areas easy to irrigate
- Borders are easier to irrigate

Netafim is one of the only companies that manufacture a subsurface dripline product that is proven to work in turf - Techline® CV and Techline® DL Dripline. For the purposes of this book we are going to focus on Techline CV, the newer of the two products and the product that incorporates a check valve into every emitter. **Note:** Techline has proven itself in the most rigorous conditions possible and its emitter, which dates back to 1983, is still performing today around the world. Whenever 'Techline CV' is noted, except when we describe a built-in check valve, you can also say 'Techline DL'.

We also need to get past a few of the issues that can confuse a legitimate discussion on subsurface irrigation in turfgrass (also known as Subsurface Drip Irrigation or SDI). Once we do that, we can make more sense of the subject. They include:

- Not every dripline is capable of performing subsurface (or not all driplines are created equal)
- The fear of root intrusion needn't chase you away
- Neither should the fear of stripes in the grass



NOT EVERY DRIPLINE IS CAPABLE OF PERFORMING SUBSURFACE

The answer rests in how the emitter was designed and what it was intended for.

Most companies that produce dripline do so with the expectation that the dripline will end up in a garden environment, laid out in rows, stapled down and covered with a layer of mulch. They never planned on the dripline being buried in the ground.

There was a time when product designers and sales people fought over whether an emitter should be pressure compensating (PC) or not. From a design standpoint, pressure compensation is more challenging because engineers have to design an emitter that emits the same amount of water over a broad range of pressure. However, the cost to design such an emitter is much more than designing an emitter that simply delivers less and less water along the length of the tubing as the pressure decreases. (Much like a sprinkler or tubing made from ground-up car tires.) Then, in order to bury the tubing, a design solution was needed to keep roots from growing into the emitters and the tubing - which meant designing an emitter that mounts inside the tubing.

There are several products on the market that are either non-pressure compensating or are pressure compensating but cannot protect against root intrusion or soil infiltration. But because most rotors and sprays are assumed to be largely the same, companies decided that contractors and end-users probably wouldn't notice that not all driplines are created equal.

Conclusion: A non-pressure compensating dripline is fine for a garden where the run lengths aren't too long and it is being laid on-surface. To install dripline in a subsurface application, you are going to need a dripline that has PC emitters and the emitters must be designed with a permanent way to keep the roots from freely invading the emitter outlets. The dripline must also have an anti-siphon feature to keep soil from being sucked back into the emitter when the system turns off and a vacuum is created.

The Netafim Solution: Techline® CV Dripline. The emitters in this product were designed for use in rigorous agricultural applications, with the full knowledge that they could end up irrigating a field of crops where the only water source is ditch water, and where, if the system failed, the farmer might lose not only his crop, but his livelihood as well. So when these emitters are used in Techline CV, you know they were meant for a much harsher world than the emitters designed for a typical homeowner's garden. If Techline CV will work in agricultural applications, they will certainly work in Mr. and Mrs. Smith's yard.



Techline CV Dripline

Note: When other brands of products make their tubing the same color as Netafim, it's a marketing response, not an engineering or product quality response.

THE FEAR OF ROOT INTRUSION NEEDN'T CHASE YOU AWAY

Root intrusion can occur by burying a dripline that was only designed for on-surface application, doesn't have a physical root barrier or by not irrigating properly. One is easy to fix, one isn't.

Using an on-surface dripline in subsurface applications is asking for trouble. Because it isn't always easy to determine what can be used in a specific application, look at the manufacturer's printed product application data. The catalog is always the best place to start. If they do not specifically and clearly say that a product can be used in subsurface applications, or that it can be used in turf, it cannot. If used in a subsurface application, these poorly engineered emitters can and will allow roots to penetrate the emitter opening(s) and grow into the passageways of the emitters, eventually clogging the emitter.

Remember the engineers and sales people battling it out above? Here's what could have happened. They decided to sell their product for garden applications (on-surface or under mulch) because it was easier, it was a good-sized market, and they probably decided not to worry about subsurface, choosing instead to take the Scarlett O'Hara way out. They designed an emitter without concern for roots, and the emitter they came up with is frequently used in on-surface dripline products. Many

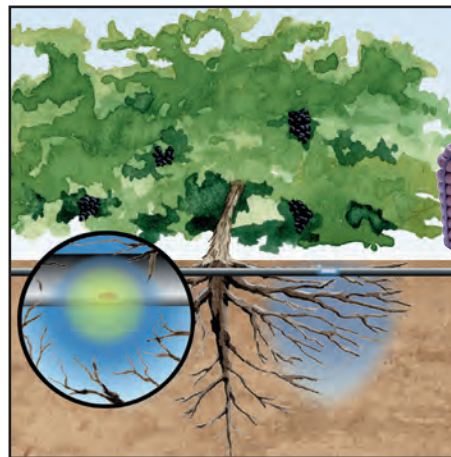
**THE FEAR OF
ROOT INTRUSION
NEEDN'T CHASE
YOU AWAY**
(continued)

companies sell such a product. It has two outlets for each emitter and the tubing has the look of a snake that swallowed a mouse. That is, the tubing's outside diameter (O.D.) increases where the emitter is located. Though brands and models vary, the two holes in a emitter's outlet allow the water to flow out of either or both holes. Importantly, and not for a good reason, the holes are at the immediate end of the emitter's passageway, or labyrinth. Because of this design, the water leaves the labyrinth and the tubing in the same place. This means that the roots have a far easier pathway into the emitter. These emitters are also plagued by the issue of having to capture the water from the inside wall of the tubing, where it is dirtiest. In contrast, water that flows down the center of tubing is the cleanest, but these emitters that bulge on the inside of the tubing cannot get their water from the center of the water flow.

Realizing the inherent flaw in this type of emitter, one company decided to impregnate the emitter with a chemical that would inhibit roots from penetrating the emitter's hole. Actually, this wasn't a bad idea, except that the chemical used is both heat and time sensitive. As long as the chemical remains active and in proper concentrations in the emitter, it will battle the roots. But when the chemical's potency rapidly decreases, the emitter becomes no better than what it was before being chemically altered, and becomes a root sensitive emitter.

We don't want to sour you on the idea of using a chemical to help protect against root intrusion because Netafim sells Techfilter®, a product that uses the same chemical described above but in a renewable cartridge form. Simply put, if chemical protection needs to be replaced, it needs to be placed where people can get to it. In this case, Netafim put it in the rings of a disc filter. When you use Netafim Techfilter and replace the cartridge per instructions, Netafim offers a Limited Lifetime Warranty against root intrusion.

Trifluralin
forms a
chemical
barrier
around the
emitter.



Techfilter System

Sold with Techline CV and Techline DL Dripline for use on a new installation. Techfilter is sold as part of a system and cannot be sold without the proper amount of dripline.

Figure 8 - Netafim Techfilter system.

FREQUENT, SHALLOW-ROOT WATERING CAN POTENTIALLY LEAD TO SHALLOW ROOTS

There is another reason why roots could become a problem. The system is being irrigated incorrectly. While it is true that you can promote shallow roots by irrigating daily with overhead sprinklers, you can't compare daily sprinkler watering to daily dripline watering.

Sprinklers throw water through the air. Depending on the water's velocity and the droplet size leaving the nozzle, the droplets will land somewhere out in the yard. Once there, the droplets sit on the surface, or slowly get absorbed into the soil. As more and more droplets hit the same area, a wetted area on the top of the soil is created. If you water too quickly, exceeding the basic intake rate of the soil much of the water will run off. If you don't lay enough water down, the effect is to create a very shallow area for roots to grow.

In contrast, subsurface dripline irrigation relies on the soil to hand off and absorb water molecules as you irrigate. Because the dripline is already below the surface, some of the water moves upward, (through capillary action) some radiates outward and some moves downward. How much is determined by the speed of application and the type of soil.

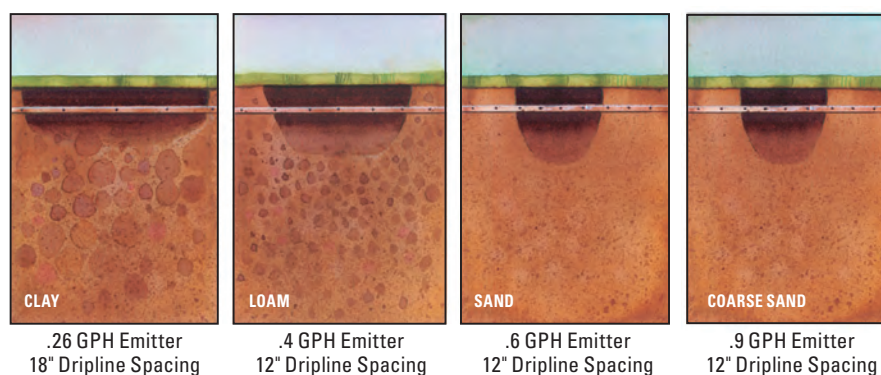


Figure 9 - Relative movement of water based on soil type and recommended emitter flow and dripline spacing.

Note: Always use the lowest flow rate emitter possible. We recommend the following emitter flow rates:

- **0.26 GPH** for clay
- **0.4 GPH** for loam
- **0.6 GPH** for sand
- **0.9 GPH** for coarse sand

These flow rates not only allow you to maximize zone size, they apply the water at the proper rate for the soil to properly absorb and radiate it.

By irrigating on a daily basis, we develop a very large wetted area below the surface, and as such, two things happen:

- 1** The roots are allowed to reach deep into the soil because there is moisture available for them.
- 2** The water can reach out to its maximum radius when the soil stays moist. That's because it is easier for water molecules to move when they are in a consistently moist environment. (Capillary action)

Note: The physics and hydraulics are not the same with subsurface dripline irrigation as they are with overhead sprinklers. As such - those who believe in infrequent deep-root watering practice for overhead sprinklers may continue to do so.

FREQUENT, SHALLOW-ROOT WATERING CAN POTENTIALLY LEAD TO SHALLOW ROOTS
(continued)

The rationale is simple. If you allow the soil to go through dry/wet cycles, the area nearest the emitter will be the area where most of the roots will congregate. It will also make it harder for the water molecules to reach outward as far as possible. **Note:** Daily or every-other-day irrigation allows the area immediately around the emitter to be at or above field capacity. When the soil is in this 'super-saturated' state, roots won't grow into that area.

Moral: Root intrusion is not a problem if you choose the proper product and irrigate on a daily or every-other-day basis. You are simply maintaining a consistent and balanced level of moisture in the soil allowing the plants and turf to thrive without having to 'search' for water. As for the product to use, that is where you need to do your homework. But no method of water application will maintain an optimal mix of air and water in the soil profile better than subsurface drip irrigation.

The Netafim Solution: Use Techline CV Dripline. Here's why - the emitter uses a single hole outlet, but more importantly, the water leaves the emitter in one place and exits the emitter in another. We call this the 'physical root barrier'. Water exits Techline CV emitters into an air gap chamber area. When the emitter isn't running, the area is void of water. Also, Techline CV emitters are mounted to the inside wall of the tubing and have a raised lip surrounding the exit hole while the inlet area extends down into the center of the tubing where it captures the cleanest possible water. Techline CV Outside Diameter (O.D.) tubing is consistent with no increases in diameter where the emitter is located.

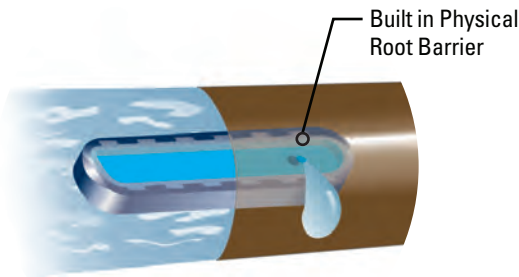


Figure 10 - Transparent view of emitter inside tubing.

EXPLODED VIEW OF TECHLINE CV EMITTER

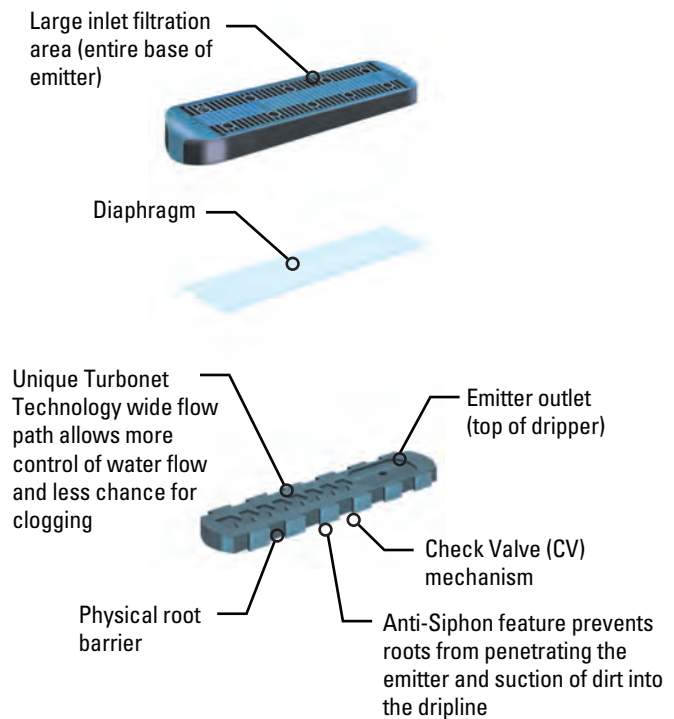


Figure 11 - Exploded view of a Netafim Techline CV Emitter.

THE FEAR OF STRIPES IN THE GRASS

The issue boils down to proper design, installation, and operation. Any irrigation system design that takes into account the type of soil, the plant material being watered, the available water source and all of the other external factors needed will translate into a good system. If down the road the plant material show signs of stress, there are two possible scenarios. Either the system was improperly designed or the system is improperly scheduled.

We'll talk later about the importance of the charts we use in helping you determine the type and amount of dripline based on the soil type and the plant materials being watered. For now, we need to introduce a concept called 'pulsing.'

Pulsing is the frequent on-off cycling of a zone of dripline for the purpose of moving water as far outward, upward and downward as possible.

While some may think that increasing the watering time is the way to push the water farther out, it isn't. Neither is using an emitter with a flow rate above our recommendations. In fact, both go counter to what you should do.

Long run times allow the soil to become super-saturated with water. As such, the soil loses its ability to hold water against gravity, (field capacity) and the water becomes 'gravitational.'



Figure 12 - Aerial view of sports field with severe 'donuts' caused by rotary sprinklers.

IMPORTANT DEFINITIONS

Capillary Action: The radial (outward and upward) movement of water through the soil that fills the spaces between particles with capillary moisture.

Capillary Moisture: The water held in pore spaces by the surface tension between the water and the soil particles. This is the primary source of water for plants and is also referred to as "available moisture."

Gravitational Water: Free water in the soil which moves downward due to gravity. After a soil has been saturated, the gravitational water percolates downward, leaving the soil at field capacity.

Field Capacity: As much water as the soil can hold against the influence of gravity. If a soil is saturated by rainfall or irrigation and then allowed to drain freely for 24 hours, the soil is usually at field capacity.

Infiltration Rate: The rate at which water enters the soil. This rate varies greatly, and may impose a limitation upon the design of an irrigation system since water application rates in excess of the infiltration rate may result in runoff and erosion.

As we discussed earlier, a dripline system should be run every day or every other day to establish and maintain a consistent moisture balance in the soil. It is this consistent moisture level that will allow the water to radiate as far outward, upward and downward as far as possible, and it is precisely because of this that you will achieve optimal plant growth. Should plant materials show signs of stress in an otherwise well-designed system, the culprit is typically improper scheduling.

Before we move on, some people may ask about water quality. That is, what kind of water should I use, or more importantly not use.

THE FEAR OF STRIPES IN THE GRASS (continued)

Netafim driplines are designed to operate for a lifetime regardless of whether the water comes from a municipal source, a lake, or a well. All that is required is a way of removing debris from the water and for that we use a filter. For water with dissolved minerals such as calcium, there are some simple and straightforward ways of dealing with that as well.

Calcium can become a problem in water when it has a chance to precipitate and dry. When it does it can cake into a hard obstruction and possibly become a problem. But calcium has a very hard time affixing itself to polyethylene, which is what Netafim dripline is made from. In many cases, this will eliminate any problem. But to further reduce the chance of drying and caking, we recommend that the dripline be buried subsurface and irrigated daily. By doing so, the surrounding soil will keep the environment moist and preclude any problems.

WHERE CAN DRIPLINE BE USED?

Driplines can be used virtually any place where you can use overhead sprinklers because sprinklers and dripline are trying to accomplish the same thing. Both are trying to create an even wetted pattern throughout the soil profile.

Problems with sprinklers arise though because they are less capable of delivering a consistent balance of water throughout the zones:

- Sprinklers throw water through the air. Sometimes it is windy, sometimes it isn't. Sometimes it is very dry, and other times it isn't.
- Sprinkler performance can also be negatively impacted by changes in pressure. Water pressure changes during the day alter performance, as does the ever-decreasing pressure down a sprinkler lateral.
- Even identical sprinklers farther downstream on a piping lateral do not perform the same as sprinklers closer to the beginning of the line.
- Choosing the proper sprinkler nozzle based on radius and arc can create even more imbalance in a zone, along with how the radius adjustment is set and if the head is properly set to grade.
- Trees, plants, shrubs, flowers, and other natural or man-made obstructions further hinder the proper performance of a sprinkler.

Conclusion: Even if the sprinklers are laid out and installed properly, there are many influences out of a designer or contractor's control that play a major role in the erratic application of water.

FACTORS Affecting Performance		
Condition	Sprinklers	Netafim Dripline
Water Pressure	Yes	No
Humidity	Yes	No
Wind	Yes	No
Obstructions	Yes	No
Arc	Yes	No
Nozzle Adjustment	Yes	No
Decreasing Flow Over Distance	Yes	No
Properly Set to Grade	Yes	No
Slope	Yes	No

Table 1 - Performance factors of sprinklers versus dripline.

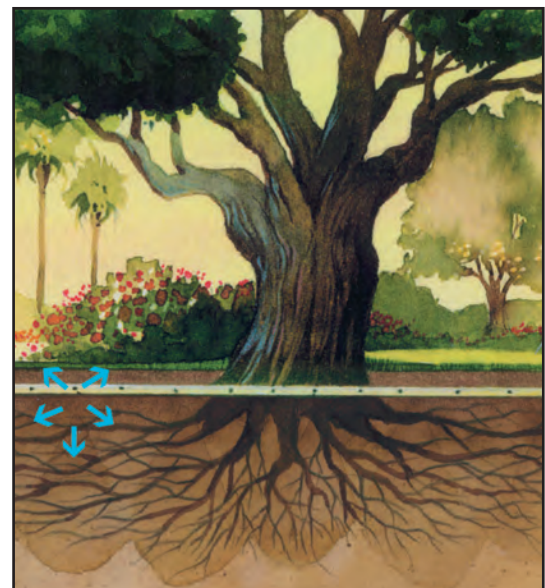


Figure 13 - The upward, outward and downward movement of water in a dripline system.

WHERE CAN DRIPLINE BE USED? (continued)

Dripline irrigation on the other hand relies on soil as its transportation medium. As water leaves the emitter, it is captured by the soil. Just like a napkin that absorbs a drop of water and the water spreads upward and outward, water moves outward, upward, and downward away from the emitter outlet into the outlying soil.

Note: For those who do not think that water could possibly move upward against gravity, hold a napkin vertically as you dip it into some water.

In order to simplify the process of choosing the proper dripline flow rate, emitter interval and row spacing, Netafim has developed guidelines based on the answers to these simple questions. Try answering these questions with a sprinkler!

- 1 What Are You Irrigating - Turf or Garden?
- 2 Do you Have a Clay, Loam, or Sandy Soil?
- 3 How Many Square Feet are You Irrigating?

WHERE DRIPLINE MAY NOT BE THE BEST CHOICE

If you have a very rocky, shaly soil, it could be labor intensive to install dripline. Once installed, however, it will work fine. If you live along an ocean coastline, where plants may benefit from having the salt spray washed off the leaves, sprinklers may be an option, or may be used in conjunction with a dripline system. Lastly, if you are relying on the irrigation system to break down and water-in granular fertilizers and chemicals, dripline may not be your best choice.

AERATING THE SOIL AND A SUBSURFACE DRIPLINE SYSTEM

The rationale for aerating is to relieve soil compaction, ensuring that there is good pore space between soil particles and that there is enough oxygen in the soil. One of the reasons aeration is necessary is that the soil can become compacted by foot, vehicular, or mower traffic.

Aeration can be done several ways, among them core, deep tine and water injecting.

Our work has shown that a properly installed and irrigated subsurface dripline actually requires less aeration, if any, when compared to an overhead sprinkler system.

Because of the dripline's ability to create a very uniform, wetted pattern that reaches far below the surface, the pore spaces of the soil are actually filled with water. As such, they are more resilient to traffic and less likely to compact.

If core aeration will be done, the tines must be set to a depth less than the depth of the dripline. Knowing this ahead of time is important, as you may need to install the dripline consistently at a depth of 6 inches, while ensuring that any aeration is done no deeper than 4 inches.

If deep tine aeration is going to be used on a project, it is probably not logical to use dripline. The risk of substantial damage may be too great.

If a water-injecting aerator unit is being used, an area should be tested to determine what pressure the injector should be set so it does not damage the dripline.

WHERE DRIPLINE IS THE BEST CHOICE

The list of applications where dripline is the best choice is long for two reasons. Netafim dripline products do the best job of creating an even wetted pattern in the soil because they move the water through the soil, while sprinklers need to throw water to get it where it's going. As we have seen, throwing water through the air is the sprinkler's downfall.

WHERE DRIPLINE IS THE BEST CHOICE (continued)

LONG, ODD-SHAPED OR NARROW AREAS:

- 'Border Zones' - Along sidewalks, streets, windows, fences, parking areas and walls
- Curvilinear design layouts that cannot be properly watered with sprinklers
- Eliminates the maintenance related to wet roads, sidewalks and other hardscapes
- Helps save water
- Reduces tripping hazards
- Reduces wet surface slipping hazards to pedestrian and vehicle traffic
- Irrigates areas with less water in long narrow areas where either getting the water is hard, or zoning the area is difficult
- Allows for a smaller station-count controller, smaller point-of-connection and fewer valves
- Eliminates overspray
- Staining and bleaching of hardscapes and landscapes are eliminated



Figure 14 - Before and after pictures of Techline CV Dripline installed on grass strips along light railway bed.



Figure 15 - Examples of subsurface Techline Dripline in narrow strips, medians and odd-shaped public areas.



WHERE DRIPLINE IS THE BEST CHOICE
(continued)

AREAS CLOSE TO BUILDINGS AND AT-GRADE WINDOWS:

- Stops windows and facades from getting wet or spotted with water
- Reduces deterioration and discoloration of building facades

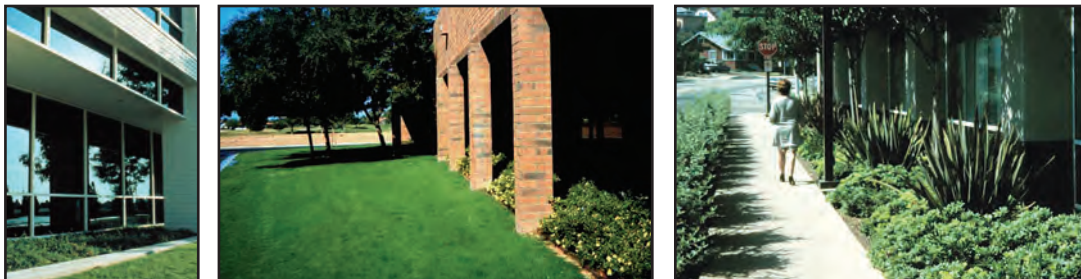


Figure 16 - Dripline installations along buildings, at-grade windows and sidewalks.

ATHLETIC FIELDS:

- Safety - no exposed sprinklers means no slipping or tripping injuries
- No wet grass
- On tight-soil fields:
 - Fields can be irrigated and softened prior to play without wetting the surface
 - Helps reduce impact injuries from hard soil surfaces
- Because water window issues are eliminated, time of play increases
- Soil conditions that remain consistently moist reduce the need for aeration
- Fields that have low water pressure or supply can now be irrigated



Figure 17 - Formal Croquet Court.



Figure 18 - Professional Championship Tennis Court.

WHERE DRIPLINE IS THE BEST CHOICE
(continued)

AUTO DEALERSHIPS AND OTHER PARKING AREAS:

- Areas that have low water pressure or supply can now be irrigated. No overspray reduces the cost of auto detailing
- Reduces slipping and tripping hazards
- Reduces wet surface hazards to pedestrian and vehicle traffic
- Allows for a small station-count controller and fewer valves because many similar areas can be tied together



Figure 19 - Irrigating narrow strips at auto dealerships.

GARDENS:

- Gets water to all areas
- Plants sensitive to water on petals such as roses are protected
- Water is applied directly to the root zone
- Seasonal plant growth interference is eliminated



Figure 20 - Irrigating delicate flowers and roses without damaging plants.



Figure 21 - Plantings allowed to grow to maturity without sprinkler interference.

HIGH WIND, OR CONSTANT WIND AREAS:

- Overspray and wasted water are eliminated
- Water gets to where it is supposed to be
- Uniform irrigation regardless of wind

WHERE DRIPLINE IS THE BEST CHOICE
(continued)



Figure 22 - Irrigating small, tight areas in planters where "soil-less" or minimal soils are used.

GREEN ROOFS:

- Either intensive or extensive
- Can be used below grade in media less than an inch
- Allows for a minimum level of soil and soil mixes (1" to 5")
- Netafim driplines are not affected by the thin soil layer that can lead to a mat that is highly populated with roots
- Reduces weeds which is a plus on "extensive" roofs that are not designed for public use

HIGH LIABILITY AREAS:

- Tripping, slipping and other liability issues are significantly reduced
- Maintenance costs to repair broken sprinkler heads are greatly reduced or eliminated

VANDAL-PRONE & PUBLIC PROPERTIES:

- "Out of sight, out of mind"
- Greatly reduces maintenance costs
- Reduces potential liability caused by unrepaired problems
- Eliminates phone calls in the middle of the night
- Allows for a 24 hour-a-day water window

WHERE DRIPLINE IS THE BEST CHOICE
(continued)



Figure 23 - All areas in these photos, including turf, odd-shaped areas, narrow grass strips between pavers and planters are irrigated with drip and dripline.

HARDSCAPES:

- Eliminates bleaching and staining of hardscapes, such as wooden fences maintaining the aesthetics of hardscapes
- Excellent for grass strips between pavers on patios

REDUCES LANDSCAPE PLANTING BUDGET:

- Drip and dripline dramatically increase a plant's growth to maturity
- Allows for more, less expensive container sized plants to be used with the same result as more larger, more expensive containers

STEEP SLOPES:

- Allows turf or plantings to be used on slopes
- Plant's speed of growth to maturity is significantly increased, meaning a reduced risk of slope damage early on
- Water is more easily managed on slopes with dripline
- Wash outs and swales are virtually eliminated
- Pocket walls



Figure 24 - Examples of pocket walls irrigated with Netafim Dripline.

WHERE DRIPLINE IS THE BEST CHOICE (continued)

LOCALES WHERE THE COST OF WATER IS VERY HIGH:

Unlike overhead irrigation, which does not have an even application rate across its pattern, products like Netafim Techline CV and Techline DL Dripline:

- Have an extremely well-balanced application rate in the entire area
- Eliminate over-watering ensuring the driest area receives enough water
- Uses about half (frequently less than half) of the water of an overhead system
- 90% + efficient vs. overhead irrigation, which is about 60% efficient
- Techline CV seals in 1.3 gallons of water for every 100 feet, saving water from draining out of the dripline when the zone shuts off

RECYCLED/RECLAIMED WATER OR FERTIGATION APPLICATIONS WHERE SPRAYING WATER IS ILLEGAL:

- Allows for use of nutrient-rich water, often at a greatly reduced cost
- Conserves precious potable water supplies
- Great solution for when no human contact with recycled/reclaimed water is required by health codes

Note: When working with on-site wastewater drip dispersal, federal, state and local regulations will typically require the use of Netafim Bioline. Please contact Netafim's Wastewater Division for more information.



Coil of Techline RW for Reclaimed Water

WATER WINDOW ISSUES:

Irrigate whenever it is necessary because the system will not interfere with any activities being conducted.

SNOW-BELT AREAS USING SALT ON STREETS AND SIDEWALKS:

- Dripline can help leach salts from the soil in early spring
- Approximately 50% of the salts can be removed when the water gets 12" into the soil
- Approximately 90% of the salts can be removed when the water gets 24" into the soil

OTHER AREAS:

- Areas with extensive large tree roots
- Fertigation systems
- Green building projects
- Highly regulated water use areas

IRRIGATION APPLICATION RATE EFFICIENCY

Before we begin this section, we need to agree that plants have a requirement for a certain amount of water, and that this requirement will vary by plant type, region and time of year. The irrigation system that can deliver the proper amount of water to meet those needs without waste due to runoff, overspray, evaporation, over-watering to ensure you don't get donuts, etc., will be the most efficient. By now you have seen that dripline and drip irrigation do just that, and by being the most efficient method, and drip and driplines, they save water that otherwise would not have been used by the landscape.

'Irrigation Application Rate Efficiency' is one of those topics where good contractors are often separated from other contractors. It refers to what percentage of water being applied actually gets into the active root zone. What that percentage is has been a hotly-debated topic.

Dripline uses less water (because it reduces waste) and grows healthier plants than sprinklers. If it didn't, most of the vineyards in California and around the world would use sprinklers, and most of the greenhouses would just use sprinklers. But they don't, because they know they can use less water (higher application rate efficiency) with drip and dripline than with sprinklers. The amount varies from area to area. On a hot, windy day in southern Arizona, maybe 30% of the water from a sprinkler gets useably into the root zone. In New England, maybe it's 70%. Where does the other water go? Everywhere but where it should.

SOME PLACES WHERE SPRINKLER WATER GOES (that it shouldn't):

- Evaporation due to low humidity
- Evaporation due to nozzles that are atomizing the water because the pressure is too high
- Wind drift
- Onto the blades of grass or petals and leaves, there to be evaporated
- Down the sidewalk
- Down the driveway
- On your car
- On cars driving by
- On to pedestrians walking by
- Into the storm sewer
- Into the trees
- Into the neighbor's lawn
- Onto your house, or the neighbor's house

In short, sprinklers are inefficient. They use too much water and waste much of it.

THE ISSUE OF WATER

Water has always been critical to life, but it is only now beginning to get the national attention it deserves. In areas like Marin County, restrictions have been in effect since the late 1970's regarding the amount of turf allowed. In areas like Denver, Colorado, entire bans have been placed on sprinkler systems because of the drain they place on available water. In several southwest U.S. communities, sprinkler irrigation has been completely banned for narrow areas.

Here are some realities of water in the United States:

- With increasing populations come increasing strains on the water delivery networks
- Almost half of the potable water delivered is used for outdoor water (in some areas in the southwest it approaches 80%)
- Municipalities cannot afford to build new infrastructure to support the wasteful use of water
- Much of what can be done in the home to save water (low flush toilets, low flow shower heads, etc.), has already been done. Yet these have a more limited impact on water usage than conserving irrigation water.

THE ISSUE OF WATER (continued)

That leaves outdoor water use, and water districts are taking an increasingly aggressive position on its use. Their position is clear and simply put. Just because you buy the water doesn't give you the right to waste it.

Having said that, water purveyors are also sensitive to the political climate and they are not about to demand that everyone forfeit their lawns and gardens "for the cause." They are prepared however, to issue restrictions, and in some cases outright bans if needed. They also recognize the important role a healthy landscape plays in housing values, quality of life as well as the vital role that landscape plays in cleaning the air of pollutants, its cooling effects, and its ability to create oxygen.

So here we are, wrapping back around to the issue of application rate efficiency and the proof statements that drip and dripline irrigation saves water yet deliver as good or better a result in lawns or gardens. We find it in programs written by the U.S. Green Building Council (www.usgbc.org) which developed a comprehensive, voluntary, consensus-based national standard for developing high-performance, sustainable buildings. In it, they recognize the water saving ability of low volume by assigning an efficiency standard to it that is far higher than for sprinklers.

It is found in municipalities that allow drip and dripline systems to be used without interference when restrictions or bans are being placed on overhead sprinkler systems.

We say that our products will typically grow a plant to maturity in about half of the time of a sprinkler system, that we will use about half the water, and that when restrictions are being placed on sprinkler systems, low volume irrigation will not typically be part of the restriction. As you can now see, we say it from a strong position.

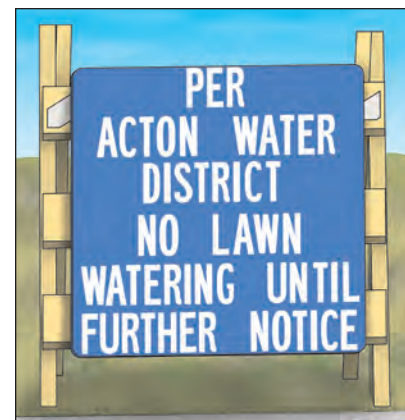


Figure 25 - How easy is it to ban watering? This easy.

LIFETIME COST OF AN IRRIGATION SYSTEM

There is an excellent story that Herb Kelleher, the genius behind Southwest Airlines tells. He was approached by a Southwest Airlines board member and asked if they should raise their \$19 fare because a competing airline on the same route was charging \$59. Mr. Kelleher pointed out that Southwest wasn't competing with other airlines. They were competing with ground transportation.

Herein rests the heart of the matter with low volume products:

- They grow and maintain turf and plant materials better than sprinklers
- They use far less water
- They require less maintenance
- They typically enjoy an exemption when other forms of irrigation are restricted or banned

Conclusion: A Netafim dripline system is less expensive over its lifetime. Not just for the end user, but for the community and the environment as well. To compare dripline irrigation systems to sprinkler systems is like comparing airplanes to buses.

WHAT ARE PEOPLE BUYING?

In the 1970's it was common to see manufacturers run ads touting how the "grass is always greener" with their brand of products. Those ads were based on the assumption that people wanted green grass. It seemed logical, but it was a bit over-simplified.

As companies began doing more research, they found that people wanted green grass but they also wanted more free time. They were willing to buy an irrigation system if it gave them the free time they wanted, but it had to be within reason. The contractor largely determined the system that was installed because the buyer was basing most of his decision on which contractor he wanted. The type and brand of products that would be installed was left primarily to the contractor. Studies at the time concluded that over 70% of potential irrigation system purchasers could not even name one brand of underground irrigation equipment!

Where are we today? The dynamics of the buyer have changed. They grasp resource conservation, and it has become something they (we) all deal with, and in many cases embrace. Whether it's the recycling bin, taking cans and bottles back to the grocery store, or considering a hybrid car, the conservation theme has permeated the minds of the consumer. The use of rain shut-off devices is one such example in the irrigation industry today. Something else has happened as well, the internet.

It is common today for a potential buyer to be much more active in the product selection process than he was in the 70's, 80's and early 90's. He studies which furnace, dishwasher, TV, automobile, and irrigation system is best suited to his needs.

This carries over and beyond residential irrigation and includes commercial and institutional as well. Today's buyer has a better idea of what is available than ever before. As well, he is prepared to listen to a water-conserving proposition from the contractor.

Conclusion/Reality: It's not a day that is coming. It is a day that is here, and the contractor best able to fulfill the needs of today's client, not yesterday's client, is the contractor who won't have to try to understand why business has dropped off.

LET'S TALK MAINTENANCE

Everyone knows that the least expensive truck, microwave, house paint, or trencher is not simply the one with the lowest price tag. Rather, the product that ends up costing the least over its useable life is the least expensive.

So too with an irrigation system. Without getting caught up in a bidding war with a competing contractor, the professional who can explain why his system will perform better, over a longer time, and ultimately cost less, has an excellent chance of winning the job.

When you can add both the savings in water and the savings in maintenance to the total system cost, you have a compelling proposition for the buyer.

We already know that a dripline system is going to save from 30% to 70% of the water of a sprinkler system, and with water cost increases and watering restrictions and bans a reality, that would be enough for most. But here is a study done by a maintenance company in Arizona that compared the maintenance cost of an overhead sprinkler system to a subsurface Netafim dripline system. It included three apartment buildings with approximately the same amount and type of landscape to maintain. All of the properties were maintained in the same way and by the same company.

MAINTENANCE Costs			
	COMPLEX A: 188 Ground Units SPRINKLER SYSTEM	COMPLEX B: 176 Ground Units SPRINKLER SYSTEM	COMPLEX C: 170 Ground Units SUBSURFACE NETAFIM DRIPLINE SYSTEM
	Maintenance Cost	Maintenance Cost	Maintenance Cost
January	\$75	\$120	\$0
February	\$135	\$195	\$0
March	\$85	\$105	\$0
April	\$80	\$45	\$0
May	\$70	\$75	\$0
June	\$100	\$250	\$30
July	\$135	\$175	\$10
August	\$391	\$46	\$0
September	\$65	\$133	\$0
October	\$114	\$189	\$0
November	\$108	\$446	\$0
December	\$42	\$219	\$20
TOTAL	\$1,400	\$1,998	\$60

Maintenance cost includes the cost of materials to replace heads, risers, etc. and all other components in a zone. Repair cost for repairing valves, controllers and mainlines was collected separately.

Table 2 - Study of repair and maintenance costs of a dripline vs. a sprinkler system.

The reality of maintenance is this:

- Maintenance of a subsurface dripline system is dramatically less than a sprinkler system
- Special training is not needed for crews

Specifics regarding system maintenance are covered at the end of this guide.

Note: A contractor in Maryland has told Netafim that he "hates" drip. When asked to explain, he said that he simply cannot generate the same number of repair calls with Netafim that he can with a sprinkler system.

DRIPLINE MECHANICS

When companies extrude dripline, they do so using a variety of emitters, flow rates, and styles. Once the emitter and emitter flow rate are chosen, decisions then have to be made on how far apart the emitters will be from each other in the tubing, how thick the walls of the tubing will be and how large the diameter of the tubing will be.

For our purposes, Netafim USA's Landscape & Turf Division only recommends a 'heavywall' pressure-compensating emitter in its subsurface-approved products. They include Techline CV and Techline DL. These pressure compensating driplines not only provide the same flow rate all the way along the dripline, but the emitters also have a continuous self-flushing mechanism that make them more dirt and debris resistant - superior performers. Lastly, they are designed to last as long or longer than any other component in the system.

ANTI-SIPHON FEATURE

This unique feature prevents soil and debris from being sucked back into the emitter when the system turns off and a vacuum is created.

SELF-FLUSHING VS. CONTINUOUS FLUSHING EMITTERS

Netafim Techline CV and Techline DL Dripline have a 'Continuous Self-Flushing' feature that sets them apart from other products. The operative word is 'continuous'. Any time debris gets into the emitter, the same diaphragm that creates the pressure compensating feature, momentarily shifts position and flushes the debris out of the emitter. After that split-second of purging is complete, the emitter goes back to its normal operation. In comparison, other emitters on the market tout a self-flushing feature but all that means is that at the moment the dripline turns on, or just after it shuts off, debris may be released. What isn't being said is that during operation, if an emitter becomes clogged, it stays clogged.

EMITTER FLOW RATES AND SPACINGS

Different companies have different flow rates for their emitters. Virtually all emitters used in subsurface landscape applications use a flow rate of less than 1.0 gallon per hour (GPH). Netafim Techline CV and Techline DL are offered in a broad range of flow rates in order to match the flow rate to the soil's ability to absorb the water.

In deciding the proper emitter to use, it is based primarily on the soil (and slope):

- Sandy soil, use an emitter that emits either 0.6 or 0.9 GPH
- Loam soil, use a 0.4 or 0.6 GPH flow rate
- Tight soils like clay, either a 0.26 or 0.4 GPH flow rate emitter

EMITTER FLOW Rate Choices				
	0.26 GPH	0.4 GPH	0.6 GPH	0.9 GPH
Techline CV	X	X	X	X
Techline	X	X	X	X

Table 3 - Emitter flow rate choices of Netafim Techline CV and Techline DL Dripline.

EMITTER FLOW Recommendation Based on Soil				
	0.26 GPH	0.4 GPH	0.6 GPH	0.9 GPH
Clay	X*	X		
Loam		X*	X	
Sand			X*	X

*Recommended flow rate.

Table 4 - Emitter flow rate recommendations based on soil.

MAXIMUM PRECIPITATION RATES (inches per hour)								
Soil Texture	0% to 5% Slope		5% to 8% Slope		8% to 12% Slope		12% to 20% Slope	
	Covered	Bare	Covered	Bare	Covered	Bare	Covered	Bare
Coarse Sandy Soil	2.00	2.00	2.00	1.50	1.50	1.00	1.00	1.00
Coarse Sandy Soil Over Compact Sub Soil	1.75	1.50	1.25	1.00	1.00	0.75	0.75	0.40
Light Sandy Loam	1.75	1.00	1.25	0.80	1.00	0.60	0.75	0.40
Light Sandy Loam Over Compact Sub Soil	1.25	0.75	1.00	0.50	0.75	0.40	0.50	0.30
Uniform Silt Loam	1.00	0.50	0.80	0.40	0.60	0.30	0.40	0.20
Silt Loam Over Compact Sub Soil	0.60	0.30	0.50	0.25	0.40	0.15	0.30	0.10
Heavy Clay / Clay Loam	0.20	0.15	0.15	0.10	0.12	0.08	0.10	0.06

Note: The above average values are for reference purposes. Data may vary with respect to actual soil and site conditions. Data from USDA.

Table 5 - Maximum precipitation rates based on type of soil and slope.

The Maximum Precipitation Rates Chart from the U.S. Department of Agriculture shows the ability of various soils to absorb water. This information is important because it is the best way to show how different soils manage water. In the case of Coarse Sandy Soil on a 0 to 5% Slope, it can absorb 2.00" of water if covered with vegetation. Conversely, a heavy clay/clay loam soil can only accept about 0.20". This means that sandy soil does not hold water as well as tighter soils. It also means that sandy soil will not radiate the water as far laterally and upward as a tighter soil. As such, care needs to be taken when deciding what emitter flow rate to use and how far apart the emitters can be from each other. And as the slope increases, this takes on even greater importance.

Once the proper emitter flow rate is selected (based on soil and slope), the proper emitter spacing inside the tubing needs to be determined. Netafim uses emitter intervals of either 12" or 18," regardless of emitter flow rate. We also offer a 24" spacing for specialty applications. The last determinate is how far apart the rows will go.

Note: When Netafim's Landscape & Turf Division first began, there were many myths about drip, most of them concerning point source emitters. The most common misconception was that it took hours and hours of irrigation to get the right amount of water applied. With most low volume products at that time being point source emitters, this might have been the case. After all, if too few emitters were used, it would be necessary to run the zone for long periods to deliver enough water. But the advent of dripline changed that. If you were going to get a contractor's attention, you needed to be able to deliver a lot of water in a short amount of time. That is the reason recommendations from several years ago for emitter flow rates, emitter spacings and row spacings that delivered more water than is recommended today.

As for the various inside diameter (I.D.) or outside diameter (O.D.) of tubings today, it varies. Unlike most mid sized rotors with a 3/4" inlet, or sprays with a 1/2" inlet, driplines come in a variety of wall thickness and I.D./O.D.

Netafim Techline CV and Techline DL tubing have a wall that is thicker than most, (0.050") and have a 0.560" I.D. This converts to 17mm (1/2" nominal) and is considered the norm for dripline. With its thicker wall, it is considered a permanent product, meaning it is designed to last as long or longer than any other component in the system.

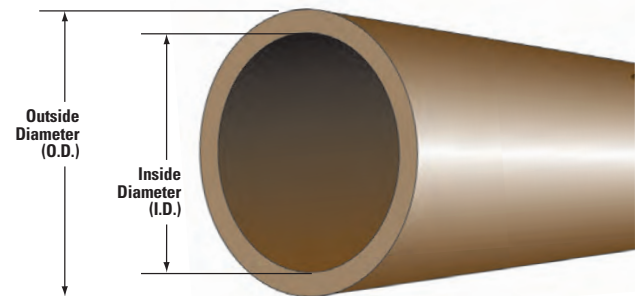


Figure 26 - Dripline diameters.

THE BOTTOM LINE ON APPLICATION RATES

Low volume does not mean low application rate or low precipitation rate.

If an average rotor system is applying 0.4 inches per hour, that does not mean it is delivering 0.40" of water useably to the root zone. In fact, it is probably only delivering about half that amount.

Conversely, Netafim Techline CV and Techline DL, using a 0.9 GPH flow rate on a 12" x 12" grid are applying 1.44 inches per hour, and anywhere from 85% to 95% of the water is useable.

If a low application rate is used, it will most likely be in response to the realities of the earlier United States Department of Agriculture Chart linking application rate to type of soil and slope. In this case, using something that puts down more water than the soil can handle is bad water management.

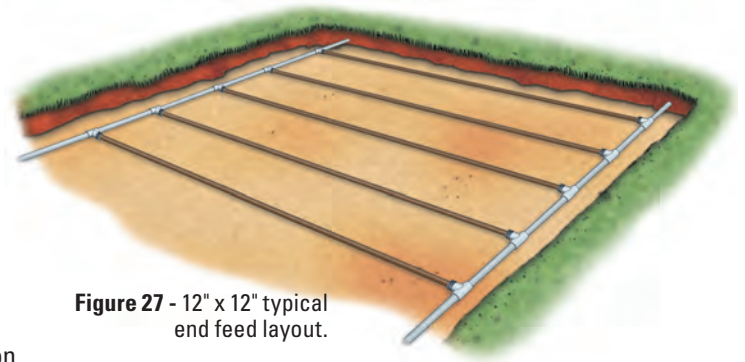


Figure 27 - 12" x 12" typical end feed layout.

DETERMINING SOIL TYPE

Knowing the soil type is important to picking the proper flow rate for the emitter. It is equally important to know the type of soil because it will drive what emitter interval you use (12" or 18") as well as how far apart you space the rows.

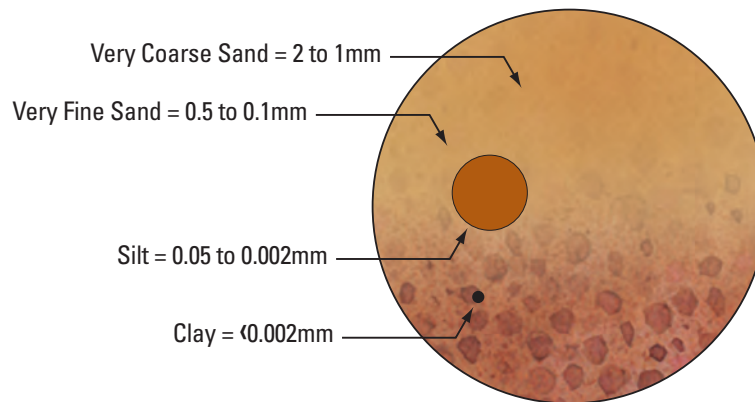


Figure 28 - Sizes of various soil particles. The relative proportions of sand, silt and clay particles in a mass of soil (material less than 2mm in size).

Most contractors can easily determine soil type from these three choices, but what if your professional opinion is that it is clay-loam, or a sandy-loam?

As you review our General Guidelines Chart on page 26 you will see that as the soil selection changes from clay to sand, we move from a lower flow rate emitter to a higher flow rate emitter and our emitter interval and row spacings get closer.

Bottom Line: If you are in doubt between clay and loam, choose loam. If the decision is between loam or sand, choose sand. Why? The rows and emitter intervals will be closer, and yes, the emitter's flow rate could increase as well. The result will be that you have not overextended the spacings. Remember too that the information in Table 4 from the United States Department of Agriculture regarding the soil's ability to absorb water is based on type, cover and slope.

Note: When amending a soil, do not add more than 15% to 20% organic compound to it. Adding too much organic compound can cause the water to be absorbed and reduce the effective wetted area.

JAR TEST METHOD FOR DETERMINING SOIL TYPES

The following is a simple way to determine the correct soil. There is another faster method in the back of this guide, see page 43.

SUPPLIES YOU NEED:

- 1 quart "Mason" jar with straight sides and a tight lid
- 2 cups of soil
- 1 teaspoon water softener (optional)
- Water
- Ruler

WHAT TO DO:

1. Collect about 2 cups of soil samples from the area to be irrigated
2. Confine the soil to samples to the top 6" of soil
3. Remove any debris and organic matter
4. Put the soil into the jar
5. Add 1 to 2 teaspoons of fabric or water softener to help break up the particles
6. Fill the jar with clean water
7. Shake until the soil particles are suspended in the water

WHAT TO DO NEXT:

1. After about 1 minute, measure the depth of the sand at the bottom of the jar
2. After about 2 hours, measure the layer of silt layer that has settled onto the top of the sand
3. After 24 hours, measure the clay layer
4. Determine what percent is made up of each layer
5. Use the chart below to determine the type of soil you have

Note: Whenever planting trees or plants in a new landscape, be aware that you must irrigate both the native soil and the ball of the plant or tree. This is due to the difference in soils and the inability of the two soils to hand-off water.

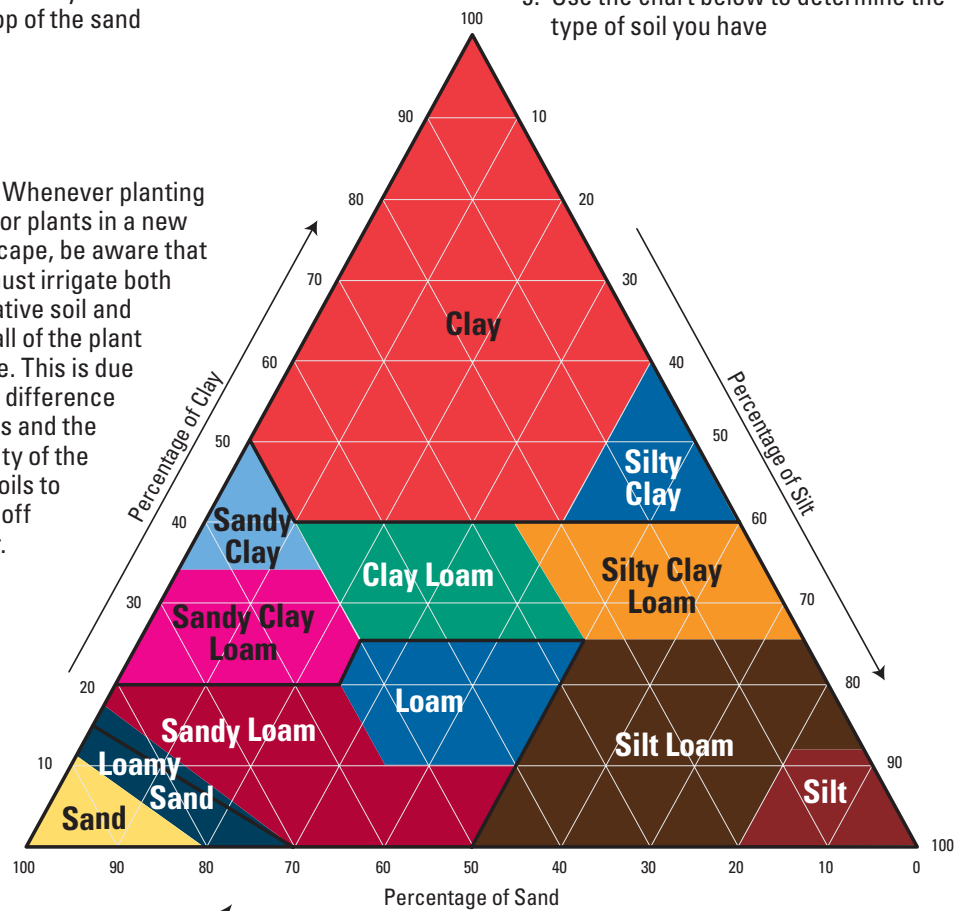


Figure 29 - Soil triangle.

SELECTING THE PROPER DRIPLINE

This will be remarkably easy because Netafim USA has developed a series of charts that answer virtually all product selection, flow rate, spacing and run length questions.

TECHLINE CV® General Guidelines																								
	TURF												SHRUB AND GROUND COVER											
	Clay Soil			Loam Soil			Sandy Soil			Coarse Soil			Clay Soil		Loam Soil		Sandy Soil		Coarse Soil					
Emitter Flow	0.26 GPH			0.4 GPH			0.6 GPH			0.9 GPH			0.26 GPH		0.4 GPH		0.6 GPH		0.9 GPH					
Emitter Interval	18"			12"			12"			12"			18"		18"		12"		12"					
Lateral (Row) Spacing	18"	20"	22"	18"	20"	22"	12"	14"	16"	12"	14"	16"	18"	21"	24"	18"	21"	24"	16"	18"	20"			
Burial Depth	Bury evenly throughout the zone from 4" to 6"												On-surface or bury evenly throughout the zone to a maximum of 6"											
Application Rate (inch/hour)	0.19	0.17	0.15	0.30	0.27	0.25	0.98	0.84	0.73	1.48	1.27	1.11	0.19	0.16	0.14	0.30	0.26	0.23	0.73	0.65	0.59	1.11	0.99	0.89
Time to Apply ¼" of Water (minutes)	80	89	97	50	55	61	15	18	20	10	12	13	80	93	106	50	58	66	20	23	26	13	15	17

Following these maximum spacing guidelines, emitter flow selection can be increased if desired by the designer. 0.9 GPH flow rate available for areas requiring higher infiltration rates, such as coarse sandy soils.
 NOTE: 0.4, 0.6, and 0.9 GPH are nominal flow rates. Actual flow rates used in the calculations are 0.42, 0.61, and 0.92 GPH.

Table 6 - Techline CV General Guidelines Chart.

The General Guidelines Chart above tells you what type of Techline CV to use. The specific dripline chosen is based on the answers you provide and what is being irrigated and its soil type.

For instance, if you are irrigating turf and with clay soil, the chart tells you to use:

- Emitters with 0.26 GPH flow rates
- Emitters spaced 18" apart in the dripline
- Rows spaced anywhere from 18" - 22" apart

The type of plant and its soil are two questions that need to be answered regardless of what type of irrigation system you are designing. The important thing is, even if you have never used dripline before, you have just been steered to the proper product. In this case, you would ask your Netafim Landscape & Turf Distributor for 0.26/18" (0.26 GPH flow rate per emitter with emitters spaced every 18") Techline CV dripline.

As we continue down the column there is more information available for us. The chart indicates that you can bury the dripline down to 6", as well as what the application rate is in inches per hour. Going one step further, we have translated application rates into how long it will take to apply ¼ inch of water.

Now that we know what flow rate and emitter interval to use, (0.26 GPH and 18" emitter interval in this example) we can move to the Maximum Length of a Single Lateral Chart on the next page. Here we'll learn how far a single dripline lateral can run.

Note: We are often asked how many feet of dripline you can put in a zone. We normally answer the question by asking, "How many rotors or sprays can you put on a line?" The answer to that question comes fast. "It all depends on how much water you have, and the pressure." It's no different with dripline. The amount of dripline you can put on a zone is a function of the pressure and the amount of water available.

SELECTING THE PROPER DRIPLINE (continued)

TECHLINE CV® Maximum Length of a Single Lateral (feet)											
Emitter Spacing		12"				18"				24"	
Emitter Flow Rate (GPH)		0.26	0.4	0.6	0.9	0.26	0.4	0.6	0.9	0.6	0.9
Inlet Pressure (psi)	20	331	242	190	144	468	344	270	204	342	260
	25	413	302	238	180	584	429	338	257	430	326
	30	471	345	272	206	668	491	387	293	492	374
	35	518	380	299	227	737	540	426	323	542	412
	40	559	410	223	244	794	584	459	348	584	444
	45	594	436	343	260	845	620	489	371	622	472
	50	626	459	361	274	890	654	515	390	656	498
	55	655	480	378	287	932	684	539	410	686	522
	60	681	500	393	298	969	713	561	426	716	544

Table 7 - Techline CV Maximum Length of a Single Lateral Chart.

The Techline CV Maximum Length of a Single Lateral chart takes the information we learned from the General Guidelines Chart and expands on it. In our example, we are using 0.26/18" Techline CV for our turfgrass in clay zone. This chart tells us that if we have 45 psi available at the beginning of the dripline lateral, we could run a single lateral 845 feet. If the pressure is 35 psi, the length of a single lateral could be 737 feet.

The science behind this number is simple. We have taken the friction loss over distance and the amount of water it can flow at velocities at or below 5 feet per second and determined for you the point that the dripline would no longer work properly. In short, this is a friction loss chart with all the heavy lifting done.

As to the number of rows needed, each of them extending as far as 845 feet, that is a function of how much water you have. Just like the number of rotors you have depends on available water, pressure, and piping, so does dripline.

TECHLINE CV® Flow per 100 Feet								
Emitter Spacing	0.26 GPH Emitter		0.4 GPH Emitter		0.6 GPH Emitter		0.9 GPH Emitter	
	GPH	GPM	GPH	GPM	GPH	GPM	GPH	GPM
12"	26.4	0.44	42.3	0.71	60.8	1.01	92.5	1.54
18"	17.6	0.29	28.2	0.47	40.5	0.68	61.6	1.03
24"	13.2	0.22	21.2	0.35	30.4	0.51	46.2	0.77

Table 8 - Techline CV Flow per 100 Feet Chart.

The last of the three charts designed to speed the selection process is the Techline CV Flow per 100' chart. This chart simply translates the gallons per hour world of low volume into gallons per minute. Because Techline CV and Techline DL driplines are pressure compensating, we can accurately determine the flow. In the case of 0.26/18" Techline CV, every 100 feet would use 17.58 gallons per hour, or 0.29 GPM. For example, a lateral that is 800 feet long would use 2.32 GPM (8 x 0.29).

LET'S REVIEW

Armed with what you are trying to grow and what type of soil you have, we have answered many questions with our easy-to-use charts.

- Dripline flow rate
- Dripline interval
- Dripline row spacing
- How deep to bury the dripline
- Application rate
- How much time to apply ¼" of water
- The potential maximum length of a lateral (once we know the psi available to us)
- The flow per 100 feet in GPM and GPH

There is another piece of information that would be nice to know. That is, how many feet of dripline do we need for the zone?

ESTIMATING THE TOTAL AMOUNT OF DRIPLINE IN A ZONE

Of all the calculations, this one should be memorized, because doing this math quickly is what can help make system design go faster.

$$\frac{\text{Irrigated Area (square feet)} \times 12}{\text{Minimum Recommended Row Spacing (inches)}} = \text{Total Amount of Dripline in Feet in a Zone}$$

Example: We have a 1,000 square foot area to irrigate. It's a turf area with clay soil. By checking the General Guidelines chart, we see that 0.26 GPH/18" dripline on 18" to 22" rows is called for. Since the formula tells us to divide by the minimum recommended row spacing, 18", that's what we'll do.

$$\frac{1,000 \times 12}{18} = \text{Use 667 feet of 0.26/18" Techline CV}$$

WHY USE THE MINIMUM RECOMMENDED ROW SPACING?

While the formula is accurate, there are any number of geometric shapes that an area may have. By using the minimum row spacing, you'll never end up on a job site with too little dripline. So even if you have to move the rows out an inch or two, you will not run short.

Note: Formulas like this are not intended to replace the skills of a designer.

HOW DEEP IS DEEP ENOUGH?

Netafim USA recommends that dripline be buried anywhere from just below the surface to about 6". We also recommend trying to keep the burial depth consistent.

The deeper you bury the dripline, the more work it will take to bring the water close to the surface. The result is that you will need to bring the rows closer together to do it. When you see deeper burial depth recommendations from other companies, it may be an effort to protect chemically-impregnated emitter from hot soils. Because the chemical is very sensitive to heat, burial depths of 8" are common, but can be more labor intensive to install.

If the Netafim USA General Guidelines Charts are followed, Techline CV and Techline DL may be used anywhere from on-surface to 6". The issue about consistency in burying depth has more to do with creating an even wetted environment to the same height, width, and depth across the zone.

Note: Past claims have been made that dripline can be buried 1" or 2" deep in soil even though published applications for the product clearly show that the product is designed for non-subsurface applications. Soil is soil, whether it is 1" deep or 6" deep. The issue is not whether "being one or two inches deep is nothing more than being under mulch," but rather the emitter's inability to guard against root intrusion. If the catalog doesn't clearly call out a subsurface application that includes turf, it shouldn't be used anywhere but on-surface, where the roots won't be.



Figure 30 - Examples of wetted pattern of Techline CV after running for four minutes and prior to being covered with topsoil.

LEVEL TUBING INSTALLATION

A myth that nay-sayers use to dissuade you from using subsurface drip irrigation is, "you must have all emitter emission points at the same depth all along the run, because if you don't, this will affect the evenness of the water distribution."



Figure 31 - A Vermeer® LM42 laying Netafim dripline three rows at a time.

The reality is that if you follow the General Guidelines Chart for what you are irrigating, Netafim has already determined the water's ability to move in the soil. The emitter overlap pattern is such that the water is radiating out past any neighboring emitters. With that as the case, you end up with a very well-balanced application of water. In fact, far better than anything you could create with sprinklers.

STEPS TO INSTALLING DRIPLINE IN TURFGRASS

(or any subsurface application)

Refer to the Quick Install Guide (located on the Netafim website) for tips on choosing what components to use and how to size each element. For even more information, refer to the Netafim Design Guide for Techline CV and the Netafim Design Guide for Techline DL.

METHODS OF INSTALLING Dripline		
On-Surface, Subgrade and Bringing in Top Soil	<ul style="list-style-type: none"> Easy to lay out Ensures very accurate row spacings 	<ul style="list-style-type: none"> Soil needs to be laid over the exposed tubing Time consuming Labor intensive
Trenching	<ul style="list-style-type: none"> Row spacing accurately established Depth of tubing is consistent 	<ul style="list-style-type: none"> Trenches need to be tamped and retamped to ensure properly compacted soil Tires could slip into nearby trenches
Vibratory Plow (pulling the dripperline)	<ul style="list-style-type: none"> Fast in good soils Reduced clean-up Easier than trenching to maintain row spacing in good soils 	<ul style="list-style-type: none"> Possibility of stretching and harming the tubing as it is pulled through the soil Slow in rocky and tight soils Dripperline could be damaged as it is pulled past sharp objects Requires the operator to stop and couple tubing to avoid damage when it gets hard to pull Harder to maintain accurate row spacing in problem soils
Vermeer® Multi-Blade Vibratory Plow with chutes (laying-in dripperline rather than pulling)	<ul style="list-style-type: none"> Fast and efficient Several rows can be installed at once Tubing is laid in the ground behind the blade, eliminating damage by pulling Easy to maintain row spacings Soil stays better compacted Cleanup is greatly reduced Can be used on new or existing landscapes Any appropriate lateral length can be installed without stopping, coupling and starting again 	

Table 9 - Methods of installing dripline.

STEPS TO INSTALLING DRIPLINE IN TURFGRASS (continued)

Of the mechanical methods listed, the use of the Vermeer® multi-blade vibratory plow with chutes that drops the tubing into the ground rather than pulling it is clearly the best.

Imagine a knife being stuck into the ground and moved forward and backward as the sharp edge of the blade is moved through the soil. That is how this type of plow works, but on a much larger scale. The blades each have a chute behind them that lay the dripline into the ground, allowing for a very clean and efficient installation of pipe with minimum damage to the turf.

INSTALLATION METHODOLOGY

Given the opportunity to lay dripline rows lengthwise in a zone rather than in shorter rows across the zone, choose lengthwise.

The exception to this rule is that you should always lay dripline perpendicular (across a slope). While the details of design and layout have been left to the specific product design guides, here is a design detail to show the philosophy of dripline layout on a slope.

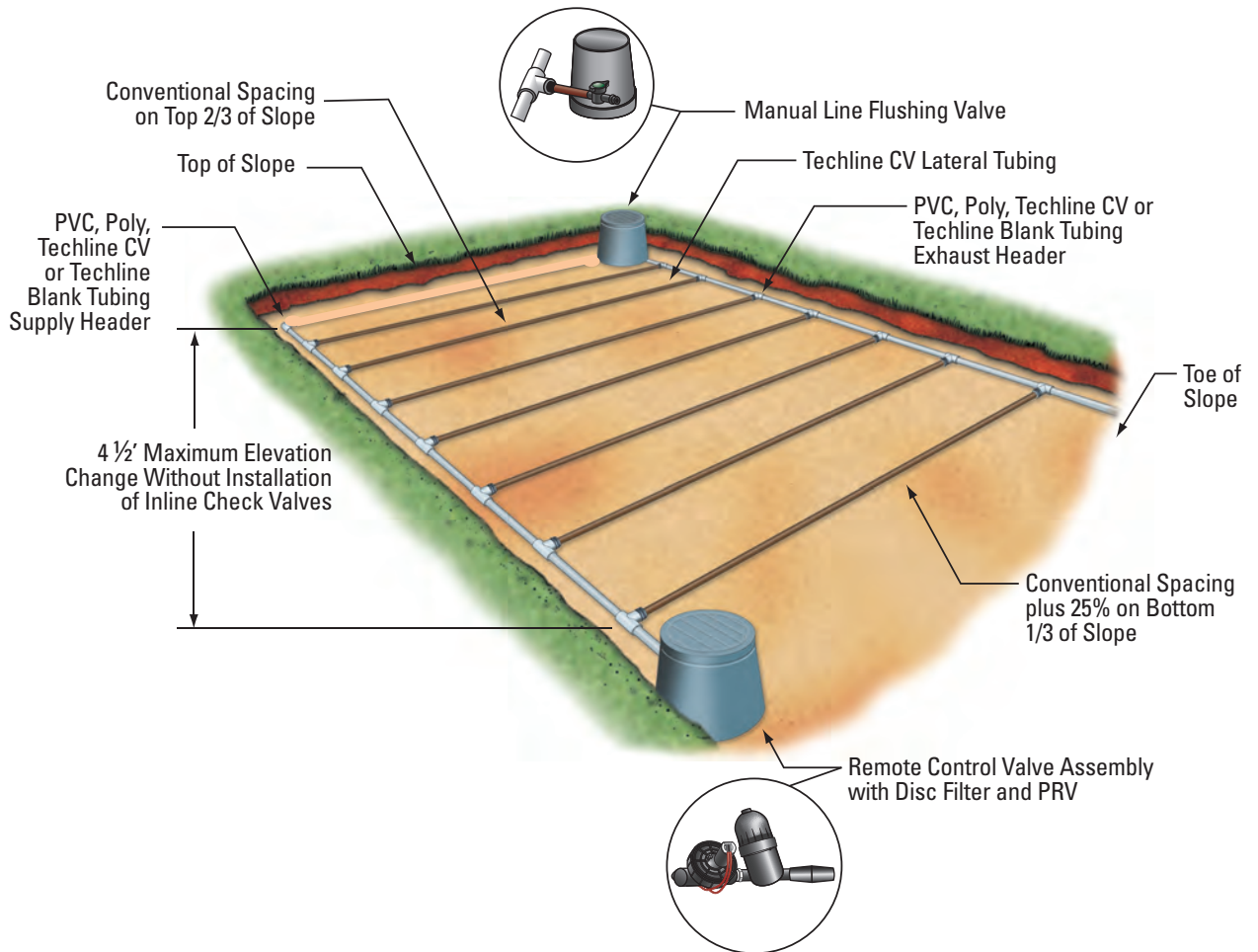


Figure 32 - Design detail showing dripline layout across a slope.

**INSTALLING
DRIPLINE****IN TURF:**

Regardless of how you get the tubing into the ground, you need to ensure the soil is compacted back around the dripline so the water can radiate outward uniformly. We discussed this earlier, but it cannot be emphasized enough. Even in sprinkler systems, getting trenches properly compacted is critical. The picture below illustrates what can happen if the trenches are not as tightly packed as the surrounding undisturbed soil.



Figure 33 - Example of a sprinkler system where the trenches were not properly compacted after the PVC pipe was installed.

In order to compact the soil, some contractors will use a vibrating roller when they are done installing the dripline or the piping network in a sprinkler system. Others will simply drive their trencher over the rows to pack them down.

Next we will go through some tips and hints about the various methods of installing dripline in turf. Then we'll discuss using seed, hydroseed, and laying sod.

INSTALLING DRIPLINE

ON SUBSURFACE / SUBGRADE AND BRINGING TOPSOIL IN:

This method typically requires that the dripline be laid in rows, frequently by hand. For best results, follow these simple steps:

- Keep rows spaced properly by using staples to hold the dripline in place. One staple per 3 feet is usually sufficient
- Always cover the dripline with several inches of soil before driving over the dripline
- When topsoil is brought in:
 - Do not walk or drive over the dripline unless soil is covering it
 - Do not create a “highway” by always driving in one area. Vary the direction from which you approach the zone
- Ensure the tubing is not shifting as the dirt is being dumped over it
- Dumping the soil over tubing that is laid straight out in front of you ensures the least amount of shifting. (If the tubing is laying perpendicular to you rather than parallel as the topsoil is dumped, there is a greater chance of shifting the tubing and changing the row spacing)



Figure 34 - Subgrade installation of Techline CV with soil being laid over a grid layout. Note how the loader is moving parallel to the driplines to minimize the rows from shifting.

IN A TRENCH AND COVERING IT WITH SOIL:

Netafim USA recommends that a narrow bladed trencher be used, with the blade’s cutting width only slightly wider than the tubing. This will minimize cleanup.

- Keep the dripline securely in place before fill is added
- Ensure that clean fill is used. Remove rocks and other sharp debris
- Ensure the soil is compacted to the same firmness of the surrounding soil

INSTALLING DRIPLINE (continued)

BY HAND TRENCHING:

Rent a narrow bladed trencher or use a Techline CV/Techline DL Multi-Blade Vibratory Insertion Plow.

For hand trenching:

- Maintain accurate row spacing and trench depth
- Keep the dripline securely in place before fill is added
- Ensure that clean fill is used. Remove rocks and other sharp debris
- Ensure the soil is compacted to the same firmness of the surrounding soil

WITH A VERMEER MANUFACTURING COMPANY MULTI-BLADE VIBRATORY INSERTION PLOW:

This unit was specially designed and built in conjunction with Vermeer® Manufacturing, a world leader in trenching equipment. This vibratory plow differs from other plows on the market in a number of important ways, including:

- The vibratory plow lays several rows of dripline at once. As such, production rates are very high
- The chutes have been specifically designed to allow the free movement of Techline CV, Techline DL, Techline RW for Reclaimed Water (Purple-striped Techline) and Bioline for wastewater
- Tubing is inserted into the ground directly behind the blade, so the dripline is not pulled through the ground and damaged
- Dripline can be laid without concern that the pipe will get 'lost' as it can with a plow that pulls the pipe behind it
- The plow is designed to be used with a Vermeer® LM42 or RT450. They have proven track records in the irrigation industry and work with a variety of other attachments, including a trencher, single blade plow and boring accessory
- Netafim couplers inserted into the dripline move through the chute without binding
- Burial depth is adjustable
- Row spacing is adjustable
- Roller wheel behind the unit compresses the turf back down



Figure 35 - Vermeer® LM42 shown with 3-blade vibratory plow. Standard tubing rack not shown on picture at right.

LABOR GUIDELINES

We offer the the following guidelines to help you determine the rate of installation.

LABOR Guidelines	
Action	Feet per Hour
Hand Trenching	25' to 50'
Conventional Trencher	100' to 250'
Narrow Bladed Trencher	150' to 300'
On-Surface, Sub Grade	500' to 700'
Vermeer's Multi-Blade Vibratory Insertion Plow	1,200' to 1,500' per blade

Table 10 - Approximate installation rates of various methods.

INSTALLING TECHLINE CV, TECHLINE DL DRIPLINE

IN A NEWLY SODDED LAWN, FOLLOW THE GENERAL GUIDELINES RECOMMENDED FOR TURF:

- 1** Bury Techline CV or Techline DL Dripline:

 - Approximately 4" to 6" below final grade
 - We do not recommend laying the sod directly on top of the dripline
 - In areas where mechanical aeration may be used, bury the dripline 6" below final grade and ensure that aeration does not exceed 4"
- 2** When installing the sod:

 - It is important that the final grade is smooth, ensuring that the sod makes complete contact with the soil
 - Compaction of the soil is key too even distribution of water
 - Turn the system on before laying sod. Visually look at the wetting pattern and evenness of distribution
 - Roll the sod to ensure good contact with the soil
 - Properly 'knit' the edges of the soil together
 - Thoroughly wet the sod from above after installation
 - Depending on weather conditions, supplemental overhead sprinklers may be necessary during establishment, however good results have been achieved without supplemental overhead irrigation
- 3** If the irrigation system is automatic:

 - Set the zone to run several times daily, the object is to maintain a very moist soil condition until the roots establish themselves
 - You may wish to rope off the area to keep traffic away
 - Once you cannot pull the edges of the sod up, discontinue any overhead watering
 - Irrigate on a daily or every-other-day basis
- 4** Protection against root intrusion - following any of these recommendations will help. Following all of them will ensure a lifetime of protection:

 - Use Netafim Techline CV or Techline DL dripline since they are the only subsurface irrigation products designed with a physical root barrier proven most resistant to root intrusion in tests conducted by the renowned Center for Irrigation Technology (CIT)
 - Apply some water every day. Running your Netafim dripline system for even several minutes a day (more may be required depending on your local climate) will help keep soil moisture consistent so the roots do not seek additional water
 - For 100% warranty protection against root intrusion use the Netafim Techfilter, with replaceable cartridges

INSTALLING TECHLINE CV, TECHLINE DL DRIPLINE (continued)

IN A NEWLY SEEDED OR HYDROSEEDED LAWN, FOLLOW THE GENERAL GUIDELINES RECOMMENDED FOR TURF:

- 1** Bury the Techline CV or Techline DL Dripline:
 - At any depth down to 6" below final grade
 - In areas where mechanical aeration may be used, bury the dripline 6" below final grade and ensure that aeration does not exceed 4"
 - Compaction of the soil is key too even distribution of water
- 2** After the seeding or hydro-seeding is complete:
 - The object will be to create a soil condition that is held near field capacity so that adequate moisture moves upward to establish the seed
 - You may wish to rope off the area to keep traffic off while the seed is being established and the soil is wet
 - Supplemental overhead sprinklers may be necessary, however good results have been achieved without

If the irrigation system is automatic:

 - Set the zone to run several times daily- the object is to maintain a very moist soil condition until the roots establish themselves
 - Irrigate on a daily or every-other-day basis
- 4** Protection against root intrusion - Following any of these recommendations will help. Following all of them will ensure a lifetime of protection:
 - Use Netafim Techline CV or Techline DL dripline since they are the only subsurface irrigation products designed with a physical root barrier proven most resistant to root intrusion in tests conducted by the renowned Center for Irrigation Technology (C.I.T.)
 - Apply some water every day. Running your Netafim dripline system for even several minutes a day (more may be required depending on your local climate) will help keep soil moisture consistent so the roots do not seek additional water
 - For 100% warranty protection against root intrusion use the Netafim Techfilter, with replaceable cartridges

FERTIGATION

Fertigation is the process of injecting liquid fertilizers into the zone while irrigating. This is already a popular methodology in many areas.

The benefit of fertigation includes the ease of application and the knowledge that along with the water, the nutrients are being applied uniformly in a proper designed and installed dripline system to the plant's root zone in an ongoing basis throughout the growing season. With Netafim driplines, the use of pressure compensating emitters further ensures that the application rate is even.

Netafim Techline CV and Techline DL are specially designed to support fertigation where local codes allow it, and where backflow codes regarding its use are followed.

Any fertilizer that is used should be liquid or completely liquid soluble and be non-destructive toward polyethylene. If the product meets these simple criteria, the ability to fertigate just became another reason to use Netafim Techline CV or Techline DL.

While there is little scientific data on how to determine row spacing when using fertigation, some professionals recommend that closer rows spacings should be used to ensure that the fertilizers are being as evenly applied as possible. Example - If the recommended row spacings are from 12" to 16" apart, you may wish to consider 12" to 14".

MAINTAINING A SUBSURFACE SYSTEM

When designed and installed properly, a Netafim Techline CV or Techline DL subsurface system offers the designer, contractor and system owner very high quality equipment, unparalleled performance, system reliability and low maintenance.

As we discussed earlier, training, repair and maintenance considerations are actually less with a subsurface system than with a sprinkler system.

As with any irrigation system, it is important that it be designed according to the manufacturer's specifications and installed according to the designer's specifications. Note that on the following chart, the major elements relating to a dripline system vs. a sprinkler system are the same.

MAINTENANCE COMPARISON Sprinklers vs. Dripline		
	Sprinklers	Dripline
Calculate or determine from water meter and record zone flow for future reference	✓	✓
Clean filters or screens in sprinklers	✓	✓
Visually inspect all irrigated areas	✓	✓
Check for leaks	✓	✓
Test pressure and flow	✓	✓
Reset heads that are too high or low	✓	
Adjust nozzles, arcs and radius	✓	
Replace nozzles due to wear	✓	

Table 11 - Comparing the maintenance needs of sprinkler and dripline systems.

DISC FILTERS

2" Disc Filter



Disc filters should be inspected and cleaned periodically.

Note: With a sprinkler system, all of the basket screens on rotors and sprays should be cleaned periodically because the mesh of the screen is frequently the same or greater than a Netafim filter's mesh. If someone tells you that it is harder to rinse the rings of one filter on a dripline system than it is to clean the screens on every sprinkler, you may wish to reconsider the value of their opinions.

The filter should be inspected several times after installation until a determination on cleaning frequency can be established.

To clean the discs, unscrew the plastic housing, or unlatch the band, exposing the spindle on which the discs are stacked. The spindle is held in place by snap-fit.



Figure 36 - The rings of this filter show how much dirt and debris can exist even in potable water, which this system is used on.



Disc Filter Rings

To remove the discs, pull on the spindle. No special tools are needed. The discs can be cleaned in a bucket of water, or by spraying them with a hose. The discs are stacked loosely on the spindle and are easily separated for the thorough removal of debris.

Commercial installations should include pressure gauges or places to connect pressure gauges immediately upstream and downstream of the filter. This allows personnel to determine when the filter needs to be cleaned by observing the pressure differential between the upstream and downstream gauges.

Filters should be cleaned when the pressure loss across the filter is between 5 to 10 psi, or when the downstream pressure falls below the designed working pressure of the system. Record the pressure differential between the gauges when the system is installed as a reference for determining periodic inspection and cleaning.

LINE FLUSHING VALVES

Line Flushing Valves eliminate the need for periodic manual flushing. They are not required on a zone of Techline CV dripline because of Techline CV's unique check valve feature, but they do work well with Techline DL as a means of flushing the lines automatically.

These 'automatic' flush valves release approximately one gallon of water each time the zone is turned on. Observe the flushing operation at each line flushing valve at the beginning of each irrigation season to ensure that flushing is occurring properly.

If the line flushing valve does not seal, (continues to flush) disassemble the flush valve. Inspect all components, cleaning or replacing all components, and reassemble. You should be able to blow and draw air through the emitter that is attached to the diaphragm, and the diaphragm should be free of any rips or tears.

Damage may occur if the flush valve has been subjected to higher than recommended pressure (greater than 57 psi).

If manual flush valves or flush ports have been installed in lieu of line flushing valves, they should be opened and the system flushed at least three times each irrigation season until the flowing water is visibly clean. The zone may need to be flushed more frequently depending on the water source.

Flushing is also recommended anytime that the system has been repaired.

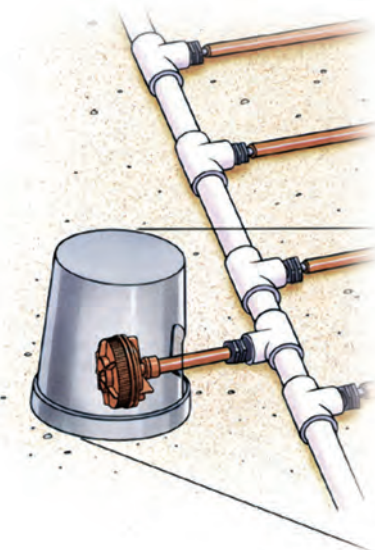
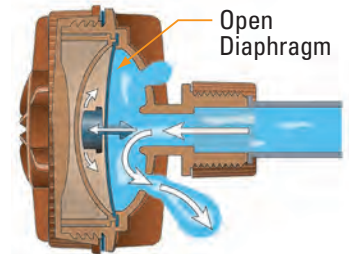


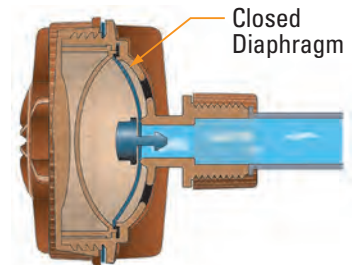
Figure 38 - View of Line Flushing Valve Mounted on an Exhaust Header and Cut-Away View During Operation.

Figure 37 - Diaphragm in operation.

Diaphragm in open position allows flushing.



As irrigation starts, valve flushes out dirt particles in the open position.



After flushing, the valve closes. Normal system operation begins.

SYSTEM INSPECTION

A physical inspection of the zone is recommended after installation, at the beginning of each season, after any landscape planting, or after any maintenance that requires digging deeper than the installed depth of the dripline.

System Inspections Include:

- 1 Observation of the flushing operation of all line flushing valves.** Check the pressure at the flush valves and compare to the last maintenance inspection. The minimum pressure should be at least 10 psi, (14.5 psi with Techline CV) and the maximum pressure should not exceed 58 psi.
- 2 Inspection of the zone while it is operating,** looking for excessively wet or dry areas that might indicate leaks. If a leak is found, and the system is installed as a grid or closed loop system, water will flow from both sides of the break. With the zone still on, allow the running water to flush any debris clear, and repair the leak with the appropriate fitting.
- 3 Check the operational flow of each zone** to see if it coincides with the designed or initial flow of the zone. Higher flow could indicate a leak. Locate any wet areas and repair. Lower than expected flows could indicate clogged emitters or kinked dripline tubing.

A historical record of the system should be kept.

Recorded data should include:

- Type of dripline installed (emitter flow and spacing)
- Lateral spacing
- Depth of the dripline
- Initial zone flows and pressures
- Initial pressures at the flush points

WINTERIZING A NETAFIM SYSTEM

Winterizing your Netafim system is fast and easy when you follow these simple steps. In general, the polyethylene tubing found on most drip and dripline systems has the ability to expand and contract. Winterizing your system is necessary to protect the hard plastic and metal components that are normally present.

WINTERIZING TECHLINE

Emitters in these products will drain some water from the dripline each time the zone shuts off, but there are still a few important steps to follow.

MANUAL WINTERIZATION

A drain port must be present at all low point(s) in the zone:

These ports may be a tee or elbow with a threaded plug, or a Netafim TLSOV or TLF168 which, when opened, will allow water to drain. If Netafim Line Flushing Valves are installed, unthread and disassemble.

When the zones are layed out in a grid or closed system:

The supply and exhaust headers may contain a significant amount of water. It is important to provide drain ports for these lines.

When zone has laterals that dead-end:

When the zone is not connected to an exhaust header, the lateral end(s) should be opened to drain at the lowest point(s).

The filter should be disassembled.

Remove the disc or screen element to allow water to drain. Leave the filter disassembled in the event that some water remains in the system.

In zones where elevation is a concern:

You may need to install a drain port upstream of the filter to ensure proper drainage. Follow manufacturer instructions for any automatic zone valves.

WINTERIZATION WITH COMPRESSED AIR (Blowing Out)

Follow the same initial procedure for a Techline zone as you would for a zone of sprinklers.

Ensure the fittings are Netafim-brand fittings.

Winterizing instructions may vary if other fittings are used.

Fittings for Techline are rated at 50 psi without clamps.

As such, the air pressure must be adjusted accordingly. It is air volume, not pressure that is effective when winterizing in this manner.

Pressure Regulators (PRVs) do not regulate air pressure.

PRV's only regulate water pressure. These are normally installed in the valve box along with the zone valve and filter.

Air volume is effective, not pressure.

When winterizing with compressed air.

Air pressure on the compressor should be regulated to 40 psi or less.

If the compressor outlet pressure cannot be adjusted to 40 psi or less, consider turning on another zone at the same time. Drain ports (a fitting with a threaded plug, Netafim TLSOV or TLF168, or Netafim Line Flushing Valves) normally installed as far away from the water source of the zone as possible, must be opened. Unscrew and disassemble any Line Flushing Valves. Open any TLSOV or TLF168.

With all drain ports open, compressed air should be applied until no water is seen exiting the zone.

All drain ports should be left open.

WINTERIZING TECHLINE CV

Techline CV dripline has a check valve in each emitter. These check valves hold water inside the dripline, so care should be taken to ensure water is adequately drained from the zone.

MANUAL WINTERIZATION

A drain port must be present at all low point(s) in the zone:

These ports may be a tee or elbow with a threaded plug or a Netafim TLSOV or TLFIG8 which, when opened, will allow water to drain. If Netafim Line Flushing Valves are installed, unthread and disassemble.

When the zones are a grid or closed system:

The supply and exhaust headers may contain a significant amount of water. It is important to provide drain ports for these lines.

When the zone has laterals that dead-end:

When the zone is not connected to an exhaust header, the lateral end(s) should be opened to drain at the lowest point(s)

The filter should be disassembled.

And the disc or screen element removed to allow water to drain. Leave the filter disassembled in the event that some water remains in the system.

In zones where elevation is a concern:

You may need to install a drain port upstream of the filter to ensure proper drainage. Follow manufacturer instructions for any automatic zone valves.

WINTERIZATION WITH COMPRESSED AIR (Blowing Out)

Follow the same initial procedure for a Techline CV zone as you would for a zone of sprinklers.

Ensure the fittings are Netafim-brand fittings.

Winterizing instructions may vary if other fittings are used.

Fittings for Techline CV are rated at 50 psi without clamps.

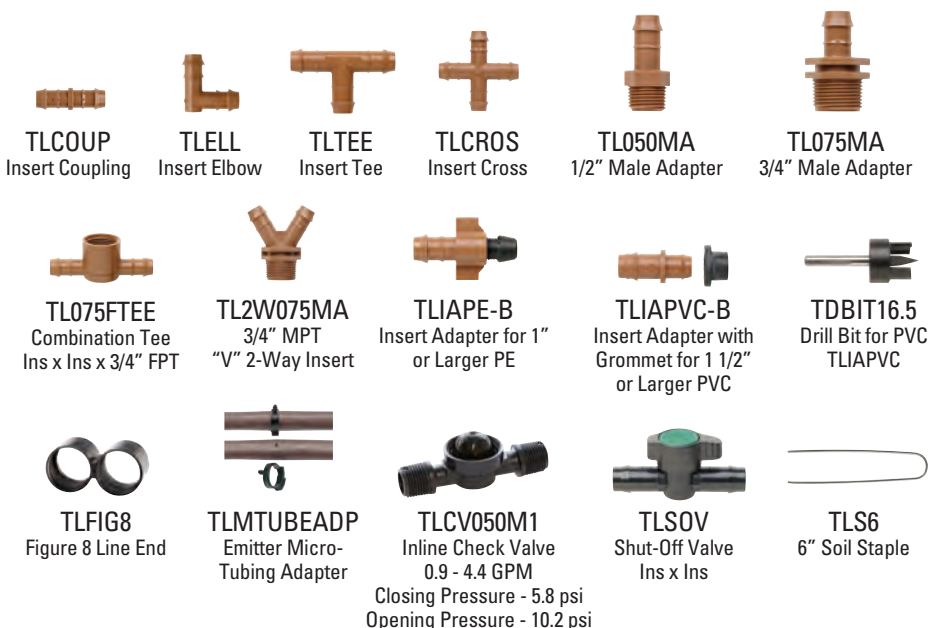
As such, the air pressure must be adjusted accordingly. It is air volume, not pressure, that is effective when winterizing in this manner.

Pressure regulators (PRVs) do not regulate air pressure.

PRV's only regulate water pressure. These are normally installed in the valve box along with the zone valve and filter.

With all drain ports open, compressed air should be applied until no water is seen exiting the zone.

All drain ports should be left open.



CONCLUSION

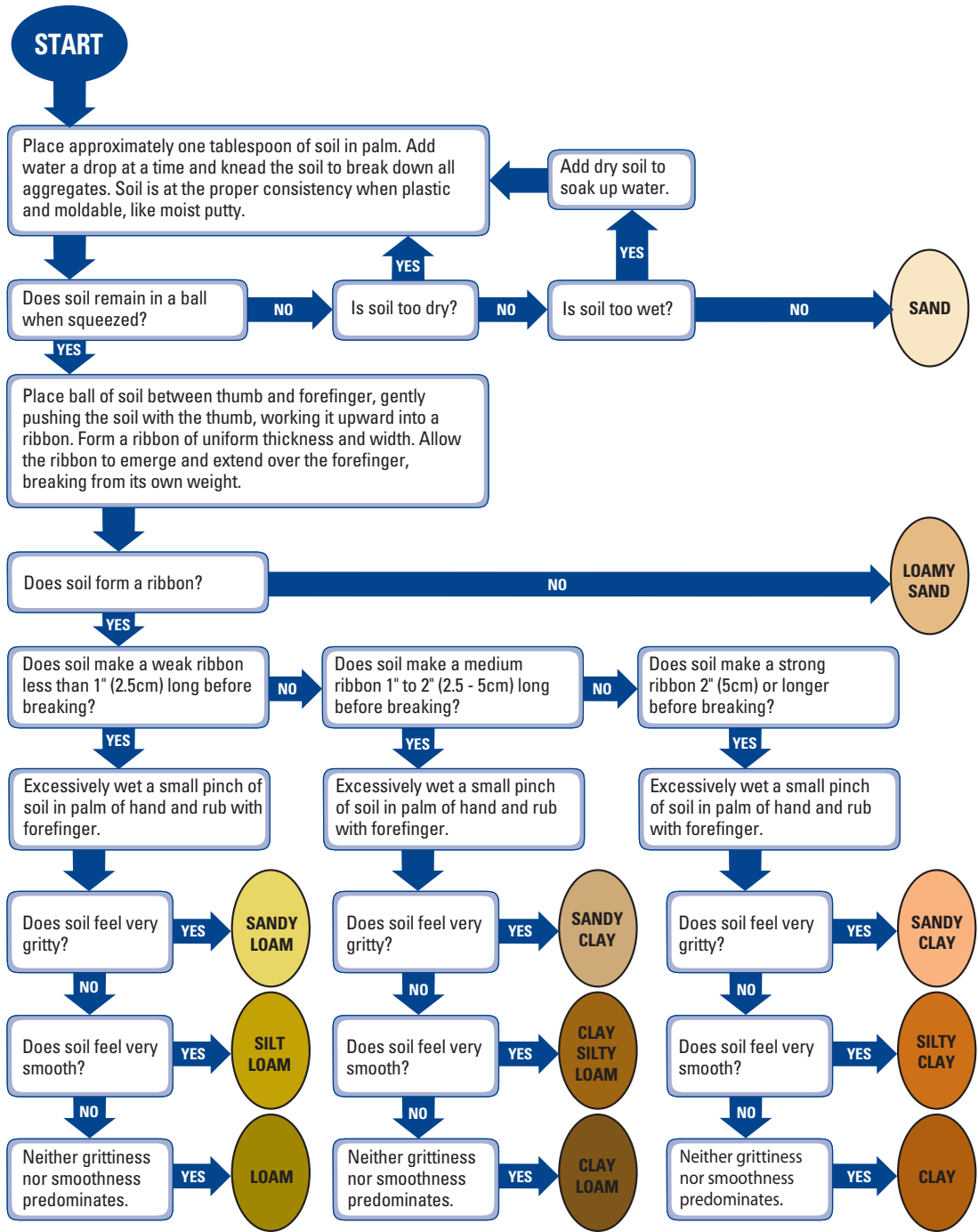
It has been our goal to explain the concept of subsurface dripline using Techline CV and Techline DL in a simple, informative way. Subsurface dripline is an irrigation technology that contractors around the world have been using for years with excellent success. We hope that you agree that because much is known about it, using it is both a logical and safe decision.

For specific product and design recommendations, we encourage you to review the following materials:

- Netafim USA Landscape & Turf Division Catalog
- Techline CV Design Guide
- Techline DL Design Guide
- Netafim USA web site at www.netafimusa.com/landscape

Each of these will provide you with even more specifics regarding the proper choice and application of products. They are available at your local Netafim Landscape & Turf Distributor or on-line at www.netafimusa.com/landscape.

DETERMINING SOIL TEXTURE BY THE "FEEL METHOD"



Modified from: Thien, Steve J.; Kansas State University, 1979 Jour. Agronomy Education.



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